

WATER PERMIT NO. 2360-2

Name of Applicant: City of Rapid City

Address: 300 6th St, Rapid City SD

Phone: 605 394-4165

Amount of Water Claimed: 0.37 cfs

Total Acres: NA

Source of Water Supply: Rapid Creek

Water to be used for: municipal use

County: Pennington

Type of Waste Disposal System: NA

Location:

PRIORITY

Date Received: 4-26-96

Fee: \$50.00

Corrected Application Received:

Period of Annual Use: Jan 1- Dec 31

Remarks: Transfer use of a portion of irrigated land under South Side Ditch - Soetaert Property

Diversion Point:

Land to be Irrigated:

Depth of Well: _

Well Driller:

Remarks:

Type of Map:

Prepared by:

Reviewed and the Number Assigned on: 4-25-96

By: **Karen Schlaak**

Notice of Hearing - date to intervene: _____

No. 2360-2 Hydrologic Unit 10/20110
 Map No. _____ Basin UPPER Cheyenne
 Newspaper Rapid City Journal, Rapid city, SD

Application For Permit To Appropriate Water Within The State Of South Dakota

Check use of water: Industrial ☒ Commercial ☒ Municipal ☒ Other Common Distribution System ☒
 Rural Water System ☒ Suburban Housing ☒ Geothermal Heat ☐ Institutional ☐ Recreational ☐
 Domestic ☒ (above 18gpm) Other ☐

Type of Application: Check one or more of the following

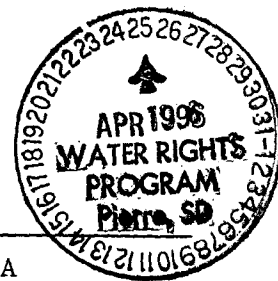
New ☐ Vested Right ☐ Future Use ☐ Change Use ☒

☒ Amend Permit No. 2040-2 with old priority date retained

Change diversion point(s) ☒ Add diversion point(s) ☒ Other ☐

☐ Application to: Change diversion point(s) ☐ Add diversion point(s) ☐ on Permit No. N/A

☐ Construction to use water reserved by Future Use Permit No. N/A



1. Name of Applicant CITY OF RAPID CITY Phone No. (605) 394-4165

Post Office Address 300 SIXTH STREET, RAPID CITY State SD 57701
(Street, RR or Box) (City) Zip Code

2. Amount of water claimed (c.f.s) 0.37 CFS NOT TO EXCEED 61.3 AF/YR OR 31.3 AF/YR AT ALTERNATE PACTOLA RESERVOIR DIVERSION

3. Source of water supply RAPID CREEK (SEE ATTACHED EXHIBIT 1)

4. Location of point of diversion SEE ATTACHED EXHIBIT 2 FOR LEGAL DESCRIPTIONS OF CITY OF RAPID CITY WATER TREATMENT PLANT, GALLERIES AND ALTERNATE PACTOLA RESERVOIR DIVERSION POINTS

County PENNINGTON

5. Counties where water will be used PENNINGTON COUNTY, SOUTH DAKOTA

6. Annual period during which water is to be used APRIL 15 THRU OCTOBER 15 (JANUARY 1 THRU DECEMBER 31 FOR PACTOLA DIVERSION RELEASE FROM STORAGE)

7. Give a brief description of proposed project. When available include any preliminary engineering report or other reports or information that will help explain the project. (Attach sheet if more space is needed)

THE PROJECT IS DESCRIBED IN DETAIL IN THE ACCOMPANYING MC LAUGHLIN WATER ENGINEERS, INC. REPORT. THE PROJECT WILL DIVERT WATER FROM RAPID CREEK TO THE CITY OF RAPID CITY WATER TREATMENT PLANT THROUGH THE EXISTING DIVERSION STRUCTURE ON RAPID CREEK, AND TO THE EXISTING INFILTRATION GALLERIES. THE PROJECT WILL ALSO, IN THE ALTERNATIVE BUT NOT SIMULTANEOUSLY, DIVERT WATER FROM RAPID CREEK TO STORAGE IN PACTOLA RESERVOIR.

Attachments: Attach Form 2A if diversion from a well or dugout, or if storage of water, is proposed. Attach map (see instruction)

STATE OF SOUTH DAKOTA)
 County of PENNINGTON)^{ss}

I, EDWARD R. MC LAUGHLIN, MAYOR FOR THE CITY OF RAPID CITY the applicant, certify that I have read this application, have examined the attached map and that the matters stated are true and that I intend, and am able to complete the necessary construction.

Signed Ed McLaughlin

Subscribed and sworn to before me this 24th day of April 1996

My commission Expires 11/12/2000

Notary Public

SOUTH DAKOTA
WATER PERMIT NO. 2360-2

Date of first receipt of application April 25, 1996.

The Water Management Board approved Water Permit Application No. 2360-2 on July 10, 1996 for the City of Rapid City, 300 6th St, Rapid City SD 57701 authorizing the construction of the water use system and the placing of water to beneficial use subject to the following limitations, conditions and qualifications:

1. Water Permit No. 2360-2 transfers the use of a portion of Rapid Creek natural flows historically used to irrigate 32.6 acres known as the Soetaert property. The portion of Rapid Creek natural flows to be transferred to the city is 0.37 cubic feet of water per second (cfs) with an annual volume limitation of 61.3 acre-feet, if diverted at the city's water treatment plant and infiltration galleries or 31.3 acre-feet, if stored in Pactola Reservoir. Historically, the 0.37 cfs has been used to irrigate 32.6 acres located in the W 1/2 NW 1/4 Section 33-T1N-R9E also known as the Soetaert Property. The existing diversion point on Rapid Creek for South Side Ditch is located in the SE 1/4 NW 1/4 Section 15-T1N-R8E. This permit is to change the diversion point for 0.37 cfs to diversion points for use by the city to be located in the SE 1/4 NE 1/4 Section 3 (Rapid City Water Treatment Plant); SW 1/4 SW 1/4 Section 3 (Sioux Park Gallery); SE 1/4 NE 1/4 Section 9 (Meadowbrook Gallery); NW 1/4 SE 1/4 Section 8 (Jackson Springs Gallery); all in T1N-R7E or to allow storage in Pactola Reservoir. The location of the Pactola Reservoir diversion point is the NW 1/4 SW 1/4 Section 2-T1N-R5E and the reservoir impounds water in portions of Sections 2, 3, 4, 5, 10, 11 of T1N-R5E and Sections 31, 32, 33, 34 of T2N-R5E. This permit does not authorize any new water appropriations from Rapid Creek.
2. The water appropriated shall be used for the purpose of meeting Rapid City's water needs and may not exceed the amount of water needed for beneficial use for municipal, industrial, commercial, common distribution system, rural water system, suburban housing and domestic purposes.
3. The water is to be used during the following described annual period: May 1 - September 30 for diversion from the Water Treatment Plant, Sioux Park Gallery, Meadowbrook Gallery and Jackson Springs Gallery and January 1 - December 31 for Pactola Reservoir diversion releases from storage.
4. The date from which applicant may claim right is May 3, 1880.
5. Water rights obtained in compliance with the laws of the State of South Dakota may not be unlawfully impaired by this appropriation.

QUALIFICATIONS

1. Permit No. 2360-2 is limited to a diversion rate of 0.37 cfs for a total annual volume of 31.3 acre feet at Pactola Reservoir or a total annual volume of 61.3 acre-feet at Sioux Park Gallery (SW 1/4 SW 1/4 Section 3) Meadowbrook Gallery (SE 1/4 NE 1/4 Section 9), Jackson Springs Gallery (NW 1/4 SE 1/4 Section 8) and Rapid City Water Treatment Plant (SE 1/4 NE 1/4 Section 3); all in T1N-R7E. Maximum monthly diversion volumes at Pactola or the diversion points within Rapid City are as follows:

(continued)

Month	Monthly acre feet at Pactola	Monthly acre feet at diversion points within Rapid City
May	4.3	8.9
June	6.5	12.6
July	6.7	13.0
August	7.9	15.3
September	5.9	11.6
October	0.0	0.0

Diversion during a month may be at either Pactola Reservoir or at the diversion points within Rapid City, but not simultaneously at both Pactola and the Rapid City diversion points.

2. Permit No. 2360-2 authorized diversions of only natural flow water by the City of Rapid City and does not include any rights to stored irrigation water available under contract from Pactola Reservoir.
3. That the City of Rapid City report to the chief engineer annually the amount of water withdrawn each month at Pactola Reservoir or the diversion points within Rapid City.
4. That the Water Management Board is retaining jurisdiction of Permit No. 2360-2 in the event that additional information shows that changes need to be made in the monthly or total annual volumes authorized by Permit No. 2360-2.
5. Diversion under Permit No. 2360-2 may not interfere with existing water rights in effect prior to approval of No. 2360-2, or any domestic rights.
6. The amount of water with a May 3, 1880, priority date, which may be appropriated under Vested Water Right No. 2040-2 is reduced by 0.37 cfs.
7. Approval of Water Permit No. 2360-2 retires the 32.6 acres, known as the Soetaert Property, which has been historically irrigated from the South Side Ditch, located in the W 1/2 NW 1/4 Section 33-T1N-R9E from future irrigation.

WATER MANAGEMENT BOARD

By: _____

John Hatch, Chief Engineer
Water Rights Program
Department of Environment and Natural Resources

OCT 1 1996

date



Supplemental Information

(type or print in ink)

1. Well Information - Proposed construction N/A

- Drill Hole Diameter _____ Depth _____
- Casing Type _____ Diameter _____ Thickness _____
- Screen Type _____ Diameter _____ Thickness _____
- Gravel Pack Thickness _____ Length of Gravel Pack _____
- Depth to Top of Water Bearing Material _____
- Depth to Water (ground surface to water level) _____
- Distance to nearest existing domestic well:

On applicants property _____ On property owned by others _____

2. Dugout Information Estimates N/A

- Surface Dimensions _____ Depth _____
- Depth to water (ground surface to water level) _____

3. Water Storage Dams (EXISTING PACTOLA RESERVOIR)

If the proposed water use system contains one or more storage dams, please furnish the information requested below. The locations of each dam should be shown on the map submitted with the application.

- If a private engineering firm or government agency was involved in the design of this dam please give their name and address

UNITED STATES BUREAU OF RECLAMATION

DEPARTMENT OF THE INTERIOR

b) Freeboard 3.3 FT

c) Crest Width 40 FT

Crest Length 5,200 FT (INCLUDING DIKES)

d) Height 245 FT

e) Primary Outlet Capacity 1,150 CFS
If Pipe, diameter TWO 2.75 FT X 2.75 FT GATES

f) Secondary Spillway Capacity 245,000 CFS
Spillway width 425 FT

g) X & Y Slope
Upstream 2-1/2:1

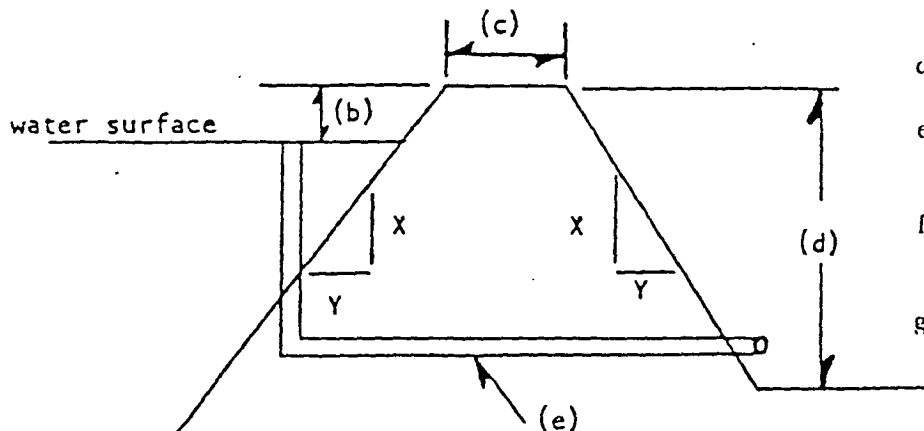
Downstream 2:1

Surface Area of Impoundment 1,232 ACRES
1/

Storage 99,029 1/ acre feet

Drainage area above dam 319 SQ MI

1/ INCLUDES FLOOD POOL



Ed McLaughlin

Signature of Applicant EDWARD R. McLAUGHLIN, Mayor
City of Rapid City

EXHIBIT 1

**LEGAL DESCRIPTION OF IRRIGATED LAND
AFFECTED BY APPLICATION**

Lot 1 of Jundt Subdivision located in the West One-half of the Northwest Quarter of Section Thirty-three (33), Township One (1) North, Range Nine (9) East of the Black Hills Meridian, Pennington County, South Dakota, consisting of 40 acres, more or less.

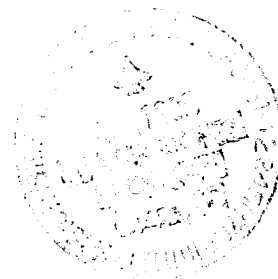


EXHIBIT 2

APPLICATION FOR PERMIT TO APPROPRIATE WATER
WITHIN THE STATE OF SOUTH DAKOTA



4) LOCATION OF POINTS OF DIVERSION

City of Rapid City Water Treatment Plant:

North 71° 39' West, 1205 ft. from East $\frac{1}{4}$ corner of Section Three (3), Township One (1) North, Range Seven (7) East of the Black Hills Meridian.

Sioux Park "Girl Scout" Gallery:

1270 ft. North 54° 05' East of Southwest corner of Section Three (3), Township One (1) North, Range Seven (7) East of the Black Hills Meridian.

Meadowbrook Gallery:

2032 ft. South 31° 41' West of Northeast corner of Section Nine (9), Township One (1) North, Range Seven (7) East of the Black Hills Meridian.

Jackson Springs Gallery:

2943 ft. North 58° 54' West of Southeast corner of Section Eight (8), Township One (1) North, Range Seven (7) East of the Black Hills Meridian.

Alternate Pactola Reservoir Diversion (Inlet to Service Spillway:

South 19° East, 3740 ft. of Northwest corner of Section Two (2), Township One (1) North, Range Five (5) East of the Black Hills Meridian.

Reservoir generally located in portions of Sections Two (2), Three (3), Four (4), Five (5), Ten (10) and Eleven (11), Township One (1) North, Range Five (5) East of the Black Hills Meridian, and portions of Sections Thirty-One (31), Thirty-Two (32), Thirty-Three (33) and Thirty-Four (34), Township One (1) North, Range Five (5) East of the Black Hills Meridian.

All of the above in Pennington County, South Dakota.



RECEIPT

414950

Division of Water Rights

South Dakota Department of Environment and Natural Resources

Pierre, _____ May 8, 19 96

RECEIVED OF City of Rapid City, 300 6th St., Rapid City, SD 57701

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

Fee for Application for Permit No. <u>2360-2</u> to Appropriate Water, to construct and to put water to beneficial use _____	50	00
Fee for Application for Permit No. _____ to Appropriate Water, for Future Use _____		
Fee to retain Future Use Permit No. _____ after period of seven years.		
Fee for Inspecting Constructed Works, confirming beneficial use and issuing Water License No. _____		
Fee for Filing Transfer Form _____		
Fee for Filing Extension Request _____		
Fee for _____		

(Any Other Work Provided by Law)	Total	50 00

By John Hatch 
Chief Engineer

Purchase Order

PO Number 325275



Year

Vendor Number **V 0** _____

Computer Entry Date _____

Remittance

Address 523 E Capitol

Pierre SD 57501

CR	Amount	Cost Center	Line Item	Invoice No.
1	50.00	0933	4390	

Quantity/Description
Water Rights Division
Soetaert Property

50.00 TOTAL

This order is regularly issued only when countersigned by Purchasing Agent and approved by the Mayor, if over \$500.00.

Formal Bid - Date Approved _____

Informal bid, see supporting data attached

No bid required

Will be reimbursed by _____

REMARKS

Dept. Head Markus Heppner Date _____

Mayor _____ Date _____

Purchasing Agent _____ Date _____

Date 4-24-96

Date _____

Date _____

VENDOR COPY



McLaughlin Water Engineers, Ltd.

2420 Alcott Street, Denver, Colorado 80211 (303) 458-5550

Facsimile (303) 480-9766

103060,1344 @compuserve.com

April 19, 1996

Mr. Daniel L. Bjerke, P.E./L.S.
City Engineer
City of Rapid City
300 Sixth Street
Rapid City, South Dakota 57701



RONALD C. McLAUGHLIN
LEO M. EISEL
HALFORD E. ERICKSON
WILLIAM R. KENDALL
RALPH L. TOREN
TERRENCE P. KENYON
RICHARD E. McLAUGHLIN
RONALD J. McLAUGHLIN

GENE A. BURRELL
MICHAEL E. MERCER
JOHN M. PFLAUM
MICHAEL R. GALUZZI
SCOTT E. LEHMAN
BRIAN S. KOLSTAD
G. DEAN DEROSIER
EDWARD D. BAIN
BRIAN E. CHEVALIER
DANIEL F. BLAHA

J. HAROLD ROBERTS
LEANDER L. URMY
DANIEL M. PETRAMALA
RONALD D. LUCERO

RE: Soetaert Property Water Rights Transfer

Dear Mr. Bjerke:

McLaughlin Water Engineers, Ltd. has determined the irrigated acreage under the South Side Ditch belonging to Richard Soetaert and the amount of water that can be transferred to the Rapid City water treatment plant and infiltration galleries as it relates to information detailed in the engineering report prepared for the Stromer property dated March 1992.

These calculations are based upon a flood irrigation efficiency of 50 percent and a 9.8 percent seepage loss for the South Side Ditch.

The October 27, 1987 vested rights for license N^o 2040-2 on the South Side Ditch indicates Don Jundt had 286 acres of irrigated land in the southwest portion of Section 28 and the central and northwest portion of Section 33, Township 1 North, Range 9 East of the Black Hills Meridian. Mr. Jundt in recent years sold a 40 acre parcel of his property including approximately 32.6 acres of irrigable land and its accompanying water rights. This 40 acre parcel is now owned by Richard Soetaert. The total remaining acres owned and irrigated by Mr. Jundt is 253.4 acres. A field inspection by Daniel L. Bjerke and Mr. Terry Rathbun on November 23, 1992 verified that 275 acres were irrigated including the 40-acre panel which was sold by Mr. Jundt. Therefore, the licensed acreage (286 acres) net the 32.6 acres of irrigated land sold by Jundt were used as the basis for the Jundt water rights transfer.

A field inspection of the Soetaert property was made in March 1996 by Daniel Bjerke and it was determined that 33.2 acres of the Soetaert property were irrigated for hay. Therefore, the 32.6 acres of irrigated land sold by Jundt and considered in the calculations for the net transfer of 253.4 acres by Donald Jundt is used as the basis for the Soetaert water transfer.

ASPEN, CO
(970) 925-1920

PHOENIX, AZ
(602) 248-7702

The consumptive use calculations in the attached Table A yield the following:

- a. To storage in Pactola Reservoir, the average year transferable amount is:

$$(32.6 \text{ acres}) \times (0.96 \text{ acre-feet/acre}) = 31.3 \text{ acre-feet.}$$

The consumptive use calculations for average year hay are included in Table A-1.

- b. To the City WTP and infiltration galleries, the average year transferable amount is:

$$(32.6 \text{ acres}) \times (1.93 \text{ acre-feet/acre} - 2.8 \text{ percent due to return flows from the Murphy and Cyclone ditches}) = 61.3 \text{ acre-feet (see attached Table B).}$$

The calculations to determine if a full irrigation supply was provided by the South Side Ditch to the Soetaert property are based on 1,313 acres of presently irrigated land for the South Side Ditch as agreed to in the January 3, 1992 telephone conference with Del Brosz and Mark Rath. The 1,313 acres consist of 1,078 acres irrigated under the South Side Ditch priority and 235 acres irrigated under the Little Giant Ditch priority.

The monthly transferable amounts to Pactola Reservoir and the City's WTP and infiltration galleries are presented in Table C. Diversion at the alternate points of diversion at the water treatment plant, infiltration galleries and Pactola Reservoir will only take place during the permitted irrigation season for the South Side Ditch of April 15 to November 1; Table C, however, includes transferable amounts for May through September because no historic diversion by the South Side Ditch is recorded for April or October.

The rate of diversion for the transferable amount from the Soetaert property is calculated by the following method:

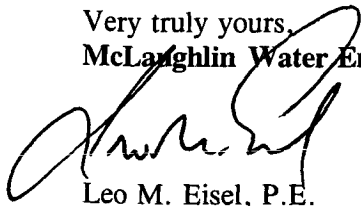
$$\frac{32.6 \text{ acres}}{1,877 \text{ acres}} \times 23.4 \text{ cfs at the ditch headgate} \times (1.0 - 0.098) = 0.37 \text{ cfs}$$

Where the 9.8 percent carriage loss would remain in the ditch, the 1,877 acres is the licensed acreage for the South Side Ditch, and the 23.4 cfs is the licensed diversion.

These transferable amounts and this rate of diversion insure that there will be no injury to downstream water rights and that depletions to Rapid Creek will not exceed historic depletions.

If you have any questions regarding these calculations, please do not hesitate to contact us.

Very truly yours,
McLaughlin Water Engineers, Ltd.

A handwritten signature in black ink, appearing to read 'Leo M. Eisel', is written over the company name.

Leo M. Eisel, P.E.
President

DETERMINATION OF CONSUMPTIVE USE FOR TRANSFER
RAPID CITY WATER RIGHTS
95-002.001PO
APRIL 17, 1996

FILENAME: C:\RAPIDCITY\SOETAERT\AVCU.WB2

TABLE A

TRANSFERABLE AMOUNT FROM SOETAERT PROPERTY PORTION OF SOUTH SIDE DITCH WATER RIGHTS (AVERAGE)

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
MONTH	C.U. (IN)	PRECIP. (IN)	EFFECT. PRECIP. (IN)	PRECIP. ADJ. C.U. (IN)	EXCESS PRECIP. TO SOIL MOIST. DURING MONTH (IN)	SOIL MOIST. USED TO SATISFY ADJUST. C.U. (IN)	REMAIN. CROP REQUIRE (IN)	GROSS CROP NEEDS (IN)	FARM IRRIG. SUPPLY (IN)	EXCESS IRRIG. SOIL MOIST. CONTRI (IN)	ACCUM. SOIL MOIST. STORAGE AFTER IRRIG. (IN)	ADDITIONAL WATER REQUIRED TO MEET C. NEEDS FRO SUBIRRIG (IN)	DEEP PER (25.0%) (IN)	SURFACE WATER RETURN FLOW (25.0%) (IN)	GLAINED IRRIG C.U. FOR TRANSFER (IN)
NOV	0.00	0.53	0.37	0.00	0.37	0.00	0.00	0.00	0.00	0.00	0.37	0.00	0.00	0.00	0.00
DEC	0.00	0.41	0.29	0.00	0.29	0.00	0.00	0.00	0.00	0.00	0.66	0.00	0.00	0.00	0.00
JAN	0.00	0.50	0.35	0.00	0.35	0.00	0.00	0.00	0.00	0.00	1.01	0.00	0.00	0.00	0.00
FEB	0.00	0.59	0.41	0.00	0.41	0.00	0.00	0.00	0.00	0.00	1.42	0.00	0.00	0.00	0.00
MAR	0.00	1.11	0.78	0.00	0.78	0.00	0.00	0.00	0.00	0.00	2.20	0.00	0.00	0.00	0.00
APR	0.58	2.11	0.38	0.20	0.00	0.20	0.00	0.00	0.00	0.00	2.00	0.00	0.00	0.00	0.00
MAY	3.29	2.58	1.72	1.57	0.00	1.57	0.00	0.00	0.00	0.00	2.09	0.00	0.00	0.00	0.00
JUN	4.71	3.29	2.31	2.40	0.00	2.09	0.31	0.61	3.33	1.67	2.08	0.00	0.83	0.83	1.57
JUL	6.54	1.87	1.55	4.99	0.00	2.08	2.91	5.81	4.78	2.08	0.00	0.44	1.20	1.20	2.39
AUG	5.70	1.55	1.24	4.46	0.00	0.00	4.46	8.92	4.94	0.00	0.00	1.57	1.23	1.23	2.47
SEP	3.24	1.10	0.78	2.46	0.00	0.00	2.46	4.92	5.78	0.00	0.00	0.27	1.44	1.44	2.89
OCT	1.53	0.75	0.40	1.13	0.00	0.00	1.13	2.26	4.38	0.00	0.00	1.13	1.09	1.09	2.19
TOTAL	25.59	16.39	10.58	17.21	2.20	5.95	11.26	22.53	23.21	3.75	11.83	3.41	5.80	5.80	11.51

AVERAGE CONDITIONS; CROP = 100% HAY

SOUTH SIDE DITCH AND LITTLE GIANT DITCH IRRIGATED ACREAGE (1989) = 1078 + 235 = 1313

9.8% SEEPAGE LOSS IN 1989

SOETAERT IRRIGATED ACREAGE = 32.6

50% IRRIGATION EFFICIENCY USING FLOOD IRRIGATION

DEEP PERCOLATION IS ONE HALF OF IRRIGATION INEFFICIENCY (25.0%) PLUS EXCESS SOIL MOISTURE

OTHER HALF OF IRRIGATION INEFFICIENCY (25.0%) IS SURFACE WATER RETURN FLOW

PACT. = PACTOLA RESERVOIR

WTP = RAPID CITY WATER TREATMENT PLANT AND INFILTRATION GALLERIES

SOUTH SIDE DITCH AVERAGE MONTHLY DIVERSION IS FOR YEARS 1949-1979 DUE TO CONSISTENCY OF DATA

GROSS TRANSFERABLE AMOUNT FROM SOETAERT PROPERTY UNDER SOUTH SIDE DITCH		
(INCHES)	(FEET)	(AC.FT)
TO PACT.	11.51	0.96
TO WTP	23.21	1.93
		31.3
		63.0

TABLE A-1

TR-21 CONSUMPTIVE USE CALCULATIONS (AVERAGE) - HAY

LATITUDE: 44 N IRR. APPL. IN.: 3.00 f= 1.00067
 CROP: HAY STATION: RAPID CITY WSO AP LIMIT: 45 F MEAN TEMP
 YEAR: 49-54,56-59,63-68,70-79

MONTH	DAYS	TEMP	ADJ. TEMP.	% DAY	ADJ. DAY	CU FACTOR	CLIMATE COEFF.	GROWTH COEFF.	CU COEFF.	MONTH CU	MONTH PPT.	PPT. FACTOR	EFFECT. PPT.	ADJUSTED CU
A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
JAN	--	--	--	6.48	0.00	0.0000	0.3000	0.49	0.1470	0.00	--	-0.12	0.00	0.00
FEB	--	--	--	6.57	0.00	0.0000	0.3000	0.57	0.1710	0.00	--	-0.12	0.00	0.00
MAR	--	--	--	8.29	0.00	0.0000	0.3000	0.73	0.2190	0.00	--	-0.12	0.00	0.00
APR	9	43.9	47.4	9.05	2.84	1.3466	0.5060	0.85	0.4301	0.58	0.63	0.38	0.38	0.20
MAY	31	55.4	55.4	10.25	10.25	5.6785	0.6444	0.90	0.5800	3.29	2.58	1.72	1.72	1.57
JUN	30	63.2	63.2	10.39	10.39	6.5665	0.7794	0.92	0.7170	4.71	3.29	2.31	2.31	2.40
JUL	31	72.3	72.3	10.49	10.49	7.5843	0.9368	0.92	0.8618	6.54	1.87	1.55	1.55	4.99
AUG	31	70.8	70.8	9.71	9.71	6.8747	0.9108	0.91	0.8289	5.70	1.55	1.24	1.24	4.46
SEP	30	60.5	60.5	8.41	8.41	5.0881	0.7327	0.87	0.6374	3.24	1.10	0.78	0.78	2.46
OCT	26	49.3	51.1	7.64	6.67	3.4062	0.5700	0.79	0.4503	1.53	0.63	0.40	0.40	1.13
NOV	--	--	--	6.50	0.00	0.0000	0.3000	0.67	0.2010	0.00	--	-0.12	0.00	0.00
DEC	--	--	--	6.22	0.00	0.0000	0.3000	0.55	0.1650	0.00	--	-0.12	0.00	0.00

SUM	188
-----	-----

INCHES	25.59	11.65	8.39	17.20
FEET	2.13	0.97	0.70	1.43

RAPID CITY WATER RIGHTS

95-002.001PO

SOETAERT CONSUMPTIVE USE SUMMARY

APRIL 17, 1996

FILENAME: C:\RAPIDCITY\SOETAERT\TABLEB.WB2

TABLE B

TRANSFERABLE AMOUNTS FROM SOETAERT PROPERTY PORTION OF THE SOUTH SIDE DITCH WATER RIGHTS

DIVERSION POINT	GROSS SOETAERT TRANSFER (IN)	GROSS SOETAERT TRANSFER (AF)	RETURN FLOW CONTRIBUTION (%)	RETURN FLOW CONTRIBUTION (AF)	NET TRANSFERABLE AMOUNT (AF)
AVERAGE TO WTP	23.2	63.0	2.8	1.8	61.3
AVERAGE TO PACTOLA	11.5	31.3	--	--	31.3

The return flow contribution is that portion of the Soetaert property South Side Ditch water rights that composed of return flows from upstream ditches which reach Rapid Creek upstream from the South S Ditch point of diversion. These percentages and amounts are calculated in Appendix N.

MONTHLY TRANSFER SUMMARY

RAPID CITY WATER RIGHTS

95-002.001P0

APRIL 17, 1996

FILENAME: C:\RAPIDCITY\SOETAERT\TABLEC.WB2

TABLE C

MONTHLY TRANSFER SUMMARY

SOETAERT PROPERTY

MONTH	DIVERSION TO STORAGE IN PACTOLA RESERVOIR (AC.FT)*	DIVERSION AT THE RAPID CITY WTP AND INFILTRATION GALLERIES (AC.FT)**
MAY	4.3	9.0
JUNE	6.5	13.0
JULY	6.7	13.4
AUGUST	7.8	15.7
SEPTEMBER	5.9	11.9
OCTOBER	0.0	0.0
TOTAL	31.3	63.0

* Monthly amount transferable to storage in Pactola Reservoir:

Column P (Table A) x 32.6 acres x 1 foot/12 inches

** Monthly amount transferable to Rapid City WTP and infiltration galleries:

(Column J (Table A) x 32.6 acres x 1 foot/12 inches) -
2.8 percent return flows from Murphy and Cyclone
ditches (See attached Table B)

NOTE: All calculations based on 32.6 acres of hay.



**DEPARTMENT of ENVIRONMENT
and NATURAL RESOURCES**

JOE FOSS BUILDING
523 EAST CAPITOL
PIERRE, SOUTH DAKOTA 57501-3181

* INVOICE *

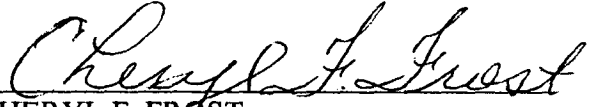
Invoice No. 20211-28-04/25/96

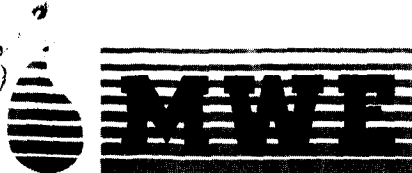
Jackie Gerry, Department Head
City of Rapid City
300 Sixth Street
Rapid City, SD 57701

Fee for Application to Appropriate Water (Soetaert Property).

PLEASE PAY THIS AMOUNT:

\$50.00


CHERYL F. FROST
Secretary
Water Rights Program
(605) 773-3352



McLaughlin Water Engineers, Ltd.

2420 Alcott Street, Denver, Colorado 80211 (303) 458-5550
Facsimile (303) 480-9766
103060,1344 @compuserve.com

May 21, 1996



RONALD C. McLAUGHLIN
LEO M. EISEL
HALFORD E. ERICKSON
WILLIAM R. KENDALL
RALPH L. TOREN
TERRENCE P. KENYON
RICHARD E. McLAUGHLIN
RONALD J. McLAUGHLIN

GENE A. BURRELL
MICHAEL E. MERCER
JOHN M. PFLAUM
MICHAEL R. GALUZZI
SCOTT E. LEHMAN
BRIAN S. KOLSTAD
G. DEAN DEROSIER
EDWARD D. BAIN
BRIAN E. CHEVALIER
DANIEL F. BLAHA

J. HAROLD ROBERTS
LEANDER L. URMY
DANIEL M. PETRAMALA
RONALD D. LUCERO

Mr. Mark Rath
Water Rights Division
Department of Environment and Natural Resources
Joe Foss Building
523 East Capitol Avenue
Pierre, South Dakota 57501-3181

RE: Soetaert Water Rights Transfer

Dear Mr. Rath:

Attached is a corrected Table C for the April 1996 Water Rights Report which has been supplied to ;you concerning the Soetaert property water rights transfer. A small correction has been made in Table C to allow for the 2.8 percent return flows from the Murphy and Cyclone Ditches. This correction was inadvertently not made in the original version. Would you be so kind as to substitute this Table C for the one in your copy.

Very truly yours,

Leo M. Eisel, P/E.
President

Enclosure

cc: Dan Bjerke, City of Rapid City (w/encl)

LME:djm/95-002.001/LME-16

ASPEN, CO
(970) 925-1920

PHOENIX, AZ
(602) 248-7702

TABLE C
MONTHLY TRANSFER SUMMARY
RAPID CITY WATER RIGHTS

SOETAERT PROPERTY

MONTH	DIVERSION TO STORAGE IN PACTOLA RESERVOIR (Acre-Feet)*	DIVERSION AT THE RAPID CITY WTP AND INFILTRATION GALLERIES (Acre-Feet)**
MAY	4.3	8.0
JUNE	6.5	12.6
JULY	6.7	13.0
AUGUST	7.8	15.3
SEPTEMBER	5.9	11.6
OCTOBER	0.0	0.0
TOTAL	31.3	61.3

* Monthly amount transferable to storage in Pactola Reservoir:
Column P (Table A) x 32.6 acres x 1 foot/12 inches

** Monthly amount transferable to Rapid City WTP and infiltration galleries:
(Column J (Table A) x 32.6 acres x 1 foot/12 inches) - 2.8 percent return flows from Murphy
and Cyclone Ditches (See attached Table B)

NOTE: All calculations based on 32.6 acres of hay.

Water Rights Program -- File Documentation

NAME: City of Rapid City

ADDRESS:

DATE: May 30, 1996 **COUNTY:** Pennington

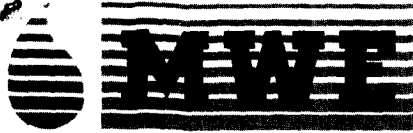
RE: Change in Table C diversion rates to reflect loss of 2.8% return flows.

COMMENTS:

Mr. Eisel with McLaughlin Water Engineers, LTD. submitted a corrected Table C which reflected the loss of 2.8 percent return flows from Murphy and Cyclone Ditches. There was an error in the May diversion at the WTP and Infiltration Galleries. I spoke with Mr. Eisel and he agreed that the diversion rate should be 8.8 ac-ft.



DelRon Peters, Natural Resources Engineer
Water Rights Program



McLaughlin Water Engineers, Ltd.

2420 Alcott Street, Denver, Colorado 80211 (303) 458-5550
Facsimile (303) 480-9766
103060,1344 @compuserve.com

May 31, 1996

RONALD C. McLAUGHLIN
LEO M. EISEL
HALFORD E. ERICKSON
WILLIAM R. KENDALL
RALPH L. TOREN
TERRENCE P. KENYON
RICHARD E. McLAUGHLIN
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DANIEL F. BLAHA

J. HAROLD ROBERTS
LEANDER L. URMY
DANIEL M. PETRAMALA
RONALD D. LUCERO

Mr. Eric Gronlund
Water Rights Division
Department of Environment and Natural Resources
Joe Foss Building
523 East Capital Avenue
Pierre, South Dakota 57501-3181



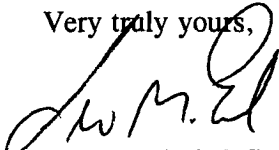
RE: Soetaert Water Rights Transfer

Dear Eric:

DelRon Peters indicated that there was apparently an error in the revised Table C which I recently sent to you concerning the Soetaert water rights transfer. Mr. Peters was correct. There was a typo in the revised table. I have corrected this typo and a hopefully totally correct version of Table C is attached. I am sending a copy of this by mail to you.

If you have any questions or concerns please contact me.

Very truly yours,


Leo M. Eisel, P.E.
President

Enclosure

cc: Dan Bjerke, City of Rapid City
DelRon Peters

LME:djm/95-002.001P/LME-17

ASPEN, CO
(970) 925-1920

PHOENIX, AZ
(602) 248-7702

TABLE C
MONTHLY TRANSFER SUMMARY
RAPID CITY WATER RIGHTS

SOETAERT PROPERTY

MONTH	DIVERSION TO STORAGE IN PACTOLA RESERVOIR (Acre-Feet)*	DIVERSION AT THE RAPID CITY WTP AND INFILTRATION GALLERIES (Acre-Feet)**
MAY	4.3	8.8
JUNE	6.5	12.6
JULY	6.7	13.0
AUGUST	7.8	15.3
SEPTEMBER	5.9	11.6
OCTOBER	0.0	0.0
TOTAL	31.3	61.3

* Monthly amount transferable to storage in Pactola Reservoir:
Column P (Table A) x 32.6 acres x 1 foot/12 inches

** Monthly amount transferable to Rapid City WTP and infiltration galleries:
(Column J (Table A) x 32.6 acres x 1 foot/12 inches) - 2.8 percent return flows from Murphy
and Cyclone Ditches (See attached Table B)

NOTE: All calculations based on 32.6 acres of hay.

Report on Water Permit Application No. 2360-2

City of Rapid City

May 21, 1996

Application No. 2360-2, City of Rapid City, proposes to transfer an annual volume of 61.3 acre-feet of water if diverted at the city's water treatment plant or infiltration galleries, or 31.3 acre-feet if stored in Pactola Reservoir. The maximum diversion rate proposed for this transfer is 0.37 cubic feet of water per second (cfs) from the natural flows of Rapid Creek. The transfer is from irrigation to the City of Rapid City for municipal use which includes industrial, commercial, common distribution system, rural water system, suburban housing, and domestic uses.

Application No. 2360-2 proposes to transfer South Side Ditch Company stockholder/landowner's water which has been historically used to irrigate 32.6 acres located in the W 1/2 of the NW 1/4 Section 33, Township 1N, Range 9E BHM also known as the Soetaert Property (previously part of the Jundt Property).

The source of water for the proposed transfer is from the natural flow available from Rapid Creek through South Side Ditch. Vested Water Right No. 2040-2, South Side Ditch, was validated for 23.40 cfs with a priority date of May 3, 1880. The existing diversion point for South Side ditch is located in the SE 1/4 NW 1/4 of Section 15 T1N-R8E. The locations of the diversion points for the proposed transfer are in the SE 1/4 NE 1/4 Section 3 (Rapid City Treatment Plant); SW 1/4 SW 1/4 Section 3 (Sioux Park Gallery); SE 1/4 NE 1/4 Section 9 (Meadowbrook Gallery); NW 1/4 SE 1/4 Section 8 (Jackson Springs Gallery); all in T1N-R7E and NW 1/4 SW 1/4 Section 2 T1N-R5E (Pactola Reservoir). Pactola Reservoir impounds water in portions of Sections 2, 3, 4, 5, 10, and 11 of T1N-R5E and Sections 31, 32, 33, and 34 of T2N-R5E. This application does not request any new water appropriation from Rapid Creek and the validated priority date of May 3, 1880 is to be retained by the city.

Review of Existing Water Rights

The water to be transferred has been appropriated under Vested Water Right No. 2040-2, South Side Ditch, with a priority date of May 3, 1880. Vested Water Right No. 2040-2 authorizes 284 acres of irrigation in sections 28 and 33 T1N-R9E which were all previously owned by Don Jundt. Mr. Jundt sold a 40 acre parcel of land to Richard Soetaert which included 32.6 acres authorized by Vested Water Right No. 2040-2. These 32.6 acres are located in the W 1/2 NW 1/4 Sec. 33 T1N, R9E BHM and have been continually irrigated.

There are 72 existing water rights/permits appropriating 259.19 cfs from Rapid Creek between Pactola Reservoir and the confluence with the Cheyenne River. Of these, 14 water rights which appropriate approximately 28.37 cfs have priority dates which are senior to this proposed transfer.

Table 1. Water Rights Senior to Permit Application No. 2360-2.

Owner Name	Water Right No.	Diversion Rates (CFS)
Cleghorn Springs Water Users	504-2	0.89
Leedy Ditch	2023-2	1.00
Rapid Valley Water Co. (Murphy Ditch)	1727-2, 2239-2, 2240-2, 2241-2 and 2242-2	16.2
Rapid Valley Water Service Co.	1101-2	1.73
Little Giant Ditch	653-2	6.27
City of Rapid City	0646-2, 1998-2, 2142-2, 2199-2 and 2201-2	2.28
Total	14 water rights	28.37 cfs

Review of the Proposed Transfer

SDCL 46-5-34.1 states that no transfer can occur unless the transfer can be made without detriment to existing rights or to individual domestic use rights. SDCL 46-5-34.1 also states "No land which has had an irrigation right transferred from it pursuant to this section, may qualify for another right from any water source." SDCL 46-2A-12 allows a change in use "only if the change does not unlawfully impair existing rights and is for a beneficial use and in the public interest." Calculations using accepted scientific methods and available climatic and cropping data have been made to insure that adverse affects on existing water rights do not occur.

The volume of water which could be stored in Pactola Reservoir is 31.3 acre-feet annually. This volume of water is equal to the amount of water estimated to have been consumed annually by the crop. The amount of water which can be diverted at Rapid City water system intakes is 61.3 acre-feet annually. This volume of water includes the amount consumed by the crop plus the return water to Rapid Creek. Murphy and Cyclone Ditches contribute return water, which becomes natural flow water, to Rapid Creek upstream of the South Side Ditch head gate. The Soetaert property has historically received a portion of this water as part of its natural flow. Because the source of this natural flow is located downstream of any of Rapid City's proposed diversion points, this water cannot be included in the volume of water transferred to the City's intakes. This extra water will be a benefit to downstream water rights.

The volume of water which was estimated to have been consumed by the crop is calculated on a monthly basis. For each month the maximum amount of water the crop would use is calculated. This is compared to the amount of water that is available for the crop's use based on historical ditch diversions and the total acreage irrigated annually from the ditch. A determination is made, on a monthly basis, whether maximum crop water usage or available water supply is the limiting factor. The lessor of these is used as the volume of water consumed by the crop for that particular month. Water which has been returned to Rapid Creek by Rapid City irrigation would also be returned to Rapid Creek by Rapid City through their waste water treatment system. (Wright, 1992) If in the future the City of Rapid City stops returning effluent to Rapid Creek, then the diversion proposed by this application will need to be recalculated to reflect that condition.

1

Farm turnouts do not have measuring devices, so actual individual diversions from the ditch are unknown. Water in the ditch is shared by the users as needed. Based on actual past operations, the calculated diversion rate transfer is based on a pro rata share of the total ditch diversion. The proposed diversion rate transfer is based on water beneficially used as described under SDCL 46-1-8.

The transferable diversion rate is based on the pro rata share of water which is decreased by the 9.8 percent carriage loss that is to remain in the ditch. This gives a transferable diversion rate of 0.37 cfs.

If this transfer is approved, the diversion rate and acreage authorized by the May 3, 1880 priority date of Water Right No. 2040-2 should be decreased by 0.37 cfs and 32.6 acres due to the transfer.

The water available for transfer is only from the natural flow in Rapid Creek and does not include stored water or stored releases from Deerfield - Pactola Reservoirs.

To insure that the transfer of the water can be made without detriment, the Water Management Board should monitor the management and operation of the proposed transfer.

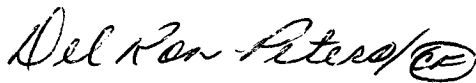
Conclusions

1. SDCL 46-5-34.1 allows for the transfer of irrigation water rights apart from the land to municipal use when the transfer can be made without causing detriment to existing rights. SDCL 46-2A-12 allows a change in use "only if the change does not unlawfully impair existing rights and is for a beneficial use and in the public interest."
2. The water has been historically used to irrigate 32.6 acres.
3. The priority date of May 3, 1880 should be retained.
4. The diversion rate to be transferred is 0.37 cfs, and is based on the pro-rated share of the total ditch diversion rate.
5. The amount of water requested to be transferred, 61.3 acre-feet of water if diverted at the city's water treatment plant or infiltration galleries, or 31.3 acre-feet if stored in Pactola Reservoir is reasonable. The following table lists the monthly diversion associated with each volume:

Table 2. Monthly diversions at Pactola Reservoir or if diverted at City intakes.

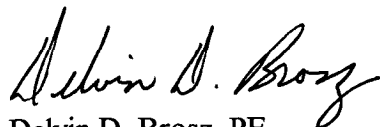
Month	Pactola (acre-feet)	Diversion at Intakes (acre-feet)
May	4.3	8.52
June	6.5	12.98
July	6.7	13.42
August	7.8	15.70
September	5.9	11.88
October	0.0	0.0

6. If application No. 2360-2 is approved, the authorized diversion rate and acreage for the South Side Ditch Water Right No. 2040-2 under the May 3, 1880 priority date should be decreased by 0.37 cfs and 32.6 acres.
7. The Water Management Board should continue to monitor the management and operation of the transfer of the water right and of existing water rights.
8. Approval of Application No. 2360-2, only approves transfer of natural flow water and does not include any rights to stored irrigation water available under contract from Pactola Reservoir.
9. Because natural flow water has not been available for Vested Water Right No. 2040-2 during lower flow periods, approval of Application No. 2360-2 does not guarantee that natural flow water will be available for diversion or storage during low flow periods.
10. The effect of approving Application No. 2360-2 will be to retire the Soetaert property from irrigation.
11. SDCL 46-5-34.1 states "No land which has had an irrigation right transferred from it pursuant to this section, may qualify for another irrigation right from any water source."



DelRon Peters
Natural Resources Engineer II

Approved by,



Delvin D. Brosz, PE
Natural Resources Engineer IV

References

1. Wright Water Engineers, Inc. 1992. Engineering Report for Transfer of Stromer Property Portion of South Side Ditch Water Rights. Wright Water Engineers, Inc. Engineering Consultants, Denver, Colorado.
2. U.S. Bureau of Reclamation. 1990. Rapid Valley Water Management Study. U.S. Bureau of Reclamation, Belle Fourche Projects Office, Newell, South Dakota.
3. SD Department of Environment and Natural Resources. Water Rights Program Records.

**RECOMMENDATION OF CHIEF ENGINEER FOR WATER PERMIT
APPLICATION NO. 2360-2, City of Rapid City**

Pursuant to SDCL 46-2A-2, the following is the recommendation of the Chief Engineer, Water Rights Program, Department of Environment and Natural Resources concerning Water Permit Application No. 2360-2, City of Rapid City, %Daniel Bjerke, 300 Sixth Street, Rapid City, SD 57701.

The Chief Engineer is recommending APPROVAL of Application No. 2360-2 because 1) the proposed diversion has been developed without unlawful impairment of existing rights, 2) the proposed use is a beneficial use and 3) in the public interest with the following qualifications:

1. Permit No. 2360-2 is limited to a diversion rate of 0.37 cfs for a total annual volume of 31.3 acre feet at Pactola Reservoir or a total annual volume of 61.3 acre feet at Sioux Park Gallery (SW 1/4 SW 1/4 Section 3), Meadowbrook Gallery (SE 1/4 NE 1/4 Section 9), Jackson Springs Gallery (NW 1/4 SE 1/4 Section 8) and the Rapid City Water Treatment Plant (SE 1/4 NE 1/4 Section 3); all in T1N, R7E. Maximum monthly diversion volumes at Pactola or the diversion points within Rapid City are as follows:

<u>Month</u>	<u>Monthly acre feet at Pactola</u>	<u>Monthly acre feet at diversion points within Rapid City</u>
May	4.3	8.9
June	6.5	12.6
July	6.7	13.0
August	7.9	15.3
September	5.9	11.6
October	0.0	0.0

Diversion during a month may be at either Pactola Reservoir or at the diversion points within Rapid City, but no simultaneously at both Pactola and the Rapid City diversion points.

2. Permit No. 2360-2 authorized diversions of only natural flow water by the City of Rapid City and does not include any rights to stored irrigation water available under contract from Pactola Reservoir.
3. That the City of Rapid City report to the chief engineer annually the amount of water withdrawn each month at Pactola Reservoir or the diversion points within Rapid City.
4. That the Water Management Board is retaining jurisdiction of Permit No. 2360-2 in the event that additional information shows that changes need to be made in the monthly or total annual volumes authorized by Permit No. 2360-2.

5. Diversion under Permit No. 2360-2 may not interfere with existing water rights in effect prior to approval of No. 2360-2 or any domestic rights.
6. The amount of water with a May 3, 1880, priority date, which may be appropriated under Vested Water Right No. 2040-2 is reduced by 0.37 cfs.
7. Approval of Water Permit No. 2360-2 retires the 32.6 acres, known as the Soetaert Property, which has been historically irrigated from South Side Ditch, located in the W 1/2 NW 1/4 Section 33, T1N, R9E from future irrigation.

See report on application for additional information.

A handwritten signature in cursive script, reading "John Hatch".

JOHN HATCH, Chief Engineer
June 5, 1996



**DEPARTMENT of ENVIRONMENT
and NATURAL RESOURCES**

JOE FOSS BUILDING
523 EAST CAPITOL
PIERRE, SOUTH DAKOTA 57501-3181

NOTE: TO BE SURE OF PUBLICATION ON
THE CORRECT DATES, CONTACT
THE NEWSPAPER RIGHT AWAY.

June 7, 1996

City of Rapid City
%Daniel Bjerke
300 6th Street
Rapid City, SD 57701

Dear Mr. Bjerke:

Water Permit Application No. 2360-2 for municipal use has been examined and found to comply with the South Dakota Water Laws and applicable rules. A notice of hearing has been sent to the Publisher of the Rapid City Journal printed at Rapid City, SD (Ph # (605) 394-8300). For your information, a copy of the notice, the recommendation of the Chief Engineer and a report on the application are enclosed. Please review the notice prior to publication and notify this office, if you have any corrections or questions.

Be sure to contact the above newspaper to authorize publication of your Notice of Hearing and to arrange for payment. Early contact with the paper can eliminate delays. The publisher has been instructed to publish your notice once each week for two consecutive weeks with the last publication to occur twenty days before the board meeting. The newspaper has been instructed to send us the Proof of Publication. We must receive Proof of Publication before action can be taken on the application.

Sincerely,

Eric Gronlund
Natural Resources Engineer
605 773-3352

enclosures

NOTE: If you plan to contest any part of the Chief Engineer's recommendation, you must file a petition pursuant to the procedures outlined in the attached notice of hearing. The Water Management Board will then consider your concerns during a hearing on the application.



**DEPARTMENT of ENVIRONMENT
and NATURAL RESOURCES**

JOE FOSS BUILDING
523 EAST CAPITOL
PIERRE, SOUTH DAKOTA 57501-3181

June 7, 1996

Rapid City Journal
P.O. Box 450
Rapid City, SD 57709-0450

ATTENTION: Legal Department

Enclosed is a Notice of Hearing on Application No. 2360-2 to be published twice. Please publish the first notice on June 13, 1996, with the second publication 7 days later.

The APPLICANT MUST VERIFY TO YOU THAT THE NOTICE IS TO BE PUBLISHED, before you make the first publication. Please BILL the APPLICANT for the cost of publication. The APPLICANT is City of Rapid City, %Daniel Bjerke, 300 6th Street, Rapid City, SD 57701 (Ph # (605) 394-4165).

A copy of BOTH publications must be SENT to the WATER RIGHTS PROGRAM. IMMEDIATELY return the FIRST publication with the FIRST Transmittal form on the bottom of this page. The first copy is needed to check the publication for errors so any corrections can be made in the second publication. Publication errors can invalidate the public notice and cause the applicant costly delays.

Please be sure the SECOND publication is returned IMMEDIATELY with the enclosed Proof of Publication form. DO NOT WAIT until the end of the month or the billing cycle. No action may be taken on the permit application until proof of publication has been received.

Sincerely,

Eric Gronlund
Natural Resources Engineer
605 773-3352

enclosures

-----CUT HERE-----

FIRST TRANSMITTAL NOTICE

TO: Eric Gronlund
Water Rights Program
Joe Foss Building
Pierre SD 57501-3181

No. _____

Date _____

We are in receipt of your letter of _____ enclosing Notice of Hearing to Appropriate Water by Application No. _____ which was first published in our issue of _____. ENCLOSED IS A COPY OF THIS FIRST PUBLICATION.

Name

Newspaper

Instruction to Newspaper - Publish first Notice on June 13, 1996, with the second publication 7 days later. The applicant is responsible for payment.

NOTICE OF HEARING on Application No. 2360-2 to Transfer Use

Notice is given that the City of Rapid City, 300 6th St., Rapid City, SD 57701 has filed an application for a water permit. Water Permit Application No. 2360-2 pursuant to 46-5-34.1 to transfer the use of a portion of Rapid Creek natural flows appropriated for irrigation use by South Side Ditch to municipal, industrial, commercial, common distribution system, rural water system, suburban housing, and domestic use by the City of Rapid City.

Water Permit No. 2360-2 is to transfer the use of a portion of Rapid Creek natural flows historically used to irrigate approximately 33 acres known as the Soetaert property. The portion of Rapid Creek natural flows to be transferred to the city is 0.37 cubic feet of water per second (cfs) with an annual volume limitation of 61.3 acre-feet, if diverted at the city's water treatment plant and infiltration galleries or 31.3 acre-feet, if stored in Pactola Reservoir. Historically, the 0.37 cfs has been used to irrigate approximately 33 acres located in the W 1/2 NW 1/4 Section 33-T1N-R9E also known as the Soetaert Property. The existing diversion point on Rapid Creek for South Side Ditch is located in the SE 1/4 NW 1/4 Section 15-T1N-R8E. This application is to change the diversion point for 0.37 cfs to diversion points for use by the city to be located in the SE 1/4 NE 1/4 Section 3 (Rapid City Water Treatment Plant); SW 1/4 SW 1/4 Section 3 (Sioux Park Gallery); SE 1/4 NE 1/4 Section 9 (Meadowbrook Gallery); NW 1/4 SE 1/4 Section 8 (Jackson Springs Gallery); all in T1N-R7E or to allow storage in Pactola Reservoir. The location of the Pactola Reservoir diversion point is the NW 1/4 SW 1/4 Section 2-T1N-R5E and the reservoir impounds water in portions of Sections 2, 3, 4, 5, 10, 11 of T1N-R5E and Sections 31, 32, 33, 34 of T2N-R5E. This application does not authorize any new water appropriations from Rapid Creek and the claimed priority date of May 3, 1880, for use of 0.37 cfs is to be retained by the city.

Pursuant to SDCL 46-2A-2, the Chief Engineer recommends APPROVAL of Application No. 2360-2 because 1) existing rights will not be unlawfully impaired, 2) it is a beneficial use of water, and 3) it is in the public interest.

Any person interested in opposing or supporting this application must file a written petition with BOTH the applicant and Chief Engineer. The applicant must also file a petition if opposed to the Chief Engineer's recommendation. The Chief Engineer's address is "Water Rights Program, Foss Building, 523 E Capitol, Pierre SD 57501 (605 773-3352)" and the applicant's mailing address is given above. A petition filed by either an interested person or the applicant must be filed by July 1, 1996. The petition may be informal, but must include a statement describing the petitioner's interest in the application, the petitioner's reasons for opposing or supporting the application, and the signature and mailing address of the petitioner or the petitioner's legal counsel, if legal counsel is obtained.

The Water Management Board will consider this application at 10:30 a.m., July 10, 1996, Floyd Matthew Training Center, 523 E. Capitol, Pierre, SD. The Chief Engineer's recommendation is not final or binding upon the Board. The Board is authorized to 1) approve, 2) approve with qualifications, 3) defer, or 4) deny this application based on the facts presented at the public hearing. The July 10, 1996, hearing date will be automatically delayed for at least 20 days upon written request to the Chief Engineer from the applicant or any interested person opposing the application. The request for an automatic delay must be filed by July 1, 1996.

Any hearing will be an adversary proceeding. Any person filing a petition and/or the applicant have the right to be represented by a lawyer and may present evidence or cross-examine witnesses according to SDCL 1-26. These and other due process rights will be forfeited if not exercised. Decisions of the Board may be appealed to the Circuit Court and State Supreme Court as provided by law. Contact Eric Gronlund by July 1, 1996, at the above Water Rights Program address to request copies of information pertaining to this application, to assure access to the hearing by the handicapped or to obtain an interpreter for the hearing impaired.

This application is made pursuant to SDCL 46-1-1 thru 46-1-9, 46-1-12 thru 46-1-16; 46-2-3.1, 46-2-9, 46-2-11, 46-2-13, 46-2-17; 46-2A-1 thru 46-2A-10, 46-2A-12, 46-2A-14, 46-2A-15, 46-2A-20, 46-2A-21; 46-5-1 thru 46-5-11, 46-5-13 thru 46-5-15, 46-5-24, 46-5-25, 46-5-30.2, 46-5-30.4, 46-5-31; 46-5-33 thru 46-5-35; and Board Rules ARSD 74:02:01:01 thru 74:02:01:15. Nettie H. Myers, Secretary, Department of Environment and Natural Resources.

PROOF OF PUBLICATION

STATE OF SOUTH DAKOTA)
County of Pennington) SS

I, Patricia K. Van Patten

certify that the attached printed Notice was

taken from the Rapid City
Journal

printed and published in Rapid City

County of Pennington and State of

South Dakota. The notice was published in
the newspaper on the following two dates:

June 13, 1996

June 20, 1996

Cost of Printing: \$ 136.84



June 13, 20 L1942

**NOTICE OF HEARING
ON APPLICATION NO. 2360-2
TO TRANSFER USE**

Notice is given that the City of Rapid City, 300 6th St., Rapid City, SD 57701 has filed an application for a water permit, Water Permit Application No. 2360-2 pursuant to 46-5-34.1 to transfer the use of a portion of Rapid Creek natural flows appropriated for irrigation use by South Side Ditch to municipal, industrial, commercial, common distribution system, rural water system, suburban housing, and domestic use by the City of Rapid City.

Water Permit No. 2360-2 is to transfer the use of a portion of Rapid Creek natural flows historically used to irrigate approximately 33 acres known as the Soetaert property. The portion of Rapid Creek natural flows to be transferred to the city is 0.37 cubic feet of water per second (cfs) with an annual volume limitation of 61.3 acre-feet, if diverted at the city's water treatment plant and infiltration galleries or 31.3 acre-feet, if stored in Pactola Reservoir. Historically, the 0.37 cfs has been used to irrigate approximately 33 acres located in the NW 1/4 NW 1/4 Section 33-T1N-R9E also known as the Soetaert Property. The existing diversion point on Rapid Creek for South Side Ditch is located in the SE 1/4 NW 1/4 Section 15-T1N-R8E. This application is to change the diversion point for 0.37 cfs to diversion points for use by the city to be located in the SE 1/4 NE 1/4 Section 3 (Rapid City Water Treatment Plant); SW 1/4 SW 1/4 Section 3 (Sioux Park Gallery); SE 1/4 NE 1/4 Section 9 (Meadowbrook Gallery); NW 1/4 SE 1/4 Section 8 (Jackson Springs Gallery); all in T1N-R7E or to allow storage in Pactola Reservoir. The location of the Pactola Reservoir diversion point is the NW 1/4 SW 1/4 Section 2-T1N-R5E and the reservoir impounds water in portions of Sections 2, 3, 4, 5, 10, 11 of T1N-R5E and Sections 31, 32, 33, 34 of T2N-R5E. This application does not authorize any new water appropriations from Rapid Creek and the claimed priority date of May 3, 1880, for use of 0.37 cfs is to be retained by the city.

Pursuant to SDCL 46-2A-2, the Chief Engineer recommends APPROVAL of Application No. 2360-2 because 1) existing rights will not be unreasonably impaired, 2) it is a beneficial use of water, and 3) it is in the public interest.

Any person interested in opposing or supporting this application must file a written petition with BOTH the applicant and Chief Engineer. The applicant must also file a petition if opposed to the Chief Engineer's recommendation. The Chief Engineer's address is "Water Rights Program, Foss Building, 523 E. Capitol, Pierre SD 57501 (605 773-3352)" and the applicant's mailing address is given above. A petition filed by either an interested person or the applicant must be filed by July 1, 1996. The petition may be informal, but must include a statement describing the petitioner's interest in the application, the petitioner's reasons for opposing or supporting the application, and the signature and mailing address of the petitioner or the petitioner's legal counsel, if legal counsel is obtained.

The Water Management Board will consider this application at 10:30 a.m., July 10, 1996, Floyd Matthew Training Center, 523 E. Capitol, Pierre, S.D. The Chief Engineer's recommendation is not

final or binding upon the Board. The Board is authorized to 1) approve, 2) approve with qualifications, 3) defer, or 4) deny this application based on the facts presented at the public hearing. The July 10, 1996, hearing date will be automatically delayed for at least 20 days upon written request to the Chief Engineer from the applicant or any interested person opposing the application. The request for an automatic delay must be filed by July 1, 1996.

Any hearing will be an adversary proceeding. Any person filing a petition and/or the applicant have the right to be represented by a lawyer and may present evidence or cross-examine witnesses according to SDCL 1-26. These and other due process rights will be forfeited if not exercised. Decisions of the Board may be appealed to the Circuit Court and State Supreme Court as provided by law. Contact Eric Granlund by July 1, 1996, at the above Water Rights Program address to request copies of information pertaining to this application, to assure access to the hearing by the handicapped or to obtain an interpreter for the hearing impaired.

This application is made pursuant to SDCL 46-1-1 thru 46-1-9, 46-1-12 thru 46-1-16; 46-2-3.1, 46-2-9, 46-2-11, 46-2-13, 46-2-17; 46-2A-1 thru 46-2A-10, 46-2A-12, 46-2A-14, 46-2A-15, 46-2A-20, 46-2A-21; 46-5-1 thru 46-5-11, 46-5-13 thru 46-5-15, 46-5-24, 46-5-25, 46-5-30.2, 46-5-30.4, 46-5-31; 46-5-33 thru 46-5-35; and Board Rules ARSD 74:02:01:01 thru 74:02:01:15.

Nettie H. Myers
Secretary
Department of Environment
and Natural Resources

Patricia K. Van Patten
(Signature)

(Title)

6/20/96
(Date Signed)

**PARTIES OF RECORD LIST
APPLICATION NOS. 2234-2, 2316-2 AND 2317-2
CITY OF RAPID CITY**

Applicant

Daniel L. Bjerke, P.E./L.S.
Water/Wastewater Division Manager
City of Rapid City
300 Sixth Street
Rapid City, SD 57701

Attorney for Applicant

Bob Jackson, Attorney
%City of Rapid City
300 Sixth Street
Rapid City, SD 57701

Petitioners

Mark Kieffer
Keystone Rt., Box 3808
Rapid City, SD 57702

Zoltan Szakacs
P.O. Box
Caputa, SD 57725

Jerry Marsh
Marsh Ranch
HCR 36, Box 35
Caputa, SD 57725

Jerry Hammerquist
P.O. Box 26
Caputa, SD 57725

Melvin Brassfield
P.O. Box 24
Caputa, SD 57725

George Sanders Ranch
3023 Tomahawk Dr.
Rapid City, SD 57702

Walter Jones
Jones Ranch
15248 Caputa Loop
Rapid City, SD 57701


Ed Taylor
HCR 36, Box 60
Caputa, SD 57725

Robert Dustman
Dustman Ranch
P.O. Box 53
Caputa, SD 57725

Wm Ham, President
St. Germain Irrigating Co.
P.O. Box 32
Caputa, SD 57725

Tom Odom
Odom Ranch
23232 Huntington Place
Rapid City, SD 57702



**DEPARTMENT of ENVIRONMENT
and NATURAL RESOURCES**

JOE FOSS BUILDING
523 EAST CAPITOL
PIERRE, SOUTH DAKOTA 57501-3181

June 10, 1996

Craig Kjar
Bureau of Reclamation
P.O. Box 226
Newell, SD 57760

Dear Mr. Kjar:

Enclosed is a copy of the report, recommendation and notice of hearing for Water Permit Application No. 2360-2. This application, filed by the City of Rapid City, proposes to transfer the use of a portion of Rapid Creek natural flows from irrigation use to municipal use.

If you have any questions concerning this application, please contact DelRon Peters at (605) 394-2229.

Sincerely,

Eric Gronlund
Water Rights Program
(605) 773-3352

enclosure



**DEPARTMENT of ENVIRONMENT
and NATURAL RESOURCES**

JOE FOSS BUILDING
523 EAST CAPITOL
PIERRE, SOUTH DAKOTA 57501-3181

June 10, 1996

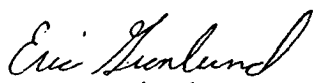
Jerry Hammerquist
Rapid Valley Water Conservancy District
Box 26
Caputa, SD 57725

Dear Mr. Hammerquist:

Enclosed is a copy of the report, recommendation and notice of hearing for Water Permit Application No. 2360-2. This application, filed by the City of Rapid City, proposes to transfer the use of a portion of Rapid Creek natural flows from irrigation use to municipal use.

This information is being sent to you because of your interest in Rapid City's applications to transfer Rapid Creek irrigation rights to municipal use. If you have any questions concerning this application, please contact DelRon Peters at (605) 394- 2229.

Sincerely,


Eric Gronlund
Water Rights Program
(605) 773-3352

enclosure



**DEPARTMENT of ENVIRONMENT
and NATURAL RESOURCES**

JOE FOSS BUILDING
523 EAST CAPITOL
PIERRE, SOUTH DAKOTA 57501-3181

June 10, 1996

Mark Kieffer
Keystone Rt., Box 3808
Rapid City, SD 57702

Dear Mr. Kieffer:

Enclosed is a copy of the report, recommendation and notice of hearing for Water Permit Application No. 2360-2. This application, filed by the City of Rapid City, proposes to transfer the use of a portion of Rapid Creek natural flows from irrigation use to municipal use.

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Sincerely,

Eric Gronlund
Water Rights Program
(605) 773-3352

enclosure



**DEPARTMENT of ENVIRONMENT
and NATURAL RESOURCES**

JOE FOSS BUILDING
523 EAST CAPITOL
PIERRE, SOUTH DAKOTA 57501-3181

June 10, 1996

Zoltan Szakacs
P.O. Box
Caputa, SD 57725

Dear Mr. Szakacs:

Enclosed is a copy of the report, recommendation and notice of hearing for Water Permit Application No. 2360-2. This application, filed by the City of Rapid City, proposes to transfer the use of a portion of Rapid Creek natural flows from irrigation use to municipal use.

This information is being sent to you because of your interest in Rapid City's applications to transfer Rapid Creek irrigation rights to municipal use. If you have any questions concerning this application, please contact DelRon Peters at (605) 394- 2229.

Sincerely,

Eric Gronlund
Water Rights Program
(605) 773-3352

enclosure



**DEPARTMENT of ENVIRONMENT
and NATURAL RESOURCES**

JOE FOSS BUILDING
523 EAST CAPITOL
PIERRE, SOUTH DAKOTA 57501-3181

June 10, 1996

Jerry Marsh
Marsh Ranch
HCR 36, Box 35
Caputa, SD 57725

Dear Mr. Marsh:

Enclosed is a copy of the report, recommendation and notice of hearing for Water Permit Application No. 2360-2. This application, filed by the City of Rapid City, proposes to transfer the use of a portion of Rapid Creek natural flows from irrigation use to municipal use.

This information is being sent to you because of your interest in Rapid City's applications to transfer Rapid Creek irrigation rights to municipal use. If you have any questions concerning this application, please contact DelRon Peters at (605) 394- 2229.

Sincerely,

Eric Gronlund
Water Rights Program
(605) 773-3352

enclosure



**DEPARTMENT of ENVIRONMENT
and NATURAL RESOURCES**

JOE FOSS BUILDING
523 EAST CAPITOL
PIERRE, SOUTH DAKOTA 57501-3181

June 10, 1996

Melvin Brassfield
P.O. Box 24
Caputa, SD 57725

Dear Mr. Brassfield:

Enclosed is a copy of the report, recommendation and notice of hearing for Water Permit Application No. 2360-2. This application, filed by the City of Rapid City, proposes to transfer the use of a portion of Rapid Creek natural flows from irrigation use to municipal use.

This information is being sent to you because of your interest in Rapid City's applications to transfer Rapid Creek irrigation rights to municipal use. If you have any questions concerning this application, please contact DelRon Peters at (605) 394- 2229.

Sincerely,

Eric Gronlund
Water Rights Program
(605) 773-3352

enclosure



**DEPARTMENT of ENVIRONMENT
and NATURAL RESOURCES**

JOE FOSS BUILDING
523 EAST CAPITOL
PIERRE, SOUTH DAKOTA 57501-3181

June 10, 1996

George Sanders Ranch
3023 Tomahawk Drive
Rapid City, SD 57702

Dear Mr. Sanders:

Enclosed is a copy of the report, recommendation and notice of hearing for Water Permit Application No. 2360-2. This application, filed by the City of Rapid City, proposes to transfer the use of a portion of Rapid Creek natural flows from irrigation use to municipal use.

This information is being sent to you because of your interest in Rapid City's applications to transfer Rapid Creek irrigation rights to municipal use. If you have any questions concerning this application, please contact DelRon Peters at (605) 394- 2229.

Sincerely,

A handwritten signature in cursive script that reads "Eric Gronlund".

Eric Gronlund
Water Rights Program
(605) 773-3352

enclosure



**DEPARTMENT of ENVIRONMENT
and NATURAL RESOURCES**

JOE FOSS BUILDING
523 EAST CAPITOL
PIERRE, SOUTH DAKOTA 57501-3181

June 10, 1996

Walter Jones
Jones Ranch
15248 Caputa Loop
Rapid City, SD 57701

Dear Mr. Jones:

Enclosed is a copy of the report, recommendation and notice of hearing for Water Permit Application No. 2360-2. This application, filed by the City of Rapid City, proposes to transfer the use of a portion of Rapid Creek natural flows from irrigation use to municipal use.

This information is being sent to you because of your interest in Rapid City's applications to transfer Rapid Creek irrigation rights to municipal use. If you have any questions concerning this application, please contact DelRon Peters at (605) 394- 2229.

Sincerely,

Eric Gronlund
Water Rights Program
(605) 773-3352

enclosure



**DEPARTMENT of ENVIRONMENT
and NATURAL RESOURCES**

JOE FOSS BUILDING
523 EAST CAPITOL
PIERRE, SOUTH DAKOTA 57501-3181

June 10, 1996

Ed Taylor
HCR 36, Box 60
Caputa, SD 57725

Dear Mr. Taylor:

Enclosed is a copy of the report, recommendation and notice of hearing for Water Permit Application No. 2360-2. This application, filed by the City of Rapid City, proposes to transfer the use of a portion of Rapid Creek natural flows from irrigation use to municipal use.

This information is being sent to you because of your interest in Rapid City's applications to transfer Rapid Creek irrigation rights to municipal use. If you have any questions concerning this application, please contact DelRon Peters at (605) 394- 2229.

Sincerely,

Eric Gronlund
Water Rights Program
(605) 773-3352

enclosure



**DEPARTMENT of ENVIRONMENT
and NATURAL RESOURCES**

JOE FOSS BUILDING
523 EAST CAPITOL
PIERRE, SOUTH DAKOTA 57501-3181

June 10, 1996

Robert Dustman
Dustman Ranch
P.O. Box 53
Caputa, SD 57725

Dear Mr. Dustman:

Enclosed is a copy of the report, recommendation and notice of hearing for Water Permit Application No. 2360-2. This application, filed by the City of Rapid City, proposes to transfer the use of a portion of Rapid Creek natural flows from irrigation use to municipal use.

This information is being sent to you because of your interest in Rapid City's applications to transfer Rapid Creek irrigation rights to municipal use. If you have any questions concerning this application, please contact DelRon Peters at (605) 394- 2229.

Sincerely,

Eric Gronlund
Water Rights Program
(605) 773-3352

enclosure



**DEPARTMENT of ENVIRONMENT
and NATURAL RESOURCES**

JOE FOSS BUILDING
523 EAST CAPITOL
PIERRE, SOUTH DAKOTA 57501-3181

June 10, 1996

Wm Ham, President
St. Germain Irrigation Co.
P.O. Box 32
Caputa, SD 57725

Dear Mr. Ham:

Enclosed is a copy of the report, recommendation and notice of hearing for Water Permit Application No. 2360-2. This application, filed by the City of Rapid City, proposes to transfer the use of a portion of Rapid Creek natural flows from irrigation use to municipal use.

This information is being sent to you because of your interest in Rapid City's applications to transfer Rapid Creek irrigation rights to municipal use. If you have any questions concerning this application, please contact DelRon Peters at (605) 394- 2229.

Sincerely,

Eric Gronlund
Water Rights Program
(605) 773-3352

enclosure



**DEPARTMENT of ENVIRONMENT
and NATURAL RESOURCES**

JOE FOSS BUILDING
523 EAST CAPITOL
PIERRE, SOUTH DAKOTA 57501-3181

June 10, 1996

Tom Odom
Odom Ranch
23232 Huntington Place
Rapid City, SD 57702

Dear Mr. Odom:

Enclosed is a copy of the report, recommendation and notice of hearing for Water Permit Application No. 2360-2. This application, filed by the City of Rapid City, proposes to transfer the use of a portion of Rapid Creek natural flows from irrigation use to municipal use.

This information is being sent to you because of your interest in Rapid City's applications to transfer Rapid Creek irrigation rights to municipal use. If you have any questions concerning this application, please contact DelRon Peters at (605) 394- 2229.

Sincerely,

Eric Gronlund
Water Rights Program
(605) 773-3352

enclosure



**DEPARTMENT of ENVIRONMENT
and NATURAL RESOURCES**

JOE FOSS BUILDING
523 EAST CAPITOL
PIERRE, SOUTH DAKOTA 57501-3181

June 10, 1996

Wayne Anderson
South Side Ditch Company
P.O. Box 648
Rapid City, SD 57709

Dear Mr. Anderson:

Enclosed is a copy of the report, recommendation and notice of hearing for Water Permit Application No. 2360-2. This application, filed by the City of Rapid City, proposes to transfer the use of a portion of Rapid Creek natural flows from irrigation use to municipal use.

This information is being sent to you because of your interest in Rapid City's applications to transfer Rapid Creek irrigation rights to municipal use. If you have any questions concerning this application, please contact DelRon Peters at (605) 394- 2229.

Sincerely,

A handwritten signature in cursive script that reads "Eric Gronlund".

Eric Gronlund
Water Rights Program
(605) 773-3352

enclosure



McLaughlin Water Engineers, Ltd.

2420 Alcott Street, Denver, Colorado 80211 (303) 458-5550
Facsimile (303) 480-9766
103060,1344 @compuserve.com

June 11, 1996

Mr. Mark Rath
Water Rights Division
Department of Environment and Natural Resources
Joe Foss Building
523 East Capitol Avenue
Pierre, South Dakota 57501-3181



RONALD C. McLAUGHLIN
LEO M. EISEL
HALFORD E. ERICKSON
WILLIAM R. KENDALL
RALPH L. TOREN
TERRENCE P. KENYON
RICHARD E. McLAUGHLIN
RONALD J. McLAUGHLIN

GENE A. BURRELL
MICHAEL E. MERCER
JOHN M. PFLAUM
MICHAEL R. GALUZZI
SCOTT E. LEHMAN
BRIAN S. KOLSTAD
G. DEAN DEROSIER
EDWARD D. BAIN
BRIAN E. CHEVALIER
DANIEL F. BLAHA

J. HAROLD ROBERTS
LEANDER L. URMY
DANIEL M. PETRAMALA
RONALD D. LUCERO

RE: Analysis of Water Quality in Rapid Creek Pertaining to Water Rights Transfers

Dear Mark:

Please find enclosed a copy of an investigation concerning the expected water quality effects of water rights transfers by the City of Rapid City.

This report summarizes the effects of an investigation to determine on the basis of available data what expected effects on water quality in Rapid Creek will likely result from past and future changes in water rights by the City of Rapid City. The results of this investigation are summarized in the Executive Summary and provided in detail the body of the report.

This report uses the Soetaert transfer as an example but the results should apply to all of Rapid City's past and expected future transfers.

After you have had a chance to review this please contact me if you have questions.

Very truly yours,

Leo M. Eisel, P.E.
President

Enclosure

cc: Dan Bjerke, City of Rapid City

LME:djm/95-002.001P/LME-18

ASPEN, CO
(970) 925-1920

PHOENIX, AZ
(602) 248-7702

ANALYSIS OF WATER QUALITY IN RAPID CREEK
PERTAINING TO WATER RIGHTS TRANSFERS

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ANALYSIS OF WATER QUALITY IN RAPID CREEK PERTAINING TO WATER RIGHTS TRANSFERS

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EXECUTIVE SUMMARY

The objective of this report is to determine the effect on water quality in Rapid Creek that is likely to occur from changing the use and point of diversion for 61.3 acre-feet per year of South Side Ditch water that was formerly used on the Soetaert property with return flows to Rapid Creek and, instead, diverting this water at Rapid City's infiltration galleries or water treatment plant for municipal purposes with return flows to Rapid Creek at the Rapid City wastewater treatment plant. In order to meet water supply demand, this 61.3 acre-feet of water supply could be obtained from other sources including groundwater and/or releases from Pactola Reservoir instead of transferring the 61.3 acre-feet of South Side Ditch water. The question this investigation seeks to answer is whether there is likely to be different water quality in Rapid Creek as a result of transferring the 61.3 acre-feet of Soetaert South Side Ditch water to municipal use rather than obtaining the 61.3 acre-feet from groundwater or releases from Pactola Reservoir thereby allowing the 61.3 acre-feet to continue in its historical irrigation use on the Soetaert property.

The proposed transfer of the Soetaert property share of the South Side Ditch is very similar to other water rights transfers made by Rapid City in the past. Consequently, the water quality effects of the Soetaert transfer should provide some indication of the water quality effects to other past and future transfers by Rapid City.

In order to determine the water quality effects of water rights transfers, it is first necessary to determine the effects of Rapid City's Wastewater Treatment Plant (WWTP) discharging to Rapid Creek and then ascertain the incremental effects that could be expected from transferring the 61.3 acre-feet of Soetaert South Side Ditch water as compared to pumping 61.3 acre-feet of groundwater or releasing 61.3 acre-feet from reservoir storage.

Wastewater Treatment Plant Discharge Standards

Rapid City has met, and will continue to meet, all requirements in its wastewater treatment plant discharge permit. These requirements include standards on BOD, total suspended solids, fecal coliforms, oil and grease, total residual chlorine, ammonia, dissolved oxygen, and pH.

Salinity Hazard

There has been historically an increase in salinity in Rapid Creek downstream from the Rapid City WWTP. This salinity increase is not beneficial for irrigation of crops which are sensitive or moderately sensitive to salts. Conductivity data for Rapid Creek downstream from the wastewater treatment plant indicate average conductivity levels of approximately 1000 microsiemens/cm. Data indicate that alfalfa is the most salinity sensitive crop grown in Rapid Valley and that average soil

conductivity must approach approximately 3400 microsiemens/cm before alfalfa is affected. It is realized that interpretation of water salinity data must be evaluated together with an extensive analysis of soil salinity data before reaching conclusions concerning potential injury to crops from irrigation with water with specific salinity concentrations. However, based on the 3400 microsiemens/cm threshold value for crop injury together with the existing approximately 1000 microsiemens/cm average conductivity downstream from the WWTP and the present absence of injury to crops which are irrigated with Rapid Creek water diverted downstream from the WWTP, continued use of Rapid Creek water diverted downstream from the WWTP should present little threat to future crop production.

With the exception of irrigation use on Beckton soils, Rapid Creek water downstream from the WWTP to Farmingdale is suitable for irrigation use. The Beckton soils occur on approximately 10 percent of the farmland area downstream from the Rapid City WWTP.

Sodium Hazard

Analysis of the SAR levels indicates that the levels are low for Rapid Creek water above the WWTP, below the WWTP and at Farmingdale. With any subsurface drainage whatsoever to carry some of the salts out of the root zone, the level of sodium in the water should not cause a problem for plant production.

The adjusted sodium absorption ratio (ASAR) measures the tendency of water to precipitate calcium and magnesium. Data are only available for Rapid Creek at Farmingdale where the ASAR values indicate a low sodium hazard.

Boron

No data are available for boron in Rapid Creek above or downstream from the WWTP until Farmingdale. These data do not indicate possible reductions in crop yields in Rapid Valley because of boron.

Phosphorous

Phosphorous in the WWTP effluent does not present, nor will it present a threat to crop production; it will instead promote crop production. Phosphorous in the WWTP effluent, however, promotes growth of aquatic vegetation in Rapid Creek.

Impacts on Groundwater

The data available on groundwater quality in the Rapid Creek Valley are very limited. The limited information that has been collected indicates no clear geographical pattern of chemical concentrations in the valley's groundwater. No influence of the WWTP on groundwater quality is evident.

Incremental Effect from Water Rights Change

During those periods of low flow in Rapid Creek when Rapid City can only transfer the historic consumptive use associated with the Soetaert share of the South Side Ditch (31.3 acre-feet/year), there will be little or no increase in total dissolved solids as a result of the change in point of diversion and use of the Soetaert share of the South Side Ditch. During those periods of relatively high flows when the Soetaert share of the South Side Ditch historic diversion can be transferred, an increase in salinity (TDS) may occur. During those periods of relatively high flows in Rapid Creek when Rapid City can transfer the 61.3 acre-feet of historic diversion, flows in Rapid Creek should have relatively lower salinity levels. This will reduce the chance that the transfer of the Soetaert rights will increase salinity levels in Rapid Creek. Based on crop salinity tolerances for those crops grown in the Rapid Creek Valley, existing salinity levels in Rapid Creek, and expected levels of salinity increases from water rights transfers, these possible increases in salinity should not cause reductions in crop yields.

ANALYSIS OF WATER QUALITY IN RAPID CREEK PERTAINING TO WATER RIGHTS TRANSFERS

INTRODUCTION

Rapid City is located in western South Dakota, just east of the Black Hills. Rapid Creek, a major water supply source for Rapid City, flows through the City immediately after passing out of the Black Hills from the west. After its passage through the City, Rapid Creek flows southeast past the towns of Caputa and Farmingdale (approximately 18 miles downstream of Rapid City). Rapid Creek is tributary to the Cheyenne River in South Dakota.

Rapid Creek meanders widely within its relatively flat floodplain in the reach between Rapid City and Farmingdale. The floodplain is fertile and supports irrigation farming of mostly hay and forage crops, predominately alfalfa. The irrigation system utilized is gravity flood with water delivered by a series of ditches running generally parallel to Rapid Creek. Some of the major ditches providing irrigation downstream of Rapid City are Southside, Murphy, St. Germaine and Lone Tree.

In recent years population growth and development within Rapid City has resulted in the need for the City to acquire water rights to provide sufficient water supply. Part of the City's water rights acquisition program has been to purchase existing rights from irrigation farmers in the floodplain of Rapid Creek downstream of the City. Following the purchase of these irrigation water rights the City has had the water rights' use classifications changed to allow for their utilization for municipal supply purposes. The City has also transferred the water rights' points of diversion from the irrigated parcels downstream of Rapid City upstream to Pactola Reservoir and the Rapid City Water Treatment Plant (WTP).

Recently, concerns have been raised about Rapid City's change in point of diversion and change in use by some of the irrigators utilizing the Rapid Creek supplied ditch systems. These irrigators believe there may be an effect on irrigation water quality available for their crops due to the water rights transfers taking place. Specifically, the irrigators' concerns center around allowing Rapid City to replace historic irrigation return flows to Rapid Creek with the discharge of effluent from the City's wastewater treatment Plant (WWTP). The transfer from the Soetaert property provides an example in which Rapid City seeks to transfer 31.3 acre-feet of historic consumptive use to Pactola Reservoir or 61.3 acre-feet of diversion to the infiltration galleries or Rapid City Water Treatment plant. The Soetaert property has been historically irrigated from the South Side Ditch. Irrigation of the Soetaert

property from the South Side Ditch will be terminated with the transfer of the Soetaert South Side Ditch water to Rapid City. Cessation of irrigation from the South Side Ditch on the Soetaert property will result in termination of historic return flows to Rapid Creek from irrigation on the Soetaert property. The City will divert the Soetaert share of the South Side Ditch to storage in Pactola Reservoir or directly divert it to the City's water supply system at the infiltration galleries/WWTP. Treated sewage effluent will return to Rapid Creek from the Rapid City WWTP.

The objective of this investigation is to determine what the effect on Rapid Creek water quality will be from replacing the historic irrigation return flows from the Soetaert property with wastewater treatment plant effluent.

Scope of Work

McLaughlin Water Engineers, Ltd. (MWE) was retained for this investigation to determine the extent to which water quality in Rapid Creek might be affected as a result of the water rights transfers from Rapid Valley irrigators to the City of Rapid City. There are two components to this investigation:

1. A compilation, overview and analysis of water quality data for Rapid Creek focusing on water quality upstream from the WWTP, immediately downstream from the WWTP and at Farmingdale.
2. Within the limits of available data, an analysis of the possible effects on Rapid Creek water quality and Rapid Creek Valley soils from substituting the wastewater effluent for the historic irrigation return flows from the Soetaert property.

This study evaluates the potential degradation of water quality downstream of the WWTP relating to: (1) raising of specific crops, and (2) application of Rapid Creek irrigation water to the alluvial soils supporting agricultural production.

Available data on the water quality in Rapid Creek have been collected and organized to characterize the potential effect of substituting wastewater effluent for the historical irrigation return flows from the Soetaert property. The impact on crop production was investigated for: boron, phosphorus, total dissolved solids, and modified SAR. Potential effects on crops (primarily hay and alfalfa) irrigated by Rapid Creek water were considered.

Potential impacts of the water rights transfers on soils used for irrigation in the Rapid Creek Valley were investigated. Effects of increasing proportions of WWTP effluent flow in the Creek's flow

volume was evaluated to determine if local soils' ability to support production agriculture would be affected. Specific concerns regarding elevated levels of phosphorus and its chemical derivatives have been raised by Mr. John West of the South Dakota State Extension Service. The impact of phosphorus-based chemicals, modified SAR and boron on soils are addressed.

To characterize the nature of the existing water quality in Rapid Creek, all available data collected by local, state and federal agencies were inspected and organized. This report presents the data that were reviewed for those chemical parameters most relevant to this investigation.

WATER QUALITY DATA

Water quality in Rapid Creek in the vicinity of Rapid City has been monitored since 1949 by various agencies, including the South Dakota Department of Environment and Natural Resources (DENR), the United States Geological Survey (USGS) and the Environmental Protection Agency (EPA). For the purposes of this investigation, data were reviewed, organized and evaluated at three locations in Rapid Creek downstream from Rapid City. Three locations were chosen so as to identify potential water quality effects in Rapid Creek from water rights transfers: (1) immediately upstream of the WWTP discharge, (2) immediately downstream of the WWTP discharge, and (3) near Farmingdale.

Rapid Creek water quality samples have been analyzed for a wide range of parameters over the years. To address the specific concerns of this report, the data were summarized for: pH, calcium, magnesium, sodium, bicarbonate, carbonate, phosphorus, orthophosphorus, solids residue at 105°C (Tot.), solids residue at 180°C (Dis.), and specific conductance. These data are presented in Appendix A in four tables. Tables A-1 and A-2 show the data collected by the South Dakota DENR. Table A-3 presents the data collected by the USGS and Table A-4 displays statistical summaries of data collected by the EPA.

A summary of the data collected in Rapid Creek is given in Table 1. Table 1 displays mean values for calcium, magnesium, sodium, phosphorus, solids residue at 180°C (Dis.), and specific conductance. In addition, means of chemical concentrations over two different time periods (the entire reporting period, and May 1986 through the most recent data) are reported in Table 1 for the DENR data. It was possible to report results over two different periods because there was significantly more data available from the DENR than from either the USGS or the EPA. Dividing these data made it possible to assess differences in the pattern exhibited by more recent conditions compared to averages from the longer complete period of sample collection.

Data for Total Dissolved Solids in mg/l were plotted for the period 1991 through 1995 on Figure 1. The data were taken from Rapid Creek upstream and downstream of the WWTP. Similarly, data for Phosphorus in mg/l upstream and downstream of the WWTP are plotted on Figure 2. These data are plotted over the period from 1979 to 1982.

In general, there is a shortage of data on the quality of groundwater in the Rapid Creek valley downstream of Rapid City. Neither DENR, USGS, or EPA appear to have collected data on groundwater quality there. The only significant source of groundwater quality data for the Rapid Valley was provided as a part of a graduate thesis prepared in 1981 by Diane Coker. This document was prepared under the direction of Professor Perry Rahm at the South Dakota School of Mines and Technology. Groundwater quality results as reported in the thesis are given in Appendix B.

As can be seen in the surface water quality data in Appendix A, there are gaps in the collected data, in terms of both time and parameters. Data for some parameters, such as pH and specific conductance, have been collected in a consistent fashion over certain portions of the reported sampling period. One of the characteristics of all of the surface water quality data displayed in the tables in Appendix A is significant variance. Much of the water quality data analyzed show large variations from means calculated for the parameters. Most of the data tabulated in Appendix A display this characteristic. This variation is also evident in the plots of TDS and phosphorus in Figures 1 and 2.

The water quality data plotted in Figures 1 and 2 show raised concentrations in TDS and phosphorus downstream of the effluent discharge from the WWTP. This difference between the upstream and downstream concentrations, in the case of TDS, is very consistent over the time period for which the data are plotted. The data plotted for phosphorus contain more gaps; however, the same pattern of elevated levels downstream of the WWTP can be seen here as well.

An examination of the orthophosphate groundwater data shows that at only three locations was the concentration higher than 0.04 mg/l. These three locations were widely dispersed indicating no general geographical pattern. By far, most of the samples of orthophosphate in groundwater yielded little to no measurable concentrations (< 0.01).

TDS concentrations reported in groundwater in Appendix B show a large range of values inconsistent with any general geographical pattern. The difference in measured concentrations approach an order of magnitude. The relative magnitude of TDS concentrations reported does not depend on the downstream distance from Rapid City nor the lateral distance from Rapid Creek.

ANALYSIS OF WATER QUALITY DATA

Several central concerns have to be addressed related to the transfer of water rights in the Rapid Creek Valley. These issues were investigated for the water quality data that have been collected and presented in this report. Specifically, concern about the levels of phosphorus in Rapid Creek and the possible effects on crop production were evaluated. In addition, potential water quality degradation resulting from water rights transferral was investigated with respect to the effect on the crops raised in the Rapid Creek Valley and on the soils in the Rapid Creek Valley on which crops are raised.

In order to better characterize the local agricultural and soil conditions present in the study area, and thereby account for the water rights transfers' impacts on these conditions, Mr. John Bischoff of South Dakota State University was retained. Mr. Bischoff's area of expertise is soil/water compatibility as related to production agriculture. He is familiar with the various soil types present in the region and the influence different chemical constituents will have on crop production.

Mr. Bischoff reviewed the water quality data presented in Appendix A. Soil types and characteristics at and near the Soertaert property were also considered by him in his analysis. Mr. Bischoff was asked if the water in Rapid Creek below the WWTP was suitable for irrigation purposes given the increased levels in the various chemical parameters due to the effluent addition there. He was also asked to evaluate the levels of phosphorus-related compounds in Rapid Creek and their impact on the creek water's irrigability. Mr. Bischoff provided a report covering these and related topics which is presented in Appendix C. Much of the following discussion and findings are based on the Bischoff report.

In addition, Professor Tim Gates of Colorado State University has explored many of the same water quality issues related to production agriculture. Analysis and conclusions related to this topic may be found in "Water Quality Criteria for Agricultural Diversions in Colorado," T.K. Gates, et al., Project Technical Report No. 1, January 1993; this document may be found in Appendix E and its conclusions are reflected in the present analysis.

Phosphorus

Levels of phosphorus are elevated in Rapid Creek as a result of the discharge of effluent into the creek from the WWTP (see Figure 2). Bischoff reports a difference in the average phosphorus concentrations above and below the discharge of 0.7 mg/l.

Phosphorus is a major component of fertilizer regularly applied to farmland. Normally, phosphorus is a limiting factor for production agriculture. The additional phosphorus available to crops as a result

of the water rights transfers being made by Rapid City will enhance plant growth. This is advantageous to production when the water is applied directly to the growing crops.

A disadvantage of higher phosphorus in irrigation water occurs where the water is being conveyed to the irrigated parcels via ditches. The phosphorus will promote increased growth of weeds in the ditches and headgate areas which act to clog headgates and reduce the ability of the ditches to convey flows. Despite this condition, however, elevated phosphorus levels are an advantage for production agriculture in Rapid Creek.

With regards to soils in the Rapid Creek valley and their ability to support production agriculture, high levels of phosphorus should not have any effect on the continued productivity of the soils.

Impacts of Water Rights Transfers to Crop Production

Levels of salinity in irrigation water are given in terms of TDS or specific conductance. As shown in Figure 1, Table 1 and Table A-1 in Appendix A, salinity (TDS and specific conductance) concentrations in Rapid Creek remain relatively constant downstream from the WWTP discharge to Farmingdale. One likely conclusion from this data is that irrigation return flows and tributary inflows between the WWTP outfall and Farmingdale have levels of salinity approximately equivalent to the average salinity concentrations in Rapid Creek immediately downstream of the WWTP.

This conclusion assumes generally uniform additions to salinity along Rapid Creek and neglects possible sources of salinity at particular locations. These inputs could occur, for instance, at the Town of Caputa or individual feedlot operations near Rapid Creek. Caputa is a small community, though, whose few houses are served by septic systems that will attenuate salinity additions to Rapid Creek. Due in part to the lack of feedgrain production in the region, there are no significant cattle feeding operations downstream of the WWTP. Therefore, this absence of treated wastewater discharge to Rapid Creek and cattle feeding operations downstream of the Rapid City WWTP provides support for the conclusion that the salinity levels in irrigation return flows and tributary inflows to Rapid Creek between the Rapid City WWTP and Farmingdale are approximately equivalent to the average salinity concentrations in Rapid Creek immediately downstream from the WWTP.

Levels of salinity both upstream and downstream of the WWTP are sufficient to class Rapid Creek water as high in salinity. Salinity levels downstream of the WWTP are more consistently in the high salinity level, however. This potentially can have a detrimental effect on crop production as more salt sensitive crops have greater difficulty uptaking moisture with increasing salinity levels.

Conductivity data for Rapid Creek downstream from the wastewater treatment plant indicate average conductivity levels of approximately 1000 microsiemens/cm. Data indicate that alfalfa is the most salinity sensitive crop grown in Rapid Valley and that average soil conductivity must approach approximately 3400 microsiemens/cm before alfalfa is affected. It is realized that interpretation of water salinity data must be evaluated together with an extensive analysis of soil salinity data before reaching conclusions concerning potential injury to crops from irrigation with water with specific salinity concentrations. However, based on the 3400 microsiemens/cm threshold value for crop injury together with the existing approximately 1000 microsiemens/cm average conductivity downstream from the WWTP and the present absence of injury to crops which are irrigated with Rapid Creek water diverted downstream from the WWTP, continued use of Rapid Creek water diverted downstream from the WWTP should present little threat to future crop production.

Alfalfa, the dominate crop produced in the Rapid Creek Valley, is considered moderately sensitive to salinity. Alfalfa's ability to thrive in the Rapid Creek Valley will depend on salinity levels in the irrigation water; however, the salinity effects on the crops will also be influenced by soil type and drainage. This is discussed in more detail below. Given this influence, it is difficult to predict impacts on crop production due strictly to the elevated salinity levels in Rapid Creek water resulting from Rapid City water rights transfers.

The effect of sodium on crop production is assessed using the Sodium Adsorption Ratio (SAR) and adjusted SAR indices. The SAR and, where available, adjusted SAR values calculated in Rapid Creek for this study indicate a low sodium hazard for the purpose of crop production. This condition is true downstream of the WWTP where SAR levels are elevated due to the influence of the effluent discharge.

Boron is considered a salt for the purpose of limiting agricultural production as a specific ion toxicity problem. In the study area, the only data available on boron in Rapid Creek were collected near Farmingdale. The concentration levels are tolerable for alfalfa production with the few measured amounts less than the concentration levels reported to have a detrimental effect on production.

Impacts on Groundwater

The limited data collected on groundwater quality shown in Appendix B indicate that for the parameters for which results are reported (chloride, nitrate-nitrogen, orthophosphate and TDS), there is no strong aerial pattern to chemical concentrations in the Rapid Valley groundwater and no increase in concentrations of these constituents appears to occur downgradient from the Rapid City WWTP.

Effects of Water Rights Transfers on Production Soils

Soil types found in the Rapid Creek Valley are somewhat variable, but fall into two major categories:

- (1) Soils that are able to drain naturally and purge themselves of the detrimental effects of salts, and
- (2) Soils that drain poorly leading to salts retainage and, hence, negative impacts on crop production.

A review of soils maps for Pennington County in the area of the Rapid Creek Valley indicate a variety of soils types are present. Bischoff's report in Appendix C evaluates the four main soil groups found in the area of the Soetaert property and downstream in the areas irrigated by the Lone Tree and Saint Germaine ditches. These soil groups include: Bridgeport silt loam, Owanka clay loam, Kyle clay and Beckton loam. Of these four, the first three generally drain well and should have little problem of compatibility with the Rapid Creek water for irrigation purposes.

The Beckton loam, part of the Owanka-Beckton complex, is a soil that can have significant problems with applied irrigation water. The Beckton loam tends to have a highly impermeable layer approximately 6 to 10 inches below the ground surface caused by clay particles left in the soil at that depth from water infiltration. This layer also tends to be high in sodium and very susceptible to salts build up. Part of this condition is caused by the relatively poor draining characteristics of the Beckton loam.

Analysis of soils maps in the area of the Rapid Creek Valley indicates that approximately 10 percent of the section in which the Soetaert property is located is Beckton Complex soils and approximately 11 percent of the area irrigated by the Saint Germaine and Lonetree Ditches are Beckton Complex soils. Deposits of Beckton Loam do not appear to exist in any significant pattern or be particularly concentrated within the Rapid Creek Valley.

Soil types and their ability to drain are critical features governing the influence of salinity on crop production. As stated above, salinity levels in Rapid Creek are classified as high. Most of the soils supporting agricultural production in the Rapid Creek Valley should be able to accept the application of Rapid Creek water with little to no adverse impacts on crops due to salinity build up as a result of the water rights transfers.

Some degradation in crop production could occur due to raised salinity levels in the poorer draining soils as a result of the water rights transfers. The Beckton soils are naturally low producing because of their inability to drain and tendency to build up salts.

It is difficult to predict the amount of salinity build-up in soils and the possible detrimental effects on crop production simply from an analysis of the salinity levels in irrigation water. Many factors work to influence the build-up of salts and these factors are dynamic. The concentration of salts in the root zone can change on a daily basis. Concentrations can depend on the seasonal precipitation, irrigation water applied, soil type and distribution (drainage ability), farming practices, topography and other factors.

In order to more thoroughly evaluate the ability of soils to build-up salts and adversely impact crop production, soil sampling and analysis could be carried out at particular locations in the Rapid Creek Valley deemed representative of the various soil conditions. The field sampling could be scheduled to coincide with the various stages of irrigation occurring throughout the year. Water quality sampling and analysis would need to be performed on water used for irrigation on the representative parcels to provide a general correlation between the salinity levels in the irrigation water and soils.

The impact of the application of Rapid Creek water to SAR levels in soils in the Rapid Creek Valley is influenced heavily by the soil type. In most soils in the Rapid Creek Valley, regular application of water with a given SAR for approximately 5 years will lead to an equilibrium of concentration between the soils and the water. Since levels of SAR measured in Rapid Creek are not considered very high (from a crop production standpoint), SAR level build-up in the soils resulting from water rights transfers would not be expected to be a production problem.

Similar to salinity, sodium build-up is much higher in poorly drained soils such as the Beckton loam. Application of irrigation water to these types of soils can have a mixed effect on crop production in the short run, even leading to increased crop yields. In the long run, however, production will be reduced by application of irrigation water, independent of the SAR level in the water. While the SAR concentrations measured in Rapid Creek are very moderate, application of this water to Beckton loam soils will lead to decreased production. This condition is independent of the program of water rights transferral.

pH levels in irrigation water can lead to similar levels in the receiving soils. Higher pH levels in soils create an alkaline condition, with the result being possible high sodium problems in the soils. As with SAR, this tendency is worse in poorly drained soils such as the Beckton loam.

Water quality analyses in Rapid Creek indicated a mixed picture of the pH pattern. Individual values of pH varied widely at each of the three locations, with significant deviation from the averages. Average pH values in Rapid Creek upstream and downstream of the WWTP effluent discharge are 7.9

and 7.85, respectively. This indicates the influence of the WWTP on pH in Rapid Creek is presently not too significant. At Farmingdale the average pH value is 8.2.

Overall, it would be difficult at the present time to attribute negative effects on crop production from pH levels altered by the water rights transfers. Again, a carefully planned soil sampling program carried out in tandem with a water quality sampling program would yield more definitive correlations between water and soil pH and their effect on crop production.

INCREMENTAL EFFECT OF WATER RIGHTS CHANGE

The above data and analysis provide information on the water quality upstream and downstream from the wastewater treatment plant. These data do not directly address the question of what are the water quality impacts from the actual change in use and change of point of diversion from applying approximately 61.3 acre-feet per year of water from the South Side Ditch to the Soetaert property as compared to transferring 31.3 acre-feet of consumptive use and/or 61.3 acre-feet of diversion to the City of Rapid City for diversion at the City's WTP or infiltration galleries and receiving return flows at the WWTP.

Preliminary mass balance calculations on total dissolved solids in irrigation return flows versus sewage effluent are presented in Appendix D in an effort to determine the water quality effects of the Soetaert transfer of South Side Ditch water to Rapid City. These calculations are based on the assumption that the average salinity levels in Rapid Creek at Farmingdale provide an upper limit on salinity levels in surface water and groundwater irrigation return flows to Rapid Creek. This assumption is necessary because of the absence of water quality data for return flows to Rapid Creek from irrigated agriculture in the Rapid Creek Valley.

Calculations and data presented in Appendix D indicate that during those periods of low flow when Rapid City can transfer only the consumptive use (31.3 acre-feet per year) there will be little or no increase in total dissolved solids as a result of the change in point of diversion and change in use. This situation results in part because:

1. The transferred South Side Ditch rights can only be used by Rapid City during the historical irrigation season. During this period, more than one-half of Rapid City's water supply is used for landscape irrigation. TDS concentrations in return flows from landscape irrigation can be expected to be similar to those in irrigated agriculture return flows.

2. The higher irrigation efficiencies in sprinkler irrigation for landscape irrigation as compared to flood and sprinkler agricultural irrigation will result in reduced quantities of return flows from the portion of the transferred South Side Ditch rights as compared to the quantity of return flows from the historical use of these rights on the Soetaert property.
3. Diversion of the 31.3 acre-feet of historic consumptive use at the water treatment plant will as compared to the 61.3 acre-feet of historic diversion for the Soetaert property means that less water will be diverted and consequently reduced return flows with elevated TDS concentrations.

During those periods of high stream flow, however, when the City can transfer the diversion of 61.3 acre-feet to the WTP, an increase in TDS in Rapid Creek can be expected as a result of the change in use and change in point of diversion of the Soetaert rights. The exact increase cannot be calculated because it has not been possible to obtain data on the TDS loadings of irrigation return flows from Rapid Valley irrigators. This increase will occur during periods of relatively high flows when Rapid City can divert the 61.3 acre-feet; consequently, concentrations in Rapid City will be reduced because of the relatively higher flows. Furthermore, as indicated above, the salinity levels in Rapid Creek are sufficiently below threshold levels at which reduced crop yields could be expected, that no injury will occur to irrigators downstream from the Rapid City WWTP as a result of the Soetaert water rights transfer.

TABLE 1

WATER QUALITY DATA SUMMARY

(All Values are Means)

	DATA SOURCE			
	DENR		USGS	EPA
	All Data	5/86 - 1985	All Data	All Data
RAPID CREEK IMMEDIATELY ABOVE WWTP DISCHARGE				
CALCIUM TOTAL RECOVERABLE (MG/L as CA)	94	94	(1)	94
MAGNESIUM TOTAL RECOVERABLE (MG/L as MG)	37	37	(1)	37
SODIUM TOTAL RECOVERABLE (MG/L as NA)	17	17	(1)	17
PHOSPHORUS TOTAL (MG/L as P)	0.04	0.04	0.11	0.07
SOLIDS RESIDUE AT 180 DEGREES C DISSOLVED (MG/L)	466	466	220	443
SPECIFIC CONDUCTANCE (μ S/CM)	715	715	411	715
RAPID CREEK BELOW WWTP DISCHARGE				
CALCIUM TOTAL RECOVERABLE (MG/L as CA)	97	97	(1)	83
MAGNESIUM TOTAL RECOVERABLE (MG/L as MG)	41	42	(1)	34
SODIUM TOTAL RECOVERABLE (MG/L as NA)	50	52	(1)	49
PHOSPHORUS TOTAL (MG/L as P)	1.74	1.77	(1)	(1)
SOLIDS RESIDUE AT 180 DEGREES C DISSOLVED (MG/L)	598	608	(1)	(1)
SPECIFIC CONDUCTANCE (μ S/CM)	981	1006	965	965
RAPID CREEK NEAR FARMINGDALE				
CALCIUM TOTAL RECOVERABLE (MG/L as CA)	99	106	(1)	95
MAGNESIUM TOTAL RECOVERABLE (MG/L as MG)	44	46	(1)	40
SODIUM TOTAL RECOVERABLE (MG/L as NA)	57	62	(1)	45
PHOSPHORUS TOTAL (MG/L as P)	0.69	0.94	0.87	0.87
SOLIDS RESIDUE AT 180 DEGREES C DISSOLVED (MG/L)	656	680	659	661
SPECIFIC CONDUCTANCE (μ S/CM)	983	1038	953	847

(1) No data available

FIGURE 1
TDS Upstream and Downstream from WWTP

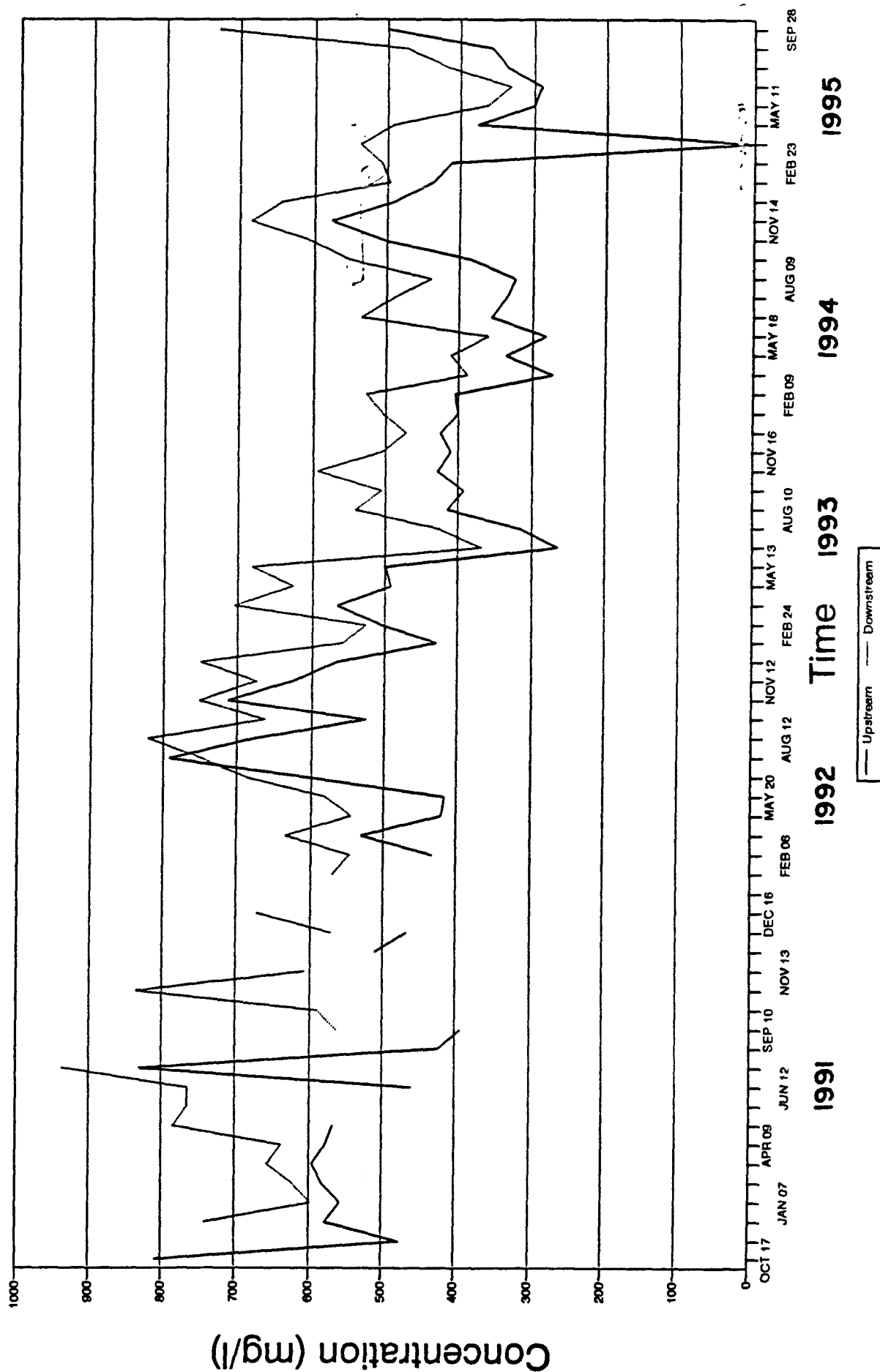
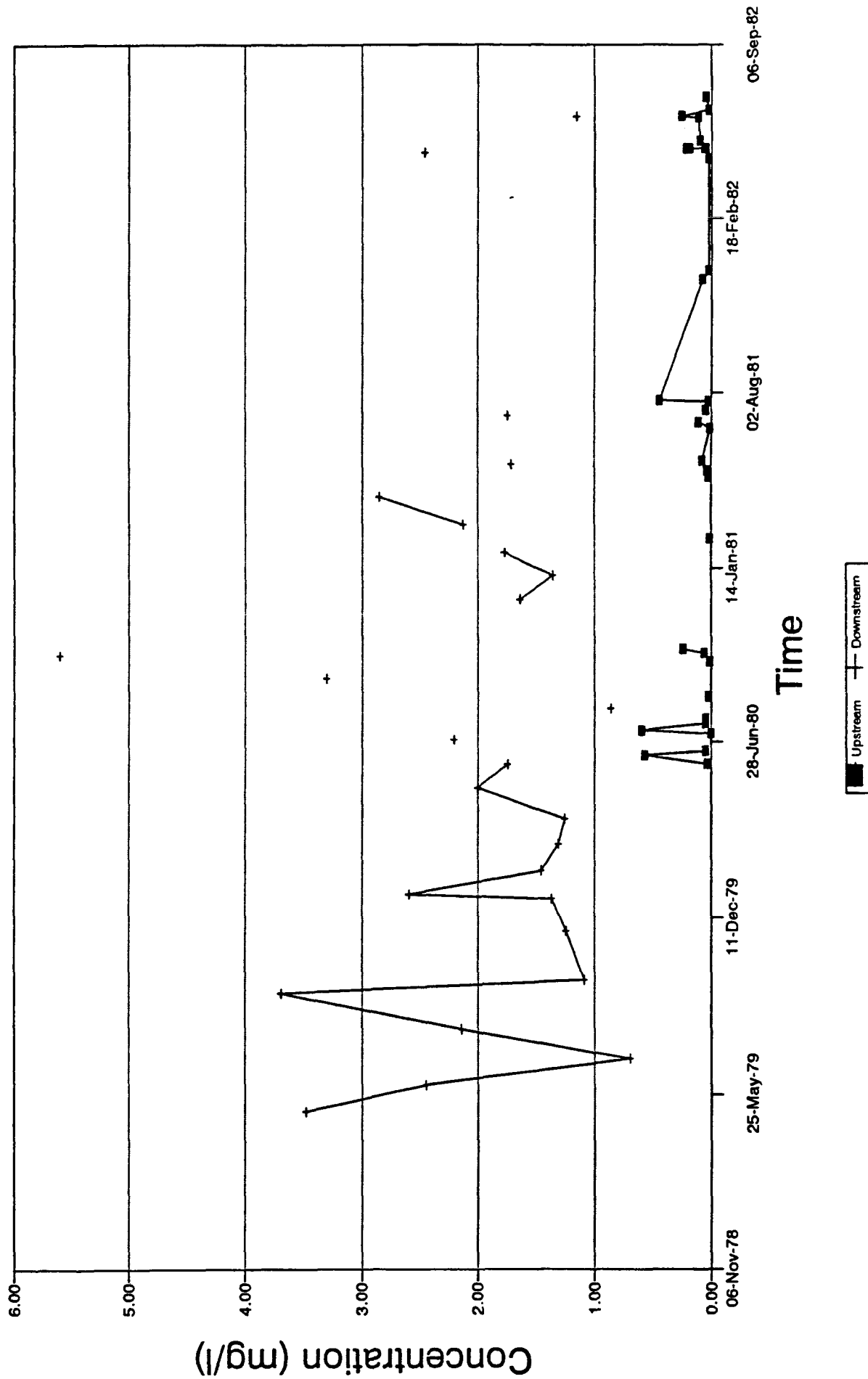


FIGURE 2
PHOSPHORUS U/S and D/S from WWTP



APPENDIX A
WATER QUALITY DATA

TABLE A-1
South Dakota Department of Environment and Natural Resources
Water Quality Data For Rapid Creek (pH, Ca, Mg, Na)

DENR DATA

Site 00460110 Rapid Creek Immediately above WWTP Discharge					Site 00460692 Rapid Creek below WWTP Discharge					Site 00460910 Rapid Creek near Farmingdale					
	PH (STAND- ARD UNITS)	CALCIU TOTAL RECOV- ERABLE (MG/L AS CA)	MAGNE- SIUM TOTAL RECOV- ERABLE (MG/L AS MG)	SODIUM TOTAL RECOV- ERABLE (MG/L AS NA)	PH (STAND- ARD UNITS)	CALCIU TOTAL RECOV- ERABLE (MG/L AS CA)	MAGNE- SIUM TOTAL RECOV- ERABLE (MG/L AS MG)	SODIUM TOTAL RECOV- ERABLE (MG/L AS NA)		PH (STAND- ARD UNITS)	CALCIU TOTAL RECOV- ERABLE (MG/L AS CA)	MAGNE- SIUM TOTAL RECOV- ERABLE (MG/L AS MG)	SODIUM TOTAL RECOV- ERABLE (MG/L AS NA)	BICAR- BONATE WATER WH FET FIELD MG/L AS HCO3	CAR- BONATE WATER WH FET FIELD MG/L AS CO3
AVG	7.9	94	37	17	7.8	97	41	50		8.1	99	44	57	244	9
DATE															
1967															
JUN 27										7.3					
JUL 28										8.0					
AUG 21										7.8					
1968															
MAY 08															
JUL 31														250	
AUG 29										7.8					
SEP 25										8.6					
1969										8.6				280	
JAN 26															
APR 06										7.4					
JUN 30										8.6				250	
JUL 13										8.5					
AUG 10										9.2					
SEP 21										9.0					
1970										9.2				280	
JAN 18															
MAY 11										8.0					
JUN 07										8.2				200	
1973										8.0					
MAY 22										8.4					
SEP 18														190	
NOV 12										8.1	81	34	29	210	
NOV 20										8.3				220	
1974														210	
APR 02															
MAY 01										8.2	98	39	51	240	10
JUN 06										8.1	100	50	69	230	14
AUG 19										8.1				310	0
SEP 30										8.4	100	44	60	270	1
OCT 28											110	48	69	220	19
NOV 25											120	47	72	290	
DEC 16										8.4	110	39	52	240	
1975											100	37	49	270	
JAN 15															
FEB 26										7.8	120	44	75	310	
MAR 13										8.1	86	31	51	210	
APR 23											99	39	44	250	
MAY 27										8.4	100	39	47	230	
JUN 25										8.2	92	38	37	240	
JUL 24										8.4	110	39	35	240	
AUG 19										8.4	98	42	46	260	
SEP 24										8.4	110	48	66	270	
OCT 28										8.4	110	45	64	260	
NOV 18										8.4	130	51	74	270	
DEC 17										8.4	110	41	56	260	
1976										8.0	120	46	64	290	

DENR DATA

Site 00460110					Site 00460692					Site 00460910					
Rapid Creek Immediately above WWTP Discharge					Rapid Creek below WWTP Discharge					Rapid Creek near Farmingdale					
	PH (STAND- ARD UNITS)	CALCIU TOTAL RECOV- ERABLE (MG/L AS CA)	MAGNE- SIUM TOTAL RECOV- ERABLE (MG/L AS MG)	SODIUM TOTAL RECOV- ERABLE (MG/L AS NA)	PH (STAND- ARD UNITS)	CALCIU TOTAL RECOV- ERABLE (MG/L AS CA)	MAGNE- SIUM TOTAL RECOV- ERABLE (MG/L AS MG)	SODIUM TOTAL RECOV- ERABLE (MG/L AS NA)	PH (STAND- ARD UNITS)	CALCIU TOTAL RECOV- ERABLE (MG/L AS CA)	MAGNE- SIUM TOTAL RECOV- ERABLE (MG/L AS MG)	SODIUM TOTAL RECOV- ERABLE (MG/L AS NA)	BICAR- BONATE WATER WH FET FIELD MG/L AS HCO3	CAR- BONATE WATER WH FET FIELD MG/L AS CO3	
JAN 12									7.4	110	41	54	280		
FEB 12									8.2	84	33	54	210		
MAR 29									8.2	93	38	52	250		
APR 12									8.0	12	37	58	230		
MAY 11									8.4	110	49	66	260		
JUN 22									6.0	67	28	15	200		
JUL 14									8.4	97	42	39	240		
AUG 24									8.4	81	45	56	170		
SEP 29									8.4	100	43	58	270		
OCT 26										100	43	55	260		
NOV 22									7.7	100	41	56	260		
DEC 15									8.1	93	38	46	240		
1977															
JAN 12									7.8	110	42	50	280		
FEB 08									7.8	88	36	58	240		
MAR 16									8.2	92	39	41	240		
APR 11									8.2				150		
MAY 23									8.2	80	35	35	220		
JUN 29									8.0	88	39	42	250		
JUL 26									8.2	93	40	54	240		
AUG 23									8.4	110	51	72	280		
SEP 26									8.2	71	29	31	170		
OCT 05									8.2						
NOV 08									8.2						
DEC 19									7.8						
1978															
JAN 09									7.5						
FEB 22									7.4						
MAR 08									7.7						
APR 05									7.5						
MAY 01									7.4	91	30	39			
JUN 06									7.8	68	25	9.5			
JUL 10									7.4	69	29	22			
AUG 08									7.5	91	37	40			
SEP 06									7.6						
OCT 03									7.4						
NOV 08									7.8						
1979															
FEB 07															
APR 04									7.7						
MAY 08					8.1				8.2						
JUN 06					7.8	100	40	64	7.6	110	51	75			
JUL 05					7.5			31	7.6			54			
AUG 07					7.7	94	34	48	8.5	94	35	39			
SEP 17					7.5				7.8						
OCT 03					7.9				8.5						
NOV 05									8.3						
NOV 27					8.5										
DEC 12									8.4						
DEC 12									8.6						

DENR DATA

Site 00460110 Rapid Creek Immediately above WWTP Discharge					Site 00460692 Rapid Creek below WWTP Discharge				Site 00460910 Rapid Creek near Farmingdale						
	PH (STAND- ARD UNITS)	CALCIU TOTAL RECOV- ERABLE (MG/L AS CA)	MAGNE- SIUM TOTAL RECOV- ERABLE (MG/L AS MG)	SODIUM TOTAL RECOV- ERABLE (MG/L AS NA)	PH (STAND- ARD UNITS)	CALCIU TOTAL RECOV- ERABLE (MG/L AS CA)	MAGNE- SIUM TOTAL RECOV- ERABLE (MG/L AS MG)	SODIUM TOTAL RECOV- ERABLE (MG/L AS NA)	PH (STAND- ARD UNITS)	CALCIU TOTAL RECOV- ERABLE (MG/L AS CA)	MAGNE- SIUM TOTAL RECOV- ERABLE (MG/L AS MG)	SODIUM TOTAL RECOV- ERABLE (MG/L AS NA)	BICAR- BONATE WATER WH FET FIELD MG/L AS HCO3	CAR- BONATE WATER WH FET FIELD MG/L AS CO3	
1980															
JAN 02					8.1										
JAN 08					8.1				8.1						
FEB 04					8.4				7.9						
MAR 05					7.9				8.1						
APR 02					8.1				8.6						
MAY 07					7.9	88	36	50	8.2	120	54	86			
JUN 03					8.1	94	36	50	8.2	86	57	32			
JUL 02					8.5	94	37	59	7.9	100	110	73			
AUG 06					8.2	80	32	33	8.3	120	62	82			
SEP 10					8.0				8.2						
OCT 08					7.8				8.3						
DEC 11					8.2				8.4						
1981															
JAN 07					8.0				8.2						
FEB 03					7.4				7.6						
MAR 06					7.9				8.3						
APR 08					7.3				7.8						
MAY 14					7.8	81	32	48	8.6	96	46	79			
JUN 22					7.4	110	42	68	7.8	110	45	63			
JUL 08					7.8	98	38	54	8.6	100	44	52			
NOV 04					7.4				8.2						
1982															
APR 07					8.0				8.5						
MAY 06					7.6			51	8.6			72			
JUN 16					7.5			46	7.6			57			
JUL 15									7.8	68	30	24			
AUG 19									7.9	76	32	240			
SEP 09									7.9						
OCT 21									7.9						
NOV 02	7.8								7.9						
DEC 16	7.6								7.8						
1983															
JAN 06	7.7								7.7						
FEB 03	7.8				7.7				7.8						
APR 14	7.9				7.5				7.9						
MAY 18	7.6				7.8	65	30	11	7.7	71	32	16			
JUN 09	7.6				7.5	110	45	40	8.1	120	52	51			
JUL 13	7.6				7.6	110	45	40	7.6	98	45	44			
AUG 04	7.8				7.5	150	54	110	8.5	100	54	49			
SEP 08	7.9				7.6				8.3						
OCT 06	7.6				7.5				8.0						
NOV 02	7.8														
DEC 08	7.5				7.6				7.6						
1984															
JAN 05	7.5				7.4				7.4						
FEB 08	8.1				8.0				7.9						
MAR 08	7.6				7.4				7.9						
APR 11	7.6				7.6				7.8						
MAY 10	7.6				7.6	69	27	12	7.7	74	31	20			

DENR DATA

Site 00460110 Rapid Creek Immediately above WWTP Discharge					Site 00460692 Rapid Creek below WWTP Discharge				Site 00460910 Rapid Creek near Farmingdale					
	PH (STAND- ARD UNITS)	CALCIU TOTAL RECOV- ERABLE (MG/L AS CA)	MAGNE- SIUM TOTAL RECOV- ERABLE (MG/L AS MG)	SODIUM TOTAL RECOV- ERABLE (MG/L AS NA)	PH (STAND- ARD UNITS)	CALCIU TOTAL RECOV- ERABLE (MG/L AS CA)	MAGNE- SIUM TOTAL RECOV- ERABLE (MG/L AS MG)	SODIUM TOTAL RECOV- ERABLE (MG/L AS NA)	PH (STAND- ARD UNITS)	CALCIU TOTAL RECOV- ERABLE (MG/L AS CA)	MAGNE- SIUM TOTAL RECOV- ERABLE (MG/L AS MG)	SODIUM TOTAL RECOV- ERABLE (MG/L AS NA)	BICAR- BONATE WATER WH FET FIELD MG/L AS HCO3	CAR- BONATE WATER WH FET FIELD MG/L AS CO3
JUL 10	7.6				7.7	79	30	21	7.9	75	34	15		
AUG 08	8.3				8.0	94	34	30	8.2	100	40	31		
SEP 14	8.0				7.6				8.1					
OCT 01	6.9				7.3				8.1					
NOV 14	7.6				7.1				8.2					
DEC 05	7.5				7.8				7.6					
1985														
JAN 09	7.1				7.4				7.5					
FEB 07	7.6				7.8				7.6					
MAR 14	7.9				7.9				7.8					
APR 02	7.3				7.5				7.1					
MAY 08	7.9				7.9	130	48	89	8.8	110	66	97		
JUN 11	7.4				7.4	120	48	54	8.2	89	42	61		
JUL 18	7.8				7.6	79	35	50	8.0	70	37	47		
AUG 22	8.2				7.9	89	31	45	8.0	75	30	47		
SEP 03	7.6				7.5				8.8					
OCT 17	7.9				7.9				8.2					
NOV 06	8.1				7.8				8.2					
DEC 09	7.2				7.3				7.5					
1986														
JAN 09	7.6				7.8				7.5					
FEB 21	7.9				7.7				7.6					
MAR 26	8.0				8.0				8.5					
APR 09	7.1				7.0				7.1					
MAY 06	8.3	110	37	19	8.5	130	170	67	8.6	130	100	70		
JUN 04	7.8				7.9	160	69	56	8.2	160	66	100		
JUL 07	7.6	71	42	16	7.3	84	48	140						
AUG 13	7.6				7.4	120	31	42	8.0	100	43	70		
SEP 24	8.1	100	35	12	8.0				8.1					
OCT 22	7.9	84	32	15	7.9				8.2					
NOV 06	8.0				8.0				7.8					
DEC 03	8.0	90	35	16	8.1				8.3					
1987														
JAN 06	8.1				7.9				7.7					
FEB 04	8.2				8.1				8.2					
MAR 05	8.0				8.1				8.0					
APR 08	8.0				8.0				8.2					
MAY 14	7.8	80	32	16	7.3	91	36	44	7.8	110	45	57		
JUN 10	7.6	79	25	11	7.4	94	32	25	7.8	120	50	46		
JUL 16	7.3	120	54	22	7.4	110	49	100	8.4	110	50	61		
AUG 12	8.0	75	35	12	7.8	93	40	63	8.0	93	35	43		
SEP 03	8.2	100	45	11	7.8				8.4					
OCT 28	8.1	110	42	19	7.9				8.4					
NOV 04	8.3	100	39	23	8.3				8.6					
DEC 01	8.2	100	39	15	8.2				8.3					
1988														
JAN 19									7.1					
JAN 20	7.4	93	35	12	7.6									
FEB 16	7.1	94	31	12	7.1				7.6					
MAR 10	8.5	87	32	14	8.4				8.5					

DENR DATA

Site 00460110 Rapid Creek Immediately above WWTP Discharge					Site 00460692 Rapid Creek below WWTP Discharge				Site 00460910 Rapid Creek near Farmingdale					
	PH (STAND- ARD UNITS)	CALCIU TOTAL RECOV- ERABLE (MG/L AS CA)	MAGNE- SIUM TOTAL RECOV- ERABLE (MG/L AS MG)	SODIUM TOTAL RECOV- ERABLE (MG/L AS NA)	PH (STAND- ARD UNITS)	CALCIU TOTAL RECOV- ERABLE (MG/L AS CA)	MAGNE- SIUM TOTAL RECOV- ERABLE (MG/L AS MG)	SODIUM TOTAL RECOV- ERABLE (MG/L AS NA)	PH (STAND- ARD UNITS)	CALCIU TOTAL RECOV- ERABLE (MG/L AS CA)	MAGNE- SIUM TOTAL RECOV- ERABLE (MG/L AS MG)	SODIUM TOTAL RECOV- ERABLE (MG/L AS NA)	BICAR- BONATE WATER WH FET FIELD MG/L AS HCO3	CAR- BONATE WATER WH FET FIELD MG/L AS CO3
APR 21	8.1	92	37	20	8.0				8.0					
MAY 25	7.6	92	37	16	7.1	120	44	67	7.9	130	54	91		
JUN 07	8.3	9	41	20	8.4	110	44	75	8.2	150	73	99		
JUL 11	8.2	65	30	10	7.9	88	36	43	8.2	130	60	130		
AUG 22	7.6	110	50	19	7.7	100	41	63	8.4	110	54	77		
SEP 12	9.1	70	31	10	7.8				8.7					
OCT 17	7.8				7.9									
OCT 19									8.6					
NOV 09	8.0	84	34	1	7.7				7.9					
1989														
JAN 10	7.1	96	18	25	7.0				7.1					
FEB 14	7.9	80	31	15	7.9				8.0					
MAR 20	8.0	79	28	45	7.6				7.8					
APR 03	8.6	120	38	15	8.2				8.2					
MAY 09	7.1	130	52	25	7.6	110	48	110	8.7	110	58	91		
JUN 19	7.6	80	30	10	7.5	120	32	29	7.6	160	56	73		
JUL 12	7.1	68	30	8	7.1	75	30	26	7.3	130	62	88		
AUG 09	8.2	78	32	9	7.7	95	35	53	8.0	140	53	61		
SEP 18	7.6	120	49	20	7.3				7.8					
OCT 18	8.6	100	37	11	8.5				8.1					
NOV 08	8.0	83	31	14	7.6				7.9					
DEC 20	7.5	130	38	13	7.6				7.8					
1990														
JAN 09					6.9									
JAN 10	7.4	120	40	17	7.6				7.6					
FEB 14					8.1									
FEB 21	7.0	90	31	47	6.9				7.1					
MAR 12	7.1	120	38	26	7.1				7.2					
MAR 13					7.6									
APR 11	7.6	100	42	19	7.1									
APR 26									7.2					
MAY 01	7.5	99	43	24	7.5	110	41	99	8.0	130	57	86		
MAY 14					8.1	88	47							
JUN 06	7.8	140	44	19	8.0	130	48	55	7.9	170	40	94		
JUN 11					8.1	100	48							
JUL 18	8.2	83	37	17	8.2	97	39	72	8.3	89	42	66		
AUG 07	7.8	60	29	15	8.0	110	34	75	8.7	74	34	67		
AUG 13					8.2	97	60							
SEP 10					8.6									
SEP 12	8.7	145	59	29					8.7					
SEP 17					8.0									
OCT 17	8.2				8.1				8.7					
NOV 06	7.8				8.3				11.3					
DEC 06	7.0				7.8				7.7					
1991														
JAN 07	7.5				7.5				7.5					
FEB 14	8.0				8.3				8.1					
MAR 14	8.0				8.4				8.4					
APR 09	7.4				7.6				8.1					
MAY 09	7.5				7.8	97	44	49	8.2	117	48	60		

DENR DATA

Site 00460110 Rapid Creek Immediately above WWTP Discharge					Site 00460692 Rapid Creek below WWTP Discharge				Site 00460910 Rapid Creek near Farmingdale					
	PH (STAND- ARD UNITS)	CALCIU TOTAL RECOV- ERABLE (MG/L AS CA)	MAGNE- SIUM TOTAL RECOV- ERABLE (MG/L AS MG)	SODIUM TOTAL RECOV- ERABLE (MG/L AS NA)	PH (STAND- ARD UNITS)	CALCIU TOTAL RECOV- ERABLE (MG/L AS CA)	MAGNE- SIUM TOTAL RECOV- ERABLE (MG/L AS MG)	SODIUM TOTAL RECOV- ERABLE (MG/L AS NA)	PH (STAND- ARD UNITS)	CALCIU TOTAL RECOV- ERABLE (MG/L AS CA)	MAGNE- SIUM TOTAL RECOV- ERABLE (MG/L AS MG)	SODIUM TOTAL RECOV- ERABLE (MG/L AS NA)	BICAR- BONATE WATER WH FET FIELD MG/L AS HCO3	CAR- BONATE WATER WH FET FIELD MG/L AS CO3
MAY 13					8.2	112	53	43						
JUN 12	7.1				7.2	59	27	24	7.3	67	29	34		
JUL 08	8.5				8.0	92	48	64	9.0	97	45	76		
AUG 14	8.2				7.9	66	36	40	8.9	94	50	64		
SEP 10	8.1				8.0				8.3					
OCT 15					8.5			36						
OCT 17	8.2				7.9				8.5					
NOV 13					7.2				8.6					
NOV 14	8.2													
DEC 11	8.1				8.2				8.2					
DEC 16								40						
1992														
JAN 12	8.1													
JAN 21					8.1				8.3					
FEB 06	8.2				8.0				8.5					
MAR 10	8.3				8.3				8.5					
APR 15	8.8				8.7				8.8					
MAY 20	8.3				8.2	83	37	41	8.8	88	41	52		
JUN 10	8.1				7.9	102	46	69	8.6	97	50	66		
JUL 07					7.7	116	44	78						
JUL 21	8.0								8.4	129	49	68		
AUG 12	8.7				7.6	102	47	64	9.0	86	54	90		
SEP 16	8.1				8.1				8.5					
OCT 20	8.4				8.2				8.9					
NOV 11					8.0									
NOV 12	7.1								8.4					
DEC 09	7.0				8.5				8.2					
1993														
JAN 21	7.6				7.6				7.8					
FEB 24	7.4				8.0				7.9					
MAR 10	7.4				7.8				7.7					
APR 13	8.7	91	32	16	8.4	104	37	36	8.9					
MAY 13	9.0				8.4	117	43	42	8.6	103	42	52		
JUN 09	7.9				7.5				7.6	36	24	26		
JUL 26	7.9				7.8	83	27	15	7.9	81	25	18		
AUG 10	7.7				7.6	77	31	29	8.2	120	40	34		
SEP 30	7.9				7.8				8.5					
OCT 27														
NOV 16	7.8				7.2				8.6					
DEC 09	7.8				8.0				8.2					
1994														
JAN 05	7.8				7.9				8.2					
FEB 09	8.0				7.2				8.3					
MAR 28	8.0				8.0				8.4					
APR 19	7.8				7.8				8.4					
MAY 18	8.0				8.1	73	26	19	8.2	64	25	17		
JUN 21	7.9				8.0	81	30	45	8.3	96	37	45		
JUL 13	7.9				8.0	91	31	43	8.7	105	40	53		
AUG 09	7.8				7.6	70	28	31	8.2	96	40	48		
SEP 20	7.8				7.9				8.6					

DENR DATA

Site 00460110 Rapid Creek Immediately above WWTP Discharge					Site 00460692 Rapid Creek below WWTP Discharge					Site 00460910 Rapid Creek near Farmingdale				
	PH (STAND- ARD UNITS)	CALCIU TOTAL RECOV- ERABLE (MG/L AS CA)	MAGNE- SIUM TOTAL RECOV- ERABLE (MG/L AS MG)	SODIUM TOTAL RECOV- ERABLE (MG/L AS NA)	PH (STAND- ARD UNITS)	CALCIU TOTAL RECOV- ERABLE (MG/L AS CA)	MAGNE- SIUM TOTAL RECOV- ERABLE (MG/L AS MG)	SODIUM TOTAL RECOV- ERABLE (MG/L AS NA)	PH (STAND- ARD UNITS)	CALCIU TOTAL RECOV- ERABLE (MG/L AS CA)	MAGNE- SIUM TOTAL RECOV- ERABLE (MG/L AS MG)	SODIUM TOTAL RECOV- ERABLE (MG/L AS NA)	BICAR- BONATE WATER WH FET FIELD MG/L AS HCO3	CAR- BONATE WATER WH FET FIELD MG/L AS CO3
OCT 31	8.4				8.5				8.8					
NOV 14	8.0				8.6				8.7					
DEC 15	8.1				8.2				8.0					
1995														
JAN 09	8.0				8.3				8.2					
FEB 23	8.3				8.0				8.3					
MAR 16	8.0				8.0				8.4					
APR 18	8.1													
MAY 11	7.8				8.1				8.1					
JUN 22	8.0				7.9	60	20	12	8.1	57	20	13		
JUL 12	8.0				8.0	59	22	23	8.1	60	23	25		
AUG 23	7.9				7.8	82	30	31	8.2	92	34	32		
SEP 28	8.1				8.0				8.8					

**South Dakota Department of Environment and Natural Resources
Water Quality Data For Rapid Creek (P, TDS, Conductance)**

DENR DATA

[illegible]

DENR DATA

Site 00460110 Rapid Creek Immediately above WWTP Discharge										Site 00460692 Rapid Creek below WWTP Discharge										Site 00460910 Rapid Creek near Farmingdale									
PHOS- PHORUS TOTAL (MG/L AS P)	PHOS- ORTHO, DIS- SOLVED (MG/L AS P)	SOLIDS RESIDU AT 105 DEG. C TOTAL (MG/L)	SOLIDS RESIDU AT 180 DEG. C DIS- SOLVED (MG/L)	SPE- CIFIC CON- DUCT- ANCE (US/CM)	PHOS- PHORUS TOTAL (MG/L AS P)	PHOS- ORTHO, DIS- SOLVED (MG/L AS P)	PHOS- ORTHO TOTAL (MG/L AS P)	SOLIDS RESIDU AT 105 DEG. C TOTAL (MG/L)	SOLIDS RESIDU AT 180 DEG. C DIS- SOLVED (MG/L)	SPE- CIFIC CON- DUCT- ANCE (US/CM)	PHOS- PHORUS TOTAL (MG/L AS P)	PHOS- ORTHO, DIS- SOLVED (MG/L AS P)	PHOS- ORTHO TOTAL (MG/L AS P)	SOLIDS RESIDU AT 105 DEG. C TOTAL (MG/L)	SOLIDS RESIDU AT 180 DEG. C DIS- SOLVED (MG/L)	SPE- CIFIC CON- DUCT- ANCE (US/CM)													
DEC 16											1.73		1.5	680		896													
1975																													
JAN 15											2.15		1.85	839		1140													
FEB 26											1.2		1.08	627		832													
MAR 13											1.28		1.22	664		863													
APR 23											0.92		0.7	801		905													
MAY 27											0.31		0.31	693		811													
JUN 25											0.66		0.597	838		880													
JUL 24											0.55		0.519	735		933													
AUG 19											0.73		0.634	873		1040													
SEP 24											0.8		0.737	785		1070													
OCT 28											1.26		1.11	927		1230													
NOV 18											1.12		1.02	724		946													
DEC 17											1.46		1.39	803		1170													
1976																													
JAN 12											1.61		1.49	717		1050													
FEB 12											0.94		0.815	623		910													
MAR 29											1.07		1.04	659		870													
APR 12											0.86		0.858	715		910													
MAY 11											0.33		0.284	817		1020													
JUN 22											0.16		0.156	947		560													
JUL 14											0.34		0.295	704		830													
AUG 24											0.25		0.041	731		880													
SEP 29											0.66		0.66	749		980													
OCT 26											1.17		1.16	738		980													
NOV 22											1.04		1.02	718		960													
DEC 15											1.18		1.17	656		890													
1977																													
JAN 12											1.38		0.838	723		960													
FEB 08											1.17		1.08	681		890													
MAR 16											0.8		0.597	648		830													
APR 11												0.173		946		670													
MAY 23											0.31		0.257	652		750													
JUN 29											0.46		0.42	690		800													
JUL 26											0.45		0.405	779		890													

[illegible]

Site 00460110										Site 00460692										Site 00460910									
Rapid Creek Immediately above WWTP Discharge										Rapid Creek below WWTP Discharge										Rapid Creek near Farmingdale									
PHOS- TOTAL (MG/L AS P)	PHOS- ORTHODIS- SOLVED (MG/L AS P)	PHOS- ORTHODIS- SOLVED (MG/L AS P)	SOLIDS RESIDU AT 105 DEG. C TOTAL (MG/L)	SOLIDS RESIDU AT 180 DEG. C DIS- SOLVED (MG/L)	SPE- CIFIC CON- DUCT- ANCE (US/CM)	PHOS- TOTAL (MG/L AS P)	PHOS- ORTHODIS- SOLVED (MG/L AS P)	PHOS- ORTHODIS- SOLVED (MG/L AS P)	PHOS- ORTHODIS- SOLVED (MG/L AS P)	SOLIDS RESIDU AT 105 DEG. C TOTAL (MG/L)	SOLIDS RESIDU AT 180 DEG. C DIS- SOLVED (MG/L)	SPE- CIFIC CON- DUCT- ANCE (US/CM)	PHOS- TOTAL (MG/L AS P)	PHOS- ORTHODIS- SOLVED (MG/L AS P)	PHOS- ORTHODIS- SOLVED (MG/L AS P)	SOLIDS RESIDU AT 105 DEG. C TOTAL (MG/L)	SOLIDS RESIDU AT 180 DEG. C DIS- SOLVED (MG/L)	SPE- CIFIC CON- DUCT- ANCE (US/CM)											
MAR 26						1.28	0.6			646	628	950	0.7	0.41			797	774	1150										
APR 09						1.2	0.671			734	692	990	0.5	0.288			1000	930	1250										
MAY 06						1.76	0.995			696	672	1110	0.6	0.365			754	722	1140										
JUN 04						1.12	1.06				976	1350	0.66	0.635				1000	1440										
JUL 07					750	1	0.195			741	702	1030																	
AUG 13						0.83	0.675			846	634	960	1.15	0.57			1580	638	1040										
SEP 24						1.04	0.648			573	528	825	1.7	0.511			743	664	1010										
OCT 22						0.94	0.76			550	534	840	0.72	0.45			557	518	815										
NOV 06						0.46	0.45			325	312	660	0.5	0.5			447	424	775										
DEC 03						0.781	0.641			490	480	825	0.595	0.567			533	524	825										
1987																													
JAN 06	0.04	<0.010	426	418	685	1.15	0.775	549	540	549	540	840	1.15	0.86			568	18	920										
FEB 04						1.05	0.752	558	550	558	550	925	0.881				640	628	1010										
MAR 05						0.9	0.9	566	551	566	551	855	1.15	1.15			694	670	1030										
APR 08						0.525	0.357	441	410	441	410	655	0.695	0.445			576	536	850										
MAY 14						0.925	0.769		482		482	810	0.7	0.519			606	606	950										
JUN 10						1	0.501		426		426	700	0.775	0.459			608	608	950										
JUL 16						2.8	2.7		818		818	1300	0.46	0.389			721	721	1050										
AUG 12						1.98	1.81		654		654	1000	0.63	0.446			594	594	910										
SEP 03						3.46	3.28		909		909	1440	0.695	0.53			538	538	885										
OCT 28						2.04	1.92		678		678	1110	1.27	1.13			704	704	1170										
NOV 04						1.8	1.47		654		654	970	1.64	1.52			740	730	1200										
DEC 01						2.01	1.92		608		608	980	1.36	1.22			704	682	1070										
1988																													
JAN 19													1.51	1.44			589	586	960										
JAN 20						0.9	0.88		472		472	850																	
FEB 16						1.72	1.05		474		474	775	1.4				674	667	1180										
MAR 10						1.05	0.881		496		496	825	0.99	0.859			528	520	855										
APR 21						2.04	1.63		661		661	1070	0.625	0.26			962	903	1360										
MAY 25					700	5.3	2.26		734		734	1100	0.8	0.425			986	850	1200										
JUN 07						2.25	2		669		669	1100	0.365	0.25			1220	1150	1650										
JUL 11						1.3	1.08		401		401	740	0.604	0.295			950	754	1200										
AUG 22						3.88	3.45		684		684	1050	0.508	0.213			816	761	1200										
SEP 12						2.06	1.94		500		500	800	0.374	0.231			832	794	1190										
OCT 17						0.713	0.713		514		514	825																	

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DENR DATA

Site 00460110 Rapid Creek Immediately above WWTP Discharge													Site 00460692 Rapid Creek below WWTP Discharge													Site 00460910 Rapid Creek near Farmingdale												
PHOS- TOTAL (MG/L AS P)	PHOS- ORTHO, DIS- SOLVED (MG/L AS P)	SOLIDS RESIDU AT 105 DEG. C TOTAL (MG/L)	SOLIDS RESIDU AT 180 DEG. C DIS- SOLVED (MG/L)	SPE- CIFIC CON- DUCT- ANCE (US/CM)	PHOS- TOTAL (MG/L AS P)	PHOS- ORTHO, DIS- SOLVED (MG/L AS P)	PHOS- ORTHO TOTAL (MG/L AS P)	SOLIDS RESIDU AT 105 DEG. C TOTAL (MG/L)	SOLIDS RESIDU AT 180 DEG. C DIS- SOLVED (MG/L)	SPE- CIFIC CON- DUCT- ANCE (US/CM)	PHOS- TOTAL (MG/L AS P)	PHOS- ORTHO, DIS- SOLVED (MG/L AS P)	PHOS- ORTHO TOTAL (MG/L AS P)	SOLIDS RESIDU AT 105 DEG. C TOTAL (MG/L)	SOLIDS RESIDU AT 180 DEG. C DIS- SOLVED (MG/L)	SPE- CIFIC CON- DUCT- ANCE (US/CM)																						
NOV 06	0.01		475	785		1.59				1060		1.71		794	782	1210																						
DEC 06	0.01		578	845		1.87			742	1140		1.8		726	715	1090																						
1991																																						
JAN 07			556	820		1.85			598	995		2.43		826	808	1190																						
FEB 14	0.02		581	795		1.11			621	920		1.41		652	644	900																						
MAR 14	0.016		595	940		1.14			656	990		1.21		688	668	995																						
APR 09	0.015		577	790		1.46			637	960				842		1120																						
MAY 09	0.021		566	925		0.241			784	1120		0.61		904	863	1210																						
MAY 13						0.02			765	1009																												
JUN 12	0.04		460	645		0.465			765	780		0.4		906	827	870																						
JUL 08	0.01		830	1065		2.35			936	1250		0.04		946	910	1245																						
AUG 14	0.011		422	658		1.39				995		0.233		876	793	1150																						
SEP 10	0.014		392	640		0.475			562	810		0.064		948	795	1195																						
OCT 15						0.043			590	949																												
OCT 17	0.014		640	845		0.093			834	1160		1.24		1020	921	1255																						
NOV 13						0.795			606	920		1.04		646	609	955																						
NOV 14	<.01		510	798		0.95			572	990		1		582	572	1010																						
DEC 11	<.01		468	770		0.027			672	1051																												
DEC 16																																						
1992																																						
JAN 12	<.01		439	665																																		
JAN 21						1.09			568	895		1.38		716	705	1060																						
FEB 06	<.1		433	693		0.855			546	940		1.19		616	602	940																						
MAR 10	0.015		530	900		0.92			633	9660		0.86		698	659	910																						
APR 15	0.014		421	720		0.69			544	910		0.94		541	472	870																						
MAY 20	0.012		417	650		1.05			579	910		0.555		722	682	1050																						
JUN 10	0.01		601	860		2.08			687	1095		0.41		810	727	1090																						
JUL 21	0.015		793	1090		1.83			748	1120		0.605		878	728	1090																						
AUG 12	0.012		678	850		1.19			820	1150		0.261		962	912	1275																						
SEP 16	0.033		524	770		2.86			662	950		1.17		710	652	1000																						
OCT 20	0.01		713	1010		2.35			752	1200		1.5		952	889	1350																						
NOV 12	0.011		626	845		1.43			674	1050		1.36		860	850	1220																						
DEC 09	<.010		564	810		1.6			750	1120		1.5		898	888	1280																						
1993																																						
JAN 21	<.010		428	675		0.805			557	900		1.1		684	673	980																						

DENR DATA

Site 00460110 Rapid Creek Immediately above WWTP Discharge										Site 00460692 Rapid Creek below WWTP Discharge										Site 00460910 Rapid Creek near Farmingdale									
PHOS- TOTAL (MG/L AS P)	PHOS- ORTHODIS- SOLVED (MG/L AS P)	SOLIDS RESIDU AT 105 DEG. C TOTAL (MG/L)	SOLIDS RESIDU AT 180 DEG. C DIS- SOLVED (MG/L)	SPE- CIFIC CON- DUCT- ANCE (US/CM)	PHOS- TOTAL (MG/L AS P)	PHOS- ORTHODIS- SOLVED (MG/L AS P)	PHOS- ORTHODIS- SOLVED (MG/L AS P)	SOLIDS RESIDU AT 105 DEG. C TOTAL (MG/L)	SOLIDS RESIDU AT 180 DEG. C DIS- SOLVED (MG/L)	SPE- CIFIC CON- DUCT- ANCE (US/CM)	PHOS- TOTAL (MG/L AS P)	PHOS- ORTHODIS- SOLVED (MG/L AS P)	PHOS- ORTHODIS- SOLVED (MG/L AS P)	SOLIDS RESIDU AT 105 DEG. C TOTAL (MG/L)	SOLIDS RESIDU AT 180 DEG. C DIS- SOLVED (MG/L)	SPE- CIFIC CON- DUCT- ANCE (US/CM)													
FEB 24	0.03		504	750		1.2			527	950		1.23		698	690	1030													
MAR 10	0.035		564	900		0.975			704	1120		0.585		562	480	790													
APR 13	0.019		492	600		0.805			626	800		0.415		1006	723	825													
MAY 13	0.019		501	730		0.278			680	1000		0.053		1060	712	1000													
JUN 09	0.035		263	425		0.306			369	545		0.227		720	370	555													
JUL 26	0.015		315	500		0.243			427	575		0.218		638	387	550													
AUG 10	0.01		415	600		0.52			540	710		0.37		726	643	900													
SEP 30	0.01		393	550		0.71			507	760		0.321		460	413	700													
OCT 27	<.010		428	600		0.822			593	850		0.475		604	591	850													
NOV 16	0.01		411	650		0.465			506	770		0.342		622	616	850													
DEC 09	<.010		425	600		0.81			471	800		0.57		660	658	890													
1994																													
JAN 05	<.010		400	640		0.758			504	790		0.494		360	342	810													
FEB 09	<.010		405	655		1.18			527	900		0.645		620	617	910													
MAR 28	<.010		270	460		0.38			388	560		0.315		540	474	620													
APR 19	<.010		336	475		0.4			411	600		0.25		572	491	680													
MAY 18	<.010		280	450		0.366			361	560		0.225		616	363	550													
JUN 21	0.01		356	540		0.798			535	770		0.416		620	592	850													
JUL 13	0.011		335	540		0.99			490	790		0.293		680	622	900													
AUG 09	0.014		324	490		0.575			440	660		0.355		716	596	890													
SEP 20	0.028		384	650		1.36			550	900		0.289		585	570	1000													
OCT 31	0.01		505	750		1.06			605	870		0.78		744	720	1050													
NOV 14	0.018		576	780		0.78			684	900		0.712		764	740	1040													
DEC 15	<.010		490	700		1.12			641	1025		0.82		688	682	990													
1995																													
JAN 09			438	610					496	725				696	687	950													
FEB 23			412	640					509	800				544	519	825													
MAR 16			0	1040					536	825				498	468	655													
APR 18			376	605					491	760				694	643	940													
MAY 11			300	450					364	520				992	442	630													
JUN 22			289	450					332	510				602	292	470													
JUL 12			335						416					562	429	620													
AUG 23			356						473					574	520														
SEP 28			498						730					600	598														

TABLE A-3
U.S.G.S. Water Quality Data for Rapid Creek

USGS DATA

Site 06413700

Rapid Creek above WWTP Discharge

	PHOS- PHORUS TOTAL (MG/L AS P)	PHOS- PHORUS DIS- SOLVED (MG/L AS P)	SOLIDS RESIDU AT 180 DEG. C DIS- SOLVED (MG/L)	SPE- CIFIC CON- DUCT- ANCE (US/CM)
AVG	0.11	0.02	220	411
DATE				
1980				
MAY 21				383
JUN 03	0.03			354
JUN 14	0.57			336
JUN 14				378
JUN 18	0.04			377
JUL 09	<0.10	<0.10		360
JUL 12	0.59	0.18		595
JUL 12				457
JUL 20	0.04	0.01		337
JUL 25	0.05	<0.10		363
JUL 25				353
AUG 20	0.02	<0.01		363
AUG 20				357
SEP 29	0.01	<0.01		389
OCT 03		0.01		
OCT 09	0.06			415
OCT 15	0.23	0.04		340
OCT 15				363
OCT 15				365
1981				
FEB 18	0.01	<0.01		410
APR 29	0.02	<0.01		370
MAY 06	0.03	0.01		355
MAY 06				357
MAY 06				355
MAY 06				355
MAY 06				363
MAY 07				365
MAY 17	0.07	0.02		325
MAY 17				373
MAY 17				351
MAY 18				363
MAY 23				390
JUN 24	0.01	0.01		353
JUL 01	0.11	0.02		
JUL 13	0.05	0.02		361
JUL 13				355
JUL 23	0.02	<0.01		346
JUL 25	0.44	0.03		415
JUL 25				397
DEC 10	0.07			411
DEC 20	0.02	<0.01		520
DEC 20				548
DEC 20				545
1982				
MAR 07				436
MAR 07				473
MAR 07				439

Site 06418900

Rapid Creek below WWTP Discharge

	PHOS- PHORUS TOTAL (MG/L AS P)	PHOS- PHORUS DIS- SOLVED (MG/L AS P)	SOLIDS RESIDU AT 180 DEG. C DIS- SOLVED (MG/L)	SPE- CIFIC CON- DUCT- ANCE (US/CM)
AVG				965
DATE				
1981				
NOV 02				1090
DEC 04				1040
1982				
JAN 04				930
FEB 09				950
MAR 08				967
APR 05				1070
MAY 10				965
MAY 15				653
JUN 10				1040
JUL 13				650
AUG 12				759
SEP 09				723
OCT 15				1100
NOV 15				1090
DEC 15				764
1983				
JAN 26				937
MAR 14				733
APR 15				819
MAY 12				595
JUN 23				727
JUL 12				1180
SEP 06				1400
OCT 03				800
NOV 04				1040
DEC 01				930
1984				
JAN 10				990
FEB 02				930
MAR 02				940
APR 16				880
MAY 04				970
JUN 15				835
JUL 02				910
AUG 14				1000
SEP 05				1250
OCT 17				1250
NOV 20				1010
DEC 11				1100
1985				
JAN 14				770
FEB 22				860
MAR 19				930
APR 10				770
MAY 15				740
JUN 12				1060
JUL 03				950

Site 06421500

Rapid Creek near Farmingdale

	PHOS- PHORUS TOTAL (MG/L AS P)	PHOS- PHORUS DIS- SOLVED (MG/L AS P)	SOLIDS RESIDU AT 180 DEG. C DIS- SOLVED (MG/L)	SPE- CIFIC CON- DUCT- ANCE (US/CM)
AVG	0.87	0.74	659	953
DATE				
1949				
DEC 22			609	837
1953				
FEB 13			548	813
FEB 15			570	828
FEB 25			518	783
MAR 11			680	924
MAR 19			614	864
MAR 31			558	820
MAY 04			554	809
MAY 12			516	807
MAY 22			550	856
MAY 30			462	689
JUN 27			471	690
JUL 02			524	761
JUL 15			698	959
JUL 18			839	1110
AUG 11			556	802
AUG 16			583	830
AUG 24			679	948
SEP 08			866	1150
1955				
OCT 01			665	942
OCT 24			714	1020
NOV 21			590	868
NOV 26			629	914
1956			561	828
JAN 17			606	881
FEB 01			578	859
FEB 19			578	868
FEB 24			578	888
FEB 25			523	782
MAR 18			457	691
MAR 27			390	560
APR 01			592	763
APR 20			611	865
MAY 01			744	1030
MAY 28			984	1320
MAY 30			647	925
JUN 07			881	1190
JUL 01			848	1150
JUL 03			426	629
JUL 07			1010	1310
AUG 07			674	942
AUG 14			775	1060
AUG 25			753	1040
OCT 01			1210	1540
OCT 27			987	1280
NOV 05			320	477

USGS DATA

Site 06413700

Rapid Creek above WWTP Discharge

	PHOS- PHORUS TOTAL (MG/L AS P)	PHOS- PHORUS DIS- SOLVED (MG/L AS P)	SOLIDS RESIDU AT 180 DEG. C DIS- SOLVED (MG/L)	SPE- CIFIC CON- DUCT- ANCE (US/CM)
MAR 07				412
MAR 09				416
MAR 09				664
MAR 09				524
MAR 09				432
APR 28	0.02	<0.01		426
MAY 10	0.06	0.03	214	309
MAY 10	0.21	0.07	221	352
MAY 10	0.19	<0.01	222	369
MAY 10	0.05	0.03	223	
MAY 19	0.1	0.01		399
MAY 20				364
MAY 20				394
MAY 20				411
JUN 15	0.11	0.01		425
JUN 16	0.25	0.01		330
JUN 16				372
JUN 23	0.02	0.01		380
JUL 08	0.04	0.01		
1987				
SEP 22				440
OCT 23				480
DEC 07				460
1988				
JAN 13				460
FEB 19				430
MAR 30				560
APR 21				425
MAY 24				395
JUN 27				375
AUG 01				370
SEP 15				370
OCT 12				420
OCT 25				455
NOV 02				410
NOV 25				450
DEC 29				460
1989				
FEB 13				425
MAR 15				560
APR 12				420
JUN 09				390
JUL 07				395
AUG 08				390
SEP 27				470
OCT 18				470
NOV 09				485
NOV 28				455
DEC 21				480
1990				
FEB 02				450

Site 06418900

Rapid Creek below WWTP Discharge

	PHOS- PHORUS TOTAL (MG/L AS P)	PHOS- PHORUS DIS- SOLVED (MG/L AS P)	SOLIDS RESIDU AT 180 DEG. C DIS- SOLVED (MG/L)	SPE- CIFIC CON- DUCT- ANCE (US/CM)
AUG 07				770
SEP 10				1240
OCT 07				1150
NOV 07				1080
DEC 10				1060
1986				
JAN 09				1020
FEB 11				1180
MAR 20				1010
APR 09				1140
MAY 06				1060
JUN 06				930
JUL 01				930
AUG 11				1160
AUG 13				872
SEP 08				1010
OCT 29				770
NOV 26				1070
DEC 15				890
1987				
JAN 12				870
FEB 27				950
APR 14				630
MAY 11				870
JUN 05				960
JUL 02				1330
AUG 18				1220
SEP 30				1300
NOV 16				940
DEC 21				970
1988				
JAN 29				930
MAR 18				830
APR 11				1050
JUN 13				790
JUL 08				1050
AUG 18				1190
OCT 07				1130
NOV 18				1010
1989				
JAN 06				1060
FEB 17				1100
MAR 30				1180
APR 17				940
MAY 15				870
JUN 15				1100
JUL 20				1120
AUG 24				1210
OCT 02				1140
NOV 09				1000
DEC 19				1140

Site 06421500

Rapid Creek near Farmingdale

	PHOS- PHORUS TOTAL (MG/L AS P)	PHOS- PHORUS DIS- SOLVED (MG/L AS P)	SOLIDS RESIDU AT 180 DEG. C DIS- SOLVED (MG/L)	SPE- CIFIC CON- DUCT- ANCE (US/CM)
NOV 10			500	750
NOV 13			326	503
NOV 14			436	656
NOV 15			683	960
DEC 06			692	988
DEC 27			598	848
1957				
JAN 01			719	1010
JAN 12			675	953
FEB 06			534	767
FEB 16			570	800
FEB 20			616	885
FEB 25			446	668
MAR 01			473	719
MAR 04			570	821
MAR 16			689	988
APR 01			751	1050
APR 17			788	1090
APR 26			962	1210
MAY 20			363	873
MAY 28			717	969
JUL 01			722	997
JUL 16			478	703
JUL 20			701	974
AUG 02			805	1090
AUG 27			723	1000
OCT 01			769	1050
NOV 01			705	979
NOV 30			393	590
DEC 12			664	947
DEC 13			425	629
DEC 26			662	923
1958				
JAN 06			362	562
JAN 09			610	888
FEB 01			595	860
FEB 21			511	752
FEB 27			642	905
MAR 15			456	684
MAR 19			600	862
APR 06			786	1070
APR 30			518	722
MAY 01			800	1090
MAY 31			946	1210
JUN 17			620	844
JUL 01			726	986
JUL 21			604	831
JUL 23			696	863
AUG 08			766	1060
SEP 10			1030	1320
1968				

Site 06413700

Rapid Creek above WWTP Discharge

[illegible]

Site 06418900

Rapid Creek below WWTP Discharge

	PHOS- PHORUS TOTAL (MG/L AS P)	PHOS- PHORUS DIS- SOLVED (MG/L AS P)	SOLIDS RESIDU AT 180 DEG. C DIS- SOLVED (MG/L)	SPE- CIFIC CON- DUCT- ANCE (US/CM)
1990				
FEB 02				950
MAR 16				960
APR 09				580
MAY 17				1200
JUN 05				1280
JUL 12				943
AUG 10				1140
SEP 24				925
NOV 06				1200
DEC 14				1100
1991				
FEB 14				1200
MAR 28				1200
MAY 16				920
JUN 18				935
JUL 18				945
AUG 29				998
OCT 21				1050
DEC 18				964
1992				
JAN 31				1010
MAR 03				1090
APR 02				968
MAY 07				1370
JUN 08				990
JUL 06				854
AUG 24				729
OCT 01				1140
NOV 02				965
DEC 01				1200
1993				
JAN 04				877
FEB 08				873
MAR 15				970
APR 08				1010
MAY 08				519
MAY 18				982
AUG 06				810
SEP 02				765
OCT 05				916
NOV 08				792
DEC 07				902
1994				
JAN 05				849
FEB 07				815
MAR 30				881
JUN 25				895
AUG 24				800
OCT 06				1010
NOV 07				965

Site 06421500

Rapid Creek near Farmingdale

	PHOS- PHORUS TOTAL (MG/L AS P)	PHOS- PHORUS DIS- SOLVED (MG/L AS P)	SOLIDS RESIDU AT 180 DEG. C DIS- SOLVED (MG/L)	SPE- CIFIC CON- DUCT- ANCE (US/CM)
OCT 01			881	1260
OCT 08			935	1290
OCT 31			908	1260
NOV 01			758	1140
DEC 10			789	1120
1969				
JAN 22			625	885
JAN 26				
FEB 01			610	907
FEB 14			674	945
MAR 06			611	861
MAR 26			617	829
APR 01			645	902
APR 06				1000
APR 18			561	760
MAY 01			722	1050
MAY 23			764	1040
JUN 20			870	1140
JUN 30				990
JUL 01			930	1220
JUL 11			1150	1450
JUL 29			580	840
AUG 20			955	1280
SEP 12			1220	1550
SEP 21				1250
OCT 01			950	1290
OCT 24			944	1280
NOV 12			693	1000
DEC 23			667	1010
1970				
JAN 16			646	949
FEB 04			640	918
FEB 27			588	888
MAR 19			674	977
APR 01			667	891
APR 09			699	1070
MAY 01			490	676
MAY 11				590
MAY 21			473	656
JUN 01			447	670
JUN 10			595	766
JUL 01			688	965
AUG 01			742	1030
AUG 12			656	926
SEP 01			628	905
OCT 01	1.7		710	1020
OCT 13		1.5	736	1060
NOV 01			674	958
DEC 01	2.2		700	1020
DEC 15		1.2	756	988
1971				

Rapid Creek above WWTP Discharge

[illegible]

Rapid Creek below WWTP Discharge

[illegible]

Rapid Creek near Farmingdale

	PHOS- PHORUS TOTAL (MG/L AS P)	PHOS- PHORUS DIS- SOLVED (MG/L AS P)	SOLIDS RESIDU AT 180 DEG. C DIS- SOLVED (MG/L)	SPE- CIFIC CON- DUCT- ANCE (US/CM)
JAN 01	1.7		660	978
FEB 01	1		564	824
FEB 17	0.49		394	630
MAR 01	1.5		592	890
APR 01	2.1		434	678
APR 23	0.2			580
MAY 01	1.4		372	570
JUN 01	0.63		406	
JUN 02	0.55			705
JUL 01	0.64		498	769
JUL 12	0.25			802
AUG 01	0.49			963
AUG 04	0.46			986
SEP 01	0.83			987
SEP 14	0.95			878
OCT 01	1.1			1070
NOV 01				970
DEC 01	1.4	1.3		959
1972				
JAN 01	1.5	1.4		931
JAN 18	1.8			1060
FEB 01	1.3	1.3		812
MAR 01	0.8	0.78		705
APR 01	0.74	0.77		772
APR 10	0.95	0.82		775
MAY 01	0.66	0.65		828
JUN 01	0.27	0.21		657
JUL 01	0.28	0.26		634
AUG 01	0.41	0.42		748
AUG 18	0.56	1.4		880
SEP 01	0.69	0.69		807
OCT 01	0.68	0.69		636
OCT 19	0.99	0.96		739
NOV 01	0.88	0.88		851
NOV 28	0.83	0.69		828
DEC 01	1	1		848
1973				
JAN 01	1.1	1.1		856
FEB 01	1	1		802
FEB 12	1.2	1.2		875
MAR 01	0.94	0.92		892
MAR 20	0.74	0.53		811
APR 01	0.56	0.54		975
APR 09	0.64	0.56		1100
MAY 01	0.36	0.34		628
MAY 08	0.52	0.22		574
MAY 22				630
JUN 01	0.47	0.47		727
JUN 05	0.46	0.34		767
JUL 01	0.4	0.36		916
JUL 19	0.53	0.31		887

Site 06413700

Rapid Creek above WWTP Discharge	
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[illegible]

Site 06418900

Rapid Creek below WWTP Discharge

[illegible]

Site 06421500

Rapid Creek near Farmingdale

		PHOS- PHORUS TOTAL (MG/L AS P)	PHOS- PHORUS DIS- SOLVED (MG/L AS P)	SOLIDS RESIDU AT 180 DEG. C DIS- SOLVED (MG/L)	SPE- CIFIC CON- DUCT- ANCE (US/CM)
	AUG 01	0.51	0.45		1120
	AUG 27	0.62	0.57		1170
	SEP 01	0.89	0.81		912
	SEP 18				714
	SEP 29	0.83	0.71		810
	OCT 23	0.94	0.96		944
	NOV 12				790
	NOV 20	0.94	0.9		847
	NOV 20				680
	1974				
	JAN 16	1.4	1.3		936
	MAR 19	1.2	1.1		879
	APR 02				789
	APR 16	0.84	0.76		1010
	MAY 01				803
	MAY 16	0.53	0.35		1070
	JUN 06				1290
	JUL 18	0.71	0.3		968
	AUG 13	0.6	0.32		880
	AUG 19				898
	SEP 11	0.71	0.62		1030
	SEP 30				921
	OCT 09	0.84	0.84		1080
	OCT 28				1020
	NOV 08	1.4	1.3		1340
	NOV 25				908
	NOV 25	1.3	1.3		930
	DEC 16				896
	1975				
	JAN 15				1140
	JAN 21	1.3	1.3		1220
	FEB 26				832
	MAR 13				863
	MAR 17	0.74	0.7		735
	APR 14	0.79	0.57		820
	APR 23				905
	MAY 12	0.73	0.5		1040
	MAY 27				811
	JUN 11	0.72	0.27		805
	JUN 25				880
	JUL 07	1.5	0.32		840
	JUL 24				833
	AUG 11	0.28	0.16		950
	AUG 19				1040
	SEP 09	0.32	0.15		1090
	SEP 24				1070
	OCT 14	0.82	0.74		1440
	OCT 28				1230
	NOV 13	1.3	1.1		900
	NOV 18				946
	DEC 10	1.1	1.1		860

Site 06421500 Rapid Creek near Farmingdale				
	PHOS- PHORUS TOTAL (MG/L AS P)	PHOS- PHORUS DIS- SOLVED (MG/L AS P)	SOLIDS RESIDU AT 180 DEG. C DIS- SOLVED (MG/L)	SPE- CIFIC CON- DUCT- ANCE (US/CM)
DEC 17				1170
1976				
JAN 12				1050
JAN 29	1.8	1.7		1100
FEB 12				910
FEB 25	1.2	1		990
MAR 24	1	0.87		960
MAR 29				870
APR 12				910
APR 20	0.56	0.52		900
MAY 11				1020
MAY 17	0.42	0.33		
JUN 17	0.77	0.13		810
JUN 22				560
JUL 14				830
JUL 22	0.42	0.33		1050
AUG 18	0.51	0.42		920
AUG 24				880
SEP 16	0.66	0.52		1100
SEP 29				980
OCT 21	1.3	1.2		1140
OCT 26				980
NOV 17	1	0.99		1100
NOV 22				960
DEC 15				890
DEC 15	1.2	1.1		1090
1977				
JAN 12				960
JAN 13	1.4	1.4		980
FEB 08				890
FEB 09	1.2	1.1		970
MAR 08	1			820
MAR 16				830
APR 11				670
APR 12	0.93	0.19		630
MAY 11	0.49	0.27		
MAY 23				750
JUN 29				800
JUL 13	0.5	0.41		975
JUL 26				890
AUG 16	0.69	0.56		820
AUG 23				1080
SEP 20	0.8	0.57		1300
SEP 26				650
OCT 05				860
OCT 19	1	0.86		1200
NOV 07				480
NOV 08				1040
NOV 08	0.95	0.99		935
DEC 06	1.5	1.4		1200
DEC 08				400

[illegible]

Site 06421500				
Rapid Creek near Farmingdale				
	PHOS- PHORUS TOTAL (MG/L AS P)	PHOS- PHORUS DIS- SOLVED (MG/L AS P)	SOLIDS RESIDU AT 180 DEG. C DIS- SOLVED (MG/L)	SPE- CIFIC CON- DUCT- ANCE (US/CM)
DEC 19				940
1978				
JAN 09				950
JAN 11				410
FEB 09	1.7	2		1300
FEB 22				860
MAR 07	2.2	2		1050
MAR 08				1120
MAR 14	0.8	0.51		550
MAR 17				440
APR 03				400
APR 05				940
MAY 01				720
MAY 09	0.76	0.16		800
MAY 09				350
JUN 05				420
JUN 06	0.57	0.42		430
JUL 06				785
JUL 10				605
AUG 01				377
AUG 03	0.82	0.66		840
AUG 08				805
SEP 06				930
SEP 11	0.47	0.3		1220
SEP 11				360
OCT 03				890
OCT 11				1050
OCT 11	0.86	0.81		1050
NOV 07				840
NOV 07	0.84	0.77		840
NOV 08				760
DEC 05				1100
DEC 05	0.99	0.94		1100
DEC 07				800
1979				
JAN 02	1.3	1.2	296	1300
JAN 04				920
FEB 05	0.86	0.84		860
FEB 07				670
MAR 06				690
MAR 23	0.75	0.72		850
APR 04				1590
APR 17	0.81	0.63		790
MAY 08				960
MAY 18	0.27	0.25		1050
JUN 06				1110
JUN 13	0.34	0.3		1040
JUL 05				850
JUL 10	0.56	0.38		908
AUG 07				820
AUG 15	0.57	0.5		1020

Site 06413700

Rapid Creek above WWTP Discharge

[illegible]

Site 06418900

Rapid Creek below WWTP Discharge

[illegible]

Site 06421500

Rapid Creek near Farmingdale

		PHOS- PHORUS TOTAL (MG/L AS P)	PHOS- PHORUS DIS- SOLVED (MG/L AS P)	SOLIDS RESIDU AT 180 DEG. C DIS- SOLVED (MG/L)	SPE- CIFIC CON- DUCT- ANCE (US/CM)
	SEP 10	0.38	0.3		
	SEP 10				1070
	SEP 17				1120
	OCT 03				1200
	OCT 04	0.77	0.71		1180
	NOV 05				880
	NOV 16	1.4	1.1		1050
	DEC 12	0.76	0.69	545	967
	DEC 12				870
	DEC 12				1330
	1980				
	JAN 08				1030
	JAN 16	0.8	0.82	403	860
	FEB 04				915
	MAR 05				880
	MAR 20	0.86	0.88	499	865
	APR 02				1100
	APR 17	0.9	0.86	647	1020
	MAY 07				1290
	MAY 14	0.64	0.37	575	957
	JUN 03				720
	JUN 06	0.53	0.31		959
	JUN 16				540
	JUL 02				1200
	JUL 16	0.61	0.37	484	732
	AUG 06				1240
	AUG 07	0.4	0.17		1140
	SEP 03	0.88	0.67	657	1020
	SEP 10				1200
	OCT 08				1250
	OCT 09				1320
	NOV 12				1220
	NOV 15				1220
	DEC 11				990
	1981				
	JAN 07				925
	JAN 12				1120
	FEB 03				1180
	MAR 06				900
	MAR 09				975
	APR 03				1010
	APR 08				988
	MAY 08				978
	MAY 14				1040
	JUN 04				1230
	JUN 22				1010
	JUL 08				920
	JUL 09				950
	AUG 06				1140
	AUG 06				1140
	SEP 03				1060

Rapid Creek above WWTP Discharge	
1	10/10/1998
2	10/10/1998
3	10/10/1998
4	10/10/1998
5	10/10/1998
6	10/10/1998
7	10/10/1998
8	10/10/1998
9	10/10/1998
10	10/10/1998
11	10/10/1998
12	10/10/1998
13	10/10/1998
14	10/10/1998
15	10/10/1998
16	10/10/1998
17	10/10/1998
18	10/10/1998
19	10/10/1998
20	10/10/1998
21	10/10/1998
22	10/10/1998
23	10/10/1998
24	10/10/1998
25	10/10/1998
26	10/10/1998
27	10/10/1998
28	10/10/1998
29	10/10/1998
30	10/10/1998
31	10/10/1998
32	10/10/1998
33	10/10/1998
34	10/10/1998
35	10/10/1998
36	10/10/1998
37	10/10/1998
38	10/10/1998
39	10/10/1998
40	10/10/1998
41	10/10/1998
42	10/10/1998
43	10/10/1998
44	10/10/1998
45	10/10/1998
46	10/10/1998
47	10/10/1998
48	10/10/1998
49	10/10/1998
50	10/10/1998
51	10/10/1998
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53	10/10/1998
54	10/10/1998
55	10/10/1998
56	10/10/1998
57	10/10/1998
58	10/10/1998
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60	10/10/1998
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72	10/10/1998
73	10/10/1998
74	10/10/1998
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78	10/10/1998
79	10/10/1998
80	10/10/1998
81	10/10/1998
82	10/10/1998
83	10/10/1998
84	10/10/1998
85	10/10/1998
86	10/10/1998
87	10/10/1998
88	10/10/1998
89	10/10/1998
90	10/10/1998
91	10/10/1998
92	10/10/1998
93	10/10/1998
94	10/10/1998
95	10/10/1998
96	10/10/1998
97	10/10/1998
98	10/10/1998
99	10/10/1998
100	10/10/1998

[illegible]

Rapid Creek below WWTP Discharge

[illegible]

Rapid Creek near Farmingdale

Rapid Creek near Farmingdale				
	PHOS-PHORUS TOTAL (MG/L AS P)	PHOS-PHORUS DIS-SOLVED (MG/L AS P)	SOLIDS RESIDU AT 180 DEG. C DIS-SOLVED (MG/L)	SPE-CIFIC CON-DUCT- ANCE (US/CM)
OCT 02				1250
NOV 04				1250
DEC 04				1120
FEB 09				1080
MAR 22				1020
APR 07			656	1300
APR 28				1120
MAY 06			812	1130
MAY 10				1040
JUN 10				1020
JUN 16			628	910
JUL 13				593
JUL 15			400	670
AUG 11				810
AUG 19			574	740
SEP 07				605
SEP 09			498	750
OCT 15				1100
NOV 02			596	860
NOV 12				1080
DEC 03				908
DEC 16			510	800
1983				
JAN 06			602	890
JAN 26				585
FEB 03			632	1000
MAR 14				876
APR 14			490	800
APR 19				760
MAY 18			368	575
MAY 25				560
JUN 09			698	1060
JUN 23				624
JUL 12				1020
JUL 13			610	925
AUG 04			602	630
SEP 08			794	1200
SEP 09				1060
OCT 06			656	1040
OCT 07				1020
NOV 04				1030
DEC 01				1040
DEC 08			654	990
1984				
JAN 05			586	910
JAN 10				880
FEB 02				850
FEB 08			536	810
MAR 02				920
MAR 08			596	900
APR 11			470	725

Site 06413700

Rapid Creek above WWTP Discharge

[illegible]

Site 06418900

Rapid Creek below WWTP Discharge

[illegible]

Site 06421500

Rapid Creek near Farmingdale

	PHOS- PHORUS TOTAL (MG/L AS P)	PHOS- PHORUS DIS- SOLVED (MG/L AS P)	SOLIDS RESIDU AT 180 DEG. C DIS- SOLVED (MG/L)	SPE- CIFIC CON- DUCT- ANCE (US/CM)
APR 16				730
MAY 10			398	650
MAY 15				570
JUN 15				720
JUL 02				740
JUL 10			478	710
AUG 08			536	860
AUG 14				940
SEP 06				1100
SEP 14			774	1150
OCT 01			672	1050
OCT 17				1060
NOV 14			608	870
NOV 20				870
DEC 05			662	900
DEC 10				810
1985				
JAN 08			544	870
JAN 09				890
FEB 07			641	1000
FEB 14				870
MAR 14			536	800
MAR 18				850
APR 02			424	670
APR 10				770
MAY 08			826	1230
MAY 14				790
JUN 11			706	1100
JUN 12				1130
JUL 03				1040
JUL 18			504	810
AUG 07				730
SEP 03			746	1200
SEP 11				1380
OCT 07				1160
OCT 17			688	1050
NOV 06			582	940
NOV 07				950
DEC 09			710	1150
1986				
JAN 09			666	960
JAN 14				960
FEB 11				1220
FEB 21			746	1250
MAR 17				1140
MAR 26			774	1150
APR 06				990
APR 09			930	1250
APR 18				750
MAY 06			722	1140
MAY 08				1120

[illegible]

Site 06421500 Rapid Creek near Farmingdale				
	PHOS- PHORUS TOTAL (MG/L AS P)	PHOS- PHORUS DIS- SOLVED (MG/L AS P)	SOLIDS RESIDU AT 180 DEG. C DIS- SOLVED (MG/L)	SPE- CIFIC CON- DUCT- ANCE (US/CM)
JUN 04			1000	1440
JUN 06				1480
JUL 01				1100
AUG 08				1190
AUG 13			638	1040
SEP 08				810
SEP 24			664	1010
OCT 15				780
OCT 22			518	815
NOV 06			424	775
NOV 14				840
DEC 03			524	825
DEC 12				1080
DEC 30				940
1987				
FEB 04			628	1010
FEB 12				1060
MAR 05			670	1030
APR 06				860
APR 08			536	850
MAY 07				910
MAY 14			606	650
JUN 04				900
JUN 10			608	950
JUL 09				980
JUL 16			721	1050
AUG 10				730
AUG 12			594	910
SEP 03			538	885
SEP 29				1330
OCT 28			704	1170
NOV 04			730	1200
NOV 10				1240
DEC 01			682	1070
DEC 18				1140
1988				
JAN 19			586	960
FEB 08				1060
FEB 16			667	1180
MAR 10			520	855
MAR 15				1140
APR 12				1290
APR 21			903	1360
MAY 05				1020
MAY 25			850	1200
JUN 07			1150	1650
JUN 13				1240
JUL 08				1030
JUL 11			754	1200
AUG 18				1070
AUG 22			761	1200

[illegible][illegible]

Site 06421500 Rapid Creek near Farmingdale				
	PHOS- PHORUS TOTAL (MG/L AS P)	PHOS- PHORUS DIS- SOLVED (MG/L AS P)	SOLIDS RESIDU AT 180 DEG. C DIS- SOLVED (MG/L)	SPE- CIFIC CON- DUCT- ANCE (US/CM)
SEP 12			794	1190
OCT 06				1120
OCT 15	0.88	0.88		
OCT 19			1700	2400
NOV 09			731	1130
NOV 17				1050
DEC 22	1.5	1.5		
DEC 22				1040
1989				
JAN 10			876	1320
FEB 14			686	1070
FEB 16				970
MAR 20			749	1150
MAR 21		1.2	660	995
MAR 30				1070
APR 03			770	1150
APR 14	0.92	0.63		1000
MAY 09			676	1100
MAY 15				1350
JUN 02		0.41	658	983
JUN 15				1300
JUN 19			762	1200
JUL 10				1320
JUL 12			962	1340
JUL 20				1000
JUL 31				1270
AUG 01	0.48	0.28		1150
AUG 09			657	1110
AUG 24				1060
SEP 13		0.75	576	870
SEP 18			764	1800
OCT 02				1240
OCT 18			701	1100
NOV 08			669	1000
DEC 20			792	1200
1990				
SEP 24				900
NOV 05				1310
NOV 20		1.2	868	1290
DEC 14				980
1991				
MAR 12				1040
MAR 25				1080
JUN 18				902
JUL 18				1080
AUG 28		0.52	692	1010
OCT 21				1310
1992				
JAN 30				904
MAR 03				1010
APR 06			646	1050

Rapid Creek above WWTP Discharge

[illegible]

Rapid Creek below WWTP Discharge

[illegible]

Rapid Creek near Farmingdale

	PHOS-PHORUS TOTAL (MG/L AS P)	PHOS-PHORUS DIS-SOLVED (MG/L AS P)	SOLIDS RESIDU AT 180 DEG. C DIS-SOLVED (MG/L)	SPE-CIFIC CON-DUCT- ANCE (US/CM)
MAY 07				1270
JUN 08				1110
JUN 18		0.73	760	1160
JUL 06				646
AUG 06		0.55	786	1150
AUG 24				1020
OCT 01				1370
NOV 02				1240
DEC 01				1260
1993				
JAN 04				1210
FEB 09		1	630	1030
MAR 15				1180
APR 08				990
MAY 08				658
MAY 18				1000
JUN 23				529
AUG 06				730
SEP 02				844
OCT 05				866
NOV 08				958
DEC 07				897
1994				
JAN 05				835
FEB 07				872
MAR 30				630
MAY 04				594
JUN 21				909
JUL 28		0.28		921
SEP 15				1110
OCT 05				1040
NOV 23				1170
DEC 28				942
1995				
FEB 01				861
MAR 02				913
APR 03				934
MAY 01				868
MAY 12				614
JUN 07				517
JUL 10				614
JUL 12		0.31		640
AUG 21				750

TABLE A-4
U.S. Environmental Protection Agency
Statistical Summaries of Rapid Creek Water Quality Data

STORET RETRIEVAL DATE 96/04/04										PGH=INVENT										PAGE: 138									
460110										44 01 24.0 103 08 23.0 2										RAPID CREEK IMMEDIATELY ABOVE WHTP DISCHARGE									
46103										MISSOURI										PENNINGTON									
090300										CENTRAL MISSOURI										HQ 10120110001 0035.170 OFF									
215DAK01										840121										/TYPE/ABENT/STREAM									
0000										0000 FEET DEPTH																			
PARAMETER										MEDIUM										RMK									
00010 WATER										WATER																			
00011 WATER										WATER																			
00020 AIR										WATER																			
00021 AIR										WATER																			
00028 ANALYZE										WATER																			
00095 AGENCY										WATER																			
00300 CONDUCTV										WATER																			
00400 DO										WATER																			
00403 PH										WATER																			
00410 T ALK										WATER																			
00415 CACO3										WATER																			
00500 PHEN-PH-										WATER																			
00500 RESIDUE										WATER																			
00530 RESIDUE										WATER																			
00610 NH3+NH4-										WATER																			
00613 NO2-N										WATER																			
00620 NO3-N										WATER																			
00630 NO2&NO3										WATER																			
00665 PHOS-TOT										WATER																			
00671 PHOS-DIS										WATER																			
00900 TOT HARD										WATER																			
00916 CALCIUM										WATER																			
00927 MAGNESIUM										WATER																			
00929 SODIUM										WATER																			
00931 SODIUM										WATER																			
00937 PTSSIUM										WATER																			
00940 CHLORIDE										WATER																			
00945 SULFATE										WATER																			
01002 ARSENIC										WATER																			
NUMBER										VARIANCE										STAN DEV									
130										60.84600										7.800400									
152										193.0600										13.89500									
129										132.2400										11.50000									
152										440.8600										20.99700									
152										0.000000										0.000000									
151										26982.00										164.2600									
151										3.307300										1.818600									
151										1744800										41.77100									
172										44708.00										211.4400									
139										6854.000										82.78900									
11										172.1800										13.12200									
11										16255.00										127.4900									
58										535.2700										23.13600									
3										0.000000										0.000000									
61										526.5900										22.94800									
97										0.355420										1.885300									
50										0.014580										0.381840									
147										0.0250280										0.1582000									
45										0.0709230										0.2663200									
44										0.003597										0.189660									
89										0.0503860										0.2244700									
2										0.0950000										0.0494980									
54										0.153300										0.1238100									
4										0.000000										0.000000									
58										0.144670										0.1202800									
36										0.000714										0.084528									
15										0.000000										0.000000									
51										0.000591										0.076937									
77										10060.00										100.3000									
45										562.1000										23.70900									
45										61.30100										7.829500									
45										68.27300										8.262800									
1										3.700000										4.00									
1										4.000000										4.00									
1										17.00000										17									
1										198.0000										198									
3										5.000000										5									
K										.0000000										.0000000									

STORET RETRIEVAL DATE 96/04/04
 460110
 44 01 24.0 103 08 23.0 2
 RAPID CREEK IMMEDIATELY ABOVE WHTP DISCHARGE
 46103 SOUTH DAKOTA
 MISSOURI
 CENTRAL MISSOURI
 21SDAK01 840121
 0000 FEET DEPTH

PGH=INVENT

/TYPA/AMNT/STREAM

HQ 10120110001 0035.170 OFF

PAGE: 139

PARAMETER	UG/L	MEDIUM	RMK	NUMBER	MEAN	VARIANCE	STAN DEV	MAXIMUM	MINIMUM	BEG DATE	END DATE
01002 ARSENIC AS, TOT	UG/L	WATER	TOT K	4	5.000000	.0000000	.0000000	.50	.50	94/10/31	95/07/12
01012 BERYLLIUM BE, TOT	UG/L	WATER	TOT K	3	5000000	.0000000	.0000000	.65	.65	94/10/31	95/04/18
01027 CADMIUM CD, TOT	UG/L	WATER	TOT K	3	22.46700	1331.600	36.49100	10	10	94/10/31	95/07/12
01032 CHROMIUM HEX-VAL	UG/L	WATER	TOT K	4	16.97500	1008.400	31.75500	65	65	94/10/31	95/07/12
01034 CHROMIUM CR, TOT	UG/L	WATER	TOT K	3	10.00000	.0000000	.0000000	10	10	95/01/09	95/07/12
01042 COPPER CU, TOT	UG/L	WATER	TOT K	4	5.000000	.0000000	.0000000	10	10	94/10/31	94/10/31
01051 LEAD PB, TOT	UG/L	WATER	TOT K	4	5.000000	.0000000	.0000000	10	10	94/10/31	95/07/12
01059 THALLIUM TL, TOTAL	UG/L	WATER	TOT K	2	1.400000	.7200000	.8485300	5	5	94/10/31	95/07/12
01067 NICKEL NI, TOTAL	UG/L	WATER	TOT K	3	1.600000	.4800000	.6928200	3	3	95/01/09	95/04/18
01077 SILVER AG, TOT	UG/L	WATER	TOT K	4	5.000000	.0000000	.0000000	.5	.5	94/10/31	95/04/18
01092 ZINC ZN, TOT	UG/L	WATER	TOT K	1	.7100000	.0000000	.0000000	.7	.7	94/10/31	95/07/12
01097 ANTIMONY SB, TOT	UG/L	WATER	TOT K	4	.5525000	.0110260	.1050000	10	10	95/01/09	95/07/12
01105 ALUMINUM AL, TOT	UG/L	WATER	TOT K	2	45.00000	1250.000	35.35500	70	70	94/10/31	95/07/12
01147 SELENIUM SE, TOT	UG/L	WATER	TOT K	4	5.000000	.0000000	.0000000	5	5	95/01/09	95/07/12
31616 FEC COLI HFM-FCBR	UG/L	WATER	TOT K	1	25.00000	.950.0000	30.82200	70	70	94/10/31	95/04/18
70300 RESIDUE DISS-180 C	MG/L	WATER	TOT K	3	2.000000	.0000000	.0000000	2	2	95/04/18	95/07/12
71900 MERCURY HG, TOTAL	UG/L	WATER	TOT K	4	5.000000	.0000000	.0000000	5	5	94/10/31	95/07/12
74041 WQF SAMPLE	UG/L	WATER	TOT K	3	246.6700	46633.00	215.9500	450	450	94/10/31	95/07/12
	UPDATED	WATER	TOT K	4	100.0000	36467.00	190.9600	100	100	95/01/09	95/07/12
			TOT K	4	210.0000	8100000	9000000	450	450	94/10/31	95/07/12
			TOT K	5	1550000	322430.0	567.8300	2	2	94/10/31	95/07/12
			TOT K	9	209.1300	12.42500	3.527700	4000	4000	82/11/02	95/09/28
			TOT K	65	180.6900	282200.0	531.2300	4000	4000	86/01/09	95/09/28
			TOT K	38	442.8400	22576.00	150.2500	830	830	82/11/02	95/09/28
			TOT K	23	504.0000	15231.00	123.4100	793	793	87/01/06	95/09/28
			TOT K	61	465.9000	20400.00	142.8300	830	830	91/11/14	95/09/28
			TOT K	4	2000000	.0000000	.0000000	2	2	94/10/31	95/07/12
			TOT K	115	908130.0	8066E+05	28401.00	951103	860528	85/07/18	95/09/28

STORET RETRIEVAL DATE 96/04/04

SD-0023574-1

44 06 00.0 103 15 00.0 2

RAPID CITY STP

46103 SOUTH DAKOTA PENNINGTON

MISSOURI RIVER

CENTRAL MISSOURI RIVER

1118EP8 760310

0000 FEET DEPTH

10120110001 0044.640 ON

/TYP/MUN/TREATD/OUTFL/STREAM

PGH=INVENT

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PARAMETER	CENT	MEDIUM	RMK	NUMBER	MEAN	VARIANCE	STAN DEV	MAXIMUM	MINIMUM	BEG DATE	END DATE
00010 WATER	MG/L	WATER		8	12.58800	15.04700	3.879100	17.0	5.0	75/12/09	82/05/17
00310 BOD	SU	WATER		7	25.90000	195.9300	13.99800	49.0	10.7	75/12/09	82/05/17
00400 PH		WATER		8	7.556300	2739300	5233800	8.20	6.60	75/12/09	82/05/17
00530 RESIDUE	MG/L	WATER		8	28.37500	126.5500	11.25000	11.20	1.70	75/12/09	82/05/17
00556 OIL-CRSE	MG/L	WATER		8	5.660000	13.07300	3.615700	11.20	1.70	75/12/09	82/05/17
00610 NH3+NH4-N TOTAL	MG/L	WATER		2	6.925000	8.201300	2.863800	8.340	4.340	78/10/25	79/12/13
31506 TOT COLI MPN CONF	TUBECODE	WATER		1	340.0000			8.340	2	75/12/09	75/12/09
31615 FEC COLI MPNECHD	/100ML	WATER		1	2.000000			2	2	75/12/09	75/12/09
50050 CONDUIT FLOW	MGD	WATER	R	7	8.050000	1.375900	1.173000	9.500	6.600	75/12/09	82/05/17
50060 CHLORINE TOT RESD	MG/L	WATER		3	.1466700	.0025333	.0503320	.20	.10	75/12/09	82/05/17

PGM=INVENT

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STORET RETRIEVAL DATE 96/04/04
440123103053300
44 01 23.0 103 05 33.0 2
RAPID CR BLW SEWAGE PLANT NR RAPID CITY SD
46103 SOUTH DAKOTA PENNINGTON

/TYPE/AMENT/STREAM

112NRD 760830 10120110
0000 FEET DEPTH

PARAMETER	UG/L	MEDIUM	RHK	NUMBER	MEAN	VARIANCE	STAN DEV	MAXIMUM	MINIMUM	BEG DATE	END DATE
01000 ARSENIC	UG/L	WATER		1	.0000000			0	0	70/10/09	70/10/09
01025 CADMIUM	UG/L	WATER		1	.0000000			0	0	70/10/09	70/10/09
01032 CHROMIUM	UG/L	WATER		1	.0000000			0	0	70/10/09	70/10/09
01034 CHROMIUM	UG/L	WATER		1	.0000000			0	0	70/10/09	70/10/09
01035 COBALT	UG/L	WATER		1	.0000000			0	0	70/10/09	70/10/09
01049 LEAD	UG/L	WATER		1	.0000000			0	0	70/10/09	70/10/09
01090 ZINC	UG/L	WATER		1	20.00000			20	20	70/10/09	70/10/09
71900 MERCURY	UG/L	WATER		1	.7000000			.7	.7	70/10/09	70/10/09

STORET RETRIEVAL DATE 96/04/04
06418900
44 01 24.0 103 05 43.0 2
RAPID CR BL SEWAGE TREATMENT PL NR RAPID CITY, S
46103 SOUTH DAKOTA PENNINGTON

PGM=INVENT

PAGE: 73

112WRD 830409
0000 FEET DEPTH

/TYPA/AMENT/STREAM

10120110

PARAMETER	WATER	AIR	TEMP	TEMP	CENT	WATER	MEDIUM	RMK	NUMBER	MEAN	VARIANCE	STAN DEV	MAXIMUM	MINIMUM	BEG DATE	END DATE
00010	WATER								145	11.30600	46.61500	6.827500	27.0	-21.0	81/11/02	95/08/21
00020	AIR								141	12.32600	133.8700	11.57000	34.5	673	81/11/02	95/08/21
00025	BARONTRC	PRESSURE	MM OF HG						154	1028.000	0000000	0000000	1038	1028	94/08/24	94/08/24
00027	COLLECT	AGENCY	CODE						154	3592.700	1972E+05	14046.00	80020	1028	81/11/02	95/08/21
00028	ANALYZE	AGENCY	CODE						151	67.56700	4956.300	70.40100	491	18	81/11/02	95/08/21
00061	STREAM	FLOW	INST-CFS						146	3592900	8433300	9183300	276	00	81/11/02	95/08/21
00065	STREAM	STAGE	FEET						146	964.6900	29752.00	172.4900	1400	511	92/10/01	94/10/06
00095	CNDUCTVY	AT 25C	MICROMHO						2	6.350000	.1250000	.3535500	6.6	6.1	81/11/02	95/08/21
00300	DO		MG/L						2	7.675000	.0480500	.2192000	7.83	7.52	94/08/24	94/10/06
00400	PH		SU						2	7.250000	.0050049	.0707450	7.3	7.2	94/08/24	94/10/06
00403	PH		SU						2	3000000	.0200000	.1414200	400	75.0	94/08/24	94/10/06
00608	NH3+NH4-	LAB	MG/L						2	82.50000	112.5000	10.60700	90.0	33.0	94/08/24	94/10/06
00915	CALCIUM	CA, DISS	MG/L						2	34.00000	2.000000	1.414200	35.0	37.00	94/08/24	94/10/06
00925	MGNSIUM	MG, DISS	MG/L						2	48.50000	264.5000	16.26400	60.00	37.00	94/08/24	94/10/06
00930	SODIUM	NA, DISS	MG/L						2	7.050000	5.845000	2.616300	8.90	5.39	94/08/24	94/10/06
00935	PTSIUM	K, DISS	MG/L						2	55.00000	512.0000	22.62800	71	160	94/08/24	94/10/06
00940	CHLORIDE	TOTAL	MG/L						2	180.0000	800.0000	28.28400	200	.50	94/08/24	94/10/06
00945	SULFATE	SO4-TOT	MG/L						2	.6500000	.0450010	.2121400	.80	.1	94/08/24	94/10/06
00950	FLUORIDE	F, DISS	MG/L						2	1.000000	.0000000	.0000000	.1	.1	94/08/24	94/10/06
01025	CADMIUM	CD, DISS	UG/L						2	4.500000	5000000	7071100	1.5	1.4	94/10/06	94/10/06
01040	COPPER	CU, DISS	UG/L						2	6.500000	12.50000	3.535500	9	4	94/08/24	94/10/06
01042	COPPER	CU, TOT	UG/L						2	37.50000	12.50000	3.535500	40.0	35.0	94/08/24	94/10/06
01056	MANGNESE	MN, DISS	UG/L						2	4.000000	.0128000	.1131400	1.0	1.0	94/08/24	94/10/06
01075	SILVER	AG, DISS	UG/L						2	1.000000	.0000000	.0000000	1.0	1.0	94/08/24	94/10/06
01077	SILVER	AG, TOT	UG/L						2	10.00000	39.60500	6.293300	1.0	1.0	94/08/24	94/10/06
01090	ZINC	ZN, DISS	UG/L						1	1.000000	.0000000	.0000000	1.0	1.0	94/08/24	94/10/06
01092	ZINC	ZN, TOT	UG/L						1	1.000000	.0000000	.0000000	1.0	1.0	94/08/24	94/10/06
49237	ALUMINUM	REC'D DRY	WT	UG/G					1	20.00000	50.00000	7.071100	20	20	94/08/24	94/10/06
49238	BARIUM	REC'D DRY	WT	UG/G					1	1.900000	.0000000	.0000000	1.900	1.900	94/10/06	94/10/06
49239	BORON	REC'D DRY	WT	UG/G					1	1.000000	.2700000	.5196200	1.900	1.000	94/10/06	94/10/06
49240	CHROMIUM	REC'D DRY	WT	UG/G					1	1.000000	.0000000	.0000000	1.100	.100	94/10/06	94/10/06
									1	5000000	.0000000	.4509300	1.100	.200	94/10/06	94/10/06
									1	5000000	.0000000	.0000000	.500	.500	94/10/06	94/10/06

STORET RETRIEVAL DATE 96/04/04

06418900

44 01 24.0 103 05 43.0 2

RAPID CR BL SEWAGE TREATMENT PL NR RAPID CITY, S
46103 SOUTH DAKOTA PENNINGTON

PGH-INVENT

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112WRD 830409
0000 FEET DEPTH

10120110

/TYP/ANBNT/STREAM

PARAMETER	RECV	DRY	WT	UG/G	MEDIUM	RMK	TOT	NUMBER	MEAN	VARIANCE	STAN DEV	MAXIMUM	MINIMUM	BEG DATE	END DATE
49240 CHROMIUM	RECV	DRY	WT	UG/G	WATER			3	5000000	0000000	0000000	500	500	94/10/06	94/10/06
49241 COPPER	RECV	DRY	WT	UG/G	WATER			3	56.10000	379.2100	19.47300	76.100	37.200	94/10/06	94/10/06
49242 IRON	RECV	DRY	WT	UG/G	WATER			3	391.6700	29559.00	171.9300	590.000	285.000	94/10/06	94/10/06
49243 MANGANESE	RECV	DRY	WT	UG/G	WATER			3	6.700000	3700600	6083200	7.100	6.000	94/10/06	94/10/06
49244 STRONTIUM	RECV	DRY	WT	UG/G	WATER			3	5666700	0233330	1527500	112.000	75.400	94/10/06	94/10/06
49245 ZINC	RECV	DRY	WT	UG/G	WATER			3	92.23300	347.0800	18.63000	300	200	94/10/06	94/10/06
49246 ANTIMONY	RECV	DRY	WT	UG/G	WATER			3	2333300	0033333	0577350	300	200	94/10/06	94/10/06
49247 ARSENIC	RECV	DRY	WT	UG/G	WATER			3	2333300	0033333	0577350	300	200	94/10/06	94/10/06
49248 BERYLIUM	RECV	DRY	WT	UG/G	WATER			3	2333300	0033333	0577350	300	200	94/10/06	94/10/06
49249 CADMIUM	RECV	DRY	WT	UG/G	WATER			3	2000000	0033333	0577350	200	200	94/10/06	94/10/06
49250 COBALT	RECV	DRY	WT	UG/G	WATER			3	2500000	0049999	0707100	200	200	94/10/06	94/10/06
49251 LEAD	RECV	DRY	WT	UG/G	WATER			3	2333300	0033333	0577350	300	200	94/10/06	94/10/06
49252 MOLYBDENUM	RECV	DRY	WT	UG/G	WATER			3	2333300	0033333	0577350	300	200	94/10/06	94/10/06
49253 NICKEL	RECV	DRY	WT	UG/G	WATER			3	2333300	0033333	0577350	300	200	94/10/06	94/10/06
49254 SILVER	RECV	DRY	WT	UG/G	WATER			3	8666700	0233340	1527600	1.000	700	94/10/06	94/10/06
49255 SELENIUM	RECV	DRY	WT	UG/G	WATER			3	6000000	0300010	1732100	7.300	4.500	94/10/06	94/10/06
49256 URANIUM	RECV	DRY	WT	UG/G	WATER			3	2333300	2.293400	1.514000	4.800	1.800	94/10/06	94/10/06
49257 MERCURY	RECV	DRY	WT	UG/G	WATER			3	4000000	2.280000	1.510000	78.800	71.400	94/10/06	94/10/06
49258 WTRPRNT	RECV	DRY	WT	UG/G	WATER			3	2333300	0033333	0577350	300	200	94/10/06	94/10/06
49273 BIOTOTALIV	RECV	DRY	WT	UG/G	WATER			3	1666700	0033334	0577350	300	200	94/10/06	94/10/06
49465 VANADIUM	RECV	DRY	WT	UG/G	WATER			3	76.00000	16.11900	4.014900	78.800	71.400	94/10/06	94/10/06
71900 MERCURY	RECV	DRY	WT	UG/G	WATER			3	2333300	0033333	0577350	300	200	94/10/06	94/10/06
80154 SUSP SED	RECV	DRY	WT	UG/L	WATER			3	1000000	0000000	0000000	1	1	94/08/24	94/10/06
84164 SAMPLER	RECV	DRY	WT	MG/L	WATER			3	8.000000	0000000	0000000	1	1	94/08/24	94/08/24

STORET RETRIEVAL DATE 96/04/04
06421500
43 56 31.0 102 51 12.0 2
RAPID CR. NEAR FARMINGDALE SD
46103 SOUTH DAKOTA PENNINGTON
090491

PGM=INVENT

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112WRD 10120110
0000 FEET DEPTH

/TYPA/AMNT/STREAM

PARAMETER	WATER	AIR	BAROMTRC	PRESSURE	TEMP	CENT	WATER	MEDIUM	RHK	NUMBER	MEAN	VARIANCE	STAN DEV	MAXIMUM	MINIMUM	BEG DATE	END DATE
00010	WATER									296	10.87800	78.98200	8.887200	29.5	0	68/10/08	95/08/21
00020	AIR									156	16.32400	122.5800	11.07200	37.0	-19.0	74/01/16	95/08/21
00025	BAROMTRC									156	16.32400	122.5800	11.07200	37.0	-19.0	74/01/16	95/08/21
00027	COLLECT									469	18960.00	4855E+05	22044.00	46002	1028	49/12/22	95/07/12
00028	ANALYZE									495	7570.800	4749E+05	21794.00	80020	1028	49/12/22	95/07/12
00049	SURFACE									88	58.15400	4701.800	68.57000	602.00	602.00	53/02/13	95/08/21
00060	STREAM									188	58.15400	4701.800	68.57000	602.00	602.00	53/02/13	95/08/21
00061	STREAM									255	69.75100	9885.400	99.42600	770	0	73/10/23	95/08/21
00065	STREAM									23	2.510900	7.311600	2.704000	6.25	0	89/03/21	95/07/12
00076	TURB									9	20.28000	212.7000	14.58400	44.0	3.8	53/05/04	93/02/09
00080	COLOR									28	6.178600	63.04100	7.939800	42	370	69/04/06	70/06/07
00094	CONDUCTVY									612	955.1300	79673.00	282.2700	1090	350	49/12/22	95/07/12
00095	CONDUCTVY									14	10.48200	46481.00	215.6000	2400	6.00	88/10/15	95/07/12
00300	DO									448	8.001300	5.252600	2.291900	9.20	6.00	49/12/22	95/07/12
00400	PH									1	8.400000	1630700	4038200	9.20	6.00	49/12/22	95/07/12
00403	PH									449	8.400000	1630700	4038200	9.20	6.00	49/12/22	95/07/12
00405	CO2									106	8.322200	1545100	3930800	21.0	7.9	49/12/22	93/02/09
00410	T ALK									297	203.8700	167700	4.083800	342	12	49/12/22	79/08/15
00415	PHEN-PH-									1	1.000000	1607.600	40.09500	1	1	78/12/05	89/12/05
00440	HCO3 ION									298	203.1900	1607.600	40.09500	342	1	78/12/05	89/12/05
00445	CO3 ION									26	93.66900	11379.00	106.6700	238	0	49/12/22	86/06/04
00455	RESIDUE									251	240.4800	1606.800	40.08400	404	116	49/12/22	79/08/15
00515	RESIDUE									150	9200000	10.53100	1.245100	20	294	68/10/01	79/08/15
00530	RESIDUE									99	684.6300	20589.00	143.4900	1365	0	69/01/26	93/02/09
00535	RESIDUE									198	79.82600	25547.00	159.8300	1350	0	69/01/26	93/02/09
00608	NH3+NH4-									4	10.00000	62.00000	7.874000	21	0	88/10/15	89/08/01
00610	NH3+NH4-									47	6.689700	7957000	8920200	4.300	0.02	73/09/18	89/08/01
00613	NO2-N									53	0.0156670	0.001270	0.112720	4.030	0.002	75/01/24	89/08/01
00618	NO3-N									3	0.0933330	0.0043203	0.0657290	0.139	0.002	88/10/15	89/08/01
00620	NO3-N									1	0.020000	0.0049657	0.0704680	0.002	0.002	89/04/14	89/04/14
00623	KJELDL N									10	0.0705000	0.0020456	0.0452280	0.139	0.002	88/10/15	89/08/01
00625	TOT KJEL									35	2.336900	3.049700	1.746400	6.70	0.00	89/03/21	95/07/12
00625	TOT KJEL									14	5.300000	1118700	3344700	1.500	0.30	68/10/08	71/02/17
00625	TOT KJEL									14	1.125000	2491700	4991700	1.800	0.700	88/10/15	89/08/01

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PARAMETER	MG/L	MEDIUM	RMK	NUMBER	MEAN	VARIANCE	STAN DEV	MAXIMUM	MINIMUM	BEG DATE	END DATE
00630 NO2&NO3 N-TOTAL	MG/L	WATER		5	1.731200	3.080700	1.755200	4.30	.05	88/07/11	89/08/01
00631 NO2&NO3 N-DISS	MG/L	WATER		141	1.538200	.9909100	.9954500	4.7	.0	70/10/01	95/07/12
00650 T PO4	MG/L	WATER	K	143	1.1000000	.0000000	.0000000	1	.1	79/05/18	79/07/10
00660 ORTHOPO4	MG/L	WATER	TOT	4	1.518100	1.005700	1.002800	4.7	.0	70/10/01	95/07/12
00665 PHOS-TOT	MG/L P	WATER		129	2.009100	1.5795600	1.7612900	5.50	.83	79/04/17	79/07/10
00665 PHOS-DIS	MG/L P	WATER		133	.8738300	1.492100	1.221500	2.200	.03	68/10/08	89/09/03
00671 PHOS-DIS	MG/L P	WATER		125	.7363200	.1619200	.4023900	2.200	.200	70/10/01	89/08/01
				214	.6372200	.1524100	.3904000	1.800	.130	70/10/13	95/07/12
			K	1	.0010000			1.001	.007	70/04/01	95/07/12
00720 CYANIDE	MG/L	WATER	TOT	215	.6342600	.1535800	.3918900	1.800	.001	89/09/13	95/07/12
00723 CYANIDE	UG/L	WATER	K	8	.0100000	.0000000	.0000000	.010	.001	70/04/01	95/07/12
00900 TOT HARD	MG/L	WATER	K	8	.0100000	.0000000	.0000000	.010	.010	89/03/21	93/02/09
00902 NC HARD	MG/L	WATER		263	403.4600	6052.500	77.79800	690	.01	89/06/02	93/02/09
00915 CALCIUM	MG/L	WATER		263	206.3400	3516.600	59.30100	418	170	49/12/22	80/09/03
00925 MGNSTUM	MG/L	WATER		268	95.34300	272.6000	16.51100	150.0	.73	49/12/22	80/09/03
00930 SODIUM	MG/L	WATER		268	40.28000	86.81800	9.317600	77.0	44.0	49/12/22	93/02/09
00931 SODIUM	RATIO	WATER		271	44.92600	291.1700	17.06400	114.00	15.0	49/12/22	93/02/09
00932 PERCENT	%	WATER		262	9874000	3195700	5653000	7.0	13.00	53/02/13	93/02/09
00933 NA+K	MG/L	WATER		263	18.65000	15.80900	3.976100	35	.3	53/02/13	80/09/03
00935 PTSSIUM	MG/L	WATER		10	57.10000	259.8800	16.12100	78.00	11	49/12/22	80/09/03
00940 CHLORIDE	MG/L	WATER		243	6.190500	2.374900	1.541100	12.00	27.00	49/12/22	80/01/16
00945 SULFATE	MG/L	WATER		268	26.61200	282.8400	16.81800	140	2.40	53/02/13	93/02/09
00946 SULFATE	MG/L	WATER		272	257.7700	6323.100	79.51800	595	2	49/12/22	93/02/09
00950 FLUORIDE	MG/L	WATER		1	196.0000			196.0	100	49/12/22	93/02/09
00955 SILICA	MG/L	WATER		220	2.313600	725.5300	26.93600	400.00	196.0	77/04/11	77/04/11
01000 ARSENIC	MG/L	WATER		221	7.469200	13.89700	3.727800	26.0	.2	49/12/22	93/02/09
01002 AS-DISS	UG/L	WATER		9	2.666700	1.500000	1.224800	4	.2	49/12/22	93/02/09
01005 BARUM	UG/L	WATER		8	3.000000	1.142900	1.069100	4	.1	89/03/21	93/02/09
01020 BORON	UG/L	WATER		9	45.55600	22.53000	4.746600	54	.1	89/05/02	93/02/09
01025 CADMIUM	UG/L	WATER	K	242	185.6900	18664.00	136.6200	1240	40	89/03/21	93/02/09
01030 CHROMIUM	UG/L	WATER		9	7.000000	20.25000	4.500000	10	0	49/12/22	93/02/09
			K	1	1.000000			1	.1	89/03/21	93/02/09
01040 COPPER	UG/L	WATER	TOT	8	1.000000	.0000000	.0000000	1	.1	89/06/02	89/06/02
				9	1.000000	.0000000	.0000000	1	.1	89/03/21	93/02/09
01045 IRON	UG/L	WATER	K	8	1.625000	.2678600	.5175500	2	.1	89/03/21	93/02/09
			TOT	9	1.000000			1	.1	89/03/21	93/02/09
				62	15.64500	2777800	5270500	120	.1	92/04/06	92/04/06
						510.2300	22.58800		0	89/03/21	93/02/09

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PARAMETER	UG/L	MEDIUM	RMK	NUMBER	MEAN	VARIANCE	STAN DEV	MAXIMUM	MINIMUM	BEG DATE	END DATE
01046 IRON FE, DISS	UG/L	WATER	K TOT	29	66.690000	9265.400	96.25700	426	4	49/12/22	93/02/09
01049 LEAD PB, DISS	UG/L	WATER	K TOT	31	3.000000	0.000000	0.000000	426	3	92/06/18	92/08/06
01055 MANGNESE MN	UG/L	WATER	K TOT	18	62.58100	8900.700	94.34400	426	1	49/12/22	93/02/09
01056 MANGNESE MN, DISS	UG/L	WATER	K TOT	9	1.500000	2.000000	1.414200	310.0	1	89/09/13	89/09/13
01090 ZINC ZN, DISS	UG/L	WATER	K TOT	9	1.44500	1.777800	1.333300	260.0	1	89/03/21	93/02/09
01095 ANTIMONY SB, DISS	UG/L	WATER	K TOT	22	236.6700	16133.00	127.0200	310.0	0	69/04/18	69/06/20
01145 SELENIUM SE, DISS	UG/L	WATER	K TOT	8	110.9100	5507.800	74.21500	260.0	0	68/10/08	93/02/09
03515 BETA-D AS CS137	PC/L	WATER	K TOT	1	1.25000	33.35700	5.775600	18	3	92/04/06	92/04/06
09510 RA-226-D PLCHT CT	PC/L	WATER	K TOT	1	3.000000	36.75000	6.062200	18	3	89/03/21	93/02/09
31616 FEC COLI MFM-FCBR	/100ML	WATER	K TOT	5	10.33300	30.00000	5.477300	2	1	89/06/02	93/02/09
31625 FEC COLI M-FCAGAD	/100 ML	WATER	K TOT	4	1.000000	0.000000	0.000000	2	1	89/03/21	92/08/06
31673 FECSTREP MFKFAGAR	/100ML	WATER	K TOT	7	1.333300	25.00000	5.000000	2	1	89/03/21	93/02/09
32730 PHENOLS TOTAL	UG/L	WATER	K TOT	2	1.142900	1.428600	3.779700	13.0	1	89/03/21	92/04/06
39330 ALDRIN	TOT UG/L	WATER	K TOT	9	1.000000	0.000000	0.000000	1	1	90/11/20	92/04/06
39340 GAMMABHC LINDANE	TOT UG/L	WATER	K TOT	3	1.933300	11.1100	3.333400	1	1	89/03/21	93/02/09
39350 CHLRDANE TECHENET	TOT UG/L	WATER	K TOT	3	8.933300	12.76400	3.572600	1	1	89/06/02	89/09/13
			K TOT	2	1.000000	0.000000	0.000000	1	1	89/03/21	89/09/13
			K TOT	3	1.000000	0.000000	0.000000	1	1	89/03/21	89/09/13
			K TOT	170	218.4800	177170.0	420.9200	2700	1	69/01/26	89/12/20
			K TOT	9	6.333300	12.50000	3.535500	10	3	73/05/22	87/10/28
			K TOT	180	600.0000	170280.0	412.6500	600	1	89/07/12	89/07/12
			K TOT	5	210.0000	8075.800	89.86600	2700	1	69/01/26	89/12/20
			K TOT	4	127.4000	19628.00	140.0900	240	1	89/03/21	93/02/09
			K TOT	9	177.7500	12102.00	110.0100	350	7	90/11/20	92/08/06
			K TOT	9	149.7800	54693.00	233.8700	760	1	89/03/21	93/02/09
			K TOT	5	221.7800	3.300000	1.816600	5	1	89/03/21	93/02/09
			K TOT	1	2.600000	3.056700	1.751200	1	1	92/06/18	92/06/18
			K TOT	6	1.000000	0.000000	0.000000	1	1	90/11/20	93/02/09
			K TOT	2	2.333300	0.000000	0.000000	0.000	0.000	90/11/20	93/02/09
			K TOT	1	0.000000	0.000000	0.000000	0.000	0.000	70/01/26	70/05/21
			K TOT	3	0.000000	0.000000	0.000000	0.000	0.000	70/06/10	70/06/10
			K TOT	2	0.000000	0.000000	0.000000	0.000	0.000	70/01/26	70/05/21
			K TOT	1	0.000000	0.000000	0.000000	0.000	0.000	70/01/26	70/05/21
			K TOT	3	0.000000	0.000000	0.000000	0.000	0.000	70/06/10	70/06/10
			K TOT	2	0.000000	0.000000	0.000000	0.000	0.000	70/01/26	70/05/21

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PARAMETER	AS U-NAT	UG/L	MEDIUM	RMK	NUMBER	MEAN	VARIANCE	STAN DEV	MAXIMUM	MINIMUM	BEG DATE	END DATE
80030 ALPHA-D	AS U-NAT	90	PC/L		3	5.433300	0634390	2518700	5.700	5.200	89/03/21	89/09/13
80050 BETA-D	AS SR-Y-	90	PC/L		3	6.733300	4.813400	2.194000	9.200	5.000	89/03/21	89/09/13
80154 SUSP SED	CONC	MG/L	WATER		4	61.30000	886.0600	29.76700	100	28	91/08/28	92/08/06
84164 SAMPLER	TYPE C ODE		WATER	TXT	1	TEXT	TEXT	TEXT	TEXT	TEXT	94/07/28	94/07/28

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460910 S.D. NO. 19
43 56 30.0 102 51 15.0 2
RAPID CREEK NEAR FARMINGDALE
46103 SOUTH DAKOTA PENNINGTON
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CENTRAL MISSOURI
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00010	WATER	PARAMETER	TEMP	CENT	MEDIUM	RNHK	NUMBER	MEAN	VARIANCE	STAN DEV	MAXIMUM	MINIMUM	BEG DATE	END DATE
							202	10.23500	78.82200	8.878200	30.0	0	74/08/19	94/02/09
							1	-1.00000			-1.0	-1.0	75/01/15	75/01/15
00011	WATER	TEMP		FAHN	WATER		203	10.17900	79.05400	8.891200	30.0	0	74/08/19	94/02/09
00020	AIR	TEMP		CENT	WATER		259	51.31000	255.2600	15.97700	86.0	0	74/08/19	94/02/09
00021	AIR	TEMP		FAHN	WATER		200	12.79400	165.6400	22.87000	38.0	0	67/06/27	95/09/28
00028	ANALYZE	AGENCY		CODE	WATER		254	55.79400	525.1700	22.91700	102.0	-28.9	74/08/19	94/02/09
00070	TURB	JKSN		JTU	WATER		268	2.000000	0000000	0000000	102.0	-20.0	67/07/28	95/09/28
00094	CONDUCTVY	FIELD		MICROMHO	WATER		15	114.0000	13100.00	114.4500	480.0	36.0	67/06/27	95/09/28
00095	CONDUCTVY	AT 25C		MICROMHO	WATER		9	915.8900	11680.00	267.7300	1200	370	68/07/31	70/06/07
00300	DO			MG/L	WATER		253	982.4000	50583.00	224.9100	2400	430	68/05/08	95/07/12
00310	BOD	5 DAY		MG/L	WATER		257	10.44200	3.640500	1.908000	18.7	6.4	67/06/27	95/09/28
00400	PH			SU	WATER		252	8.11200	.2349200	.4846900	11.30	3.9	68/07/31	70/01/18
							1	8.400000			11.30	6.00	67/06/27	95/09/28
							253	8.112400	2343300	4840800	11.30	8.40	74/11/25	74/11/25
00403	PH	LAB		SU	WATER		175	12.88000	3840.600	61.97300	118.0	6.7	67/06/27	95/09/28
00410	T ALK	CACO3		MG/L	WATER		196	202.6300	1774.800	42.12900	342	12	67/06/27	95/04/18
00415	PHEN-PH-	LFIN ALK		MG/L	WATER		34	85.89400	10692.00	103.4000	238	0	67/06/27	95/07/12
00440	HCO3 ION	HCO3		MG/L	WATER		50	242.7300	1154.600	33.97900	307	0	67/06/27	94/08/09
00445	CO3 ION	CO3		MG/L	WATER		5	8.740000	66.99800	8.185200	19	149	68/05/08	77/09/26
00500	RESIDUE	TOTAL		MG/L	WATER		174	762.1200	31724.00	178.1100	1720	360	74/04/02	74/09/30
00515	RESIDUE	DISS-105		MG/L	WATER		104	680.1100	20887.00	144.5200	1365	294	67/06/27	95/09/28
00530	RESIDUE	TOT NPLT		MG/L	WATER		260	88.97500	26080.00	161.4300	1350	0	67/06/27	95/09/28
00608	NH3+NH4-	N DISS		MG/L	WATER		35	.8402800	.9256200	.9620900	4.300	.020	73/09/18	79/08/07
							4	.0225000	.0000250	.0050000	.030	.020	75/07/24	81/11/04
00610	NH3+NH4-	N TOTAL		MG/L	WATER		39	.7554100	.8913700	.9441200	4.300	.020	73/09/18	81/11/04
							142	.4117400	.3637700	.6031400	3.660	.010	77/07/26	95/07/12
00613	NO2-N	DISS		MG/L	WATER		56	.0285710	.0000270	.0051978	.050	.010	77/06/29	95/06/22
							198	.3033700	.2903100	.5388000	3.660	.010	77/06/29	95/07/12
							35	.0316000	.0004235	.0205800	.075	.010	77/02/08	80/12/11
							26	.0100000	.0000000	.0000000	.010	.010	79/03/06	85/09/03
00620	NO3-N	TOTAL		MG/L	WATER		61	.0223930	.0003560	.0188680	.075	.010	77/02/08	85/09/03
							182	1.741200	1.543000	1.242200	6.500	.100	67/06/27	95/07/12
							15	2.753300	1.409800	1.3754800	1.000	.030	76/05/11	95/03/16
00625	TOT KJEL	N		MG/L	WATER		197	1.629600	1.586900	1.259700	2.630	.310	74/04/02	90/09/12
00630	NO2NO3	N-TOTAL		MG/L	WATER		11	1.484600	.3784200	.6151600	1.20	.31	88/07/11	88/07/11
00653	SOLPO4-T	PO4		MG/L	WATER		2	.8500000	.2450000	.4949800	1.20	.50	67/07/28	67/08/27
							1	.1000000			.10	.10	67/06/27	67/06/27

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RAPID CREEK NEAR FARMINGDALE
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MISSOURI RIVER
CENTRAL MISSOURI
21SDAK01
0000 FEET DEPTH

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10120110001 0014.140 ON

PARAMETER	MG/L	MEDIUM	RMK	NUMBER	MEAN	VARIANCE	STAN DEV	MAXIMUM	MINIMUM	BEG DATE	END DATE
00653 SOL/PO4-T	PO4	WATER	TOT	144	6000000	3100000	5567800	1.20	0.33	67/06/27	97/08/21
00665 PHOS-TOT	MG/L P	WATER	TOT	144	9077100	2250500	4743900	2.500	0.010	83/01/06	95/07/12
00671 PHOS-DIS	MG/L P	WATER		145	9015200	2290400	4785900	2.500	0.010	93/05/13	93/05/13
00900 TOT HARD	MG/L	WATER		144	6981600	2166700	4654800	2.430	0.016	77/04/11	94/12/15
00910 CALCIUM	MG/L	WATER		122	439 5900	8166 200	90 36700	2.430	0.189	68/05/08	94/10/31
00915 CALCIUM	MG/L	WATER		16	93 01300	1668 800	40 85100	144.2	13.0	67/06/27	70/05/11
00916 CALCIUM	MG/L	WATER		104	99 34700	624 8400	24 99700	144.2	64.3	67/06/27	82/06/16
00917 CA MUD	MG/KG-CA	WATER		104	99 73600	494 9600	22 24800	170.0	36.0	73/09/18	95/08/23
00920 MGNSIUM	MG/L	WATER		18	49 30000	229 0600	15 13500	49 30	49 30	76/05/11	76/05/11
00925 MGNSIUM	MG/L	WATER		16	32 76300	173 3700	13 16700	55.0	6.1	67/06/27	70/05/11
00927 MGNSIUM	MG/L	WATER		104	43 56300	178 5900	13 36400	56.4	20.0	67/06/27	82/06/16
00929 SODIUM	MG/L	WATER		107	56 55600	182 2900	27 97000	111.0	20.0	73/09/18	95/08/23
00930 SODIUM	MG/L	WATER		13	43 10600	535 8400	23 14800	237.0	15.00	73/09/18	95/08/23
00935 PTSSIUM	MG/L	WATER		40	5 600000	2 063400	1 436400	82.80	3.40	67/06/27	77/04/11
00937 PTSSIUM	MG/L	WATER		40	5 37500	9373300	9681600	9 80	5.00	67/06/27	77/04/11
00940 CHLORIDE	MG/L	WATER		54	40 45900	359 0100	18 94800	85	8	73/09/18	85/09/03
00945 SULFATE	MG/L	WATER		49	257 4900	3541 000	59 50600	411	131	67/06/27	77/09/26
00946 FLUORIDE	MG/L	WATER		1	196 0000	0167750	1295200	196.0	196.0	77/04/11	77/04/11
01045 IRON	MG/L	WATER		5	4733300	1662700	1289 500	68	32	68/05/08	73/11/20
01046 IRON	UG/L	WATER		5	698 0000	1662700	1289 500	3000	20	68/05/08	70/05/11
01055 MANGNESE	UG/L	WATER		49	221 2300	33144.00	182 0600	990.0	20.0	77/04/11	77/04/11
01056 MANGNESE	UG/L	WATER		1	10 00000	33144.00	182 0600	990.0	20.0	68/05/08	77/04/11
13616 INVALID	NUMBER	WATER		1	39 00000	39.00000	5682 400	39.00000	39.00000	77/04/11	77/04/11
31501 TOT COLI	/100ML	WATER		3	6200 000	32290000	5682 400	12200	900	79/09/17	79/09/17
31505 TOT COLI	/100ML	WATER		3	6000 000	19960000	4467 700	11000	2400	67/06/27	67/08/21
31615 FEC COLI	/100ML	WATER		2	1830 000	5577800	2361 700	3500	160	67/06/27	67/08/21
31616 FEC COLI	/100ML	WATER		248	242 4900	198800 0	445 8700	3400	160	77/04/11	78/05/01
31673 FECSTREP	/100ML	WATER		11	1300 000	12 20000	3 452900	10	3	67/06/27	95/09/28
31677 FECSTREP	/100ML	WATER		261	1300 000	980000 0	989 9500	2000	600	89/07/12	93/07/26
70300 RESIDUE	DISS-180 C	WATER		54	287 7400	203580 0	451 2000	3400	5	67/06/27	95/09/28
	MG/L	WATER		55	282 5800	501400 0	708 0900	4000	4	74/05/01	74/05/01
		WATER		133	656 2000	36549 00	191 1800	210	210	67/06/27	77/09/26
		WATER		23	653 8300	23817 00	154 3300	1701	18	82/04/07	95/09/28
		WATER						912	370	91/11/13	93/09/30

STORET RETRIEVAL DATE 96/04/04
460910
43 56 30.0 102 51 15.0 2
RAPID CREEK NEAR FARMINGDALE
46103 SOUTH DAKOTA PENNINGTON
MISSOURI RIVER 090491
CENTRAL MISSOURI
21SDAK01
0000 FEET DEPTH

10120110001 0014.140 ON

/TYPA/AMENT/STREAM

PGH=INVENT

PAGE: 133

PARAMETER	NUMBER	MEAN	VARIANCE	STAN DEV	MAXIMUM	MINIMUM	BEG DATE	END DATE
70300 RESIDUE DISS-180 C	156	655.8500	34507.00	185.7600	1701	18	82/04/07	95/09/28
70505 T PO4 P-COL	111	8185400	1582900	3978600	2.15	.16	74/04/02	85/10/17
70506 SOL PO4- T P-COL	10	7008000	1947900	4413500	1.43	.18	77/04/11	82/05/06
70507 PHOS-T ORTHO	89	1753100	25258.00	158.9300	1500.000	.041	74/04/02	88/02/16
74010 IRON FE	49	118000	7034600	1.017100	5.37	.02	68/05/08	77/09/26
74041 WQF SAMPLE	114	908550.0	7943E+05	28184.00	951103	860528	85/07/18	95/09/28

APPENDIX B

AVAILABLE RAPID CREEK GROUNDWATER QUALITY DATA

321

SHALLOW GROUND WATER RESOURCES OF
A PORTION OF RAPID VALLEY,
PENNINGTON COUNTY, SOUTH DAKOTA

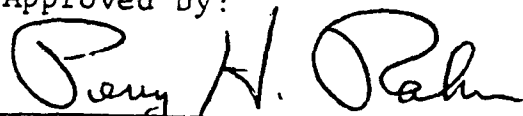
by

Diane Coker

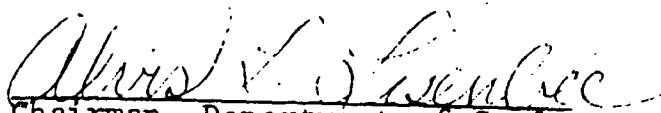
A thesis submitted to the Graduate Division
in partial fulfillment of the requirements
for the degree of
MASTER OF SCIENCE IN GEOLOGICAL ENGINEERING
SOUTH DAKOTA SCHOOL OF MINES AND TECHNOLOGY
RAPID CITY, SOUTH DAKOTA

1981

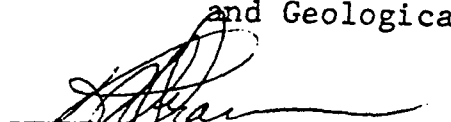
Approved by:



Major Professor



Chairman, Department of Geology
and Geological Engineering


Dean, Graduate Division

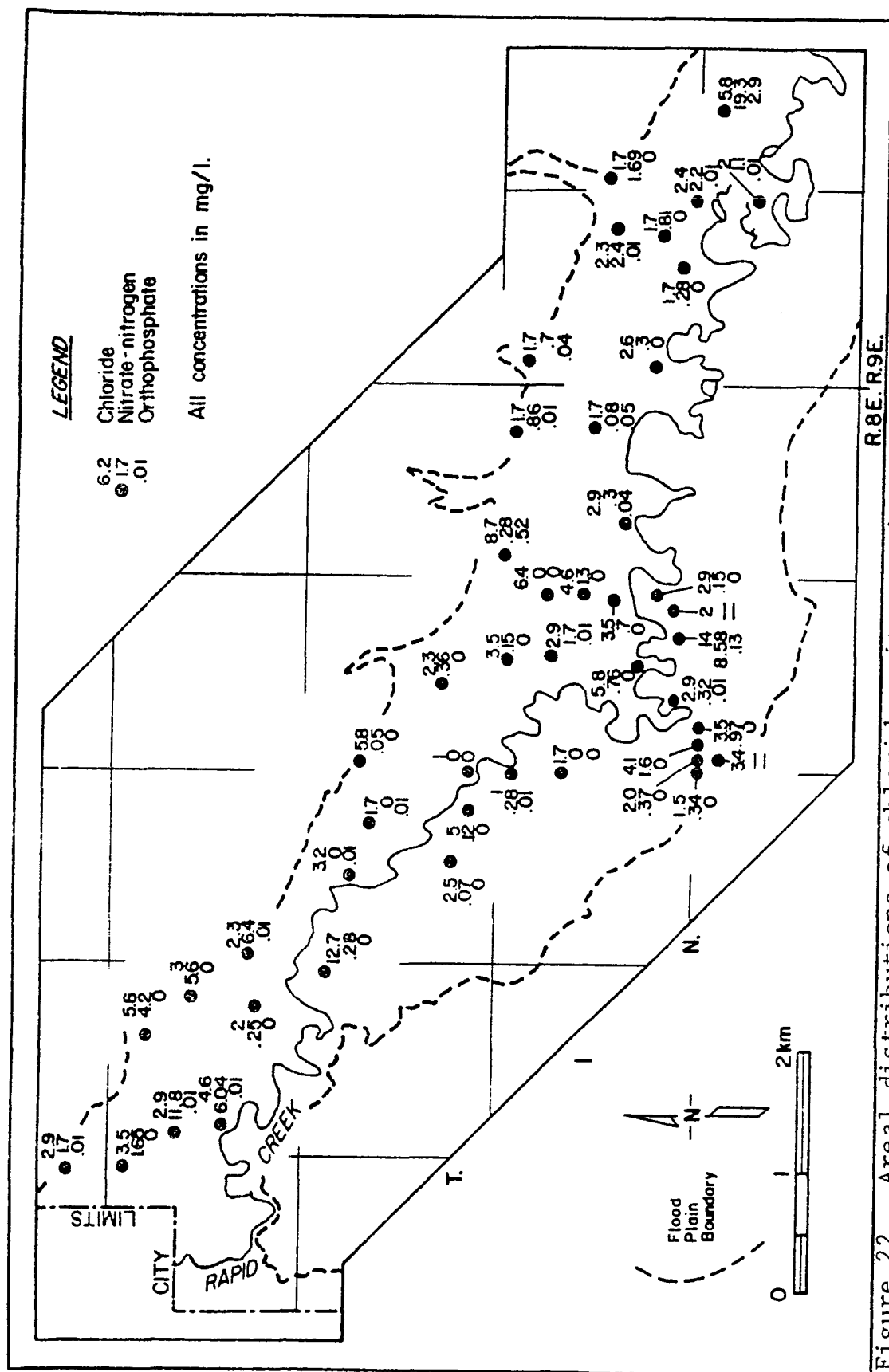


Figure 22. Areal distributions of chloride, nitrate-nitrogen, and orthophosphate concentrations. Note the general lack of significant distribution trends.

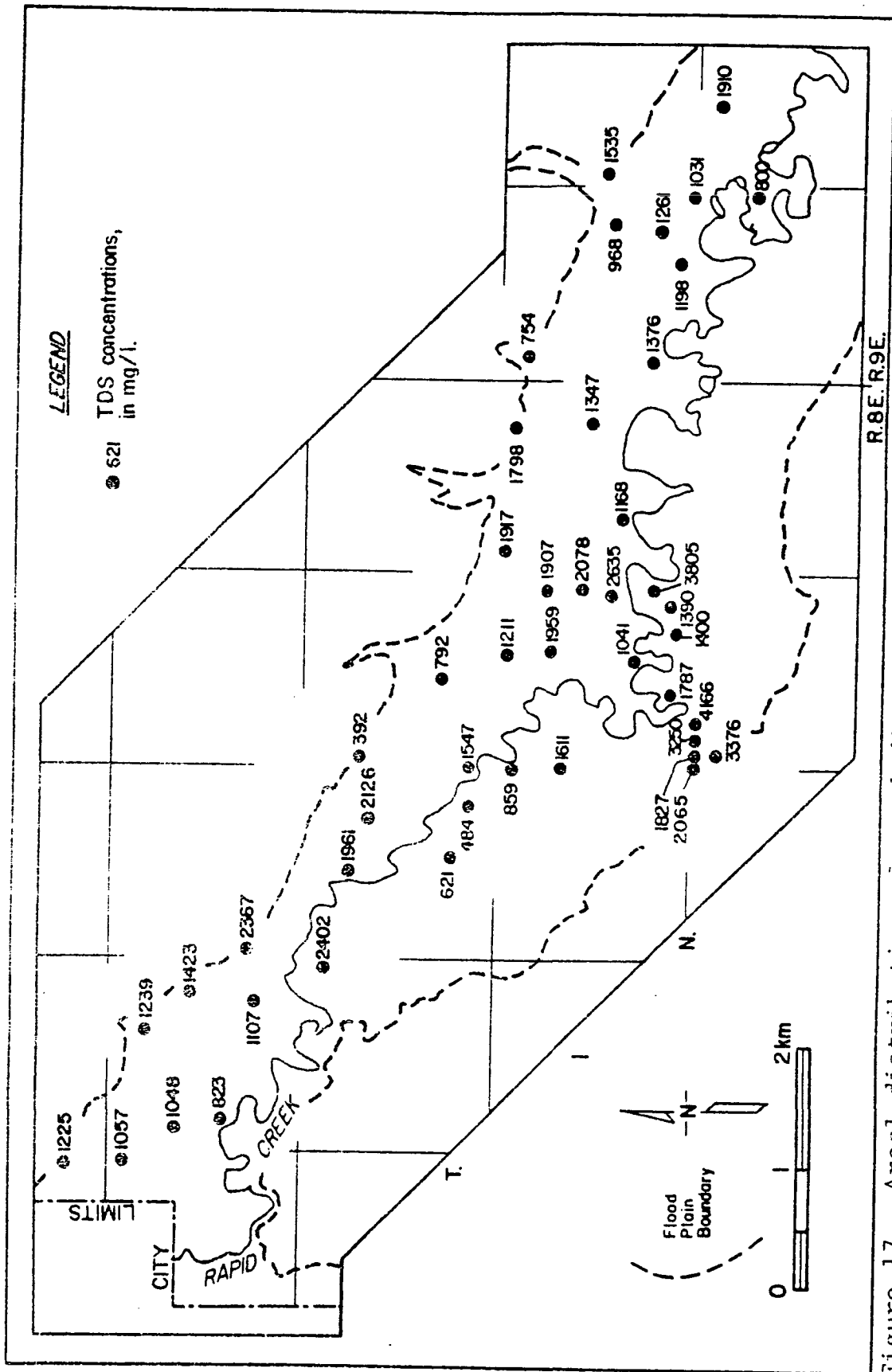


Figure 17. Areal distribution of total dissolved solids concentrations. Note the general lack of significant distribution trends.

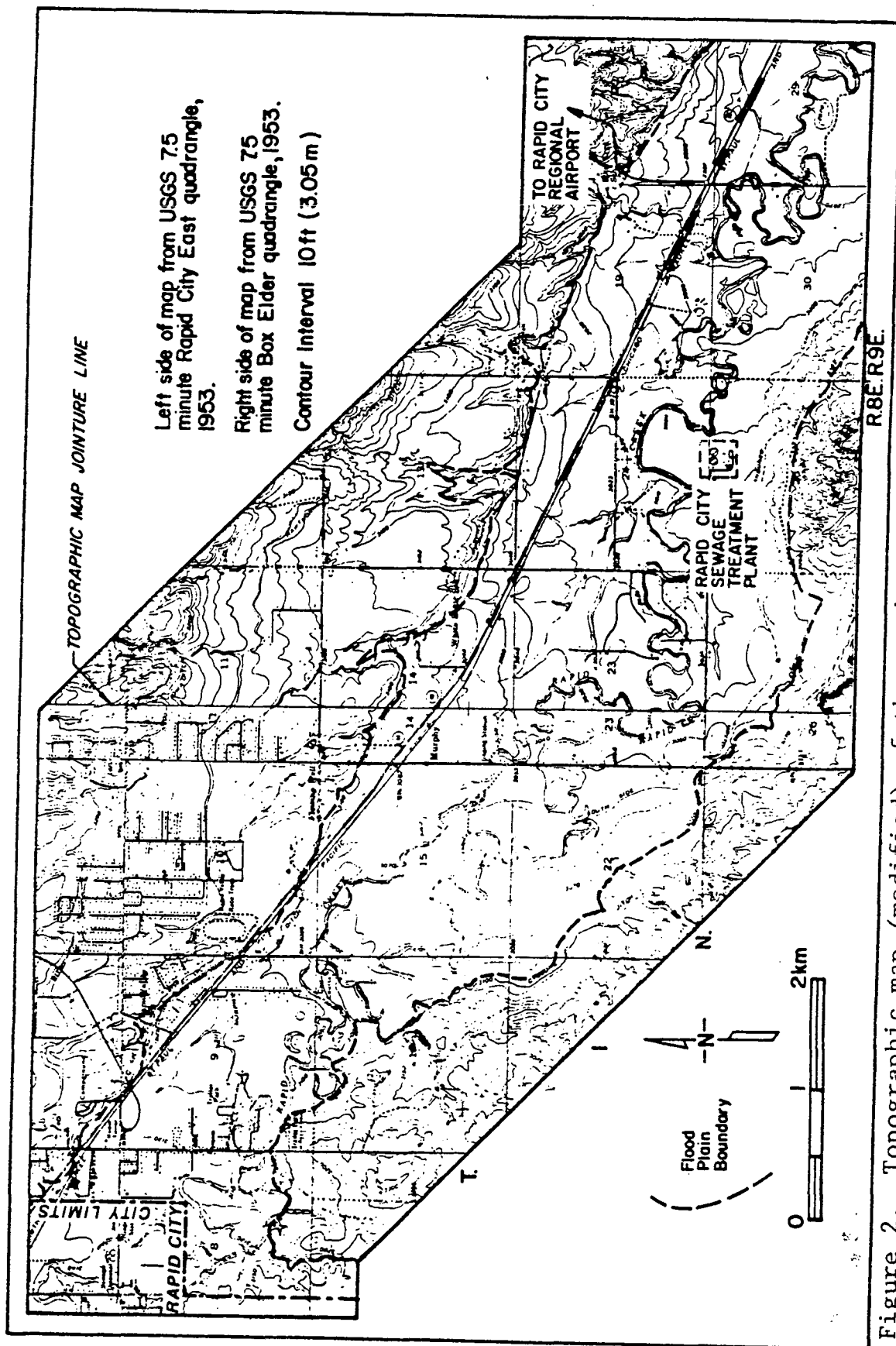


Figure 2. Topographic map (modified) of the study area.

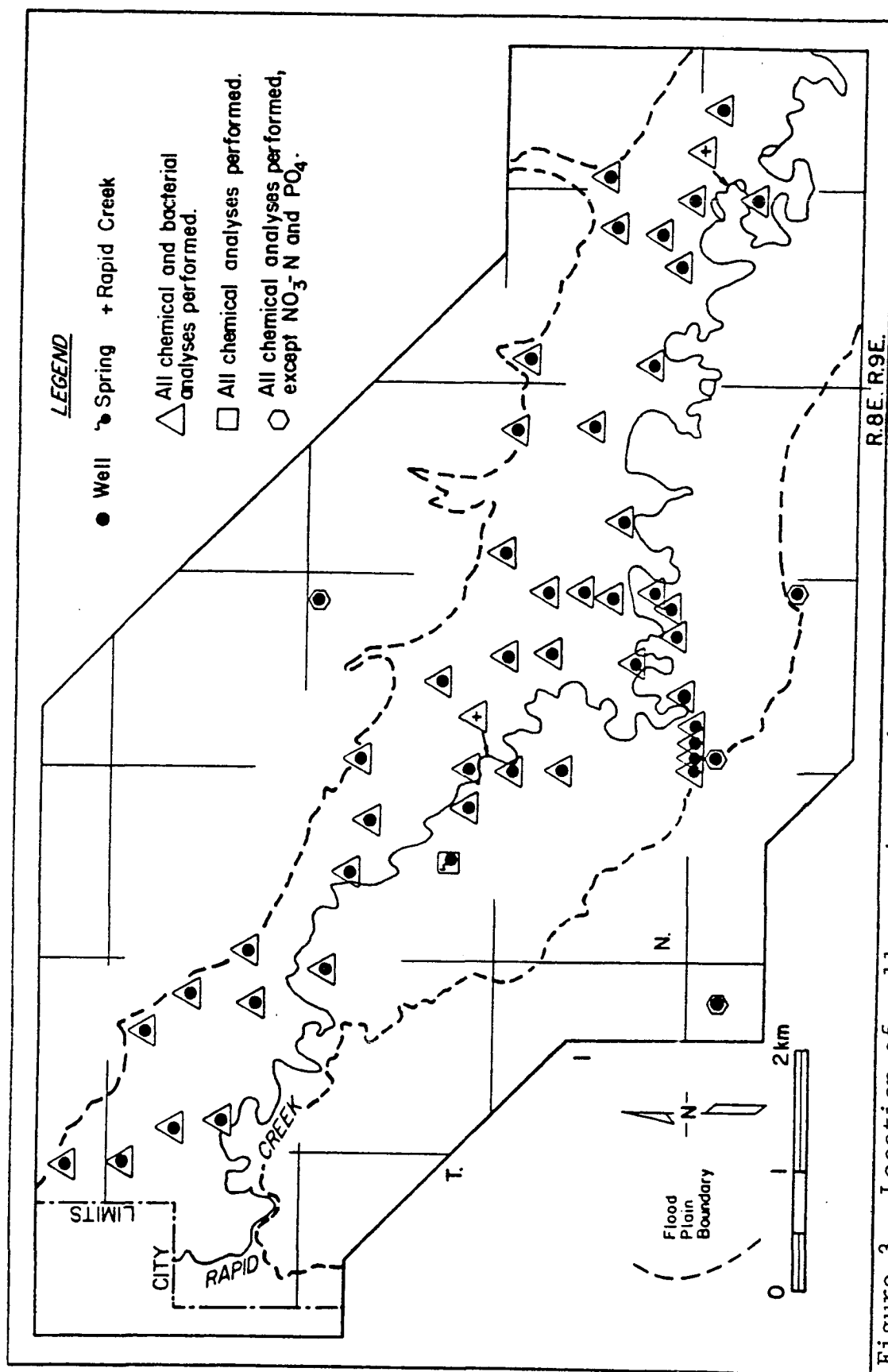


Figure 3. Location of wells, spring, and points along Rapid Creek that were sampled during study. The type of analyses performed on each sample is shown.

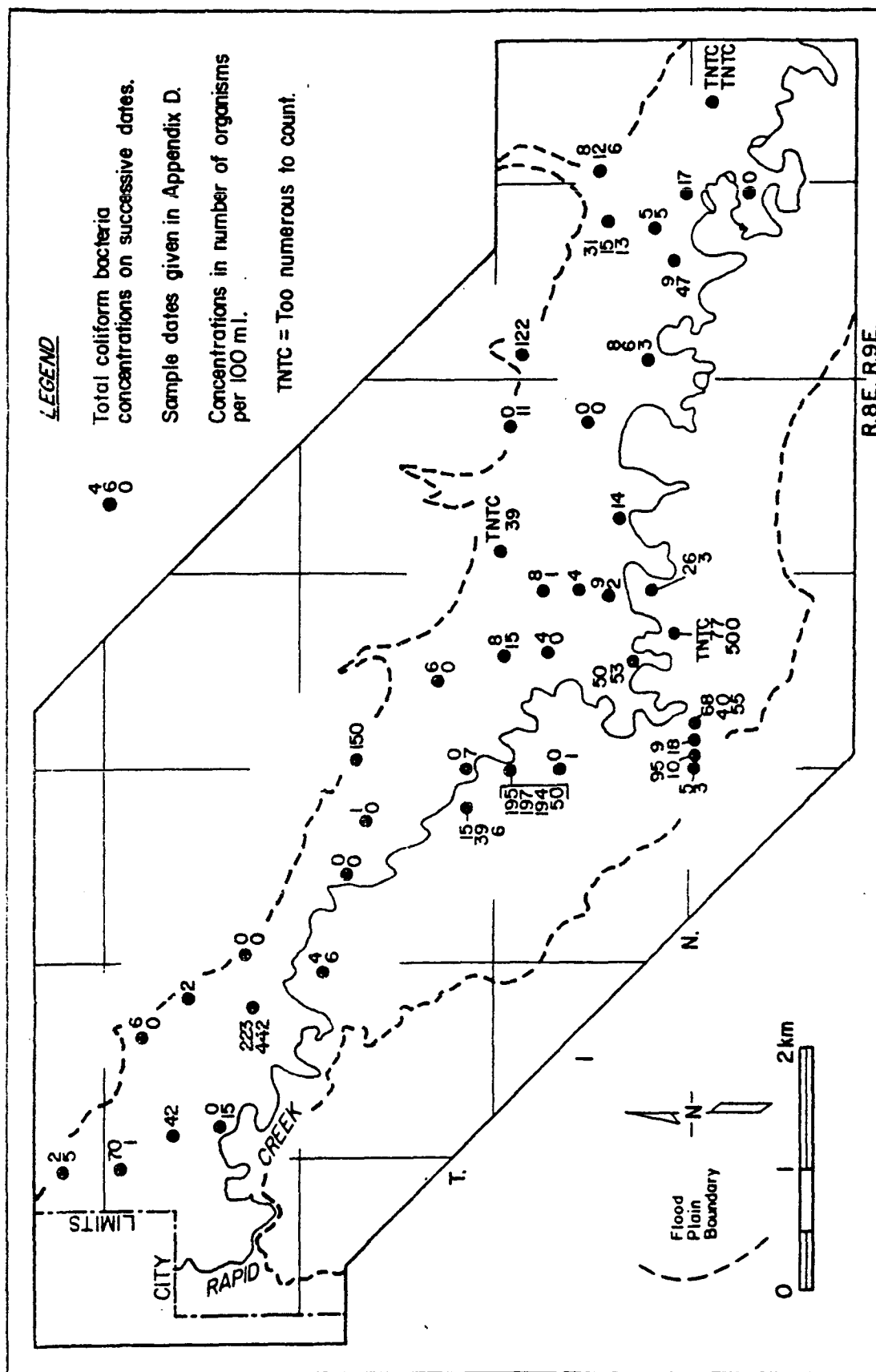


Figure 26. Areal distribution of total coliform bacteria concentrations. Note the general lack of significant distribution trends.

APPENDIX C

**AN EVALUATION OF THE FEASIBILITY OF
USING RAPID CREEK WATER FOR IRRIGATION**

**AN EVALUATION
OF THE FEASIBILITY OF USING
RAPID CREEK WATER FOR IRRIGATION**

BY

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Soil Salinity/Reclamation Consultant**

For

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2420 Alcott St.
Denver, Colorado 80211**

April 25, 1996

Introduction

This is an evaluation of the irrigability of water from Rapid Creek near Farmingdale, South Dakota for various water quality parameters. It mainly is an assessment of the compatibility of these waters for perpetual irrigation on soils common to the area downstream of the Rapid City Wastewater Treatment. Much of the data has been collected and provided by the US Geological Survey and the SD Department of Natural Resources over a course of several years from about 1949 through 1995. This evaluation is based on the data provided which is graphed and provided in Figures 1 through 9.

A brief assessment of the soil-water compatibility will be made regarding the soils near and around the creek near the legal description of T1N R9E Sec. 33 NW 1/4 (northwest of Caputa, South Dakota).

Salinity Hazard

The salinity of the water is expressed in units of specific conductance, or electrical conductivity, as micro-Siemens per cm ($\mu\text{S}/\text{cm}$), the International designation for water conductivity. Specific conductance is a relatively inexpensive method of estimating the salt load of waters, and an approximate relationship between these units and Total Dissolved Solids (TDS) are related by the following equation:

$$0.64 * \text{Specific conductance}(\mu\text{S}/\text{cm}) = \text{TDS}(\text{mg}/\text{l})$$

Figure 1 shows 3 graphs of the water salinity above and below the wastewater treatment plant and at Farmingdale, SD over the course of several years (data collected by SDDENR). The average of the specific conductance for the data shown for above, below and at Farmingdale is approximately 730, 935, and 980 microSiemens/cm, respectively. These are in high salinity category when used for irrigation. ^{the}

If a farmer were to use 24" of water per acre to irrigate, he would be adding 870 more pounds of salt per acre than if he were using water from above the WWTP (using averages of 730 $\mu\text{S}/\text{cm}$ above and 980 $\mu\text{S}/\text{cm}$ at Farmingdale). If he has sufficient subsurface internal drainage to remove some salts each year to prevent build-up in his soil, then he has little to worry about. However, if he has a closed drainage system where there is no leaching of salts, then his salinity levels would increase. To determine the natural subsurface drainage (amount of water/salts leached each year - on the average) is a very difficult task. Soil tests can be determined to see

if salts are building up in the soil. However, these tests are very much determined by the type of climate patterns that have been recently present. Salinity levels are very dynamic and can only be determined accurately by monitoring salinity levels for a long period of years.

Specific Conductance level data collected by the USGS (Figure 2) shows very similar results compared to the SDDENR data. The salinity levels are 410 for above the WWTP, 950 for below, and 980 μ Siemens/cm at Farmingdale. The time frames for data collection are different for each set of data, although some do overlap. Each graph shows the cutoff for low, medium, high, and very high salinity ranges for irrigation purposes (USDA Diagnosis and Improvement of Saline and Alkali Soils). A high majority of the samples taken at all three locations fall into the high salinity category for irrigation (between 750-2250 μ S/cm). There are only a couple of samples which fall into the very high salinity category. There is a relationship which has developed that the water salinity level increases as average precipitation over the growing season decreases, regardless of the collection location. There is a definite increase in loading of salts added by the wastewater treatment plant at Rapid City. This salinity increase is not beneficial for irrigation of crops which are sensitive or moderately sensitive to salts.

The total salinity of water affects plants by restricting the "availability of water" for use. The water is there to use, but the plants cannot pull it away from the salt. It is similar to a person drinking seawater. The water does not quench your thirst, but only makes you more thirsty. The salt is actually pulling water from within your body to your stomach rather than water moving from your stomach to your body. Therefore, crops sensitive or moderately sensitive to salts may have a decline in production relative to what their potential would be without the salts.

Sodium Hazard (Sodium Adsorption Ratio)

Data collected by SDDENR provided information for calculating the sodium adsorption ratio (SAR) and the adjusted sodium adsorption ratio (ASAR) of the water. SAR is calculated by the following equation:

$$SAR = \frac{Na(me/l)}{\sqrt{\frac{Ca(me/l) + Mg(me/l)}{2}}}$$

The SAR is given in the three graphs in Figure 3 for above, below, and at Farmingdale. The variability is quite high but all values above, below, and at Farmingdale are in the low sodium hazard for sodium problems. If there is any subsurface drainage whatsoever to carry some of the salts out of the root zone, the level of sodium in the water should not cause a problem for plant production.

Higher sodium levels, and associated SAR levels tend to disperse soils when used extensively on them to supplement water for crops. The permeability subsequently becomes reduced and it becomes more difficult to get water into the soil for the plants to use. This problem is one of reducing water infiltrating into the soil.

The wastewater treatment plant does contribute to a higher level of sodium and thus, SAR, however, it is not a problem in this case. The average SAR for the water above, below, and at Farmingdale is approximately 0.4, 1.1, and 1.2, respectively.

The ASAR is a measure of the tendency of the water to precipitate calcium and magnesium from the water as they tie up with bicarbonates and carbonates. If there is sufficient bicarbonate and carbonate to combine with calcium and magnesium, the sodium hazard becomes worse than if these compounds were missing in the water. The following parameters are needed to calculate the ASAR: calcium, magnesium, sodium, bicarbonate, and carbonate. It appears that the level of carbonates is relatively low in these waters as indicated by some samples taken over the course of time. Where there were bicarbonate, sodium, calcium, and magnesium determined on water samples, the carbonate was assumed to be zero, and insignificant, and the ASAR was calculated accordingly. There were very few samples which had all five parameters available for calculations. Figure 4 shows the range in the ASAR for waters at Farmingdale. There was insufficient data available to calculate the ASAR above and below the treatment plant. The average ASAR at Farmingdale is given as approximately 2.75 (low sodium hazard). The ASAR is calculated in the following way:

$$ASAR = SAR * [1 + (8.4 - pH_c)]$$

where

$$pH_c = (pK_2^* - pK_c^*) + pCa + pAlk$$

where pK_2^* is the negative logarithm of the second dissociation constant for H_2CO_3 (carbonic acid) corrected for ionic strength, and

where pK_c^* is the negative logarithm of the solubility constant of $CaCO_3$ corrected for ionic strength, and

where pCa is the negative logarithm of the molal concentration of calcium, and

where $pAlk$ is the negative logarithm of the equivalent concentration of titratable base ($CO_3 + HCO_3$).

The pH_c term is defined as the theoretical pH that the water would have if it were in equilibrium with $CaCO_3$.

Classification of Waters For Irrigation by Sodium and Salinity

The Salinity Laboratory at Riverside, California produced a chart which classifies water for irrigation by total salinity and the SAR factor (Figure 5 - Classification of Irrigation Waters). As the salinity level increases the soils can tolerate less and less sodium as a percent of the total cations. This is indicated by downward sloping lines to the right displayed in Figure 5. Each block marked off by the sloping SAR lines and the salinity lines indicate a different hazard associated with irrigation. As an example, a water with a specific conductance of $1000 \mu S/cm$ and an SAR of 8 is in the "high salinity, medium sodium hazard" for irrigation. Most of the samples which were collected by the USGS and the SDDENR indicate that the waters are in the "medium-high salinity, low sodium hazard". It is interesting to note that there is an upward and to the right trend in the data plotted on the chart. This is an indication of the concentrating effect of different climatic patterns associated with this creek. As the salt concentration increases, the SAR level goes up slightly, also.

There is a wide variation in the water quality taken at both below the treatment plant and at Farmingdale (indicated by the "plus" sign and empty square, respectively). Many of the samples collected above the wastewater treatment plant are in the medium salinity hazard (Figures 1 and 2).

Phosphorus

The wastewater treatment plant provides a large volume of phosphorus in the form of PO_4^{3-} to the creek. The SDDENR shows concentrations of Total PO_4^{3-} above the treatment plant as 0.04 mg/l (Figure 6). There is only one sample, however. The USGS provides several more samples taken from 1979 through 1982 above the treatment plant (Figure 7). These values are as high as 0.60 mg/l as P. The downstream concentrations of Total PO_4^{3-} are quite variable at both downstream stations from both sources of data. The range is from 0.1 to 2.2 mg/l of P as PO_4^{3-} . The average concentration of total phosphorus as PO_4^{3-} at Farmingdale is approximately 1.0 mg/l.

If a farmer were to apply 24" of water to a field on an annual basis with an average concentration of 1.0 mg/l P, this would amount to 5.4 pounds of P per acre, or equivalent to 12.4 pounds of pure P_2O_5 . If triple superphosphate [0-46-0] (46% P_2O_5 = 20% P) cost \$220 per ton (1995 price), then P is worth \$0.55 per pound. The worth of 5.4 pounds of P would be equivalent to \$2.97 (~\$3) per acre.

If the difference between above the wastewater treatment plant and at Farmingdale were about 0.7 mg/l (avg of 0.9 mg/l at Farmingdale, and 0.2 mg/l above), then the worth of this difference in P would equal about \$2.10 P per acre.

The phosphorus in the water available at Farmingdale does not pose a threat to crop production for irrigation because of the small load of P in the water. I have never heard of P as a limiting factor for the irrigability of waters on soils except in unusual industrial food processing situations.

Boron

Soluble boron in the water has been shown to range from 0 to 1.24 mg/l (medium level) at Farmingdale. There are no data available for above the Rapid City WWTP. This level of boron should pose only a slight hazard to crop production if drainage is sufficient to allow some leaching of the boron. If drainage is not sufficient, boron can build up in the soil like other salts. A list of the boron tolerance of ~~some~~ some crops is given in Figure 8. Corn begins to start a decline in production after average soil boron levels reach 1.4 mg/l of soluble boron. Alfalfa is much more tolerant and the threshold level is over 3.0 mg/l.

pH

The pH of the water is not a prime indicator of the irrigability of water for irrigation, but it does give some indication as to what the soil pH may become after years of irrigation. Higher pH levels in waters (alkaline) tend to limit the availability of soluble calcium in the soil. As the soil pH goes up, the solubility of CaCO_3 goes down exponentially. Therefore, higher pH waters tend to create alkaline soil conditions with subsequent precipitation of calcium bicarbonate, making a sodium problem worse.

The pH at all 3 sites varies considerably. The average pH above and below the WWTP and at Farmingdale are 7.9, 7.85, and 8.2 respectively (Figure 9). One sample at Farmingdale was as high as 11.3. It can generally be concluded that the pH at Farmingdale (on the average) is higher than the pH above the WWTP. For irrigation purposes, it would be better if the pH were lower (less than 7.0) to keep the calcium and magnesium and metal ions in solution to prevent the sodium problem from developing.

Higher pH levels also tend to tie up some of the phosphorus as calcium phosphates (CaPO_4). This rather insoluble compound makes the phosphorus essentially unavailable for crop use. Upon lowering the pH, however, the compound becomes more readily soluble again (Pearson and Adams, 1967).

Soil Types

The soils which are under consideration for irrigation are similar to those soils on T1N R9E for sections 28 and 33, SW 1/4 and NW 1/4, respectively. The main soils on these land areas are alluvial soils classified as Owanka clay loam, Owanka-Beckton complex, Bridgeport silt loam, and Kyle clay. The category of soils in order of the irrigability is as follows with the best soils listed first:

- Bridgeport silt loam
- Owanka clay loam
- Kyle clay
- Beckton loam

These soils are fine-textured with high clay contents and montmorillonitic clays (high swelling).

The Beckton soils have a natric horizon at about 6-10" below the soil surface. This means that they are high in sodium with saline subsoils. These soils are not typically irrigable because of their poor permeability and poor subsurface drainage. The other soils are good cropland soils but are fine-textured with slow permeability. Generally, if there is sufficient natural internal drainage of water and salts below the root zone, then the water found in the creek at Farmingdale is suitable for use on the three soils except the Beckton soils. The drainage issue is a big one in this situation. Since the soils are alluvial and fairly flat, water tables may be present within 10' of the surface. For further evaluations of the soil-water compatibility, on-site investigations should be made to determine soil salinity levels and water table positions.

Crop Salinity Tolerances

Different crops have different abilities to tolerate salts in the soil water solution. Some crops are extremely sensitive to salts (strawberries) and other plants are extremely tolerant (barley). Figures 10 (fiber and grain crops) and 11 (grasses and forage crops) show the yield decrement to be expected when the average seasonal soil salinity reaches certain levels. As an example, corn begins to be affected at a soil water salinity level of 1700 $\mu\text{S}/\text{cm}$ (this is equivalent to 1700 $\mu\text{mhos}/\text{cm}$). It will suffer a 25% yield decline at an average soil rooting zone salinity level of 3800 $\mu\text{S}/\text{cm}$. If the soil salinity level were 3800 $\mu\text{S}/\text{cm}$ and your potential yield goal was 120 bushels of corn, then a 25% yield decline would only allow 94 bushels of corn per acre.

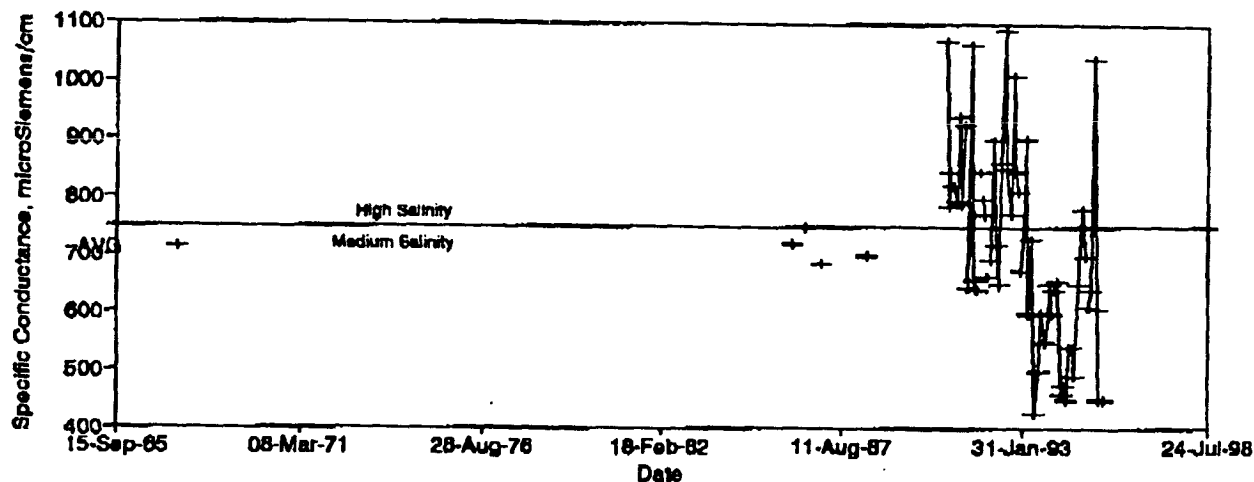
If soil salinity levels can be documented from soil tests, potential yield declines can be calculated based on yield goals, past crop performances records, and soil salinity levels.

REFERENCES

Diagnosis and Improvement of Saline and Alkali Soils. 1954. US Department of Agriculture. Handbook No. 60

Pearson, R.W. and F. Adams. 1967. Soil Acidity and Liming. American Society of Agronomy Monograph No. 12. Madison, Wisconsin.

Specific Conductance, microSiemens/cm
Above WWTP



Below WWTP

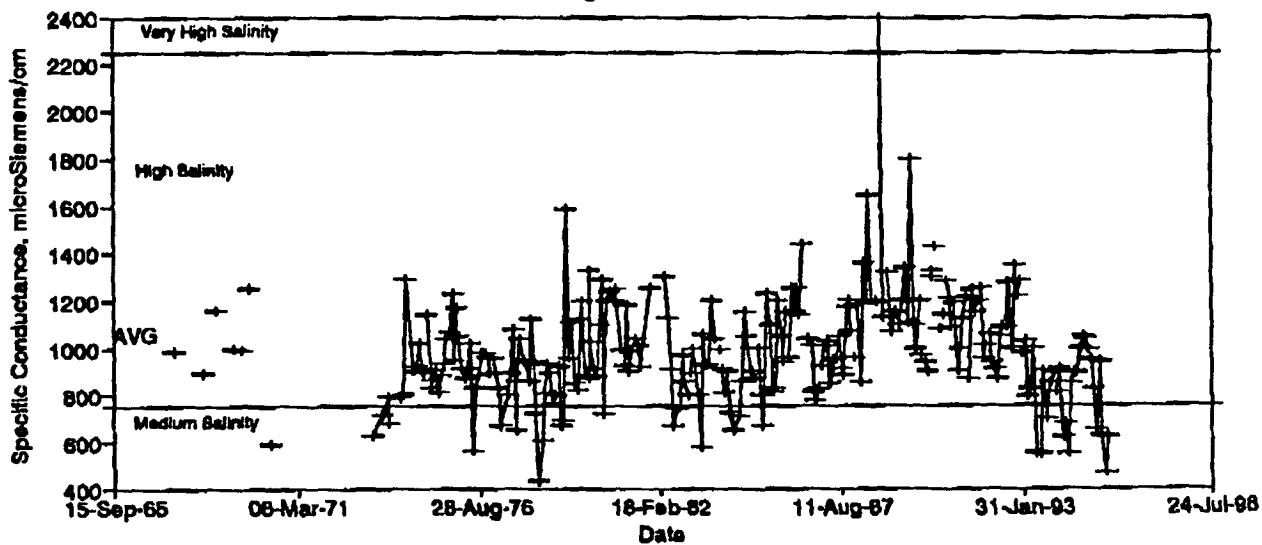
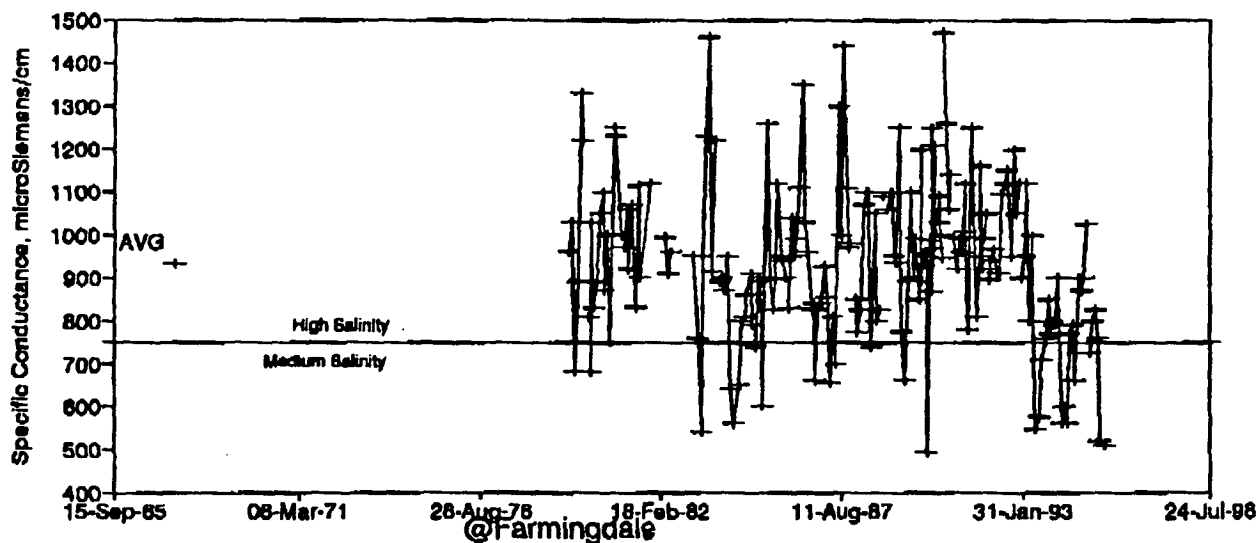
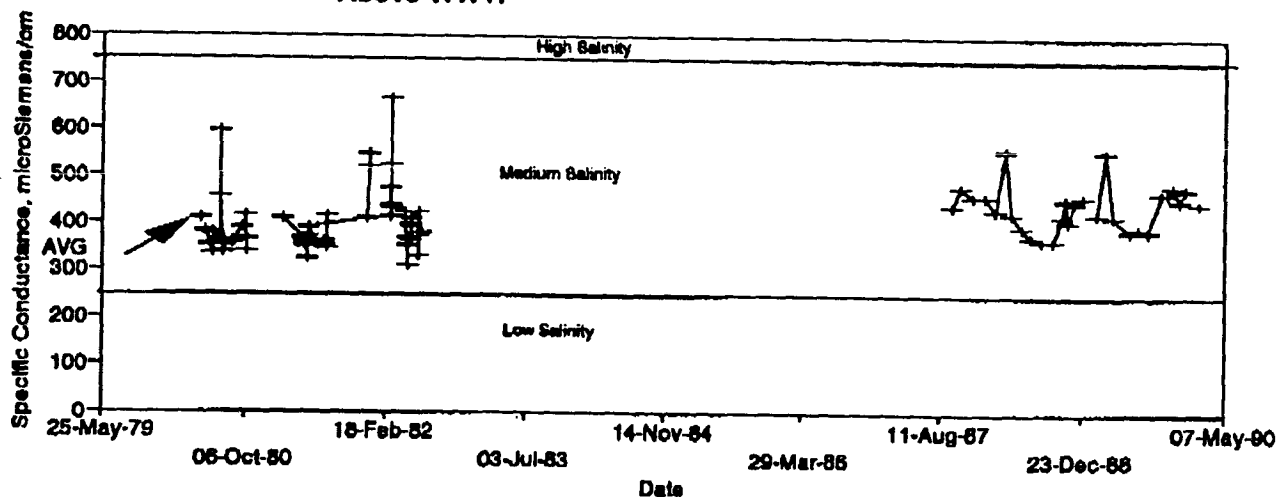


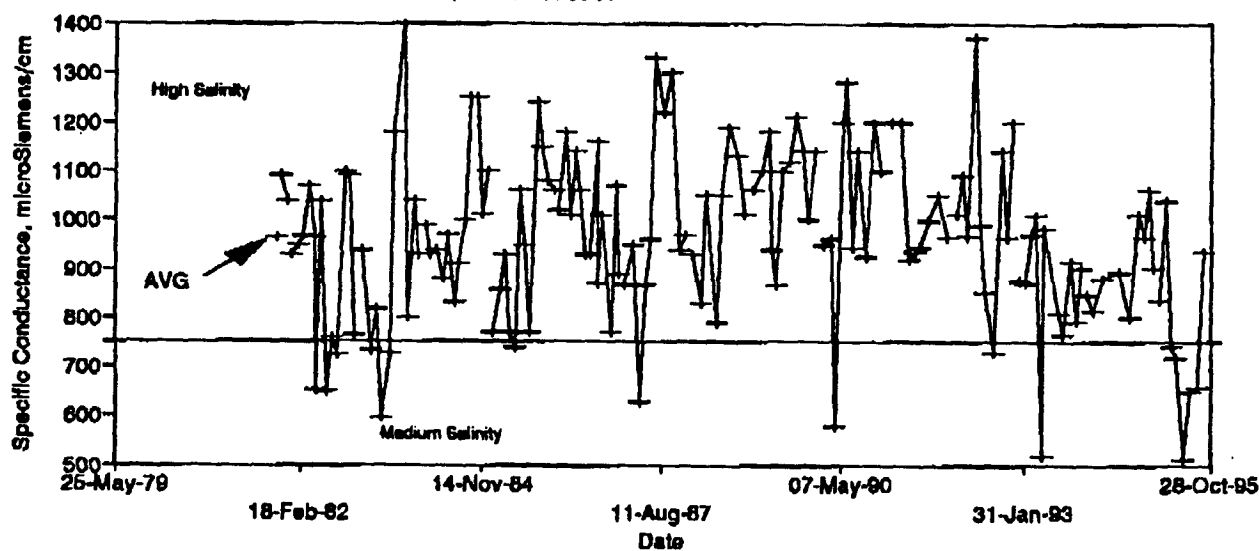
Figure 1

Specific Conductance by Location, USGS

Above WWTP



Below WWTP



@Farmingdale

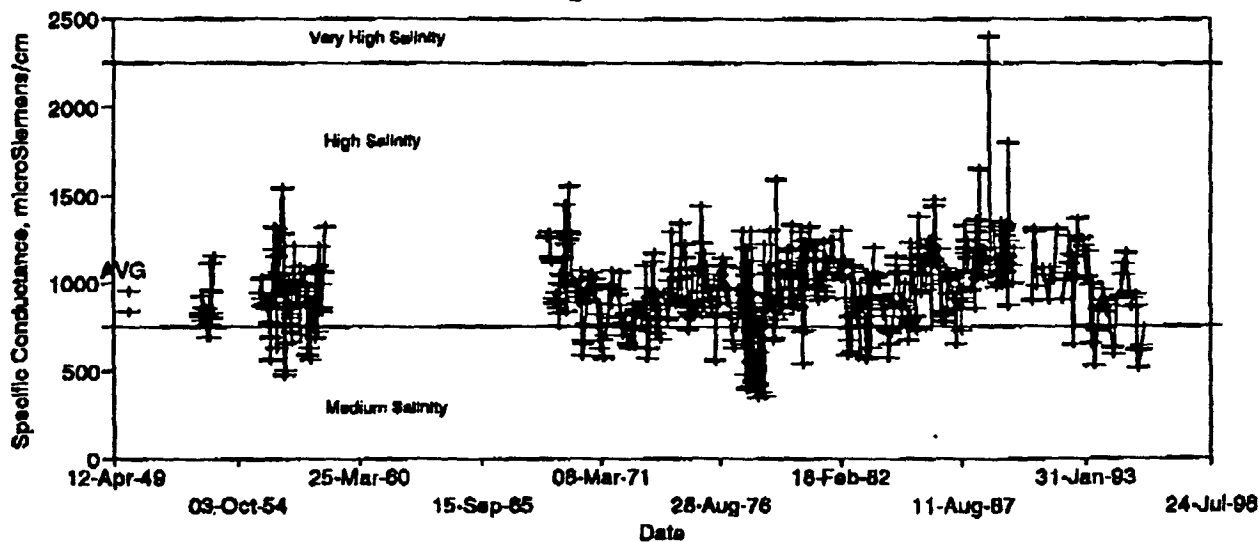
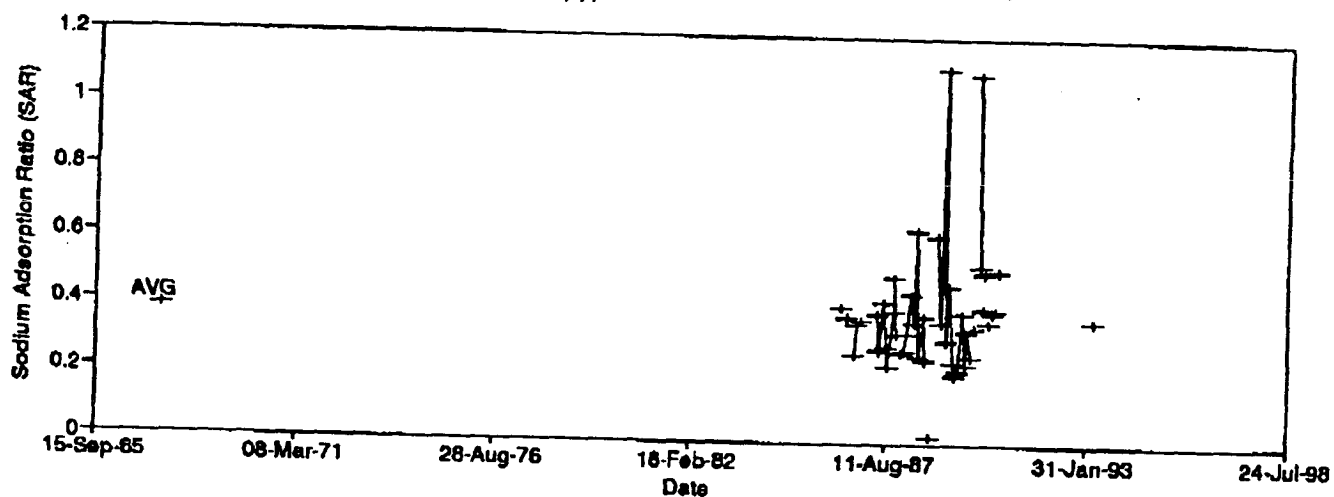
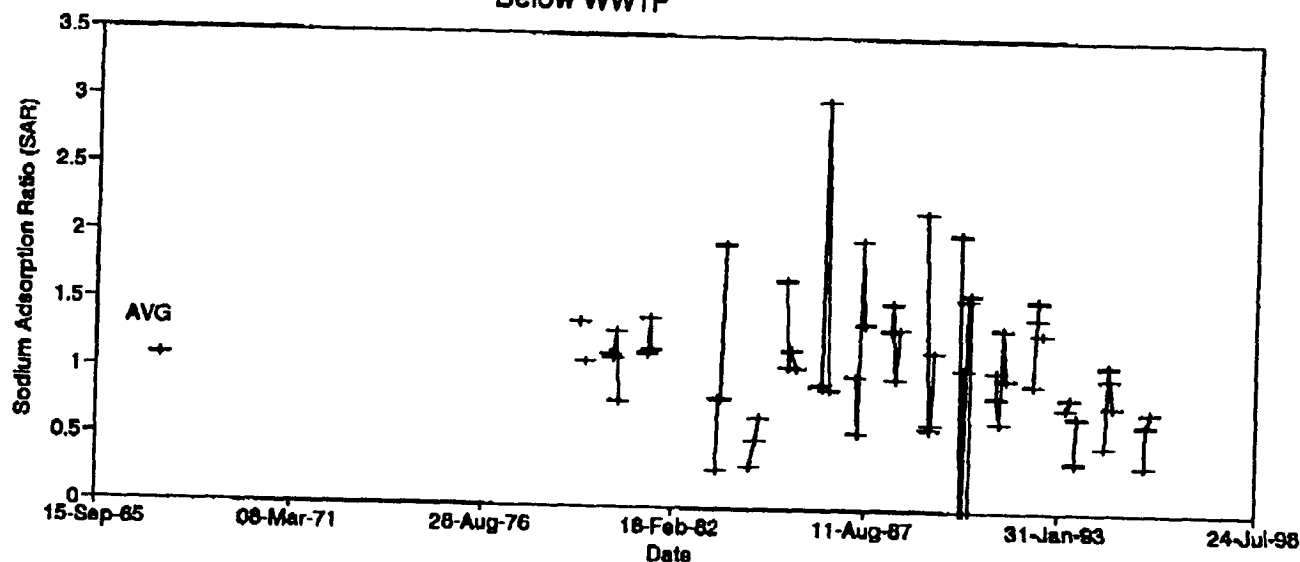


Figure 2.

Comparison of SAR by Location Above WWTP



Below WWTP



@Farmingdale

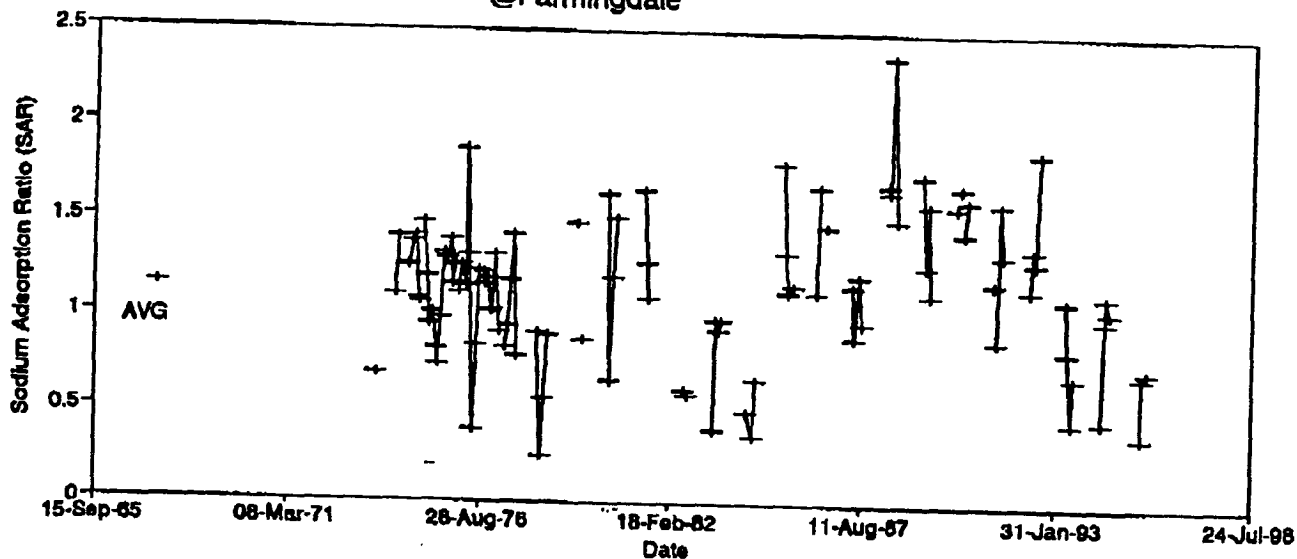


Figure 3

Adjusted Sodium Adsorption Ratio (ASAR) @Farmingdale

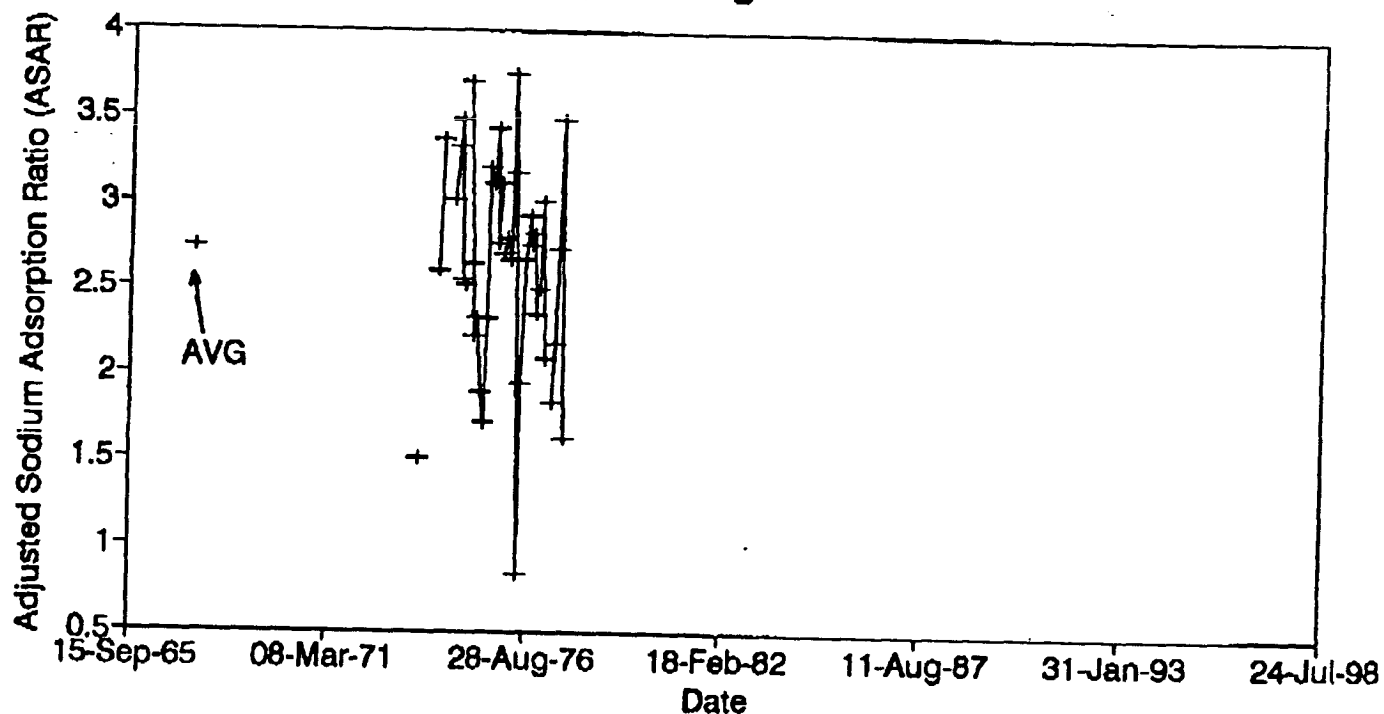


Figure 4

Classification of Irrigation Waters

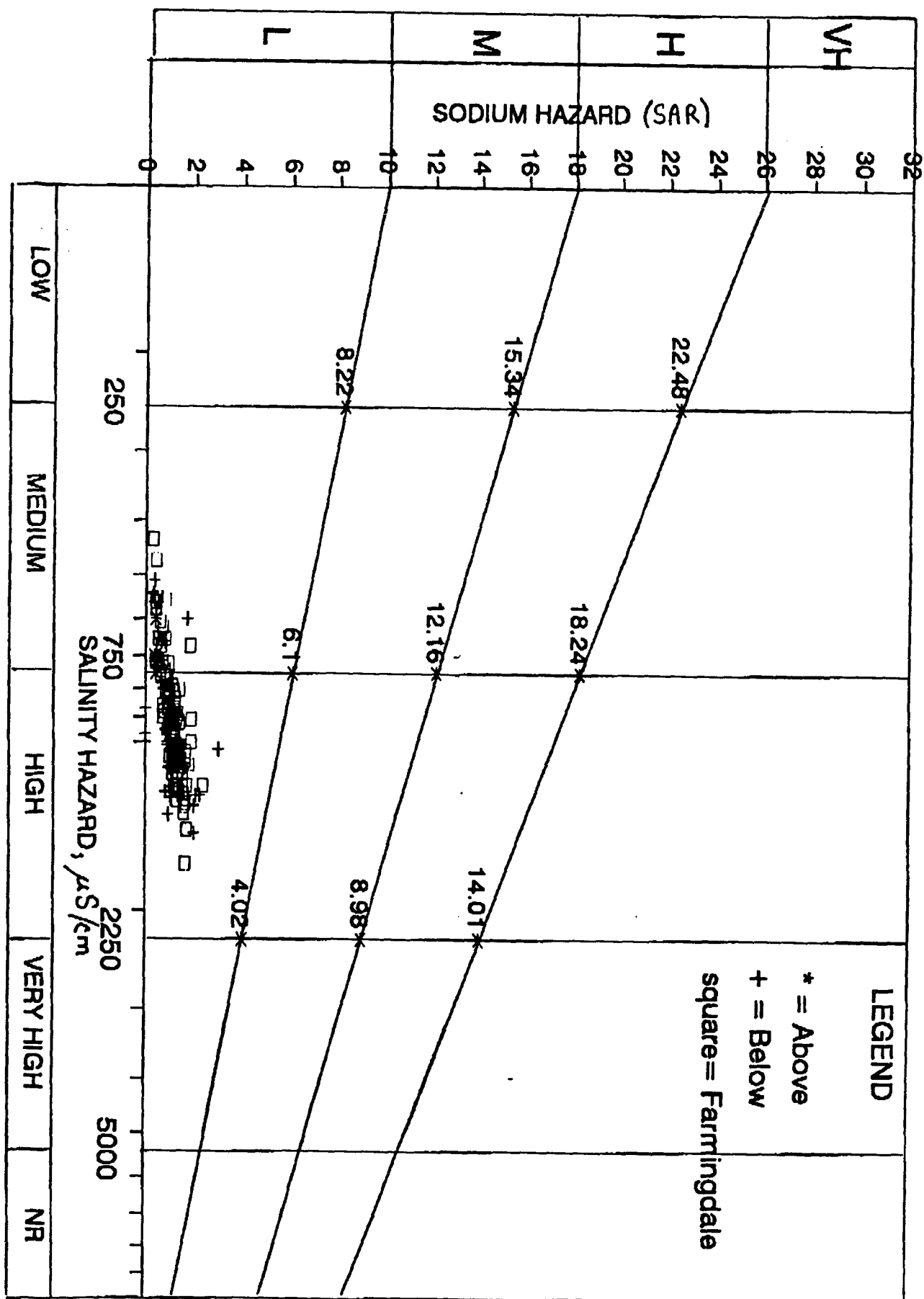
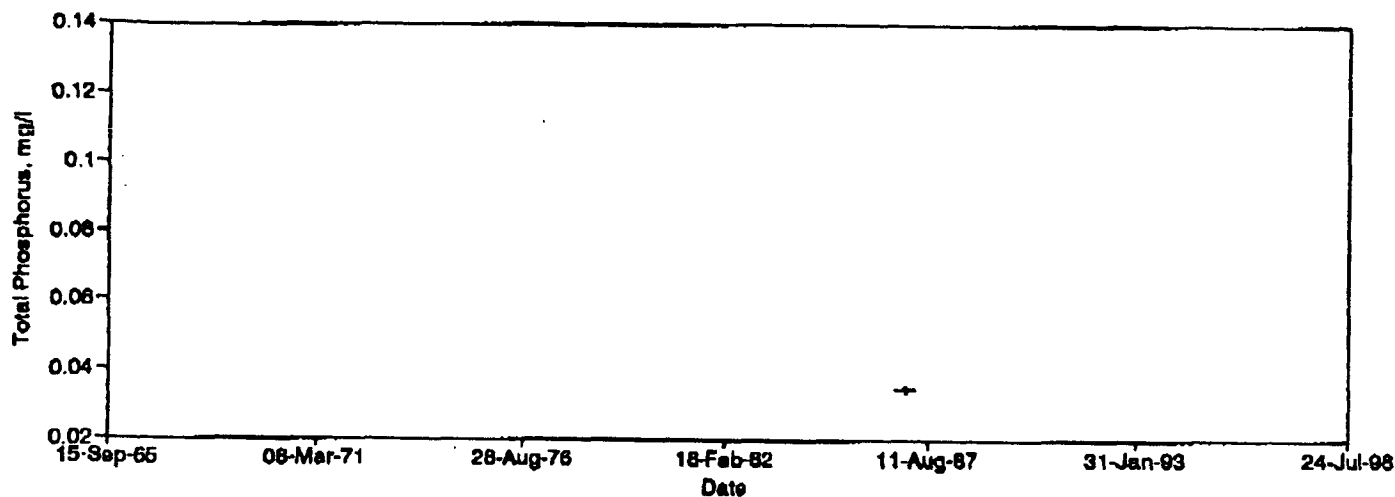
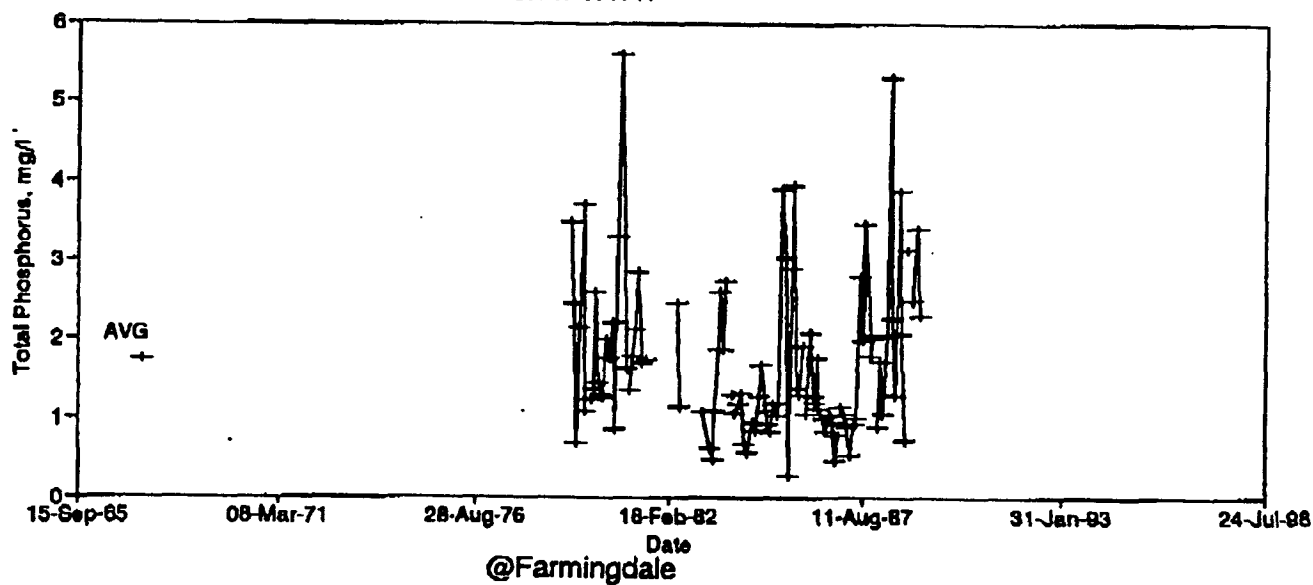


Figure 5

Total Phosphorus by Location Above WWTP



Below WWTP



@Farmingdale

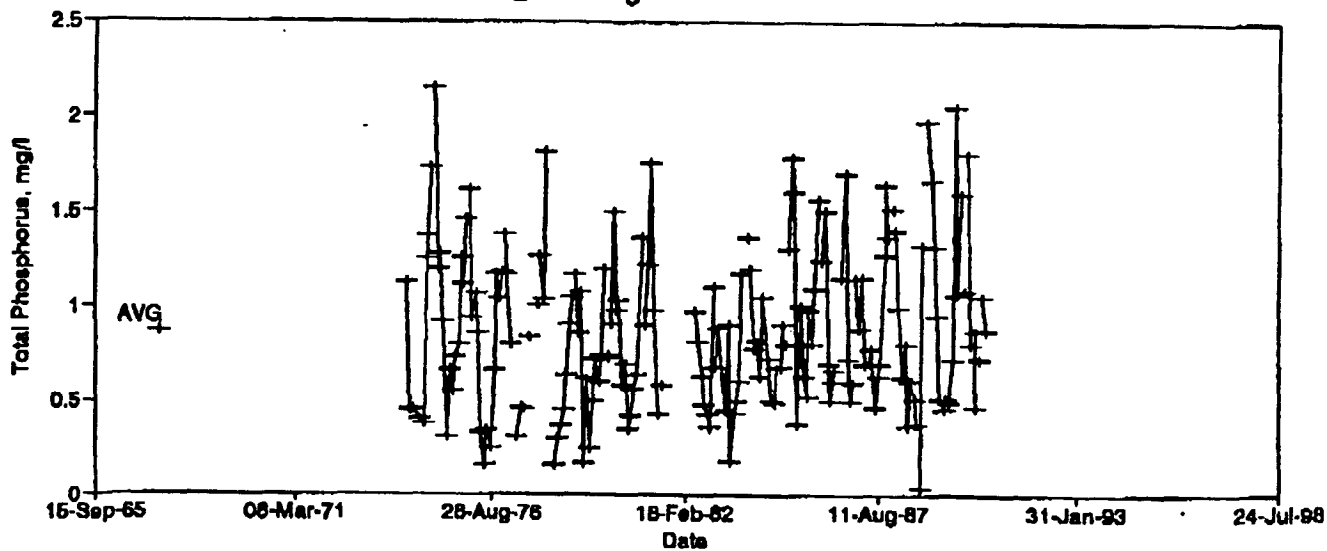
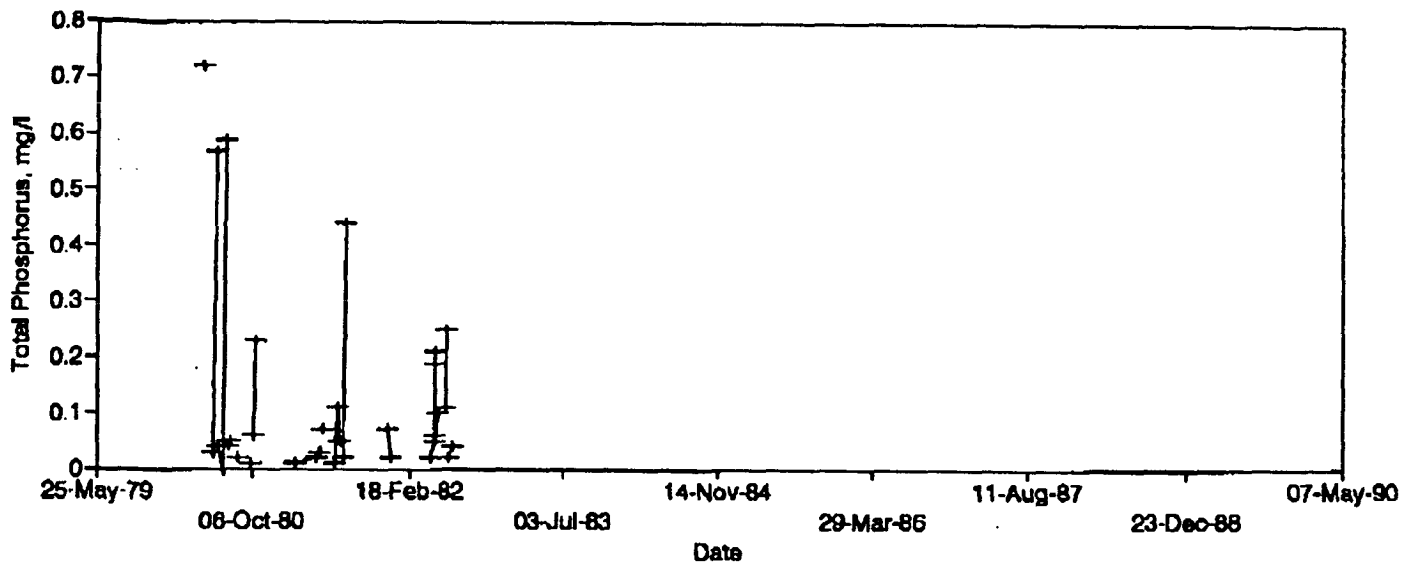


Figure 6.

Total Phosphorus by Location, USGS Above WWTP



Total Phosphorus by Location, USGS @Farmingdale

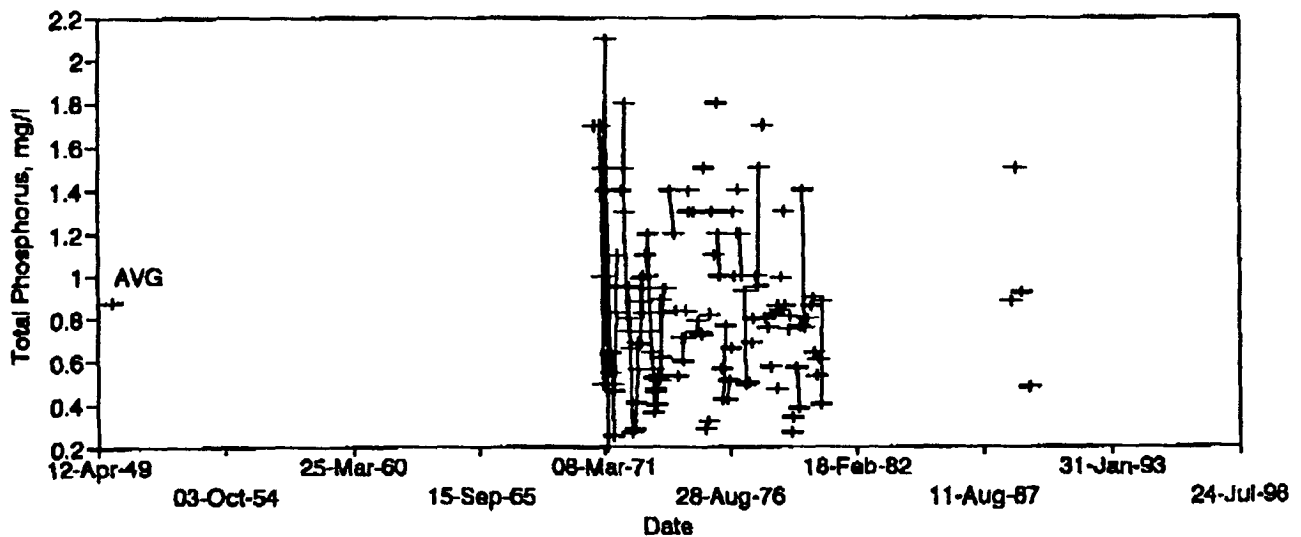
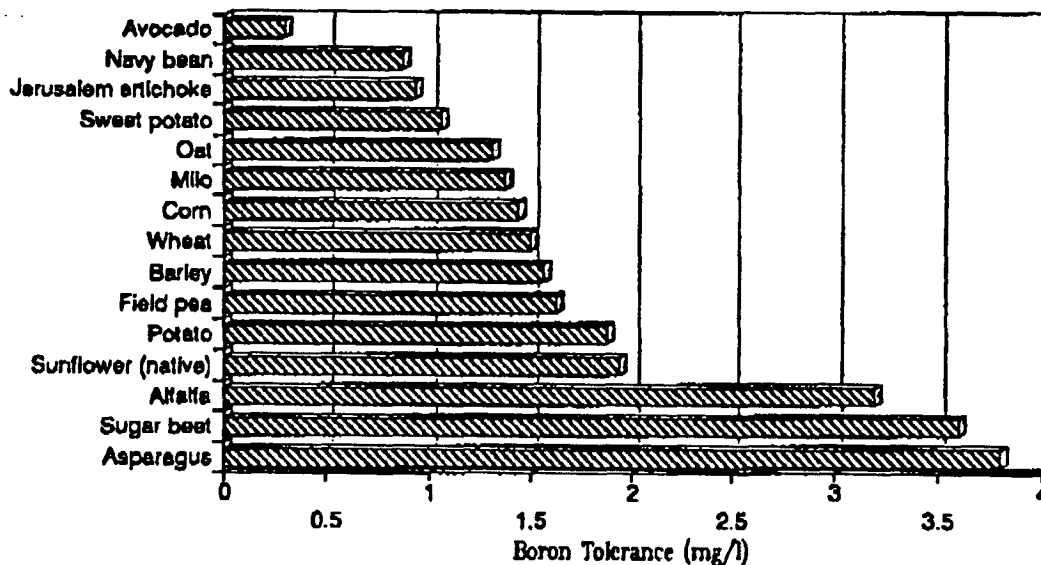


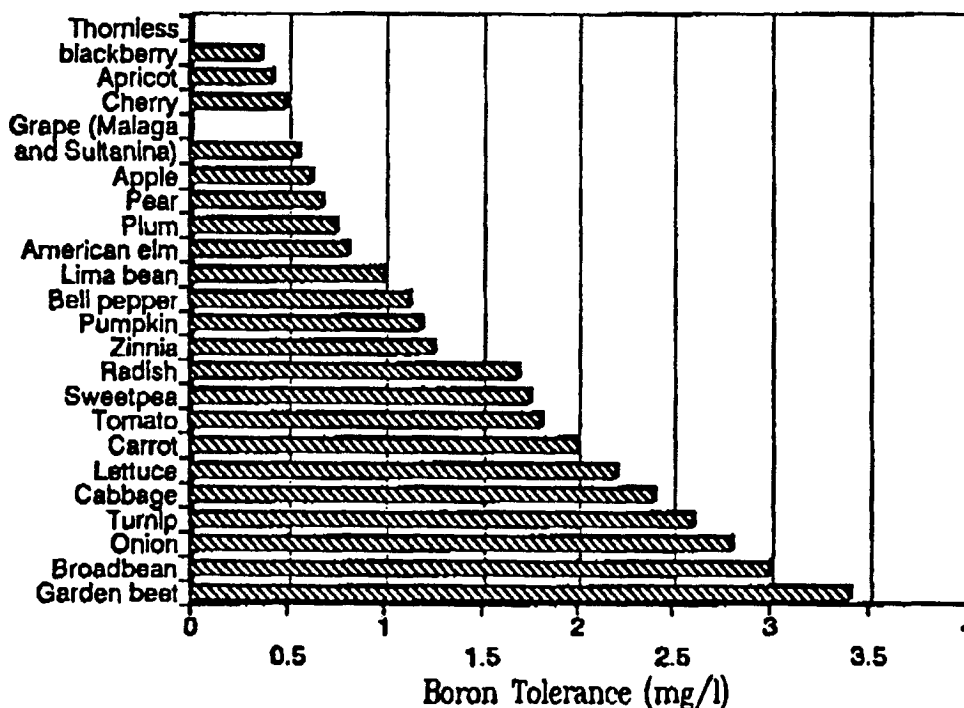
Figure 7

Limits of Boron in Irrigation Water for Crops of Different Degrees of Boron Tolerance.

Field Crops



Other Crops



* The magnitude of the number may vary somewhat within these groups. The rank, however, is correct. (Taken from Trace Elements in the Environment. 1972. Binham, F.T. "Boron in Cultivated Soils and Irrigation Waters".)

Figure 8

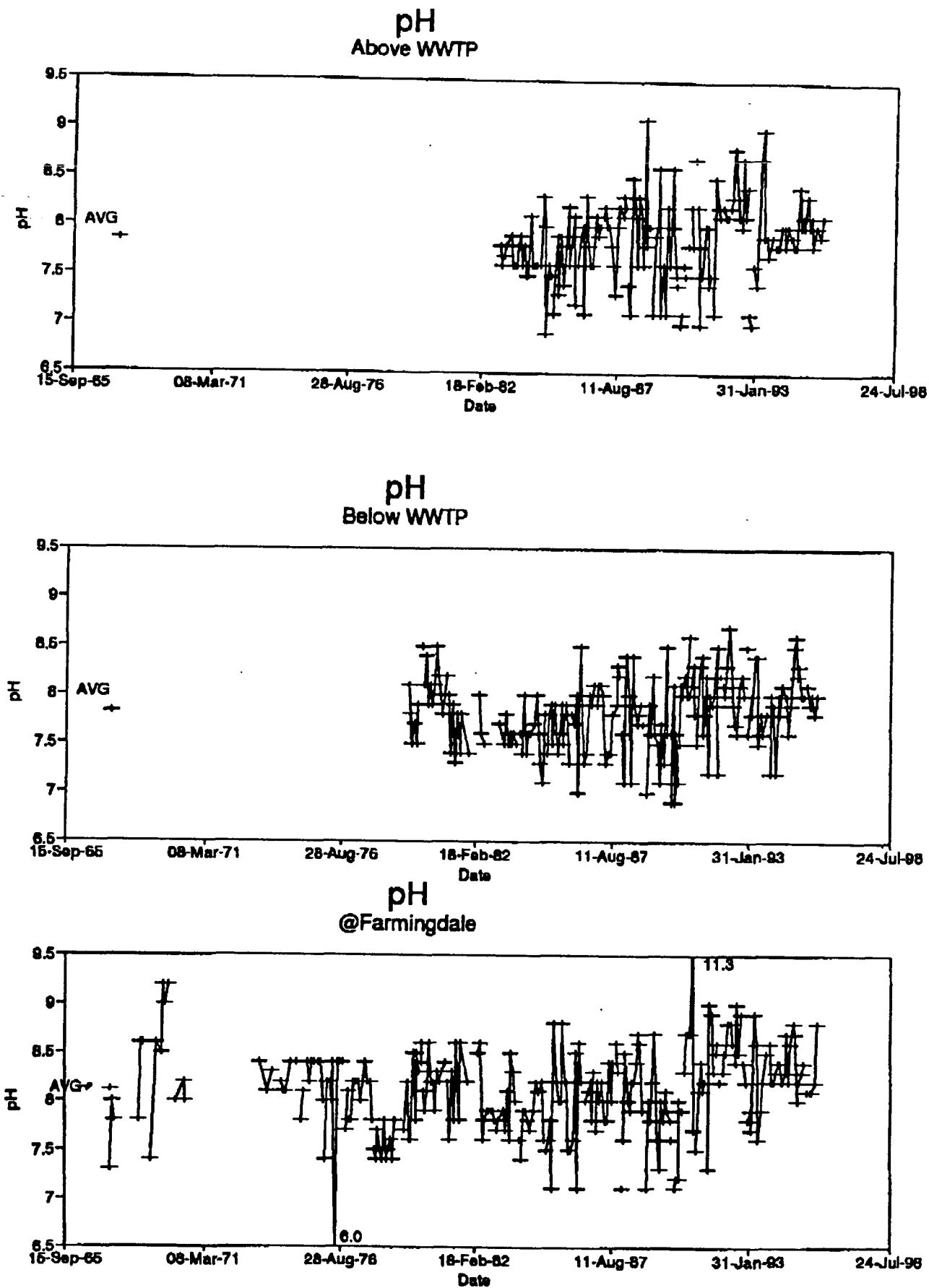


Figure 9

SALINITY TOLERANCE TABLE

FIBER & GRAIN CROPS^a

YIELD DECREMENT TO BE EXPECTED FOR CERTAIN CROPS DUE TO SALINITY OF IRRIGATION WATER WHEN COMMON SURFACE IRRIGATION METHODS ARE USED.

CROP	RATING ^b	0% EC _E ¹	10% EC _E	25% EC _E	50% EC _E	MAXIMUM EC _E
Barley ^c	T	8000	10000	13000	18000	28000
Bean	S	1000	1500	2300	3600	6300
Broadbean	MS	2600	2600	4200	6800	12000
Corn	MS	1700	2500	3800	5900	10000
Cotton	T	7700	9600	13000	17000	27000
Cowpea	MT	4900	5700	6800	8900	13000
Flax	MS	1700	2500	3800	5900	10000
Millet, foxtail	MS	---	---	---	---	---
Oats	MT [*]	---	---	---	---	---
Rye	MT [*]	---	---	---	---	---
Safflower	MT	---	---	---	---	---
Sorghum	MT	6800	7400	8400	9900	13000
Soybean	MT	5000	5500	6200	7500	10000
Sugarbeet ^d	T	7000	8700	11000	15000	24000
Sunflower	MS [*]	---	---	---	---	---
Triticale	T	---	---	---	---	---
Wheat ^e	MT	6000	7400	9500	13000	20000
Wheat, semidwarf ^e	T	8600	12000	17000	25300	42000
Wheat, Durum	T	5900	8500	12500	19000	32000

[OVER]

Figure 10

* These data serve only as a guideline to relative tolerances among crops. Absolute tolerances vary, depending upon climate, soil conditions, and cultural practices.

^b Ratings are S=sensitive; MS=moderately sensitive; MT=moderately tolerant; T=tolerant to salts.

^c Less tolerant during emergence and seedling. Salinity at this stage should not exceed 4000 or 5000 $\mu\text{mhos/cm}$.

^d Sensitive during germination. Salinity should not exceed 3000 $\mu\text{mhos/cm}$.

* Data from one cultivar "Probred"

* Ratings with an * are estimates.

¹ EC_e = Electrical Conductivity of the saturation extract of the average root zone (micromhos/cm).

Data as reported by E.V. Maas, 1987. "Salt Tolerance of Plants". Applied Agricultural Research Vol. 1, No. 1, pp 12-26.

SALINITY TOLERANCE TABLE

GRASSES & FORAGE CROPS^a

YIELD DECREMENT TO BE EXPECTED FOR CERTAIN CROPS DUE TO SALINITY OF IRRIGATION WATER WHEN COMMON SURFACE IRRIGATION METHODS ARE USED.

<u>CROP</u>	<u>RATING^b</u>	<u>0%</u> <u>EC_e¹</u>	<u>10%</u> <u>EC_e</u>	<u>25%</u> <u>EC_e</u>	<u>50%</u> <u>EC_e</u>	<u>MAXIMUM</u> <u>EC_e</u>
Alfalfa	MS	2000	3400	5400	8850	15700
Alkaligrass, Nuttall	T [*]	---	---	---	---	---
Alkali sacaton	T [*]	---	---	---	---	---
Barley (forage)	MS	6000	7400	9500	13000	20000
Bentgrass	MS	---	---	---	---	---
Bermudagrass ^c	T	6900	8500	10800	14700	22500
Bluestem, Angleton	MS [*]	---	---	---	---	---
Brome, Mountain	MT [*]	---	---	---	---	---
Brome, smooth	MS	---	---	---	---	---
Buffelgrass	MS [*]	---	---	---	---	---
burnet	MS [*]	---	---	---	---	---
Canarygrass, Reed	MT	---	---	---	---	---
Clover, alsike, ladino, red, & strawberry	MS	1500	2350	3600	5700	9800
Clover, Berseem	MS	1500	3250	5900	10300	19000
Clover, Hubam & sweet	MT [*]	---	---	---	---	---
Clover, White Dutch	MS [*]	---	---	---	---	---
Cowpea (forage)	MS	2500	3400	4800	7000	11600
Dallisgrass	MS [*]	---	---	---	---	---
Fescue, tall & meadow	MT	3900	5800	8600	13300	22800
Foxtail, meadow	MS	1500	2500	4100	6700	12000

[OVER]

<u>CROP</u>	<u>RATING</u>	<u>0%</u> <u>EC_E¹</u>	<u>10%</u> <u>EC_E</u>	<u>25%</u> <u>EC_E</u>	<u>50%</u> <u>EC_E</u>	<u>MAXIMUM</u> <u>EC_E</u>
Gramma, blue	MS*	---	---	---	---	---
Hardinggrass	MT	4600	5900	7900	11200	17800
Kallargrass	T*	---	---	---	---	---
Lovegrass ^d	MS	2000	3200	5000	8000	14000
Orchardgrass	MS	1500	3100	5500	9600	17600
Ryegrass, perennial	MT	5600	6900	8900	12200	18800
Saltgrass, desert	T*	---	---	---	---	---
Sudangrass	MT	2800	5100	8600	14400	26000
Timothy	MS*	---	---	---	---	---
Trefoil, big	MS	2300	2800	3600	4900	7600
Trefoil, narrowleaf birdsfoot	MT	5000	6000	7500	10000	15000
Vetch, common	MS	3000	3900	5300	7500	12000
Wheat (forage) ^e	MT	4500	8300	14100	23700	43000
Wheat, Durum (forage)	MT	2100	6100	12100	22100	42100
Wheatgrass, standard crested	MT	3500	6000	9800	16000	28500
Wheatgrass, fairway crested	T	7500	9000	11100	14700	22000
Wheatgrass, intermediate & slender	MT	---	---	---	---	---
Wheatgrass, tall	T	7500	9900	13500	19400	31300
Wheatgrass, western	MT*	---	---	---	---	---
Wildrye, Altai & Russian	T	---	---	---	---	---
Wildrye, beardless	MT	2700	4400	6900	11000	19400

* These data serve only as a guideline to relative tolerances among crops. Absolute tolerances vary, depending upon climate, soil conditions, and cultural practices.

^b Ratings are S = sensitive; MS = moderately sensitive; MT = moderately tolerant; T = tolerant to salts.

^c Average of several varieties.

^d Average for Boer, Wilman, Sand, and Weeping cultivars. Lehmann seems about 50% more tolerant.

^e Data from one cultivar, "Probred"

* Ratings with an * are estimates.

¹ EC_E = Electrical Conductivity of the saturation extract of the average root zone (micromhos/cm).

Data as reported by E.V. Maas, 1987. "Salt Tolerance of Plants". Applied Agricultural Research Vol. 1, No. 1, pp 12-26.

APPENDIX D

EFFECT OF SOETAERT SOUTH SIDE DITCH TRANSFER

EFFECTS OF SOETAERT SOUTH SIDE DITCH TRANSFER

ASSUMPTIONS

- 5% CU for inhouse use
- 50% CU for irrigation and landscape irrigation
- 57% of Rapid City's use during May - September is for landscape irrigation (See Appendix K in Tyler Report)
- 43% of Rapid City's use during May - September is for Inhouse use (See Appendix K in Tyler Report)
- 31.3 AF/year of transferable CU from Soetaert share of South Side Ditch right 61.3 AF/year of transferable diversion (See Table B in 4/19/96 letter to Dan Bjerke for Soetaert property)
- 960 mg/l of TDS in WWTP effluent

CALCULATE EFFECTS FOR TRANSFER OF CU

Calculate return flows

- Proportion of Soetaert right that will go to lawn irrigation = $.57 \times 31.3 \text{ AF} = 17.8 \text{ AF}$
- Return flows from lawn irrigation = $17.8 \times .2 = 3.6 \text{ AF}$ (Assume irrigation efficiency of 80%)
- Proportion of Soetaert right that will go to inhouse use = $31.3 - 17.8 = 13.5 \text{ AF}$
- Return flows from inhouse use = $13.5 \times .95 = 12.8 \text{ AF}$
- Return flows from historic irrigation on Soetaert property with 50% efficiency:
 $0.5 \times 63.0 = 31.5 \text{ AF}$

Calculate increase in TDS due to transfer:

$$\begin{array}{lcl} \text{Increase} = & \text{Mass of TDS} & - \quad \text{Mass of TDS} \\ & \text{in return flows} & \text{in return flows} \\ & \text{resulting from} & \text{from historical} \\ & \text{transfer of 31.3} & \text{irrigation of} \\ & \text{AF to Rapid City} & \text{Soetaert property} \end{array}$$

$$= [\text{TDS Concentration in WWTP effluent (mg/l)} \times 12.8 \text{ AF} \times (1.23 \times 10^6) \text{ l/AF}]$$

$$+ [\text{TDS Concentration in landscape irrigation return flows} \times 3.6 \text{ AF} \times (1.23 \times 10^6) \text{ l/AF}]$$

$$- [\text{TDS Concentration in historic irrigation return flows} \times 31.5 \text{ AF} \times (1.23 \times 10^6) \text{ l/AF}]$$

$$\text{Let } C_1 = \begin{array}{l} \text{Concentration} \\ \text{in Irrigation} \\ \text{Return flows} \end{array} = \begin{array}{l} \text{Concentration in} \\ \text{Landscape Irrigation} \\ \text{Return flows} \end{array}$$

We have no data on C_1

Therefore set TDS Increase in above equation equal to 0.0 and solve for C_1

$$0 = (960) (12.8) (1.23 \times 10^6 \text{ l/AF}) + C_1 (3.6) (1.23 \times 10^6) - C_1 (31.5) (1.23 \times 10^6 \text{ l/AF})$$

$$0 = 15,114 + 4.4 C_1 - 38.7 C_1 = 15,114 - 34.3 C_1$$

$$C_1 = \frac{15,114}{34.3} = 441 \text{ mg/l}$$

$C_1 = 441 \text{ mg/l}$ indicates that if the actual average annual concentration of TDS in return flows from irrigated agriculture is less than 441 mg/l of TDS, then the change in point of diversion and change in use of the Soetaert share of the South Side Ditch right will increase TDS concentrations in Rapid Creek. On the other hand if the actual mean annual TDS concentration of TDS in return flows from irrigated agriculture is greater than 441 mg/l the change in point of diversion and use will decrease TDS concentrations in the Rapid Creek.

The following provides indication that the TDS concentration in return flows from irrigated agriculture may be greater than 441 mg/l:

<u>Location</u>	<u>Mean TDS (mg/l)</u>
Upstream from WWTP	467
Downstream from WWTP	570
At Farmingdale	627
WWTP	960

Conclusion: These data suggest that return flows from irrigation will have TDS greater than 441 mg/l. Therefore it is likely that the transfer will not increase TDS levels in Rapid Creek.

The data for Farmingdale provides some indication of the TDS concentrations of return flows because a major proportion of low flows at Farmingdale will be return flows from irrigation. This assumes that wastewater return flows from Caputa are small.

CALCULATE EFFECTS FOR TRANSFER OF DIVERSION

- Proportion to Lawn irrigation = $(0.57) (61.3 \text{ AF/year}) = 34.9 \text{ AF}$
Return Flows = $(34.9 \text{ AF}) (0.2) = 7.0 \text{ AF}$
- Proportion to Inhouse = $61.3 - 34.9 = 26.4 \text{ AF}$
Return Flows = $(0.95) (26.4) = 25.1 \text{ AF}$

$$\begin{array}{lcl} \text{Increment change in} & = & \text{TDS Concentration} \\ \text{Water quality due to} & & \text{In WWTP effluent} \\ \text{Water rights change} & & \times 25.1 \text{ AF} + C_1 (7.0 \text{ AF}) - C_1 (31.5) \end{array}$$

Ignore the 1.23×10^6 l/AF conversion since it is in every term and cancels

$$= (960) (25.1) - 24.5 C_1$$

$$C_1 = \frac{24,096}{24.5} = 984 \text{ mg/l}$$

Therefore if the actual concentration of TDS in the irrigation return flows is less than 984 mg/l, the water rights change will increase TDS concentration in Rapid Creek.

Based on the tabular data above, it would appear that the TDS concentrations in the irrigation return flows are less than 984 mg/l. Consequently, it would appear that when the 61.3 AF/year of diversion is transferred, that this may increase TDS concentrations in Rapid Creek.

APPENDIX E

**RECOMMENDED WATER QUALITY CRITERIA
FOR AGRICULTURAL DIVERSIONS IN COLORADO**

Recommended Water Quality Criteria for Agricultural Diversions in Colorado

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Project Technical Report No. 1
Colorado Agricultural Experiment Station
Project No. 1372-647
January, 1993

Acknowledgements

This study was funded by the Colorado Agricultural Experiment Station (Project No. 1372-647) at Colorado State University, the Central Colorado Water Conservancy District, the Farmers Reservoir and Irrigation Company, the Northern Colorado Water Conservancy District and the Consolidated Ditches Company. Support was provided in the interest of sustaining irrigated agriculture in Colorado through cooperative water management and environmental preservation. The support is gratefully acknowledged by the authors. All findings, conclusions and recommendations reported herein are those of the authors and do not necessarily represent the views of the funding agencies.

The significant contribution of Mr. Patrick C. McGrane, former graduate student in the Department of Civil Engineering, in the preparation of this document is gratefully acknowledged.

Introduction

Recent years have seen increasing competition between urban/industrial areas and irrigated agriculture for the limited water resources of the western United States. One attempt to ease this tension in Colorado has been through the utilization of agricultural water decrees for urban purposes through augmentation, transfer and exchange agreements. A key requirement of these arrangements under Colorado water law is that water returned to the stream must be of "acceptable quality" relative to historical use. However, there is a growing concern among agricultural water users regarding the interpretation of what constitutes "acceptable quality". At times, the South Platte River which supplies the most productive agricultural region of Colorado consists largely of secondary treated sewage effluent from the Denver metropolitan region. Recently, the city of Thornton has spent more than \$50 million to buy water from 114 farms in northern Colorado and plans to exchange the city's lower quality South Platte water with farmers to obtain higher quality Cache la Poudre River water. This water transfer probably will precipitate the incorporation of water quality concerns into future water rights transactions. Water quality problems resulting from urban wastewater discharges also exist in the Arkansas River basin. If irrigated agriculture is to survive in this competitive water environment, the water quality issue must be better understood, managed and incorporated into water rights doctrine.

There are various constituents that occur in secondary treated urban wastewater which may pose environmental hazards to irrigated agriculture. Significant levels of total dissolved solids may promote long-term salinization on irrigated lands having poor drainage. High nitrate levels can adversely affect crop yields (sugar beets, as an example) and pollute shallow aquifers underlying croplands. Other chemical constituents may degrade soil structure and prove toxic to crops and/or livestock. The presence of pathogenic organisms and heavy metals in waters used to irrigate vegetable crops may present a direct threat to public health, particularly when humans are exposed to direct contact. Also, algal growth promoted by wastewater effluent may create costly maintenance problems in irrigation reservoirs and water distribution systems in the future.

Other states and countries have established quality criteria for waters used in irrigation. This report presents the background for developing agricultural water quality criteria for Colorado and explores the major chemical and biological constituents of interest to Colorado agriculture. Criteria are proposed for each constituent based upon a scientific review of the most recent literature.

Effects of Water Quality in Agriculture

One man's waste being another's supply is not a new concept; the practice of recirculating and reusing wastewaters is an inherent aspect of the hydrologic cycle. What is new, however, is the complexity and degree of effects which presently occur from water

pollution. Research to establish pollution guidelines and standards has been driven primarily by concern about direct effects on public health. However, a previously neglected issue has drawn increasing attention in Colorado in recent years: the extent to which return flows and wastewater effluent from municipalities impair the quality of water for downstream use by irrigated agriculture. State water laws, modified in the 1970's to allow upstream users to divert flows under augmentation and exchange plans, permit large portions of a stream to be diverted as long as return flows do not impair downstream quantity requirements (Vranesh 1987). Over the past ten years, water rights decrees have been predominated by urban augmentation and exchange plans. Downstream agricultural users are concerned that as urban areas grow, this trend will continue, creating in-stream flows which are made up primarily of secondary-treated municipal wastewater effluent. Colorado water courts have long recognized that an owner of a water right is entitled to receive that water without impairment in quality (Hobbes and Raley 1986). Understanding water quality impairment in light of agricultural needs, especially in the current context of growing urban competition and associated litigation, is a critical issue needing immediate attention. Conservation of Colorado's water resources necessarily includes the preservation of their use in sustaining the state's productive agricultural economy.

Poor water quality can affect agriculture in several ways. First of all, and usually of primary concern, is the health of users exposed to direct contact. Safety for agricultural workers exposed to tainted irrigation water has been referenced in many studies (Bausum et al. 1982, Shuval et al. 1986). Poor health can develop from either toxicant or pathogenic sources (Rose 1986, Sheikh et al. 1985, Smith 1982). Pollutants also can be transferred to the crop consumer through pathogens and toxicants being on or incorporated into agricultural products (Burau et al. 1987, Hyde and Young 1984, Bagdasaryan 1964). The potential of this causing ripple effects on the agricultural industry as consumers refuse to purchase regional products or specific crops has been discussed from the viewpoint of economics (Victurine 1985, Crites and Meyer 1981), sociology (Lohman and Milliken 1985), and legal-institutional barriers (Milliken and Lohman 1979). Recent marketing problems in the agricultural industry developing from pesticide use on products, has made the producer more sensitive to the quality and health aspects of his product (California Agricultural Issues Center 1988).

The production system of soils, crops, and livestock also can be degraded or destroyed through polluting elements in agricultural waters (Ayers and Tanji 1981, Schirado et al. 1986, Rohnen 1985). A major problem in the western U.S. and around the world is the destruction of prime agricultural land through irrigation-induced salinization (Kovda 1983, National Research Council 1989, van Schilfgaarde 1990, Dinar and Zilberman 1991). The salinity problem is exacerbated when waters diverted to the farm headgate are brackish (Shainberg and Shalhevet 1984). Without careful design and management, salinity-affected regions suffer from degradation of soil structure (permeability and aeration) and reduction in crop yields (Tanji 1990, Gates and Grismer 1989). Salinity problems are produced by the total concentration of dissolved inorganic solids. However, attention also must be given to excessive levels of individual chemical species (trace elements, sodium, chloride, sulfates, etc.) which can prove toxic to crops (McKee and Wolf 1963, Ayers and Westcot 1985) and to livestock (Environmental Protection Agency 1976).

Another important factor to consider is the impact that the quality of waters coming onto the farm will have on the resulting quality of agricultural return flows. Because of the transfer of urban-polluted water through the agricultural system, the agricultural sector may find itself accused of surface water or ground water pollution merely by using the supplies made available at its headgates (Mansell et al. 1985, Smettem et al. 1983, Linden et al. 1984).

Numerous studies have been conducted addressing impacts of water quality on agriculture. There is a need, however, to gather, synthesize, summarize and interpret this information relative to the Colorado situation. This report attempts to provide such a composition in brief form.

Status of Water Quality Law in Colorado

In 1969 the Colorado legislature passed the *Water Rights Determination and Administration Act*, which explicitly endorsed the objective of maximizing water use in Colorado. The Act introduced the idea of a "plan of augmentation" that would increase the supply of water for beneficial use through exchange projects, the pooling of water resources, and substitute supplies of water (MacDonnell 1986):

"In the case of plans for augmentation including exchange, the supplier may take an equivalent amount of water to his point of diversion or storage if such water is available without impairing the rights of others. Any substituted water shall be of a quality and quantity so as to meet the requirements for which the water of a senior appropriator has normally been used, and such substituted water shall be accepted by the senior appropriator in substitution for water derived by the exercise of his decreed rights." (Colorado Rev. Stat. 37-92-305(10), 1985 Supp.)

It is important to note that an agricultural user *must* accept the substituted water as long as it is of a quality to meet existing agricultural requirements.

Here is how augmentation works. If a municipality diverts 1,000 acre-feet of water upstream under an out-of-priority junior right, it might return 900 acre-feet to the stream as treated sewage. Only 100 acre-feet of replacement water would need to be furnished to augment the out-of-priority depletion (Porzak 1986).

Central to this process is the *Colorado Water Quality Control Act* of 1973 (Colorado Rev. Stat. 1973, 25-8-101). Under this Act all surface waters of the state are classified according to past, present, and desired future uses. The major categories of classified use are aquatic life, domestic water supply, agriculture, and recreation. The Colorado Department of Health would allow or not allow discharge of a contaminant based on the classified uses of the receiving waters.

A precedent-setting case in which agricultural interests prevented an augmentation plan from being approved was case 83-CW-361 in District Court 1, Greeley. At issue was the city of Golden's request to divert 20 ft³/s of streamflow from Clear Creek, a tributary of the South Platte River, and replace that flow with treated sewage from a wastewater treatment plant. The sewage effluent would be returned to Clear Creek one half mile above the Croke Canal which is the primary source of raw water to Standley Reservoir. Standley Reservoir, which is 15 miles down the canal from Clear Creek is the terminal raw water storage facility for three Denver suburbs (Westminster, Northglenn, and Thornton), and for the Farmers Reservoir and Irrigation Company (FRICO, a major agricultural irrigation company northeast of Denver). Golden had a valid permit from the Colorado Water Quality Control Division of the Colorado Department of Health and planned to comply with all current state discharge permit regulations. Clear Creek was classified for all four major uses by the state. However, the court denied the augmentation plan because secondary-treated effluent could contain inadequately regulated pollutants that could cause public health problems. Richard Behrman, the presiding judge, wrote

"... that present knowledge of long-term effects of indirect reuse is only recently developed and not complete. It is the subject of much on-going research among engineers, utilities, and in the academic world. This new knowledge means that some practices considered acceptable as recently as ten years ago are now questioned or condemned."

It is noteworthy here that this case was rejected not only because of its possible negative effects on municipal water supplies, but also because

"the preponderance of the evidence is that ... discharge of GWTP effluent into the agricultural water supply, which does not receive any additional treatment prior to use, will lead to additional disease in the men and animals that come into contact with it, and degradation of agriculture and the contamination of crops." (Behrman 1986).

Current Surface Water Quality in Colorado

Several major river systems originate in Colorado: the Arkansas, the Colorado, the Platte, the Rio Grande and the Republican. These rivers have major tributaries like the Green, the San Juan, the Cache la Poudre, the North Platte and the South Platte. All of these river systems support some part of Colorado's vast irrigated agriculture -- a total of 3 million acres statewide. The major crops under irrigation in Colorado are listed in Table 1. The status of surface water quality in some of the more intensively irrigated basins is briefly described.

Water Quality in the South Platte Basin

The South Platte river basin is the home of 68% of the state's population, and is also the most agriculturally productive region of the state. The South Platte watershed produces 88%

of the irrigated corn, 71% of the irrigated winter wheat, 86% of the irrigated dried beans, as well as a considerable percentage of other grains, cattle and vegetables (Colorado Agricultural Statistics Service 1991). Man's activities have impacted water quality more than in any other river basin in the state; hence, the South Platte basin is the most intensively monitored in the state. Most monitoring stations are located in the upstream tributaries of the river, however, away from the agriculturally-dominated regions. Exceedances of existing water quality standards for dissolved oxygen, un-ionized ammonia, fecal coliform, and trace metals have been identified. Phosphorus, nitrates, and dissolved solids concentrations are among the highest in the state. These conditions are due primarily to point discharges of treated municipal wastewaters into the river system. While urban wastewater contributors have significantly reduced fecal coliform in their effluent in the past few years, concentration levels exceeding 2000 colonies per 100 ml have been detected at times in the downstream reaches of the river. Data indicate that total dissolved solids, even in the downstream reaches of the river, currently are not high enough to pose hazards to crop production (Colorado Department of Health 1990, Mueller 1990).

Return flows from irrigated agriculture do not appear to contribute a significant amount of nutrients to the South Platte River. In fact, measured phosphorous and nitrogen levels generally decrease in the downstream direction. It has been documented that nitrogen and phosphorus concentrations are highest just downstream of discharge points of large municipal wastewater treatment plants (Colorado Department of Health 1990).

In the South Platte River system, about 1.2 million acre-feet of runoff occurs annually and about 0.37 million acre feet are imported, primarily by the Colorado-Big Thompson project which conveys water from the western slope across the continental divide to the eastern slope region of the state. Total water use in the basin is estimated at about 4.6 million acre-feet, indicating a reuse intensity of about 300% (CWRRI 1990). One reason is that only a small fraction of all water diverted for in-house domestic purposes is consumed; most is returned to the river system (Porzak 1986). The fraction of the river's flow that is made up of treated municipal sewage is telling. Comparison of streamflow and diversion records of the United States Geological Survey (USGS) and the Colorado Division of Water Resources with Metro Wastewater Reclamation District's records of measured effluent indicate that large fractions of the flow in Segment 15 of the river (from just downstream of Denver extending 26 miles north to Fort Lupton) are composed of secondary-treated effluent. During the recent three-year period of 1988-1990, effluent from Metro Wastewater Reclamation District made up from about 14% to about 53% of the monthly average flow rate in Segment 15 during the irrigation season (March to September). Data also indicate that daily average flows in the segment during the irrigation season were as high as 85% treated wastewater. For this same period, monthly average flows in the off-season (October to February) were composed of about 21% to 75% treated sewage effluent.

Numerous irrigation supplies are diverted from the South Platte River immediately downstream of Denver. The Colorado Department of Health requires a permit for reuse of effluent directly from a municipal sewage treatment plant. However, no permit is required for

Table 1. Major Crops Under Irrigation in Colorado, 1990

Field Crops	Area Irrigated (acres)
Corn (grain)	804,000
Alfalfa	650,000
Other Hay	550,000
Dry Beans	190,000
Wheat (winter)	150,000
Barley	126,000
Sorghum	64,000
Sugar Beets	40,000
Wheat (spring)	31,500
Oats	27,000

Major Fruits: apples, pears, peaches, tart cherries.

Major Vegetables: onions, lettuce, sweet corn, carrots, cucumbers, tomatoes.

water diverted from streams for irrigation purposes, even if the point of diversion is immediately downstream from municipal sewage outfalls which dominate the streamflow.

The South Platte is not the only river with water quality concerns. The Arkansas River in the southeastern part of the state has a few problems as well.

Water Quality in the Arkansas Basin

The Arkansas River basin is home to about 20% of Colorado's population. The upper river is in the mountains, near the town of Leadville, where little irrigated agriculture takes place and where the main water quality problem is the result of metals leaching from abandoned mines. There are approximately 300,000 acres under irrigation in the lower Arkansas River valley (Cain 1985) where 25% of Colorado's irrigated winter wheat, 71% of its irrigated sorghum, 23% of its alfalfa, as well as a variety of vegetables, are grown (Colorado Agricultural Statistics Service 1991).

Fecal coliform problems have been detected in the lower Arkansas basin in Fountain Creek (Cain and Edelman 1986) below Colorado Springs, and in the main stem downstream from Pueblo (Cain 1985). Water quality data indicate that concentrations of calcium, manganese, and bicarbonates decrease proceeding downstream from the Pueblo wastewater treatment plant while specific conductivity (a measure of total dissolved solids), sodium, chloride, sulfate and total suspended solids increase due primarily to surface and groundwater return flows from irrigation (Cain et al. 1980; Cain 1985). The source of fecal coliform in the lower Arkansas is unclear since there are several wastewater treatment plants and the nonpoint source contribution has not been quantified. With respect to municipal discharges, no violation of dissolved oxygen or un-ionized ammonia standards for aquatic life occurred between 1984 and 1989. High nutrient levels have been detected downstream of municipal wastewater plants. As in the South Platte basin, agriculture does not appear to be a significant contributor of nutrients (Colorado Department of Health 1990). A detailed study near the city of Lamar concluded that dissolved nitrite plus nitrate was less concentrated in water leaving the study area than in the applied irrigation water, suggesting removal during the irrigation/plant extraction processes (Cain 1985). The same conclusion was made about Fountain Creek (Cain and Edelman 1986).

Fountain Creek, a tributary of the Arkansas River below Colorado Springs, is another classic example of a stream affected by large wastewater flows. During the period 1977-1982 the flow in Fountain Creek below the Colorado Springs Wastewater Treatment Plant consisted of greater than, or equal to, 54% effluent from the plant about 67% of the time. Downstream, where virtually all of the land is surface irrigated, there were increases in specific conductivity, all major inorganics (including boron), lithium, selenium, strontium, and uranium. This suggests that these contaminants came from agricultural return flows. However, it was also observed that nitrates, nitrites, nickel, magnesium, and barium decreased in the downstream direction (Cain and Edelman 1986). Canal No. 4, an irrigation canal diverting 15 ft³/s to some small storage reservoirs, is located only 200 yards downstream from the outfall of the activated

sludge treatment plant. Complete mixing does not occur in the creek, so that most of the water in the canal is effluent (Loomis and Warner 1990).

A problem of growing concern in the Arkansas basin is salinity. Average annual concentration of total dissolved salts increases from 200 mg/L where flow leaves the mountains to 3500 mg/L where it crosses the Kansas state line (Cain 1987). This downstream salinization primarily results from accumulation of return flows from irrigated lands where concentration of salts occurs due to soil salt leaching and evapotranspiration. Such salinity levels pose moderate to severe threats to crop production (Maas and Hoffman 1977, Dinar et al. 1991).

Water Quality in the Colorado Basin

The Colorado River basin has the best water quality in the state due to low population density (7% of state total), little industry and generally excellent sewage treatment. The economy is based primarily on outdoor recreation so that the state has focused on maintaining high water quality. Most of Colorado's fruit crop, 23% of its irrigated alfalfa, and a variety of vegetables are grown in the basin. All segments of the river in Colorado have low nitrate and phosphorus concentrations. The wastewater effluent-dominated streams in eastern Colorado, such as the South Platte and Fountain Creek, generally have 100 times the phosphorus concentration of the upper Colorado River (Colorado Department of Health 1990). Even in the lower Colorado and the Uncompaghre River basins where extensive irrigation takes place, the concentrations of nutrients are low. Metal concentrations, especially copper, have plagued mountainous regions of the upper Colorado, but the problems do not extend to lower elevations where most of the irrigated agriculture is located. Though not a problem in that portion of the river that runs through the state of Colorado, irrigation-induced salinization is a grave concern downstream (El-Ashry et al. 1985).

Water Quality in the Rio Grande Basin

The Rio Grande River supplies water to the San Luis Valley where 64% of the state's irrigated barley, 91% of its irrigated spring wheat, and large amounts of oats and potatoes are grown (Colorado Agricultural Statistics Service 1991). Metals (lead, zinc, cadmium, copper) provide the major water quality impairment. They appear in the section of river that runs directly through the San Luis Valley. High arsenic levels are reported in some deep wells in the valley, but have not been reported in significant amounts in the river (Colorado Department of Health 1990). High concentrations of un-ionized ammonia have been detected in the segment of the river downstream of the wastewater discharge point from the city of Alamosa.

Water Quality in the San Juan and Republican Basins

The San Juan River basin produces 20% of the state's irrigated oats and 10% of the dry beans. It supports a small population and has no water quality problems with the exception of metals in the headwaters and high concentrations of suspended and dissolved solids along several segments.

The Republican River basin in eastern Colorado has few people, supports a small amount of surface irrigation (most irrigation in the region is supplied by groundwater wells) and has no point source water quality problems.

In summary, from a municipal wastewater effluent standpoint, the primary issues of concern at this time, based on Colorado's current water quality standards, are the South Platte and Arkansas River basins. The specific problem areas are below Denver on the South Platte river, below Colorado Springs on Fountain Creek and below Pueblo on the main stem of the Arkansas river, where fecal coliform levels have commonly exceeded 2000 CFU/100 ml (USGS 1989).

Toward a Water Quality Criteria for Colorado Agriculture

The first guidelines for agricultural water quality in the United States were recommended by the Federal Water Pollution Control Administration (1968). They were succeeded by agricultural guidelines in the Environmental Protection Agency's (EPA) *Water Quality Criteria - 1972* developed by the National Academy of Sciences (1973) and EPA's *Quality Criteria for Water* (EPA 1976). Perhaps the most comprehensive study on agricultural water quality was reported in 1985 for the Food and Agriculture Organization (FAO) of the United Nations (Ayers and Westcot 1985). Also, considerable work in agricultural water quality has been done in Australia (Smith 1982, Hart 1982, McNeill 1985).

In 1973 the World Health Organization (WHO) developed international standards for the direct reuse of municipal effluent (WHO 1973). Israel adopted reuse standards in 1981 (Bouwer and Idelovitch 1987). At least eight states in the United States have developed water quality criteria for the direct reuse of municipal wastewater for agriculture.

Current Colorado standards for contaminants in agricultural waters (Code of Colorado Regs. 12CR9, 9-89) based on the EPA's 1972 and 1976 water quality criteria standards are shown in Table 2. Colorado has no microbial guidelines (i.e. bacteria, protozoa, helminths and viruses) for agricultural use of raw water as well as recycled wastewater in sprinkler or surface irrigation of food crops (Task Force for Water Reuse 1989). Also, no standards currently exist for pH, total dissolved solids and several ions and trace elements.

Several water quality constituents of interest to Colorado agriculture are discussed in the following sections. Recommendations for amendments to current state standards, based on recent research and practice, are presented.

Table 2. Current Colorado Water Quality Standards for Agriculture

Constituent	Standard
Microbial Constituents	
Fecal Coliforms	No standard
Viruses	No standard
Helminths	No standard
Protozoa	No standard
Dissolved Solids	No standard
Sodium	No standard
Chloride	No standard
Boron (30 day)	0.75 mg/l
Nitrogen (total)	No standard
Nitrate (1 day)	100 mg/l
Nitrite (1 day)	10 mg/l
Phosphorus	No standard
Cyanide (free)	0.2 mg/l
Fluoride	No standard
Dissolved Oxygen	3.0 mg/l
Trace Elements	
Aluminum	No standard
Arsenic	0.10 mg/l
Barium	No standard
Beryllium	0.10 mg/l
Cadmium	0.01 mg/l
Chromium III	0.10 mg/l
Chromium IV	0.10 mg/l
Copper	0.20 mg/l
Iron	No standard
Lead	0.10 mg/l
Manganese	0.10 mg/l
Mercury	No standard
Molybdenum	No standard
Nickel	0.20 mg/l
Selenium	0.02 mg/l
Silver	No standard
Vanadium	No standard
Zinc	2.0 mg/l
Alkalinity	
Bicarbonates	No standard
pH	No standard

Microbial Contaminants

Disease can be transferred by wastewater to the agricultural environment through a variety of routes. Direct contact by farm workers may result in ingestion or inhalation. Workers routinely handle contaminated vegetation and surfaces. Consumers may eat produce contaminated with active pathogens. Livestock can ingest disease causing agents. However, before a disease would be apparent, a pathogen would have to survive the municipal sewage treatment process, persist in the environment, and be present in sufficient numbers to cause disease.

A variety of pathogens can be isolated from wastewater. They fall into four categories: bacteria, protozoa, helminths, and viruses. A list of pathogens potentially present in raw domestic wastewater and the diseases they can cause is presented by Crook (1986). There are numerous cases where untreated effluent has caused disease in agricultural workers and consumers, but little evidence exists that secondary-treated effluents have caused disease outbreaks (McNeill 1985, Crook 1986, Pettygrove et al 1985, Shuval 1977, Shuval 1987, Shende et al. 1988).

Primary treatment usually removes less than 50% of coliforms and pathogenic bacteria from sewage, and is relatively ineffective in removing viruses and protozoa (Crook 1985). Secondary treatment reduces the density of infectious agents (Sorber 1985), but does not produce an effluent free of infectious agents. Disinfection with chlorine or ozone improves the microbiological quality of a secondary effluent with respect to bacteria, but protozoan cysts (including giardia lamblia), helminth ova, and enteric viruses are not totally inactivated by disinfection as commonly practiced today. Even with an average reduction of viruses in treated sewage of 98.8%, "human sewage is the most potent source of human pathogenic viruses capable of contaminating the environment of today's civilized communities" (Slade and Ford 1983).

The epidemiological data currently available does not "conclusively" correlate wastewater aerosols with a public health risk (McNeill 1985). No actual disease outbreaks have been specifically attributed to wastewater aerosols, but the occurrence of viral and bacterial pathogens in them has been demonstrated (Crook 1986, Camann et al. 1988). The question of conclusive implication of aerosols as a health hazard awaits additional research and observation. However, the answer is becoming increasingly important on lands irrigated through sprinklers with mixes of treated wastewater effluent.

Irrigation with reclaimed wastewater in California has not resulted in any confirmed disease outbreaks, even though wastewater has been applied to land for several decades (Pettygrove et al. 1985). The key word here is "confirmed". With today's technology it is difficult to identify viruses, let alone "confirm" that they caused a specific outbreak of disease (Crook 1985).

Since, during the irrigation season, a sizeable fraction of the flow in the South Platte and Arkansas rivers consists of municipal sewage effluent, it would seem prudent to adopt the same quality standards for irrigating with raw surface water diversions as would exist for direct reuse of municipal sewage effluent. Thirteen states, including Colorado, have some sort of microbiological guidelines for the reuse of wastewater for parks, playgrounds, golf courses, cemeteries, open spaces, etc. At least seven of those states, but not Colorado, have guidelines for agricultural reuse of wastewater.

Arizona has developed reclaimed water standards that reflect research in toxicology (Arizona Department of Health Services 1983). These standards could be adopted as basic microbial water quality criteria for Colorado agricultural waters (Table 3). In the proposed standards a fecal coliform level of 1000 CFU/100 ml (geometric mean of 5 samples) is the highest level permissible for any agricultural reuse. The current Colorado standard for fecal coliform for domestic water supplies is 2000 CFU/100 ml (before treatment). For primary recreation, like swimming, the Colorado standard is 200 CFU/100 ml. For secondary recreation (non-water contact), it is 2000 CFU/100 ml.

In the Code of Colorado Regulations it is stated that "fecal coliform counts from agricultural and urban runoff may not indicate organisms detrimental to human health " (Code of Colorado Regulations 1989). Though fecal coliform is merely an indicator of possible health risk, it is a widely accepted indicator. In the absence of a better test it would seem wise to err on the side of safety. Since farm workers are subject to frequent exposure to water during the irrigation process, a 1000 CFU/100 ml standard seems a reasonable standard for agricultural diversions.

Adoption of the Arizona reuse standards for Colorado agricultural diversions would mean that occasionally reaches of the South Platte and Arkansas rivers would not meet standards for *any* agricultural use. The 2.2 CFU/100 ml (geometric mean of 5 samples) standard for food eaten raw (e.g. carrots, tomatoes, celery, lettuce) is used in both Arizona and California for reused wastewater (Crook 1985). Such a standard would be virtually unattainable in any of Colorado's subalpine streams without tertiary treatment. Recent analyses by Blum and Feechem (1985) and Shuval et al. (1986) suggest that such restrictions are overly conservative. Accordingly, recent guidelines presented by the World Health Organization (WHO Scientific Group 1989) recommend a standard of 1000 CFU/100 ml for general irrigation of crops likely to be eaten raw. However, the authors of the report emphasize that their guidelines are based upon existing epidemiological evidence rather than potential health risk. Until more conclusive data have been presented regarding the health hazards of irrigating raw vegetable crops with sewage-tainted waters, we have adopted the risk-averse posture of the Arizona and California criteria for implementation in Colorado.

Salinity, Sodium, Chloride and Boron

A large portion of the world's irrigated land is subjected to a process which threatens productivity -- salinization. It has been estimated that 1 to 1.5 million hectares of mostly prime

**Table 3. Proposed Criteria for Microbial Constituents in
Water Diverted to Agriculture in Colorado**

Constituent	Allowable Limits for Specific Uses					
	Orchards	Fiber, Seed, and Forage	Pasture	Livestock Watering	Processed Food	Food Consumed Raw
Fecal Coliforms (CFU/100 ml)						
Geometric Mean (5 Samples)	1000	1000	1000	1000	1000	2.2
Single Sample	4000	4000	4000	4000	2500	25
Enteric Virus	--	--	--	--	--	PFU/40 l
Entamoeba Histolyst	--	--	--	--	--	None Detectable
Giardia Lambliia	--	--	--	--	--	None Detectable
Ascaris Lumbricoides	--	--	--	--	--	None Detectable
Common Tapeworm	--	--	None Detectable	None Detectable	--	--

agricultural land are being destroyed through man-induced salinization each year (Kovda 1983). Tanji (1990) indicated that 23% of the cultivated lands in the world are saline and another 37% are sodic. Frederick and Hanson (1982) estimated that between 25 and 35% of irrigated land in the western United States is seriously affected by salt. In Colorado, salinity is a problem in the lower Arkansas basin and in selected locations in the Rio Grande basin.

All waters contain salts, primarily in the form of chlorides, sulfates and bicarbonates of sodium, calcium, magnesium and potassium. Municipal and industrial wastewaters commonly contain 200 to 800 mg/l more salts than the water supplies from which they come (Metcalf & Eddy 1979, Asano et al. 1985, Feigin et al. 1991). Though the total dissolved salts added to effluents through municipal use is usually not large, it may be enough to diminish the suitability of the water for some agricultural uses.

The storage, distribution and use of water diverted for irrigation causes significant increases in salt concentrations. Water stored in reservoirs and conveyed through long reaches of canals becomes more saline as evaporation occurs. After application to fields, water is lost through both evaporation and crop transpiration, leaving salts behind which can accumulate over time and cause a decline in agricultural productivity. High soil salinity limits the availability of root extractable soil water and may result in ion toxicity to the crop (Bernstein 1974). Data on the tolerance of major irrigated crops in Colorado to soil water salinity concentrations is summarized in Table 4 (Maas 1986, Franklin and Follet 1985). Dinar et al. (1991) presented equations for predicting crop yield responses to salinity of irrigation water.

To leach salts from the crop root zone, water must be applied in excess of that required to fill the water deficit in the soil for crop consumptive use. Salts in the water passing through the soil profile are transported downward out of the root zone. When restrictive soil layers are present in the profile, natural drainage is impeded and shallow perched aquifers often form, a problem that is growing in parts of Colorado. As irrigation continues, the water table rises and accentuates the problem of salinity in the root zone due to upward movement of saline water in response to the gradient induced by evapotranspiration. Eventually, the water table may rise to invade the root zone of the crop, causing poor soil aeration. Thus, a "vicious cycle" is established: more water is applied to leach increasing soil salinity thereby maintaining a saline high water table which in turn aggravates soil salinity and causes waterlogging. Even where the water table is deep, salinity concentrations in the underlying groundwater will increase and salts will be transported by the groundwater flow field. Eventually, the integrity of adjacent aquifers and streams may be threatened with salinity contamination (Gates and Grismer 1989, Grismer and Gates 1991).

Though problems in the field can be prevented and controlled by chemical treatment of the soil, planting salt tolerant crops, specialized bedding and seed placement, and careful management of irrigation and drainage (Ayers and Westcot 1985, Follet and Franklin 1985, Gates and Grismer 1989) an important and often lower cost alternative is to minimize salinity concentrations at the source. Salinity problems in an irrigated region are exacerbated by poor

Table 4. Affect of Salinity on Yield of Major Irrigated Crops in Colorado
(Maas 1986, Franklin and Follet 1985)

Field Crops

	Salinity Levels (dS/m) Effecting Different Relative Yield Reduction (%)			
	0%	10%	25%	50%
Barley	8	10	13	18
Sugar Beet	7.0	8.7	11	15
Wheat	6.0	7.4	9.5	13
Sorghum	4.0	5.1	7.2	11
Corn	1.7	2.5	3.8	5.9
Fieldbean	1.0	1.5	2.3	3.6

Forage Crops

	Salinity Levels (dS/m) Effecting Different Relative Yield Reduction (%)			
	0%	10%	25%	50%
Tall wheatgrass	7.5	9.9	13.3	19.4
Wheatgrass	7.5	9.0	11	15
Crested wheatgrass	3.5	6.0	9.8	16
Barley hay	6.0	7.4	9.5	13
Perennial ryegrass	5.6	6.9	8.9	12.2
Tall fescue	3.9	5.8	8.6	13.3
Beardless wildrye	2.7	4.4	6.9	11.0
Sweet clover	1.5	3.2	5.9	10.3
Orchardgrass	1.5	3.1	5.5	9.6
Vetch	3.0	3.9	5.3	7.6
Alfalfa	2.0	3.4	5.4	8.8
Corn fodder	1.8	3.2	5.2	8.6
Lovegrass	2.0	3.2	5.0	8.0
Meadow foxtail	1.5	2.5	4.1	6.7
Clover (alsike, red, ladino, strawberry)	1.5	2.3	3.6	5.7

Table 4. Affect of Salinity on Yield of Major Irrigated Crops in Colorado
(Maas 1986, Franklin and Follet 1985) (Continued)

Vegetable Crops	Salinity Levels (dS/m) Effecting Different Relative Yield Reduction (%)			
	0%	10%	25%	50%
Broccoli	2.8	3.9	5.5	8.2
Tomato	2.5	3.5	5.0	7.6
Cucumber	2.5	3.3	4.4	6.3
Cantaloupe	2.2	3.6	5.7	9.1
Potato	1.7	2.5	3.8	5.9
Sweet Corn	1.7	2.5	3.8	5.9
Pepper	1.5	2.2	3.3	5.1
Lettuce	1.3	2.1	3.2	5.2
Radish	1.2	2.0	3.1	5.0
Onion	1.2	1.8	2.8	4.3
Carrot	1.0	1.7	2.8	4.6
Beans	1.0	1.5	2.3	3.6
Fruit Crops	Salinity Levels (dS/m) Effecting Different Relative Yield Reduction (%)			
	0%	10%	25%	50%
Apple	1.7	2.3	3.3	4.8
Pear	1.7	2.3	3.3	4.8
Plum	1.5	2.1	2.9	4.3
Peach	1.7	2.2	2.9	4.1

quality water flowing in at the diversion, which can occur in part due to the presence of wastewater effluent.

Some specific ions pose special problems to crops and soils. The ions most prevalent in effluent waters which are of concern are sodium, chloride and boron. Sodium (Na^+) present in irrigation waters can accumulate in the soil causing sodium toxicity and nutritional imbalance through impaired availability of calcium or potassium (Bernstein 1964). Pearson (1960) described crop tolerance to exchangeable sodium percentage under nonsaline conditions. The most prevalent problems caused by excess sodium, however, are associated with damage to soil physical properties resulting in poor aeration and inadequate water availability. The effect of sodium on soils is a complex issue based on the sodium content relative to the calcium and magnesium content in both soil and water (Ayers and Westcot 1985). This relationship is described by the Sodium Adsorption Ratio (SAR). When calcium and magnesium are low relative to sodium, the storage and transmissive properties of soils, such as permeability, are impaired due to altered geometry and continuity of soil pores. The magnitude of the sodicity effect is also dependent on the total salinity of the soil solution (Oster et al. 1984). Young calcareous soils such as those found throughout Colorado are sometimes able to release salts fairly rapidly so that permeability can be maintained at acceptable levels (Rolston 1984).

Chloride, like sodium, can be toxic to some plants in sufficient concentrations. The degree of toxicity is variable. Woody perennial fruit trees, green beans, and onions are particularly susceptible (Ayers and Westcot 1985, Maas 1986). Irrigation waters with concentrations as low as 300-900 mg/l may produce hazards for such crops. Peaches are probably the most susceptible Colorado crop.

Though boron is an essential nutrient for most crops it can prove toxic in concentrations as low as 0.2 mg/l. There is a wide range of tolerances to boron toxicity among crops. Important irrigated crops in Colorado which are sensitive to boron (0.5-1.0 mg/l soil water concentration before yield reduction) include dry beans, wheat, onions, peaches and cherries. Carrots, cucumbers and potatoes are moderately sensitive (1.0-2.0 mg/l soil water concentration) and barley, oats, corn and lettuce are moderately tolerant (2.0-4.0 mg/l) (Maas 1986).

According to Feigen et al. (1991) sodium levels in secondary municipal wastewater effluent typically range from 50-250 mg/l. Concentrations added to effluent waters through municipal use typically range from 40-70 mg/l for sodium, 20-50 mg/l for chloride and 0.1 to 0.4 mg/l for boron (Metcalf and Eddy 1991, Asano et al. 1985). Hence, under appropriate hydrologic and chemical conditions, wastewater effluent added to Colorado streams may raise concentrations to levels of concern to agriculture.

Currently, no standards have been adopted in Colorado for regulating salinity, sodium, chloride or boron concentrations in agricultural diversions. As discussed above, the hazards posed by these constituents vary depending on particular conditions. However, the criteria summarized in Table 5 (Ayers and Westcot 1985, Maas 1986, Task Force on Water Reuse 1989) seem appropriate guidelines for the range of conditions anticipated in Colorado.

Table 5. General Guidelines for Interpretation of Water Quality Constituents with Variable Impacts on Irrigated Soil-Crop Systems in Colorado
(Ayers and Westcot 1985, Maas 1986, Task Force on Water Reuse 1989)

Potential Problem	Units	Degree of Restriction of Use		
		None	Moderate	Severe
Salinity	dS/m	<0.7	0.7 - 3.0	>3.0
	mg/l	<450	450-2000	>2000
Impaired Permeability				
SAR = 0-3	and dS/m =	>0.7	0.7 - 0.2	<0.2
= 3-6		>1.2	1.2-0.3	<0.3
= 6-12		>1.9	1.9-0.5	<0.5
= 12-20		>2.9	2.9-1.3	<1.3
= 20-40		>5.0	5.0-2.9	<2.9
Specific Ion Toxicity				
Sodium				
Surface irrigation	SAR	<3	3-9	>9
Sprinkler irrigation	mg/l	<70	>70	
Chloride				
Surface irrigation	mg/l	<140	140-350	>350
Sprinkler irrigation	mg/l	<100	>100	
Boron	mg/l	<0.5	0.5-4.0	>4.0
Trace Elements (see Table 6)				
Nitrogen (Total N)*	mg/l	<5	5-30	>30
Alkalinity				
Bicarbonates	mg/l	<150		
pH		6.5-8.4		

* Affected plants only (see text)

Nitrogen

Municipal sewage effluent contains nitrogen (N) in four major forms: NO_2^- , NO_3^- , NH_4^+ , and organic. Total nitrogen concentrations in secondary-treated effluent commonly range from 10-40 mg/l. About 80% of this nitrogen is in the form of NH_4^+ which typically occurs in concentrations of 1-40 mg/l. Concentrations of N-NO_3^- and N-NO_2^- usually range from 0-10 mg/l and 0-1 mg/l, respectively (Thomas and Law 1977, Pound and Crites 1973).

Nitrogen is an essential nutrient for crop growth and is usually added in large quantities to agricultural land as a fertilizer. Irrigation waters that are partly composed of secondary sewage effluent may contain high nitrogen concentrations. Irrigations not properly managed in conjunction with fertilizer applications can produce undesirable effects in such cases: e.g. too much vegetative growth and not enough fruit and seed production, delayed maturity and harvestability, reduced flavor and poor texture (fruits and vegetables), reduced sugar content (sugar beets), or reduced starch content (potatoes) (Task Force on Water Reuse 1989, Bouwer and Idelovitch 1987). Crops grown in Colorado which are most affected by excess nitrogen are sugar beets, tomatoes, potatoes, peaches, apricots and apples. Experiments by Feigin et al. (1978) revealed a large reduction in the sucrose level of sugar beets due to uptake of large amounts of nitrogen derived from sewage effluent. The Northern Colorado Water Conservancy District recently began a cooperative study with the Western Sugar Company to determine how the quality of sugar beets is affected by N-NO_3^- in irrigation water in the South Platte basin (Northern Colorado Water Conservancy District 1991).

Criteria for total nitrogen based on crop tolerance are given in Table 5 (Ayers and Westcot 1985, Task Force on Water Reuse 1989). In general, total nitrogen concentrations below 5 mg/l present no problems while concentrations exceeding 30 mg/l may cause severe damage to susceptible plants. However, evidence from the study conducted by Western Sugar Company may suggest that *any* nitrogen applied to sugar beets in the second phase of the growing cycle, usually after July 1 in Colorado, is harmful to the grower and processor of sugar beets.

Though sewage effluents are dominated by nitrogen in the form of NH_4^+ , transformation to the nitrate (NO_3^-) form takes place in agricultural soils through nitrification. Loss of nitrates to underlying groundwater by leaching through the root zone can be large. Accumulation of highly soluble nitrates in aquifers and their subsequent flow to adjacent streams is of concern since high concentrations pose dangers to human and animal health if ingested (the nitrite (NO_2^-) form also poses a danger to livestock health when in excess quantities). Concentrations of nitrite and of total nitrate plus nitrite (as N) for watering livestock should not exceed 10 mg/l and 100 mg/l, respectively (National Academy of Sciences 1972). In addition, high concentrations of nitrates in surface waters enhance the proliferation of algae blooms which diminishes potable quality and can pose maintenance problems to irrigation structures. In recent years increased attention has been given to establishing standards and controls for nitrate concentrations in agricultural return flows. What must be kept in mind, however, is the contribution to the problem made by nitrogen present in agricultural diversions containing sewage effluent.

Phosphorus

Phosphorus, like nitrogen, is a nutrient essential to crop growth and enhanced crop yields. Secondary sewage effluent often contains fairly high concentrations of phosphorus, typically ranging from 6-17 mg/l (Pound and Crites 1973) but seldom exceeding 20 mg/l (Ryden and Pratt 1980). Excessive phosphorus has not been shown to cause significant problems for most soils and crops (Ayers and Westcot 1985, Bouwer and Idelovitch 1987). However, when amounts exceeding those typically applied through fertilization accumulate in the soil, micronutrient (e.g. copper, iron and zinc) deficiencies may result (Ryden and Pratt 1980). No clear criteria for upper limits on phosphorus concentrations can be offered at this time.

Alkalinity and pH

The alkalinity of irrigation waters is defined by the concentration of bicarbonate (HCO_3^-) and carbonate (CO_3^{2-}) ions. Most sewage effluent is dominated by the bicarbonate ion associated with pH values less than 8.4. Alkalinity, determined as calcium carbonate (CaCO_3), of secondary municipal effluents usually ranges from 200-700 mg/l.

Since bicarbonates and carbonates tend to precipitate with the calcium ion, they increase the SAR and aggravate soil sodicity problems. Bicarbonates and carbonates may also tie up micronutrients in the soil, reducing their availability to plants. In concentrations exceeding 150 mg/l, bicarbonates can physiologically damage plant roots causing a reduction in nutrient absorption (California Fertilizer Association 1985, Wallace 1992).

High values of pH (> 8.4) of soil waters, while not a problem in themselves, are indicative of the types of alkalinity problems described above. On the other hand, acidic conditions indicated by pH values less than 6.5 also present problems (Ayers and Westcot 1985).

Trace Elements

Trace elements (silver, arsenic, boron, barium, cadmium, cobalt, chromium, copper, mercury, manganese, molybdenum, nickel, lead, selenium, tin, vanadium, and zinc) are present in relatively small amounts in natural surface waters. Their concentration is multiplied in municipal wastewater (both in sewage effluent and storm runoff), being much higher in wastewaters derived from industrial processes than those derived from domestic use (Page et al. 1981). Range and median concentrations of trace elements commonly found in secondary effluents are given in Feigin et al. (1991). Irrigation with waters contaminated with secondary-treated wastewater effluents usually does not pose significant problems over the short term. Long-term accumulation, however, can result in toxicity to soil-plant systems and should be monitored.

Many trace elements (iron, manganese, zinc, copper, molybdenum and boron) are essential to plant growth in small amounts. It is recognized that trace elements are readily bound up in the soil matrix, especially in basic ($\text{pH} > 7.0$) soils. This process is largely irreversible.

Repeated applications of trace elements in excess of plant needs eventually can contaminate the soil-plant system, diminishing crop productivity. More than 85% of trace elements accumulate in a soil and most accumulate in the top 20 cm of the soil surface. Although plants extract trace elements from the soil, the uptake is small and cannot be expected to reduce appreciably the amount present in the soil profile (Ayers and Westcot 1985). Metal accumulation within plants grown using sewage effluent has been found to pose no health risk to consumers (Smith 1982).

Current Colorado standards for trace elements are based on those prescribed by Pratt (1972). The intent of these suggested limits were to ensure that the soil could remain productive for all potential crops in the future. Further studies have indicated that irrigation with a typical treated municipal wastewater could occur for hundreds to thousands of years before the accumulation of trace elements in the soil would reach the current upper limits for soil deposition (Page and Chang 1985). Hart (1982) thoroughly reviewed Pratt's (1972) standards for 10 trace elements, agreed with the limits set on 8 of them and raised the allowable limits on chromium and lead. Pratt's criteria have been criticized for the huge discrepancy between agricultural standards for beryllium, copper, and zinc and the corresponding aquatic biota standards adopted by the U.S. Environmental Protection Agency (Burau 1986). Overall, however, Pratt's (1972) standards appear justifiable.

Follet et al. (1991) reported that 85% of samples taken from cropland across the state of Colorado have a pH greater than 7.0. This basic soil condition tends to mitigate the toxicity problem associated with many trace metals, especially aluminum, cobalt, iron, manganese, nickel and zinc (Ayers and Westcot 1985) as there is a tendency to precipitate out of solution.

Selenium (Se) is a trace element that has drawn particular attention in recent years due to toxic accumulations in California's San Joaquin Valley. In December, 1988 the *Sacramento Bee* newspaper published a special report on the dangers of selenium and reported high levels of selenium in the Grand Valley of western Colorado. The *Rocky Mountain News* in Denver picked up the story and warned consumers about purchasing western Colorado produce as a result. An extensive study performed by the Colorado Agricultural Experiment Station in 1989 which revealed that all irrigation water samples taken were below the EPA limit of 0.02 mg/l. Furthermore, all soil samples indicated a safe and acceptable level of selenium (Follet et al. 1990).

Recommended criteria for trace element concentrations in irrigation water and livestock water are presented in Table 6. Further classification of livestock tolerances to dietary trace elements for cattle, sheep, swine and chicken may be found in the National Research Council (1980).

Conclusion and Recommendations

Competition between urban and agricultural interests for the limited water resources of Colorado's appropriated streams can be reduced through the use of transfer and exchange agreements. Such arrangements result in the replacement of higher quality water diverted for

**Table 6. Current and Recommended Water Quality Criteria
for Diversions to Agriculture in Colorado**

Constituent	Current Standard	Proposed Criteria for Irrigation	Proposed Criteria for Livestock
Microbial Constituents			
Fecal Coliforms	No standard	see Table 3 (S)	see Table 3 (S)
Viruses	No standard	see Table 3 (S)	see Table 3 (S)
Helminths	No standard	see Table 3 (S)	see Table 3 (S)
Protozoa	No standard	see Table 3 (S)	see Table 3 (S)
Dissolved Solids	No standard	see Tables 4,5 (G)	No standard
Sodium	No standard	see Table 5 (G)	No standard
Chloride	No standard	see Table 5 (G)	No standard
Boron (30 day)	0.75 mg/l	see Table 5 (G)	5 mg/l (S)
Nitrogen (total)	No standard	see Table 5 (G)	No standard
Nitrate (1 day)	100 mg/l	see Table 5 (G)	100 mg/l (S)
Nitrite (1 day)	10 mg/l	see Table 5 (G)	10 mg/l (S)
Phosphorus	No standard	No standard	No standard
Cyanide (free)	0.2 mg/l	0.2 mg/l (S)	0.2 mg/l (S)
Fluoride	No standard	1 mg/l (S)	2 mg/l (S)
Dissolved Oxygen	3.0 mg/l	No standard	No standard
Trace Elements			
Aluminum	No standard	5.0 mg/l (S)	5.0 mg/l (S)
Arsenic	0.10 mg/l	0.10 mg/l (S)	0.20 mg/l (S)
Barium	No standard	No standard	No standard
Beryllium	0.10 mg/l	0.10 mg/l (S)	0.10 mg/l (S)
Cadmium	0.01 mg/l	0.01 mg/l (S)	0.05 mg/l (S)
Chromium (Total)	No standard	1.0 mg/l (S)	1.0 mg/l (S)
Chromium III	0.10 mg/l	No standard	No standard
Chromium IV	0.10 mg/l	No standard	No standard
Copper	0.20 mg/l	0.20 mg/l (S)	0.50 mg/l (S)
Iron	No standard	5.0 mg/l (S)	No standard
Lead	0.10 mg/l	5.0 mg/l (S)	0.05 mg/l (S)
Manganese	0.20 mg/l	0.20 mg/l (S)	0.05 mg/l (S)
Mercury	No standard	No standard	0.001 mg/l (S)
Molybdenum	No standard	0.01 mg/l (S)	No standard
Nickel	0.20 mg/l	0.20 mg/l (S)	5.0 mg/l (S)
Selenium	0.02 mg/l	0.02 mg/l (S)	0.05 mg/l (S)
Silver	No standard	No standard	No standard
Vanadium	No standard	0.10 mg/l (S)	0.10 mg/l (S)
Zinc	2.0 mg/l	2.0 mg/l (S)	20 mg/l (S)
Alkalinity			
Bicarbonates	No standard	150 mg/l (S)	No standard
pH	No standard	6.5-8.4 (S)	6.5-8.4 (S)

(G) : Recommended as guidelines for agricultural water quality assessment and management

(S) : Recommended for adoption as regulatory standards by the state of Colorado

urban and industrial use with treated municipal wastewater effluent. Sewage effluent-contaminated streams contain concentrations of constituents that can significantly impair the soil-plant-animal systems of irrigated agriculture. Management to minimize or prevent such impairment requires the adoption of water quality criteria.

This report provides a scientific review of the latest research findings and policies regarding water quality criteria for irrigated agriculture. Major constituents of interest to Colorado are addressed and associated criteria are presented in Table 6. Several of the criteria must be interpreted subject to the variable physical and agroeconomic conditions in a river basin. For example, salinity levels that may be acceptable for the soils and crops at a given diversion point may be unacceptable at another point upstream. Such criteria can be used right away as guidelines for water quality assessment and management but are difficult to adopt as rigid regulatory standards. We have indicated these criteria as guidelines (G) in Table 6 and suggest that further study be done before prescribing associated standards. On the other hand, many of the criteria presented in Table 6 are well-established as relatively invariant limits. We indicate these criteria as standards (S) and recommend that Colorado water quality regulations be revised to include them.

Further studies are being conducted to define appropriate spatial and temporal statistical descriptions of each constituent and associated measures of water quality performance and exceedance of standards. Difficult questions regarding the implementation of the recommended criteria within regulatory and management contexts also must be addressed. The tension such issues create, particularly between competing economic interests, can be discomfoting. Nevertheless, in the long-term interest of sustaining Colorado agriculture and its benefits to the public, we put forward these recommendations for consideration.

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**DEPARTMENT of ENVIRONMENT
and NATURAL RESOURCES**

JOE FOSS BUILDING
523 EAST CAPITOL
PIERRE, SOUTH DAKOTA 57501-3181

OCT 1 1996

2360-2

Dan Bjerke
Public Works Director
City of Rapid City
300 6th St.
Rapid City, SD 57701

Dear Mr. Bjerke:

Enclosed is Water Permit No. 2360-2 authorizing the water diversion system and beneficial use of the water, not exceeding the limits as specified in the Water Permit.

Very truly yours,

JOHN HATCH, Chief Engineer
Water Rights Program
(605) 773-3352

Enclosure



**DEPARTMENT of ENVIRONMENT
and NATURAL RESOURCES**

JOE FOSS BUILDING
523 EAST CAPITOL
PIERRE, SOUTH DAKOTA 57501-3181
www.state.sd.us/denr

November 5, 1998

Daniel L Bjerke
City of Rapid City
300 6th St
Rapid City SD 57701-2724

Dear Mr. Bjerke:

The investigation of the City of Rapid City's water use systems was conducted on September 9, 1998, by Mark Rath, staff engineer. The investigation included the extent of application of water to beneficial use, as developed under each permit. The final water right documents, the Water Licenses, can now be issued. Below is a list of the permits that were investigated.

Permit No.	amount	source	
2136-2	0.78 cfs	Rapid Creek	Sioux Park
2138-2	12.38 cfs	Rapid Creek	Water Treatment Plant
* 2274-2	0.78 cfs	Rapid Creek	Water Treatment Plant
2156-2	1.11 cfs	Madison Formation	SW ¼ SE ¼ Sec 16-T1N-R7E
transfer the use of a portion of Rapid Creek flows			formerly known as
2142-2	0.62 cfs	Murphy Ditch	Tyler property
2199-2	0.05 cfs	Murphy Ditch	Pelle property
2201-2	0.13 cfs	Murphy Ditch	Long property
2217-2	0.33 cfs	South Side Ditch	Keller property
2218-2	2.16 cfs	South Side Ditch	Stromer property
2234-2	0.79 cfs	South Side Ditch	Eisenbraun property
2249-2	1.19 cfs	South Side Ditch	Weber property
2296-2	2.85 cfs	South Side Ditch	Jundt property
2316-2	0.81 cfs	Murphy Ditch	Morris property
2317-2	0.84 cfs	Hawthorne Ditch	Morris property
2360-2	0.37 cfs	South Side Ditch	Soetaert property
2397-2	0.59 cfs	South Side Ditch	Eisenbraun property
2399-2	0.75 cfs	Murphy & Little Giant Ditch	Wileman property

* license fee already submitted

Statutes require that we charge \$50.00 fee for the investigation and issuance of the each Water License. Upon receipt of the \$800.00 fee (16 permits x \$50) we will process the Water Licenses.

Please sent fee to: Dept. of Environment & Natural Resources, Water Rights Program, 523 E. Capitol, Pierre, SD 57501-3181. If you have questions, please contact us.

Sincerely,

Karen Schlaak
Water Rights Program
605 773-3352

RECEIPT

Water Rights Program

South Dakota Department of Environment and Natural Resources

Nº 415964

Pierre, December 9, 19 98

RECEIVED OF City of Rapid City, 300 6th St., Rapid City, SD 57701-2724
the following amount in fees for services rendered as provided for by law:

Fee for Application for Permit No. _____ to Appropriate Water, to construct
and to put water to beneficial use _____

Fee for Application for Permit No. _____ to Appropriate Water, for Future
Use _____

Fee to retain Future Use Permit No. _____ after period of seven years.

Fee for Inspecting Constructed Works, confirming beneficial use and issuing Water
License No. 2360-2

50 00

Fee for Filing Transfer Form _____

Fee for Filing Extension Request _____

Fee for _____

(Any Other Work Provided by Law)

Total

50 00

By _____
Chief Engineer

John Hatch 

Permit No. 2360-2
Cheyenne River - Water District

Report Of Examination Of Works

TO: Chief Engineer, Water Rights Program, DENR, Foss Bldg., Pierre, SD 57501

On, September 9, 1998, I made a thorough examination of the water use system constructed by City of Rapid City of 300 6th St, Rapid City SD holder of Permit No. 2360-2, bearing the priority of May 3, 1880 authorizing the diversion of 0.37 cu. ft. per second and an annual appropriation of 61.3 acre-feet if taken at Rapid City's municipal diversion points or 31.3 acre-feet if stored in Pactola Reservoir of the natural flow waters of surface water from Rapid Creek for municipal, industrial, commercial, common distribution system, rural water system, suburban housing, and domestic purposes, in Pennington County.

I have to report on the conditions of the same as follows:

A. Works used to divert the water:

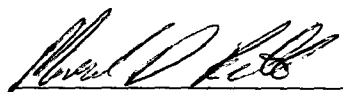
Pumps at the water treatment plant, Jackson Springs Gallery Sioux (aka Girl Scout) Gallery, Meadowbrook Gallery and storage in Pactola Reservoir.

The system is in the following condition good. The points of diversion are located in the SE1/4 NE1/4 Section 3 (Rapid City Water Treatment Plant); SW1/4 SW1/4 Section 3 (Sioux Park Gallery); SE1/4 NE1/4 Section 9 (Meadowbrook Gallery); NW1/4 SE1/4 Section 8 (Jackson Springs Gallery); all in T1N-R7E and NW1/4 SW1/4 Section 2 T1N-R5E (Pactola Reservoir). Pactola Reservoir impounds water in portions of Sections 2, 3, 4, 5, 10, 11 of T1N-R5E and Sections 31, 32, 33, 34 of T2N-R5E.

The permit holder is entitled to divert and convey to the place of use 0.37 cu. ft. per second of water and an annual appropriation of 61.3 acre-feet if taken at Rapid City's municipal diversion points or 31.3 acre-feet if stored in Pactola Reservoir which is to be used for municipal, industrial, commercial, common distribution system, rural water system, suburban housing, and domestic purposes. Water has been put to beneficial use to the maximum extent and the license should be issued for 0.37 cfs and an annual appropriation of 61.3 acre-feet if taken at Rapid City's municipal diversion points or 31.3 acre-feet if stored in Pactola Reservoir

Applicable permit qualifications have been complied with: yes

Exceptions to compliance are: none



Mark D. Rath
Natural Resources Engineer
DENR, Water Rights Program

9/29/98
Date

REPORT ON INSPECTION OF PERMIT NO. 2360-2

DATE OF INSPECTION: September 9, 1998

Contact Person & Address: John Wagner, 300 6th St, Rapid City SD 57701

DIVERSION POINT LEGAL LOCATIONS: are in the SE1/4 NE1/4 Section 3 (Rapid City Water Treatment Plant); SW1/4 SW1/4 Section 3 (Sioux Park a.k.a. Girl Scout Gallery); SE1/4 NE1/4 Section 9 (Meadowbrook Gallery); NW1/4 SE1/4 Section 8 (Jackson Springs Gallery); all in T1N-R7E and NW1/4 SW1/4 Section 2 T1N-R5E (Pactola Reservoir). Pactola Reservoir impounds water in portions of Sections 2, 3, 4, 5, 10, 11 of T1N-R5E and Sections 31, 32, 33, 34 of T2N-R5E.

WATER SUPPLY Source: Rapid Creek

WATER TREATMENT PLANT

Pump\ Motor:

- | | |
|---------------------------------------|------------------------------------|
| 1) Pump Make <u>Peerless</u> | 2) Model <u>258595</u> |
| 3) Capacity <u>5600</u> GPM | 4) Motor Make <u>GE</u> |
| 5) Model No. <u>5K405DP7011B FR2G</u> | 6) Horsepower rating <u>75</u> hp |
| | |
| 1) Pump Make <u>Layne Bowler</u> | 2) Model <u>14MSL</u> |
| 3) Capacity <u>2780</u> GPM | 4) Motor Make <u>US Electrical</u> |
| 5) Model No. <u>326UP</u> | 6) Horsepower rating <u>30</u> hp |
| | |
| 1) Pump Make <u>Vertiline</u> | 2) Model <u>27908</u> |
| 3) Capacity <u>5560</u> GPM | 4) Motor Make <u>US Electrical</u> |
| 5) Model No. <u>445UPY</u> | 6) Horsepower rating <u>60</u> hp |
| | |
| 1) Pump Make <u>Layne Bowler</u> | 2) Model <u>85522</u> |
| 3) Capacity <u>5875</u> GPM | 4) Motor Make <u>Louis Allis</u> |
| 5) Model No. <u>COG5B</u> | 6) Horsepower rating <u>60</u> hp |
| | |
| 1) Pump Make <u>Vertiline</u> | 2) Model <u>27989</u> |
| 3) Capacity <u>8000</u> GPM | 4) Motor Make <u>US Electrical</u> |
| 5) Model No. <u>CFU</u> | 6) Horsepower rating <u>100</u> hp |

SIOUX PARK (a.k.a. Girl Scout) GALLERY

Pump\ Motor:

- | | |
|---------------------------------|------------------------------------|
| 1) Pump Make <u>Worthington</u> | 2) Model <u>12H13501</u> |
| 3) Capacity <u>1400</u> GPM | 4) Motor Make <u>US Electrical</u> |
| 5) Model No. <u>324UP</u> | 6) Horsepower rating <u>25</u> hp |
| | |
| 1) Pump Make <u>Worthington</u> | 2) Model <u>12H13501</u> |
| 3) Capacity <u>1400</u> GPM | 4) Motor Make <u>US Electrical</u> |
| 5) Model No. <u>324UP</u> | 6) Horsepower rating <u>25</u> hp |

MEADOWBROOK GALLERY

Pump\ Motor:

- | | |
|---------------------------------|------------------------------------|
| 1) Pump Make <u>Worthington</u> | 2) Model <u>10QHA0</u> |
| 3) Capacity <u>1525</u> GPM | 4) Motor Make <u>US Electrical</u> |
| 5) Model No. <u>2743715</u> | 6) Horsepower rating <u>15</u> hp |
| | |
| 1) Pump Make <u>Worthington</u> | 2) Model <u>10QHA0</u> |
| 3) Capacity <u>1475</u> GPM | 4) Motor Make <u>US Electrical</u> |
| 5) Model No. <u>2745675</u> | 6) Horsepower rating <u>15</u> hp |
| | |
| 1) Pump Make <u>Worthington</u> | 2) Model <u>10QHA0</u> |
| 3) Capacity <u>1525</u> GPM | 4) Motor Make <u>US Electrical</u> |
| 5) Model No. <u>2744261</u> | 6) Horsepower rating <u>15</u> hp |

JACKSON SPRINGS GALLERY

Pump\ Motor:

- | | |
|-------------------------------------|-----------------------------------|
| 1) Pump Make <u>Fairbanks-Morse</u> | 2) Model <u>T4B242990A</u> |
| 3) Capacity <u>1390</u> GPM | 4) Motor Make <u>GE</u> |
| 5) Model No. <u>5K6258XH1A</u> | 6) Horsepower rating <u>75</u> hp |

Pump\ Motor:

- | | |
|-------------------------------------|------------------------------------|
| 1) Pump Make <u>Fairbanks-Morse</u> | 2) Model <u>T4B242992A</u> |
| 3) Capacity <u>2085</u> GPM | 4) Motor Make <u>GE</u> |
| 5) Model No. <u>5K6268XH1A</u> | 6) Horsepower rating <u>125</u> hp |

Pump\ Motor:

- | | |
|-------------------------------------|------------------------------------|
| 1) Pump Make <u>Fairbanks-Morse</u> | 2) Model <u>T4B242991A</u> |
| 3) Capacity <u>2085</u> GPM | 4) Motor Make <u>GE</u> |
| 5) Model No. <u>5K6258XH1A</u> | 6) Horsepower rating <u>125</u> hp |

PACTOLA RESERVOIR : This is a US Bureau of Reclamation dam with 55, 972 acre-feet of active storage

DISTRIBUTION LINES OR CANALS:

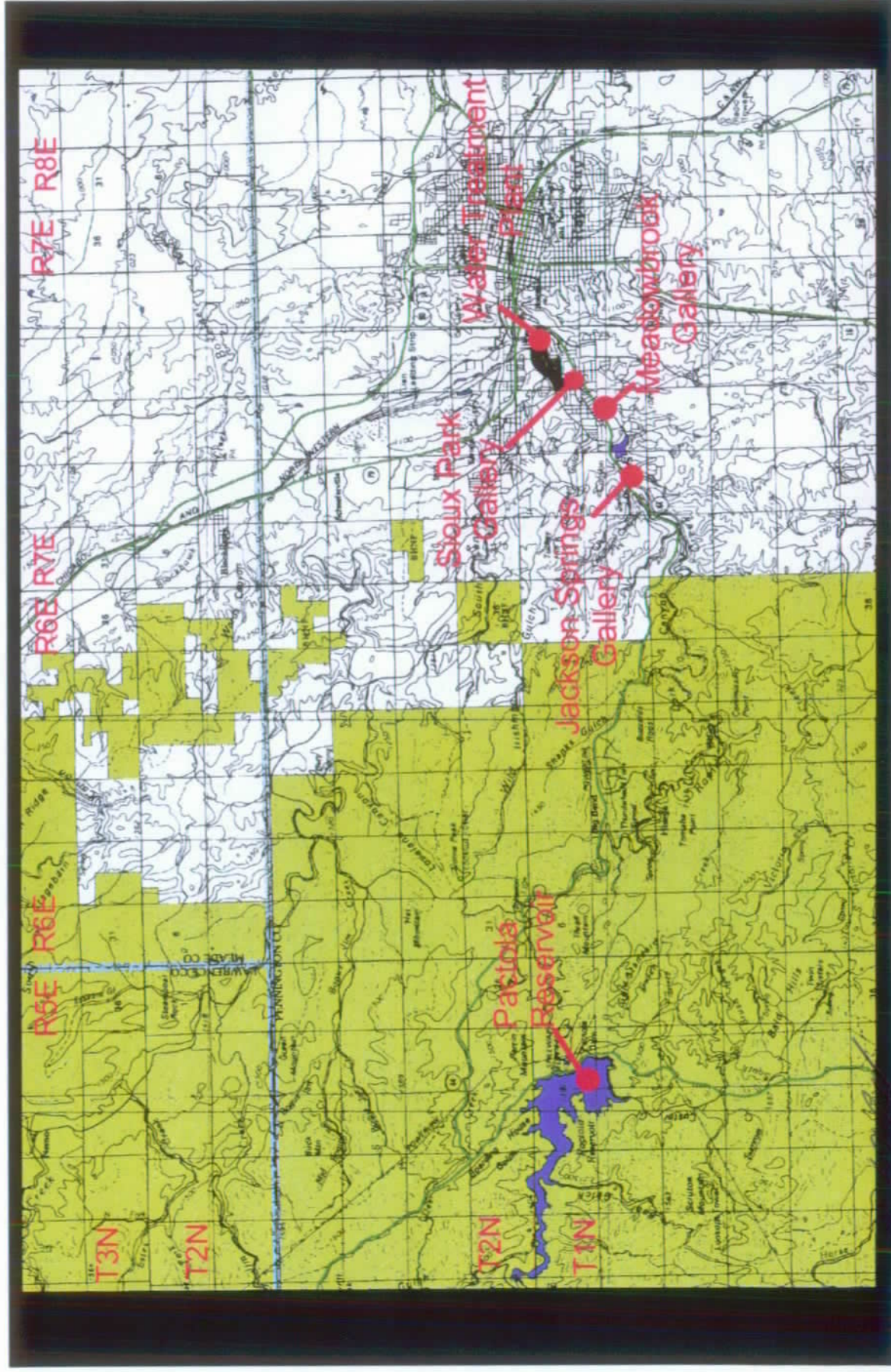
Municipal distribution system

PERMIT QUALIFICATIONS AND REGULATIONS:

- 1) Special qualifications to permit being abided by yes
- 2) All structures, wells and lands on map yes

COMMENTS: #

Area Map for Pactola Reservoir to Rapid City



Map 11-10-14
Pactola Reservoirs Feeder
9/28/98

STATE OF SOUTH DAKOTA

WATER LICENSE NO. 2360-2

(1) The City of Rapid City, 300 6th St, Rapid City SD 57701 made Application No. 2360-2, April 25, 1996 for a water permit to divert 0.37 cubic feet of water per second (cfs) from Rapid Creek with an annual volume limitation of 61.3 acre-feet, if diverted at the city's water treatment plant and infiltration galleries or 31.3 acre-feet, if stored in Pactola Reservoir, Pennington County, South Dakota for municipal, industrial, commercial, common distribution system, rural water system, suburban housing and domestic purposes. Permit No. 2360-2, with a priority date of May 3, 1880 (established by South Side Ditch) was approved July 10, 1996 and issued to the City of Rapid City for diversion of water with construction of the described water supply system and the application to beneficial use of said water completed.

(2) It is certified that the City of Rapid City has complied with the provisions of South Dakota State Law relating to completion of the construction of the water supply system and is entitled to divert 0.37 cfs from Rapid Creek with an annual volume limitation of 61.3 acre-feet, if diverted at the city's water treatment plant and infiltration galleries or 31.3 acre-feet, if stored in Pactola Reservoir for beneficial use. The location of the diversion points are: SE ¼ NE ¼ Section 3 (Rapid City Water Treatment Plant); SW ¼ SW ¼ Section 3 (Sioux Park Gallery); SE ¼ NE ¼ Section 9 (Meadowbrook Gallery); NW ¼ SE ¼ Section 8 (Jackson Springs Gallery); all in T1N-R7E and NW ¼ SW ¼ Section 2-T1N-R5E (Pactola Reservoir). Pactola Reservoir impounds water in portions of Sections 2, 3, 4, 5, 10, 11 of T1N-R5E and Sections 31, 32, 33, 34 of T2N-R5E.

(3) The City of Rapid City has complied with the provisions of South Dakota State Law relating to the application of water to beneficial use.

(4) Pursuant to South Dakota Water Law 46-5-30.1 the City of Rapid City, 300 6th St, Rapid City SD 57701 the holder and/or owner of Water Right No. 2360-2 is issued a license to appropriate water, the right to use 0.37 cfs from Rapid Creek with an annual volume limitation of 61.3 acre-feet, if diverted at the city's water treatment plant and infiltration galleries or 31.3 acre-feet, if stored in Pactola Reservoir with a priority date of May 3, 1880 (established by South Side Ditch) from the locations specified in (2) of this license for municipal, industrial, commercial, common distribution system, rural water system, suburban housing and domestic purposes. This license is subject to any limitations or qualifications listed in Water Right No. 2360-2 and subject to South Dakota State Law.



JOHN HATCH, Chief Engineer
Water Rights Program
Department of Environment and Natural Resources

JAN 15 1999

date





**DEPARTMENT of ENVIRONMENT
and NATURAL RESOURCES**

JOE FOSS BUILDING
523 EAST CAPITOL
PIERRE, SOUTH DAKOTA 57501-3181
www.state.sd.us/denr

JAN 15 1999

Daniel L Bjerke
City of Rapid City
300 6th St
Rapid City SD 57701-2724

Dear Mr. Bjerke:

Enclosed are the Water Licenses and receipts for the investigation and issuance of the water licenses. These water licenses are the final document which complete the process of obtaining a water right.

As long as the City of Rapid City uses the water beneficially, as stated in the water licenses, State Water Law provides that the City has a continuing right to use the water.

Very truly yours,

JOHN HATCH, Chief Engineer
Water Rights Program
605 773-3352

ks

enclosures



2360-2
DEPARTMENT of ENVIRONMENT
and NATURAL RESOURCES

PMB 2020
JOE FOSS BUILDING
523 EAST CAPITOL
PIERRE, SOUTH DAKOTA 57501-3182
www.state.sd.us/denr

September 30, 2005

INTERNAL MEMORANDUM

TO: Garland Erbele, Chief Engineer
DENR Water Rights Program

FROM: Donald E. Stroup *Donald E. Stroup*
Natural Resources Project Engineer
DENR Water Rights Program

SUBJECT: Rapid City – Rapid Valley Water Rights Transfers

A total of 16.75 cubic feet per second (cfs) of water has been transferred from Rapid Valley irrigation ditches to Rapid City, SD. The amounts of flow transferred and acres retired by ditch are:

<u>Ditch</u>	<u>Flow (cfs)</u>	<u>Acres</u>
Murphy	4.12	325
Little Giant	0.99	26
South Side	10.80	1001.8
Hawthorne	0.84	46

The locations of the land retired from irrigation are shown on the Rapid City-Rapid Valley Water Rights Transfers Map. Following is a list summarizing the water transfers from Rapid Valley irrigators to Rapid City:

- 2399-2: Retired 52-acres and 0.75-cfs of Wileman property from future irrigation, 26-acres and 0.33-cfs from Murphy Ditch and 26-acres and 0.42-cfs from Little Giant Ditch. Land located in the NE¼ Section 24 T1N R8E and water via Murphy Ditch at the same location.
- 2316-2: Retired 64-acres and 0.81-cfs of Morris property from future irrigation via Murphy Ditch. Land located in the SE¼ Section 9 T1N R8E and water via Murphy Ditch at the same location.
- 2201-1: Retired 10-acres and 0.13-cfs of Long property from future irrigation via Murphy Ditch. Land located in the center of Section 14 T1N R8E and water via Murphy Ditch at the same location.
- 2199-2: Retired 4-acres and 0.05-cfs of Pelle property from future irrigation via Murphy Ditch. Land located in the NW¼ Section 19 T1N R9E and water via Murphy Ditch at the same location.
- 2142-2: Retired 49-acres and 0.62-cfs of Tyler property from future irrigation via Murphy Ditch. Land located in the NW¼ and SW¼ Section 19 T1N R9E and water via Murphy Ditch at the same location.

- 2469-2** Retired 27-acres and 0.34-cfs of Murphy property from future irrigation via Murphy Ditch. Land located in the NW¼ and SW¼ Section 14 T1N R8E and water via Murphy Ditch at the same location.
- 2512-2** Retired 145-acres and 1.84-cfs of Schroeder property from future irrigation via Murphy Ditch. Land located in Section 19 T1N R9E and water via Murphy Ditch at the same location.
- 2513-2** Retired 74.9-acres and 0.84-cfs of Steen property from future irrigation via South Side Ditch. Land located in the NE¼ Section 25, and SW¼ and SE¼ Section 24 T1N R8E and water via South Side Ditch in Section 25 T1N R8E. The turnout for the supplying lateral has a turn screw gate that is functional.
- 2234-2** Retired 70-acres and 0.79-cfs of Eisenbraun property from future irrigation via South Side Ditch. Land located in the NE¼ Section 26 T1N R8E and water via South Side Ditch at the same location. The turnout for the supplying lateral is into a buried pipeline capped with a plastic bucket.
- 2411-2** Retired 3.6-acres and 0.04-cfs of Eisenbraun property from future irrigation via South Side Ditch. Land located in the NE¼ Section 26 T1N R8E and water via South Side Ditch at the same location. The turnout for the supplying lateral is into a buried pipeline capped with a plastic bucket.
- 2397-2** Retired 59.3-acres and 0.59-cfs of Eisenbraun property from future irrigation via South Side Ditch. Land located in the NE¼ Section 26 T1N R8E and water via South Side Ditch at the same location. The turnout for the supplying lateral is into a buried pipeline capped with a plastic bucket.
- 2468-2** Retired 34.8-acres and 0.57-cfs of Howie property from future irrigation via Little Giant Ditch water delivered via Murphy Ditch. Land located in the SW¼ Section 19 and NW¼ Section 30 T1N R9E and water via Murphy Ditch in the NE¼ Section 19 T1N R9E. The turnout for the supplying lateral is blocked by a silted-in board.
- 2249-2** Retired 105.5-acres and 1.19-cfs of Weber property from future irrigation via South Side Ditch. Land located in the NW¼ and SW¼ Section 30 T1N R9E and water via South Side Ditch in the SW¼ Section 30 T1N R9E.
- 2296-2** Retired 253.4-acres and 2.85-cfs of Jundt property from future irrigation via South Side Ditch. Land located in Section 33 T1N R9E and water via South Side Ditch in the NE¼ Section 33 T1N R9E. The turnout for the supplying lateral is not blocked and ditch and lateral do not appear to be maintained.
- 2360-2** Retired 32.6-acres and 0.37-cfs of Soetaert property from future irrigation via South Side Ditch. Land located in the E½ Section 33 T1N R9E and water via South Side Ditch in the NE¼ Section 33 T1N R9E. The turnout for the supplying lateral is not blocked and ditch and lateral do not appear to be maintained.
- 2415-2** Retired 146-acres and 1.64-cfs of Howie property from future irrigation via South Side Ditch. Land located in the NE¼ and SE¼ Section 32 T1N R9E and water via South Side Ditch in the NE¼ Section 32 T1N R9E. The turnout for the supplying lateral is not blocked and ditch and lateral do not appear to be maintained.

- 2217-2** Retired 29.2-acres and 0.33-cfs of Keller property from future irrigation via South Side Ditch. Land located in the SE¼ Section 29 T1N R9E and water via South Side Ditch in the NE¼ Section 32 T1N R9E. The turnout for the supplying lateral is not blocked and ditch and lateral do not appear to be maintained.
- 2218-2** Retired 192.5-acres and 2.16-cfs of Stromer property from future irrigation via South Side Ditch. Land located in the NW¼, SW¼ , and SE¼ of Section 29 T1N R9E and water via South Side Ditch in the SW¼ Section 29 T1N R9E. The turnout for the supplying lateral is not blocked and ditch and lateral do not appear to be maintained.
- 2317-2** Retired 46-acres and 0.84-cfs of Morris property from future irrigation via Hawthorne Ditch. Land located in the center of Section 9 T1N R8E and water via Hawthorne Ditch in the NE¼ Section 9 T1N R8E. Hawthorne Ditch is now piped underground through the area where the turnout for the supplying lateral was and the new Elk Vale Road by-pass, a school, and Western Electric have been constructed where the lateral previous ran. There is no evidence of a lateral at the location.

cc: Individual Files

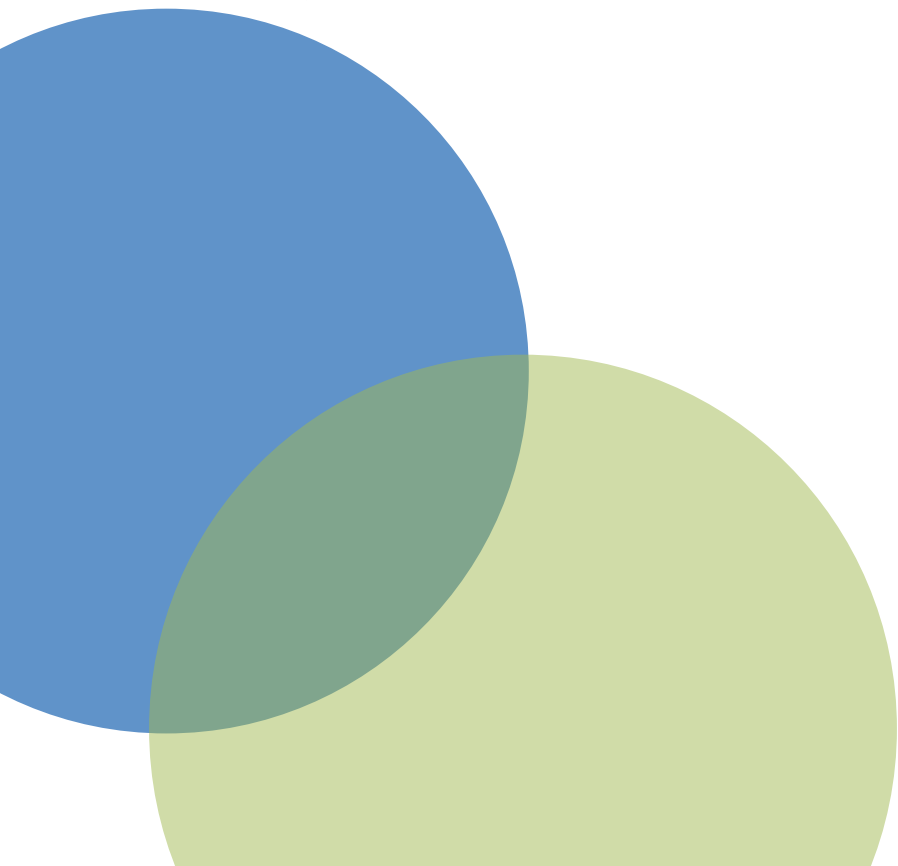
DOCUMENTATION OF
IRRIGATION DIVERSION POINT ABANDONMENT
FOR CITY OF RAPID CITY
PROJECT NO. 12-2034, CIP NO. 50922

Topical Report RSI-2317

prepared for

City of Rapid City
Public Works Department
Water Division
300 6th Street
Rapid City, SD 57701

January 2016



DOCUMENTATION OF
IRRIGATION DIVERSION POINT ABANDONMENT
FOR CITY OF RAPID CITY
PROJECT NO. 12-2034, CIP NO. 50922

Topical Report RSI-2317

by

Peter P. Rausch
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Public Works Department
Water Division
300 6th Street
Rapid City, SD 57701

January 2016

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1.0 BACKGROUND

The City of Rapid City has obtained the water permits from several irrigators served by Rapid Creek in the Rapid Valley area. According to the South Dakota Department of Environment and Natural Resources (SD DENR) Water Rights Division, the holder of a transferred permit shall permanently render inoperable the structural means of diverting water to land that is no longer subject to the water permit. The City of Rapid City has record of transfers and has now completed abandonment of the aforementioned diversion structures. The abandonment of the structures was performed by the City of Rapid City and reviewed by SD DENR personnel. This report documents the permits transferred, the diversion points associated with those permits, and the abandonment of those diversion points.

2.0 DATA SOURCES

Six sources were used to identify the diversion structures (turnouts) to be disabled. The first is the South Dakota Water Rights Program online permit database that is operated by the SD DENR [2012]. This database includes water rights documentation for each of the Rapid Valley irrigation ditches, identifies all permit transfers, and has documentation for individual water rights permits.

The second source is the Rapid Valley Water Management Study, which was completed in 1990 by the U.S. Bureau of Reclamation for ditches that have storage in Deerfield Reservoir, including the South Side, Cyclone, Little Giant, and Hawthorne irrigation ditches [U.S. Bureau of Reclamation, 1990]. The Murphy Ditch was excluded from the Rapid Valley Water Management Study because its water right is for natural Rapid Creek flows and, therefore, contractually has no storage in Deerfield Reservoir managed by the Bureau of Reclamation. The documentation from the study includes photographs of irrigation turnouts; associated notes; and irrigation ditch maps with turnout locations, photograph locations, and irrigated acreages.

The third source is an undocumented study conducted by the City of Rapid City in 2008. This study includes photographs of irrigation turnouts, associated notes, and maps that include data pertinent to water rights transferred to the city. The last three sources include parcel delineation and owner information from RapidMap [City of Rapid City and Pennington County, 2014], field investigations, and direct communication with irrigation ditch personnel and landowners.

Searches were conducted within the SD DENR Water Rights Program database to identify the water rights transferred to the City of Rapid City. Permit documentation associated with these transfers was downloaded. The water rights flow rate, acreage, location, previous owner, and approval date were identified for each transfer and this information is provided in Table 2-1.

By combining the information from Table 2-1 with the data from the RapidMap geodatabase, the parcels associated with each transfer were identified. Then, structure location maps from the Rapid Valley Water Management Study were used to identify the locations of turnouts requiring disablement. These locations were field-verified with help from ditch personnel and were recorded with Global Positioning System (GPS). Verified structure locations were digitized with ArcGIS mapping software.

Table 2-1. Information for Water Rights Transferred to the City of Rapid City

Permit No.	Ditch(s)	Previous Owner	Acres	Flow (cfs) ^(a)	Section	Township	Range	Quarter	Transfer Date
2655-2	Cyclone	Lamb	58	0.83	22	1N	8E	SW NW, NW NW	12/1/2010
2317-2	Hawthorne	Morris	46	0.84	9	1N	8E	SW NE, SE NW, NE SW, NW SE	5/1/1996
2399-2	Little Giant and Murphy	Wileman	52	0.75	24	1N	8E	E NE	5/7/1998
2468-2	Little Giant via Murphy	Howie	34.8	0.57	19; 30	1N	9E	W SW; NW NW	12/5/2001
2142-2	Murphy	Tyler	49	0.62	19	1N	9E	W NW, NW SW	5/1/1991
2199-2	Murphy	Pelle	4	0.05	19	1N	9E	NW NW	5/7/1992
2201-2	Murphy	Long	10	0.13	14	1N	8E	C	5/7/1992
2316-2	Murphy	Morris	64	0.81	9	1N	8E	W SE	5/1/1996
2469-2	Murphy	Murphy	27	0.34	14	1N	8E	S NW, N SW	12/5/2001
2512-2	Murphy	Schroeder	145	1.84	19	1N	9E	E NW, NE SW, SW SE, N SE, S NE	12/3/2003
2217-2	South Side	Keller	29.2	0.33	29	1N	9E	SE SE	7/22/1992
2218-2	South Side	Stromer	192.5	2.16	29	1N	9E	SW	7/22/1992
2234-2	South Side	Eisenbraun	70	0.79	26	1N	8E	E NE	5/1/1996
2249-2	South Side	Weber	105.5	1.19	30	1N	9E	E NW, NW SW, E SW	5/5/1993
2296-2	South Side	Jundt	253.4	2.85	28; 33	1N	9E	SW, SW SE; NW, W NE, NW SE, N SW	1/6/1994
2360-2	South Side	Soetaert	32.6	0.37	33	1N	9E	W NW	7/10/1996
2397-2	South Side	Eisenbraun	59.3	0.59	26	1N	8E	W NE	2/25/1998
2411-2	South Side	Eisenbraun	3.6	0.04	26	1N	8E	N NE	10/1/1998
2415-2	South Side	Howie	146	1.64	32	1N	9E	NE, N SE	12/2/1998
2513-2	South Side	Steen	74.9	0.84	24; 25	1N	8E	W SE; SW NE	12/3/2003

(a) cfs = cubic feet per second

3.0 IRRIGATION DITCH SUMMARIES

The information gathered for turnouts to parcels with water rights transferred from irrigation use to the City of Rapid City is described by permit number in the following sections. The information includes each turnout location, access, and disablement information. All maps can be found in Appendix A.

All references to compacted backfill or compacted embankment were completed according to City of Rapid City Specifications Section 14-Embankment. Rapid City Specifications are located at www.rcgov.org under Departments – Public Works – Engineering Services – Standard Specifications & Details 2007.

3.1 CYCLONE DITCH

A single Cyclone Ditch water right has been transferred to the City of Rapid City with a single associated turnout. Table 3-1 describes the turnout location and Figure A-1 maps the vicinity. The following section describes the turnout details.

Table 3-1. Cyclone Ditch Turnout Information

Turnout	Longitude	Latitude	Adjacent Landowner
2655-2	-103.151	44.034	David Lamb

3.1.1 Permit 2655-2

This permit is for 58 acres and 0.85 cubic feet per second (cfs) transferred from Mr. David Lamb.

3.1.1.1 Turnout

The single turnout for this permit was an open ditch cut through the bank of Cyclone Ditch. Water was directed down the turnout ditch by boarding up a steel flume immediately downstream in the Cyclone Ditch.

3.1.1.2 Access

The turnout was located adjacent to property owned by the Rapid City Area School District No. 51-4 (PIN 3822100004). Direct access to the site is along an over 1-mile, two-track road that runs through fields on property owned by Mr. David Lamb. It is accessible by a private driveway at 4555 Reservoir Road, south of East Highway 44.

3.1.1.3 Disablement

The flume has been removed, the turnout ditch filled, and the ditch reshaped by the landowner as illustrated in Figure 3-1.



Figure 3-1. The Turnout Ditch (Left Arrow) and Former Location of Flume (Right Arrow) Associated With Permit 2655-2. Cyclone Ditch Runs From Foreground to Background Through Large Concrete Pipe.

3.2 HAWTHORNE DITCH

A single Hawthorne Ditch water right has been transferred to the City of Rapid City with a single associated turnout. Table 3-2 provides the turnout location and Figure A-2 maps the vicinity. The following section describes the turnout details.

Table 3-2. Hawthorne Ditch Turnout Information

Turnout	Longitude	Latitude	Current Landowner
2317-2	-103.162	44.064	N/A

3.2.1 Permit 2317-2

This permit is for 46 acres and 0.84 cfs transferred from Mr. Morris.

3.2.1.1 Turnout

The supplying lateral and turnout for this permit no longer exist. An internal memorandum of SD DENR dated September 30, 2005, states “Hawthorne Ditch is now piped underground through the area where the turnout for the supplying lateral was and the new Elk Vale Road bypass, a school, and (the West River Electric Association building) have been constructed where the lateral previously ran. There is no evidence of a lateral at the location” [Stroup, 2005]. This statement was field-verified.

3.2.1.2 Access

The approximate, former location of the turnout is along East Highway 44 near the Elk Vale Road bypass.

3.2.1.3 Disablement

The turnout was previously disabled.

3.3 MURPHY DITCH

Eight Murphy Ditch water rights have been transferred to the City of Rapid City, and 11 associated turnout locations are described in Table 3-3 in order from upstream to downstream. Two vicinity maps of the turnouts are illustrated by Figures A-3 and A-4. The following sections describe each of the Murphy Ditch turnout locations by permit. The ditch has a 20-foot easement on either side for access and maintenance.

Table 3-3. Murphy Ditch Turnout Information

Turnout	Longitude	Latitude	Adjacent Landowner
2316-2	-103.158	44.059	Yasmeen Dream
2469-2 A	-103.128	44.049	Dennis Murphy
2469-2 B	-103.127	44.049	Dennis Murphy
2201-2	-103.121	44.047	Ramona Buchholz
2399-2 A	-103.097	44.038	Michelle Minnerath
2399-2 B	-103.091	44.037	Penn. Co. ROW
2468-2	-103.091	44.031	SD DOT
2142-2 and 2199-2	-103.089	44.037	Randall Albers or Melvin Ross
2512-2 A	-103.083	44.035	Rapid City
2512-2 B	-103.077	44.034	Rapid City
2512-2 C	-103.070	44.031	Rapid City ROW

3.3.1 Permit 2316-2

This permit is for 64 acres and 0.81 cfs transferred from Mr. Morris.

3.3.1.1 Turnout

A single turnout was associated with this permit. A wooden flume within the Murphy Ditch was used to check water up to a 12-inch-diameter corrugated metal pipe (CMP). The flume throat was 8 feet long, 4 feet 8 inches wide, and 4 feet 2 inches tall. The CMP was sedimented in and remained in segments. Figure 3-2 is a photograph of the flume and Figure 3-3 is a photograph of the CMP opening.



Figure 3-2. Wooden Flume Used as a Check for Permit 2316-2.



Figure 3-3. Opening to 12-Inch-Diameter Corrugated Metal Pipe Turnout for Permit 2316-2.

3.3.1.2 Access

The flume and pipe were adjacent to property owned by Yasmeen Dream that is accessible from Lytle Lane off of East Highway 44.

3.3.1.3 Disablement

The following are the procedures the City of Rapid City used in disabling the Permit 2316-2 turnout:

- Removed the wooden flume and all associated concrete from Murphy Ditch
- Removed the upstream CMP section from the ditch embankment
- Backfilled with compacted embankment material where items were removed
- Reshaped the ditch banks through the project area to match the cross section of existing banks outside of the project area

Figure 3-4 and Figure 3-5 document removal of the turnout.



Figure 3-4. Removal of Turnout associated with Permit 2316-2. Date 3/20/2014



Figure 3-5. Removal of Turnout associated with Permit 2316-2. Date 3/20/2014

3.3.2 Permit 2469-2

This permit is for 27 acres and 0.34 cfs transferred from Ms. Arlene Murphy.

3.3.2.1 Turnouts

Two turnouts were associated with this permit, and they were located at either end of an inverted siphon through which the Murphy Ditch passes. Both turnouts were approximately 10-inch-diameter plastic pipes through the ditch bank. The upstream pipe (Turnout A) was mostly buried and is shown in Figure 3-6. The downstream pipe (Turnout B) was exposed, as illustrated in Figure 3-7.



Figure 3-6. Pipe Turnout A for Permit 2469-2.

3.3.2.2 Access

Both turnouts were adjacent to property owned by Dennis Murphy (PIN 3814105010), and the sites are accessible from a private driveway at 5670 East Highway 44. Direct access to both turnouts was through fields along a two-track path. Access to the Turnout B site requires crossing an existing drainage or can alternatively be accessed by a two-track path off the end of Springfield Road.



Figure 3-7. Pipe Turnout B for Permit 2469-2.

3.3.2.3 *Disablement*

The following are the procedures the City of Rapid City used in disabling the Permit 2469-2 turnouts

- Removed both pipe turnouts from the ditch embankment
- Backfilled with compacted embankment material to match the existing bank cross section

Figures 3-8 and Figure 3-9 document removal of the turnouts.



Figure 3-8. Removal of Turnout A Associated With Permit 2469-2. Date 4/22/2014



Figure 3-9. Removal of Turnout B Associated With Permit 2469-2. Date 4/22/2014.

3.3.3 Permit 2201-2

This permit is for 10 acres and 0.13 cfs transferred from Mr. Long.

3.3.3.1 Turnout

The old turnout ditch for this permit was identified, but the turnout had been removed. No evidence of a turnout could be identified on the ditch side of the bank, as illustrated in Figure 3-10. The remains of wooden structures, possibly related to the turnout, were found nearby, as shown in Figure 3-11.

3.3.3.2 Access

The site is adjacent to property owned by Ms. Ramona Buchholz (PIN 3814326004) and is located directly west of Apple Tree Road. It is accessible from East Highway 44.

3.3.3.3 Disablement

The structure was previously disabled.



Figure 3-10. Photograph Taken From in the Murphy Ditch Running Right to Left (Bank in Foreground Is Likely Former Turnout Location for Permit 2201-2).



Figure 3-11. Wooden Remains Found Near the Site for Permit 2201-2.

3.3.4 Permit 2399-2

This permit is for 52 acres and 0.75 cfs transferred from Mr. Wesley Wileman.

3.3.4.1 *Turnouts*

Two turnout locations were associated with this permit. Turnout A had been removed but was not properly backfilled, as illustrated in Figure 3-12. A meeting on site with Mr. Jeep Williams, watermaster for Murphy Ditch, in April 2014 verified that the backfill at that site has been repaired since the photograph was taken. Turnout B was a 12-inch steel canal gate, as shown in Figure 3-13.

3.3.4.2 *Access*

The Turnout A site is adjacent to property owned by Ms. Michelle Minnerath (PIN 3824200002) and is north of Morris Lane. Direct access to the location is through a field with no defined path. Turnout B was located in the west ditch of Radar Hill Road.



Figure 3-12. Backfill Material at the Former Location of Turnout A for Permit 2399-2. This area has since had material added to the bank.



Figure 3-13. Turnout B for Permit 2399-2 (The 12-Inch Steel Canal Gate was Located on the Far Bank Adjacent to the Concrete Culvert, and Murphy Ditch Runs Right to Left).

3.3.4.3 *Disablement*

The following are the procedures the City of Rapid City used in disabling the Permit 2399-2 turnouts:

- Turnout A was previously disabled
- Turnout B
 - Removed the canal gate from Murphy Ditch
 - Removed a portion of the pipe from the ditch bank and backfilled with compacted embankment material to match the existing bank cross section

Figure 3-14 and Figure 3-15 document removal of Turnout B.



Figure 3-14. Removal of Turnout B for Permit 2399-2 Located on Murphy Ditch on Radar Road.
Date 4/22/2014



Figure 3-15. Removal of Turnout B for Permit 2399-2 Located on Murphy Ditch on Radar Road.
Date 4/22/2014

3.3.5 Permit 2468-2

This permit is for 34.8 acres and 0.57 cfs transferred from Mr. Gordon Howie.

3.3.5.1 *Turnouts*

A single turnout for this permit was once located on a lateral ditch. The turnout ditch was identified, as shown in Figure 3-16, but no turnout structure exists.



Figure 3-16. Disabled Turnout Ditch for Permit 2468-2 Running From the Foreground to the Background Along the East Side of Radar Hill Road (The Lateral Ditch Is in the Left Foreground, Turning Left at the Visible Tree Root).

3.3.5.2 *Access*

The site is located on property owned by the South Dakota Department of Transportation (SD DOT) on the east side of Radar Hill Road, south of East Highway 44 (PIN 3824427001).

3.3.5.3 *Disablement*

The structure was previously disabled.

3.3.6 Permits 2142-2 and 2199-2

Permit 2142-2 is for 49 acres and 0.62 cfs transferred from Mr. Tyler. Permit 2199-2 is for 4 acres and 0.05 cfs transferred from Mr. Pelle.

3.3.6.1 Turnout

A single turnout location was used for these two permits. Upon inspection, the turnout ditch was identified and a short, disconnected segment of a 12-inch-diameter CMP was found lying in the ditch at the site, but an existing turnout structure was not evident. The concrete check structure for the turnout has been removed and sits on the ditch bank at the location illustrated in Figure 3-17.



Figure 3-17. Former Location of the Turnout for Permits 2142-2 and 2199-2 (The Concrete Check Structure and a Disconnected Corrugated Metal Pipe Segment Sit on the Far Bank, and Murphy Ditch Flows Right to Left).

3.3.6.2 Access

The site is adjacent to property owned by Mr. Randall Albers (PIN 3919100002) along Morris Lane. Direct access to the site is through the Albers property or the neighboring property owned by Melvin Ross (PIN 391900001), or from the top side of the Murphy Ditch through Mr. Jerry Olson's property.

3.3.6.3 Disablement

The structure was previously disabled and no further action was required, as per a meeting with SD DENR personnel in April 2014.

3.3.7 Permit 2512-2

This permit is for 145 acres and 1.84 cfs transferred from Ms. Marilyn Schroeder.

3.3.7.1 Turnouts

Three turnouts were associated with this permit. Turnout A was a 10-inch-diameter plastic pipe through the ditch bank but was capped and buried, as shown in Figure 3-18. Turnout B was a clay pipe 12-inches in diameter and 20 feet long through the ditch bank. The downstream end of this pipe was previously buried. Figure 3-19 is a photograph of a plywood headgate used for Turnout B. Turnout C was a 24-inch steel canal gate secured in a concrete junction box, as shown in Figure 3-20. The junction box is on a lateral ditch and is shared with an identical gate for a separate, active permit.



Figure 3-18. Pipe Used for Turnout A of Permit 2512-2 (Red Arrow).

3.3.7.2 Access

Turnouts A and B were located adjacent to property owned by the City of Rapid City (PIN 3919200001). Turnout C was located in the west right-of-way for Airport Road.

3.3.7.3 Disablement

The following are the procedures the City of Rapid City used in disabling the Permit 2512-2 turnouts:

- Turnout A was previously disabled and no further action was required per discussion with the Murphy Ditch watermaster and SD DENR personnel in April 2014.
- Turnout B was previously disabled and no further action was required per discussion with the Murphy Ditch watermaster and SD DENR personnel in April 2014.

- Turnout C

- Removed the canal gate and disabled the pipe with a Class M-5 concrete plug.

Figure 3-21 and Figure 3-22 document disablement of the Turnout C structure.



Figure 3-19. Plywood Headgate for Turnout B of Permit 2512-2.



Figure 3-20. Junction Box With 24-Inch Canal Gate for Turnout C of Permit 2512-2 (Turnout C Shown With Red Arrow, Leading South).



Figure 3-21. Removal of Turnout C for Permit 2512-2 Located on Murphy Ditch on the East Side of Airport Road. Date 4/22/2014



Figure 3-22. Removal of Turnout C for Permit 2512-2 Located on Murphy Ditch on the East Side of Airport Road Going South to the Airport. Date 4/22/2014.

3.4 SOUTH SIDE DITCH

Ten South Side Ditch water rights have been transferred to the City of Rapid City, and 13 associated turnout locations were identified by using maps from the Rapid Valley Water Management Study [U.S. Bureau of Reclamation, 1990] and field investigations. The locations are described in Table 3-4 from upstream to downstream. Two vicinity maps of the turnouts are provided by Figures A-5 and A-6.

Table 3-4. South Side Ditch Turnout Information

Turnout	Longitude	Latitude	Adjacent Landowner
2234-2, 2397-2 & 2411-2	-103.115	44.017	Reinhold Eisenbraun (south) Randy Christensen (north)
2513-2	-103.100	44.018	City of Rapid City
2249-2 A	-103.095	44.017	City of Rapid City
2249-2 B	-103.091	44.015	City of Rapid City
2249-2 C	-103.091	44.015	City of Rapid City
2249-2 D	-103.084	44.011	City of Rapid City
2218-2	-103.071	44.010	Merlin Stromer
2415-2 A	-103.065	44.008	Matt Bowen
2415-2 B	-103.061	44.006	Matt Bowen
2415-2 C	-103.059	44.006	Matt Bowen
2415-2 D	-103.056	44.006	Matt Bowen
2217-2	-103.056	44.011	Leonard V. Keller Trust
2296-2 and 2360-2	-103.05	44.007	Donald Jundt

3.4.1 Permits 2234-2, 2397-2, and 2411-2

Permit 2234-2 is for 70 acres and 0.79 cfs, Permit 2397-2 is for 59.3 acres and 0.59 cfs, and Permit 2411-2 is for 3.6 acres and 0.04 cfs, all transferred from Mr. Reinhold Eisenbraun.

3.4.1.1 Turnouts

One turnout structure could be found in the described vicinity of these permits, located in Section 26, 1N 8E. The ditch was walked for approximately 1/2 mile to the west and the only turnout found is shown in Figure 3-23.

3.4.1.2 Access

The turnout for Permit 2234-2 is accessed off of Highway 44 by turning south on Anderson Rd. and continuing south past Southside Dr. approximately 3/8 mile to South Side Ditch. The site is approximately 1/4 mile west. The land north of the ditch, including the structure, is owned by Mr. Randy Christensen, and the land south of the ditch is owned by Mr. Eisenbraun.

3.4.1.3 Disablement

The structure was previously disabled, and no further action was required by SD DENR personnel.



Figure 3-23. Turnout for Permit 2234-2. Note the headwall sticking out of the snow just upstream from the culvert crossing on the left or north side of the ditch (red arrow). The ditch behind the headwall has been filled in.

3.4.2 Permit 2513-2

This permit is for 74.9 acres and 0.84 cfs transferred from Mr. Steen.

3.4.2.1 Turnouts

One turnout was associated with Permit 2513-2. The turnout was located straight south of the Rapid City Water Treatment Plant near the middle of section 25 on South Side Ditch. The turnout inlet structure was concrete with a 15-inch canal gate and PVC pipe going under the north bank to a weir box. On the north side of the weir box, 15-inch PVC pipe ran from the box to a vertical PVC air vent and then continued north. Figures 3-24, 3-25, and 3-26 show the structures associated with Permit 2513-2.



Figure 3-24. Inlet Structure, Weir Box, and Air Vent Associated With Turnout 2513-2.



Figure 3-25. Inlet Structure, Weir Box, and Air Vent Associated With Turnout 2513-2.



Figure 3-26. Inside the Weir Box for Turnout 2513-2. Note center wall weir and PVC pipe exiting the box.

3.4.2.2 Access

The site is located on land owned by the City of Rapid City and occupied by Mr. Bud Steen. The site may be accessed by turning off Highway 44 on Anderson Rd., then turning east on Southside Dr. to the treatment plant, then south on Redemption Road at the west edge of the treatment plant. At South Side Ditch, the site is located just east of the road.

3.4.2.3 Disablement

The following are the procedures the City of Rapid City used in disabling the turnout associated with Permit 2513-2:

- Cut existing turnout pipe 5 feet north from air vent
- Removed the air vent, inlet structure, and appurtenances.
- Backfilled with compacted embankment material

Figure 3-27 documents disablement of the structure.



Figure 3-27. Removal of Turnout for Permit 2513-2. Headgate removed, measurement box filled with dirt and pipeline air vent removed. Date: 10/29/2015

3.4.3 Permit 2249-2

This permit is for 105.5 acres and 1.19 cfs transferred from Mr. Weber.

3.4.3.1 *Turnouts*

Four turnouts were associated with Permit 2249-2. Turnout A was located 1,500 feet downstream from the Permit 2513-2 turnout site and consisted of a steel-framed headgate and concrete headwall. The structure is shown in Figure 3-28.

Turnout B was located upstream from a culvert crossing, shown in Figure 3-29. This culvert was used as a check structure for Turnout B and is located just west of the line between Section 25, 1N 8E and Section 30, 1N 9E. Figure 3-30 shows the outlet end of the Turnout B pipe.

Turnout C consisted of a wooden structure on the north bank of South Side Ditch, just upstream from a second culvert crossing, shown in Figure 3-31. The Turnout C site is shown in Figure 3-32 and located just east of the line between Section 25, 1N 8E and Section 30, 1N 9E.

Turnout D was located in the SW1/4 of Section 30 T1N R9E and consisted of a steel frame canal gate and division box. The gate is shown in Figure 3-33 and the division box is shown in Figure 3-34.



Figure 3-28. Turnout A structure Associated with Permit 2249-2.



Figure 3-29. Culvert Crossing Used as a Check for Turnout B Associated with Permit 2249-2.



Figure 3-30. Outlet end of Turnout B pipe (Red Arrow). (Looking South, Towards South Side Ditch).



Figure 3-31. Second Culvert Crossing, Used as Check for Turnout C Associated With Permit 2249-2.



Figure 3-32. Wooden Structure (Red Arrow) for Turnout C Associated With Permit 2249-2. This structure is immediately upstream of the culvert crossing in Figure 3-31, on the north bank.



Figure 3-33. Metal Framed Canal Gate of Turnout D Associated With Permit 2249-2.



Figure 3-34. Turnout D Division Box Associated With Permit 2249-2. Date 10/30/2015.

3.4.3.2 Access

The turnout sites may be accessed by turning south from Highway 44 on Anderson Rd., then east on Southside Dr. to the treatment plant. The sites are adjacent to property owned by the City of Rapid City, southeast from the treatment plant.

3.4.3.3 Disablement

The following are the procedures the City of Rapid City used in disabling turnouts A, B, C, and D associated with Permit 2249-2:

- Turnout A
 - Removed turnout head gate
 - Placed concrete plug in turnout pipe
 - Filled turnout ditch with compacted material
- Turnout B
 - Removed pipe and structure
 - Backfilled with compacted embankment material to match existing ditch cross section
- Turnout C
 - Removed the wooden structure
 - Backfilled with compacted embankment material to match existing ditch cross section
- Turnout B
 - Removed the steel framed canal gate and structure
 - Backfilled with compacted embankment material to match the existing ditch cross section

Figures 3-35 through Figure 3-40 document the disablement of these four turnouts.



Figure 3-35. Turnout A Associated with Permit 2249-2. Headgate removed, turnout pipe filled with concrete, and outlet filled in. Date 10/29/2015



Figure 3-36. Turnout B Associated with Permit 2249-2. The old turnout structure has been removed. Date 10/29/2015.



Figure 3-37. Turnout C Associated With Permit 2249-2. Removed turnout structure. Date 10/29/2015.



Figure 3-38. Turnout D Associated With Permit 2249-2, removed by the City. Date 10/30/2015



Figure 3-39. Turnout D Associated With Permit 2249-2. Turnout being backfilled. Date 10/30/2015.



Figure 3-40. Turnout D Associated With Permit 2249-2. Photo of the division box being removed and backfilled by the City. Date 10/30/2015.

3.4.4 Permit 2218-2

This permit is for 192.5 acres and 2.16 cfs transferred from Mr. Merlin Stromer.

3.4.4.1 *Turnouts*

One turnout was associated with Permit 2218-2. The turnout consisted of a pipe inlet, a metal valve well, and an air vent immediately downstream of the valve well, shown in Figure 3-41.

3.4.4.2 *Access*

The turnout site for Permit 2218-2 is located turning south on Airport Road from Highway 44 and travelling about 0.7 miles to the driveway into Mr. Merlin Stromer's property, then another 0.3 miles south through the Stromer property to South Side Ditch.

3.4.4.3 *Disablement*

A discussion with Mr. Merlin Stromer in April of 2014 was that after Mr. Stromer sold his water rights to the city, he hired a contractor to disable the turnout. No water can be or has been delivered through the turnout since the water right transfer. Discussion with SD DENR was that this would satisfy abandonment requirements and the turnout would not be disturbed since it has been disabled.



Figure 3-41. Turnout for Permit 2218-2. This turnout has been disabled and will not be disturbed.

3.4.5 Permit 2415-2

This permit is for 146 acres and 1.64 cfs transferred from Mr. Gordon Howie.

3.4.5.1 Turnouts

Four turnouts were associated with Permit 2415-2, designated Turnout A through Turnout D (upstream to downstream on the South Side Ditch). Turnout A consisted of a gate structure composed of timber and is shown in Figure 3-42. A wooden flume was used as a check structure for Turnout A, located approximately 35 feet downstream and shown in Figure 3-43.

Turnout B was also a gate structure composed of timbers. As shown in Figure 3-44, a wooden flume was located next to Turnout B (Turnout B indicated by red arrow) and was used as a check structure.

Turnout C consisted of a wooden gate structure supported by concrete abutments. Figure 3-45 displays Turnout C (red arrow) along with a wooden weir check structure located downstream from Turnout C. The ditch from Turnout C led to a 24-inch-diameter concrete pipe that was used to convey diverted water, shown in Figure 3-46.

Turnout D consisted of a concrete flume/check structure, shown in Figure 3-47. The structure included outlets on both the north and south walls, with timbers used to convey diverted water from the structure. Figures 3-48 and 3-49 show the north and south outlets, respectively.



Figure 3-42. Turnout A for Permit 2415-2. The turnout is composed of timber.



Figure 3-43. Wooden Flume Used as a Check for Turnout A of Permit 2415-2.



Figure 3-44. Turnout B (Red Arrow) and the Flume Associated with Permit 2415-2.



Figure 3-45. Turnout C (Red Arrow) and the Wooden Weir Associated With Permit 2415-2.



Figure 3-46. Turnout C and the 24-Inch-Diameter Concrete Pipe (Red Arrow) Associated With Permit 2415-2.



Figure 3-47. Concrete Flume/Check Structure for Turnout D Associated With Permit 2415-2 (Looking Downstream).



Figure 3-48. North Flume/Check Structure Wall and Outlet for Turnout D Associated With Permit 2415-2.



Figure 3-49. South Flume/Check Structure Wall and Outlet for Turnout D Associated With Permit 2415-2.

3.4.5.2 Access

Turnouts A through D are adjacent to property owned by Mr. Matt Bowen (PINs 3932100003 and 3932200001). The sites are accessed by travelling approximately 1/2 mile south on Bradsky Road from Highway 44 to a private drive just north of the South Side Ditch crossing.

- The Turnout A and Turnout B sites are accessed by travelling west on the private drive for approximately 1/2 mile from Bradsky Road, crossing South Side Ditch, then leaving the private drive and following South Side Ditch along its south bank.
- The Turnout C and Turnout D sites are accessed from the private drive on the north bank of South Side Ditch, approximately 1/2 mile and 1/4 mile west of Bradsky Road, respectively.

3.4.5.3 Disablement

The following are the procedures the City of Rapid City used in disabling the four turnouts associated with Permit 2415-2.

- Turnout A
 - o Removed the timber turnout and the wooden flume structure
 - o Backfilled with compacted embankment material to match existing ditch cross section

- Turnout B
 - o Removed the timber turnout and the wooden flume structure
 - o Backfilled with compacted embankment material to match existing ditch cross section
- Turnout C
 - o Removed the wooden gate turnout structure, concrete abutments, and wooden weir check structure from South Side Ditch
 - o Backfilled ditch banks with compacted embankment material to match existing ditch cross section
 - o Backfilled existing turnout ditch from South Side Ditch to existing concrete pipe with compacted material to match existing adjacent grade
- Turnout D
 - o Removed the concrete inlets and wooden turnouts from the north and south banks.
 - o Backfilled with compacted embankment material to match existing ditch cross section.

Figures 3-50 through 3-57 document the disablement of the structures associated with the four turnouts.



Figure 3-50. Removal of Turnout A associated with Permit 2415-2. Date 7/30/2015



Figure 3-51. Turnout A Wooden Flume Structure Associated With Permit 2415-2, removed. Date 7/30/2015



Figure 3-52. Turnout B Associated With Permit 2415-2. Timber Turnout Removed. Date 7/30/2015.



Figure 3-53. Turnout B Associated With Permit 2415-2. Wooden Flume Structure Removed. Date 7/30/2015.



Figure 3-54. Turnout C Associated With Permit 2415-2 Timber Gate Turnout Structure, Concrete Abutments, and Timber Weir Check Structure Removed. Date 7/30/2015.



Figure 3-55. Turnout C Associated With Permit 2415-2. Turnout ditch filled in. Date 7/30/2015.



Figure 3-56. Turnout D Associated With Permit 2415-2. Headgate removed and concrete plug put in place for south turnout. Date 7/30/2015



Figure 3-57. Turnout D Associated With Permit 2415-2. Headgate removed and concrete plug put in place for north turnout. Date 7/30/2015.

3.4.6 Permit 2217-2

This permit is for 29.2 acres and 0.33 cfs transferred from Mr. Leonard Keller.

3.4.6.1 *Turnouts*

No turnouts associated with this permit were located.

3.4.6.2 *Access*

The site is along Back Country Trail off of Bradsky Road.

3.4.6.3 *Disablement*

This turnout was previously disabled.

3.4.7 Permit 2296-2 and Permit 2360-2

Permit 2296-2 is for 253.4 acres and 2.85 cfs transferred from Mr. Donald Jundt. Permit 2360-2 is for 32.6 acres and 0.37 cfs transferred from Mr. Soetaert.

3.4.7.1 Turnouts

The turnout structure associated with transferred Permit 2296-2 and transferred Permit 2360-2, shown in Figure 3-58, also serves the active Permit 2526-2 for 0.71 cfs currently serving 50 acres of irrigated land owned by Mr. Donald Jundt. The turnout will not be disabled.



Figure 3-58. Turnout Associated With Permit 2296-2 and Permit 2360-2, Currently Serving an Active Permit for 50 Acres Irrigated by Mr. Donald Jundt.

3.4.7.2 Access

The turnout for Permit 2296-2 and Permit 2360-2 is located approximately 1/2 mile south of Highway 44 on the east side of Bradsky Road at the South Side Ditch. All associated structures are on property owned by Mr. Donald Jundt.

3.4.7.3 Disablement

No disablement was required.

4.0 PERMITS AND REGULATIONS

4.1 CLEAN WATER ACT SECTION 404 PERMIT

According to the U.S. Army Corps of Engineers [2007]:

“Under Section 404(f)(1)(C) of the CWA (see also 33 CFR 323.4(a)(3) and 40 CFR 232.3(c)(3)), discharges of dredged or fill material associated with construction or maintenance of irrigation ditches, or the maintenance (but not construction) of drainage ditches, are not prohibited by or otherwise subject to regulation under Section 404 of the CWA (i.e., these activities are exempt from the need to obtain a Section 404 Permit from the Department of the Army (DA)). Discharges of dredged or fill material associated with siphons, pumps, headgates, wingwalls, weirs, diversion structures, and such other facilities as are appurtenant to and functionally related to irrigation ditches are included in the exemption for irrigation ditches.”

A 404 Permit was not required.

4.2 CLEAN WATER ACT SECTION 402 PERMIT

According to the South Dakota Department of Environment and Natural Resources [2010] Section 2.2.2:

“Storm water discharges from operators disturbing less than one acre that are part of a larger common plan of development or sale that, combined, disturb one or more acres.”

The combination of ground area disturbed by the combination of all disablements associated with this project did not exceed 1 acre.

A 402 Permit was not required.

4.3 FLOODPLAIN DEVELOPMENT PERMITS

After reviewing both the Pennington County and Rapid City Flood Insurance Rate Maps, it was determined that none of the disablement sites lie within the 100-year floodplain.

Floodplain permits were not required.

4.4 HISTORIC PRESERVATION

As required by State Preservation Law (South Dakota Codified Law (SDCL) 1-19A-11.1), the Office of History was given notice and an opportunity to investigate and comment on this proposed project. The Office of History concluded that the irrigation ditches in Rapid Valley are listed on neither the State nor the National Register of Historic Places. Additionally, because federal funding will not be used for this proposed project, Section 106 of the National Historic Preservation Act did not apply.

5.0 REFERENCES

City of Rapid City and Pennington County, 2012. *RapidMap*, retrieved September 19, 2012, from <http://www.rcgov.org/GIS/rapidmap.html>

South Dakota Department of Environment and Natural Resources, 2012. *South Dakota Water Rights*, retrieved September 19, 2012, from <http://denr.sd.gov/des/wr/dbwrsearch.aspx>

South Dakota Department of Environment and Natural Resources, 2010. *General Permit for Storm Water Discharges Associated With Construction Activities*, prepared by the South Dakota Department of Environment and Natural Resources, Pierre, SD.

Stroup, D. E., 2005. *Rapid City – Rapid Valley Water Rights Transfers*, internal memorandum from D. E. Stroup, South Dakota Department of Environment and Natural Resources, Water Rights Program, Pierre, SD, to G. Eberle, South Dakota Department of Environment and Natural Resources, Water Rights Program, Pierre, SD, September 30.

U.S. Army Corps of Engineers, 1990. *Exemptions for Construction or Maintenance of Irrigation Ditches and Maintenance of Drainage Ditches under Section 404 of Clean Water Act*, Regulatory Guidance Letter, prepared by U.S. Army Corps of Engineers, Washington, DC, July 4.

U.S. Bureau of Reclamation, 1990. *Rapid Valley Water Management Study*, prepared by U.S. Bureau of Reclamation, Newell, South Dakota.

APPENDIX A

TURNOUT VICINITY MAPS

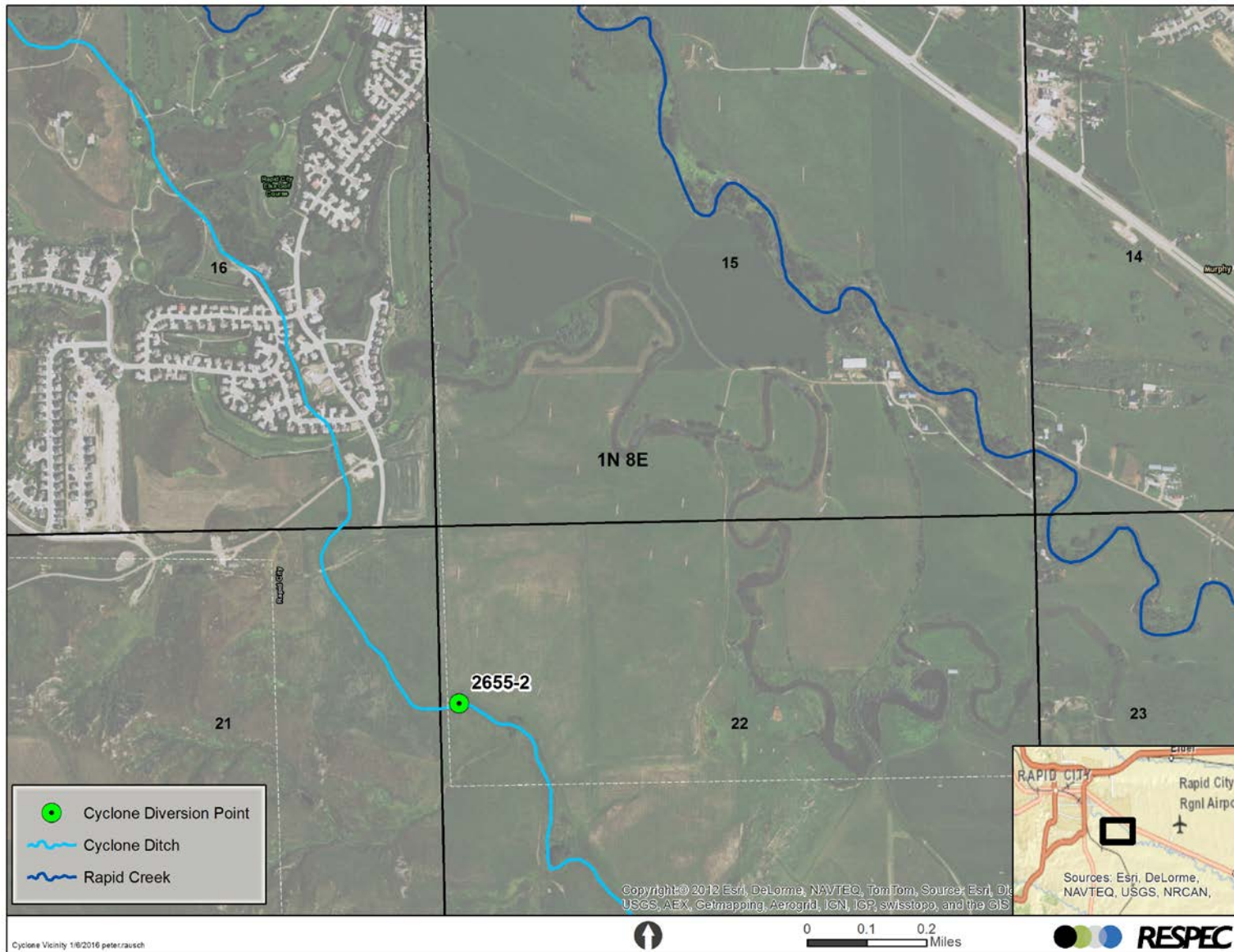


Figure A-1. Cyclone Ditch Turnout Vicinity Map.



Figure A-2. Hawthorne Ditch Turnout Vicinity Map.

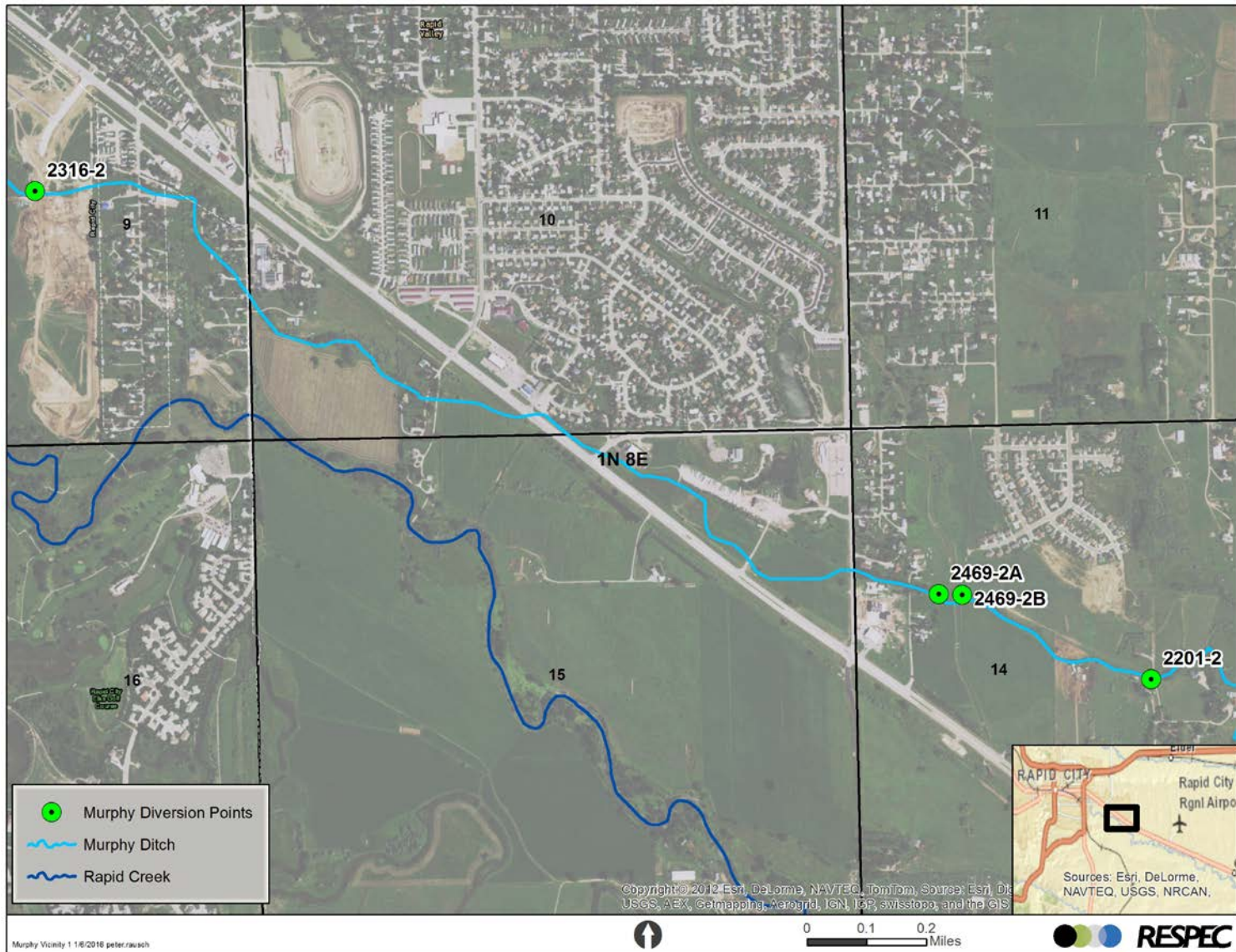


Figure A-3. Murphy Ditch Turnout Vicinity Map (1 of 2).

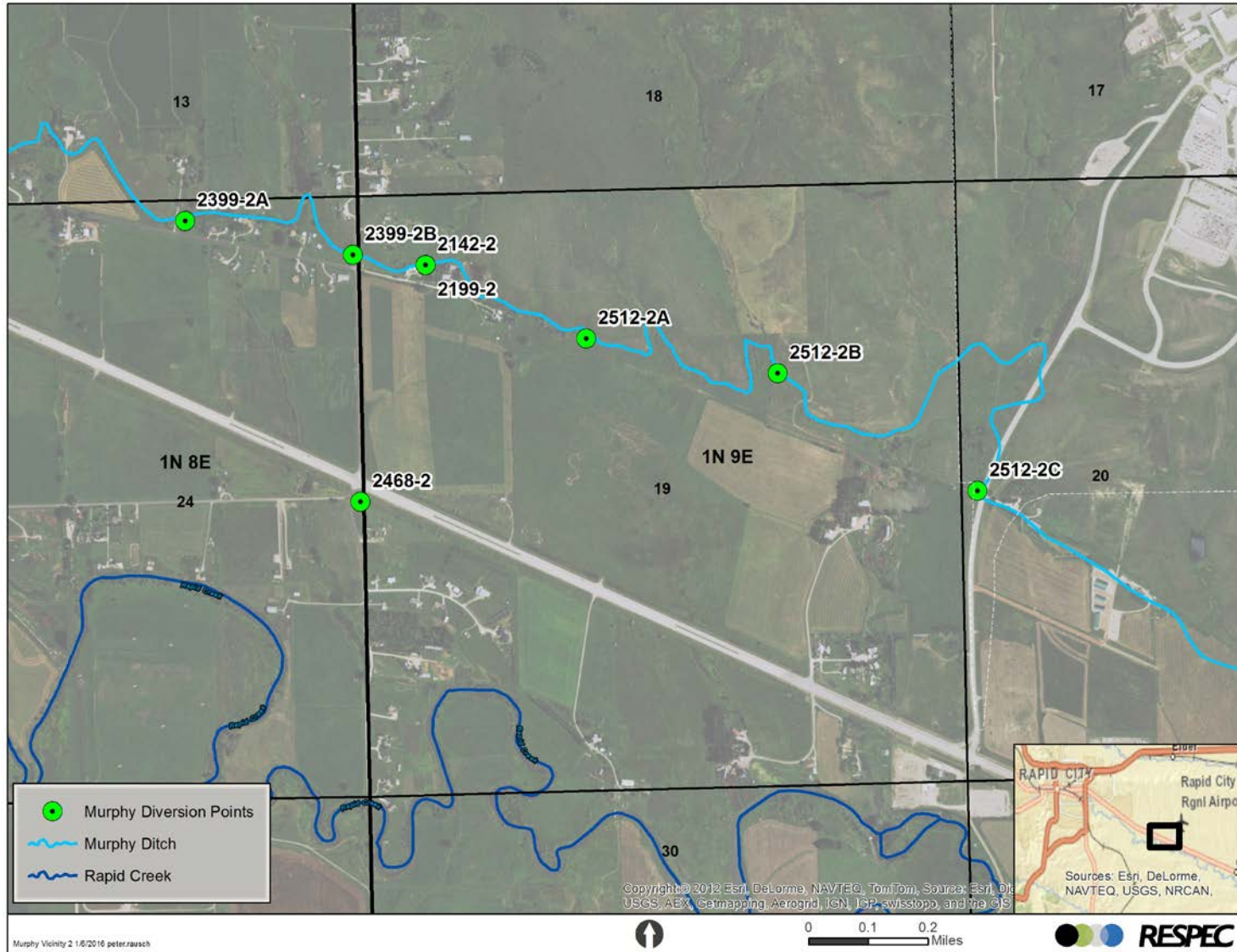


Figure A-4. Murphy Ditch Turnout Vicinity Map (2 of 2).



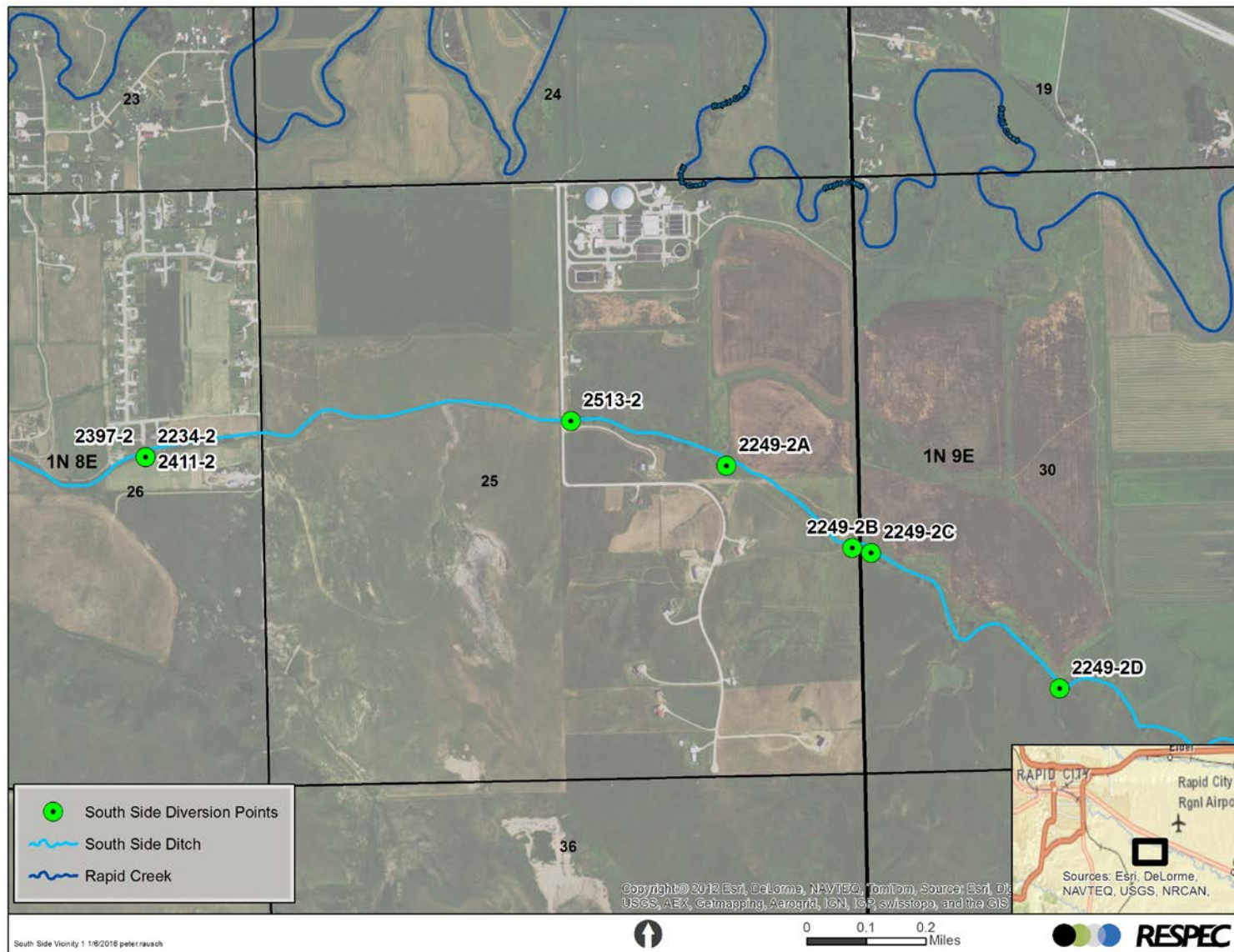


Figure A-5. South Side Ditch Turnout Vicinity Map (1 of 2).

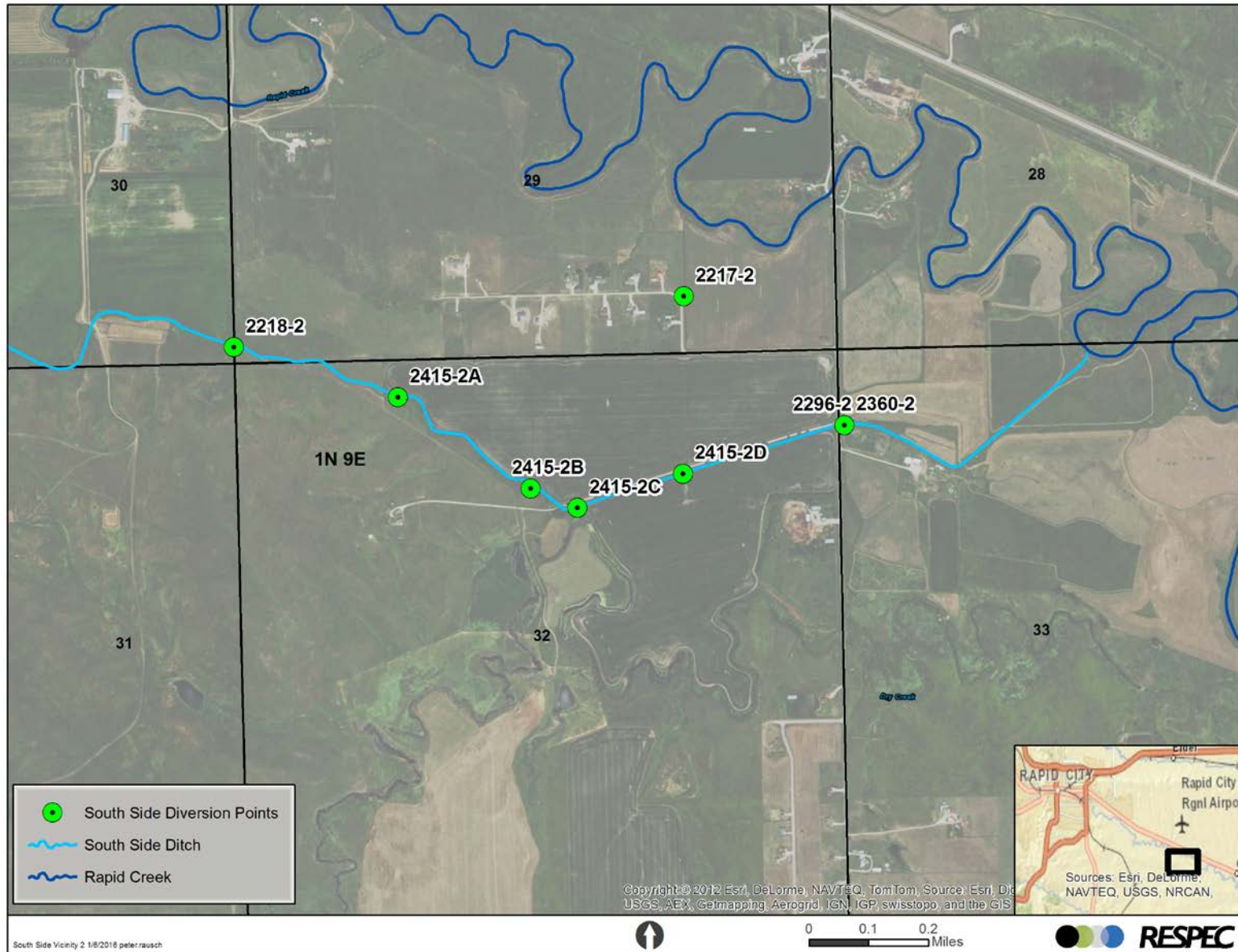


Figure A-6. South Side Ditch Turnout Vicinity Map (2 of 2)