HYDROGEOLOGIC ASSESSMENT OF RAPELJE WATER USERS ASSOCIATION WATER SUPPLY FOR GROUND WATER UNDER THE DIRECT INFLUENCE OF SURFACE WATER

Open-File Report
MBMG 401-M

Rapelje Water Users Association
PWSID #00313
Box 46
Rapelje, Montana 59067

Prepared
for
Montana Department of Environmental Quality
Water Quality Division

by
James Rose
Montana Bureau of Mines and Geology

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Earth Science Information

INTRODUCTION AND PURPOSE

This report summarizes the results of a hydrogeologic assessment for the Rapelje Water Users Association Public Water Supply (PWSID #00313) located in northern Stillwater County, Montana. The Montana Bureau of Mines and Geology (MBMG) is under contract with the Montana Department of Environmental Quality (DEQ) to conduct preliminary assessments and hydrogeologic assessments for selected community water supplies. The project was funded under DEQ contract number 400022, task order number 7.

The purpose of this hydrogeologic assessment is to determine if the spring source used by the Rapelje Water Users Association is under the direct influence of surface water as defined in 40 CFR part 141. A field inspection was completed on December 15, 1998 by James Rose, hydrogeologist for the MBMG, with Mark Doely (certified system operator). **The results of the assessment indicate that the well water used by the Rapelje Water Users Association (RWUA) may be under the direct influence of surface water as defined in 40 CFR part 141.**

This report summarizes information obtained during the field inspection and research investigation that was used to make the above determination. Information on system location, construction, geology, hydrology, and water quality are summarized. Conclusions and recommendations are presented at the end of the report. A preliminary assessment form and a well head protection form have been included in the appendices, along with site maps, photographs and water quality reports.

BACKGROUND

The Surface Water Treatment Rule (SWTR) of the Federal Safe Drinking Water Act of 1986 requires each state to examine public water supplies that use ground water to determine if there is a direct surface water influence. In Montana, the Water Quality Division (WQD) of DEQ is evaluating public water supplies for the SWTR. This project is known as the **Ground Water Under the Direct Influence of Surface Water (GWUDISW) program**. The SWTR defines ground water under the direct influence of surface water as any water beneath the surface of the ground with:

i) significant occurrence of insects or other macroorganisms, algae, or large diameter pathogens such as *Giardia lamblia*, or *Cryptosporidium*; or

ii) significant and relatively rapid shifts in water characteristics such as turbidity, temperature, conductivity or pH that closely correlate to climatological or surface-water conditions.

The evaluation begins with a preliminary assessment (PA). If the PA indicates that the ground-water supply may be under the direct influence of surface water, further study is required. Further study may include conducting a hydrogeologic assessment (HA) and / or a water quality assessment that may include conducting microscopic particulate analysis (MPA).

PRELIMINARY ASSESSMENT

A completed PA form for the Rapelje Water Users Association well is included as appendix A-1. The well is the only source of drinking water used by the residents of Rapelje. The Rapelje Water Users Association well was assigned a total score of 95 points. Under DEQ guidelines, any water source that scores 40 points or higher automatically requires further evaluation. The site was assigned 40 point because the water source for the well is a spring. The dug well is unlined (15 points) and does not have a sanitary seal (15 points). Another 10 points were assigned because the static water level in the well was less than 4 feet (ft) below the land surface. Although coliform bacteria were detected in a water sample from the water-supply system on 8/23/99, no points were assigned because this event occurred after the HA visit (Mike Brayton, DEQ, personal communication, 2000). **The total score of 95 points, out of a possible total of 180, indicates the system is at moderate risk of being under the direct influence of surface water.**

SYSTEM DESCRIPTION

Location

Rapelje, Montana is located in northern Stillwater County about 25 miles north of Columbus, Montana and Interstate 90 (Figure 1). Rapelje can be reached by traveling west on main street in Columbus and turning north on the Rapelje Road past the cemetery. The location of Rapelje is shown on the Rapelje 7.5-minute U.S. Geological Survey (USGS) topographic quadrangle map in sections 32 and 33, T. 3 N., R. 20 E. (Figure 2). The water supply spring is located at the southeast corner of town in the SW ¼ SE ¼ SW ¼ NW ¼ of section 33 of the same township and range, at 45° 58' 01"N, 109° 15' 10"W. The blue, metal-sided pump house is visible from the paved county road south of Rapelje (Appendix C, photo C-1). Mark Doely , the system operator, lives in a house adjacent to the well site.

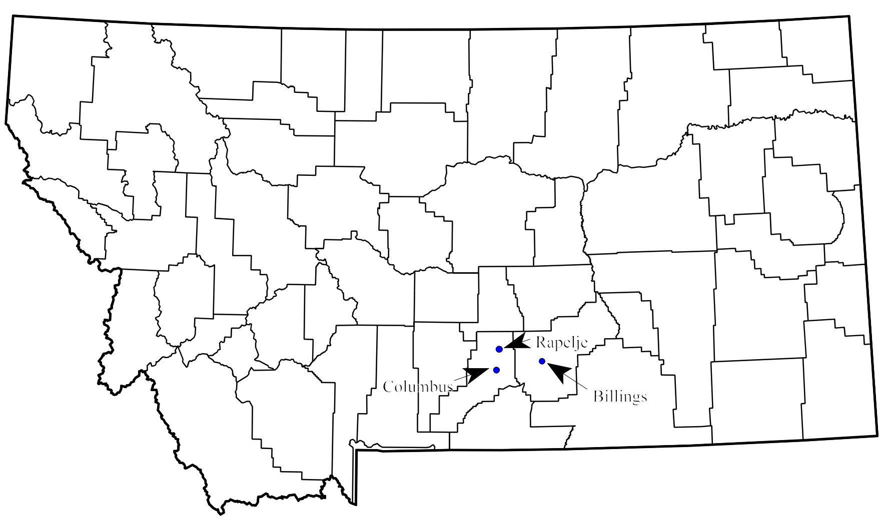

Figure 1. Montana state map showing the locations of Rapelje, Columbus and Billings.

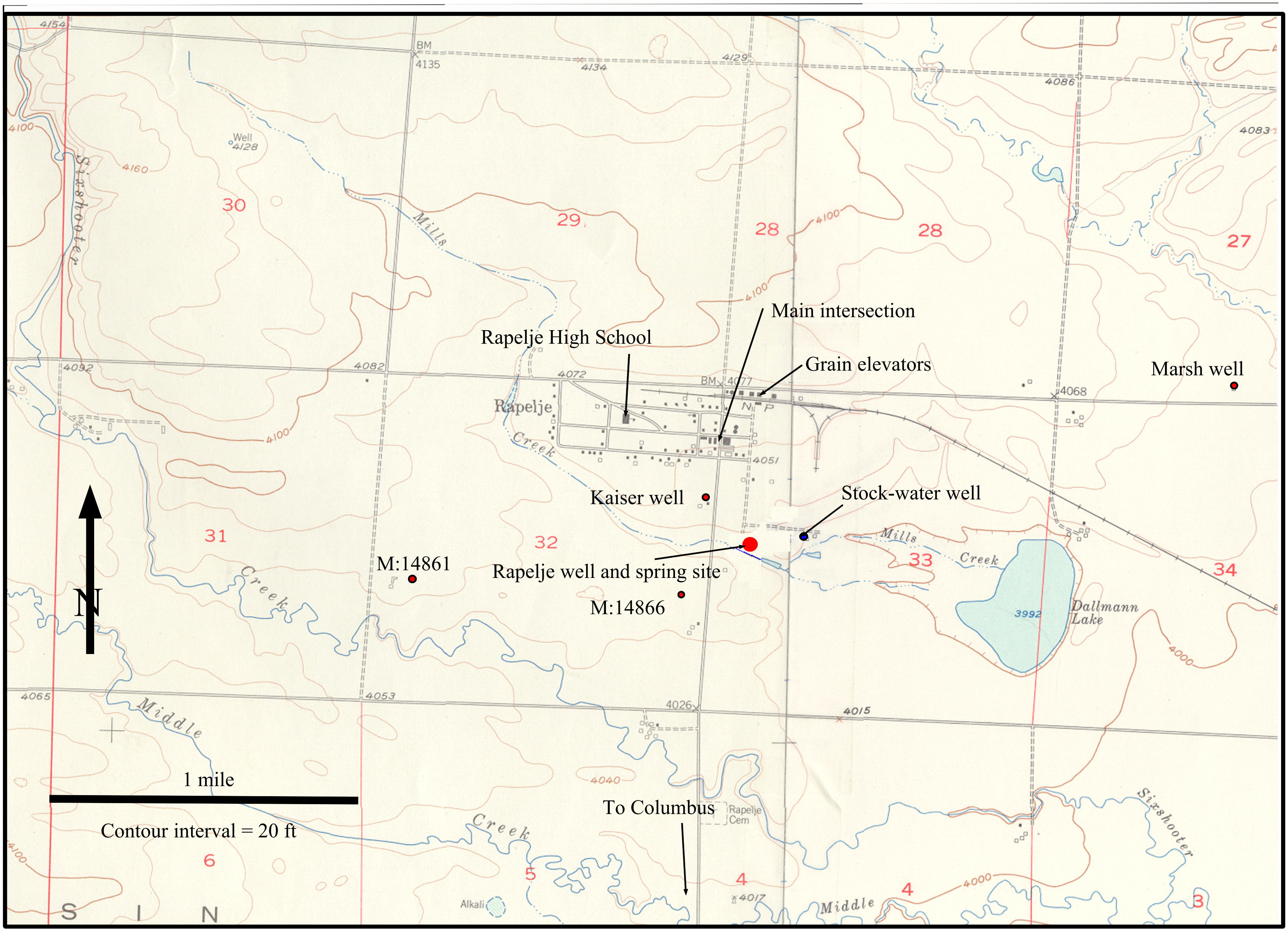

Figure 2. Topographic contour map of Rapelje area showing the town site, spring site, inventoried stock-water well, high school where water storage tanks are located and other wells sampled for nitrate (Rapelje and Battle Butte, USGS Topographic Quadrangle maps, 1956).

Source History
The water supply well was originally constructed by the Great Northern Railroad (or possibly the Northern Pacific Railroad) as a water supply for steam engines and for a bunkhouse. The bunkhouse is a brick structure that still stands just north of the well (Appendix C, photo C-2). The house is currently used as a storage shed. The well was constructed by digging an 18-foot diameter by 20-foot deep hole into the sandstone bedrock that crops out at the site. The well was located where a spring flowed from the bedrock. The town of Rapelje bought the well from the railroad in 1961. After the purchase, water mains were installed through town and a cement cover was placed over the well. The town also built the pump house over the well and installed two pumps.

Four springs are located along the creek bottom within 100 feet of the pump house. One spring discharges from the bedrock adjacent to the well along the bank of Mills Creek and one is located to the north of the pump house. Drain tiles run from a spring located north of the pump house to the creek to drain water away from the well. No evidence of surface discharge was seen in the area north of the pump house. Bank erosion by spring discharge near the well has required the system operator to backfill dirt along the stream bank and run a pipe from the spring discharge to the creek in order to move the spring discharge water away from the city well (Appendix C, photo C-3).

Well Construction and Water-Distribution System
The top of the well is a 3-foot high brick and mortar ring built on top of a sandstone outcrop. A cement cap rests on top of the brick wall with a manhole opening for access. Dirt is backfilled around the well up to the top of the cement cover (Appendix C, photo C-2). The measuring point at the top of the manhole cover is 0.75 ft above the land surface. On December 15, 1998 the static water level measured in the well was 3.76 ft below the measuring point, or 2.99 ft below the land surface.

The system operator reported that a pumping test was conducted on the well by a consultant in the 1980's. The well was pumped at an estimated 1000 gpm for several hours. During the test, the water level in the well only dropped 2 inches. During the HA inspection, the pump cycled on and off several times, but the water level did not drop. The operator reports that the lowest that the water level has ever dropped was about 4.5 ft below the manhole cover (Mark Doely, personal communication, 1998).

Water is pumped from the well by 2 pumps, rated at 100 gpm capacity each, into a series of 4 fiberglass pressure tanks in the pump house. The water is then piped into the water mains that distribute the water through town. The fiberglass pressure tanks are about 5 ft tall and 3 ft in diameter and are rated to 125 psi each. A pressure of 70 psi is maintained on the water system. The discharge rate for the pumps is controlled by an inline valve on the main line between the pumps and the pressure tanks. The tanks are experimental and were installed in 1997. Recently two of the pressure tanks have developed pinhole leaks as evidenced by white crystalline mineral deposits precipitated on the side of the tanks. A check valve is located on the main water line where the line leaves the pump house to prevent water in the distribution lines from flowing back into the well. The water is chlorinated at the pump house using a gas chlorination system. For emergencies a turbine pump is set in the well. The turbine pump is powered by a gasoline engine in the pump house that has been converted to run on propane gas. Five water-storage tanks, each with a 350-gallon capacity, are located in the basement of the high school located on the west side of town. The storage tanks are used to gravity-feed water into the town's main water lines during emergencies. Brown Engineering from Park City, Montana assisted in most of the system design. The MDHES (Montana Department of Health and Environmental Sciences, now the Department of Environmental Quality (DEQ)) conducted an inspection of the Rapelje Water Users Association water system on July 23, 1991. The report concluded that the system and operation of the system were satisfactory.

The Rapelje water system has about 40 active connections. The well supplies water to about 75 users and to the school, which has about 90 students in grades K through 12. Water is supplied to two businesses, the cafe in the center of town and to the grain elevator located north of the well site along the abandoned railroad line (Figure 2) and (Appendix C, photo C-4). The operator estimates that the water system produces about 1 million gallons of water a month in the summer but the rate drops to about 40,000 gallons during the winter months. Some of the water is used for lawn irrigation and for livestock watering. Because high levels of nitrate have been detected in several water samples from the well (see Water Quality section), the water users association supplies reverse-osmosis systems to users who request them. Other residents use distillers or bottled water.

GEOLOGY

Topography and Land Use

Rapelje is located in a broad basin that is 3 to 4 miles wide north to south, and 20 miles long, east to west. The land around Rapelje is primarily planted in grass for grazing cattle and sheep. Some land is used for dryland grain farming that uses crop-fallow rotation farming methods (Appendix C, photo C-5). The land around the well is designated as a town park but is undeveloped grassland often used for grazing livestock. The lot appears to be heavily grazed.

The land surface is gently rolling terrain formed on benches created by sandstone ledges in the Fox Hills Formation. The land rises to the north and northwest of town and slopes gently downward to the southeast of town. The well is located at 4030 ft elevation.

The town is located northwest and upgradient from the well site (Figure 2). There is no sewage treatment system for Rapelje, so all residents use septic systems. To the west of town the land is primarily grassland used for cattle and sheep grazing and areas of tilled land used for dryland farming. Immediately north and uphill from the well site is a fenced area that has been heavily grazed by sheep.

Regional Geology

Rapelje is located on upper-Cretaceous sediments in the Lake Basin physiographic region. The Lake Basin area is named for the numerous undrained depressions containing permanent or temporary lakes of variable size (Hall and Howard, 1929). The water in the shallow lakes is lost to evaporation and is generally high in dissolved mineral content and is of poor quality.

Table 1. Estimated thickness of geologic formations in Yellowstone and northern Stillwater Counties (Hall and Howard, 1929; Niebauer, 1941).

Geologic unit	Geologic age	Thickness, ft
alluvium	Quaternary	<1- 15
Lance Formation		1500
Fox Hills Formation		up to 200
Bearpaw	upper-Cretaceous	600-1000
Judith River Formation		450
Claggett Formation		560-600
Eagle Formation		200-300
Telegraph Creek Formation		320
Colorado Group shales		2,250-2550
Dakota Formation	lower-Cretaceous	100
Kootenai Formation		300

The well at Rapelje is completed in Fox Hills Formation sandstone along the southern flank of the Lake Basin Fault zone (Table 1). Outcrops of the Fox Hills Formation extend for approximately 5 miles north of Rapelje where the lower contact with the Bearpaw Shale crops out at the land surface. The Lake Basin Fault zone is an east-southeast trending structural lineament composed of a series of northeast trending normal, reverse and thrust faults that extends for about 100 miles across northern Stillwater County, central Yellowstone County and eastward into Bighorn County (Hall and Howard, 1929). The center axis of the fault lineament passes about 2-3 miles to the north of Rapelje. The fault zone is generally less than 7 miles in width. Individual faults within the fault zone typically exhibit down-to-the-east movement. No obvious evidence of faulting of the bedrock was observed near Rapelje. However, 2 miles northeast of Rapelje, near the Hailstone Basin Wildlife Refuge, ridges of tilted sandstone beds of the Judith River Formation crop out, demonstrating that displacement has occurred along the Lake Basin Fault System (Appendix C, photo C-6). Displacement along the faults is usually less than 500 ft but has been measured to be 1,000 ft at Rattlesnake Butte in Yellowstone County (Hall and Howard, 1929). Rims of Eagle Sandstone crop out north of Rapelje, indicating that offsets along the fault zone have displaced the geologic formations by hundreds of feet. Although no evidence of geologic structures were observed in the bedrock at the well site, it is possible that faults may extend through the Rapelje area but are obscured by soils and colluvium. Faults and fractures in the bedrock probably provide conduits for ground-water flow that increase the hydraulic conductivity of the aquifer that underlies the Rapelje well.

Local Geology

Rapelje is located on strata of the lower portion of the Fox Hills Formation. The Fox Hills Formation thickens to the west and thins to the east. The geologic strata beneath Rapelje are bowed upward and tilted slightly to the south due to movement along the Lake Basin Fault zone. Tilting of the strata has exposed Bearpaw Shale, the formation which underlies the Fox Hills Formation to the south, east, and north of town.

Outcrops of buff-yellow to tan colored sandstone of the Fox Hills Formation were inspected around Rapelje. The outcrops are composed of 10 to 15 foot thick layers of thinly bedded sandstones interlayered with 3 to 5 feet thick intervals of sandy, brown clay. A road cut on the north side of Rapelje has exposures of several alternating sandstone and clay intervals within the Formation. The strata of the Fox Hills Formation appears to be nearly flat lying to gently south dipping. The soil is thin, dark-brown in color and composed of clays with some sand and minor gravel. The soils also contain numerous fragments of thin-bedded sandstone.

Mark Doely, the water system operator, lives less than one-quarter mile north of the well site. When he was digging a basement for his house, Mr. Doely reported that he hit a hard blue shale 6 to 8 feet below the land surface. Mr. Doely also encountered the same shale 4 feet below the surface at the gas station on the southwest corner of the main town intersection (Mark Doely, personal communication, 1998) (Figure 2). These reports of blue shale suggest that the contact between the Fox Hills sandstone and the underlying Bearpaw Shale is less than 10 ft below the land surface at Rapelje. This is confirmed by well logs that show thick shales, interpreted as Bearpaw Shale, have been encountered 8 ft to 80 ft below the land surface near Rapelje (GWIC, 2000). The Bearpaw Shale in eastern Montana has very low permeability and is often an aquitard that marks the bottom of the shallow ground-water systems. The Fox Hills-Bearpaw Shale contact is probably the bottom of the shallow ground-water system at Rapelje.

The springs near the well site discharge from a 10-20 ft thick, sandstone layer near the base of the Fox Hills Formation. The well appears to be dug through the entire thickness of the sandstone layer. Ground water within the sandstone moves through pore spaces, along parting surfaces and through fractures within the sandstone. The Bearpaw Shale at the base of the Fox Hills Formation probably limits the downward movement of the shallow ground water.

HYDROLOGY

Surface Water

No major surface water features are located near or upgradient from the well site. Most streams in the Rapelje area are ephemeral, flowing only during periods of high precipitation or snowmelt runoff. Most were dry during the investigation visit. The creeks in the Rapelje area drain to the east, into Cedar Creek, which flows into Halfbreed Lake, Dry Lake and finally to Big Lake, which has no outlet (Appendix B-1). Big Lake is located 12 miles southeast of Rapelje. Most of the water that collects in the lakes evaporates.

The spring/well site is located along Mills Creek, an ephemeral stream that flows along the west and south sides of town (Figure 2). The springs discharge into Mills Creek which flows into Dallmann Lake, less than one mile to the east (Appendix C, photo C-1). At the time of the HA site inspection, Mills Creek was dry upgradient from the spring site and flowed with spring discharge east of the site. Mr. Doely indicated that this was the typical situation (Mike Doely, personal communication, 1998). The Mills Creek channel is poorly defined upstream from the well site. Dallmann Lake has no outlet and is reportedly highly saline.

The climate at Rapelje is semiarid. The area receives 13.9 in average annual precipitation and is subjected to 53 in of potential annual evaporation (Custer, 1976). The only irrigation apparent in the area is for the Rapelje High School football field. The field is watered by a sprinkler system that uses water from the town well.

Regional Ground-Water Flow

Wells in the Rapelje area range in depth from 18 ft to over 1,200 ft and draw water primarily from the alluvium and colluvium along drainage bottoms and from bedrock of the Fox Hills, Judith River and Eagle formations (GWIC, 2000). Some deep oil wells that have been converted to water wells draw ground water from the Madison and possibly the Kootenai formations. This water is used to water livestock. The shallow ground water at Rapelje is located in the colluvium along the drainage bottoms and in the Fox Hills Formation. The Bearpaw Shale is a confining layer that defines the base of the shallow ground-water system. The shallow ground water flows downgradient through the colluvium along drainages and through the more permeable sandstone layers within the Fox Hills Formation. The ground water in the Fox Hills Formation moves downgradient along the dip of the sandstone layers, moving generally downslope to the east and to the south with the land surface topography (Appendix B-2). The ground water within the Fox Hills Formation may be separated into perched layers bounded by clay intervals between the sandstone layers within the formation. The shallow ground water is recharged by precipitation and snowmelt that infiltrates through the land surface into the sandstone layers. The ground water discharges from springs in topographically low areas where the water table intercepts the land surface.

Few ground-water studies have been conducted in the area. Those that have been conducted have addressed the formation and occurrence of saline seeps, a widespread problem affecting ground water quality. Saline seeps occur where ground water high in salt content discharges to the land surface. Most agricultural crops cannot tolerate the high salt content and will not grow in saline areas. Custer (1976) found that saline seeps are the result of excess deep infiltration of water through the soil following cultivation of the land. The increased infiltration is caused by decreased water use by plants (the native grasses were uprooted by cultivation) and by soil left bare in crop-fallow rotation. Custer (1976) noted a strong connection between surface water and shallow ground water when he observed a rapid response in the rise in ground-water levels within days of precipitation. An additional complication is that shales in saline seep areas are typically located at shallow depths below the land surface, inhibiting the downward movement of ground water. The shallow ground water is then concentrated in a thin aquifer just below the land surface. Because of the high salininity the shallow ground water is often unfit to drink. Mr. Doely reported that cattle will not drink from some wells that produce water with a high sodium content (Mark Doely, personal communication, 1998).

Local Ground-Water Flow

The system operator reports that several small springs are located in the area, but none produce as much water as the supply well (Mark Doely, personal communication, 1998). The springs are located along drainages and in topographically low areas. It is suspected that many of the springs are contact springs that discharge from sandstone layers that lie above the Bearpaw Shale or above low-permeability, clay-rich layers within the Fox Hills Formation. The springs located along Mills Creek at Rapelje, including the water supply to the well, discharge ground water from the lower portion of the Fox Hills Formation at, or near the contact with the Bearpaw Shale. The springs are located at topographically low points in the aquifer system and discharge ground water to the land surface where the Mills Creek drainage has incised into the Fox Hills sandstone near the base of the formation. Based on reports of blue clays intercepted in excavations in town, the contact between the base of the Fox Hills Formation and the Bearpaw Shale at the well site may be 25 ft thick (20 ft deep well, ±10 ft to Bearpaw Shale). Beneath town the Formation may be less than 10 ft thick in some places.

Ground water within the Fox Hills aquifer is recharged from precipitation and snowmelt that infiltrates from the land surface into sandstone layers, through pore openings, cracks and fractures within the sandstone and through cracks within clay intervals. Recharge is probably greatest in areas where the sandstone layers crop out and receive direct recharge. The most likely recharge area for the aquifer is in the higher elevation areas west and north of the well. The flow direction of the shallow ground-water system probably mimics local topography, flowing south and east through the sandstone layers toward areas of lower elevation (Appendix B-2). Fractures or faults related to the Lake Basin Fault system may extend through or near the well site and may enhance ground-water movement through the sandstone aquifer. The hydraulic conductivity of the aquifer near the well appears to be high, based on the small amount of drawdown that was observed during the 1000 gpm pumping test. Hydraulic conductivities capable of supplying recharge at >1000 gpm, suggests that ground-water recharge to the well is probably enhanced by fractures within the sandstone.

WATER QUALITY

Field Parameters

Water-quality data reviewed for this report were obtained from measurements during the HA and from MBMG, Ground-Water Information Center records (GWIC, 2000). Temperature, pH, specific conductance and redox of water from the public water-supply well, from a nearby spring, and from a nearby shallow, stock-water well were measured during the HA site investigation (Figure 2). Redox is a measure of the oxidizing potential of the water. These data are presented in table 2.

Table 2. Field water-quality measurements for water from the Rapelje Water Users Association public water supply well, an adjacent spring, and a nearby stock-water well. All measurements were made during the HA investigation on December 15, 1998. Eh was calculated using a correction factor for the platinum redox probe electrode that was used, (Eh = measured redox potential (mv) + temperature based electrode potential correction factor (mv)).

Location	Temperature (°C)	pH	Specific Conductance (µmhos/cm @ 25° C)	Redox (mV)	Eh (mV)
water supply well	9.7	7.8	2,580	275.1	489.4
adjacent spring	9.5	8.1	2,580	250.8	465.3
stock water well	12.4	7.6	2,630	238.6	450.2

Natural Ground-Water Quality

Water samples collected from the Rapelje well by the MBMG on April 2, 1998 and March 24, 1999 show that the water is sodium-sulfate bicarbonate type that is high in nitrate (GWIC, 2000) (Table 3). Water-quality parameters measured from the adjacent spring and from the nearby stock well are similar to the Rapelje well water (Table 2). These measurements show the typical quality of the shallow ground water at Rapelje. A comparison of the water quality in the Rapelje well with water quality from wells in the Fox Hills Formation in the area show that the Rapelje water is typical of Fox Hills ground water but exceeds the safe drinking water standard for nitrate content (EPA, 1996) (Table 3). This may be due to the shallow nature of the well and the proximity to the base of the Fox Hills Formation and the crop-fallow farming practices nearby. The high sulfate content may be due to contact of the ground water with the underlying Bearpaw shale.

Saline-seep studies in central Montana found that the seep water was sodium-magnesium-sulfate type, similar to the Rapelje well water (Miller and others, 1978). The ground-water quality in the Rapelje well can be attributed in part to saline-seep influences caused by tillage and crop-fallow farming practices. The low chloride content of the water is another indicator that the source of the ground water is shallow and is influenced by saline seeps.

Table 3. Water quality of ground water from the Fox Hills Formation from the Rapelje Spring and from wells located in northern Stillwater County. Tables Showing (A) Major Ions and showing (B) Trace elements.

A.

Major Ions

sample id	mnumber	township	range	section	tract	latitude	longitude	site name	sample date	type	lab specific conductance umhos/cm	lab pH	aquifer	ca mg/L	mg mg/L	na mg/L	k mg/L	Fe ug/L	Mn ug/L	sio2 mg/L	hco3 mg/L	co3 mg/L	Cl mg/L	SO4 mg/L	NO3_N mg/L	F mg/L	opo4 mg/L
1985Q0023	7172	02S	20E	16	CCCA	45.655	-109.272	PARKINS	11/05/84	well	1928	7.8	Fox Hills	126	63	238	3.4	0.014	<.001	10	505	0	38.6	582	0.35	0.8	<.1
1998Q0871	166184	03N	20E	33	BCDC	45.967	-109.253	RAPELJE SPRING	04/02/98	spring	2580	7.5	Fox Hills	123.4	87.8	364.9	4.6	<.005	<.001	7.3	494.1	0	114	947	10.8	1.98	<1.
1999Q0596	166184	03N	20E	33	BCDC	45.967	-109.253	RAPELJE SPRING	03/24/99	spring	2560	7.57	Fox Hills	132	94.2	349	4.36	<.025	<.005	7.05	495.32	0	109.2	928.8	10.81	<.5	<.5
1999Q0597	166184	03N	20E	33	BCDC	45.967	-109.253	RAPELJE SPRING	03/24/99	spring	--	--	Fox Hills					--	--				--		11.24 P	--	
1921Q0060	1198	03N	26E	8	B	46.027	-108.524	AMMANN	10/27/21	well	--	--	Fox Hills-Hell Creek	15	6.4			0.05	--	7.8	443	40	17	266	<.023		
1979Q0607	1320	04N	26E	22	ADBB	46.083	-108.470	BROCKIE	10/04/78	well	1774	8.87	Fox Hills-Hell Creek	2.3	0.5	437	1.1	<.01	0.01	8.2	540	27.4	5.8	413	0.429	4.7	
1998Q0243	16073	04N	26E	29	DCCB	46.061	-108.518	PRATT BILL AND AL	08/22/97	well	944	8.14	Fox Hills-Hell Creek	32.7	20.8	162.4	2.3	<.003	<.002	8.4	388.9	0	14.9	152.8	.88 P	--	<.05
1998Q0243	16073	04N	26E	29	DCCB	46.061	-108.518	PRATT BILL AND AL	08/22/97	well	944	8.14	Fox Hills-Hell Creek	32.7	20.8	162.4	2.3	<.003	<.002	8.4	388.9	0	14.9	152.8	.88 P	--	<.05
1998Q0356	161820	06N	33E	28	CCBC	46.239	-107.611	BOTTS RALPH	09/05/97	well	3210	8.4	Fox Hills-Hell Creek	9.7	3.4	885	1.9	<.003	0.005	8.12	569.7	5.4	92.6	1228	<.25 P	--	<5.
1998Q0356	161820	06N	33E	28	CCBC	46.239	-107.611	BOTTS RALPH	09/05/97	well	3210	8.4	Fox Hills-Hell Creek	9.7	3.4	885	1.9	<.003	0.005	8.12	569.7	5.4	92.6	1228	<.25 P	--	<5.

B.

Trace elements

sample_id	mnumber	site name	sample date	Al ug/L	Ag ug/L	As ug/L	b mg/L	Ba ug/L	be mg/L	br mg/L	Cd ug/L	co mg/L	Cr ug/L	Cu ug/L	li mg/L	mo mg/L	Ni ug/L	Pb ug/L	sb ug/L	se ug/L	sr ug/L	ti ug/L	tl ug/L	v ug/L	Zn ug/L	zr ug/L
1985Q0023	7172	PARKINS	11/05/84	--	--	--		--		100	--		--	--			--								--	
1998Q0871	166184	RAPELJE SPRING	04/02/98	<30.	<1.	1.9	342.4	21.1	<2.	<500.	<2.	<2.	16.4	9.8	<50.	<10.	24	<2.	<2.	36.6	2569	<10.		<5.	58.6	<5.
1999Q0596	166184	RAPELJE SPRING	03/24/99	<30	<1	1.73	340	26.7	<2	<500	<2	<2	11.9	6.34	<250	<10	6.6	2.64	<2	28.9	2820	<50	<5	<5	3.36	<25
1999Q0597	166184	RAPELJE SPRING	03/24/99	--	--	--		--			--		--	--			--	--							--	
1921Q0060	1198	AMMANN	10/27/21	--	--	--		--			--		--	--			--	--							--	
1979Q0607	1320	BROCKIE	10/04/78	--	--	--	690	<50.			--		--	--	60		--	--		<.5	120				--	
1998Q0243	16073	PRATT BILL AND AL	08/22/97	<30.	<1.	1	58	21	<2.	105	<2.	<2.	10.8	2.3	<6.	13.4	3.8	<2.	<2.	5.7	1124	<10.		<5.	16.1	<20.
1998Q0243	16073	PRATT BILL AND AL	08/22/97	<30.	<1.	1	58	21	<2.	105	<2.	<2.	10.8	2.3	<6.	13.4	3.8	<2.	<2.	5.7	1124	<10.		<5.	16.1	<20
1998Q0356	161820	BOTTS RALPH	09/05/97	<30.	<1.	2.3	252	8.4	<2.	<2500.	<2.	<2.	6.9	11.4	91	<10.	<2.	<2.	<2.	6.1	644	<10.		<5.	107.8	<20.
1998Q0356	161820	BOTTS RALPH	09/05/97	<30.	<1.	2.3	252	8.4	<2.	<2500.	<2.	<2.	6.9	11.4	91	<10.	<2.	<2.	<2.	6.1	644	<10.		<5.	107.8	<20.

Inorganic water chemistry

Water samples from the well regularly exceed the EPA maximum contaminant level (MCL) for nitrate, sulfate and total dissolved solids in drinking water (Table 4). The sulfate content of the well water ranges from 929 to 947 mg/L; the safe drinking water standard for sulfate is 250 mg/L. The TDS for the well samples ranged from 1,905 to 1,879 mg/L, the safe drinking water standard for TDS is 500 mg/L. Ground water in much of eastern Montana exceeds the MCL's for sulfate and for TDS, but often ground water is all that is available. The high TDS content of the well water is the result of saline seep development in the area (Table 3). The measured levels of selenium are slightly below the MCL (Table 4). Shallow ground water with high levels of TDS, selenium, sulfate and in some cases nitrate is common in eastern Montana where farming occurs on Cretaceous bedrock formations with shallow depths to ground water.

Table 4. Nitrate, selenium, sulfate and TDS results for ground water from the Rapelje Water Users Association well. Note that all of the reported values for nitrate, sulfate and TDS exceed EPA, MCL's for drinking water.

Date	Nitrate as N (mg/L)	Selenium (mg/L)	Sulfate (mg/L)	TDS (mg/L)	sampled by
EPA, MCL for drinking water	10.0	0.05	250	500	
3/24/99	10.8	0.029	929	1,875	MBMG
4/2/98	10.8	0.037	947	1,905	MBMG
5/2/97	12.9				RPWUA
12/11/96	11.9				RPWUA
11/16/95	11.5				RPWUA
8/21/95	11.6				RPWUA
8/11/93	15.4				RPWUA
9/2/87	11.1				MDHES
6/29/87	11.7	<0.002	1005		MDHES
2/9/81		0.037			MDHES
2/9/81		0.037			MDHES
12/15/80	13.0	0.013			MDHES
12/15/80	13.2	0.016			MDHES

Nitrate
Nitrate levels above the MCL drinking water standard are regularly detected in water samples from the Rapelje well. The area around Rapelje has a considerable number of saline seeps and has been the focus of studies by the Conservation District, MBMG, and others. Custer (1976) conducted a study on saline seeps and the occurrence of nitrate in ground water at a site located 6 miles northeast of Rapelje. In his study Custer found that no nitrate occurred in ground water below native grassland but concentrations of nitrate ranging from 33 ppm to 55 ppm in ground water beneath tilled land. Based on the results of his studies, Custer attributed the source of the nitrate in the ground water to the increase in the rate of infiltration of water through the land surface caused by aeration of the soil by tillage, by the crop-fallow practice of leaving the tilled land bare, along with the decay of organic matter disturbed by the tillage. The combination of tillage opening the ground to increased infiltration and the lack of plants to use the water in tilled areas, especially in fallow areas, increases the amount of water and nitrate reaching the water table. Custer concluded that there is a general danger of high nitrate concentrations in the shallow ground water in the Rapelje area (Custer, 1976). In studies conducted by the MBMG in the Rapelje area in the 1970's, nitrate levels rose into the hundreds of mg/L at some study sites following tillage of the land (Marvin Miller, personal communication, 1999).

Nitrate has been detected in several wells sampled in Rapelje (Table 5) (Figure 2). The presence of nitrate in the well water at Rapelje indicates a connection of the ground water with surface water. Based on the saline seep studies and the sample data from wells, it is likely that most shallow ground water in the Rapelje area contains unacceptable levels of nitrate. In addition to the increased rate of water infiltration caused by crop-fallow rotation farming practices, the aquifer is thin, which aids in increasing the nitrate concentration in the shallow ground water.

Table 5. Nitrate levels measured in ground water from other wells in the vicinity of the Rapelje well (GWIC, 2000 and from the Rapelje Water Users Association records).

Well number or site name (GWIC, MBMG)	Location	Nitrate (mg/L)
M:14866	section 32, T 03N, R20E	2.8
Kaiser	section 32, T 03N, R 20E	14.9
M:14861	section 32, T 03N, R 20E	10.5
Marsh	section 27, T 03N, R 20E	17.1

The Rapelje Water Users Association supplies reverse osmosis filtration systems to home of residents who request them or have need of them, especially if the homes have infants, pregnant women or elderly residents. The Rapelje Water Users Association submitted an application for exception from the Safe Water Drinking Act to the EPA and the state MDHES dated February 11, 1981 in response to the high nitrate levels in the well water. The application was apparently not accepted. A letter from the MDHES dated 9/17/93 instructed the water users association to hire a professional engineer to design a treatment system to remove nitrate from the water supply. In 1998 and 1999 the MBMG was involved in evaluating commercial systems for extracting nitrate from the well water at the Rapelje site. So far none of the systems have been successful (James Madison, personal communication, 1999).

In addition in 1995, under advisement of the MDHES, the Rapelje Water Users Association contracted a driller to evaluate the feasibility of drilling a deep well for a replacement water supply. Based on the geology of the area, the most likely alternate source for ground water would be the Judith River Formation located more than 1,000 ft below the land surface, beneath the Bearpaw Shale. The driller concluded that a well approximately 1,300 ft deep would be required. The well would be expensive and the rate of water production would probably be inadequate to meet the town's needs (Rapelje Water Users Association memo, 1995). In addition, the water quality of the Judith River Formation would probably be poor because of a probable high TDS content.

Selenium

Concentrations of selenium in water samples from the Rapelje wells present another potential health threat to the water system users (Table 4). The concentrations measured to date are not in excess of safe drinking water standards (0.05 mg/L) but are very close. The high selenium contents are not uncommon in shallow ground water in Cretaceous sediments of central Montana (Table 3). The selenium is derived from the sediments that are in contact with the shallow ground water.

A joint evaluation of the Rapelje water supply system by the MDHES and the MBMG in 1980 concluded that "The presence of saline seeps and the type of agricultural practices in the area will probably lead to deterioration of the water quality of the shallow ground water" (Groff, 1980).

Bacterial Analyses

Several wells in Rapelje have been abandoned, including the well for the high school, because of numerous tests in which fecal-coliform bacteria were detected (Mark Doely, personal communication, 1998). Coliform bacteria have also been detected in several water samples from the Rapelje water-supply well. The following are dates of water samples in which coliform bacteria were detected:

- 8/23/99, 5 coliforms/100 ml
- 10/25/93, 23 coliforms/100 ml
- 4/1/91, coliforms detected
- 3/19/91, coliforms detected

Boil orders were issued following several of these violations. Probable bacteria sources include drainage of overland runoff from pasture land immediately north of the well site and from septic-system effluent draining into the shallow aquifer. Fractures and cracks within the aquifer formation beneath Rapelje could allow for the rapid movement of effluent from the septic system drain fields into the ground water. In addition many of the septic systems are probably old and may not operate properly.

Potential contamination hazards

Based on observations made during the HA investigation, a list of potential threats to the quality of the ground-water supply to the well was compiled (Appendix A-2). Most of the items represent hazards because of their location upgradient from the well and the shallow depth to ground water below these sites:

- leakage of fluids from the gasoline engine in the pump house may drain into the well (run on propane (LPG)).
- septic systems from houses in town
- fuel storage tanks for the gas station
- storage of liquid pesticides in tanks at the grain elevators
- storage of ammonium nitrate fertilizer in large above ground tanks and in trailers in town

CONCLUSIONS

Determination of Direct Surface-Water Influence

Based on the HA the well water used by the Rapelje Water Users Association may be under the direct influence of surface water as defined in 40 CFR part 141. The source of the water in the Rapelje public supply well is ground water from the Fox Hills aquifer. It appears, based on the HA investigation, that the ground water at the well site comes from a thin, shallow-depth aquifer that is vulnerable to contamination. Ground water in the Fox Hills Formation is recharged by the infiltration of water from the land surface to the water table. Because of crop-fallow farming practices, the infiltrating water may transport nitrate from the land surface into the ground water. Because the aquifer is thin the nitrate is concentrated. The nature of the geologic material of the formation and the reaction of the ground water with the materials contributes concentrations of selenium, sulfate and TDS in excess of safe drinking water standards. The well is an unlined hole dug in the ground with no protection from the infiltration of surface water from near the well. Septic systems from town are located upgradient from the well site and may contribute to contamination of the shallow ground-water system that supplies the well.

The high concentration of TDS in the well water are the result odf saline seep development in the area. The presence of nitrate and coliform bacteria indicate that the Rapelje Water Users Association well may be under the direct influence of surface water. The nitrate and coliform bearing water has probably not been in the aquifer for an extended period of time.

The Rapelje Water Users Association has made efforts to resolve the water quality problems associated with their water- supply well. Because the deeper aquifers in the Judith River Formation may also have water-quality or yield problems, it will be difficult to remedy Rapelje's water supply problem.

RECOMMENDATIONS

Because the well is unlined and draws ground water from a shallow aquifer underlain by Bearpaw Shale and because evidence of surface influence to the ground water is present by the detection of nitrate and coliform bacteria in the well water, further study of the water source is recommended. The water quality of the shallow ground-water system in general is marginal to poor as a drinking water source. Therefore, any modifications to the well alone may not solve the water supply problems. Although the well is not constructed to the Montana Board of water well contractors standards (Montana Department of Natural Resources and Conservation, 1997) many of the problems lie in the general quality of the shallow ground water. In order to determine if the well water is directly influenced by surface water and to improve the safety of the water supply and to resolve some of the water quality problems, several suggestions have been included:

- Conduct a macro-particulate analysis (MPA) of the well water to determine if there is a surface water influence on the spring water.

- Because of the recurring detection of coliform bacteria in the well, the water should be regularly disinfected with chlorine to control bacteria in the system.

- Determine the source of the coliform bacteria in the well water. The bacteria may be from septic systems in town or from surface runoff near the well. Testing ground water from around town for coliform bacteria may provide an indication of the prevalence of the bacteria in the ground water.

- Line the upper portion of the well to provide an adequate near-surface sanitary seal.

- Eliminate potential contaminant sources from the land near the well. In particular, do not allow livestock to graze in the pastures around the well or allow the application of pesticides or fertilizers to the land near the well.

- Remove the gasoline engine pump from the pump house to prevent potential leakage of fluids from the engine into the well.

- The shallow ground water in the Rapelje contains levels of nitrate, sulfate and TDS in concentrations above the recommended MCL for drinking water. Because there are few options for an alternate water source, it may be necessary to address the water-quality issues by developing a water-treatment system.

- Recommend using reverse-osmosis filtration systems in the homes of the system users to reduce the amount of nitrate in the domestic use water.

- Evaluate the potential for reducing the level of nitrate in the shallow ground water by the modification of agricultural practices on land upgradient from the well site.

- Control the land use along Mills Creek upgradient from the well site. The creek channel may be a conduit for the collection of surface water that could infiltrate into the ground water system.

- Evaluate potential alternate sources of water for the community. This may include locating wells in areas not impacted by agriculture, evaluating the water quality and production rates of deep aquifers, or hauling water from an acceptable water source.

REFERENCES

Custer, S. G., 1976, Shallow Ground-Water Salinization in Dryland-Farm Areas of Montana, Montana Universities Joint Water Resources Research Center, Bozeman, Montana, 1877 p.

U. S. Environmental Protection Agency, revised 1996, National Primary Drinking Water Standards, U.S. EPA Office of Water, Washington, D.C., web page address: http://www.epa.gov/OGWDW/creg.html

Ground-Water Information Center, 2000, Montana Ground-Water and well database, Montana Bureau of Mines and Geology, Butte, Montana.

Miller, M.R., Bergantino, R.N., Bermel, W. M., Schmidt, F.A., Botz, M.K., Bahls, L.L., Bahls, P.A., 1978; Regional Assessment of the Saline-Seep Problem and a Water-Quality Inventory of the Montana Plains; Open-File Report MBMG 42, Montana Bureau of Mines and Geology, Butte, Montana, 18 p.

Montana Department of Natural Resources and Conservation, 1997, Montana Board of Water Well Contractors, Montana Codes Annotated, Administrative Rules of Montana, March, 1997; Montana Department of Natural Resources and Conservation, Helena, Montana, 40 p.

U. S. Geological Survey, 1979, Big Timber 30 X60-minute topographic quadrangle map, U. S. Geologic Survey, Denver, Colorado, 1:100,000 scale map.

U. S. Geological Survey, 1956, Rapelje topographic quadrangle map, U. S. Geologic Survey, Denver, Colorado, 1:24,000 scale map.

U. S. Geological Survey, 1956, Battle Butte topographic quadrangle map, U. S. Geologic Survey, Denver, Colorado, 1:24,000 scale map.

Appendix A

A-1. Preliminary Assessment Form

A-2. Well Head Protection Inventory Form

MONTANA DEPARTMENT OF ENVIRONMENTAL QUALITY
Metcalf Building
1520 E. 6th St.
Helena, MT 59620-0901

Preliminary Assessment of Groundwater Sources that may be under the Direct Influence of Surface water

SYSTEM NAME Rapelje Springs PWS ID # 00313
SOURCE NAME Rapelje Water Users Association well COUNTY Stillwater
DATE 12/5/98 NC NTNC C POPULATION 70-75

	Index Points
A. TYPE OF STRUCTURE (Circle One)	
Well	GO TO SECTION B
Spring	40
Infiltration Gallery/Horizontal Well	40
B. HISTORICAL PATHOGENIC ORGANISM CONTAMINATION	
History or suspected outbreak of *Giardia,* or other pathogenic organisms associated with surface water with current system configuration	40
No history or suspected outbreak of *Giardia* .	0
C. HISTORICAL MICROBIOLOGICAL CONTAMINATION (Circle all that apply)	
Record of acute MCL violations of the Total Coliform Rule over the last 3 years (circle the one that applies)	
No violations	0
One violation	5
Two violations	10
Three violations	15
Record of non-acute MCL violations of the Total Coliform Rule over the last 3 years (circle the one that applies)	
One violation or less	0
Two violations	5
Three violations	10
DHES-verified complaints about turbidity . . .	5
D. HYDROLOGICAL FEATURES	
Horizontal distance between a surface water and the source	
greater than 250 feet	0
175 - 250 feet	5
100 - 175 feet	10
less than 100 feet	15
unknown	15
E. WELL CONSTRUCTION	
Poorly constructed well (uncased, or casing not sealed to depth of at least 18 feet below land surface), or casing construction is unknown .	15

In wells tapping unconfined or semiconfined aquifers, depth below land surface to top of perforated intervals or screen

greater than 100 feet	0
50 - 100 feet	5
25 - 50 feet	10
0 - 25 feet	15
unknown	15

F. WELL INTAKE CONSTRUCTION

In wells tapping unconfined or semiconfined aquifers, depth to static water level below land surface

greater than 100 feet	0
50 - 100 feet	5
0 - 50 feet	10
unknown	10

Poor sanitary seal, seal without acceptable material, or unknown sanitary seal type . . .	15

TOTAL SCORE 95

PRELIMINARY ASSESSMENT DETERMINATION (Circle the one that applies)

i) PASS: Well is classified as groundwater.
ii) FAIL:. Well must undergo further GWUDISW determination.
iii) FAIL: Spring or Infiltration Gallery; must undergo further GWUDISW determination.
iv) FAIL: Well will PASS if well construction deficiencies (section E or F) are repaired.
v) FAIL: Well may PASS if well construction details (section E or F) become available.

ANALYST James Rose ANALYST AFFILIATION MBMG

COMMENTS: The well is hand dug at a spring site. The well is unlined with walls of sandstone bedrock with a 3 ft high ring of brick and mortar for a wall at the top of the well. The well was built by the railroad around 1917.

Appendix B

B-1. Regional site map

B-2. Site map showing inferred direction of ground-water flow for the Fox Hills Formation aquifer

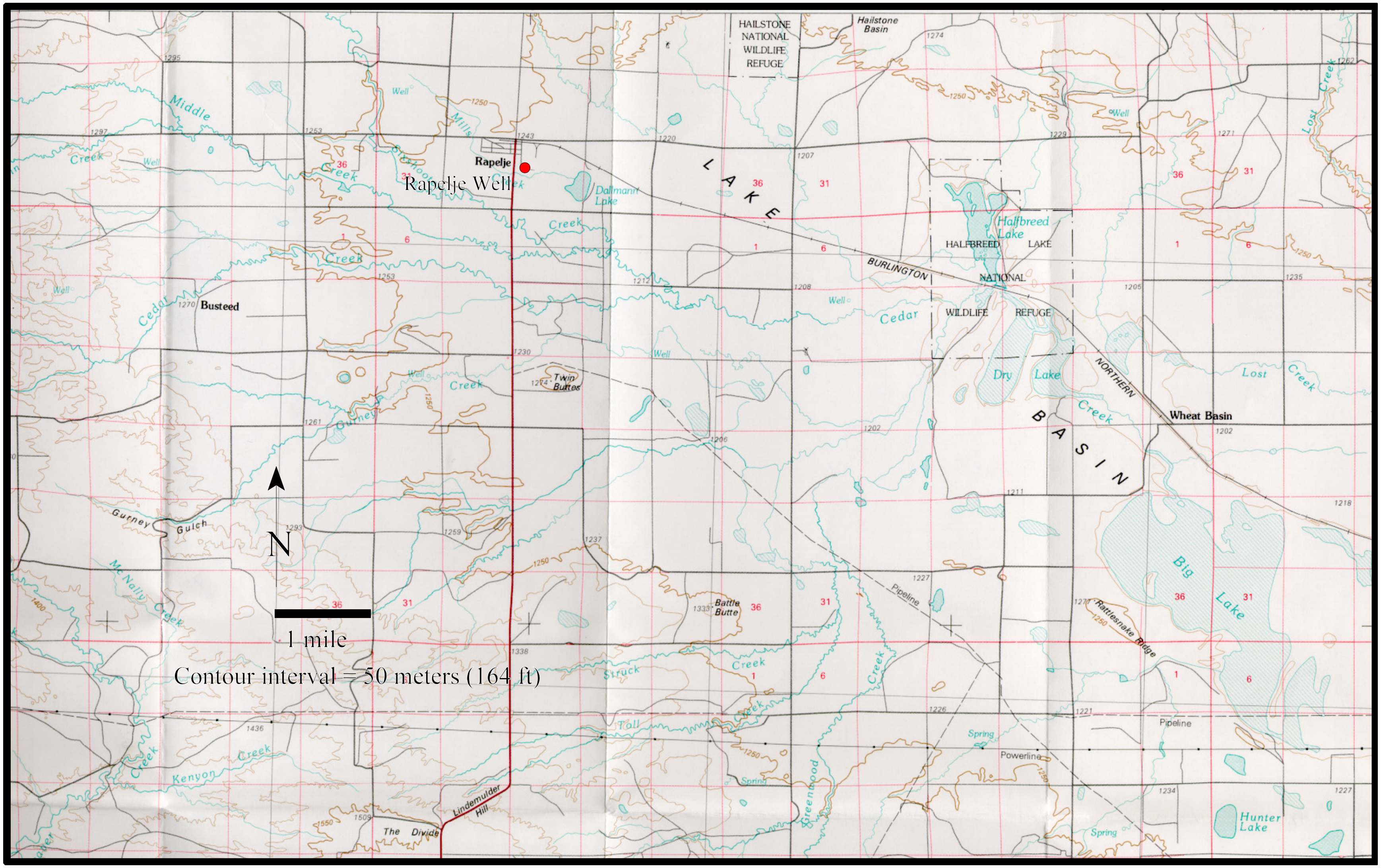

Figure B-1. Map showing the surface water drainage pattern, lakes and land surface topography near Rapelje (U.S. Geological Survey 1:100,000 scale Big Timber 30 X 60-minute topographic quadrangle map, 1979).

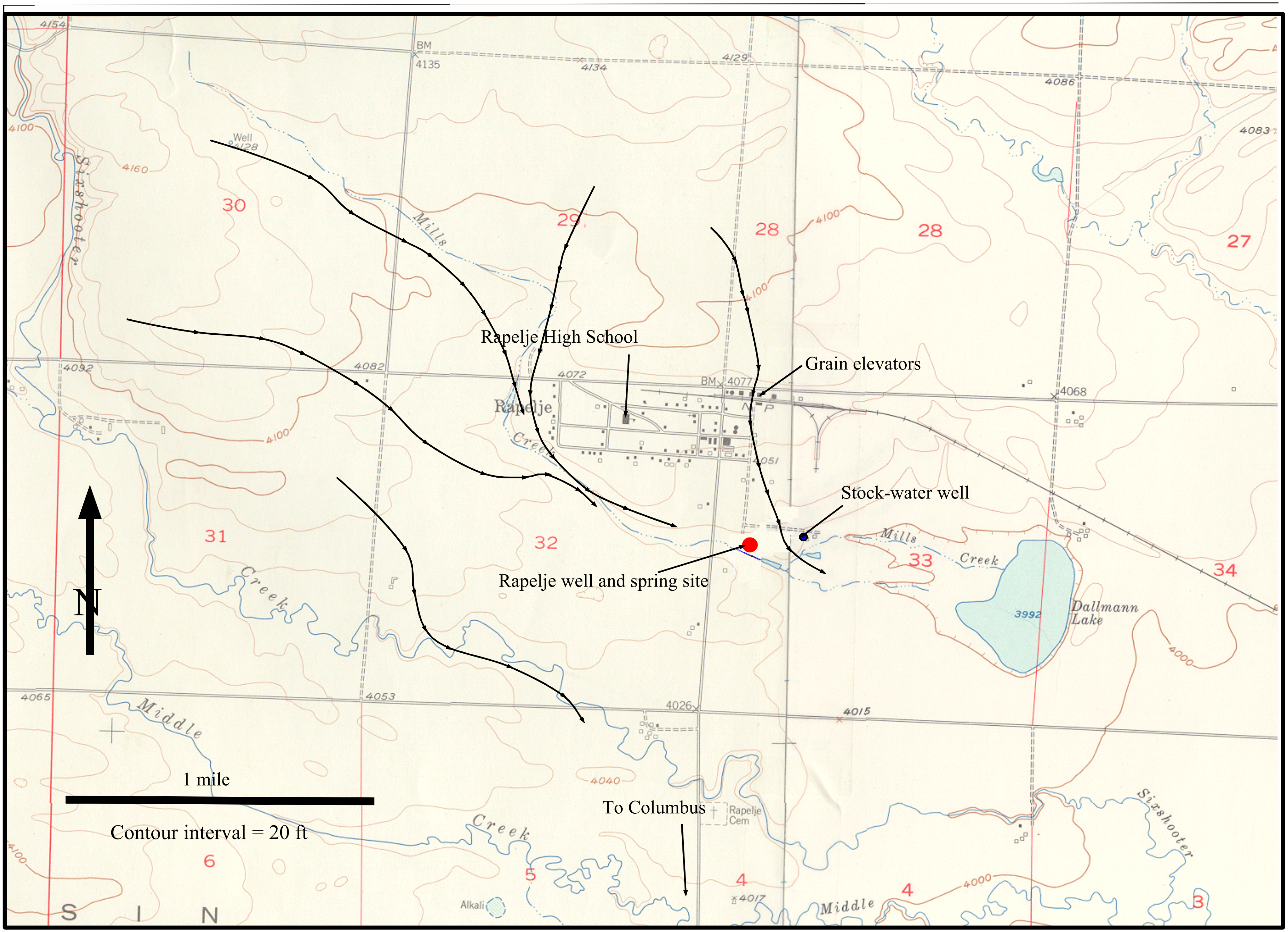

Figure B-2. Topographic contour map of Rapelje area showing the estimated direction of flow of the shallow ground water through the Fox Hills Formation (Rapelje and Battle Butte, USGS Topographic Quadrangle maps, 1956).

Appendix C

Figure C-1. View of pump house and Mills Creek from the county road.

Figure C-2. View of pump house, well cover and bunkhouse.

Figure C-3. Photo showing spring discharge into Mills Creek at the well site.

Figure C-4. Photo showing the town of Rapelje.

Figure C-5. View of Lake Basin, Rapelje and surrounding terrain.

Figure C-6. View of tilted outcrops of bedrock along the Lake Basin Fault zone northeast of Rapelje.

Figure C-1. View of pump house and spring site looking east from county road. Mills Creek runs past the pump house from left to right in the photo. Dallman Lake can be seen in the distance.

Figure C-2. Pump house in foreground. Manhole on concrete cover over the well can be seen below the two white boxes attached to the pump house. The railroad bunkhouse can be seen north of the pump house. Mark Doely's house is located northwest of the pump house and can be seen to the left in the photo. The photo was taken from the bank of Mills Creek at the spring discharge site seen in Figure C-3.

Figure C-3. Mills Creek at the spring site. The pipe carries discharge water from the spring adjacent to the pump house and supplies most of the flow to Mills Creek.

Figure C-4. View looking west across main street at the Main town intersection. The abandoned gas station is to the right, the cafe is the next building on the right and the high school can be seen in the distance behind the cafe.

Figure C-5. Photo looking north toward Rapelje on county road from Columbus showing the basin in which Rapelje is located. Rapelje is along the paved road near the center of the picture, crop-fallow fields can be seen around town. The ridge in the background is Eagle sandstone along the Lake Basin Fault zone.

Figure C-6. Fault tilted outcrops of Judith River Formation bedrock (??) along the Lake Basin Fault zone at Hailstone National Wildlife Refuge located 4 miles northeast of Rapelje (Figure B-2).