HYDROGEOLOGIC ASSESSMENT OF THE SURPRISE CREEK RANCH COLONY WATER SUPPLY FOR GROUND WATER UNDER THE DIRECT INFLUENCE OF SURFACE WATER

Open-File Report
MBMG 401-O

Surprise Creek Ranch Colony
PWSID #00391
Box 310
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Prepared
for
Montana Department of Environmental Quality
Water Quality Division

by
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INTRODUCTION AND PURPOSE

This report summarizes the results of a hydrogeologic assessment for the Surprise Creek Ranch Colony water supply (PWSID #00391). The Surprise Creek Ranch is a Hutterite Colony located in Judith Basin County in central 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 was to determine if the spring source used by the Surprise Creek Ranch Colony is under the direct influence of surface water as defined in 40 CFR part 141. A field inspection of the water supply system was completed on February 18, 1998 by Alan English, hydrogeologist for the MBMG, and Martin Hofer, certified system operator. **The results of the assessment indicate that the spring used by the Surprise Creek Ranch Colony may be under the direct influence of surface water.**

This report summarizes information obtained during the field inspection and the follow-up research investigation that were used to make the above determination. Information on system location, construction, geology, hydrogeology, and water quality are summarized. Conclusions and recommendations are presented at the end of the report. A preliminary assessment form along with photographs and water-quality reports have been included in the appendices. Site maps are included in the text.

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 Surprise Creek Ranch Colony water supply is included as appendix A-1. The sole source for drinking water for the colony is a spring and it was assigned a total score of 65 points. The site was assigned 40 point because the water source is a spring; 10 points were added for three non-acute maximum contaminant level (MCL) violations of the Total Coliform Rule over the last three years; 15 points were assigned for poor well construction because the condition of the sanitary seal around the outside of the culvert liner was not known and a grout seal may not exist. **The total score of 65 points, out of a possible total of 180, indicates the system is at moderate risk of being under the direct influence of surface water. Because the score is above 40 points, additional evaluation was required under DEQ guidelines.**

SYSTEM DESCRIPTION

Location

The Surprise Creek Ranch Colony is located in Judith Basin County, about five miles west of Stanford, Montana on State Highway 87 (figure 1). The ranch colony housing is located about one mile south of the highway on a gravel road (appendix B, photo B-1). The location of the colony is shown on the Merino 7.5-minute U.S. Geological Survey topographic quadrangle map in sections 4 and 9, T. 16 N., R. 11 E. (figure 2). The water-supply spring is located about 1.5 miles south of the colony, along a gravel road in the Surprise Creek drainage at the NE¼, NW¼, NW¼, NE¼ (ABBA) section 17, T. 16 N., R. 11 E. The latitude and longitude of the spring site are 47° 09' 21" N, 110° 21' 06" W. The spring is tracked in the MBMG's Ground-Water Information Center database as site number M:179775.

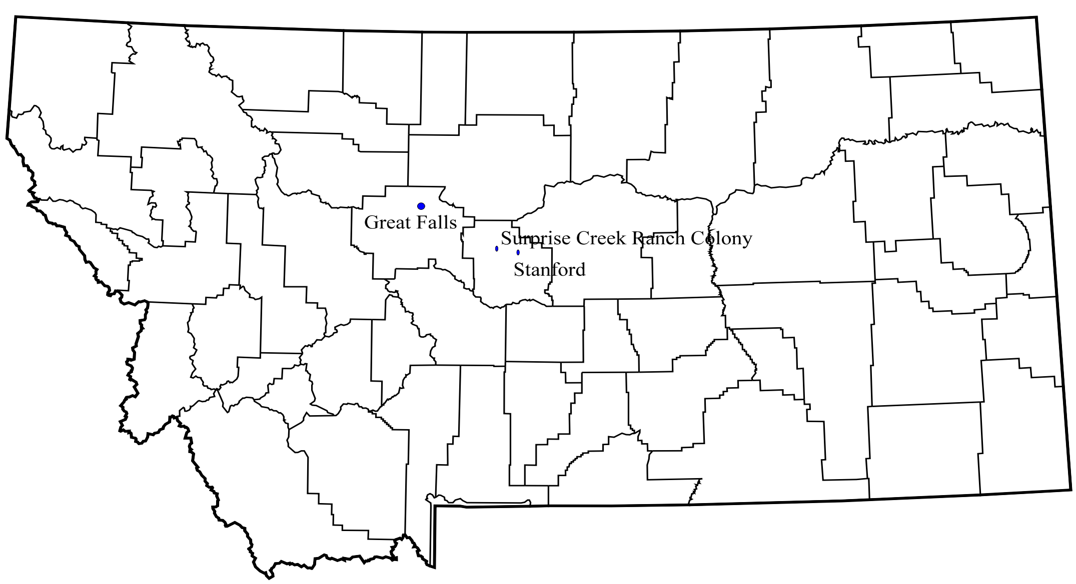

Figure 1. Map of the state of Montana showing the location of the Surprise Creek Ranch Colony, the town of Stanford and the city of Great Falls.

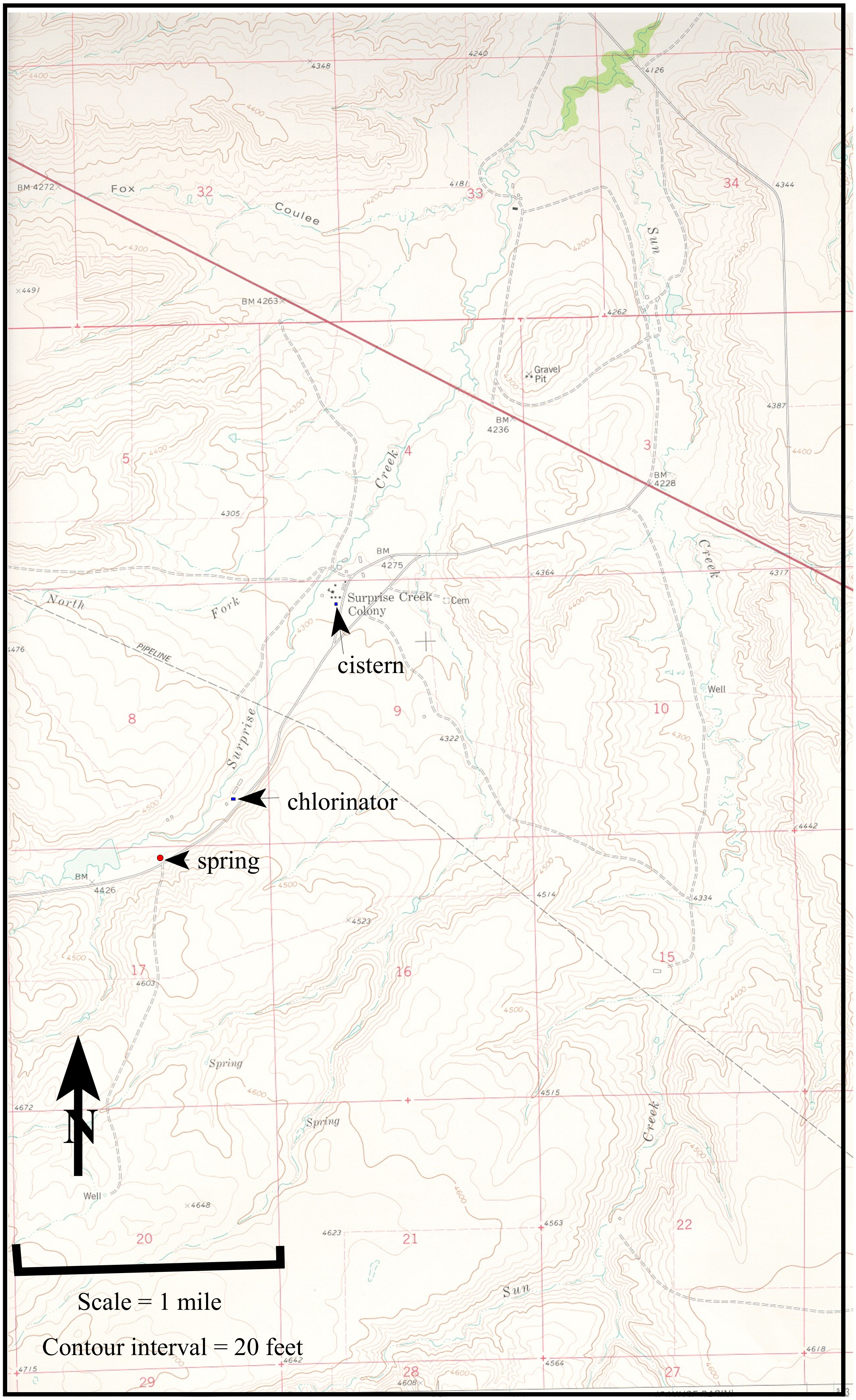

Figure 2. Topographic map of the Surprise Creek Ranch Colony area showing the location of the ranch, the water-supply spring, the inline chlorinator ,and the water-storage cistern. Modified from U. S. Geological Survey, Merino 7.5-minute map, 1978.

System

The spring is located along the south side of the Surprise Creek drainage below a graveled ranch access road (figure 2). Spring discharge was estimated to be about 10 gallons per minute (gpm) during the HA investigation. A 4-ft diameter culvert was placed over the spring and set about 5 ft into the ground to collect the water (appendix B, photos B-2, B-3 and B-4). Water enters the culvert through perforations in the bottom 2 ft , and water flows from there into a 2-inch diameter PVC pipe located about 2 ft above the bottom of the culvert. The water then flows through the collection pipe, by gravity, to a chlorinator located in a small, approximately 4 ft by 4 ft building located about 1,500 ft northeast of the spring in the Surprise Creek drainage (appendix B, photo B-5). From the chlorinator, the water flows to a 10,000-gallon cement storage tank at the ranch site almost one-mile northeast of the chlorinator (appendix B, photo B-6). A 5-horsepower pum moves water from the storage tank to the ranch homes. A back-up generator is on site to run the pump if there is a power failure. Four 50-gallon hydropneumatic pressure tanks, located in the pump house, are used to maintain water pressure in the system.

The chlorination system consists of a sodium-hypochlorite dispensing system. Records of chlorine residual are recorded by the certified operator. A Montana Department of Health and Environmental Sciences (DHES, now the DEQ) Sanitarian reported that the chlorinator appeared to be working properly and was well maintained during a previous inspection in September 1993 (DHES, 1993).

The spring is the sole water source for domestic use at the ranch colony. It is connected to a water-supply system with 14 service connections that serve about 105 residents (DHES, 1993). The ranch colony consists of a school for the children of the colony, a central kitchen and about ten homes. Two DHES sanitary inspections conducted in 1983 and in 1986 reported that the school-teachers' house-trailer and the school were connected to a 400-ft deep flowing well at the ranch complex (DHES, 1983 and DHES, 1986). According to the system operator, all domestic water now comes from the spring. Two flowing wells located at the ranch are not connected to the domestic water supply system and are used only for watering livestock (Sam Hofer, system operator, personal communication, 1998).

Ranch livestock are watered from two wells and from a stock pond formed by damming Surprise Creek near the water-supply spring (appendix B, photo B-2 and figure 2). The two wells (M:2000 and M:171332) are flowing wells located near the barns at the ranch complex in section 4, T. 16 N., R. 11 E, and are screened in the Cutbank Sandstone Member of the Cretaceous Kootenai Formation. Well M:171332 is shown in photo appendix B, B-7. The stock pond is located in the Surprise Creek drainage west, and upstream from the spring site.

Recommendations from previous DHES inspections suggested a tighter, locked cover should be placed on the spring culvert for security and to keep rodents and insects out (DHES memo, 1983). At the time of the HA inspection, a metal cover was in place but it did not form a tight seal over the culvert pipe and the lid was not locked (appendix B, photo B-4).

GEOLOGY

Topography and Land Use

The spring is located on ranch land owned by the ranch colony. The region is sparsely populated and no dwellings are upgradient from the spring site. The land is grass covered and is used for grazing sheep and cattle. Northeast of the spring site, the ranch colony raises dryland grain crops (appendix B, B-1). The terrain is steeply rolling with hills that rise about 200 ft above the bottoms of northeast trending creek drainages (figure 2 and appendix B, photo B-3). The Surprise Creek Ranch is located at 4,280 ft elevation. The spring is located along Surprise Creek at 4,420 ft elevation (figure 2).

Regional Geology

The Surprise Creek Ranch Colony is located on the southwestern edge of the Judith Basin, a topographic depression partly enclosed by several mountain ranges (Vine, 1956) (figure 3). The Little Belt Mountains rise along the western edge of the basin, near the ranch (appendix B, B-1). The strata along the western margin of the Judith Basin dip northeast, toward the basin. The beds were initially tilted to the northeast along the eastern flank of the Sweetgrass Arch and were more steeply tilted later, during uplift of the Little Belt Mountains (Vine, 1956). The Little Belt Mountains are composed of Cambrian, Devonian, Mississippian, Pennsylvanian, Jurassic and Cretaceous sedimentary formations intruded locally by younger igneous stocks. The bedrock outcrops in the foothills at the ranch colony are sandstones and mudstones of the Cretaceous Kootenai Formation (figure 4). The Kootenai Formation consists of 350 to 550 ft of sandstones and mudstones of continental origin and freshwater limestone deposits (Vine, 1956).

The Kootenai Formation is one of the most important water-bearing formations in central Montana (Perry, 1932). The lowest sandstone bed, near the base of the formation, is the Cutbank Sandstone Member (Kk_1) (figure 4) (Susan Vuke, MBMG, unpublished maps, 2000), also known as the Third Cat Creek sand by the oil and gas industry. The Cutbank Sandstone is about 80 ft thick and is the most important hydrogeologic member because it is continuous for great distances and is porous and permeable (Perry, 1932). Springs are numerous in areas where the Kootenai crops out (Zimmerman, 1966). The Cutbank Sandstone is a moderately well-sorted, coarse-grained, cross-bedded, quartz sandstone that forms ridges and cliffs where it is exposed at the land surface (Vuke and others, 1995). A large proportion of the sand grains in the sandstone are black, giving the unit a salt-and-pepper appearance (Perry, 1932). The sandstone is overlain by the Second Member, composed of red mudstone (Kk_2) (figure 4).

Many of the hilltops and ridges in the area are covered by remnants of Quaternary- to Tertiary-terrace gravel deposits (figure 4). The gravels are stream channel and alluvial fan deposits containing material eroded from the Little Belt Mountains that has been transported downstream into the Judith Basin. The gravel deposits range from very thin to 100 ft thick, but are usually less than 50 ft thick (Zimmerman, 1966).

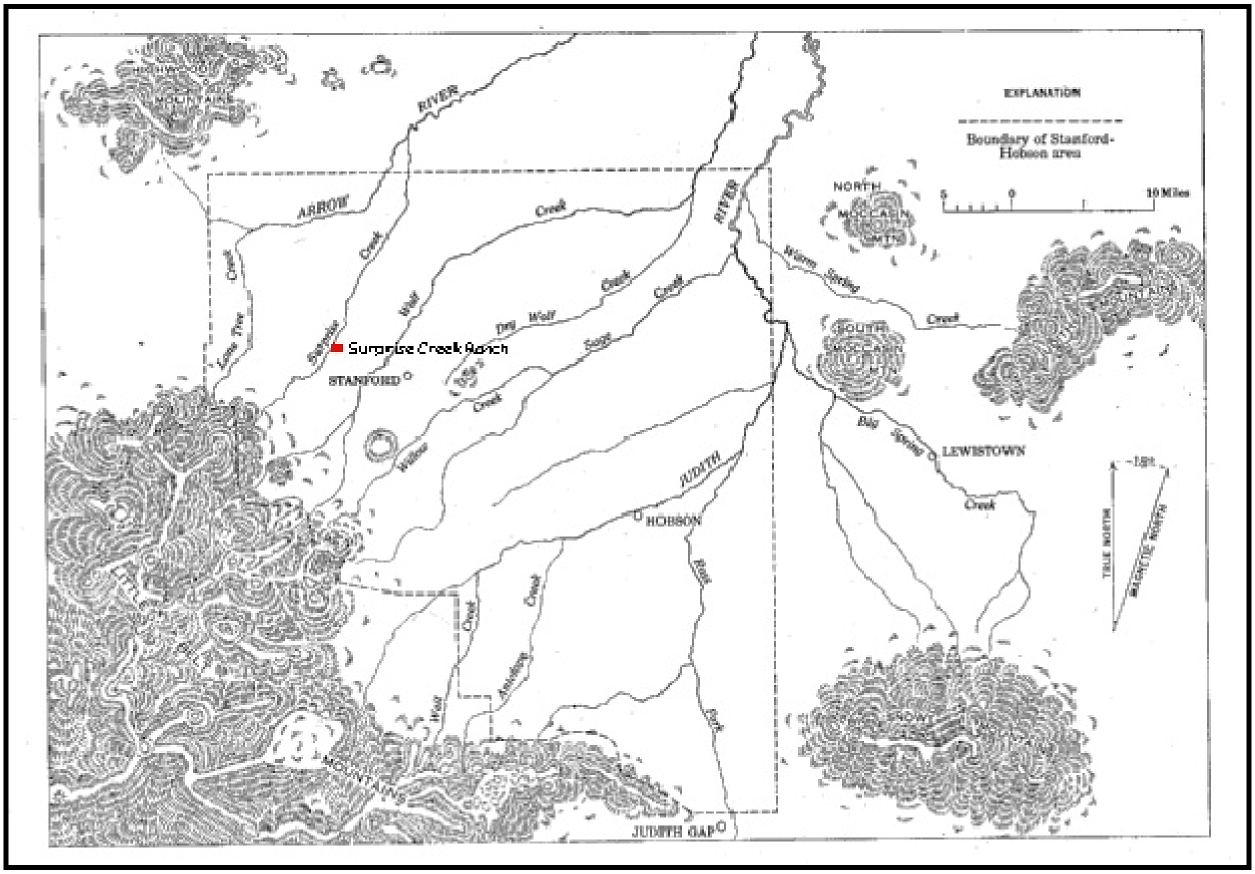

Figure 3. Location map of Judith Basin area. The Surprise Creek Ranch Colony is located along Surprise Creek just west of the Town of Stanford. Map from Vine, 1956.

Quaternary alluvium has been deposited by streams along the valley bottoms. The alluvial sediments are similar in composition to the terrace gravels and consist of material eroded from the bedrock outcrops, reworked terrace gravels and alluvium. The alluvial deposits can be as thick as 40 ft in some of the larger drainages (Zimmerman, 1966), but they are probably less than 15 ft thick near the spring site along Surprise Creek.

Local Geology

The hills on the Surprise Creek Ranch are composed of outcrops of Kootenai Formation sandstones and mudstones (figure 4 and appendix B, photos B-1, B-2 and B-3). The bedrock layers dip gently, 5-10° to the northeast, toward the Judith Basin, and are covered locally by remnants of the older fan- and stream-deposited alluvium (Qoa) (Susan Vuke, MBMG, unpublished maps, 2000). Along the drainage bottoms the bedrock is covered by a thin layer of Quaternary alluvium (figure 4 and appendix B, photo B-3). The ranch buildings are situated on the older Quaternary age alluvial fan and stream channel deposits (terrace gravels) (figure 4).

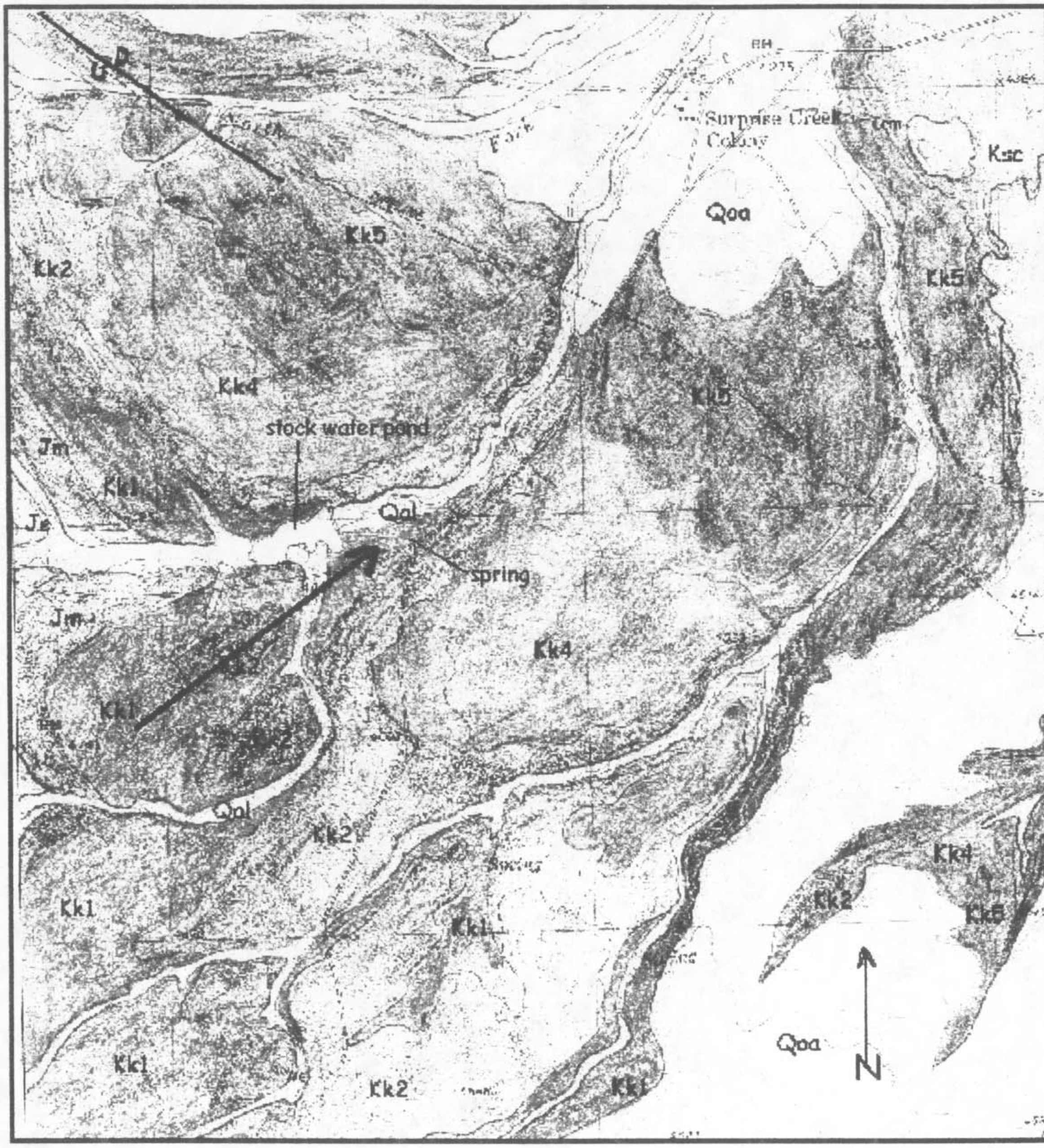

Figure 4. Geologic map of the Surprise Creek Ranch Colony area. The arrow shows the approximate direction of ground-water flow to the spring. The geologic formations mapped include 1) Jurassic Ellis Group (Je), 2) Jurassic Morrison Formation (Jm), 3) the Cretaceous Thermopolis Shale, 4) four members of the Cretaceous Kootenai Formation: the Cutbank Sandstone Member (Kk_1), the Second Member (Kk_2), the Fourth Member (Kk_4), and the Fifth Member (Kk_5), 5) Quaternary alluvium (Qal), and 6) old Quaternary alluvium (Qao). From Susan Vuke (MBMG, unpublished maps, 2000) and USGS, 1978.

Lithologic logs from wells at the ranch (GWIC ID. numbers M:2000 and M:171332) show that the alluvial gravel is 12 to 16 ft thick and overlies mudstones and shales of the Fifth Member of the Kootenai Formation (GWIC, 2000) and (Susan Vuke, MBMG, unpublished maps, 2000).

The spring is located along the south side of the Surprise Creek drainage where a thin veneer of alluvial gravel covers the upper portion of the Cutbank Sandstone Member of the Kootenai Formation (Susan Vuke, MBMG, unpublished maps, 2000).

HYDROLOGY

Surface Water

The creeks along the western edge of the Judith Basin flow to the northeast, draining snowmelt, runoff, and ground water from the Little Belt Mountains. The creeks form a dendritic drainage pattern that converges towards Arrow Creek and the Judith River. At the spring site, the streams are spaced about 1-mile apart (figure 2). Surprise Creek is an ephemeral stream fed by numerous springs that flow from the bedrock of the Little Belt Mountains. Surprise Creek flows over outcrops of Mississippian, Jurassic and Cretaceous sedimentary formations between its headwaters in the Little Belt Mountains and the Judith River Basin (figure 3). The channel of Surprise Creek is well defined at the spring location. The creek is dammed about 1,000 ft west of the spring site to hold water for livestock (appendix B, photo B-2) .

The climate of the Judith Basin is semiarid. The Town of Stanford, located about 5 miles east of the ranch, receives an average of 16.6 inches of rainfall per year (30-year mean) (WRCC, 2000). Most of the rainfall occurs from April through September.

Regional Ground-Water Flow

Regional assessments of ground-water in the Judith Basin have been completed by Perry (1932) and Zimmerman (1966). Ground water useable for wells can be found locally in the alluvium along drainage bottoms, in the older alluvium that forms terrace gravels along hilltops and in permeable sandstone and limestone layers within the bedrock. The ground water in the Cutbank Member Sandstone of the Kootenai Formation is the most popular source of water for wells in the Judith Basin (Zimmerman, 1966). Ground water from the Judith River Formation, the Eagle Sandstone, the Swift Formation of the Ellis Group, the Quadrant Sandstone and from solution channels within the Madison Formation limestone has also been tapped by wells. Areas where these aquifers are used are not as widespread as that for the Kootenai Formation and do not always overlie useable amounts of water (Zimmerman, 1966).

The permeable, water-bearing strata within the basin are commonly sandstones interlayered with shale, siltstone and bentonitic clay layers. The layering of permeable and less permeable strata causes some of the water-bearing formations, such as the Cutbank Member of the Kootenai Formation hold water under considerable pressure below the land surface. Wells that are open to the Cutbank Sandstone are typically flowing wells at the land surface in the Judith Basin. Water-bearing strata within the Judith Basin dip toward the center of the basin and regional ground-water flow within the basin is also generally toward the center of the basin. Tilting, uplift, and erosion along the margins of the Judith Basin at the mountain fronts have exposed the water-bearing formations at the land surface. Recharge to the bedrock aquifers is from rainfall and snowmelt infiltrating through the exposed surface of the outcrops and from streams flowing across the outcrops. Ground water discharges as springs in some outcrop areas. Ground water in the deeply buried formations may leak into adjacent, permeable formations or discharge as large springs in the region (Zimmerman, 1966). Numerous springs have been mapped in the areas where the Kootenai Formation crops out (figure 2).

Local Ground-Water Flow

The Surprise Creek Ranch spring discharges from the Cutbank Sandstone Member of the Cretaceous Kootenai Formation (Kk_1) which lies beneath a veneer of alluvial gravels and colluvium (figure 4). The strata of the Kootenai Formation dip 5 to 8 degrees to the northeast at the spring site (Susan Vuke, MBMG, unpublished maps, 2000). The spring is located in a shallow, dry coulee cut into a hillside and is at a topographically low point where Surprise Creek has incised into the bedrock to expose the Cutbank Sandstone (Kk_1) (appendix B, photo B-3). The hillside above the spring is composed of the Second Member (Kk_2) of the Kootenai Formation, a less-permeable, red mudstone that stratigraphically overlies the Cutbank Sandstone. The Cutbank Sandstone is underlain by the Jurassic Morrison Formation, a green-grey mudstone, which crops out about one-half mile west of the spring site, along the access road (Vuke and others, 1995) (figure 4). Ground water at the spring is recharged by the infiltration of surface water (rainfall, snowmelt and streamflow) into outcrops of Cutbank Sandstone west and south of the spring. A coulee containing alluvial gravel cuts south to north across the Cutbank Sandstone outcrop about one-quarter mile west of the spring and probably contributes water to the aquifer (figure 4). The ground water in the sandstone flows to the northeast, from the outcrops toward the spring, along the dip of the sandstone beds. At the spring site, the Formation is unconfined to possibly semi-confined and ground water is draining from the sandstone by gravity flow. Overflow from the water-supply spring discharges into the stream bottom and flows through a channel into Surprise Creek (appendix B, photo B-3). A stock pond located on Surprise Creek west of the spring site is situated on outcrops of Cutbank Sandstone (figure 4.). Surface water in the pond may infiltrate into the sandstone and flow downgradient, to the northeast along the drainage and through the spring area. The surface water elevation of the pond is at about 4,425 feet elevation. The spring is at 4,420 feet elevation, about 5 feet lower than the pond. Ground water could flow from the pond, through the Cutbank Sandstone to discharge at the spring.

Wells M:2000 and M:171332 are located at the ranch and draw water from the Cutbank Sandstone. The wells are completed in the sandstone at depths of 400 ft and 860 ft below the land surface, respectively (GWIC, 2000). The sandstone aquifer is unconfined near outcrops, but is under pressure where the sandstone lies between the overlying Cretaceous Second Member of the Kootenai Formation above, and the shales and siltstones of the Jurassic Morrison Formation below, such as at the well site. The hydrostatic pressure in the formation causes the ground water in wells to flow at the land surface.

There are several probable sources of recharge to the spring ground water:

1. Infiltration of water from the surface colluvium and alluvium around the spring.

2. Overland flow of water from the hillside of Second Member mudstones (Kk_2) south of the spring.

3. Infiltration of water from the Quaternary alluvial gravels in the coulee west of the spring into the sandstone (figure 4).

4. Seepage of water from the stock pond on Surprise Creek, west and upgradient from the spring. Water from the pond may infiltrate into the Cutbank Sandstone and flow to the spring as ground water.

All of these recharge sources may contribute some water to the ground-water system that supplies the spring. One factor common to all of these sources is that the source of recharge is from the infiltration of water from the land surface near the spring. The proximity of the recharge areas to the spring and the shallow depth of ground-water near the spring, contribute to the vulnerability of the spring to contamination from surface sources.

Recharge to the Cutbank Sandstone in the area of the spring is limited to the outcrops of sandstone between the Morrison Formation (Jm) and the Second Member mudstone (Kk_2) (figure 4). The portions of the recharge area most vulnerable to contamination from surface sources are the area immediately around the spring, the hillside of mudstone south of the spring that directs overland flow toward the well, the outcrops of the Cutbank Sandstone (Kk1), including the exposures at the stock pond, and the Quaternary alluvium along the drainages above the spring to the south and west.

WATER QUALITY

Field Parameters

During the HA investigation, the pH, temperature, and specific conductance of the spring water were measured (table 1). The same parameters were also measured in the water from the two livestock wells at the ranch colony. All measurements were taken from untreated water. The spring water was measured at the culvert casing.

Table 1. Field pH, specific conductance, and temperature measured during the HA site inspection on February 18, 1999. Well completion information and aquifer data are from GWIC (2000). The spring source is based on field interpretation of the geology observed during the HA site investigation and mapping by Susan Vuke (MBMG, unpublished maps, 2000).

Location	pH	Specific Conductance (µmhos/cm @25°C)	Temperature (°C)	Well Depth (ft)	Aquifer	Comments
Spring Box (PWS source #002)	7.3	619	6.8	0	Cutbank Sandstone	Public water-supply source
Well M:2000 (Source ID #003)	7.1	383	5.9	404	Cutbank Sandstone	Flowing well, 25 gpm
Well M:171332 (Source ID #004)	7.1	395	9.0	860	Cutbank Sandstone	Flowing well, 5 gpm

The two wells listed in table 1 are not connected to the public water-supply system. To clarify the DEQ records, the spring is source ID # 002, well M:2000 is source ID # 003 and well M:171332 was assigned source ID # 004 for this study. Source ID #004 well data needs to be updated in the DEQ database. The two wells intercept the same formation as the spring but are further down dip and draw water from much deeper below the land surface.

Background Water Quality

No major ion-analysis data were available for the spring water. The chemistry of the water from the Surprise Creek Ranch Colony supply spring is probably similar to the lower Kootenai Formation water sampled by Perry (1932) and Zimmerman (1966). A summary of regional water quality of springs by Perry (1932), shows that water from the lower Kootenai Formation, which includes the Cutbank Member, is sodium-calcium-bicarbonate type with sulfate. The spring water may be of a similar type.

Nutrient Chemistry
A nitrate concentration was measured from a water sample collected from the spring system on January 12, 1995. The DEQ analysis showed the concentration of nitrate was only 0.85 mg/L, which is below the EPA drinking water standard of 10 mg/L (EPA, 1996).

Bacteria Analyses
Coliform and fecal-coliform bacteria have been detected in several water samples from the Surprise Creek Ranch Colony water-supply system in the last 7 years (table 2). The presence of coliform bacteria in water is generally considered an indicator of fecal pollution (Hem, 1992). Fecal-coliform bacteria come from the intestines of mammals and are a strong indicator of contact with surface water.

Table 2. Results of bacteria analyses of water samples from the Surprise Creek Ranch Colony public water-supply well (Mike Brayton, DEQ, personal communication, 2000).

Sample Date	Bacteria Analysis Results	Number of bacteria detected in a 100 mL water sample
8/5/98	Non-acute	NA
8/13/96	Coliforms present	1
8/13/96	Coliforms present	59
8/6/96	Non-acute MCL violation, fecal-coliforms detected	11
7/11/95	Non-acute	6
5/2/95	Fecal -, detected	90
4/3/95	Fecal +, detected	14
9/12/94	Coliforms present	4
8/8/94	Non-acute	NA
8/1/94	Non-acute	NA
6/6/94	Coliforms present	115

NA: data not available

Memos from the DHES Water Quality Bureau, on operational conditions at the spring report that:

1. Coliform bacteria are commonly detected following high precipitation events (DHES activity report, 1995).

2. Coliform bacteria are commonly detected when the chlorinator is not in operation (DHES memo 1988 and DHES activity report, 1995).

Measured changes in the physical or chemical characteristics of ground water that can be related to climatic events or changes in surface-water conditions are strong indicators of surface-water influence of the ground water.

Several other factors were observed near the spring that may contribute to contamination of the well from surface sources:

- Short grass and sheep droppings are evidence of frequent sheep grazing around the spring, outside of the fenced area (appendix B, photos B-2 and B-3). The immediate area around the spring site is fenced off to keep animals out.

- The unconsolidated colluvial and alluvial material that overlies the bedrock near the well may transport infiltrating water into the bedrock or directly into the spring culvert.

- The hillside south of the spring, across the road, could be a source of surface-water contamination to the spring (figure 2). A shallow coulee /depression is shown on the topographic map that extends from the hilltop to the spring site (figure 2). This channel was probably formed by runoff water flowing from the hilltop. The hillside is composed of low permeability mudstones that may limit the infiltration of precipitation and snowmelt and may enhance overland flow of surface water. Some of the overland flow may be channeled through the depression, toward the spring site.

- Surprise Creek is dammed to form a stock-water pond about 1,000 ft west and upgradient from the spring. The pond overlies the Cutbank Sandstone and the pond water may infiltrate into the aquifer and flow to the spring.

- Although the system appeared to be well maintained, the presence of coliform bacteria in the water system could be indicative of other system problems or poor housekeeping of the system.

The bacteria problem appears to be chronic and can occur year round. The chlorinator was replaced in 1995 following repeated detection of coliform in water samples and is reportedly in constant use.

Well Head Protection

Changes to the water system that can improve the security and safety of the water supply might include:

- providing a tight seal on the culvert-pipe lid over the spring, and placing screen covers over the overflow pipe and vents on the water supply system to prevent rodents and insects from entering the system.

- Inspecting the grout seal around the culvert for cracks and adding bentonite grout to improve the seal between the culvert and the land surface. The grout should be built-up around the culvert to allow surface water to drain away from the culvert pipe.

- Mound dirt in the drainage above the culvert to divert surface drainage away from the spring.

- Extra precautions should be taken when handling or transporting materials on the access road above the spring to ensure nothing is spilled near the spring that could contaminate the well.

Alternate Water Sources
Alternate sources of water for the ranch supply could include springs higher in the hills, towards the mountains where agricultural impacts are less. The wells at the ranch colony draw water from the Cutbank Sandstone at depths greater than 400 ft and could be a source of drinking water that would be protected from the influence of surface-water.

CONCLUSIONS

Determination of Direct Surface-Water Influence

Based on the HA, the spring used by the Surprise Creek Ranch Colony may be under the direct influence of surface water as defined in 40 CFR part 141. The spring flows from an outcrop of the Cutbank Sandstone located in the primary recharge area for the sandstone aquifer. Three significant factors indicate that the spring system may be under the direct influence of surface water:

1. The proximity of the spring to extensive outcrops of the Kootenai Formation bedrock (Cutbank Sandstone). The spring's location suggests a short travel distance for the ground water from the surface recharge areas to the spring discharge area. The shallow ground water at the spring is recharged by infiltration of water from the land surface into the outcrops of the Cutbank Sandstone. The infiltrating water comes from the alluvium along drainages that overlie the Cutbank Sandstone, from the alluvium and colluvium around the spring site, and from the infiltration of water from the stock pond into the sandstone bedrock.

2. Coliform bacteria are regularly detected in the spring water following high precipitation events. Measurable changes in the ground water that can be attributed to climatic or surface water changes indicate a connection of the ground water with surface water.

3. Coliform bacteria are commonly detected in the water supply when the chlorinator is not in operation. The problem appears to be chronic. The presence of coliform bacteria suggests other bacterial contaminants may be present and suggests a contact with surface water.

The construction of the culvert casing around the spring may allow infiltration of rainfall and snowmelt into the ground water through openings between the culvert and the ground. The area around the spring is fenced to keep animals from the area immediately around the well, but the fenced area may not be extensive enough to eliminate contamination of the shallow ground water that supplies the spring.

It appears that the colony has attempted to provide a good drinking-water source by taking several measures to ensure that the water supply is protected and safe to drink. A water storage cistern was constructed at the ranch site, the chlorinator was replaced in 1995 when the existing system broke, and the area around the spring was fenced off to keep animals out of the immediate area. The certified system operator maintains an adequate chlorine residual in the water system for disinfection and appears to adequately maintain the system. However, the ground water source for the spring appears to be recharged from a number of surface water sources and therefore creates a real potential for contamination of the drinking-water supply. Several identified sources of potential contamination include:

1. Grazing of animals or the application of pesticides or fertilizers on any of the areas where the Cutbank sandstone crops out above the spring, on the alluvium in the drainages over the sandstone, or along the creeks that flow across the sandstone outcrop.

2. The concentration of livestock around the stock pond.

3. Overland runoff from the hills immediately south of the spring.

4. The spillage of materials from equipment that may be transported on the road above the spring.

RECOMMENDATIONS

Because the water supply may be under the direct influence of surface water and because the occurrence of coliform bacteria in the water appears to be chronic, several recommendations are suggested to maintain a safe drinking-water supply for the ranch colony:

- Conduct a macro-particulate analysis (MPA) of the well water to determine if there is a surface water influence on the spring water. The best time to collect the sample would be during periods of snowmelt around the well or after a period of heavy rainfall.

- Because the bacteria problem appears to be chronic and year round, disinfection of the system must be carried out on a continuous basis. The chlorination system must be maintained in good operating condition.

- Livestock should be restricted from areas west and south of spring, especially on the alluvium in the drainage west and south of the spring, from the Cutbank Sandstone outcrops west and south of the spring and from the hillside south of the spring. Maintain the existing fence around the spring.

- The long term historic use of the stock pond has no doubt created a large amount of animal waste around the pond and could produce a long-term source of potential ground water contamination. This may require the spring site to be abandoned as a water source as no clear solution could be identified. Draining the pond may reduce the amount of infiltration of surface water into the spring system.

- The entire system should be inspected for potential leaks or openings that might allow rodents and insects to enter the water system. A tight seal should be made for the culvert lid over the spring.

- The grout seal between the ground and the culvert pipe over the spring should be inspected to ensure that the seal is adequate to prevent the infiltration of surface water into the spring. The grout should be built up around the culvert to direct the drainage of surface water away from the culvert. Build up a dirt mound above the culvert to divert surface runoff water away from the spring from the drainage depression above the spring.

- Evaluate the use of the road above the spring and be aware of possible contamination that may enter the ground water from the road.

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Appendix A
Preliminary Assessment Form

GEOLOGY

Topography and Land Use

The spring is located on ranch land owned by the ranch colony. The region is sparsely populated and no dwellings are upgradient from the spring site. The land is grass covered and is used for grazing sheep and cattle. Northeast of the spring site, the ranch colony raises dryland grain crops (appendix B, B-1). The terrain is steeply rolling with hills that rise about 200 ft above the bottoms of northeast trending creek drainages (figure 2 and appendix B, photo B-3). The Surprise Creek Ranch is located at 4,280 ft elevation. The spring is located along Surprise Creek at 4,420 ft elevation (figure 2).

Regional Geology

The Surprise Creek Ranch Colony is located on the southwestern edge of the Judith Basin, a topographic depression partly enclosed by several mountain ranges (Vine, 1956) (figure 3). The Little Belt Mountains rise along the western edge of the basin, near the ranch (appendix B, B-1). The strata along the western margin of the Judith Basin dip northeast, toward the basin. The beds were initially tilted to the northeast along the eastern flank of the Sweetgrass Arch and were more steeply tilted later, during uplift of the Little Belt Mountains (Vine, 1956). The Little Belt Mountains are composed of Cambrian, Devonian, Mississippian, Pennsylvanian, Jurassic and Cretaceous sedimentary formations intruded locally by younger igneous stocks. The bedrock outcrops in the foothills at the ranch colony are sandstones and mudstones of the Cretaceous Kootenai Formation (figure 4). The Kootenai Formation consists of 350 to 550 ft of sandstones and mudstones of continental origin and freshwater limestone deposits (Vine, 1956).

The Kootenai Formation is one of the most important water-bearing formations in central Montana (Perry, 1932). The lowest sandstone bed, near the base of the formation, is the Cutbank Sandstone Member (Kk_1) (figure 4) (Susan Vuke, MBMG, unpublished maps, 2000), also known as the Third Cat Creek sand by the oil and gas industry. The Cutbank Sandstone is about 80 ft thick and is the most important hydrogeologic member because it is continuous for great distances and is porous and permeable (Perry, 1932). Springs are numerous in areas where the Kootenai crops out (Zimmerman, 1966). The Cutbank Sandstone is a moderately well-sorted, coarse-grained, cross-bedded, quartz sandstone that forms ridges and cliffs where it is exposed at the land surface (Vuke and others, 1995). A large proportion of the sand grains in the sandstone are black, giving the unit a salt-and-pepper appearance (Perry, 1932). The sandstone is overlain by the Second Member, composed of red mudstone (Kk_2) (figure 4).

Many of the hilltops and ridges in the area are covered by remnants of Quaternary- to Tertiary-terrace gravel deposits (figure 4). The gravels are stream channel and alluvial fan deposits containing material eroded from the Little Belt Mountains that has been transported downstream into the Judith Basin. The gravel deposits range from very thin to 100 ft thick, but are usually less than 50 ft thick (Zimmerman, 1966).

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 Surprise Creek Ranch Colony_ PWS ID # 00391
SOURCE NAME Surprise Creek Ranch Colony spring COUNTY Judith Basin
DATE 2/18/98 NC NTNC C POPULATION 105

	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 65

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 Alan English, James Rose ANALYST AFFILIATION MBMG

COMMENTS: A developed spring with a shallow depth culvert liner around the spring site.

Appendix B

B-1. Overview photo of Surprise Creek Ranch.
B-2. View of spring site along Surprise Creek drainage.
B-3. View of spring site from access road.
B-4. Close-up view of culvert pipe over spring.
B-5. View of chlorinator building.
B-6. View of pump house and cistern.
B-7. View of new well at ranch.

Figure B-1. View of Surprise Creek Ranch Colony showing dryland grain farming in the foreground and the Little Belt Mountains in the background.

Figure B-2. Overview of spring site and the Surprise Creek drainage. The spring is located in an incised side drainage along the south side of the Surprise Creek drainage. The ranch's stock pond is visible in the left background.

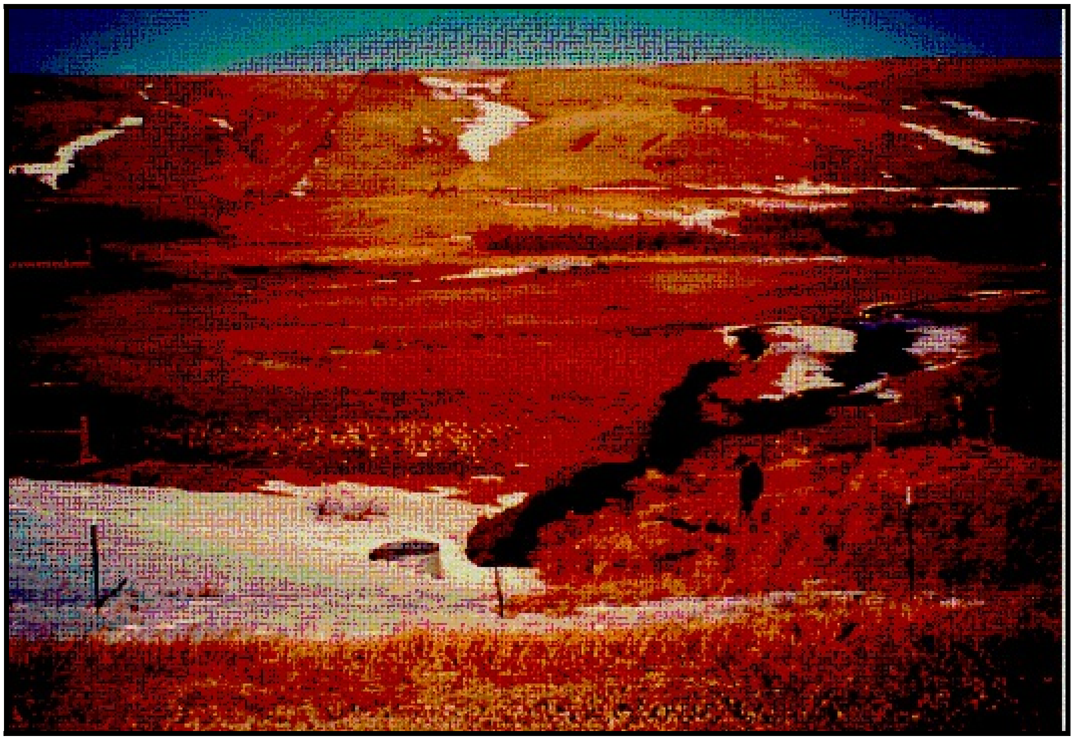

Figure B-3. View of drainage in which spring is located. The spring overflow discharge flows through a channel into Surprise Creek.

Figure B-4. Close-up view of culvert over spring discharge area. As the drifted snow melts, the water probably infiltrates into the ground around the culvert.