HYDROGEOLOGIC ASSESSMENT OF THE TOWN OF BEARCREEK MUNICIPAL WATER SYSTEM FOR GROUND WATER UNDER THE DIRECT INFLUENCE OF SURFACE WATER

Open-File Report MBMG 401-F

BEARCREEK MUNICIPAL WATER SYSTEM
PWSID #00063
Box 1082
Bearcreek, MT 59068

Prepared
for
Montana Department of Environmental Quality
Water Quality Division

by
James Rose
Montana Bureau of Mines and Geology

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INTRODUCTION AND PURPOSE

This report summarizes the results of a hydrogeologic assessment for the Bearcreek municipal water supply system (PWSID #00063) located in south-central Montana, in Carbon County. 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 430007 task order number 7.

The purpose of conducting this hydrogeologic assessment is to determine if the spring sources used by the Bearcreek Municipal Water System are under the direct influence of surface water as defined in 40 CFR part 141. A field inspection was completed on June 17, 1998 with Mr. Elmer Webb (Certified Water Supply System Operator). Mr. Webb explained the construction of the water system and the operating and monitoring procedures used. Mr. Webb showed me the storage tank and pointed out the location of the springs and chlorination system. Due to muddy roads at the time of the site inspection the chlorination system site was not accessible. Both spring sites were inspected. **The results of the assessment indicate that the Bearcreek Municipal water system may be under the direct influence of surface water as defined in 40 CFR part 141 due to system construction and infiltration of surface water near the spring discharge area.**

This report summarizes information obtained during a hydrologic assessment (HA) of the site and follow-up investigation that was used to make the above determination. Information on system location, construction, geology, hydrology and water quality are summarized. A completed preliminary assessment (PA) form is included for each spring source and a well-head protection (WHP) inventory form has been included in the appendices. Conclusions and recommendations are presented at the end of the report. Site-access maps and photographs taken during the site inspection are also included as appendices.

BACKGROUND

The Surface Water Treatment Rule (SWTR) of the Federal Safe Drinking Water Act of 1986 requires each state to examine public water supplies which 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, which closely correlate to climatological or surface water conditions.

The evaluation begins with a 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 an HA, a water-quality assessment, and/or conducting microscopic particulate analysis (MPA) sampling. For the Bearcreek system a PA and an HA were completed.

PRELIMINARY ASSESSMENT (PA)

The Bearcreek municipal water system receives water from 2 springs located in the Beartooth Mountains along upper Bear Creek (appendix C, map 1). Records of the Montana Department of Environmental Quality (DEQ) show a single spring source identified as source #002. For this investigation the lowermost spring was designated source #002, and the uppermost spring was designated source #003 (appendix C, map 1). Both spring boxes are approximately the same age, are similarly constructed, and located in similar settings. According to the system operator, both springs have been used as water supply sources for many years. A PA form is included in appendix A for each water-supply source spring. The springs were assigned a total score of 45 points each on the PA form, 40 points were automatically assigned for being spring sources. Five points were added because of two non-acute MCL violations for non-fecal coliform detection in the last 3 years. Turbid conditions have been reported in water samples collected from the water system on two occasions, once on June 30,1993 and a second time on April 24,1995 in water samples collected by the system operator. Both turbid samples were collected during high-discharge flow following spring thaw and snowmelt. DEQ water samples showed acceptable turbidity measurements of 0.25 NTUs during a site inspection on August 11, 1978. Because the turbid conditions occurred prior to the last 3 years no points were added to the PA for turbidity. **The total score of 45 points, out of a possible total of over 200, indicates the system has the potential for being influenced by surface water. Because the score is above 40 points, additional evaluation is required under DEQ guidelines.**

SYSTEM DESCRIPTION

Location

The town of Bearcreek is located on State Road 308, 8 miles southeast of Red Lodge, Montana and 8 miles west of Belfry, Montana (figure 1). Red Lodge is 62 miles southwest of Billings, Montana on U. S. Highway 212.

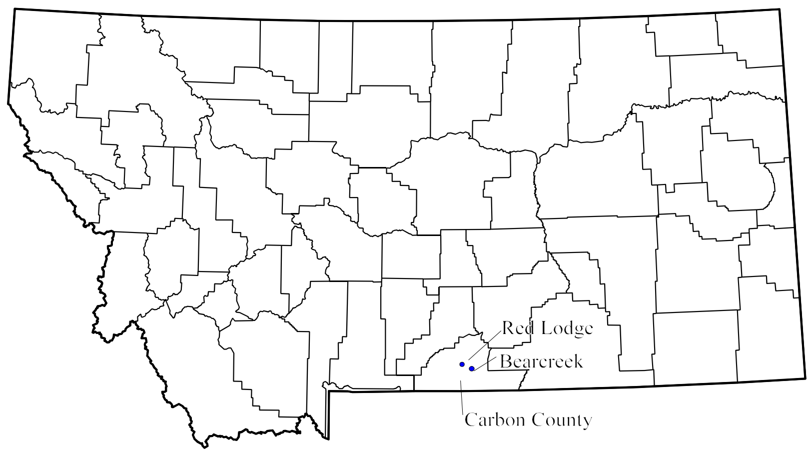

Figure 1. Map of Montana counties showing the locations of Carbon County and the town of Bearcreek.

The springs are located approximately 4½ miles southwest of Bearcreek along the northeast slopes of the Beartooth Mountain front (appendix C, map 1). The springs are normally reached along a dirt road that follows Bear Creek from State Road 308 near the town of Bearcreek, passing through an area that contains abandoned underground and surface coal mines. Some time prior to the site visit a bridge on the road had been washed out. The spring sites now have to be accessed from the town of Red Lodge by using the Metetsee Trail Road, an old wagon trail along the Beartooth Mountain front (appendix C, map 1). The Metetsee Trail Road is accessed from Highway 212 at the south side of Red Lodge, near the U.S. Forest Service Ranger Station. From the Bear Creek crossing of the Metetsee Trail Road, approximately 4 miles south of Red Lodge, the water supply springs are reached by a 10-20 minute walk to the southwest, up a very steep and overgrown trail. The water supply springs, located in the upper Bear Creek drainage along the south fork of Bear Creek, are 500 feet apart and are separated by about 100 feet in elevation. The spring sites are located in the SW¼ NE¼ NE¼ NE¼, section 22, T. 08 S., R. 20 E. The Bearcreek town site is located on the Red Lodge East, USGS 7.5-minute topographic quadrangle map (USGS, 1985a) (appendix C, map 1). The spring sites are located on the adjoining Tolman Flats 7.5-minute topographic quadrangle map (USGS, 1985b). The sites are at latitude: 45° 07' 09", longitude: 109° 14' 13".

Source History

The Bearcreek water system is currently owned by the Bearcreek Municipal Water Users Association. The original water system was constructed in the 1920's and used the same spring sites as the present water system, but the water was transported through now-abandoned wooden pipe. In the early 1960's the water distribution system was reconstructed, replacing the wooden pipe with PVC pipe. The system was inspected in 1978 by Dayton Alsaker of the Montana Department of Health and Environmental Sciences (DHES, now the Montana Department of Environmental Quality, DEQ) (Alsaker, 1978). Mr. Alsaker submitted a brief summary of the system design at that time. The present water system is virtually the same as at the time of Alsakers visit, and has changed little since reconstruction in the early 1960's.

Spring Configuration

The water-supply source is a pair of concrete collection boxes constructed directly over the two springs. The concrete boxes are open at the bottom to allow spring water to enter, and each contains a perforated 4-inch PVC, gravel-covered collection pipe laid horizontally at the bottom of the box. The collection pipes are connected to a 4-inch PVC distribution line. The uppermost spring box (source #003) is 40 feet long, 4 feet wide and 4 feet high (appendix B, photo 1). The lower elevation box (source #002) is 4 feet square by 5 feet high (appendix B, photo 2). The tops of the spring boxes have rectangular metal manholes with raised lips and lids with edges that seal the opening when closed. The lids are securely locked with chains and padlocks. Overflow discharge pipes are located along the sides of both spring boxes at about 2 feet above the ground surface (appendix B, photo 1). Because the boxes were locked at the time of the site inspection it was not possible to look inside. Mr. Webb, the system operator, reported that the 3 inch diameter overflow pipes are located above the gravel fill and above the collection pipes inside the boxes. Some of the overflow pipes have wire mesh screen covers over the outlet, but some do not. No water was observed flowing from the outlet pipes. A shut-off valve is located on the discharge line between the lower spring box and the main pipeline.

The entire water-supply system is gravity flow. Water flows from the spring boxes through a buried 4-inch PVC pipe approximately 3 miles to a pellet chlorinator housed in a brick shed located 2 miles southwest of town (appendix C, map 1). Below the chlorinator the water is piped into a 40,000 gallon standpipe-type storage tank located approximately 1½ miles southwest of town and less than ½ mile south of Highway 308 (appendix B, photo 3). Between the chlorinator and the storage tank the water line is reported to be initially 3 inches in diameter, increasing to 6 inches in diameter about 300 feet above the storage tank. The water flows 1½ miles through a 6-inch PVC water line from the storage tank to the 3-inch water mains in town (Alsaker, 1978). The town water mains are old clay or concrete composite-type pipes. The length of the buried water line from the spring boxes to the chlorination system and the water tank could not be inspected because muddy conditions made the road impassible. The upper ¾ mile of the piped system near the spring boxes, and the area around the storage tank were visually inspected. The parts of the system that were inspected were found to be in good working order and appeared to be well maintained.

The spring sites at the head of the water-distribution system were determined to be at 6100 feet elevation (source #002) and 6200 feet elevation (source #003), using a topographic map and altimeter. The water storage tank is located at 4780 feet elevation, and Bearcreek is located at 4520 feet elevation (appendix C, map 1). The total elevation drop from the spring sites to town is 1680 feet, making a potential pressure head of 727 psi possible at Bearcreek. Pressure in the distribution system is relieved at overflow discharge pipes at the chlorinator and at the storage tank. The overflow pipes discharge water into Bear Creek. Each home service connection has distribution lines rated at 200 psi and pressure regulators set to 50 psi. There are no back-flow preventers or check valves on the water supply system; however, the natural elevation head maintained in the pipeline system from the spring source to the town distribution outlets makes back flow unlikely as long as a water head is maintained.

Elmer Webb, the water system operator, lives in nearby Belfry, Montana and is a certified operator of the Belfry and Bearcreek water systems. Mr. Webb reported that the chlorinator on the Bearcreek water system is used only when water samples show a problem, such as detection of heavy non-coliform bacteria, coliform or fecal-coliform bacteria, or when a problem period is anticipated. Coliform bacteria and turbid water have appeared in water samples collected in the springtime and early-summer and usually seem to occur when the spring discharge rates are high. Non-coliform bacteria have occurred in water samples collected in late-summer and fall, a period when spring discharge is low. Mr. Webb reported that when the bacteria appear in water samples the pellet chlorinator is activated to chlorinate the water supply for 2-3 days. At the same time additional chlorine pellets are manually added to the water system through a manhole just below the spring boxes and through a manhole just above the water storage tank. This occurs once or twice per year, usually during warm weather periods, especially during periods of high springtime runoff. When in use the pellet-chlorinating system is set to a rate equivalent to one pound of chlorine per 24 hours. In 1978, Dayton Alsaker of the Montana DHES measured chlorine residual at the point of application and found the concentration to be approximately 0.4 parts per million. Alsaker recommended confirming this concentration at the points of use (ends of the water distribution system). At the time of the HA site investigation Mr. Webb did not have any residual chlorine measurement records available to verify treatment rates. The operator does not keep records of water levels, spring production rates, or chlorination rates (as far as could be determined), and no maintenance records were available for the water-supply system.

DEQ records as of January 1995 indicate that the Bearcreek water system has 53 active service connections and 37 resident users. The system operator indicated that there are currently an estimated 100 year-round users on the water system. An estimate of water use by the residents suggests that the water system needs to supply an estimated 15,000 gallons per day (gpd), based on 100 users X 150 gpd/user. Projected growth for the area is estimated to be slow but steady. About 5 new homes have been built and added to the water system in the past year.

Plans are currently being considered to expand the capacity of the Bearcreek Water System by installing an additional water tank on the spring-water distribution line. The additional tank is needed to supply water to homes located at higher elevations than the towns main water lines. During the spring and summer of 1998, engineers from the Billings, Montana office of Morrison-Maierle, an engineering consulting firm, inspected the water-supply system and were in the process of designing additional storage capacity. The Bearcreek Water Users Association is currently looking for funding to purchase the upgrades.

GEOLOGY

Topography and Land Use
Bearcreek is located at an elevation of 4520 feet on the northwestern edge of the Bighorn Basin (appendix C, map 2). The Beartooth Mountains rise rapidly to the west to an elevation of 9265 feet at the summit of Mount Maurice, located 10 miles west of Bearcreek.

Bearcreek is located at the southeastern end of the Red Lodge coal field and was founded as a mining community. Between 1887 and 1946 coal was mined in underground workings in the Bearcreek area from 8 major coal beds in the Tongue River Member of the Fort Union Formation (Stow, 1938 and Bateman, 1966). Most of the miners lived in Bearcreek and Red Lodge. No recent mining activity has been reported in the Bearcreek area. Currently, Bearcreek is surrounded by privately owned ranches and large tracts of BLM land used for grazing cattle. The land is covered by sparse grass and sagebrush indicative of the semiarid climate.

The Bearcreek economy is supported by local residents, and to a small degree tourism. Recently a private company has proposed to revive coal mining and to construct a coal-powered electrical generation facility in the Bearcreek-Belfry area. A project of the size proposed could significantly increase the population of Bearcreek and increase water demand on the public water-supply system. If the town's population were to suddenly increase, the water-supply capacity of the spring sources during extended periods of low discharge would need to determined.

Spring Site Topography and Land Use
The springs are located in the Bear Creek drainage in steep, rugged, mountain terrain on the Beartooth Mountain front 4½ miles southwest of Bearcreek. The Beartooth Mountain front at Bear Creek is characterized by upturned layers of Paleozoic sediments which form high, steeply-tilted palisades (appendix B, photo 4). The palisades are cut by streams or displaced by tear faults that form gaps in the palisade wall. Bear Creek flows through a fault offset in the palisades (appendix C, map 1 and appendix B, photo 4). The springs are located on the steeply sloping southeast flank of a glacial moraine where the creek crosses the nearly vertical Paleozoic outcrops of the Beartooth Mountain Front (appendix B, photo 5). The glacial moraine and outwash covers the bottom of the creek valley. The springs discharge into Bear Creek approximately 40 feet below the top of the moraine (appendix B, photo 1).

Between the town of Bearcreek and the spring sites the land rises 1600 feet in elevation in less than 5 miles. At the spring sites the Bear Creek drainage is very steep, rising 1300 feet/mile (appendix C, map 1). The spring sites are located in thick brush along the creek bottom (appendix B, photo 6). Coniferous trees are commonly found along the creeks and steep mountain slopes; sparse native grass grows in the large open areas (appendix B, photo 5). No developments of any kind exist within at least 3 miles of the spring sites. The spring area is primitive, with a few game and livestock trails which are occasionally used by local ranchers. The springs are located on BLM property that abuts U.S. Forest Service land, which lies to the south and west. The BLM owns most of the north half of section 22, T. 8 S. R. 20 E. (the location of the springs) and the U.S. Forest Service owns the south-half (USDA, 1995). Most of the land within the Beartooth Mountains, southwest of the spring sites, is owned by the U. S. Forest Service.

No climate records are available for Bearcreek. Climate records are available at Red Lodge, located 8 miles west and 1,000 feet higher in elevation than Bearcreek. Red Lodge receives an average of 25.8 inches of precipitation annually (30-year mean); the largest percentage of the precipitation is snowfall received during the winter and spring (WRCC, 1999). Judging by the vegetation around the town, Bearcreek probably receives much less precipitation than Red Lodge, although the precipitation rates measured at Red Lodge may be comparable to the precipitation rates that occur at the spring sites.

Regional Geology

The Beartooth Mountains are part of the northern Rocky Mountains and consist of steep rugged mountain terrain capped by high elevation, relatively flat plateaus carved into Precambrian crystalline bedrock by erosion and glaciation. The plateaus are dissected by steep, deep valleys formed contemporaneously with mountain uplift and later deepened by glacial activity.

The Beartooth Mountains are composed of a core of Precambrian metamorphic rocks dated as much as 3.96 billion years old (Meuller and others, 1985). The granitic gneiss, migmatites and metasediments were eroded to a smooth surface by peneplanation in the late-Precambrian. During the Paleozoic Era (530 to 240 mya (million years ago)) an estimated 2,000 to 3,000 feet of predominantly marine sediments were deposited on the Precambrian erosional surface. The Paleozoic bedrock is composed primarily of limestone containing layers of quartzite, sandstone, dolomite and shales (Darton, 1907). Another 4,000 to 6,000 feet of predominantly continental clastic materials were deposited in the Mesozoic Era (240 mya to about 65 mya) (Foose and others, 1961). The later deposits include shales and some limestones interbedded with conglomerate, sandstone and siltstone deposits.

The Beartooth Mountains were formed by uplift during the Laramide Orogeny, beginning in the late Cretaceous, about 65 mya. Collision of tectonic plates caused uplift and faulting of the Beartooth Mountain Block along reactivated structures within the Precambrian crystalline bedrock (James, 1995). During uplift the Beartooth Mountain Block was tilted to the southwest and thrust northeastward, displacing Precambrian and Paleozoic bedrock over Paleozoic and Mesozoic deposits (Foose, 1958). Geologic formations northeast of the Beartooth Mountain Block were folded into a syncline forming the Bighorn Basin. The total structural displacement created by the thrust faulting and uplift is nearly 20,000 feet, measured from the Precambrian surface at the bottom of the Bighorn Basin (10,000 feet below msl) to the summit of the Beartooth Mountains (over 12,000 ft elevation at the highest point) (Foose and others, 1961). As a result of the uplift, layers of Paleozoic sediments along the front of the advancing thrust block were folded and steeply tilted 50-70 degrees to the northeast, forming palisades along the mountain front (appendix B, photo 4). The Laramide Orogeny ended about 63 mya, but post-Laramide movement continued into the early-Tertiary Period (Foose and others, 1961). Folding and faulting related to the mountain uplift have been mapped in formations as recent as the Wasatch of early Eocene (38 to 55 mya) (Foose, 1958).

Post-uplift erosion removed most of the Mesozoic and Paleozoic sediments on the mountain block although the Paleozoic sediments remain in outcrop in the palisades along the northeast mountain front. Late Cretaceous and Tertiary sediments deposited along the mountain front and across much of south-central Montana are derived from materials eroded from the uplifted mountain block. Over 8,000 feet of eroded material has been deposited in the basin along the mountain front during and since Fort Union time (early Tertiary) (Foose and others, 1961).

Several episodes of glaciation occurred in the Beartooth Mountains during the Pleistocene Epoch, between 1.6 mya and 12,000 years ago. Alpine-type glaciers formed along the east and north sides of the mountains and removed more bedrock material as they scoured much of the land surface (Poldervaart and Bentley, 1958). The glaciers carved U-shaped valleys and deepened pre-existing channels into the plateau. Deposits of moraine and outwash material left by the glaciers cover many of the valley bottoms and lower valley slopes.

By the end of the Tertiary, about 2 mya, erosion had removed much of the Mesozoic and Paleozoic sediments from the Beartooth Mountains, exposing the Precambrian bedrock at higher elevations. Pediment surfaces (planar sloping erosional features) were formed on the Tertiary sediments along the mountain front beginning in late Tertiary, and later on the surfaces of the Pleistocene moraines and outwash plains (appendix B, photo 4). Recent (Quaternary and Holocene) erosion has continued to shape the present land surface forming and reshaping many of the alluvial fans, colluvial slopes and pediment surfaces along the mountain front.

Local Geology

Bear Creek is located at the point of greatest vertical structural displacement across the Beartooth Thrust Fault (20,000 feet of vertical relief) and at the largest lateral offset of the upper thrust block along tear faults. Tear faults associated with the Laramide thrust laterally displaced bedrock in the upper fault block in Paleocene and Eocene time. Displacement along the faults can seen in offsets of the upturned Paleozoic sediments (Foose, 1958). Bear Creek flows from the mountain front through a gap in the Paleozoic palisades created by offset along the Maurice-Fault, one of the largest tear faults along the mountain front (appendix C, map 2). The Maurice Fault is an east-west trending, left-lateral tear fault that offsets the Paleozoic palisades by as much as 10,000 feet at Bear Creek (Foose and others, 1961). The fault trace, as mapped by Foose and others (1961), is located just north of the spring sites (appendix C, map 1).

The springs discharge from Pleistocene glacial moraine and outwash deposits that form a wide longitudinal ridge of unconsolidated debris along the center of the Bear Creek drainage (appendix B, photo 5) (David Lopez, MBMG, personal communication, 1999). The moraine is composed of a thick accumulation of cobble- to boulder-size rock fragments consisting primarily of Precambrian granitic metasediments with occasional limestone, sandstone, and schist cobbles, derived from the narrow band of Paleozoic material exposed at the mountain front. Very little fine-grained material were observed in the glacial deposits. The moraine extends from the slopes of Mount Maurice, well above the spring sites, through the mountain front and onto the pediment surface of the Fort Union Formation where it blends into the outwash debris field (appendix C, map 1). The moraine overlies Precambrian, Paleozoic, and Tertiary formations along the upper Bear Creek drainage, and is estimated to be more than 60 feet thick at the spring sites.

Bear Creek flows through a steep, v-shaped channel that has been incised into the southeast side of the moraine. The north fork of Bear Creek flows through a channel incised into the northwest flank of the moraine. The debris washed from these channels by glacial meltwater and runoff has been transported onto the pediment surface along the mountain front and deposited as outwash and alluvial fan debris (appendix C, map 1 and map 2). The outwash and erosional debris extends approximately 2 miles northeast of the spring sites and gradually thins away from the source area to merge with the pediment surface of the Fort Union Formation. Quaternary erosional processes have eroded the top of the moraine and outwash deposits into a smooth, rounded surface (appendix B, photo 5). Few ice-formed features are visible on the surface of the moraine due to the erosion, however, some ice-formed features are visible in air photos (David Lopez, MBMG, personal communication, 1999).

The springs are located along the north slope of Bear Creek at the Paleozoic palisades, along the southeast side of the valley (appendix C, map 1). They discharge from the steep slopes of the unconsolidated moraine that forms the north side of the Bear Creek channel. The southeast side of the drainage is formed by the steep, near-vertical cliffs of Paleozoic sediments which rise over 1000 feet above the valley floor (appendix B, photo 4). At the spring sites the limestone outcrops are visible above a 50 to 100 foot high colluvial slope that covers the base of the outcrops and forms the southeast bank of the creek. The colluvium is composed of silt and sand-size material, up to cobble and boulder size fragments of limestone, dolomite and sandstone that extend down to the creek bed.

HYDROLOGY

Surface Water

Streams in the Bearcreek area flow to the northeast into the Clarks Fork of the Yellowstone River and are fed by snowmelt and runoff from the mountains. Bear Creek originates on the northeast flank of Mount Maurice and flows into the Clarks Fork of the Yellowstone River at the town of Belfry, 14 miles east of the Bearcreek water supply springs (appendix C, map 2). From its headwaters, Bear Creek flows over Precambrian bedrock and off the mountain front over the flank of the glacial moraine, across the tilted layers of Paleozoic sediments and onto Tertiary sediments composed of sandstones, siltstones, coal, silt, and clay. Streamflow in Bear Creek is fed by runoff in the mountain valley and by discharge from springs flowing from the glacial moraine and outwash along the valley bottom. A number of springs discharge from the moraine into Bear Creek between the spring boxes and the Metetsee Trail Road (appendix C, map 1).

During the site visit streamflow in Bear Creek near the spring sites was observed to vary by location due to the coarse nature of the morainal streambed materials. Total streamflow was difficult to determine through the Paleozoic outcrop area because, at some locations, the stream water flows underground and discharges back to the land surface further downstream. The streambed was dry above the upper spring. The fact that the stream flow can travel through the morainal material and re-emerge downstream with little apparent loss in flow volume shows the transmissivity of the aquifer material is high. No streamflow measurements were taken during the site visit, but visually estimated streamflow rates showed that Bear Creek is a gaining stream (Table 2). Most of the estimated increase in stream flow from the spring sites to the water-storage tank is from spring discharge from the glacial moraine, and from the merging of the north and main forks of Bear Creek near the Metetsee Trail crossing. Total contributions to streamflow from the Tertiary sediments are probably low. Water is also added to the stream from surface runoff over the Tertiary sediments during periods of high precipitation.

Regional Ground-Water Flow

Very few wells have been drilled in the Bearcreek area and no ground-water studies have been conducted, making interpretations of ground-water movement difficult. Interpretation of ground-water flow in the Bearcreek area is based on referenced maps and reports, a site investigation and the well data available in the Montana Bureau of Mines and Geology, Ground-water Information Center database (GWIC, 1999).

Ground water in the Beartooth Mountains is recharged by snowmelt and precipitation. A large percentage of the recharge is from the melting of the large accumulations of snow in the mountains. The precipitation and meltwater runs off of the Precambrian bedrock, infiltrates into fractures, or into the moraine and glacial outwash material along the valley bottoms and flows to the water table. Shallow ground water in the Bearcreek area flows to the northeast and east, similar to the streams, from the Beartooth Mountains toward the Clarks Fork of the Yellowstone River (appendix C, map 2).

The only wells drilled in the immediate vicinity of Bearcreek, on record with GWIC (1999), are screened in the Fort Union Formation and range from 45 feet to 300 feet deep, and have reported static water levels between 12 feet and 78 feet below ground level. The wells draw water from sandstone intervals within the Fort Union Formation. Drinking water sources in the Bearcreek area include the mountain front springs, creeks and deep wells in the Fort Union Formation.

Local and Intermediate Ground-water Flow

Most ground water drains from the Bear Creek valley through the coarse morainal deposits along the valley bottom or is discharged into Bear Creek (appendix C, map 1). All ground water not intercepted by evapotranspiration or public water supply discharges ultimately into Bear Creek. Ground water discharges to the land surface as springs where the land topography abruptly drops in elevation at a rate steeper than the water-table slope, causing the water-table to intersect the land surface. At the spring sites, the sides of the moraine slope steeply to the southeast (greater than 40 degrees, estimated) (appendix B, photo 1 and figure 2).

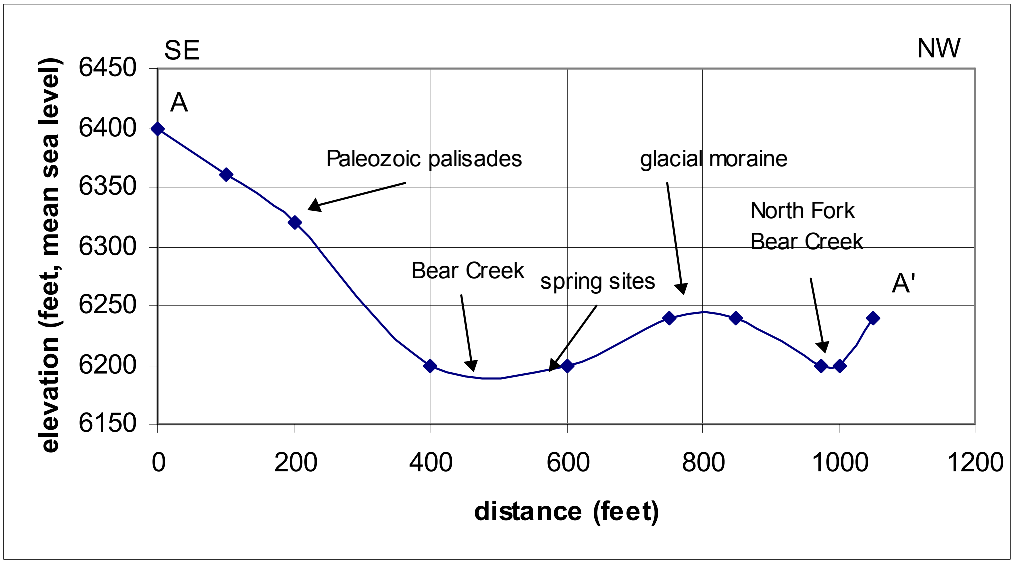

Figure 2. Southeast-northwest profile A-A', of the glacial moraine and the Bear Creek drainage between the spring sites, looking upstream to the southwest.

The system operator, Mr. Elmer Webb, reported that the spring discharge rates fluctuate seasonally (Elmer Webb, personal communication, 1998). The spring discharges have been observed to be at their lowest rates from January through April and to increase from May into June, following mountain snowmelt cycles. Discharge from the water system, measured at the chlorinator by Mr. Webb, has ranged between 4 gpm and 60 gpm. The broad range of spring discharge that increases during periods of increased snowmelt and runoff suggests that the aquifer is in good hydraulic connection with the runoff water at the land surface. At the time of the site visit there was no way to measure discharge at the spring boxes. Discharge flow was measured at a 12-inch diameter, corrugated, overflow pipe at the storage tank. The discharge end of the pipe was open with no screen or cover in place. Discharge from the pipe was measured at 60 gpm. Another overflow discharge pipe is located at the chlorinator building about one mile upgradient from the storage tank. Because the chlorinator site was inaccessible during the investigation visit, it was not determined if additional water was discharging at the chlorinator. Based on measurements at the time of the investigation the total spring discharge was estimated to be at least 60 gpm. Because the site investigation was conducted in June, a period of regional high streamflow and snowmelt runoff, and because the area had received heavy rainfall in the weeks prior to the investigation, the measured spring discharge rate could represent a higher than average rate. A previous site report by Dayton Alsaker (DHES, 1978), suggested that the spring discharge may become too low during dry years or extended dry periods to supply adequate amounts of water to the system. To date the water supply has been adequate to meet the year round needs of the users.

The morainal materials observed in the Bear Creek drainage are composed of coarse-grained cobbles, suggesting large pore spaces and good connectivity within the moraine aquifer. Therefore, ground-water movement through the aquifer is probably relatively fast and the infiltrating water may not be adequately filtered as it passes through the ground-water system to the springs. In addition some of the recharge to the aquifer may occur very close to the spring sites. The water infiltrating into the ground probably has a very short travel time as it flows vertically from areas of recharge at the land surface, through the unsaturated zone above the water table, into the ground water and then horizontally below the water table to the spring. No ground-water studies have been completed in the spring area. To estimate a general range of travel time for water to infiltrate through the land surface to the water table, some estimates of the hydraulic characteristics of the ground-water system were taken from references in literature for similar conditions.

Heath (1983) presented a table for ranges of hydraulic conductivities (K) for various geologic materials. The moraine is composed of boulders, cobbles, and some gravels. Based on the tables compiled by Heath, material similar to the moraine deposit could have a saturated hydraulic conductivity (K_{sat}) in the range of 100 to 1000 feet/day.

As the water content of the geologic material decreases the hydraulic conductivity also decreases. In unsaturated conditions the hydraulic conductivity can vary by several orders of magnitude making an accurate estimate of the actual value very difficult. As a middle range estimate of the unsaturated hydraulic conductivity of the geologic material in the unsaturated zone above the water table, a value of $\frac{1}{2}K_{sat}$ (one-half of the unsaturated hydraulic conductivity) was used (Stephens, 1996). The unsaturated material is composed of the same glacial moraine material as the aquifer. Because the moraine is an unstratified deposit, by nature of its mechanism of deposition, the vertical hydraulic conductivity was assumed to be the same as the horizontal K (100 to 1000 ft/day). The average unsaturated hydraulic conductivity $\frac{1}{2}K_{sat}$ of the cobbles and gravel was estimated to be 50 to 500 ft/day.

The vertical hydraulic gradient driving ground-water movement through the unsaturated zone above the water table is assumed to be a unit gradient (dh/dl=1), with downward vertical flow (Stephens, 1996). The effective porosity of the morainal material, equivalent to the specific yield of the material was estimated, using tables for graded materials by Fetter (1994), to range from 0.22 for coarse gravel to 0.11 for poorly-sorted, coarse gravel with fine material. The effective porosity represents the porosity available for fluid flow.

The hydraulic parameter values estimated from literature were applied to the average-linear velocity equation for determining water movement through porous materials to estimate a range of possible ground-water travel velocities through the unsaturated portions of the ground-water flow system (Fetter, 1994):

$$Vx = -((\tfrac{1}{2}K_{sat}/N_e)*(dh/dl))$$

Where Vx = average linear velocity, $\frac{1}{2}K_{sat}$ = the estimated vertical unsaturated hydraulic conductivity of the moraine material, N_e = the effective porosity (potentially saturated porosity) of the morainal material, and dh/dl=the hydraulic gradient. The negative sign indicates downgradient flow.

The distance that infiltrating water must travel from the land surface to the water table was estimated by assuming that the water table was at the elevation of the springs along the flanks of the moraine, a depth of approximately 20 feet to 40 feet below the land surface. The range of estimated average-linear velocities for unsaturated ground-water flow is summarized in Table 1. The calculated average-linear velocity suggests that that the time required for the infiltrating water to move through the unsaturated zone is much less than one day.

Table 1. The maximum and minimum calculated average linear velocity values estimating vertical, infiltrating water movement through the vadose zone of the morainal material from the land surface to the water table. The estimates were made by using hydraulic parameters values estimated from literature references for similar aquifer materials and conditions.

vertical unsaturated hydraulic conductivity ½K_{sat} ft/day	effective porosity (N_{eff})	gradient (dh/dl)	average linear velocity ft/day	vadose zone thickness ft	travel time days
50	0.22	1.0	227	40	< 1
500	0.11	1.0	4,545	20	< 1

The estimated hydraulic conductivity of the morainal material suggests that ground water could move through the aquifer, after it reaches the water table, at hundred's of feet per day. Based on the assumptions made and the observed characteristics of the aquifer material, it would not be unreasonable to assume that ground water from great distances could flow from the land surface to the spring discharge in a matter of days. While the assumptions used are based on brief observations and references in literature, other observations at the site, discussed in other sections of this report, support these conclusions. The estimated short travel time for water movement through the moraine and the coarse-grained nature of the aquifer material may not allow for adequate filtration of the ground water and may not support anaerobic conditions.

WATER QUALITY

Field Parameters

Temperature, specific conductance, pH, and Redox (a measure of the oxidizing or reducing tendency of the water, used to estimate Eh) were measured in the water at several locations along Bear Creek and from the water-supply system overflow pipe at the storage tank (appendix C, map 1 and Table 2). The chlorinator was not in operation at the time the water-quality parameters were measured. The discharge rate was measured from the overflow pipe at the storage tank using a bucket and stopwatch. The stream discharge was estimated by measuring the flow rate using a stopwatch and floating object and measuring the stream width and depth.

Table 2. Basic water-quality parameter measurements in Bear Creek and in the Bearcreek water-supply system listed by sample site and site number (appendix C, map 1). 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	pH	Specific conductance (µmhos/cm)	Temperature (°C)	Redox (mv)	Eh	discharge flow (gpm)
(1) Bear Creek above upper spring box	8.8	245	4.6	305.2	524.6	< 5 (est.)
(2) Bear Creek at lower spring box	7.8	160	4.6	322.3	541.7	5 + (est.)
(3) Bear Creek at manhole, above north fork junction	7.9	168	6.3	291.0	508.6	5 (est.)
(4) Bear Creek above water system discharge	8.2	345	8.1	215.3	431.2	50 (est.)
(5) water system storage tank overflow discharge	8.6	192	8.3	265.2	480.9	60

The field observed water-quality parameter measurements in the spring water and in Bear Creek were very similar indicating that the discharge of ground water from springs is the probable source of base flow in Bear Creek (Table 2). In general, pH decreased slightly downstream, specific conductance increased and Redox (Eh) showed a decrease downgradient in Bear Creek after the creek flowed across the Tertiary sediments (site 3 to site 4**.** The decrease in pH and the increase in the specific conductance could be the result of the runoff water reacting with the Fort Union sediments. The low specific conductance of the spring water indicates that the ground water is not retained for long periods of time in the aquifer where it can react with the minerals in the geologic material. Based on the specific conductance values water probably moves through the aquifer to the spring sites quickly.

Water-quality History

No inorganic water-quality analyses were available for the Bearcreek water-supply system. Records of coliform bacteria sampling on file with the DEQ show 3 non-acute coliform MCL violations in water samples collected in the last 3 years. Information received since the site visit shows that coliform bacteria were detected in samples collected 4/6/99, 4/16/99 and 5/4/99 (Mike Brayton, DEQ, personal communication, 1999). The water system is currently under a Health Advisory .

Samples collected between 2/1/93 and 9/24/96 showed five bacteria or turbidity problems:

1) bacteria at TNTC levels without coliforms were detected on 11/7/95
2) heavy non-coliform bacteria growths were reported on 9/22/95
3) turbid conditions were reported twice on 6/30/93 and 4/24/95
4) one fecal-coliform bacteria was detected in a sample collected 5/25/94

Mr. Elmer Webb confirmed that water samples are collected at the point of use from various household outlets in town. In a letter dated June 2, 1994, the DHES requested records of chlorine residual measurement from the water system operator. It appears that the DHES never received the residual records. Mr. Elmer Webb has been the Bearcreek water system operator for about 2 years. Mr. Webb stated that the water system is only chlorinated during short periods in the Spring when snowmelt and spring discharge rates are high. Chlorine tablets are added manually to the inflow water as the operator feels necessary. No chlorination rates or residual measurements are recorded.

The system operator has observed that turbidity increases slightly with the increase in spring discharge, but has never measured levels above acceptable public water-supply standards. Alsaker (1978) measured the turbidity level at 0.25 NTU in a water sample from the water-supply system on August 11, 1978. It has been suggested by the system operator that the detection of fecal coliform, non-coliform bacteria and turbidity in the water system in the springtime may coincide with periods of high spring discharge rates following snowmelt at the spring sites and at the head of Bear Creek. However, non-coliform bacteria growths have also been detected in samples collected in September and November, suggesting low flow periods may also pose a risk. Because of the recurring springtime contamination problem, each May for the last 2 years the water-system operator has added chlorine tablets to the water system through a manhole just below the spring boxes. An additional 8 tablets are manually added to the water system through a second manhole just above the storage tank at the same time. Each tablet is intended to treat 20,000 gallons of water. For short periods during the springtime the pellet chlorinator installed on the water-supply line may also be turned on to meter chlorine into the system. Since this springtime chlorination process has been conducted, no fecal-coliform bacteria have been detected in water samples from the water-supply system.

Typically detection of fecal-coliform bacteria indicates that the ground water has been in contact with sewage or human/animal waste. Because the Bearcreek spring sites and the surrounding area are primitive and undeveloped, with little evidence of human activity, the fecal-coliform bacteria must be derived from other animal sources. Fecal-coliform bacteria have only been detected in the water supply samples collected during the spring and appear to coincide with spring snowmelt and ground thaw, suggesting that the bacteria may originate from animal waste on the ground near the spring site. The bacteria are transported by the infiltrating snowmelt from the land surface through the recently thawed ground to the ground water. Once in the ground water the bacteria may be transported into the spring box and into the water distribution system. Table 1 shows that the estimated rate of water movement from the land surface into the ground water could facilitate the transport of bacteria in a short period of time. The overflow pipes on the side of the spring boxes are not screened. Small rodents could enter the spring box through these openings and contaminate the spring box.

Another possible source of fecal-coliform bacteria in the water system might be the Bear Creek surface water during periods of high stream flow. The spring boxes are located along the Bear Creek drainage and the bottom of the boxes are 0-5 feet above the creek bed. High streamflow runoff could raise creek levels near the spring site enough reverse the gradient between the surface water and the ground water in the moraine, allowing surface water to infiltrate into the moraine near the spring boxes. In this scenario the infiltrating water could be transported only a short distance from the creek into the ground water and into the spring discharge flow. This situation has not been observed.

CONCLUSIONS

Determination of Direct Surface-water Influence

The results of the assessment indicate that the Bearcreek Municipal water system may be under the direct influence of surface water because the water source is two springs and the potential for infiltration of surface water through the coarse grained geologic material around the springs is likely. Due to the highly transmissive material in the source aquifer, the short travel distances and relatively high potential ground-water velocities, both horizontally and vertically, **this site may be susceptible to the influence of surface water.**

Conditions observed or reported at the site that indicate that the system may be influenced by surface water include:

- Fecal coliform or non-coliform bacteria have been detected in water samples collected from the Bearcreek water system on at least three occasions. The probable source of the bacteria is from animal waste at the land surface near the spring boxes. The occurrence of fecal coliform appears to be seasonal, but has occurred on an annual and recurring basis following Spring snowmelt, during periods of high spring-discharge, suggesting ground-water contact with near surface bacteria sources. Non-coliform bacteria have been detected during low-flow periods from August through November. The appearance of coliform bacteria in the water-supply system in the spring may be the result of increased infiltration rates through the moraine material following spring thaw and during periods of high snowmelt run off. The travel time for the infiltrating water from the land surface to the water table in the coarse moraine material is relatively short, increasing the chances that the coliform bacteria are transported to the water table and into the spring. In addition, the possible lack of natural filtration through the moraine may contribute to the appearance of bacteria, coliform bacteria, and the occasional detection of fecal-coliform bacteria in the water-supply system samples. The water system operator is aware of the timing and occurrence of the coliform problem and periodically chlorinates the water-supply to control the bacteria in the system.

- The moraine-aquifer spring source is composed of coarse-grained material, the high transmissivity of the aquifer materials allows for high rates of ground-water movement. The mechanism of deposition of the morainal material

- The low specific conductance values of the spring water indicate that water is probably retained in the aquifer for only a very short period of time.

- The spring discharge increases during periods of snowmelt and runoff and decreases during dry periods. The seasonal response to the availability of water at the land surface indicates good hydraulic connectivity between the land surface and the aquifer.

- Bear Creek was observed to flow into and out of the moraine material along the bottom of the stream bed suggesting the possibility of a strong interaction between the ground water and the surface water.

- The spring discharge sites are located near potential aquifer recharge areas (10's to 100's of feet).

- Turbid conditions have been measured in water samples collected from the water system during high-flow spring runoff. Highly turbid conditions could interfere with chlorination.

Other factors to consider include:

- Chlorination of the water supply is intermittent and only occurs when a water-quality problem is expected or detected by sampling.

- Access to the chlorinator unit may be a problem when the access road is wet. The road becomes very slick and muddy and may restrict access to the chlorinator when it is most needed, during high-runoff periods.

- Despite the lack of maintenance records, the Bearcreek Municipal Water Users Association water-supply system appears clean and well maintained. The system appears to be well constructed and is managed by a capable, certified operator.

- The water-supply springs are located in a primitive area that has seen very little impact by man. Wild, and occasionally domestic, animals probably roam the area leaving behind fecal coliform-bearing waste products. Bear Creek is probably a source of drinking water for the animals in the area attracting them to the near-spring locations.

- The spring boxes are locked and secure. The location of the spring boxes in the creek bottom, which is heavily vegetated with thick brush, is remote and it is unlikely that the spring boxes would be seen by someone in the area without some knowledge of their location (appendix B, photo 6).
- The recent proposal by a small energy company to reopen some of the coal mines around the Bearcreek area and construct a small coal fired power plant near the town could greatly increase the population of Bearcreek and increase the demand on the water-supply system.

RECOMMENDATIONS

Because the water supply springs may be under the influence of surface water the following recommendations are suggested to confirm surface water influence and to improve the protection of the water source quality:

1) A microscopic particulate analysis test (MPA) should be conducted on the spring water. Because the accessibility to the spring sites is difficult an MPA would be the easiest and most efficient test to determine ground-water influence by surface water.

2) A water-quality assessment (WQA) could be conducted as an alternative to the MPA.

A WQA would require at least weekly monitoring of temperature, turbidity and specific conductivity or pH of both the ground water and the nearby surface water for up to twelve consecutive months. A WQA would be difficult to complete because the accessibility to the spring sites is difficult and time consuming, and may not be possible during the winter. Regular monitoring or sampling at the spring sites may be impractical.

3) Install screens on drain pipe outlets at spring boxes and at the chlorinator discharge pipe and storage tank discharge pipe to prevent small animals from entering the water-supply system.

4) Install a fence around the spring box sites to keep large animals out of the spring areas.

5) Improve accessibility to the chlorinator site, maintain proper set-up and operation of the chlorinator.

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Appendix A

A-1. Preliminary Assessment forms
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 Bearcreek Municipal Water Users Association PWS ID # 00063
SOURCE NAME spring source #002 along Bearcreek COUNTY Carbon
DATE 6/17/98 NC NTNC C POPULATION 100

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 seniconfined 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 45

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: Lower spring site. Chlorinator is used only for short periods of time as water quality problems arise.
Water quality analyses are from water samples collected from the distribution system. Two samples have contained non-acute, non-fecal, coliform bacteria in the last three years (4/6/98 and 4/16/98). Fecal-coliform bacteria have been detected in one water quality sample (5/25/94) by DEQ. Turbid conditions and non-coliform growths have been detected in some water quality samples since 1993.

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 Bearcreek Municipal Water Users Association PWS ID # 00063
SOURCE NAME spring source #003 along Bearcreek COUNTY Carbon
DATE 6/17/98 NC NTNC C POPULATION 100

	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 seniconfined 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 45

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: upper spring site. Chlorinator is used only for short periods of time as water quality problems arise.
Water quality analyses are from water samples collected from the distribution system. Two samples have contained non-acute, non-fecal, coliform bacteria in the last three years (4/6/98 and 4/16/98). Fecal-coliform bacteria have been detected in one water quality sample (5/25/94) by DEQ. Turbid conditions and non-coliform growths have been detected in some water quality samples since 1993.

Public Water Supply Number 20063
WHP Region ____________

Source Number 001
Inventory Person James Rose
Attached Map Number ____________

INVENTORY FORM

Occupant's Name: Town of Bearcreek Contact Elmer Webb - Belfry, MT.
Site Address: Box 1082
City: Bearcreek Zip Code 59068
County: Carbon T/R/S 08S 20E 22 AAAC
Phone Number: 406-664-3288 Lat/Long ____________

Name, address and phone number of property owner if different from above
Elmer Webb. Belfry MT Box 37 Belfry, MT 59008
406-664-3288 System operator

NATURE OF PROPERTY

Residential	___	Retail Business	___	Agricultural	___
Industrial	___	Government	___	Other (describe on back)	X ~~Public Water Supply~~ BLM

POTENTIAL SOURCES OF CONTAMINATION

Circle the number or letter of each source found at this site. Under quantity, indicate how many. Place the number or letter on the attached map to indicate the location of the source. List the chemicals used or stored on back of the form.

POTENTIAL SOURCE	QUANTITY	POTENTIAL SOURCE	QUANTITY
(1) Water well in use	___	(I) Above ground storage tank	___
(2) Water well abandoned	___	(J) Chemical storage facility	___
(3) Chemigation well	___	(K) Fertilizer/pesticide use	___
(4) Oil/gas well	___	(L) Chemical mixing/loading site	___
(5) Exploration bore hole	___	(M) Land application of waste	___
(6) Injection well	___	(N) Grain storage bin	___
(7) Mine/Quarry	___	(O) Animal feedlot	___
(A) Septic tank/privy	___	(P) Auto salvage yard	___
(B) Landfill/dump	___	(Q) Irrigated land	___
(C) Pipeline	___	(R) Artificial recharge project	___
(D) Wastewater lagoon	___	(S) Drainage canal	___
(E) Brine pit	___	(T) Highway/interstate frontage	___
(F) Service station dry well	___	(U) Railroad frontage	___
(G) Stormwater drain	___	(V) Stream, river, lake, pond	1
(H) Underground storage tank	___	(W) ____________	___

On BLM Land, downstream of U.S. Forest Service Land. Undeveloped Forest Land. Very Limited human activity

Appendix B

Photo 1. Upper spring box
Photo 2. Lower spring box
Photo 3. Water storage tank
Photo 4. Beartooth Mountain Front
Photo 5. Glacial moraine and Bear Creek drainage
Photo 6. Bear Creek drainage

Photo 1. Upper spring box (source #003), looking southwest. Slope of glacial moraine is behind the spring, Bear Creek is immediately to the left. View shows manhole covers on top of box and overflow pipe in lower center portion of the spring box side.

Photo 2. Looking southeast toward the lower spring box (source #002), Bear Creek is in the foreground. Spring box is located at the southeastern edge of the glacial moraine against a slope of colluvial material (background). Shut-off valve for spring box to water system is visible in front of box.

**Photo 3. Looking south at Bearcreek water system water storage tank.
Bear Creek is just behind the water tank.**

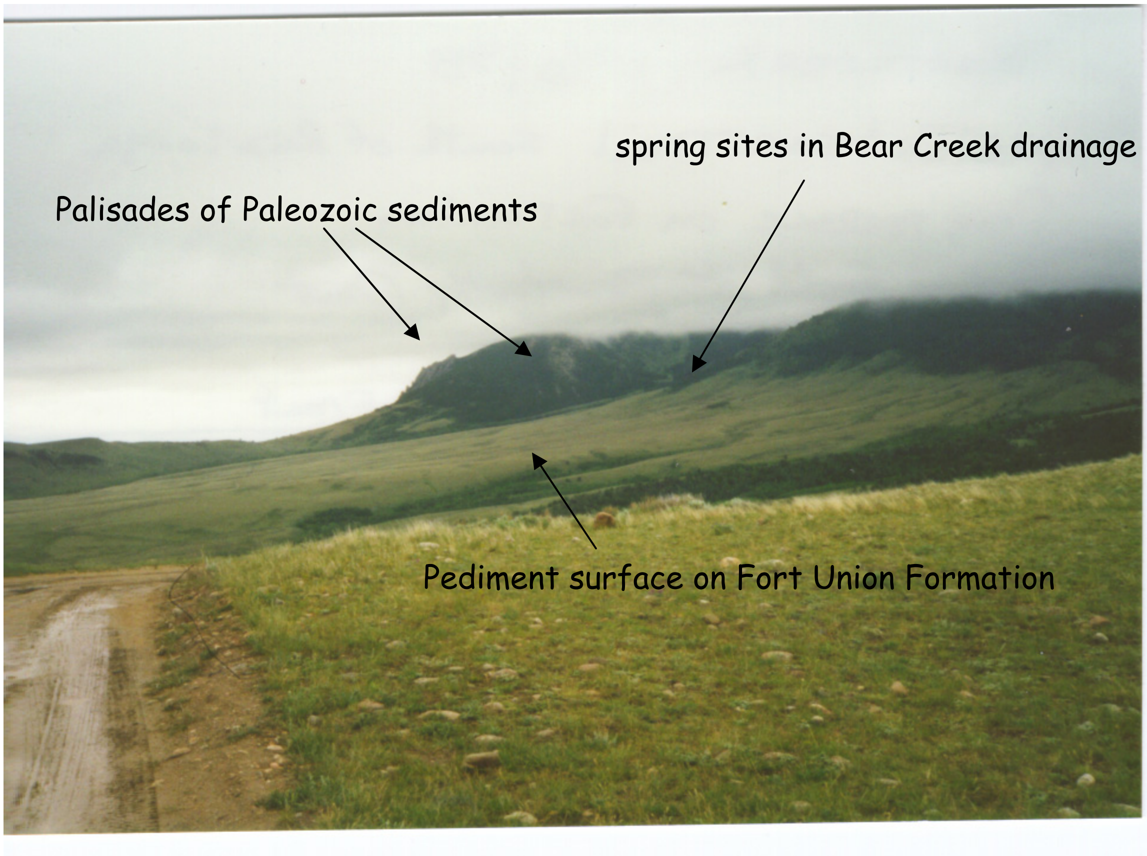


Photo 4. View looking south along Beartooth Mountain Front from Metetsee Trail Road showing the Paleozoic palisades along the Beartooth Mountain front, the water supply spring sites along the Bear Creek drainage and the pediment surface on the Fort Union Formation. Bearcreek is to the left.

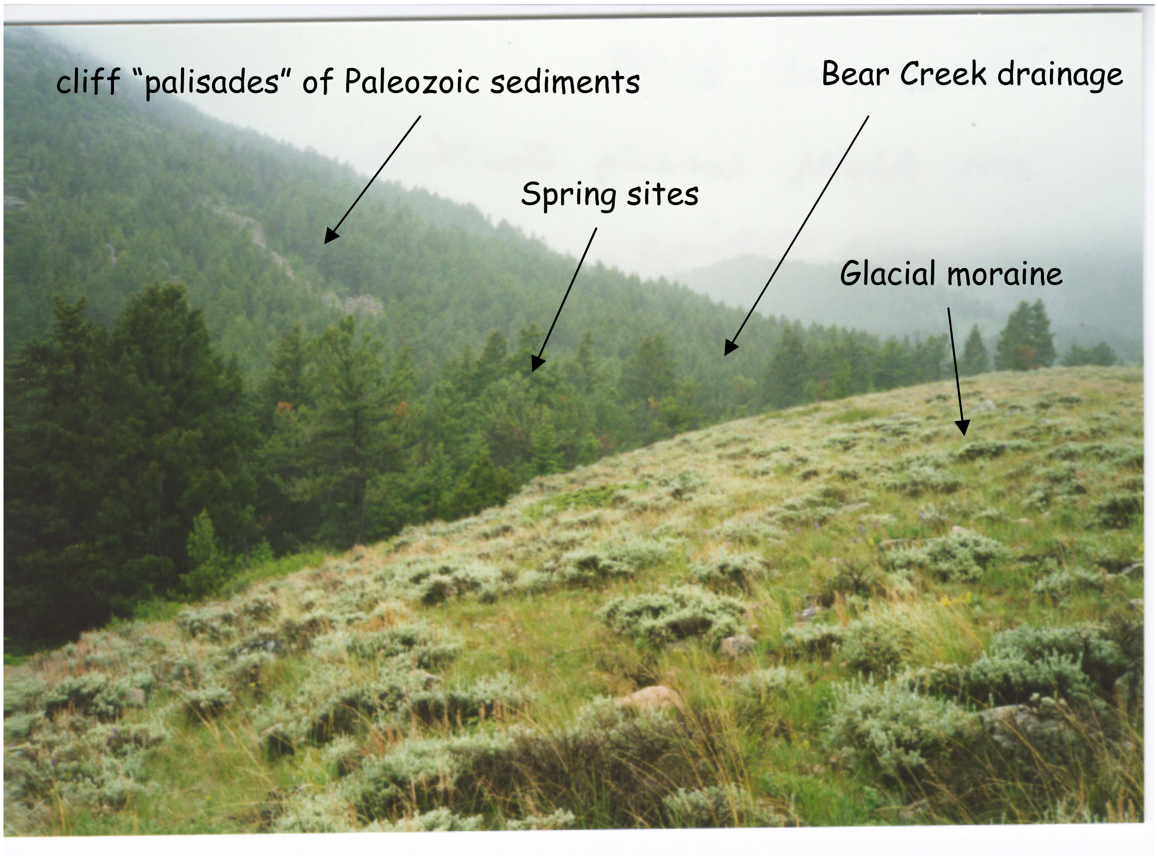


Photo 5. View of spring site area looking southwest along access trail towards spring sites in Bear Creek drainage showing the pediment surface of the glacial moraine, spring location along the Bear Creek drainage and the palisades formed by upturned Paleozoic sediments along the mountain front.

**Photo 6. Looking southwest up Bear Creek drainage between spring sites.
The glacial moraine is to the right and the colluvial slope is to the left.**

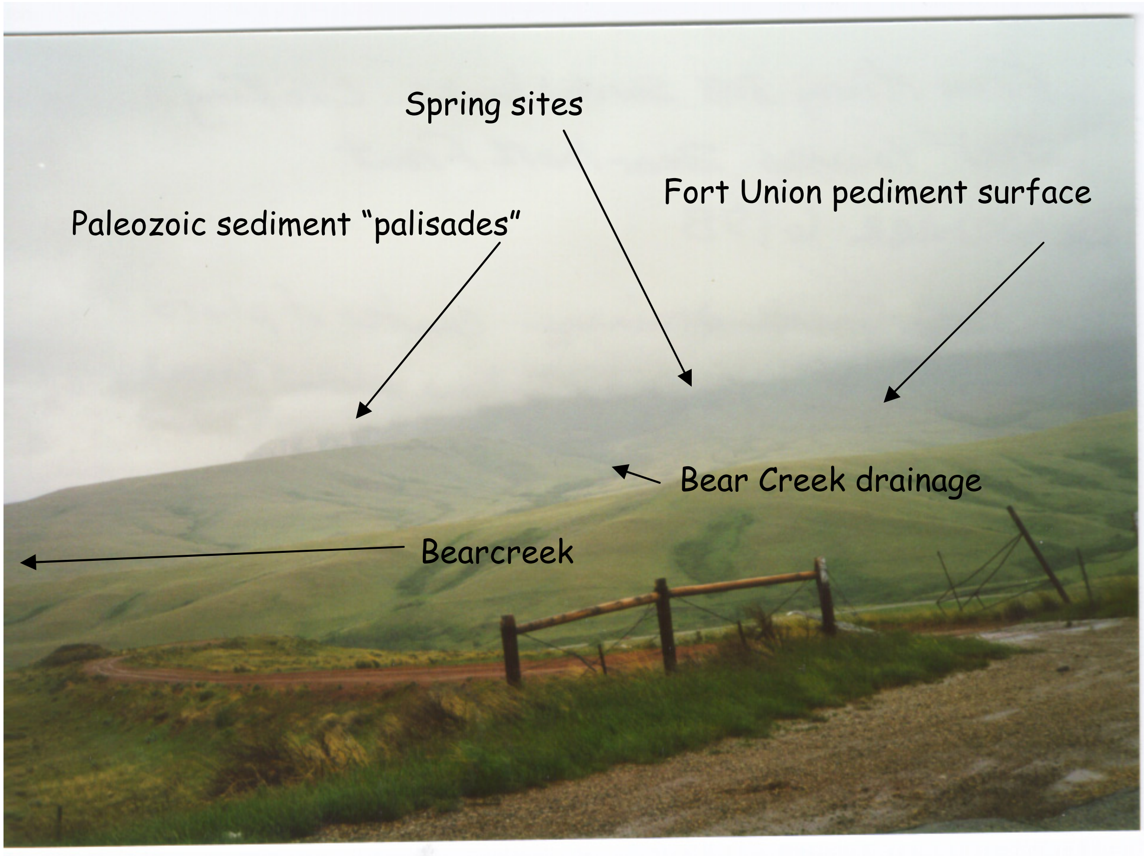
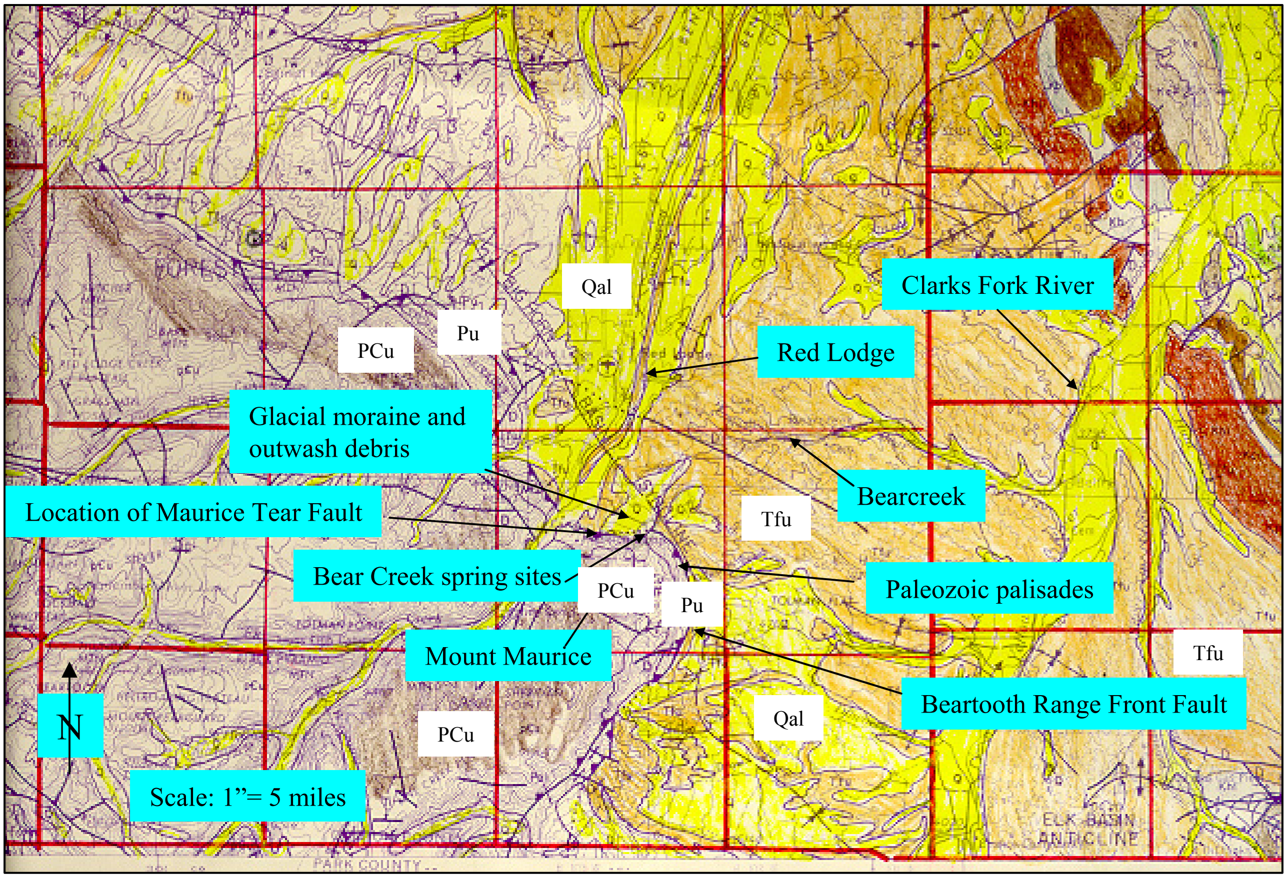


Photo
. Looking south from Highway 308 , 4-miles west of Bearcreek, looking towards spring sites and Beartooth Mountain Front

Appendix C

Map 1. Topographic map of the Bearcreek area (in pocket)
Map 2. Geologic map of the Bearcreek area



Map 2. Geologic map of Bearcreek area showing the trace of the range front thrust fault, location of the Maurice Tear Fault offset (fault not shown), axis of the Bighorn Basin Syncline, extend of the exposed Tertiary Fort Union Formation at the land surface and the Pleistocene glacial moraine and outwash at Bear Creek (IntraSearch, 1978). Geologic formations shown include PCu = Precambrian undifferentiated; Pu = Paleozoic formations undifferentiated; Tfu = Tertiary Fort Union Formation, undifferentiated; Qal = Quaternary alluvium, includes alluvium, colluvium and glacial outwash.