CROW INDIAN TRIBE

Resources Report

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HYDROLOGY

The Crow Tribe is in agreement with the hydrologic descriptions in the Statewide Draft Oil and Gas EIS (pp. 3-11 through 3-22; Hydrological Resources, and Hydrology Appendix, pp. HYD-1 through HYD-25). The following is additional information specific to the Crow Reservation. The structural and stratigraphic relationships as well as the physical and chemical characteristics of geologic formations constitute the geologic framework of the reservation. This framework affects the occurrence, movement, availability and chemical quality of both ground and surface-water resources.

Recharge to the aquifers on the reservation is mainly from infiltration of precipitation and streams on the outcrops. A smaller amount of recharge occurs by subsurface in-flow from outside the reservation, by infiltration from stock ponds and reservoirs where they have been constructed on outcrops, and from leakage across confining beds.

Discharge from aquifers on the reservation is by evapotranspiration in outcrop areas and along the stream valleys, by springs and seeps, and by wells. Discharge also occurs by interformational leakage and by subsurface outflow from aquifers along boundaries of the outcrop area.

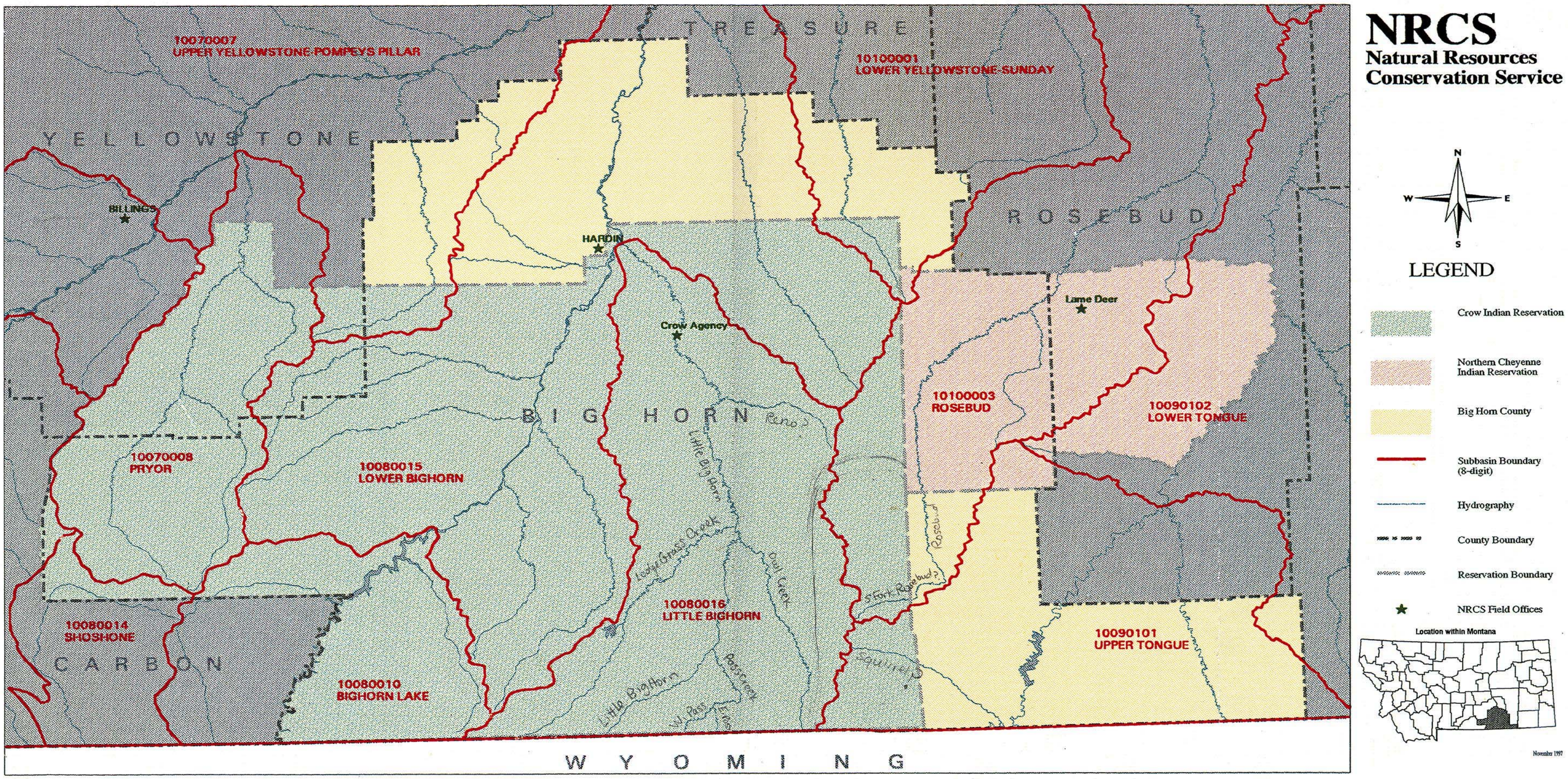
The quality of water or the types and amounts of minerals dissolved in water depend on the chemicals and physical characteristics of the soil and rocks over or through which the water passes, the length of time the water is in contact with the soil and rocks, and other factors such as temperature and pressure.

Surface Water

A high percentage of the annual runoff on the reservation occurs from March through June. Snowmelt, intense rainstorms and saturated or frozen soils are some factors contributing to high runoff during the spring. Severe thunderstorms in the summer months generally result in local flooding. Stream flow decreases from July through early September because precipitation is low and moisture loss from soil and vegetation is high. Surface water is used primarily for stock watering and irrigation, and is considered a valuable cultural resource.

There are three major drainage basins on the Crow Reservation, as shown on *Figure 12* (U.S.G.S. 1981): Lower Bighorn River (U.S.G.S. #10080015); Little Bighorn River (U.S.G.S. #10080016); and Pryor Creek (U.S.G.S. #10070008). The Bighorn River and the Little Bighorn River have their headwaters in Wyoming and flow northward into the Crow Reservation, while Pryor Creek originates on the reservation. The Little Bighorn joins the Bighorn River near Hardin Montana and then flows north off the reservation. Collectively, these drainages are part of the Yellowstone River basin.

There are three additional basins that are partially headwatered on the reservation: Bighorn Lake (U.S.G.S. #10080010); Upper Tongue River (U.S.G.S. #10090101); and Rosebud Creek (U.S.G.S. #10100003). The headwaters of Tullock Creek are also on the reservation. Tullock Creek flows north off the reservation and joins the Bighorn River near Bighorn Montana.



DATA SOURCES:
8-Digit Subbasin boundaries are USGS delineations refined by NRCS. Hydrography is generalized TIGER data.

DISCLAIMER:
This map is to be used as a primary reference source and is not intended for use in site-specific planning. This is public information and may be interpreted by organizations, agencies, units of government, or others based on needs; however, they are responsible for the appropriate application. Federal, State, or local regulatory bodies are not to reassign to the Natural Resources Conservation Service any authority for the decisions they make.

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CROW INDIAN RESERVATION
BIG HORN COUNTY, MONTANA

Figure 12
Hydrologic Basin Map

Report developed by
LAO Environmental
Billings, Montana

Table 10 is a list of the major drainages by hydrologic basin, with their primary and secondary tributaries on the reservation. Also listed are selected yearly flow rate data taken from U.S. Geological Survey gauging stations and the water rights assigned to the Crow Tribe.

Numerous unnamed tributaries and springs are not listed. Additional information on the surface waters of the Crow Reservation is contained in the following document: Inventory of Water Resources, Crow Indian Reservation, Montana, Phase I Water Resource Base (Bureau of Indian Affairs, January 3 1973).

Drainage from the western half of the coal producing area on the reservation flows into the Little Bighorn River. Surface water runoff from the southeastern part of the area eventually reaches the Tongue River. Drainage from the northeastern portion of the area is collected by the Rosebud Creek drainage system.

Numerous tributaries on the reservation are the result of bedrock discharge in the form of a spring. Springs are an important part of the Crow culture. It is critical that development does not adversely affect the springs that are tied to the Tribes' religious or economic practices. Some water sources outside of the reservation may also have spiritual importance. As part of any development on the reservation that might impact this cultural resource, geologic studies as well as baseline flow and water quality studies will need to be conducted to assess potential impact.

Ground Water

The structural and stratigraphic relationships and the physical and chemical characteristics of geologic formations constitute the hydrologic framework of the reservation

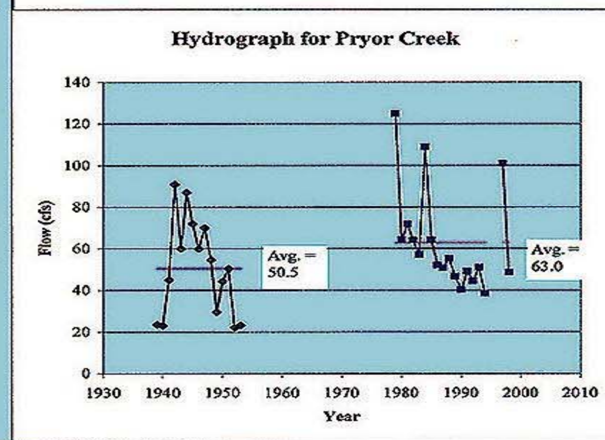
The potential for ground water resources underlies most of the Crow Reservation. The stratigraphy varies from Pre-Cambrian age granitic gneiss and schist in the Big Horn and Pryor Mountains on the west to the Eocene deposits of the Wasatch Formation in the Wolf Mountains and Powder River Basin on the east. The pronounced geologic structures, semi-arid climate, and sculptured terrain lead to highly varied, but often prolific, ground water resources within the reservation. Regional aquifers located on the reservation include the following:

- Alluvial sand and gravel (Holocene)
- Terrace gravel (Pleistocene)
- Clinker deposits (Holocene, Pleistocene, and Pliocene)
- Fort Union Formation (Paleocene)
- Fox hills-hell creek sandstone (Upper Cretaceous)
- Eagle Sandstone (Upper Cretaceous)
- Parkman Sandstone (Upper Cretaceous)
- Pryor Conglomerate (Lower Cretaceous)
- Tensleep Formation (Pennsylvanian)
- Mission Canyon limestone of the Madison Group (Mississippian)
- Jefferson limestone (Ordovician)

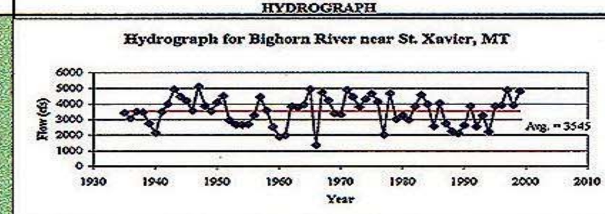
Locally many other water-bearing zones may occur in isolated sandstone and siltstone beds, and in fractured bedrock of any type.

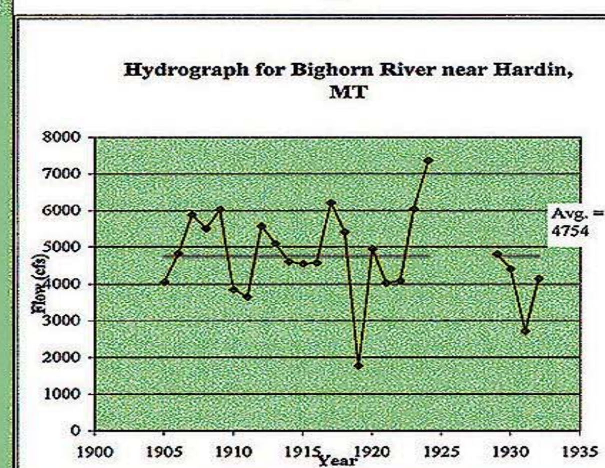
Rivers, Streams, and Tributaries within the Crow Indian Reservation

DRAINAGE BASIN	USGS HYDROLOGIC UNIT CODE	MAJOR TRIBUTARIES	SECONDARY TRIBUTARIES	ALLOTMENTS TO CROW TRIBE (cfs)	USGS STREAM GAGING STATION	STREAM FLOW STATISTICS (cfs)
PRYOR	10070008	Cashen Coulee		All	USGS 06216000 - Pryor Creek at Pryor, MT	1967 - 22.6; 1968 - 24.7; 1969 - 30.2; 1970 - 47.6; 1971 - 38.4; 1972 - 34.3; 1973 - 45.4; 1974 - 31.9; 1975 - 70.3; 1976 - 49.5; 1977 - 35.0; 1978 - 65.3; 1979 - 42.3; 1980 - 28.5; 1981 - 30.7; 1982 - 28.1; 1983 - 27.7; 1984 - 42.8; 1985 - 27.0; 1986 - 24.9; 1987 - 26.4; 1988 - 3-29.9; 1989 - 21.9; 1990 - 19.4; 1991 - 23.5; 1992 - 23.1; 1993 - 24.7; 1994 - 21.9; 1995 - 34.5; 1996 - 27.5; 1997 - 37.0; 1998 - 26.1; 1999 - 22.4; Average Flow - 33.5 cfs
		Summit Creek				
		Bird Creek				
		Lost Creek		59		
		Machete Creek	Willow Creek	4		
		Plum Creek		All	USGS 06216500 - Pryor Creek near Billings, MT and USGS 06216900 - Pryor Creek near Huntley, MT	1939 - 23.6; 1940 - 23.1; 1941 - 45.0; 1942 - 91.1; 1943 - 60.0; 1944 - 87.1; 1945 - 72.0; 1946 - 60.0; 1947 - 70.1; 1948 - 54.6; 1949 - 29.6; 1950 - 44.5; 1951 - 50.6; 1952 - 22.2; 1953 - 23.3; 1979 - 125; 1980 - 64.5; 1981 - 71.9; 1982 - 64.2; 1983 - 57.3; 1984 - 109; 1985 - 64.3; 1986 - 32.0; 1987 - 50.8; 1988 - 55.5; 1989 - 46.7; 1990 - 40.3; 1991 - 49.3; 1992 - 44.4; 1993 - 51.0; 1994 - 38.6; 1997 - 101; 1998 - 48.7; Average Flow - 57.3 cfs
		Smallpox Creek		1		
		Fourth of July Creek				
		Deep Creek	Porcupine Creek	10		
			Middle Creek			
		Mountain Creek		1.25		
		Monument Creek				
		Hay Creek	Cottonwood Creek	10		
		Hamilton Creek		3		
		East Pryor Creek	Shively Creek	35.25		
			Cottonwood Creek			
		Kent Creek & springs		1.58		
		Lincoln Coulee	South Lincoln Coulee	All		
		Vale Creek				
		Birdhead Creek				
		Wets Creek		5.25		
		East Buckeye Creek				
		West Buckeye Creek				
		Smitty Coulee				
		Sue Jane Coulee				
		Badbaby Coulee				
		South Fork Pryor Cr.		2.5		
		East Fork Creek	Flat Creek	All		
			Lone Tree Coulee			
		Alkali Creek				
		Broken Leg Creek				
		Spring Coulee				
	Outflow of Pryor Creek into the Yellowstone River			Total - 450.33		
SHOSHONE	10080014	Sage Creek	North Fork			
BIGHORN LAKE	10080010	Black Canyon Creek				
		Little Bull Elk Creek				
		Big Bull Elk Creek				
		Black Tail Creek				
		Gyp Creek				
		Twenty Mile Creek				
		Bobcat Creek				
		Porcupine Creek	Willow Creek			
			North Fork Trout Creek			
			Trout Creek			
		Dry Head Creek	Whoodoo Creek	14.75		
			Pitchfork Creek			
			Spring Creek			
			Flat Creek			
			East Fork Dry Head Creek			
			Clabber Creek			
			Punch Bowl Creek			
			Red Spring Creek			

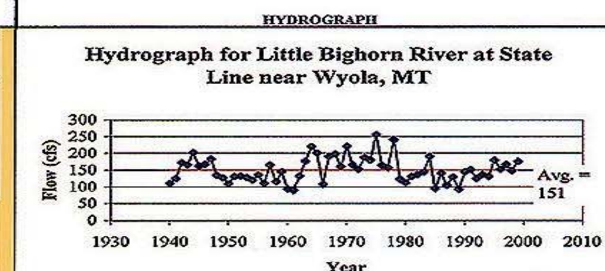


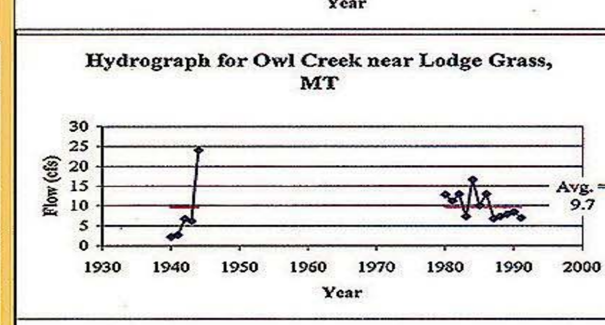
DRAINAGE BASIN	USGS HYDROLOGIC UNIT CODE	MAJOR TRIBUTARIES	SECONDARY TRIBUTARIES	ALLOTMENTS TO CROW TRIBE (cfs)	USGS STREAM GAGING STATION	STREAM FLOW STATISTICS (cfs)
LOWER BIGHORN	10080015	Bighorn River (at outflow from dam)		86,449.88	06287000 - Bighorn River near St. Xavier, MT	1935 - 3426; 1936 - 3054; 1937 - 3508; 1938 - 3466; 1939 - 2743; 1940 - 2146; 1941 - 3502; 1942 - 3996; 1943 - 4940; 1944 - 4449; 1945 - 4209; 1946 - 3572; 1947 - 5114; 1948 - 3896; 1949 - 3544; 1950 - 4092; 1951 - 4516; 1952 - 2936; 1953 - 2664; 1954 - 2653; 1955 - 2701; 1956 - 3265; 1957 - 4432; 1958 - 3597; 1959 - 2520; 1960 - 1886; 1961 - 1983; 1962 - 3846; 1963 - 3764; 1964 - 3953; 1965 - 4934; 1966 - 1351; 1967 - 4723; 1968 - 4203; 1969 - 3381; 1970 - 3316; 1971 - 4904; 1972 - 4445; 1973 - 3826; 1974 - 4304; 1975 - 4654; 1976 - 4127; 1977 - 2023; 1978 - 4663; 1979 - 3018; 1980 - 3259; 1981 - 2963; 1982 - 3831; 1983 - 4582; 1984 - 3987; 1985 - 2550; 1986 - 4039; 1987 - 2735; 1988 - 2244; 1989 - 2110; 1990 - 2610; 1991 - 3852; 1992 - 2538; 1993 - 3245; 1994 - 2212; 1995 - 3867; 1996 - 3909; 1997 - 4908; 1998 - 3916; 1999 - 4801; Average Flow - 3545 cfs
		Grape Vine Creek	Grape Vine Forks: North & South	76.5		
		Gold Springs		0.5		
		Lime Kiln Creek		7.75		
		War Man Creek		2.5		
		Whitman Coulee		17.5		
		Mountain Pocket Creek				
		Soap Creek	Dry Soap Creek	133.62		
			Deer Creek			
			West Soap Creek	4		
			South Fork Soap Creek			
		Hay Coulee	South Fork			
		Rotten Grass Creek	a spring draw	7.5	06288500 - Bighorn River near Hardin, MT	1905 - 4052; 1906 - 4824; 1907 - 5884; 1908 - 5511; 1909 - 6027; 1910 - 3836; 1911 - 3656; 1912 - 5570; 1913 - 5096; 1914 - 4604; 1915 - 4544; 1916 - 4573; 1917 - 6211; 1918 - 5413; 1919 - 1769; 1920 - 4957; 1921 - 4024; 1922 - 4081; 1923 - 6045; 1924 - 7363; 1929 - 4804; 1930 - 4404; 1931 - 2708; 1932 - 4143; Average Flow - 4754 cfs
			Packs the Hat Creek	81.75		
			Beaver Creek			
		Beauvais Creek	Push Creek	20		
			Scott Creek			
			Buster Creek	2		
			West Fork Buster Creek			
			Middle Fork Buster Creek	3		
			East Fork Buster Creek			
			Point Creek			
			Mott Creek			
			Muddy Creek	11		
			North Fork Beauvais Creek	5		
			South Fork Beauvais Creek	5		
		Spring Creek		5.05		
		Woody Creek	Big Woody & Little Woody Creeks			
		Two Leggins Creek	North, Middle, and South Forks			
		Pertisa Creek				
		Little Bighorn River				
		Dry Creek	Little Dry Creek			
		Tullock Creek	Blue Creek			
			Dipping Vat Creek			
			Willow Creek			
			Middle Fork Tullock Creek			
			Ash Creek			
			East Fork Tullock Creek	0.62		
			Dawes Creek			
			Spring Coulee	All		
			Williams Creek	68.75		
	Outflow of lower Bighorn River leaving the Crow Reservation			Total - 86,916.05		
UPPER TONGUE	10090101	Spring Creek	South Fork Spring Creek			
		Squirrel Creek	North Fork Squirrel Creek	10		
		Tanner Creek				
		Youngs Creek	Little Youngs Creek	6.75		
		Ash Creek				
ROSEBUD	10090102	North Fork Rosebud		50		
		South Fork Rosebud		2		
		Indian Creek	North Fork			
		Spring Creek		7.75		
		Cache Creek				
		Corral Creek		11.9		
		Dry Creek				
		Thompson Creek	North Fork Thompson Creek	2.25		
			Little Thompson Creek	265		
		Davis Creek	Middle Fork Davis Creek			
	Rosebud Creek tributaries leaving the Crow Reservation			Total - 338.65		
UPPER YELLOWSTONE: POMPEYS PILLAR	10070007	Yellowstone River	Fly Creek			





DRAINAGE BASIN	USGS HYDROLOGIC UNIT CODE	MAJOR TRIBUTARIES	SECONDARY TRIBUTARIES	ALLOTMENTS TO CROW TRIBE (cfs)	USGS STREAM GAGING STATION	STREAM FLOW STATISTICS (cfs)
LITTLE BIGHORN	10080016	Little Big Horn River		1161.116	USGS 06289000 - Little Bighorn River at State Line near Wyola, MT	1940 - 110; 1941 - 125; 1942 - 172; 1943 - 166; 1944 - 202; 1945 - 163; 1946 - 167; 1947 - 183; 1948 - 135; 1949 - 128; 1950 - 109; 1951 - 132; 1952 - 133; 1953 - 129; 1954 - 121; 1955 - 136; 1956 - 110; 1957 - 165; 1958 - 116; 1959 - 146; 1960 - 94.6; 1961 - 90.5; 1962 - 133; 1963 - 177; 1964 - 221; 1965 - 201; 1966 - 108; 1967 - 191; 1968 - 198; 1969 - 161; 1970 - 222; 1971 - 166; 1972 - 153; 1973 - 187; 1974 - 180; 1975 - 256; 1976 - 165; 1977 - 158; 1978 - 241; 1979 - 123; 1980 - 113; 1981 - 132; 1982 - 137; 1983 - 145; 1984 - 191; 1985 - 95; 1986 - 141; 1987 - 105; 1988 - 130; 1989 - 93; 1990 - 146; 1991 - 152; 1992 - 125; 1993 - 137; 1994 - 132; 1995 - 180; 1996 - 153; 1997 - 167; 1998 - 149; 1999 - 176; Average Flow - 151 cfs
		Eskimo Creek				
		Edge Creek				
		Sport Creek				
		Crazy Creek				
		Pass Creek	Gay Creek	3.75		
			West Pass Creek	13.5		
			East Pass Creek	42 / 5		
			Twin Creek	10		
			Wyola Creek			
			Spring Water Slough	0.85		
		Buffalo Creek				
		Halfway Creek				
		White Man Runs Him Creek				
		Alkali Creek		1.5		
		Alligator Creek		2.5		
		John Bozeman Creek-		1.5		
		Brush Coulee		All		
		Owl Creek	Coal Creek		USGS 06291000 - Owl Creek Near Lodge Grass, MT	1940 - 2.25; 1941 - 2.67; 1942 - 6.82; 1943 - 6.28; 1944 - 24.0; 1980 - 12.9; 1981 - 11.3; 1982 - 13.0; 1983 - 7.44; 1984 - 16.6; 1985 - 10.1; 1986 - 13.1; 1987 - 6.85; 1988 - 7.44; 1989 - 7.95; 1990 - 8.47; 1991 - 7.05; Average Flow - 9.7 cfs
			Line Rider Creek			
			Sheep Creek			
			Corral Creek			
			Wolf Creek			
			Big Pine Creek			
			Little Bear Creek	50		
			Bear Creek	30		
			Spring Creek	2		
			Middle Pine Creek	45.3		
			Lone Pine Creek			
			Little Beaver Creek			
			Dry Beaver Creek	8		
			Little Owl Creek	18.37		
			Glenn Creek	2.5		
			Kid Creek	12		
			Sioux Pass Creek			
			North Fork			
			Bartz Creek	3.85		
			Vanoe Creek	4		
		Grey Blanket Creek		6.75	USGS 06294000 - Little Bighorn River near Hardin, MT	1954 - 144; 1955 - 222; 1956 - 172; 1957 - 324; 1958 - 156; 1959 - 230; 1960 - 122; 1961 - 73.6; 1962 - 193; 1963 - 334; 1964 - 438; 1965 - 438; 1966 - 163; 1967 - 336; 1968 - 431; 1969 - 363; 1970 - 531; 1971 - 396; 1972 - 354; 1973 - 417; 1974 - 354; 1975 - 677; 1976 - 341; 1977 - 307; 1978 - 647; 1979 - 328; 1980 - 209; 1981 - 223; 1982 - 244; 1983 - 221; 1984 - 396; 1985 - 167; 1986 - 279; 1987 - 181; 1988 - 189; 1989 - 166; 1990 - 212; 1991 - 242; 1992 - 195; 1993 - 247; 1994 - 246; 1995 - 330; 1996 - 258; 1997 - 355; 1998 - 216; 1999 - 286; Average Flow = 290 cfs
		Lodge Grass Creek	Buck Creek			
			Percheron Creek	22.3		
			Spring Creek	10		
			Dick Creek			
			Stovie Creek	234.395		
			Willow Creek	13.5		
			Lodge Grass Storage Reservoir			
			Johnny Creek			
			Good Luck Creek	7		
		Unnamed coulees		All		
		Sunday Creek				
		Slaughter Creek				
		Shavings Creek		0.87		
		Spring Creek		7.25		
		Sand Creek	Sand Creek Forks: North & South			
		Nest Creek				
		Otter Creek				
		Mud Springs Creek				
		Bear in Middle Creek				
		Reno Creek	North Fork Reno Creek	7.5		
			South Fork Reno Creek	4.55		
		Shoulder Blade Creek	Onion Creek			
			South Fork Squaw Creek	All		
			South Fork Creek			
		Custer Creek				
	Outflow of Little Bighorn River into the lower Bighorn River			Total - 1732.97		





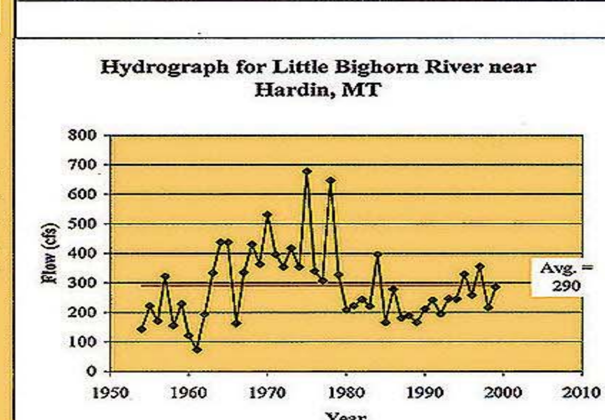


Table 10
Rivers, Streams, and Tributaries within the Crow Indian Reservation

Tables 9A and 9B are the geologic section for the reservation along with the aquifer potential of each formation. *Figure 13* is a map depicting the various potential flow rates expected across the reservation.

Table 11 is a list of the ground water wells in Big Horn County that were listed with the Montana Bureau of Mines and Geology database as of March 20, 2002.

A total of 2,237 wells have been registered with the bureau. The majority of the wells are producing at depths less than 200 feet below ground surface (bgs) and only 30 wells have been drilled deeper than 700 feet bgs. The majority of the wells are used for stock water, irrigation and domestic consumption. *Figure 14* shows locations of water wells and springs on the reservation, and *Figure 14A* shows water and coal bed methane wells in and near the eastern part of the reservation.

Water Quality

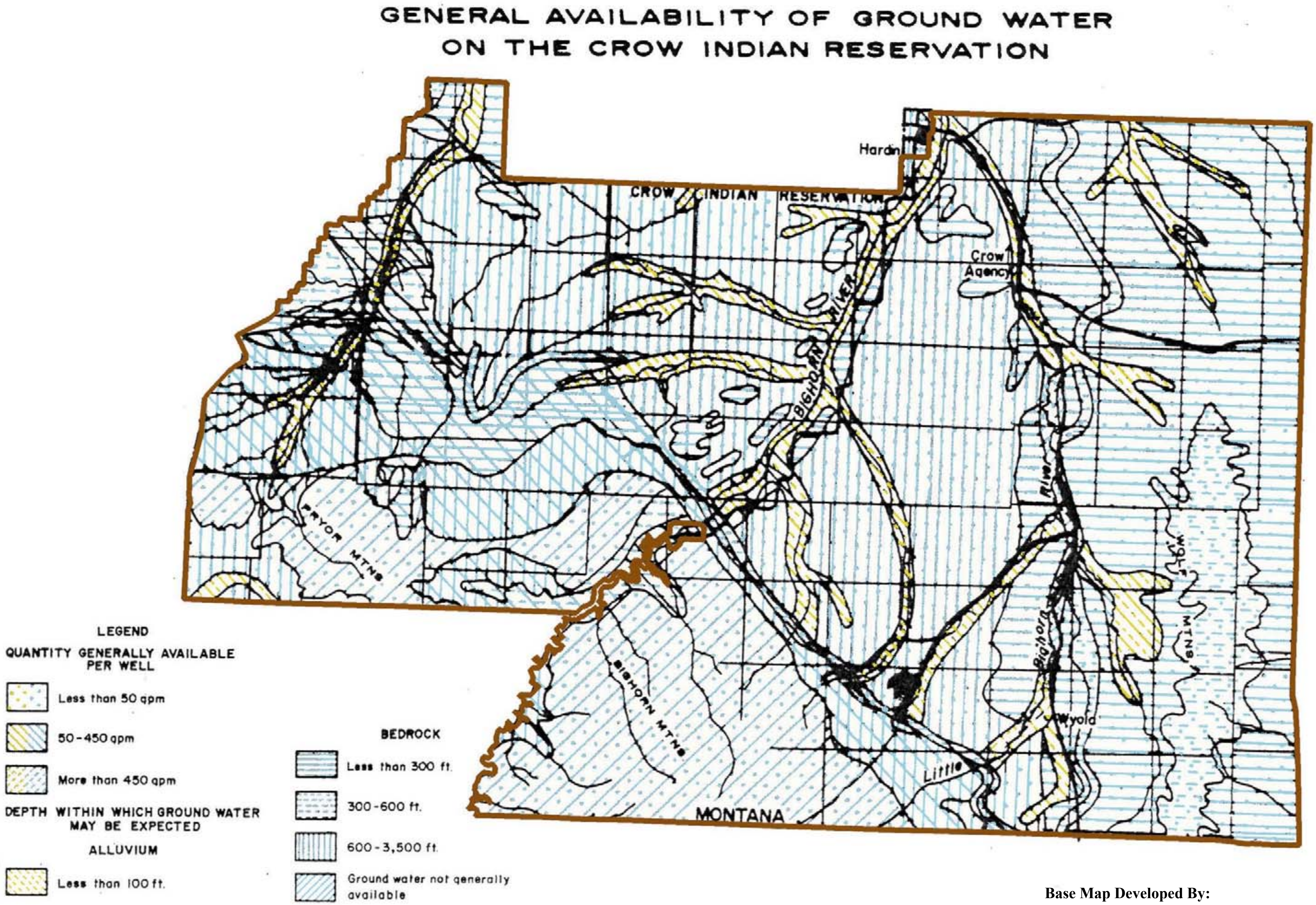
Water quality in the rivers and streams on the reservation is generally good. Pollution problems are primarily non-point source and are related to agricultural practices. High sediment and salinity are the two most common forms of pollution. The BIA and the BLM are also concerned about water quality in man-made reservoirs, which range from small livestock ponds to large irrigation, flood control, and wildlife reservoirs.

Most streams experience an increase in dissolved solid concentrations downstream because of irrigation return flow, increased base flow contributions, and pollution from human activities. Water contributed as base flow water has been in contact with soil and rocks for long periods of time. It therefore contains larger concentrations of dissolved solids than surface runoff water.

Surface water quality in the Little Bighorn River basin is affected by high quality Big Horn Mountain snowmelt, surface- and ground-water inflow, and irrigation in Montana. As in most semi-arid areas, the concentration of dissolved materials in effluent streams generally increases with distance downstream. The total sediment load is large, ranging between 158 and 16,200 tons/day for the Little Bighorn below Pass Creek. Other than its high suspended sediment concentrations, water in the Little Bighorn River can be characterized as very good water that is suitable for most uses. A two-page table in the referenced document shows the average concentrations for selected water quality parameters for the Little Bighorn River and ten creeks (BIA 1983).

Snowmelt, ground- and surface-water inflow, geology, and irrigation affect water quality in the creeks draining into the Tongue River. The chemical quality of these creeks is suitable for most uses, although the high hardness and alkalinity values might require treatment for some industrial uses. Again, water quality in these creeks degrades with increasing distance downstream. Based on an analysis for the referenced document, water in Squirrel Creek failed to meet the Secondary Drinking Water Standards for Total Dissolved Solids (TDS, BIA 1983).

Surface-and ground-water inflows as well as evaporation, degrade water quality in Rosebud Creek. The chemical quality data of Rosebud Creek as well as some of its tributaries are shown in a table in the referenced document.



Base Map Developed By:
RMR for Crow Tribe Resource Development and Land Use Plans

Figure 13
Ground Water

Report developed by
LAO Environmental
Billings, Montana

Table 11
List of Water Wells in
Bighorn County

Quick Stats for BIG HORN county

Number of wells in county	2352
Oldest well on record	01/01/1897
Most recent well on record	01/17/2002
Shallowest well on record (feet)	25.00
Deepest well on record (feet)	960.00
Number of flowing wells	38
Number of Statewide Montoring Network wells	9
Number of water quality samples on wells	791

The table below shows the breakdown of **2352** wells in BIG HORN county reported in intervals of ten years starting in 1860.

Years	# of
1860 - 1869	0
1870 - 1879	0
1880 - 1889	0
1890 - 1899	2
1900 - 1909	6
1910 - 1919	40
1920 - 1929	44
1930 - 1939	66
1940 - 1949	144
1950 - 1959	171
1960 - 1969	159
1970 - 1979	536
1980 - 1989	392
1990 - 1999	359
2000 - 2002	56
* Total	1975

* Number may differ from county total if not all wells have a reported **date of drilling**.

The table below shows the number of wells that fall between the depth ranges in the left hand column. All depths are listed in feet below ground surface

Depth (ft)	# of
0 - 49	843
50 - 99	464
100 - 149	282
150 - 199	209
200 - 249	137
250 - 299	79
300 - 399	126
400 - 499	41
500 - 599	7
600 - 699	11
700 - 799	1
800 - 899	0
900 - 999	2
1000 - 1099	4
1100 - 1199	3
1200 - 1299	1
1300 - 1399	0
1400 - 1499	1
1500 - 1599	0
1600 - 1699	3
1700 - 1799	2
1800 - 1899	2
1900 - 1999	1
2000 +	18
* Total	2237

* Number may differ from county total if not all wells have a reported **total depth**.

The table below shows the number of each type of water use has been reported for wells in this county.

Well Use	# of
Coal Bed Methane	0
Commercial	8
Domestic	770
Fire Protection	0
Geotech	0
Industrial	28
Injection	0
Institutional	0
Irrigation	102
Medical	0
Monitoring	240
Other	34
Public Water	35
Recreation	1
Research	218
Stockwater	927
Test Well	41
Unknown	199
Unused	69
Waterflood	0
Wildlife	0
* Total	2672

* Number may differ from county since one well may have several reported **water uses**.

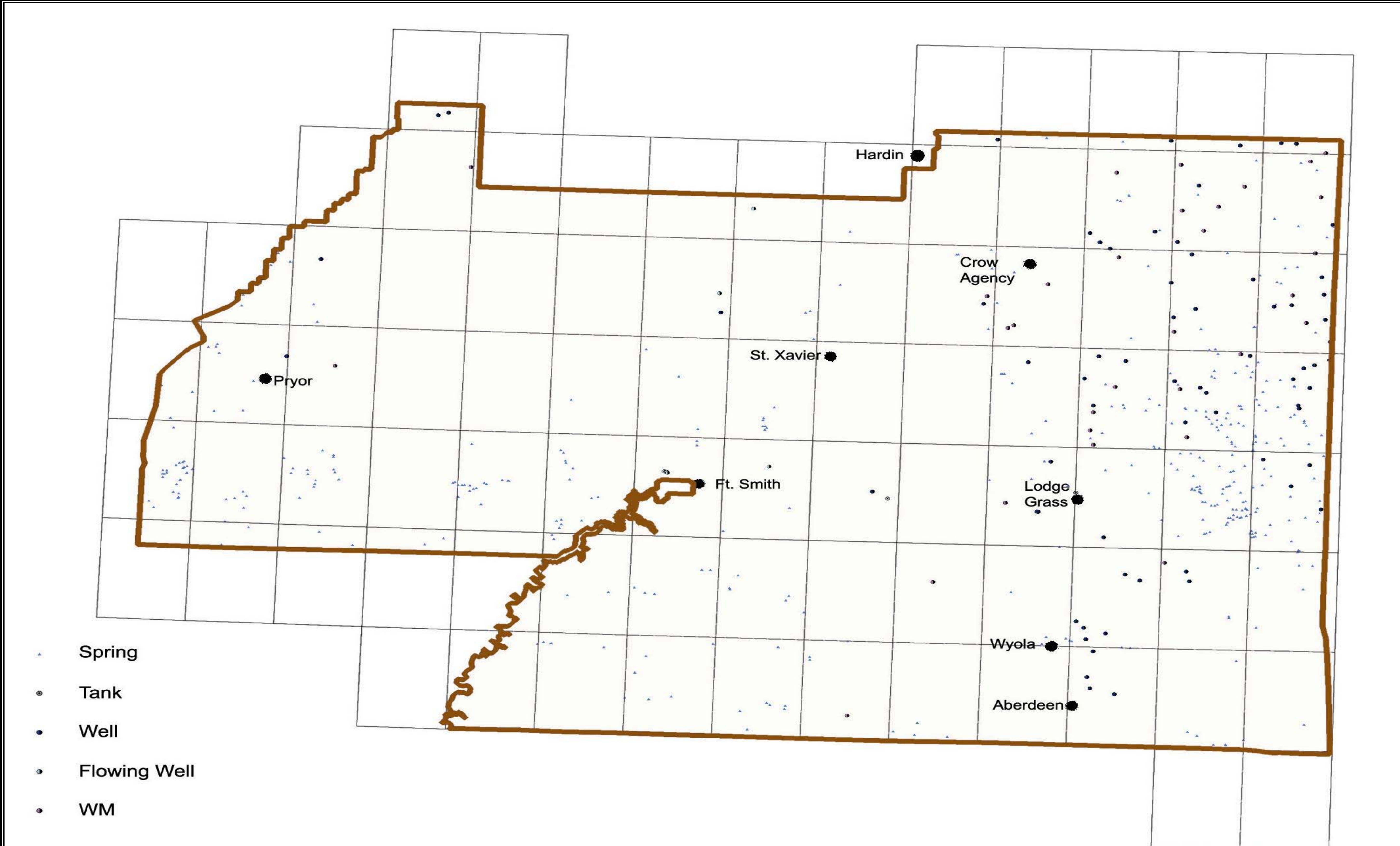


Figure 14
Water Wells and Springs

Report developed by
LAO Environmental
Billings, Montana

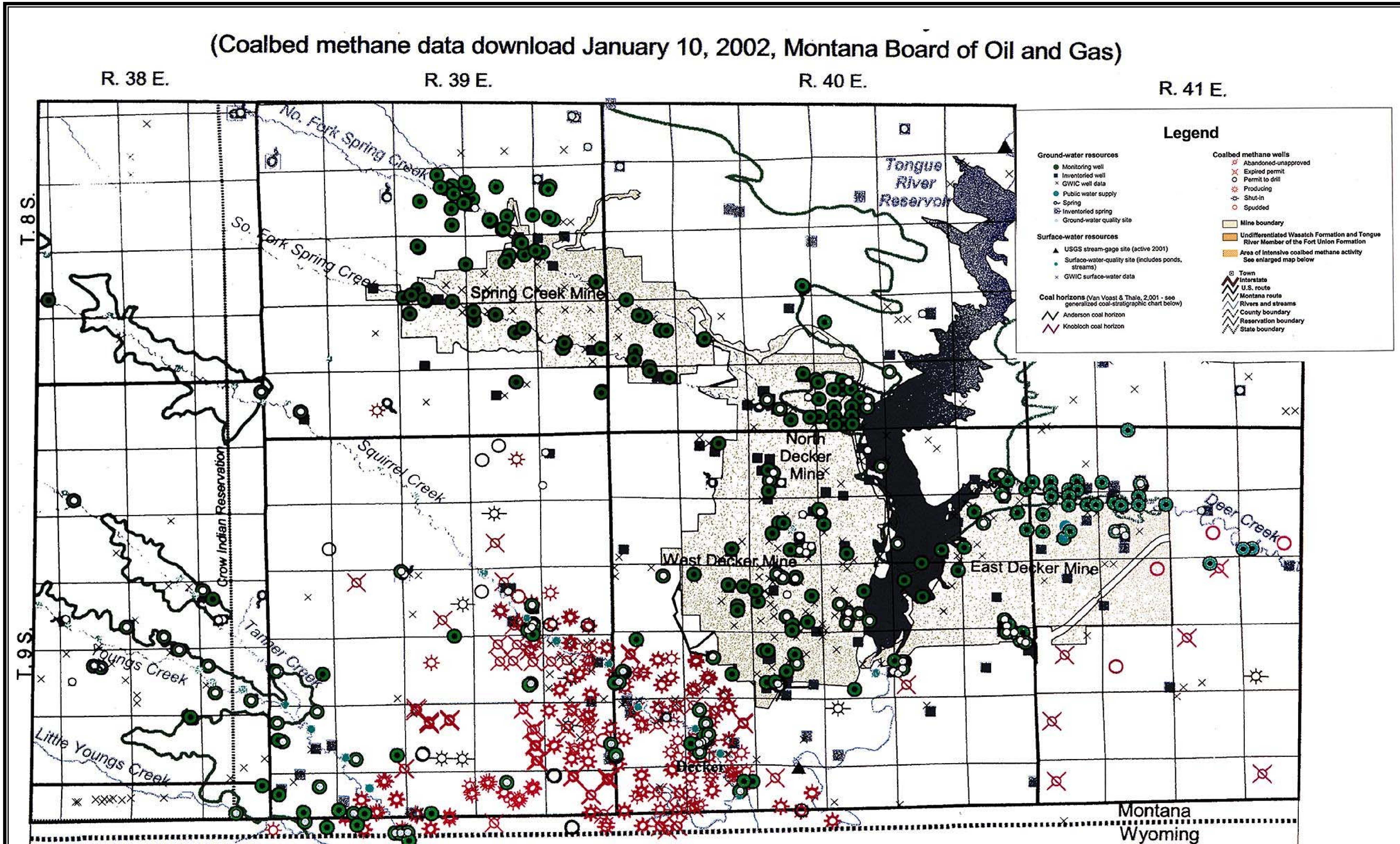


Figure 14A
Water and Coal Bed Methane Wells On and Near the Eastern Parts of the Crow Reservation

Report developed by
LAO Environmental
Billings, Montana

The chemical quality of these waters is suitable for most uses, although EPA's Secondary Drinking Water Standards for Total Dissolved Solids and sulfate are frequently exceeded in some of these creeks. Rosebud Creek also carries a large sediment load (BIA 1983).

In recharge areas where bedrock is highly weathered, oxidizing conditions generate large amounts of salts readily available for dissolution by percolating ground water. As ground water moves away from sources of soluble salts, cation-exchange processes modify the relative proportions of dissolve ions. Sodic clays, abundant in the Fort Union Formation, absorb the divalent calcium and magnesium ions on their surfaces and release monovalent sodium ions to the water through cation exchange.

The Sodium Absorption Ratio (SAR), which is the ratio of sodium to the square root of calcium plus magnesium, of the resulting waters exceeds 50 in some locations.

$$SAR = \frac{Na}{\sqrt{\frac{Ca + Mg}{2}}}$$

Deep reducing conditions in the coals promote sulfate reduction and production of bicarbonate, such that the dominate anion is bicarbonate. These processes cause coal bed waters to be sodium-bicarbonate dominated. The dissolved-solids concentration (salinity) of this water remains relatively high throughout this process (Van Voast and Reiten 1988).

These high SAR. Bicarbonate, and salinity of produced coal bed waters are the major water quality issues regarding the development of coal bed methane, both on and off the reservation. High SAR irrigation waters will cause soils with high clay content to loose their structure and become impermeable. High bicarbonate can be toxic to plants and animals. High salinity can cause significant reduction in crop yields, or limit the variety of crops that can be grown.

The Montana Bureau of Mines and Geology conducted a water quality study (Miller et al. 1977) in the Fort Union out crop area of southeastern Montana. The Yellowstone-Tongue A.P.O. Water Quality Project and the State of Montana HJR54 and HB705 funded the study. The Crow Reservation was divided into four study areas (Hardin 3, 4, 5, and 6). *Table 12* is a summary of the ground water quality regarding SAR and TDS on the reservation.

The Crow Tribe currently is working on establishing water quality standards and developing a ground water and surface water-monitoring plan. Until the U.S. Environmental Protection Agency adopts such standards, federal and state of Montana water quality regulations are applicable to tribal waters.

TABLE 12
Ground Water Sodium Absorption Ratio and Total Dissolved Solids Values
Crow Indian Reservation

Study Area	Formation	# Wells	Avg. SAR	SAR Range	Avg. TDS	TDS Range
Hardin 3 (NE)	Fort Union	22/2 36	4.7/43	55 – 0.4	 1,794	 405 – 4,672
	Quaternary	16	4.36	32 – 0.1	1,487	184 – 3,920
	Judith River	1		0.7		405
Hardin 4 (NW)	Quaternary	15	7.3	15 – 1	2,859	6,570 – 724
	Unknown	9	9	47 – 0.1	2,223	4,770 – 606
	Pre Judith River	2		0.5 – 0.4		3,170 – 2790
Hardin 5 (SW)	Quaternary	6	4	7 – 2	2,871	806 – 5,850
	Unknown	1		12		614
	Pre Judith River	2		52 – 0.4		4,990 – 2,065
Hardin 6 (SE)	Quaternary	14	1.9	11 – 0.7	1,318	7,720 – 400
	Judith River	3	54	64 – 47	1,107	1180 – 1,000
	Pre Judith River	3	50	82 - 23	3,126	8,060 – 452

Miller et al. 1977
SAR is sodium absorption ratio
TDS is total dissolved solids
Avg. is average