Pressure Head Fluctuations of the Fox Hills-Hell Creek Aquifer in McKenzie County, North Dakota

PHOTO BY MERLYN SKALEY

By
Rex P. Honeyman
Hydrologist

Water Resources Investigation No. 43
North Dakota State Water Commission
2007

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North Dakota State Water Commission
Office Memo

To: Project File #1442
From: Rex Honeyman, Hydrologist
Subject: Pressure Head Fluctuations of the Fox Hills-Hell Creek Aquifer in McKenzie County, North Dakota
Date: May 30, 2007

Introduction:

Under North Dakota Century Code §61-20-06, the State Engineer is responsible for monitoring decline, fluctuations, and permanence of artesian flowing aquifers. Once each decade the State Engineer selects representative wells to monitor the overall pressure head change and water quality of the Fox Hills-Hell Creek aquifer in western North Dakota. The results are published in three reports. One report compiles the pressure head results from wells in Billings, Golden Valley, and Slope Counties, a second report compiles the pressure head results from wells in the Knife River Basin in Oliver, Mercer, and Dunn Counties and a third report which is covered in this document compiles the pressure head results from wells within McKenzie County (Figure 1).

The purpose of the above listed studies is to promote conservation of water supplies and in doing so slow the decline in pressure head in the Fox Hills-Hell Creek aquifer, which is a valuable resource in western North Dakota. Many stockman, domestic users, municipalities and industrial users depend on the Fox Hills-Hell Creek aquifer for their water supply. Municipal water use from the aquifer has steadily declined throughout the 1990s and into the new millennium due to the advent of the Southwest Pipeline which is continually supplying more and more water users with Lake Sakakawea water (Figure 2). Industrial water use from the Fox Hills-Hell Creek aquifer fluctuates throughout the historical record (Figure 2). This fluctuation can be attributed to fluctuation in oil activity in western North Dakota, which uses fresh water for desalinization in oil wells.

The aquifer is referred to as the Fox Hills-Hell Creek aquifer, because it straddles the boundary between the marine Fox Hills Formation and the overlying

Figure 1 -- Location of study area

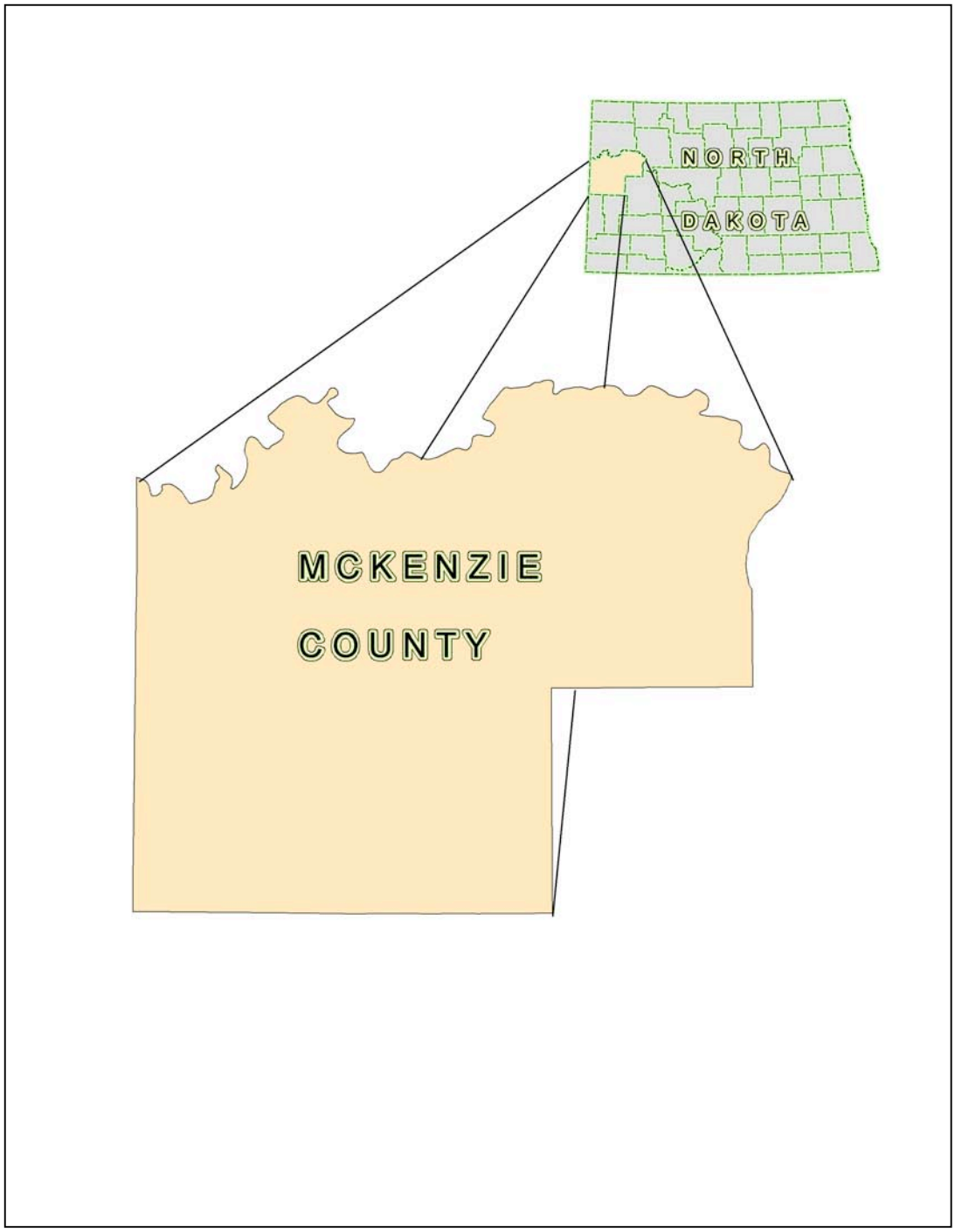
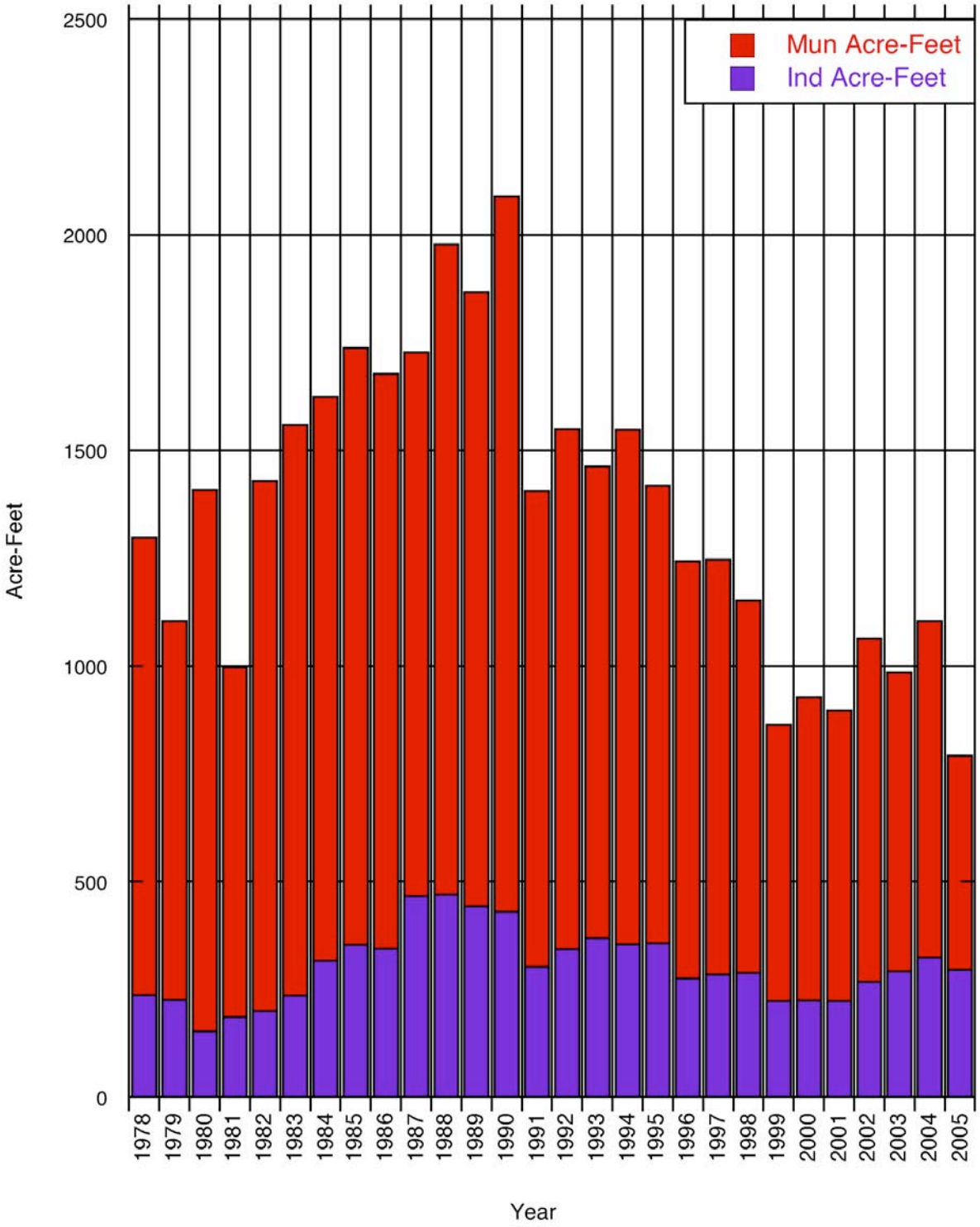


Figure 2 -- Total reported water use from the Fox Hills aquifer for municipal and industrial purposes in North Dakota



non-marine Hell Creek Formation. It was formed from sand deposits on beaches and river deltas along a sea receding to the east. The offshore deposits, with occasional marine fossils, are included in the Fox Hills Formation, while the back-beach and river flood plain landform deposits are included in the Hell Creek Formation. The somewhat unwieldy long name is often shortened to the Fox Hills aquifer. This report will refer to the Fox Hills-Hell Creek aquifer as the Fox Hills aquifer. Any references made to the Hell Creek aquifer throughout this report is referring to the middle or upper Hell Creek Formation. The pressure head of the Hell Creek aquifer is typically much less than what is measured in deeper portions of the Hell Creek Formation that is hydraulically connected to the Fox Hills aquifer.

The Fox Hills Formation underlies the western half of North Dakota as illustrated in Figure 3. Recharge to the aquifer likely occurs in areas where the Fox Hills Formation is at or near the surface in southwestern North Dakota, northwestern South Dakota, southeastern Montana, and northeastern Wyoming (Figure 3). Well depths in the Fox Hills aquifer range from just below land surface in southwestern North Dakota to over 2,000 feet below land surface in northeastern Billings County, southeastern McKenzie County, and western Stark County (Figure 4).

The pressure heads (water levels above the top of the aquifer) in the Fox Hills aquifer decline when the discharge is greater than the recharge. Recharge to the Fox Hills aquifer is very small and is easily exceeded by the discharge, which occurs mainly in the form of withdrawal of water from wells.

In May of 2006, 14 flowing domestic and stock wells from the Fox Hills aquifer were monitored within McKenzie County. The locations of these wells are illustrated in Figure 5. Pressure head measurements and water quality analysis were made on 13 of the 14 wells. A pressure head measurement was not collected from stock well 150-104-14BCA, because of the fragile appearance of the well. However, a water quality sample was collected. Domestic well 150-104-04AAB, was measured for pressure head, but a water quality sample was not collected.

Figure 3 -- Extent of the Fox Hills Formation in North Dakota

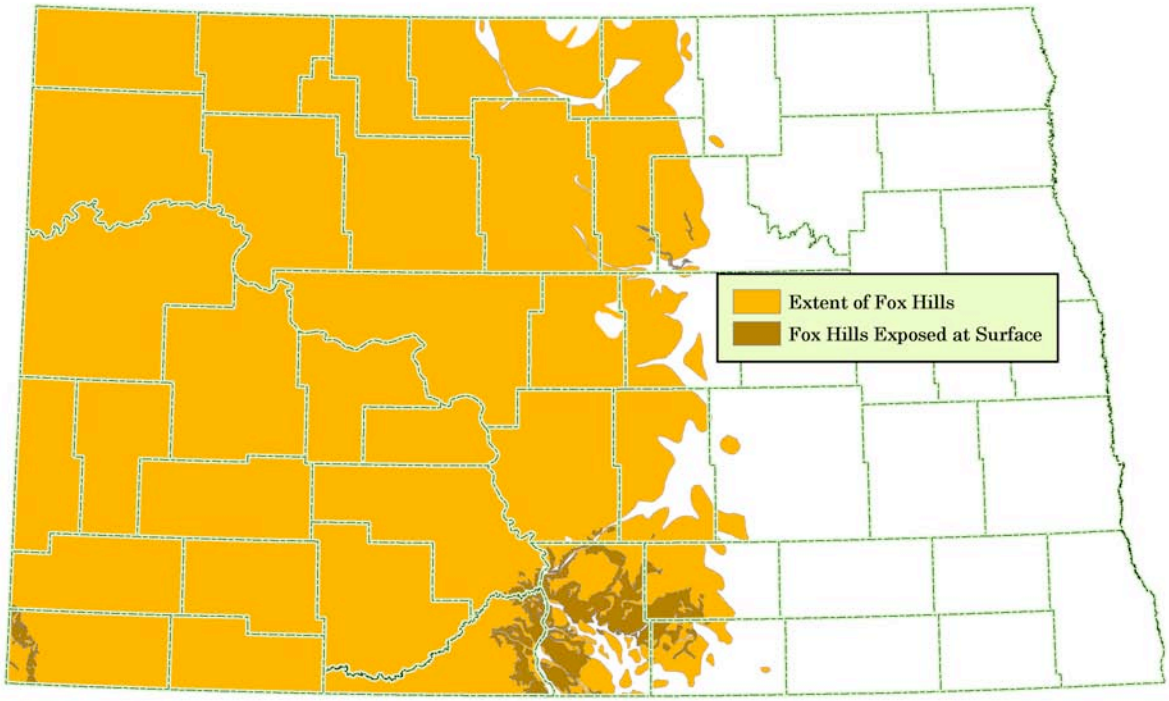


Figure 4 -- Average well depth of the Fox Hills aquifer based on screened intervals of 356 Fox Hills wells in North Dakota

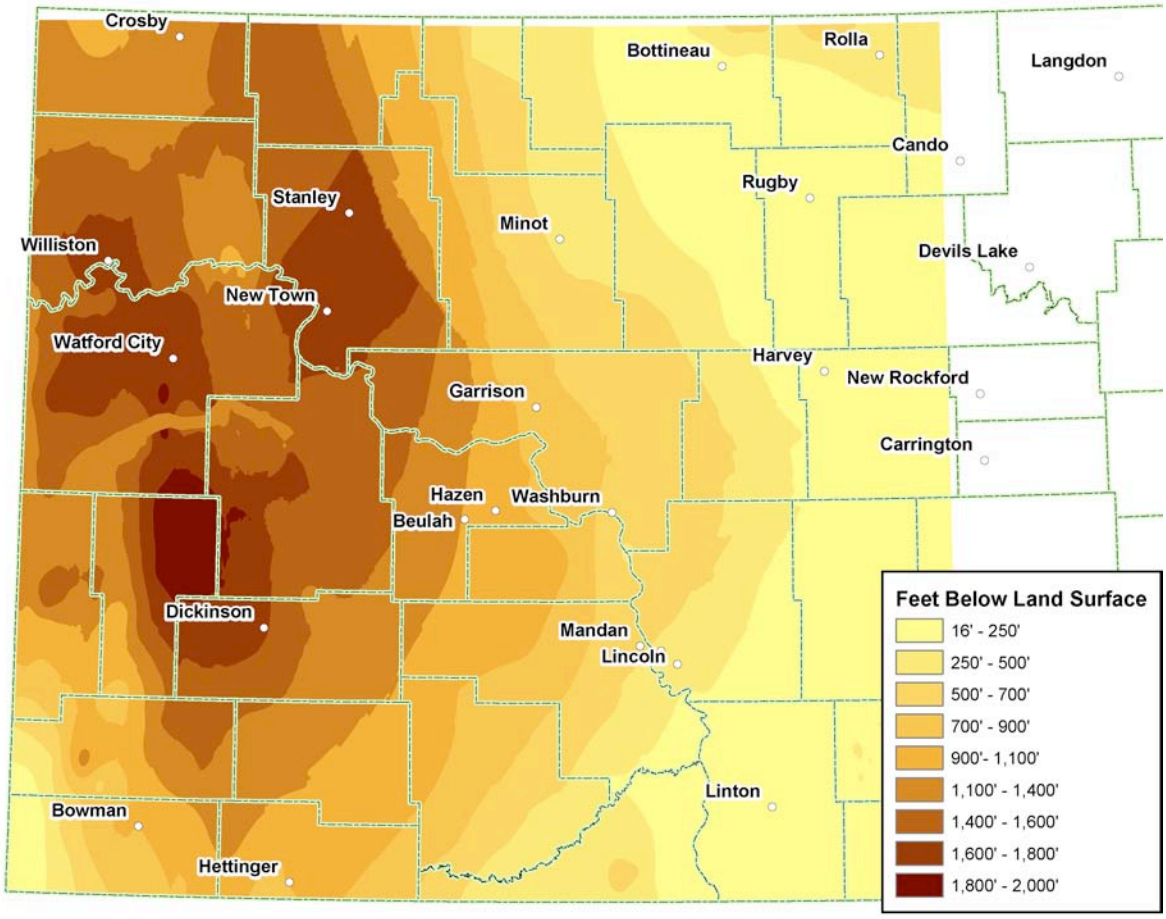
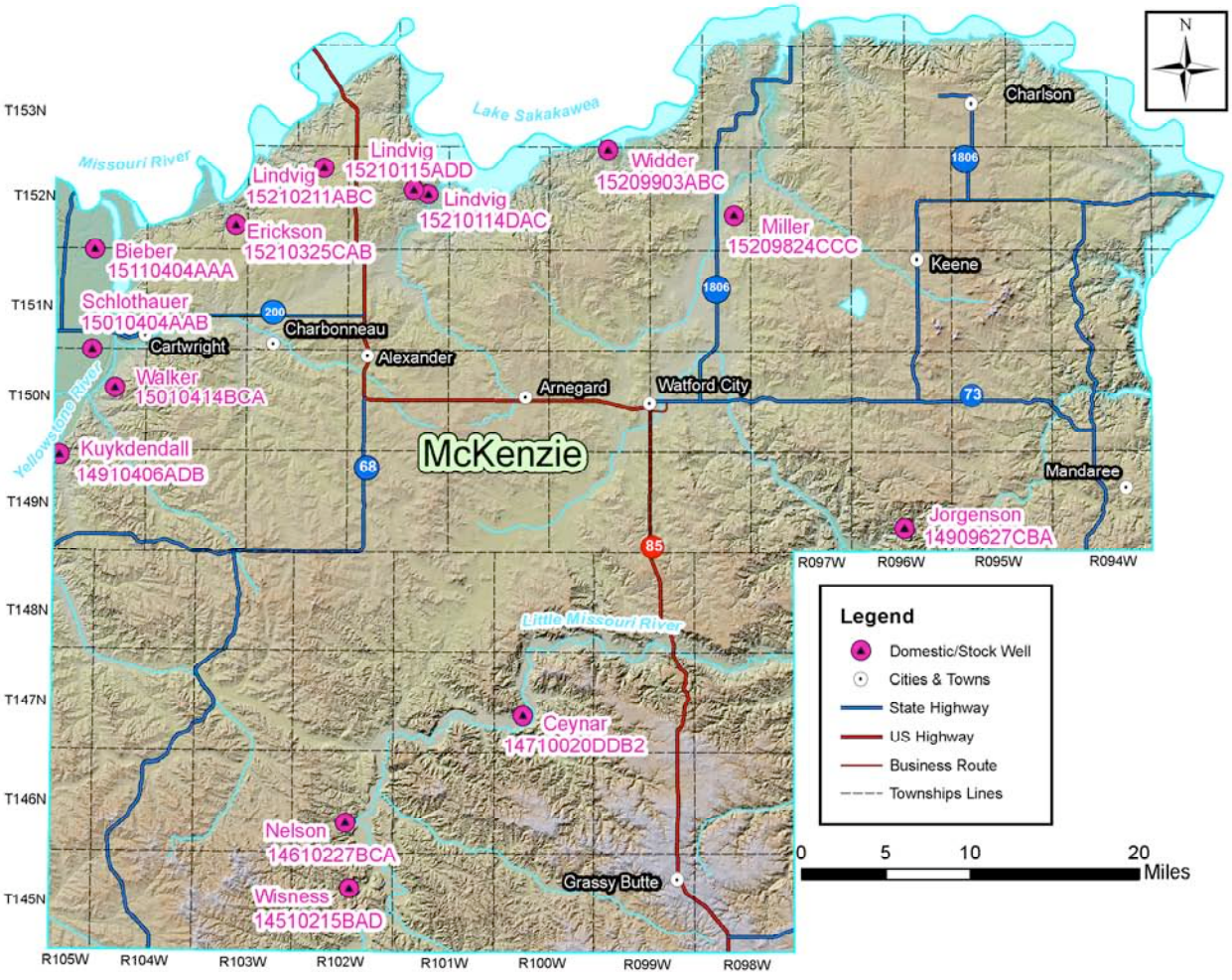


Figure 5 -- Domestic and livestock wells monitored in 2006 - well owners and well names



The pressure head measurements were made to continue monitoring the rate of pressure head decline in the Fox Hills aquifer in an area where flowing wells discharge water from the aquifer. Many of the wells have been monitored since the late 1970s to early 1980s. The 14 stock and domestic wells monitored in 2006 were also monitored in 1984-1985 and in 1995. The wells are located in low-lying areas along the valleys of the Little Missouri River, Yellowstone River, Missouri River, Lake Sakakawea, and their tributaries. The pressure head of the aquifer is higher than the land surface elevation within these low-lying areas allowing the wells to flow. Pressure head in 8 Fox Hills and 2 Hell-Creek observation wells are measured annually and have been included in Figure 6 and 7.

Well information:

For each well visited the following information was compiled and included in the appendix of this report:

- Date the well was completed
- Land surface elevation
- Depth drilled
- Screened interval
- Purpose of well
- Casing diameter and material
- Source of information
- Well owner
- Owner's address
- Well location (a detailed description to aid in finding the well)
- Any available well completion information
- Description of the above ground portion of the well
- 2006 well discharge, or flow rate
- Description of pressure head recovery following well shut in
- Remarks

Figure 6 -- 2006 potentiometric surface map of the Fox Hills aquifer

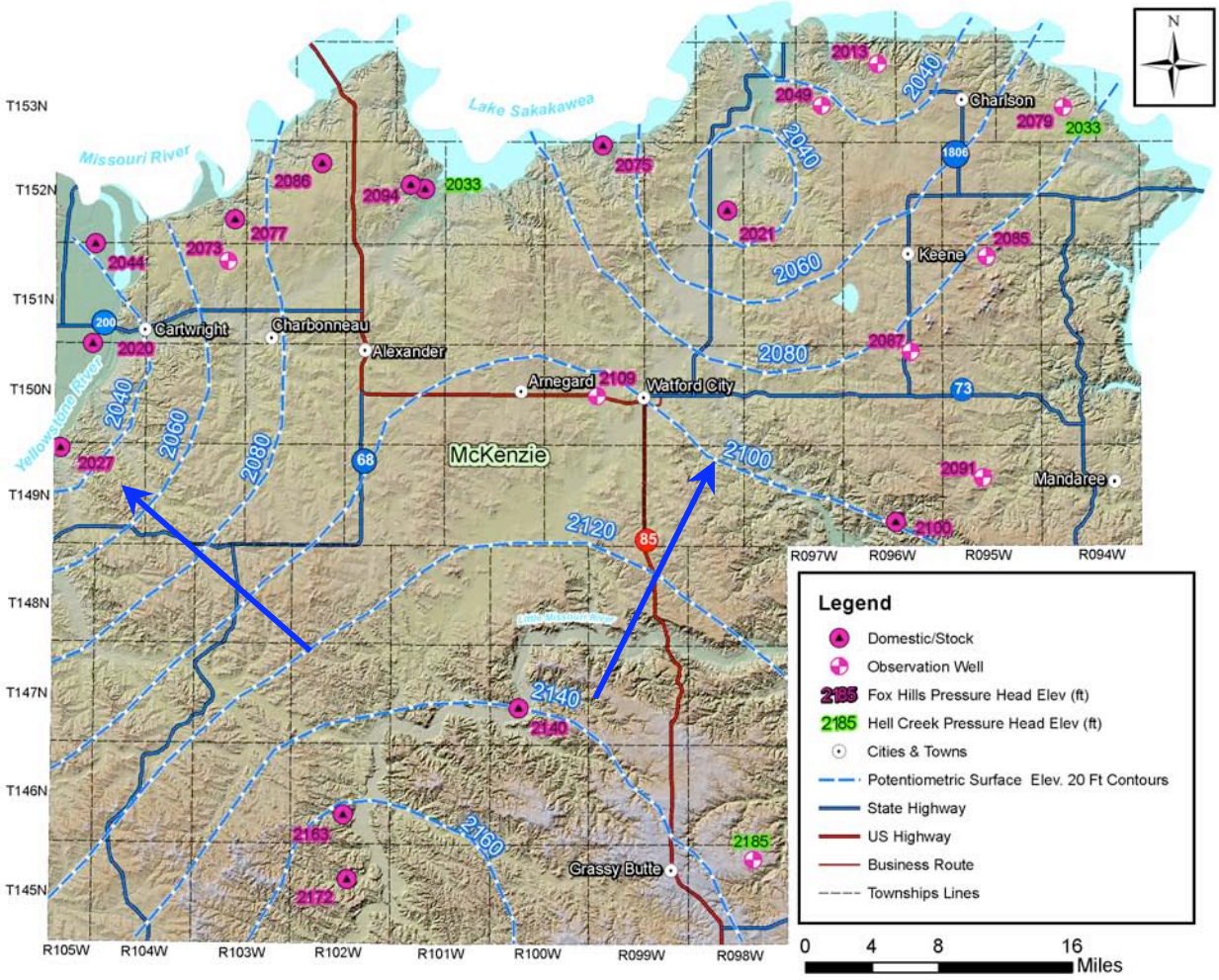
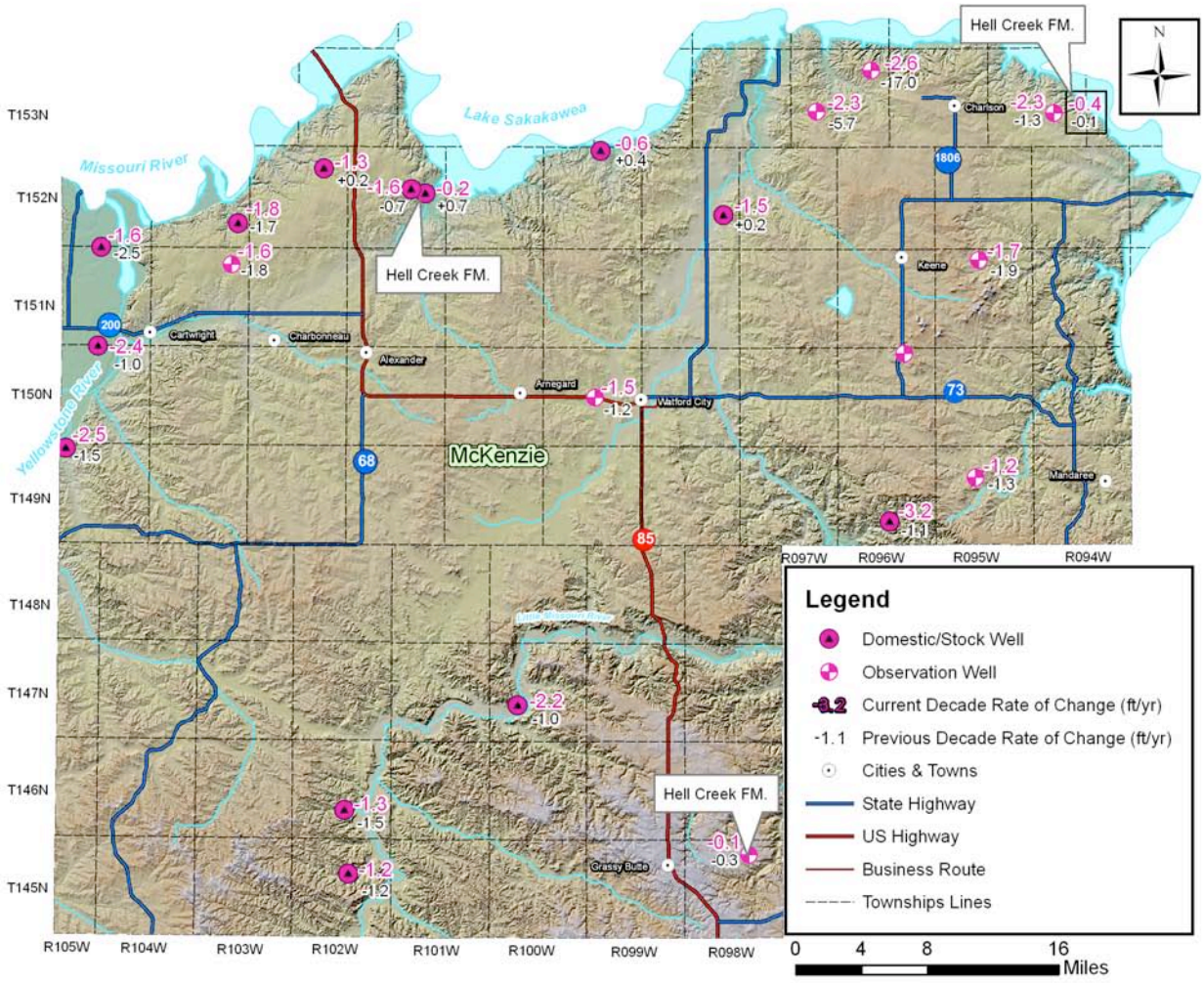


Figure 7 -- Rate of pressure head change in the Fox Hills aquifer



- Lithologic log of the well, where available
- Table showing the long term pressure head measurements
- Table of 2006 shut in time vs. pressure head readings
- Well hydrographs
- Photographs of the well in 2006
- Water quality analyses

The following is a list of working papers and materials compiled during this study and previous studies, but are not included within the report:

- Highway map
- Atlas map
- Topographic map
- Photographs (1985 and 1995)
- County study well information
- Well driller's report
- Graph of shut in time vs. pressure head recovery (1985 and 1995)
- Previous hydrographs, for brochure, etc.
- Well run sheet
- 1995 and 2006 field notes
- 1995 and 2006 water quality analysis
- Brochure titled: *Flowing Well Pressure Changes in McKenzie County* (1985 - Updated in 1995 & 2007)

Aquifer pressure head:

The elevation of the pressure head of the Fox Hills aquifer, as measured in the 13 flowing domestic and stock wells and 9 observation wells visited in May 2006, is shown in Figure 6. The potentiometric surface slopes generally to the north, but more specifically follows the surficial landscape which slopes toward the Missouri, Yellowstone, and the Little Missouri River Valleys. The potentiometric surface slopes from an elevation of 2,172 feet in the southern portion of McKenzie

County to 2,013 feet in the Missouri River Valley in the northern portion of the county for a hydraulic gradient of approximately 2.7 feet per mile.

Pressure head decline rate:

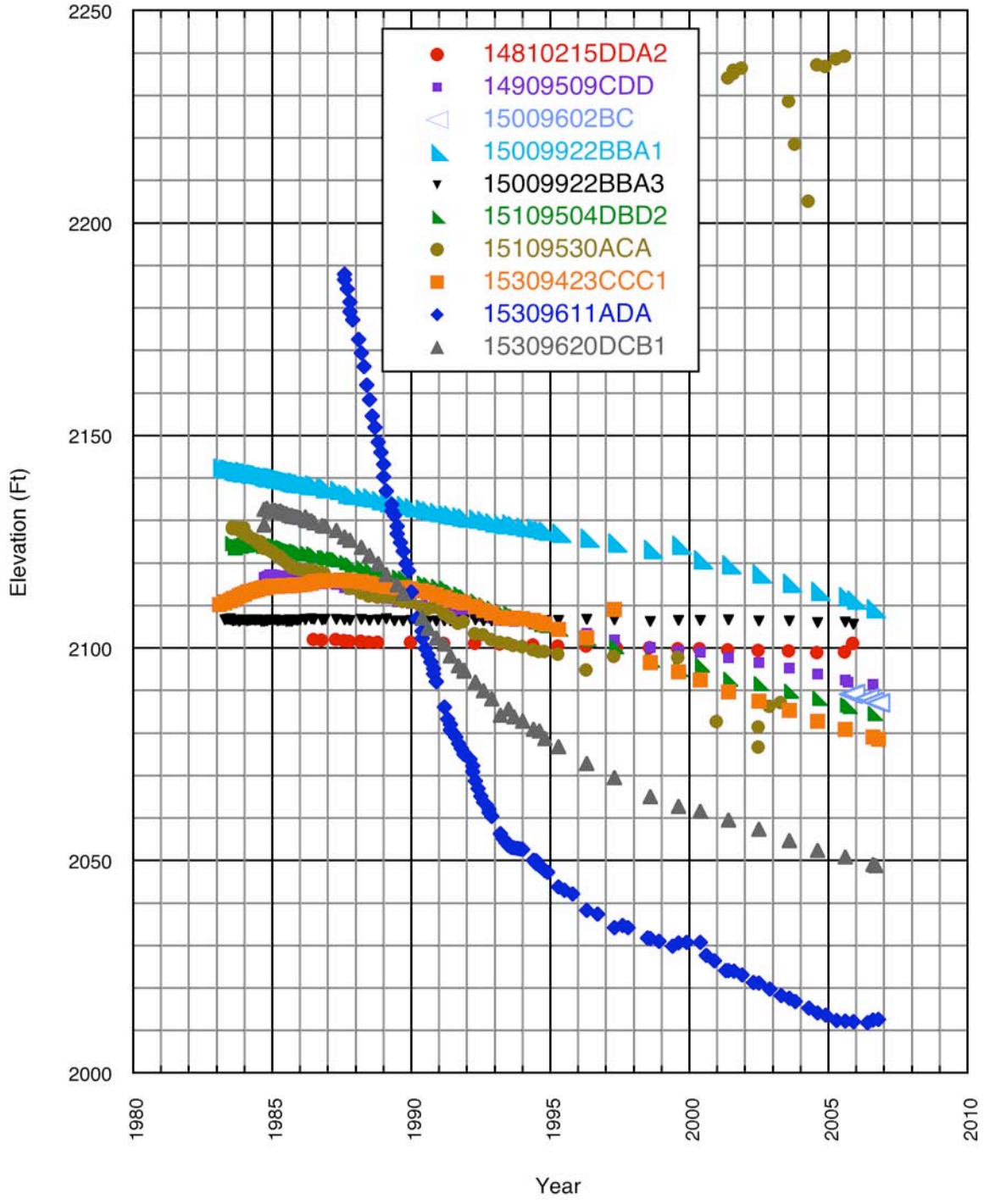
The rate of pressure head decline was determined by comparing the 2006 measurements with the 1995 measurements made in 13 flowing wells and the 9 observation wells (Table 1). Figure 7 illustrates the areal distribution of the current rate of decline for the 1995 to 2006 period and the previous rate of decline for the 1985 to 1995 period.

Figure 8 shows the pressure head declines in all the Fox Hills observation wells monitored in McKenzie County from 1983 to 2007. Fox Hills observation well 151-095-30ACA was monitored between 1983 and 2005 when the well was plugged due

Table 1 -- Pressure head rate of change based on the 1995 and 2006 measurements

Well Location	Aquifer	Purpose	Pressure head rate of change (ft/yr)	Flow rate (gpm)
145-098-03DDD1	Hell Creek	Observation Well	-0.1	NA
145-102-15BAD	Fox Hills	Domestic/Stock Well	-1.2	4
146-102-27BCA	Fox Hills	Domestic/Stock Well	-1.3	7
147-100-20DDB2	Fox Hills	Domestic/Stock Well	-2.2	10
149-095-09CDD	Fox Hills	Observation Well	-1.2	NA
149-096-27CBA	Fox Hills	Domestic/Stock Well	-3.2	12
149-104-06ADB	Fox Hills	Domestic/Stock Well	-2.5	11
150-099-22BBA1	Fox Hills	Observation Well	-1.5	NA
150-104-04AAB	Fox Hills	Domestic/Stock Well	-2.4	10
151-095-04DBD2	Fox Hills	Observation Well	-1.7	NA
151-103-11AAA	Fox Hills	Observation Well	-1.6	NA
151-104-04AAA	Fox Hills	Domestic/Stock Well	-1.6	12
152-098-24CCC	Fox Hills	Domestic/Stock Well	-1.5	3
152-099-03ABC	Fox Hills	Domestic/Stock Well	-0.6	12
152-101-14DAC	Hell Creek	Domestic/Stock Well	-0.2	0.75
152-101-15ADD	Fox Hills	Domestic/Stock Well	-1.6	3
152-102-11ABC	Fox Hills	Domestic/Stock Well	-1.3	2
152-103-25CAB	Fox Hills	Domestic/Stock Well	-1.8	4
153-094-23CCC1	Fox Hills	Observation Well	-2.3	NA
153-094-23CCC2	Hell Creek	Observation Well	-0.4	NA
153-096-11ADA	Fox Hills	Observation Well	-2.6	NA
153-096-20DCB1	Fox Hills	Observation Well	-2.3	NA

Figure 8 -- Hydrograph showing the historical water-level fluctuations in 10 observation wells installed in the Fox Hills aquifer



to erroneous water levels measured in the well beginning in 2001. The over 150 foot rise in water level in observation well 151-095-30ACA can likely be attributed to failure of the well casing. Measurements began in 2005 in Fox Hills observation well 150-096-02BC about three miles from the plugged well, which allows pressure head monitoring to continue in this area. From 1985 to 1995, two decline rates were much larger than the rest and were not caused by water usage. An oil well drilled in the mid 1980s near observation well 153-096-11ADA and 153-096-20DCB1, hit a pocket of trapped gas in the Fox Hills Formation, which caused a blow out in the well. Prior to the blow out in the oil well, the pressure head of the Fox Hills aquifer in this area was abnormally high. Following the blow out, the excessive pressure caused by the trapped gas was released, and the pressure head locally in the aquifer decreased dramatically. It is thought that there is a fault(s) nearby which allowed gases from deeper formations up into the Fox Hills Formation which is not known for producing gas. There was a very steep decline in 153-096-11ADA between 1987 and 1994, which is nearby the gas release, and a more subdued decline in 153-096-20DCB1, which is further away from the gas release. In the late 1990s, the response from the gas release had mostly dissipated to more normal declines in the two wells.

During the 1995 to 2006 period, the rate of change in pressure head in the measured Fox Hills wells in McKenzie County ranged from -0.4 to -3.2 feet per year with an average decline of 1.6 feet per year. The three wells with the smallest rate of decline are from wells completed above the Fox Hills Formation in the Hell Creek Formation. During the 1985 to 1995 period, the rate of change in pressure head ranged from +0.4 to -17.0 feet per year with an average decline of 1.9 feet per year. Excluding the two wells with dramatic declines in water levels due to the release of the trapped gas, the rate of pressure head change ranged from +0.4 to -2.5 feet per year with an average decline of 1.0 feet per year for the 1985 to 1995 period.

A majority of the wells monitored in McKenzie County are located in the northern portion of the county adjacent to Lake Sakakawea. Fluctuations in the lake levels of Lake Sakakawea have an affect on the pressure head of the Fox Hills aquifer in this area. The large volume of water in Lake Sakakawea adds more

weight on the land surface, which propagates down through the underlying formations and compresses the aquifer matrix (skeleton) in the Fox Hills aquifer, thus increasing its pressure head. A good illustration of how water levels in the aquifer respond to fluctuations in lake levels can be seen when comparing a hydrograph of observation well 153-094-23CCC1 to the historical lake elevations (Figure 9). The pressure head in this observation well can fluctuate 5 to 10 feet dependant on the elevation of Lake Sakakawea. As the lake recovered between 1983 and 1987 from a low in 1982, the water levels in 153-094-23CCC1 also recovered several feet, overcoming the overall declining head of the aquifer. The opposite occurred in the late 1980s and early 1990s when the lake levels declined due to drought conditions in the Missouri River Basin. The Fox Hills aquifer responded in 153-094-23CCC1 with a decline in pressure head. When the lake levels increased dramatically through the mid to late 1990s, the pressure head again rose dramatically in 153-094-23CCC1. When the pressure head measurements were made in June of 1995, Lake Sakakawea was at an estimated elevation of 1846 feet above mean sea level. In May of 2006, when the current pressure head measurements were made, Lake Sakakawea was at an estimated elevation of 1814 feet above mean sea level. The 32-foot decline in lake level over this period increased the rate of pressure head decline in 153-094-23CCC1 as well as other measured wells in northern McKenzie County. It is difficult to quantify the impact the declining lake levels had on the average pressure head decline rate from 1995 to 2006. However, the average decline rate of 1.6 feet per year would have likely been much lower if Lake Sakakawea maintained its elevation from 1995. During the 1984 to 1995 monitoring period, the loading effect of Lake Sakakawea had minimal effect on the pressure head declines of the aquifer, because the lake elevation in 1985 was similar to the elevation in 1995 (Figure 9).

Based on the current pressure head decline rates (Figure 7) and the current pressure head above land surface (Figure 10), estimates of when each well monitored will stop flowing were made and are shown in Figure 11.

Figure 9 -- Historical water-level elevation of Lake Sakakawea versus water-level fluctuations in observation well 153-094-23CCC1

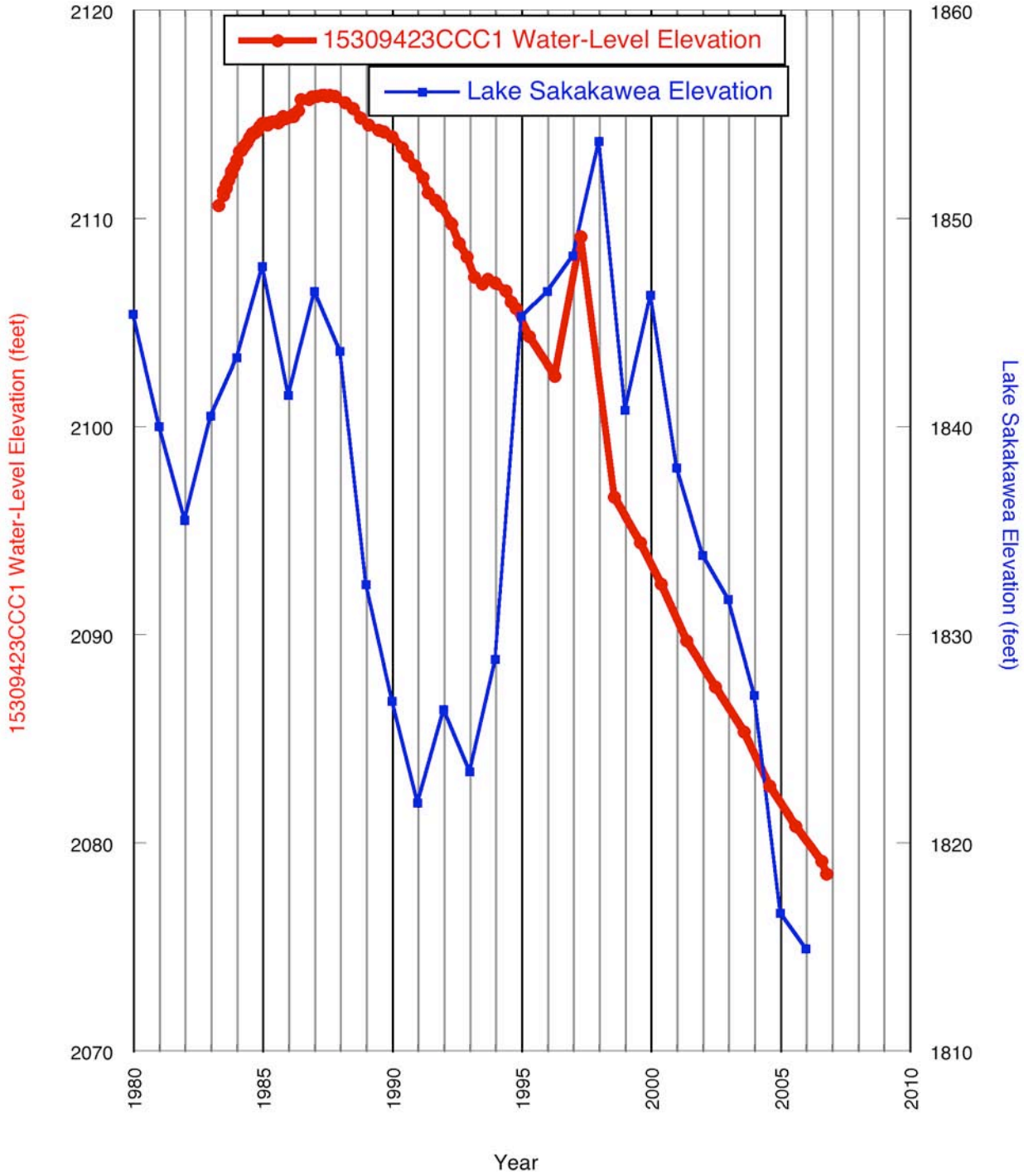


Figure 10 -- Pressure head of the Fox Hills aquifer in feet above the land surface

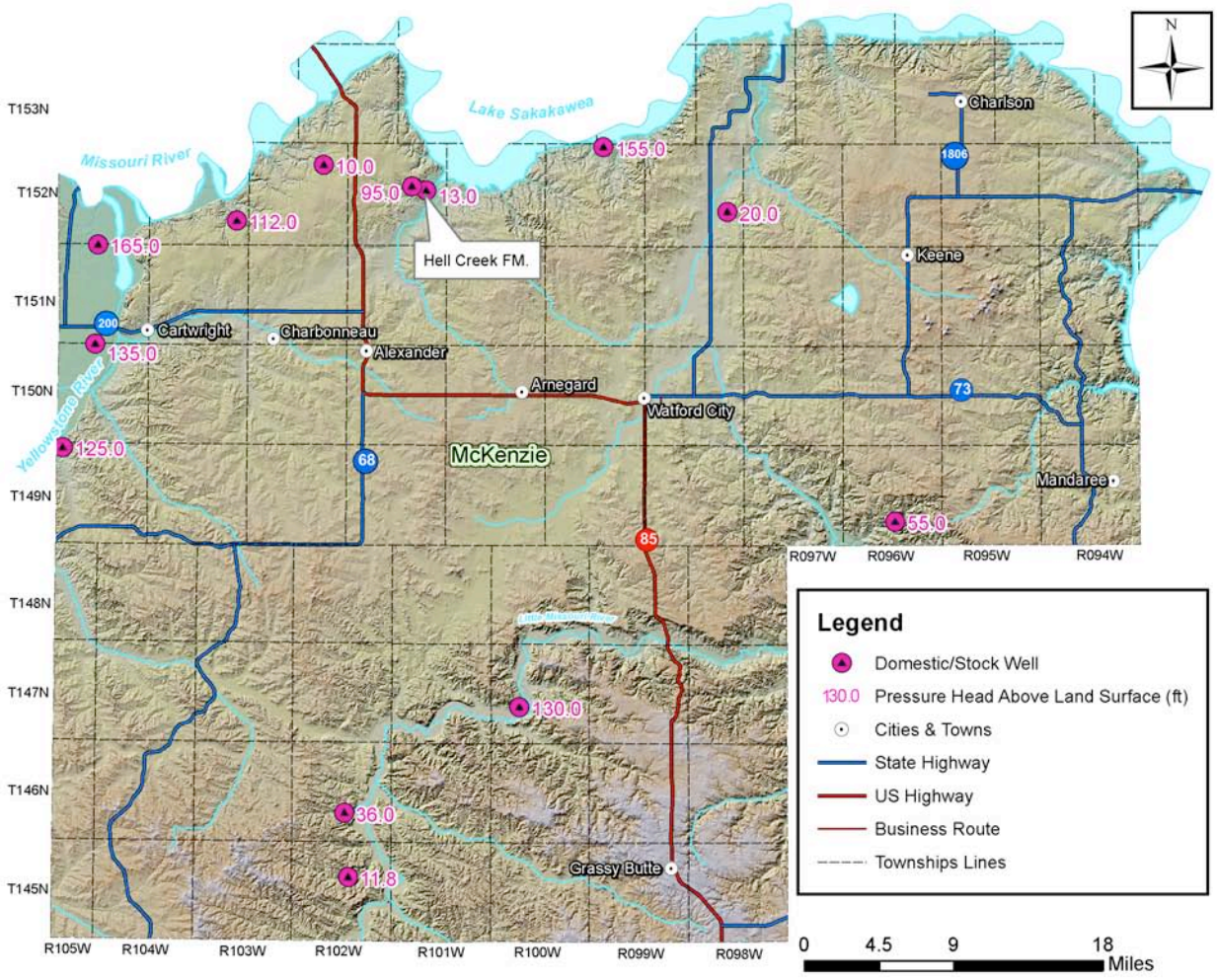
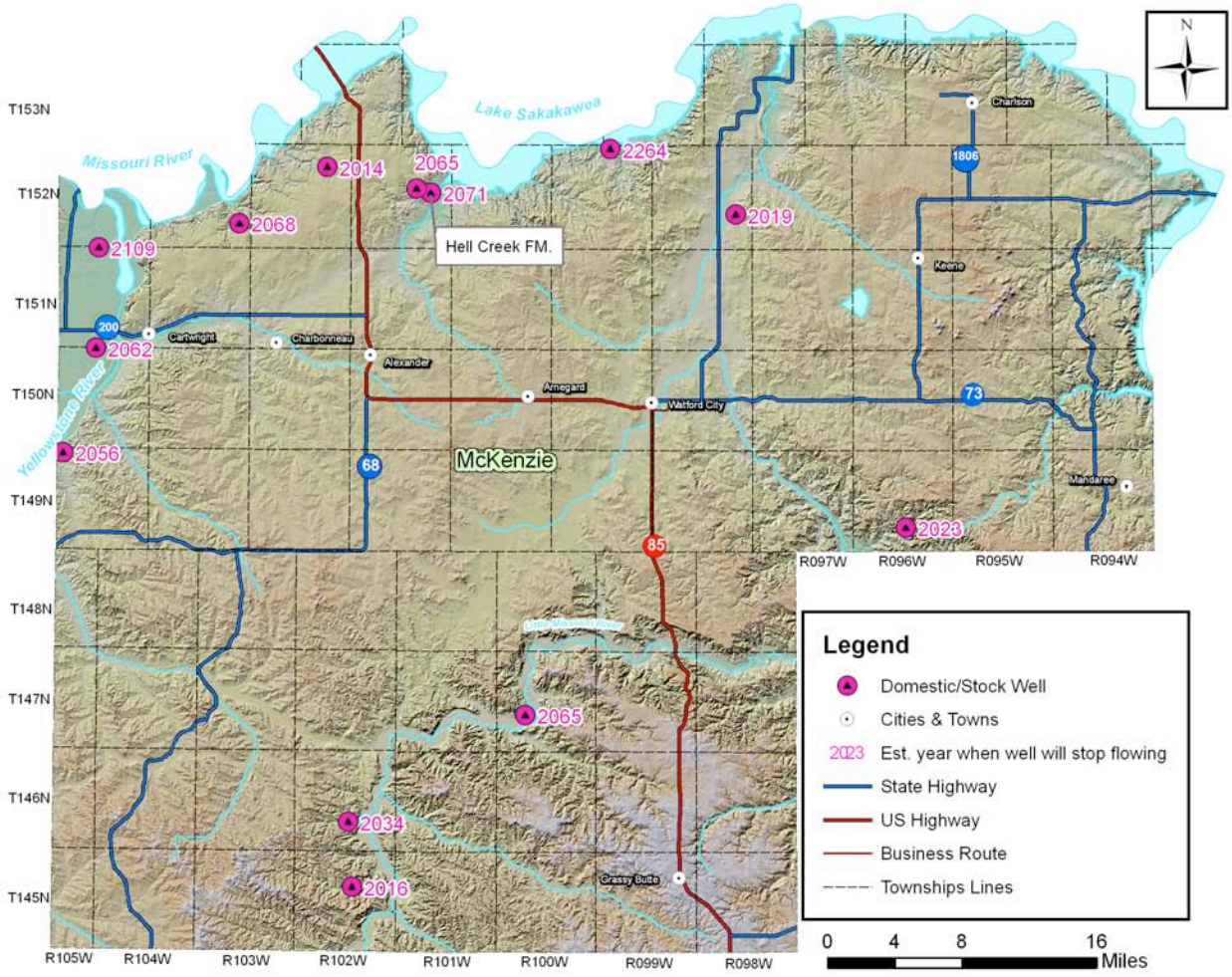


Figure 11 -- The estimated year when flowing wells in McKenzie County will cease to flow



Flow rate:

At the time of the 2006 pressure head measurements the rate at which the wells were discharging water was measured before the wells were shut in. The flow rates ranged from 2 to 12 gallons per minute with an average rate of 8 gallons per minute (Table 1). The observation wells have pressure heads below land surface and therefore no flow rate. The feet of pressure head recovery between the first and last pressure measurement are listed in Table 2. The lack of pressure head recovery in most wells when they are shut in suggests water may be leaking through a corroded well casing.

Table 2 -- Pressure head recovery between the first and last measurements after the well was shut-in

Well	Recovery (feet)	Shut-in Time (minutes)
145-102-15BAD	0.8	60
146-102-27BCA	3.0	60
147-100-20DDB2	10.0	60
149-096-27CBA	1.0	60
149-104-06ADB	0.0	30
150-104-04AAB	0.0	30
151-104-04AAA	0.0	30
152-098-24CCC	1.0	120
152-099-03ABC	0.0	60
152-102-11ABC	0.0	60
152-103-25CAB	0.0	60

Water Quality:

Water samples were collected for chemical analysis from 13 flowing wells visited in 2006. Table 3 shows concentrations for related dissolved minerals of the 13 flowing wells in 2006 as well as the concentrations for 9 observation wells sampled between May of 1983 and September of 2006. Chemical analyses indicate the water is predominantly a sodium-bicarbonate type that generally has less dissolved constituents than water in the overlying formations (Figure 12).

Figure 12 -- Major dissolved constituents in samples collected from the Fox Hills aquifer in May of 2006

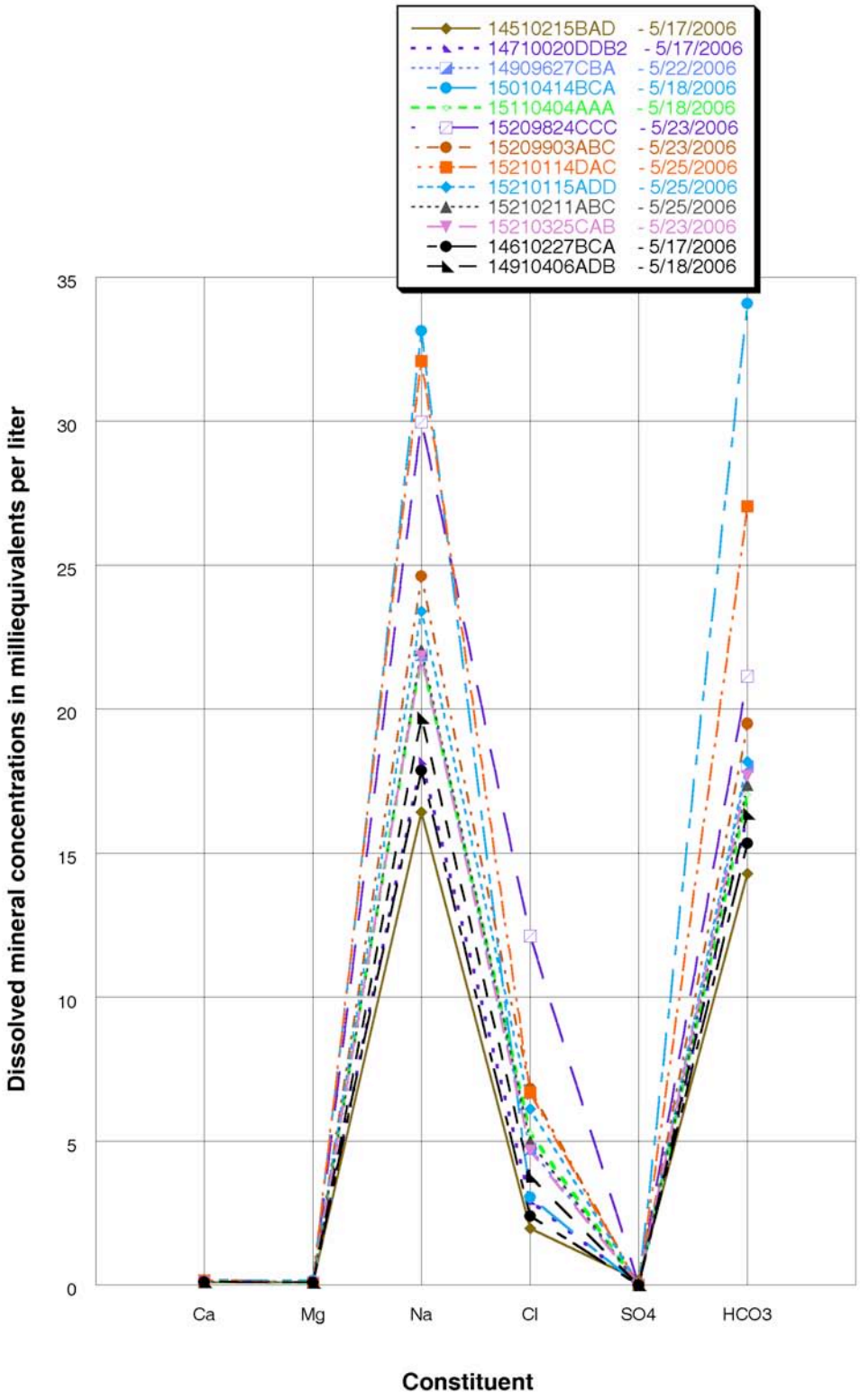


Table 3 -- Concentrations of selected ions and total dissolved solids in sampled wells

Location	Screened Interval	Date Sampled	Sodium (mg/L)	Fluoride (mg/L)	Bicarbonate (mg/L)	Chloride (mg/L)	TDS (mg/L)
*145-098-03DDD1	1659-1683	5/26/1983	710	4.00	1700	35	1730
145-102-15BAD	1212-1255	5/17/2006	378	5.28	872	69.7	1050
146-102-27BCA	1260-1310	5/17/2006	411	5.11	937	85	1090
147-100-20DDB2	1290-1330	5/17/2006	419	5.11	998	104	1160
149-095-09CCD	1539-1564	9/29/2005	530	5.23	1100	247	1360
149-096-27CBA	1380-1440	5/22/2006	503	5.64	1100	168	1370
149-104-06ADB	1192-1220	5/18/2006	453	5.26	1000	134	1260
150-099-22BBA1	1742-1772	11/09/2005	587	5.60	1000	143	1290
*150-104-14BCA	943-960	5/18/2006	762	2.41	2080	108	2030
151-095-04BDB2	1407-1432	9/27/2005	570	5.36	1130	255	1450
151-103-11AAA	1680-1753	11/08/2005	578	5.58	1000	153	1280
151-104-04AAA	1342-1405	5/18/2006	501	5.45	1040	187	1360
152-098-24CCC	1680-1730	5/23/2006	689	4.01	1290	430	1970
152-099-03ABC	1560-1610	5/23/2006	566	5.76	1190	242	1560
152-101-14DAC	1735-1855	5/25/2006	738	3.22	1650	237	1910
152-101-15ADD	1532-1547	5/25/2006	538	5.45	1110	217	1470
152-102-11ABC	NA	5/25/2006	507	5.56	1060	177	1380
152-103-25CAB	1485-1530	5/23/2006	502	5.64	1080	166	1340
153-094-23CCC1	1743-1767	10/04/2006	742	4.15	970	440	1930
*153-094-23CCC2	1410-1434	10/04/2006	833	1.26	1230	495	2160
153-096-11ADA	1289-1370	9/09/1987	810	4	1260	520	2020
153-096-20DCB1	1433-1500	9/28/2006	681	4.47	1180	386	1920
MCL	N/A	N/A	N/A	4.0	N/A	N/A	N/A
SMCL	N/A	N/A	N/A	2.0	250	250	500

*Well is installed in the Hell Creek Formation

Table 3 also lists the maximum contaminant level (MCL) and the secondary maximum contaminant level (SMCL) defined by the United States Environmental Protection Agency (EPA). MCLs are primary standards that are legally enforceable standards that apply to public water systems. Primary standards protect public health by limiting the levels of contaminants in drinking water. SMCLs are non-enforceable recommended standards and are not considered a health hazard. Most of the water samples collected and analyzed for this study exceed the MCL for fluoride (Table 3). According to the EPA, elevated levels of fluoride can cause bone disease (pain and tenderness of the bones); children may get mottled teeth. Ground water in the Fox Hills aquifer almost always exceeds SMCL for total dissolved solids (TDS) and bicarbonate and occasionally exceeds the SMCL for chloride.

The concentrations of TDS increased in 2005-2006 when compared to the previous samples collected in 1995. However, the results of water quality samples are very similar to the previous decade. There is an average 3% increase in TDS in samples collected in 2005-2006 versus 1995. When comparing samples collected in 1995 to samples collected prior to 1987, there was an average 1.0% decline in concentrations of TDS.

Temporal variations in water quality may be attributed to the amount of water pumped prior to sample collection, differences in sampling protocol between sampling events, and casing failure in wells. However, there is no relationship between the amount of water withdrawn from the Fox Hills aquifer and its water chemistry. If there were a relationship, there would be a continuous trend in TDS concentrations from the initial water sample to the subsequent sampling events as additional water is withdrawn.

In most cases the wells were flowing prior to the field visit, which allowed for the collection of representative samples from the aquifer. The length of time the wells had been flowing prior to sampling is unknown. Some wells were shut in for an extended period of time prior to the field visit, so collecting a fresh water sample from the aquifer in a timely manner was not possible. Depending on the flow rate of the well and the depth of the well, it could take any where from a few hours to several days to evacuate enough water to remove a full casing volume. A full casing volume of water was not evacuated prior to sampling observation wells, which have a pressure head below the land surface. Variations in pumping time prior to sampling could cause variations in the water quality, because representative samples may not always be obtained.

Failed well casings could also cause temporal variations in water quality. This would allow poorer quality water from overlying formations, to mix with the Fox Hills aquifer water. In this situation, the analysis will indicate that the water quality of the Fox Hills aquifer is deteriorating when in fact the well is deriving some of its water from other formations.

In general, the concentration of total dissolved solids increases to the north within McKenzie County away from the recharge area. The full suite of water quality information is included in the Appendix under each individual well.

Summary:

The pressure heads (water levels above the top of the aquifer) in the Fox Hills aquifer decline when the discharge is greater than the recharge. Recharge to the Fox Hills aquifer is very small and is easily exceeded by the discharge, which occurs mainly in the form of withdrawal from wells.

The pressure head in the Fox Hills aquifer in McKenzie County declined at an average rate of 1.6 feet per year from 1995 to 2006. Part of this decline is due to the loading effect of Lake Sakakawea. The decline in the lake level of Lake Sakakawea from 1995 to 2006 reduced the weight on the aquifer matrix (skeleton) causing it to decompress thereby reducing the pressure head. The 1985 to 1995 average rate of decline in the Fox Hills aquifer was 1.0 foot per year. During the 1984 to 1995 monitoring period, the loading effect of Lake Sakakawea had minimal effect on the pressure head declines of the aquifer, because the lake elevation in 1985 was similar to the elevation in 1995.

The potentiometric surface slopes generally to the north, but more specifically follows the surficial landscape, which slopes toward the Missouri, Yellowstone, and the Little Missouri River Valleys. The hydraulic gradient is approximately 2.7 feet per mile.

The water quality from samples collected in 2005-2006 reflects slightly poorer quality than the samples collected in 1995. There is an average 3% more Total Dissolved Solids (TDS) in samples collected in 2006 versus 1995. When comparing samples collected in 1995 to samples collected prior to 1987, there was an average 1.0% decline in concentrations of TDS. There is no relationship between the amount of water withdrawn from the Fox Hills aquifer and its water chemistry. Temporal variations in water quality may be attributed to the amount of water pumped prior to sample collection, differences in sampling protocol between sampling events, and

casing failure in wells. Most of the water samples collected and analyzed for this study exceeded the Maximum Contaminant Level for fluoride. According to the EPA, elevated levels of fluoride can cause bone disease (pain and tenderness of the bones); children may get mottled teeth. Total dissolved solids and bicarbonate exceeded the Secondary Maximum Contaminant Levels (SMCL) established by the EPA. Occasionally chloride exceeded the SMCL. SMCLs are not considered a health hazard.

Appendix -- Well Information

145-098-03DDD1
NDSWC 5952

Date Completed:	08/14/1981	Purpose:	Observation Well
L.S. Elevation (ft):	2590	Well Type:	2 in. - Steel
Depth Drilled (ft):	1720	Aquifer:	Hell Creek
Screen Int. (ft.):	1659-1683	Data Source:	NDSWC - Allen Comeskey

Completion Info:

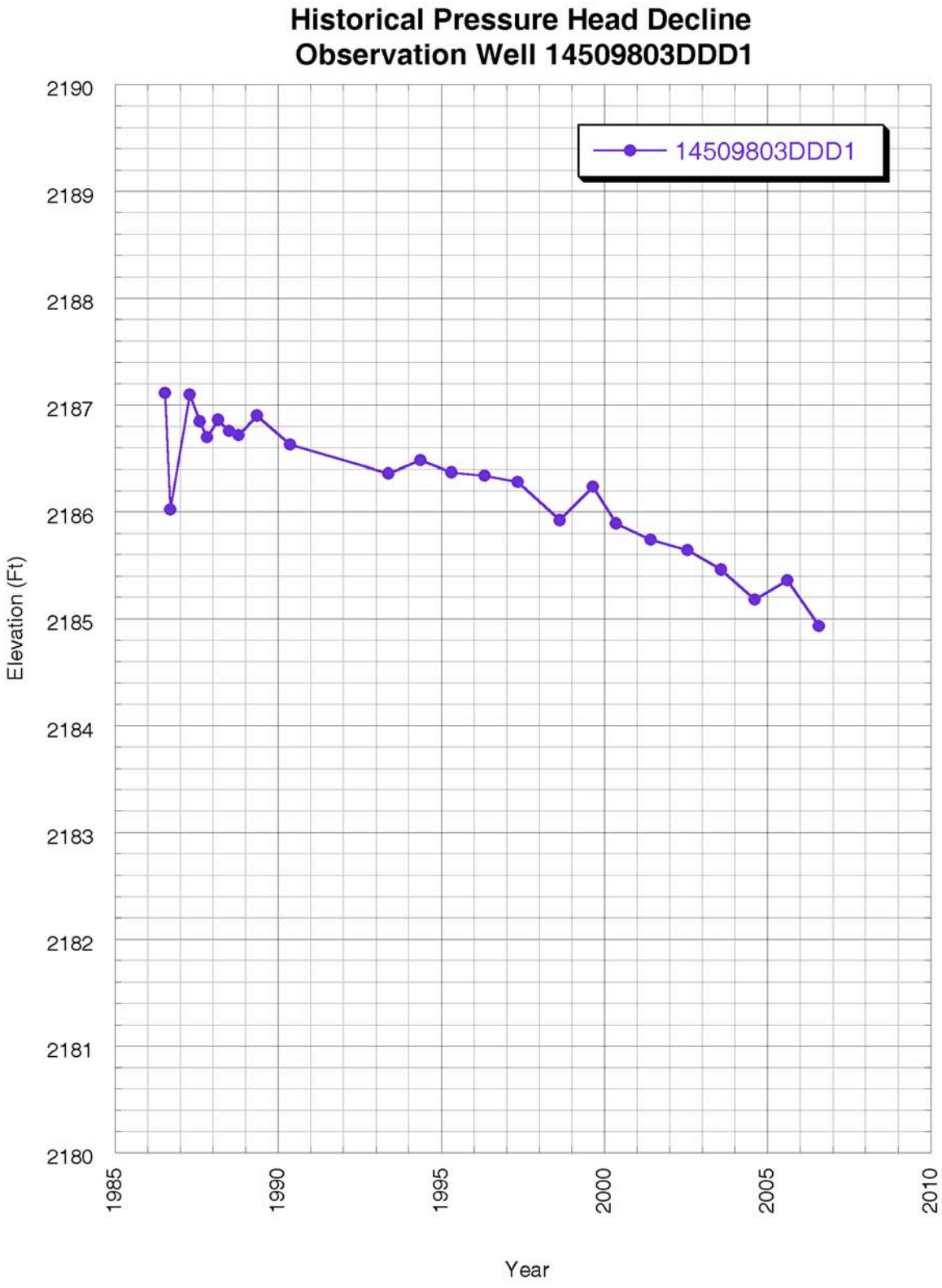
Remarks: Grassy Butte east well twin set, located north of road a bit west of section line, protective cage around well.

Lithologic Log

Depth (ft)	Unit	Description
0-29	SILT	And sand, yellowish brown
29-205	SILTSTONE	And sandstone, clayey, olive gray, (Sentinel Butte Member)
205-215	LIGNITE	
215-375	SILTSTONE	And lignite, olive gray
375-475	SANDSTONE	Silty, fine to medium
475-650	SILTSTONE	And claystone, gray
650-700	SILTSTONE	And sandstone
700-765	SILTSTONE	And claystone
765-775	LIGNITE	
775-810	SILTSTONE	And claystone, lignitic
810-950	SANDSTONE	Silty, fine to medium
950-975	LIGNITE	
975-1360	SILTSTONE	And claystone, olive gray (Fort Union Formation)
1360-1400	CLAYSTONE	Silty, greenish-gray
1400-1635	SILTSTONE	And claystone, gray, carbonaceous
1635-1700	SILTSTONE	And sandstone, lignitic
1700-1720	SILTSTONE	Sandy (Hell Creek-Fox Hills)

Water Quality

Location	145-098-03DDD1
County	McKenzie
Screened Interval	1659'-1683'
Aquifer	Hell Creek
Purpose	Observation Well
Date Sampled	05/26/83
Time Sampled	00:00:00
Yield (gpm)	2
Field Temp(C)	16
Lab pH	8.9
Field Conductivity (um/cm)	2850
Lab Conductivity (um/cm)	2650
Total Dissolved Solids (mg/L)	1730
Calcium (mg/L)	4.5
Magnesium (mg/L)	2
Potassium (mg/L)	4.6
Sodium (mg/L)	710
Fluoride (mg/L)	4
Bicarbonate (mg/L)	1700
Carbonate (mg/L)	96
Sulfate (mg/L)	20
Chloride (mg/L)	35
Hydroxide (mg/L)	
Nitrate(mg/L)	1
Iron (mg/L)	0.03
Manganese (mg/L)	0.01
Hardness(mg/L)	19
Sodium Adsorption Ratio (SAR)	71
Residual Sodium Carbonate (Equiv/L)	31
Percent Sodium	98


Historical Pressure Head Decline
Observation Well 14509803DDD1
14509803DDD1
Elevation (Ft)
2190
2189
2188
2187
2186
2185
2184
2183
2182
2181
2180
1985
1990
1995
2000
2005
2010
Year

145-102-15BAD

Date Completed:	09/17/70	*Purpose:*	Stock Well
L.S. Elevation (ft):	2160'	*Well Type:*	1.25"Steel
Depth Drilled (ft):	1255'	*Aquifer:*	Fox Hills
Screened Interval (ft):	1212' - 1255'	*Source:*	Boyce Drilling Co.

Owner:	Milo and Paul Wisness
Address:	4153 110th Avenue NW, Keene, ND 58847
Telephone #:	701-675-2346
Farmstead location:	Little Missouri Valley, 6 miles north of Golden Valley/McKenzie County line (Rockerman Ranch)
Well Location:	3 miles SW of ranch, up Cinnamon Creek
Directions to well:	Approach from the west, bear right around 13-15 H MOI well at 145-102-15BC, faint trail 1/4 mile east down valley through gate, well at north side of valley, tan stock tank with triangular supports
Wellhead description: (casing & plumbing)	4 inch surface casing, 1.5 ft, cement filled, 1.25 in casing, elbow to stock tank

Shut in time vs. pressure head: 2006 measurements

Shut in time (minutes)	1	2	3	4	5	7	9	12	15	20	25	30	35	40
Pressure head (feet)	11	11.25	11.50	11.75	11.75	11.75	11.75	11.75	11.75	11.75	11.75	11.75	11.75	11.75

Shut in time (minutes)	50	60	70	80	100	120
Pressure head (feet)	11.75	11.75				

Long-term pressure head measurements

Date	Flow rate (gpm)	Shut-in Time (min)	Pressure Head (ft)	Rate of change(ft/yr)	Measurement made by
06/10/80			57.50		USGS
12/06/84		30	36.95	-4.6	Allen Comesky
06/22/1995	1.25	120	24.40	-1.5	Alan Wanek
05/17/06	4	60	11.75	-1.2	Merlyn Skaley

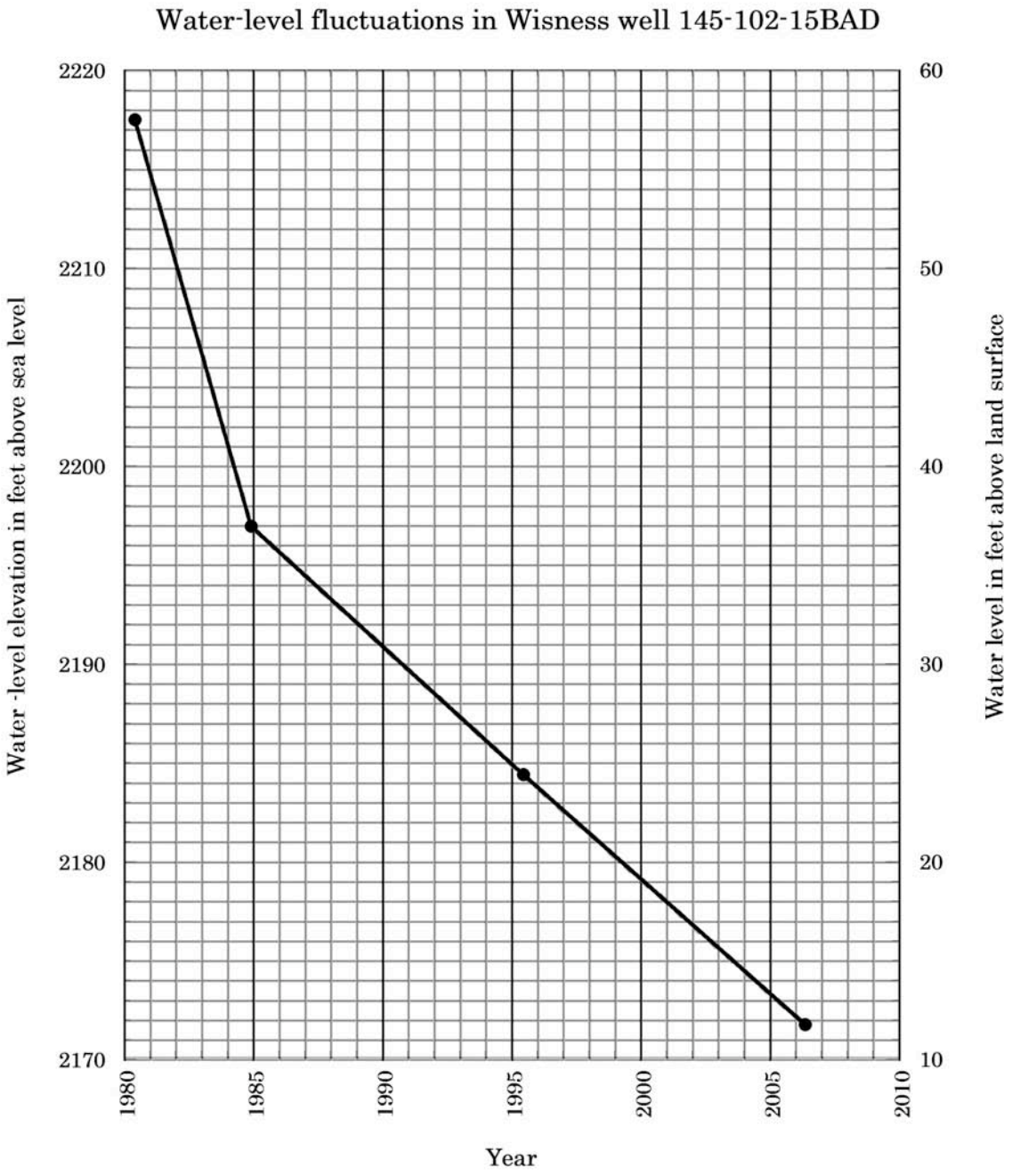
145-102-15BAD
Milo and Paul Wisness

Date Completed:	09/17/1970	Purpose:	Stock Well
L.S. Elevation (ft):	2160	Well Type:	1.25 in. - Steel
Depth Drilled (ft):	1255	Aquifer:	Fox Hills
Screen Int. (ft.):	1212-1255	Data Source:	Boyce Drilling Co.
Completion Info:			

Remarks:

Lithologic Log

Depth (ft)	Unit	Description
0-26	CLAY	Topsoil and clay fill
26-38	GRAVEL	Scoria and fine gravel
38-43	LIGNITE	Coal
43-160	CLAY	Gray
160-167	LIGNITE	Coal
167-265	CLAY	Gray, firm
265-310	SANDSTONE	
310-336	CLAY	Gray
336-338	ROCK	
338-615	CLAY	Gray, soft to medium hard
615-647	CLAY	Gray, hard
647-652	ROCK	
652-910	CLAY	Gray, hard, rocks at 689-691, 855-859
910-970	CLAY	Gray, hard, sandstone layers
970-976	ROCK	
976-1058	SANDSTONE	and gray clay, thinly layered
1058-1063	ROCK	
1063-1194	CLAY	Gray, medium hard
1194-1212	CLAY	Gray, hard
1212-1255	SAND	Artesian strata


Water-level fluctuations in Wisness well 145-102-15BAD
Water -level elevation in feet above sea level
Water level in feet above land surface
Year
2220
2210
2200
2190
2180
2170
60
50
40
30
20
10
1980
1985
1990
1995
2000
2005
2010

Water Quality

Location	145-102-15BAD
County	McKenzie
Screened Interval	1212'-1255'
Aquifer	Fox Hills
Purpose	Stock Well
Date Sampled	05/17/06
Time Sampled	09:41:00
Yield (gpm)	4
Field Temp(C)	15.50
Lab pH	8.66
Field Conductivity (um/cm)	1530
Lab Conductivity (um/cm)	1690
Total Dissolved Solids (mg/L)	1050
Calcium (mg/L)	<2
Magnesium (mg/L)	<1
Potassium (mg/L)	<1
Sodium (mg/L)	378.0
Fluoride (mg/L)	5.28
Bicarbonate (mg/L)	872.0
Carbonate (mg/L)	39.0
Sulfate (mg/L)	8.49
Chloride (mg/L)	69.7
Hydroxide (mg/L)	<1
Nitrate(mg/L)	<0.09
Iron (mg/L)	0.166
Manganese (mg/L)	0.010
Hardness(mg/L)	9.0
Sodium Adsorption Ratio (SAR)	54.4
Residual Sodium Carbonate (Equiv/L)	15.0
Percent Sodium	98.9

Milo and Paul Wisness well at 145-102-15BAD

View looking north

View looking south

146-102-27BCA

Date Completed:	02/12/74	*Purpose:*	Stock Well
L.S. Elevation (ft):	2127'	*Well Type:*	1.25"Steel
Depth Drilled (ft):	1310'	*Aquifer:*	Fox Hills
Screened Interval (ft):	1260' - 1310'	*Source:*	Boyce Drilling Co.

Owner:	Alvin Nelson
Address:	14421 West Beicegel Creek Rd., Grassy Butte, ND 58834
Telephone #:	701-863-6890
Farmstead location:	Little Missouri Valley, Beicegal Creek area
Well Location:	3 miles SW of ranch, across Little Missouri River
Directions to well:	0.7 miles west of river road, well is 100 feet NW of road, near draw, as road bends SW
Wellhead description: (casing & plumbing)	5 inch surface casing, casing extends 2.5 ft to 4 way valve, 2 not connected, 3rd valved to elbow and tan stock tank

Shut in time vs. pressure head: 2006 measurements

Shut in time (minutes)	1	2	3	4	5	7	9	12	15	20	25	30	35	40
Pressure head (feet)	33	33.50	33.75	33.75	34.00	34.25	34.50	34.75	35.00	35.00	36.00	36.00	36.00	36.00

Shut in time (minutes)	50	60	70	80	100	120
Pressure head (feet)	36.00	36.00				

Long-term pressure head measurements

Date	Flow rate (gpm)	Shut-in Time (min)	Pressure Head (ft)	Rate of change(ft/yr)	Measurement made by
06/10/80			+80.0		USGS
05/01/85			+64.5	-3.2	Allen Comesky
06/16/95	2.73	15	+49.7	-1.6	Alan Wanek
05/17/06		120	+36.0	-1.3	Merlyn Skaley

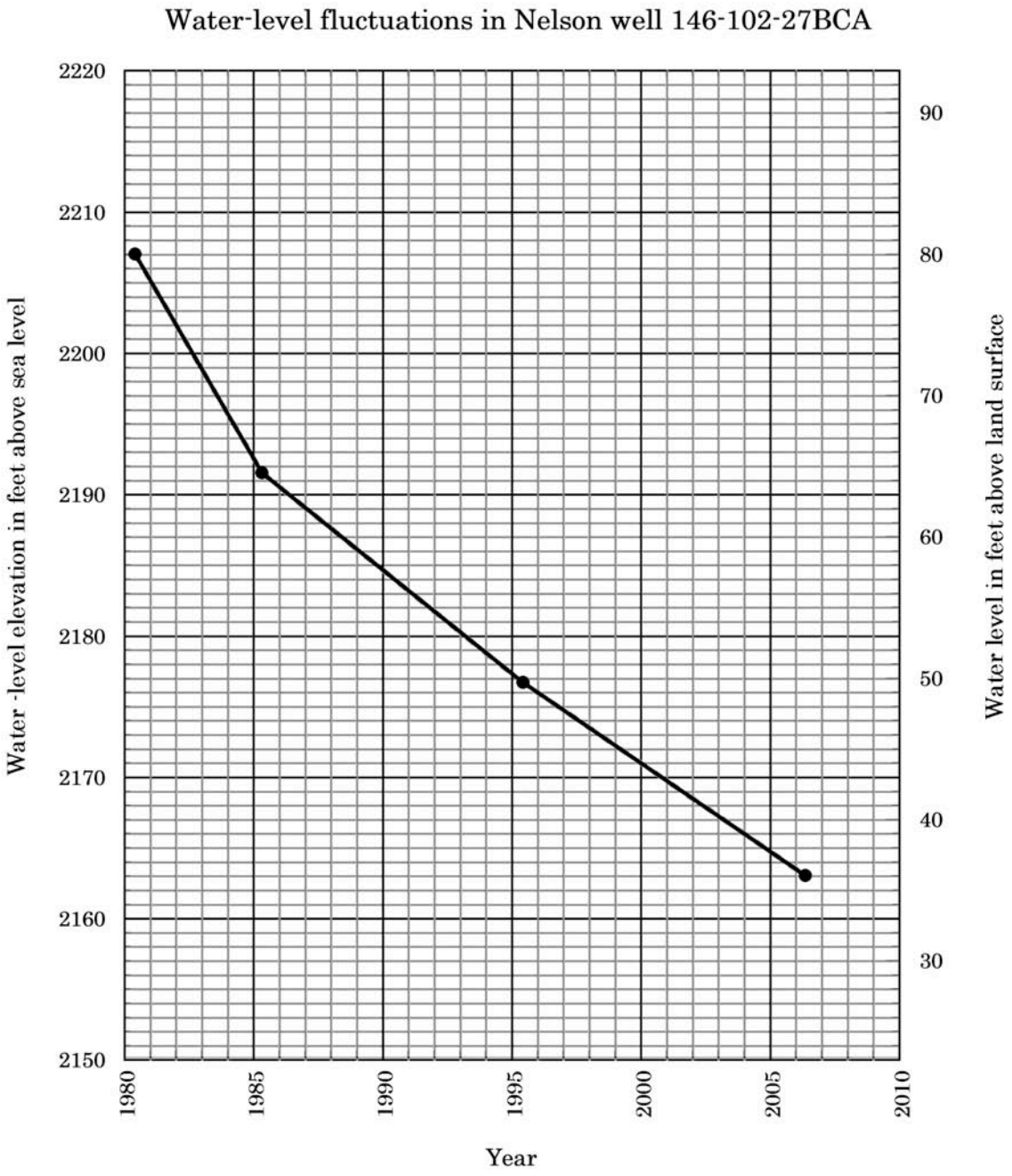
146-102-27BCA

Alvin Nelson

Date Completed:	02/12/1974	Purpose:	Stock Well
L.S. Elevation (ft):	2127	Well Type:	1.25 in. - Steel
Depth Drilled (ft):	1310	Aquifer:	Fox Hills
Screen Int. (ft.):	1260-1310	Data Source:	Boyce Drilling Co.
Completion Info:			
Remarks:	Located along trail 0.7 mile west or River Road, 100 feet NW or road, near draw as road bends SW		

Lithologic Log

Depth (ft)	Unit	Description
0-70	SAND	with brown clay
70-75	CLAY	Gray
75-79	LIGNITE	
79-130	CLAY	Gray
130-131	SANDSTONE	
131-215	SHALE	Gray
215-222	LIGNITE	
222-276	SHALE	Gray
276-279	LIGNITE	
279-293	SHALE	Gray
293-325	LIGNITE	
325-497	SHALE	Gray
497-525	SAND	Gray, water bearing
525-731	SHALE	Gray
731-732	SANDSTONE	
732-999	CLAY	Gray, sandy
999-1000	SANDSTONE	
1000-1050	SHALE	Gray
1050-1051	SANDSTONE	
1051-1250	SHALE	Gray
1250-1300	SAND	Gray, water bearing
1300-1310	SHALE	Gray


Water-level fluctuations in Nelson well 146-102-27BCA
Water -level elevation in feet above sea level
2220
2210
2200
2190
2180
2170
2160
2150
Water level in feet above land surface
90
80
70
60
50
40
30
1980
1985
1990
1995
2000
2005
2010
Year

Water Quality

Location	146-102-27BCA
County	McKenzie
Screened Interval	1260'-1310'
Aquifer	Fox Hills
Purpose	Stock Well
Date Sampled	05/17/06
Time Sampled	12:50:00
Yield (gpm)	7
Field Temp(C)	17.30
Lab pH	8.65
Field Conductivity (um/cm)	1593
Lab Conductivity (um/cm)	1760
Total Dissolved Solids (mg/L)	1090
Calcium (mg/L)	<2
Magnesium (mg/L)	<1
Potassium (mg/L)	<1
Sodium (mg/L)	411.0
Fluoride (mg/L)	5.11
Bicarbonate (mg/L)	937.0
Carbonate (mg/L)	44.0
Sulfate (mg/L)	<0.3
Chloride (mg/L)	85.0
Hydroxide (mg/L)	<1
Nitrate(mg/L)	<0.09
Iron (mg/L)	<0.01
Manganese (mg/L)	<0.01
Hardness(mg/L)	9.0
Sodium Adsorption Ratio (SAR)	59.2
Residual Sodium Carbonate (Equiv/L)	17.0
Percent Sodium	99.0

Alvin Nelson well at 146-102-27BCA

View looking North

View looking east

147-100-20DDB2

Date Completed:	11/28/72	*Purpose:*	Stock Well
L.S. Elevation (ft):	2010'	*Well Type:*	1.25"Steel
Depth Drilled (ft):	1330'	*Aquifer:*	Fox Hills
Screened Interval (ft):	1290' - 1330'	*Source:*	K.D. Thompson

Owner:	William Ceynar
Address:	1081 134th Avenue NW, Arnegard, ND 58835
Telephone #:	701-586-3435
Farmstead location:	Little Missouri Valley just SW of TR Park (Kellogg Ranch)
Well Location:	At ranch
Directions to well:	Located in NE portion of ranch, go around west side of house, turn east, then north & go along west side of barn, through gate to well just south of hill, 800 or 1000 feet NNE of house, by steel tank
Wellhead description: (casing & plumbing)	Well extends 2.5 feet, wrapped in tin and insulation, elbow and T-valves, to house and to 5 feet horizontal to steel stock tank

Shut in time vs. pressure head: 2006 measurements

Shut in time (minutes)	1	2	3	4	5	7	9	12	15	20	25	30	35	40
Pressure head (feet)	120.0	122.0	124.0	125.5	126.0	126.0	126.0	128.0	128.0	130.0	130.0	130.0	130.0	130.0

Shut in time (minutes)	50	60	70	80	100	120
Pressure head (feet)	130.0	130.0				

Long-term pressure head measurements

Date	Flow rate (gpm)	Shut-in Time (min)	Pressure Head (ft)	Rate of change(ft/yr)	Measurement made by
6/24/80			+177.9		USGS
04/23/85			+164.5	-3.0	Allen Comeskey
06/22/95	Shut in	68	+154.5	-1.0	Alan Wanek
05/17/06	10	60	+130.0	-2.2	Merlyn Skaley

147-100-20DDB2
William Ceynar

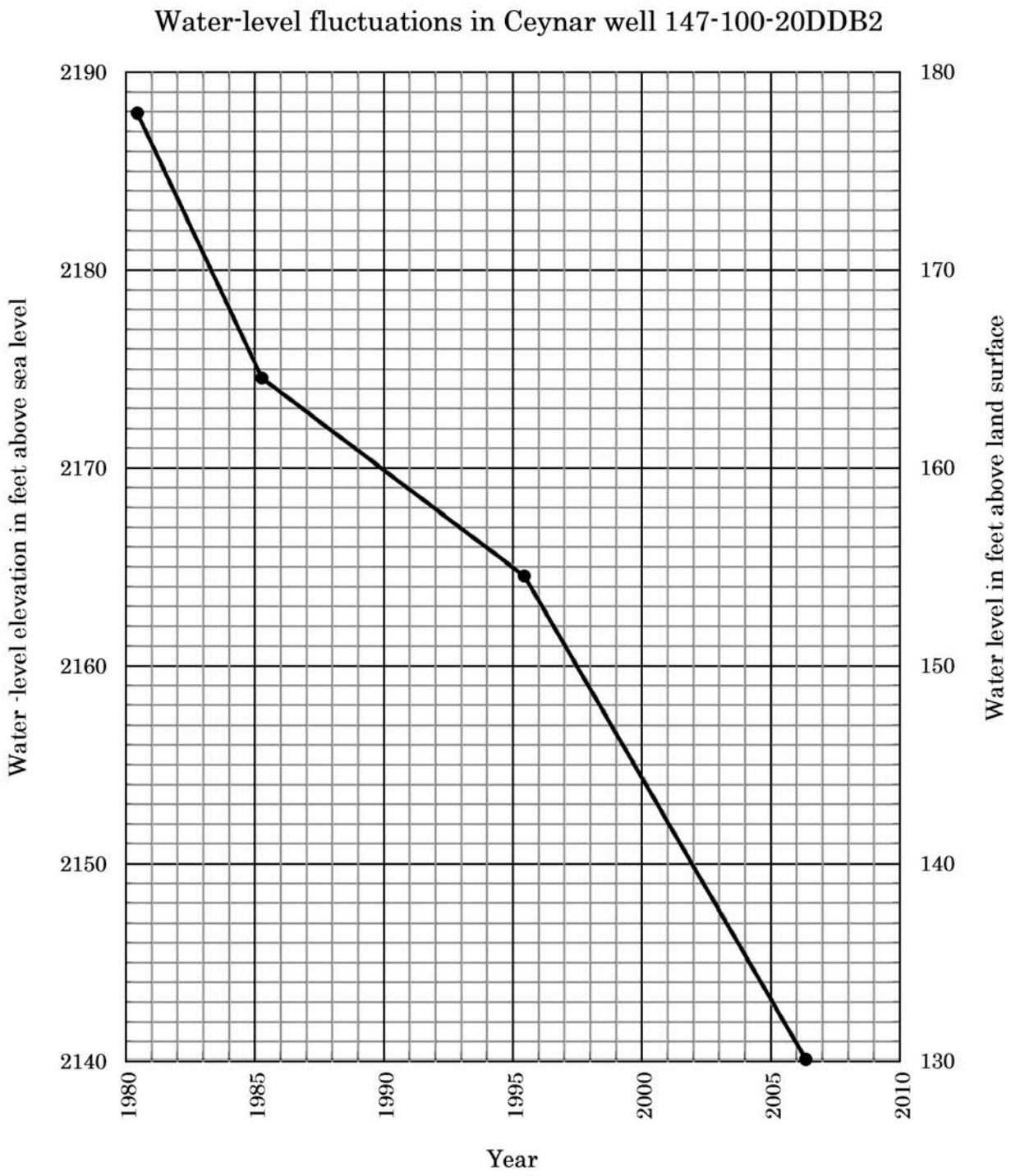
Date Completed:	11/28/1972	Purpose:	Stock Well
L.S. Elevation (ft):	2010	Well Type:	1.25 in. - Steel
Depth Drilled (ft):	1330	Aquifer:	Fox Hills
Screen Int. (ft.):	1290-1330	Data Source:	K.D. Thompson

Completion Info: 40 feet of casing perforated, grouted with 20 sacks of cement

Remarks:

Lithologic Log

Depth (ft)	Unit	Description
0-210	SHALE	Blue
210-240	SAND	
240-450	SHALE	and thin rocks
450-500	LIGNITE	Coal slack, fine
500-650	SHALE	
650-675	SAND	Fine, small flow
675-905	SHALE	
905-920	SAND	Water
920-1210	SHALE	
1210-1220	SAND	Very small flow
1220-1290	SHALE	
1290-1330	SAND	


Water-level fluctuations in Ceynar well 147-100-20DDB2
Water -level elevation in feet above sea level
Water level in feet above land surface
2190
2180
2170
2160
2150
2140
180
170
160
150
140
130
1980
1985
1990
1995
2000
2005
2010
Year

Water Quality

Location	147-100-20DDB2
County	McKenzie
Screened Interval	1290'-1330'
Aquifer	Fox Hills
Purpose	Stock Well
Date Sampled	05/17/06
Time Sampled	15:15:00
Yield (gpm)	10
Field Temp(C)	21.60
Lab pH	8.41
Field Conductivity (um/cm)	1697
Lab Conductivity (um/cm)	1870
Total Dissolved Solids (mg/L)	1160
Calcium (mg/L)	<2
Magnesium (mg/L)	<1
Potassium (mg/L)	<1
Sodium (mg/L)	419.0
Fluoride (mg/L)	5.11
Bicarbonate (mg/L)	998.0
Carbonate (mg/L)	16.0
Sulfate (mg/L)	<0.3
Chloride (mg/L)	104.0
Hydroxide (mg/L)	<1
Nitrate(mg/L)	<0.09
Iron (mg/L)	0.186
Manganese (mg/L)	0.012
Hardness(mg/L)	9.0
Sodium Adsorption Ratio (SAR)	60.3
Residual Sodium Carbonate (Equiv/L)	17.
Percent Sodium	99.0

William Ceynar well at 147-100-20DDB2

View at well

View looking south

148-102-15DDA1
NDSWC 5555

Date Completed:	09/04/1979	Purpose:	Stock Well
L.S. Elevation (ft):	2388.6	Well Type:	4 in. - Steel
Depth Drilled (ft):	1875	Aquifer:	Fox Hills
Screen Int. (ft.):	1695-1756	Data Source:	NDSWC - Allen Comeskey

Completion Info:

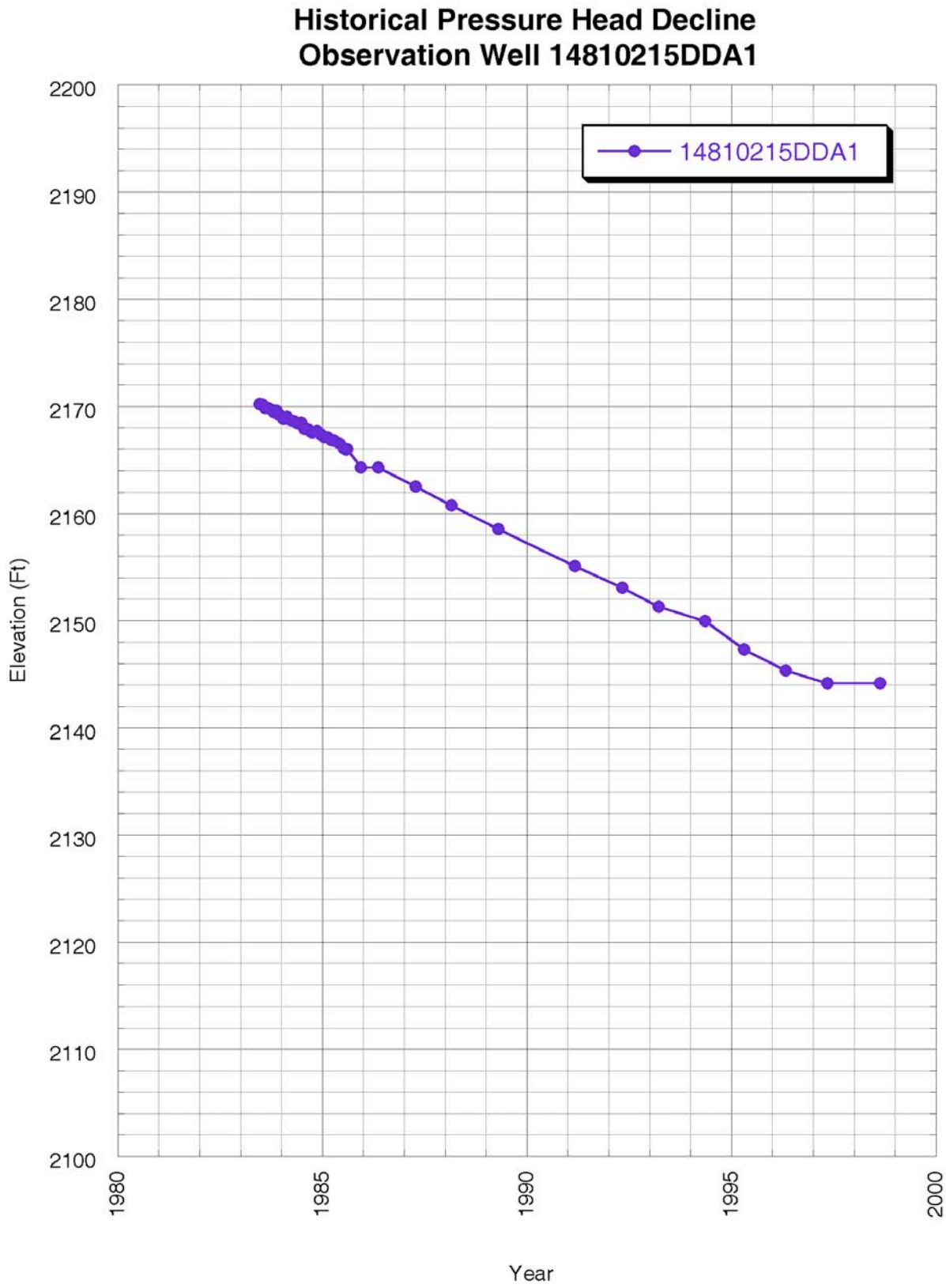
Remarks: Boxcar Butte south well located on hill a ways south of twin set of 2 inch monitoring wells (DDA2 & 3)

Lithologic Log

Depth (ft)	Unit	Description
0-110	SILTSTONE	Sandy, lignitic (Sentinel Butte)
110-234	SILTSTONE	Clayey, sandy, gray; lignite from 210 to 220 feet (Tongue River)
234-340	SANDSTONE	Silty, clayey; lignite at 312 feet
340-530	SILTSTONE	Clayey, sandy, gray; lignite from 424 to 450 feet
530-624	SANDSTONE	Silty, clayey, fine to medium, gray
624-636	LIGNITE	
636-660	SANDSTONE	And siltstone, gray
660-666	LIGNITE	
666-765	LIGNITE	And claystone, gray
765-810	SANDSTONE	Fine to medium, gray
810-862	CLAYSTONE	And lignite, gray to greenish-gray (Fort Union)
862-980	SANDSTONE	And siltstone, gray, lignitic
980-1054	SILTSTONE	And claystone, gray, lignitic
1054-1300	SANDSTONE	And siltstone, gray, lignitic
1300-1354	SILTSTONE	And claystone, gray
1354-1375	LIGNITE	And claystone
1375-1450	SILTSTONE	And claystone, gray (Hell Creek-Fox Hills)
1450-1490	SANDSTONE	And siltstone, clayey, fine to medium, carbonaceous
1490-1620	SILTSTONE	And claystone, gray, carbonaceous
1620-1680	SANDSTONE	Silty, fine to medium, gray, carbonaceous
1680-1755	SANDSTONE	Silty, fine to medium
1755-1775	SILTSTONE	Clayey, gray
1775-1850	SANDSTONE	Silty, fine to medium
1850-1875	SHALE	Gray

Water Quality

Location	148-102-15DDA1
County	McKenzie
Screened Interval	1695'-1756'
Aquifer	Fox Hills
Purpose	Stock Well
Date Sampled	09/26/79
Time Sampled	16:00:00
Yield (gpm)	
Field Temp(C)	22
Lab pH	8.6
Field Conductivity (um/cm)	1600
Lab Conductivity (um/cm)	1900
Total Dissolved Solids (mg/L)	1180
Calcium (mg/L)	2.3
Magnesium (mg/L)	2.8
Potassium (mg/L)	1.9
Sodium (mg/L)	480
Fluoride (mg/L)	5.1
Bicarbonate (mg/L)	1050
Carbonate (mg/L)	29
Sulfate (mg/L)	3.3
Chloride (mg/L)	120
Hydroxide (mg/L)	
Nitrate(mg/L)	1
Iron (mg/L)	0.73
Manganese (mg/L)	0
Hardness(mg/L)	17
Sodium Adsorption Ratio (SAR)	51
Residual Sodium Carbonate (Equiv/L)	18
Percent Sodium	98


Historical Pressure Head Decline
Observation Well 14810215DDA1
14810215DDA1
Elevation (Ft)
2200
2190
2180
2170
2160
2150
2140
2130
2120
2110
2100
1980
1985
1990
1995
2000
Year

148-102-15DDA2
NDSWC 5943

Date Completed:	09/04/1979	Purpose:	Observation Well - Plugged
L.S. Elevation (ft):	2350	Well Type:	2 in. - Steel
Depth Drilled (ft):	1500	Aquifer:	Hell Creek
Screen Int. (ft.):	1328-1352	Data Source:	NDSWC - Allen Comeskey

Completion Info:

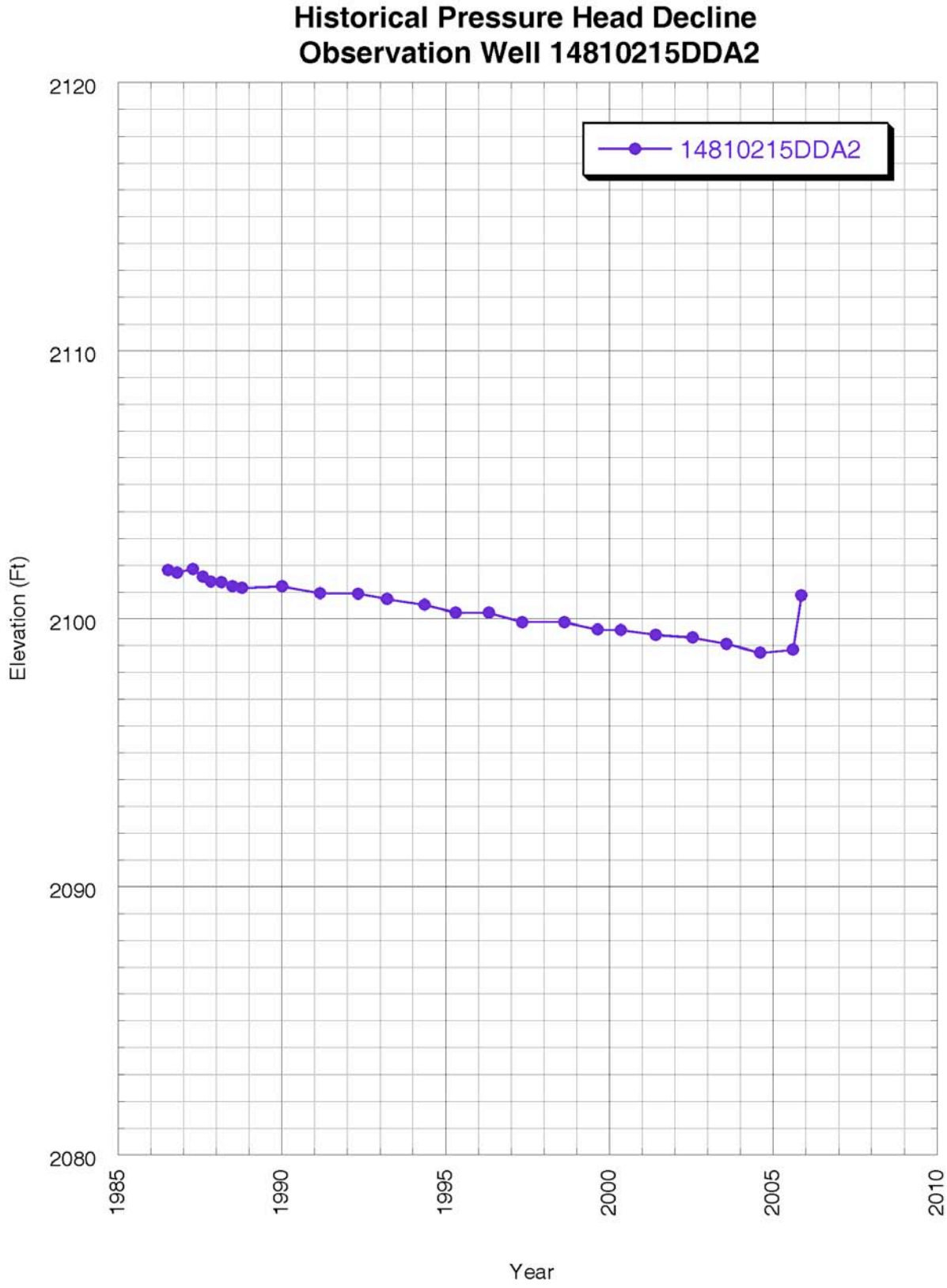
Remarks: west well of twin set, located south of trail Boxcar Butte

Lithologic Log

Depth (ft)	Unit	Description
0-110	SILTSTONE	Sandy, lignitic (Sentinel Butte)
110-234	SILTSTONE	Clayey, sandy, gray; lignite from 210 to 220 feet (Tongue River)
234-340	SANDSTONE	Silty, clayey; lignite at 312 feet
340-530	SILTSTONE	Clayey, sandy, gray; lignite from 424 to 450 feet
530-624	SANDSTONE	Silty, clayey, fine to medium, gray
624-636	LIGNITE	
636-660	SANDSTONE	And siltstone, gray
660-666	LIGNITE	
666-765	LIGNITE	And claystone, gray
765-810	SANDSTONE	Fine to medium, gray
810-862	CLAYSTONE	And lignite, gray to greenish-gray (Fort Union)
862-980	SANDSTONE	And siltstone, gray, lignitic
980-1054	SILTSTONE	And claystone, gray, lignitic
1054-1300	SANDSTONE	And siltstone, gray, lignitic
1300-1354	SILTSTONE	And claystone, gray
1354-1375	LIGNITE	And claystone
1375-1450	SILTSTONE	And claystone, gray (Hell Creek-Fox Hills)
1450-1490	SANDSTONE	And siltstone, clayey, fine to medium, carbonaceous
1490-1620	SILTSTONE	And claystone, gray, carbonaceous
1620-1680	SANDSTONE	Silty, fine to medium, gray, carbonaceous
1680-1755	SANDSTONE	Silty, fine to medium
1755-1775	SILTSTONE	Clayey, gray
1775-1850	SANDSTONE	Silty, fine to medium
1850-1875	SHALE	Gray

Water Quality

Location	148-102-15DDA2
County	McKenzie
Screened Interval	1328'-1352'
Aquifer	Hell Creek
Purpose	Observation Well - Plugged
Date Sampled	11/10/05
Time Sampled	09:00:00
Yield (gpm)	2 1/2
Field Temp(C)	
Lab pH	8.81
Field Conductivity (um/cm)	2064
Lab Conductivity (um/cm)	2690
Total Dissolved Solids (mg/L)	1700
Calcium (mg/L)	<2
Magnesium (mg/L)	1.2
Potassium (mg/L)	4.4
Sodium (mg/L)	770.0
Fluoride (mg/L)	2.73
Bicarbonate (mg/L)	1570
Carbonate (mg/L)	102.0
Sulfate (mg/L)	<0.3
Chloride (mg/L)	47.5
Hydroxide (mg/L)	<1
Nitrate(mg/L)	0.13
Iron (mg/L)	0.280
Manganese (mg/L)	0.016
Hardness(mg/L)	10.0
Sodium Adsorption Ratio (SAR)	106.0
Residual Sodium Carbonate (Equiv/L)	29.0
Percent Sodium	99.1


Historical Pressure Head Decline
Observation Well 14810215DDA2
14810215DDA2
Elevation (Ft)
2120
2110
2100
2090
2080
1985
1990
1995
2000
2005
2010
Year

149-095-09CDD
NDSWC 6275

Date Completed:	07/17/1984	Purpose:	Observation Well
L.S. Elevation (ft):	2225.8	Well Type:	2 in. - Steel
Depth Drilled (ft):	1740	Aquifer:	Fox Hills
Screen Int. (ft.):	1539-1564	Data Source:	NDSWC - Allen Comeskey

Completion Info: 25 feet of 12 slot stainless steel screen

Remarks:

Lithologic Log

Depth (ft)	Unit	Description
0-2	TOPSOIL	
2-20	SILT	Yellow brown with dark yellowish orange stringers, sandy, slightly clayey, (oxidized)
20-36	SILTSTONE	Yellowish brown, slightly argillaceous, carbonaceous streaks, lignite at 35 feet
36-55	SANDSTONE	Medium gray, very fine grained, angular, well sorted, argillaceous, slightly carbonaceous
55-85	CLAYSTONE	Medium gray, silty, lignite at 75 feet, carbonaceous below lignite
85-95	SILTSTONE	Medium gray, clayey
95-105	SANDSTONE	Very fine grained
105-165	CLAYSTONE	Medium gray, poorly indurated, interbedded lignite at 110-115 & 129-134, interbedded silt at 120-129 & 140-146
165-367	SANDSTONE	Greenish gray, very fine grained, well sorted, poorly indurated, slightly argillaceous, silty 175-190, interbedded lignite and clayey zones
367-443	SILTSTONE	Poor to no sample recovery
443-553	SANDSTONE	Light greenish gray, very fine grained, lignite bed 490-496
553-570	SILTSTONE	Greenish gray, interbedded lignite
570-625	CLAYSTONE	Greenish gray, interbedded with siltstone & lignite
625-780	SILTSTONE	Greenish gray, interbedded with lignite and clay, poor sample recovery, clayey 60-675, 700-720
780-1220	SANDSTONE	Poor sample recovery, AEC's description primarily based on relative ease/speed of drilling (4 feet/minute), primarily like sand with periodic zones of slower drilling like clay or silt, also periodic lignite beds
1220-1520	CLAYSTONE	Greenish gray, silty, poor sample recovery, drills slowly, like clay, with occasional sandier zones below 1340 feet
1520-1572	SANDSTONE	Greenish gray, very fine grained, well sorted, slightly argillaceous, glauconitic, drills much faster (Fox Hills Formation)
1572-1620	CLAYSTONE	Dark greenish gray, with some interbedded sand
1620-1659	SANDSTONE	Greenish gray, very fine grained, slightly glauconitic, slightly argillaceous, well sorted, interbedded with shale
1659-1740	CLAYSTONE	Medium dark gray, noncalcareous, drills tighter and slower (Pierre Shale or Lower Fox Hills Formation)

Water Quality

Location	149-095-09CDD
County	McKenzie
Screened Interval	1539'-1564'
Aquifer	Fox Hills
Purpose	Observation Well
Date Sampled	09/29/05
Time Sampled	08:00:00
Yield (gpm)	4.5
Field Temp(C)	
Lab pH	8.56
Field Conductivity (um/cm)	2042
Lab Conductivity (um/cm)	2510
Total Dissolved Solids (mg/L)	1360
Calcium (mg/L)	<2
Magnesium (mg/L)	<1
Potassium (mg/L)	2.6
Sodium (mg/L)	530.0
Fluoride (mg/L)	5.23
Bicarbonate (mg/L)	1100
Carbonate (mg/L)	38.0
Sulfate (mg/L)	0.99
Chloride (mg/L)	247.0
Hydroxide (mg/L)	<1
Nitrate(mg/L)	0.09
Iron (mg/L)	0.113
Manganese (mg/L)	0.029
Hardness(mg/L)	9.0
Sodium Adsorption Ratio (SAR)	76.3
Residual Sodium Carbonate (Equiv/L)	19.0
Percent Sodium	98.9

149-096-27CBA

Date Completed:	06/21/72	*Purpose:*	Stock Well
L.S. Elevation (ft):	2045'	*Well Type:*	2"Steel
Depth Drilled (ft):	1440'	*Aquifer:*	Fox Hills
Screened Interval (ft):	1380' - 1440'	*Source:*	Ralph Wold Well Drilling

Owner:	William Jorgenson
Address:	11010 16th Street NW, Watford City, ND 58854
Telephone #:	701-759-3460
Farmstead location:	Signalness Ranch, access through Rink Ranch and land, contact Delmar Rink 675-2458 or 675-2270
Well Location:	Pressure head measurement after being shut in for 1 hours
Directions to well:	Well reached through Rink Ranch (149-96-8DAA), scoria road from SW part of ranch, follow 1.5 miles south to E-W trail, short jog west then dirt trail .5 mi. to hay yard, follow ridge top (no trail) 1 mi. south to SE corner of meadow, proceed of foot .5 mile SSE across Burnt Creek draw to well and stock tank
Wellhead description: (casing & plumbing)	2 inch casing extends 18 inches, elbow, valve, faucet, steel tank

Shut in time vs. pressure head: 2006 measurements

Shut in time (minutes)	1	2	3	4	5	7	9	12	15	20	25	30	35	40
Pressure head (feet)	54.00	54.50	54.75	54.75	55.00	55.00	55.00	55.00	55.00	55.00	55.00	55.00	55.00	55.00

Shut in time (minutes)	50	60	70	80	100	120
Pressure head (feet)	55.00	55.00				

Long term pressure head measurements

Date	Flow rate (gpm)	Shut-in Time (min)	Pressure Head (ft)	Rate of change(ft/yr)	Measurement made by
07/01/1980			+110.9		USGS
04/30/85		10	+100.5	-2.2	Allen Comeskey
06/27/95	3.1	120	+89.6	-1.1	Alan Wanek
5/22/06	12	60	+55.00	-3.2	Merlyn Skaley

149-096-27CBA
William Jorgenson

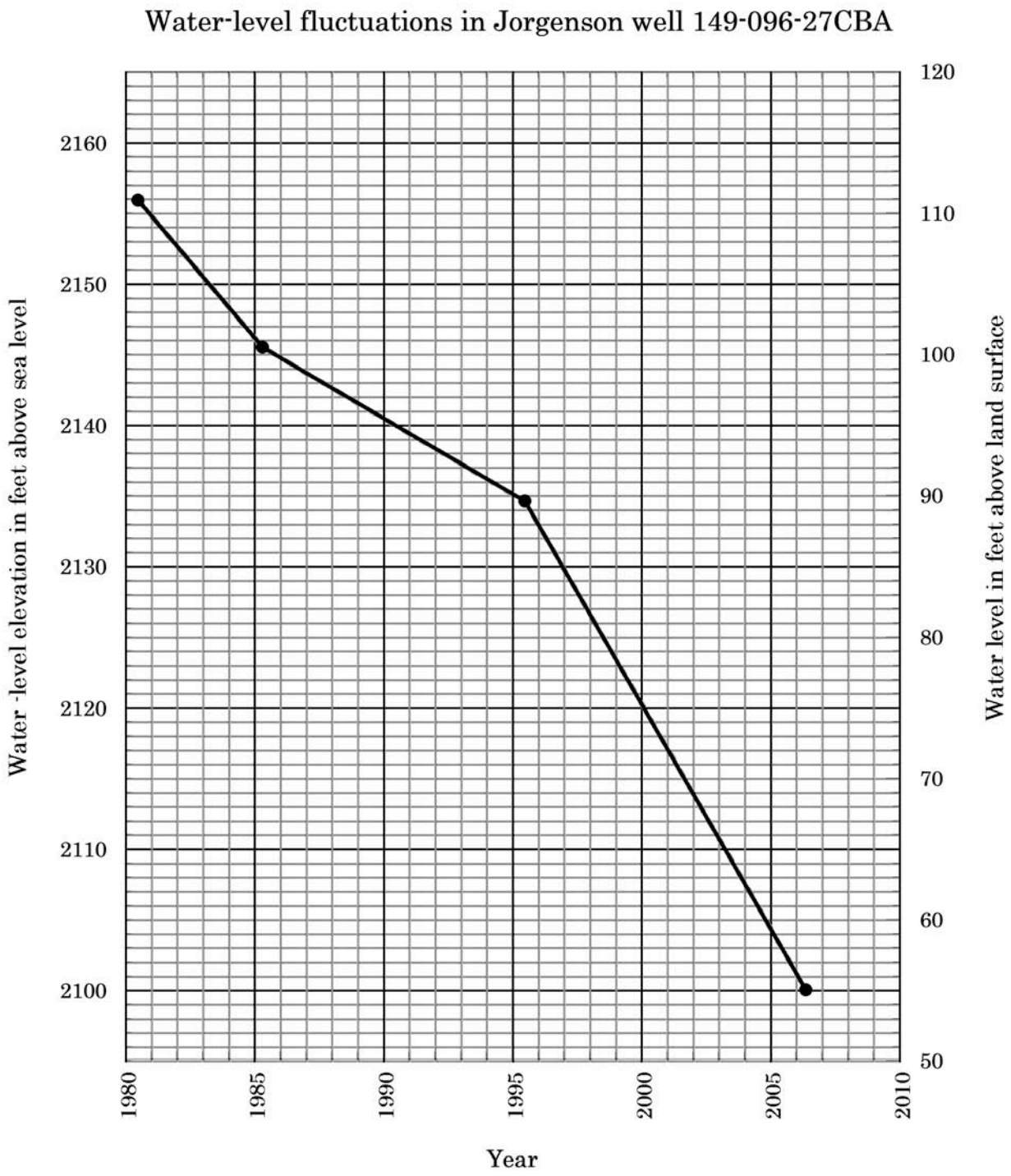
Date Completed:	06/21/1972	Purpose:	Stock Well
L.S. Elevation (ft):	2045	Well Type:	2 in. - Steel
Depth Drilled (ft):	1440	Aquifer:	Fox Hills
Screen Int. (ft.):	1380-1440	Data Source:	Ralph Wold Well Drilling

Completion Info: Lower 60 feet of casing perforated, grouted with cuttings

Remarks:

Lithologic Log

Depth (ft)	Unit	Description
0-416	CLAY	Coal: 75-78, 95-97, 128-132, 143-145, 193-196, 297-308, 410-416; rock: 224-227, 308-311
416-496	CLAY	Sandy
496-705	CLAY	Coal: 496-502, 585-593
705-727	SAND	
727-760	CLAY	
760-774	SAND	
774-808	CLAY	Rock: 774-777, Coal: 798-808
808-1210	SHALE	Coal: 1100-1115, 1180-1190
1210-1260	SAND	
1260-1377	SHALE	
1377-1440	SAND	


Water-level fluctuations in Jorgenson well 149-096-27CBA
Water -level elevation in feet above sea level
2160
2150
2140
2130
2120
2110
2100
120
110
100
90
80
70
60
50
Water level in feet above land surface
1980
1985
1990
1995
2000
2005
2010
Year

Water Quality

Location	149-096-27CBA
County	McKenzie
Screened Interval	1380'-1440'
Aquifer	Fox Hills
Purpose	Stock Well
Date Sampled	05/22/06
Time Sampled	17:00:00
Yield (gpm)	12
Field Temp(C)	
Lab pH	8.53
Field Conductivity (um/cm)	2080
Lab Conductivity (um/cm)	2210
Total Dissolved Solids (mg/L)	1370
Calcium (mg/L)	<2
Magnesium (mg/L)	<1
Potassium (mg/L)	1.85
Sodium (mg/L)	503.0
Fluoride (mg/L)	5.64
Bicarbonate (mg/L)	1100
Carbonate (mg/L)	37.0
Sulfate (mg/L)	<0.3
Chloride (mg/L)	168.0
Hydroxide (mg/L)	<1
Nitrate(mg/L)	<0.09
Iron (mg/L)	0.106
Manganese (mg/L)	<0.01
Hardness(mg/L)	9.0
Sodium Adsorption Ratio (SAR)	72.4
Residual Sodium Carbonate (Equiv/L)	19.0
Percent Sodium	99.2

William Jorgenson well at 149-096-27CBA

View looking north

View looking west

149-104-06ADB

Date Completed:	07/06/71	*Purpose:*	Domestic Well
L.S. Elevation (ft):	1902'	*Well Type:*	1.25"Steel
Depth Drilled (ft):	1220'	*Aquifer:*	Fox Hills
Screened Interval (ft):	1192' - 1220'	*Source:*	Francis Boyce Water Well

Owner:	James Kuykdendall
Address:	Box 28, Cartwright, ND 58838
Telephone #:	701-744-5808
Farmstead location:	East side of Yellowstone Valley, 7 miles south of Nelson Bridge
Well Location:	Well located at ranch (149-104-06ADB in County Study)
Directions to well:	Located at farm (white old house, red barn, quonset, corrals - other residences in area, road changed), well in corral area, hydrant at site, 3 X 12 inch planks over well curbing
Wellhead description: (casing & plumbing)	Well 6 to 8 feet below land surface, plumbed to hydrants and houses

Shut in time vs. pressure head: 2006 measurements

Shut in time (minutes)	1	2	3	4	5	7	9	12	15	20	25	30	35	40
Pressure head (feet)	125.0	125.0	125.0	125.0	125.0	125.0	125.0	125.0	125.0	125.0	125.0	125.0		

Shut in time (minutes)	50	60	70	80	100	120
Pressure head (feet)						

Long term pressure head measurements

Date	Flow rate (gpm)	Shut-in Time (min)	Pressure Head (ft)	Rate of change(ft/yr)	Measurement made by
07/01/1980			+207.9		USGS
04/30/85			+168.0	-8.4	Allen Comeskey
06/27/95		30	+152.5	-1.5	Alan Wanek
5/18/06	11	30	+125.00	-2.5	Merlyn Skaley

149-104-06ADB
James Kuykdendall

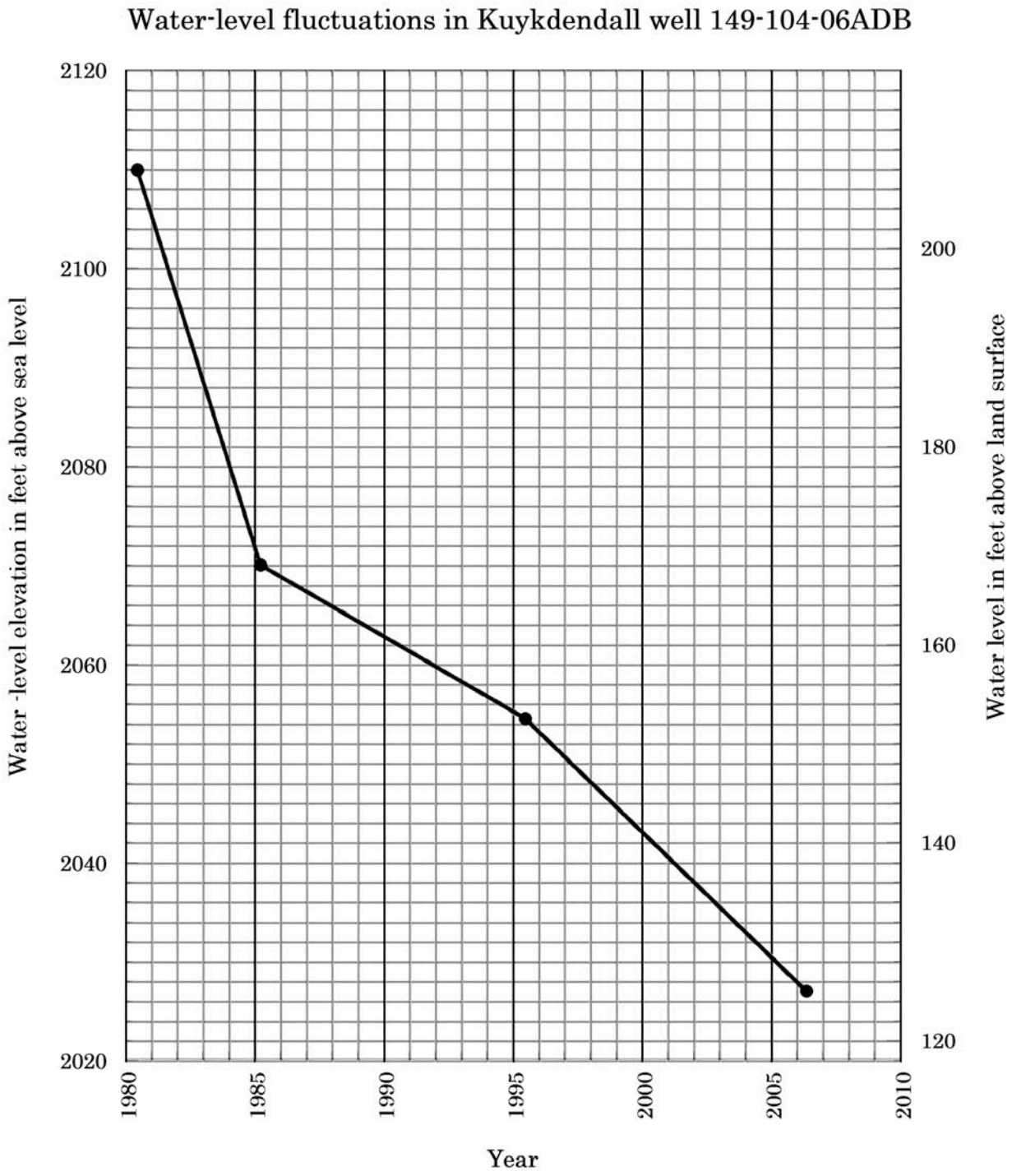
Date Completed:	07/06/1971	Purpose:	Domestic Well
L.S. Elevation (ft):	1902	Well Type:	1.25 in. - Steel
Depth Drilled (ft):	1220	Aquifer:	Fox Hills
Screen Int. (ft.):	1192-1220	Data Source:	Francis Boyce Water Well

Completion Info: Well head six feet below surface in 4X6 ft. curbing, plumbed to houses, farmyard hydrants

Remarks:

Lithologic Log

Depth (ft)	Unit	Description
0-25	CLAY	Brown, topsoil near surface
25-61	SAND	
61-87	GRAVEL	
87-263	CLAY	Gray, coal at 123-130, sandstone at 229-230, coal at 258-263
263-496	SHALE	Gray, sandstone at 300-302, coal at 370-398, 480-496
496-510	CLAY	Gray, sandy
510-760	SHALE	Gray, sandstone at 510-512, coal at 756-760
760-780	SAND	Gray
780-1160	SHALE	Gray, coal at 867-874, 915-922, sandstone at 931-932, coal at 1156-1160
1160-1190	CLAY	Gray, sandy
1190-1220	SAND	Artesian water strata, sandstone at 1190-1192


Water-level fluctuations in Kuykdendall well 149-104-06ADB
Water -level elevation in feet above sea level
2120
2100
2080
2060
2040
2020
Water level in feet above land surface
200
180
160
140
120
1980
1985
1990
1995
2000
2005
2010
Year

Water Quality

Location	149-104-06ADB
County	McKenzie
Screened Interval	1192'-1220'
Aquifer	Fox Hills
Purpose	Domestic Well
Date Sampled	05/18/06
Time Sampled	10:13:00
Yield (gpm)	11
Field Temp(C)	12.80
Lab pH	8.54
Field Conductivity (um/cm)	1821
Lab Conductivity (um/cm)	2030
Total Dissolved Solids (mg/L)	1260
Calcium (mg/L)	<2
Magnesium (mg/L)	<1
Potassium (mg/L)	<1
Sodium (mg/L)	453.0
Fluoride (mg/L)	5.26
Bicarbonate (mg/L)	1000
Carbonate (mg/L)	37.0
Sulfate (mg/L)	<0.3
Chloride (mg/L)	134.0
Hydroxide (mg/L)	<1
Nitrate(mg/L)	<0.09
Iron (mg/L)	0.145
Manganese (mg/L)	0.012
Hardness(mg/L)	9.0
Sodium Adsorption Ratio (SAR)	65.2
Residual Sodium Carbonate (Equiv/L)	17.0
Percent Sodium	99.1

James Kuykdendall well at 149-104-06ADB

View looking at hydrant

View looking west

150-099-22BBA1
NDSWC 5782-I

Date Completed:	09/01/1980	Purpose:	Observation Well
L.S. Elevation (ft):	2187.7	Well Type:	2 in. - Steel
Depth Drilled (ft):	2100	Aquifer:	Fox Hills
Screen Int. (ft.):	1742-1772	Data Source:	NDSWC - Allen Comeskey

Completion Info: 30 feet of 12 slot screen

Remarks: Watford City West well / top of hill north of hwy located on top of hill north of highway 85 and west of Madsen Flats, west most of triple set of wells

Lithologic Log

Depth (ft)	Unit	Description
0-2	TOPSOIL	
2-21	CLAY	Yellowish brown, oxidized, very sandy, pebbly, bouldery (till)
21-40	CLAY	Greenish gray, unoxidized, very sandy, pebbly, bouldery (till)
40-95	SANDSTONE	(Described from sidewall core taken at 55'), silt to medium grain sand, predominantly fine grained sand, medium to poorly sorted, angular to rounded, slightly oxidized, friable, slightly calcareous, moderately indurated
95-105	SILTSTONE	(Described from sidewall core taken at 100' and cuttings), olive gray, calcareous, argillaceous, moderately indurated, interbedded with shale-dark brownish gray to dark greenish gray, noncalcareous, bentonitic, carbonaceous, slightly silty, moderately indurated
105-107	LIGNITE	
107-117	SILTSTONE	As above
117-119	LIMESTONE	Medium gray
119-124	SILTSTONE	As above
124-126	LIGNITE	
126-140	SILTSTONE	As above
140-145	LIGNITE	
145-149	SHALE	Olive gray, noncalcareous, carbonaceous, bentonitic, moderately indurated
149-150	LIMESTONE	
150-180	SANDSTONE	(Described from sidewall core taken at 176' and cuttings), grayish green, very fine grain to fine grain, predominantly fine grain, moderately sorted, angular to rounded, calcareous, friable, very slightly argillaceous, moderately indurated, slightly interbedded with shale as above
180-194	SHALE	Olive gray, noncalcareous, carbonaceous, bentonitic, moderately indurated, interbedded with sandstone as above
194-230	SHALE	Brownish gray, noncalcareous, bentonitic, carbonaceous, moderately to well indurated, periodically interbedded with siltstone and sandstone
230-233	LIGNITE	
233-294	SILTSTONE	(Described from sidewall core taken at 310'), brownish gray, calcareous, argillaceous, periodically interbedded with shale as above
294-296	LIGNITE	
296-359	SILTSTONE	As above

150-099-22BBA1 - Continued

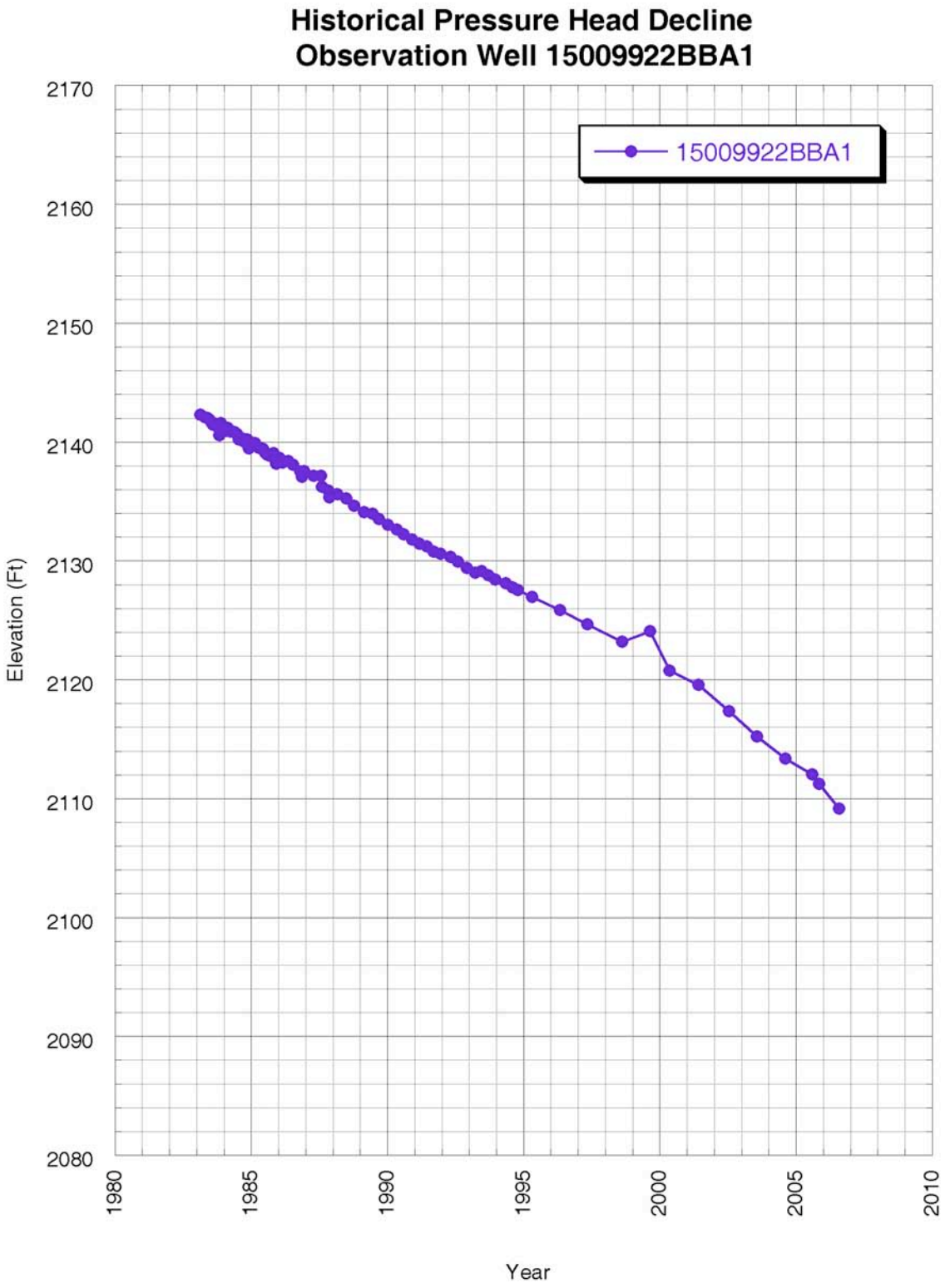
359-424	SANDSTONE	(Described from sidewall cores taken at 370', 377', 444', 504'), light olive green, very fine grain, well sorted, rounded, argillaceous, very calcareous, slightly carbonaceous, moderately indurated, interbedded with shale-greenish gray, calc., moderately indurated
424-426	LIMESTONE	Inferred from geophysical logs and drilling conditions
426-510	SANDSTONE	As above
510-545	SHALE	Dark brownish gray, moderately to well indurated, very calcareous, interbedded with less indurated shales and siltstone and carbonaceous zones
545-576	SHALE	Greenish gray to olive gray, calcareous, carbonaceous, slightly silty, moderately indurated, interbedded with shale-well indurated, fissile, and siltstone-grayish green, calcareous, slightly argillaceous
576-580	LIGNITE	
580-608	SHALE	As above
608-755	SILTSTONE	Greenish gray, calcareous, carbonaceous, very argillaceous, interbedded with shale-light olive gray, slightly silty, calcareous, moderately indurated, carbonaceous
755-775	SILTSTONE	Greenish gray, calcareous, very argillaceous, carbonaceous, moderately indurated, interbedded with sandstone-fine grain, calcareous, argillaceous, well sorted, subrounded
775-806	SHALE	Dusky yellowish brown to light olive gray, calcareous, carbonaceous, silty, moderately indurated
806-865	SILTSTONE	Greenish gray, calcareous, argillaceous, moderately indurated, interbedded with shale-olive gray, very silty, slightly calcareous, moderately indurated
865-876	SHALE	Greenish gray, silty, calcareous, carbonaceous, moderately indurated
876-892	SILTSTONE	(Described from sidewall core taken at 884'), light greenish gray, non-argillaceous, very calc., moderately indurated
892-906	SHALE	Greenish gray, silty, calcareous, carbonaceous, moderately indurated
906-916	SANDSTONE	(Described from sidewall core taken at 916'), greenish gray, silt to fine grain sand, moderately sorted, predominantly fine grain sand, angular to rounded, predominantly quartz, 5% other mineral, calcareous, slightly argillaceous, moderately indurated
916-940	SILTSTONE	(Described from sidewall core taken at 930'), dark greenish gray, calcareous, very argillaceous, moderately indurated
940-1045	SHALE	Olive gray, calcareous, very silty, moderately indurated, carbonaceous, interbedded with ss (poor sample)---Description of sidewall core taken at 1004'- Siltstone, olive gray, very calcareous, very argillaceous, bentonitic, moderately indurated
1045-1138	SILTSTONE	Greenish gray, noncalcareous, very argillaceous, moderately indurated, interbedded with shale as above--Description of sidewall core taken at 1067', Siltstone to very fine grain sandstone, light olive gray, calcareous, slightly carbonaceous, 100% quartz
1138-1140	LIGNITE	From sidewall core at 1140' and geophysical logs
1140-1145	SILTSTONE	Greenish gray, noncalcareous, very argillaceous, moderately indurated, interbedded with shale as above
1145-1176	SHALE	Olive gray, noncalcareous, silty, moderately indurated
1176-1180	LIGNITE	
1180-1190	SHALE	As above

150-099-22BBA1 - Continued

1190-1242	SILTSTONE	(Description from sidewall core taken at 1200'), greenish gray, argillaceous, slightly calcareous to noncalcareous, interbedded with sandstone-(description from sidewall core taken at 1224'), Light olive gray, very fine grain, well sorted, subrounded to angular, argillaceous, very calcareous, 100% quartz
1242-1270	SHALE	Olive gray, slightly silty, calcareous, moderately indurated
1270-1345	SANDSTONE	(Description from sidewall core taken at 1274'), dark greenish gray, very fine grain to silt, poorly sorted, angular to rounded
1345-1355	SHALE	Olive gray, noncalcareous, slightly silty, moderately indurated
1355-1395	SILTSTONE	Olive gray, noncalcareous, very argillaceous, slightly arenaceous, interbedded with olive gray shale
1395-1400	LIGNITE	
1400-1435	SILTSTONE	As above
1435-1439	LIGNITE	Inferred from geophysical logs
1439-1485	SILTSTONE	(Description from sidewall core taken at 1446' and cuttings), light olive gray, noncalcareous, very argillaceous, moderately indurated, interbedded with shale (poor sample)
1485-1500	SHALE	Olive gray, moderately indurated, poor sample
1500-1506	LIGNITE	
1506-1550	SHALE	Dark greenish gray, slightly silty, noncalcareous, moderately indurated, interbedded with sandstone (description from sidewall core taken at 1534'), greenish gray, fine grain to silt, poorly sorted, angular to rounded, noncalcareous, argillaceous, 100% quartz
1550-1690	SILTSTONE	(Description from sidewall core taken at 1560'), light olive gray, very argillaceous, very calcareous, moderately indurated, interbedded with shale (from cuttings and drilling core), greenish gray, calcareous, moderately indurated--Description of sidewall core taken at 1620' and 1660'-Siltstone, dark greenish gray, noncalcareous, very argillaceous
1690-2005	SANDSTONE	Greenish gray, fine grain to silt, moderately sorted, angular to rounded, 90% quartz, 10% dark minerals, noncalcareous, argillaceous, interbedded with brownish gray, carbonaceous shale, (ss described from sidewall core taken at 1700')--Description of sidewall are taken at 1775' and 1780'-Sandstone, silt to medium grain, poorly sorted, angular to rounded, 50% quartz, 50% dark minerals, slightly argillaceous, noncalcareous--Description of sidewall cores taken at 1790' and 1798'-Sandstone, greenish gray, fine grain to silt, moderately sorted, subangular to rounded, predominantly quartz, slightly argillaceous, noncalcareous--Description of sidewall are taken at 1806'-Sandstone, greenish gray, silt to fine grain, moderately sorted, predominantly fine grain, subangular to rounded 80% quartz, 10% glauconite, 10% oxidized minerals, noncalcareous, slightly argillaceous--Description of sidewall cores taken at 1880' and 1890'-Sandstone, dark greenish gray, fine grain, well sorted, angular, rounded, predominantly quartz, glauconitic, noncalcareous, slightly argillaceous--Description of sidewall core taken at 1912'-Sandstone, light olive gray, fine grain, well sorted, angular to rounded, predominantly quartz, 20% dark minerals and glauconite, very calcareous, slightly argillaceous--Description of sidewall core taken at 1948'-Sandstone, very fine grain, well sorted, angular to subangular, slightly calcareous, argillaceous, 90% quartz, 10% glauconite
2005-2100	SHALE	(Description from sidewall core taken at 2018'), brownish black, noncalcareous, well indurated

Water Quality

Location	150-099-22BBA1
County	McKenzie
Screened Interval	1742'-1772'
Aquifer	Fox Hills
Purpose	Observation Well
Date Sampled	11/09/05
Time Sampled	17:00:00
Yield (gpm)	5
Field Temp(C)	
Lab pH	8.68
Field Conductivity (um/cm)	2005
Lab Conductivity (um/cm)	2120
Total Dissolved Solids (mg/L)	1290
Calcium (mg/L)	<2
Magnesium (mg/L)	<1
Potassium (mg/L)	3.0
Sodium (mg/L)	587.0
Fluoride (mg/L)	5.60
Bicarbonate (mg/L)	1000
Carbonate (mg/L)	55.0
Sulfate (mg/L)	0.44
Chloride (mg/L)	143.0
Hydroxide (mg/L)	<1
Nitrate(mg/L)	0.27
Iron (mg/L)	0.012
Manganese (mg/L)	<0.01
Hardness(mg/L)	9.0
Sodium Adsorption Ratio (SAR)	84.5
Residual Sodium Carbonate (Equiv/L)	18.0
Percent Sodium	99.0


Historical Pressure Head Decline
Observation Well 15009922BBA1
15009922BBA1
Elevation (Ft)
2170
2160
2150
2140
2130
2120
2110
2100
2090
2080
1980
1985
1990
1995
2000
2005
2010
Year

15010404AAB

Date Completed:	07/25/77	*Purpose:*	Domestic Well
L.S. Elevation (ft):	1885'	*Well Type:*	2"Steel
Depth Drilled (ft):	1385'	*Aquifer:*	Fox Hills
Screened Interval (ft):	1340' - 1380'	*Source:*	Boyce Drilling, Inc.

Owner:	Harold Schlothauer
Address:	Route 2, Box 2233, East Fairview, ND 59221
Telephone #:	701-744-5741
Farmstead location:	2 miles west and 1 mile south of Jalmer Nelson Bridge
Well Location:	Pressure head measurement after being shut in for 30 minutes
Directions to well:	Located on SW corner of house, by bushes, in 5 feet dia. Upturned culvert, about 8 feet below grade, lines with valves going off to barn, outside faucets, another house, shut in
Wellhead description: (casing & plumbing)	Valved lines to house, hydrants, barn, hydrant at well head

Shut in time vs. pressure head: 2006 measurements

Shut in time (minutes)	1	2	3	4	5	7	9	12	15	20	25	30	35	40
Pressure head (feet)	135.0	135.0	135.0	135.0	135.0	135.0	135.0	135.0	135.0	135.0	135.0	135.0		

Shut in time (minutes)	50	60	70	80	100	120
Pressure head (feet)						

Long term pressure head measurements

Date	Flow rate (gpm)	Shut-in Time (min)	Pressure Head (ft)	Rate of change(ft/yr)	Measurement made by
07/25/77			+231.0		Fred Boyce
04/24/85			+171.5	-7.7	Allen Comeskey
06/23/1995	shut in	20	+161.6	-1.0	Alan Wanek
5/18/06	10	30	+135.0	-2.4	Merlyn Skaley

150-104-04AAB
Harold Schlothauer

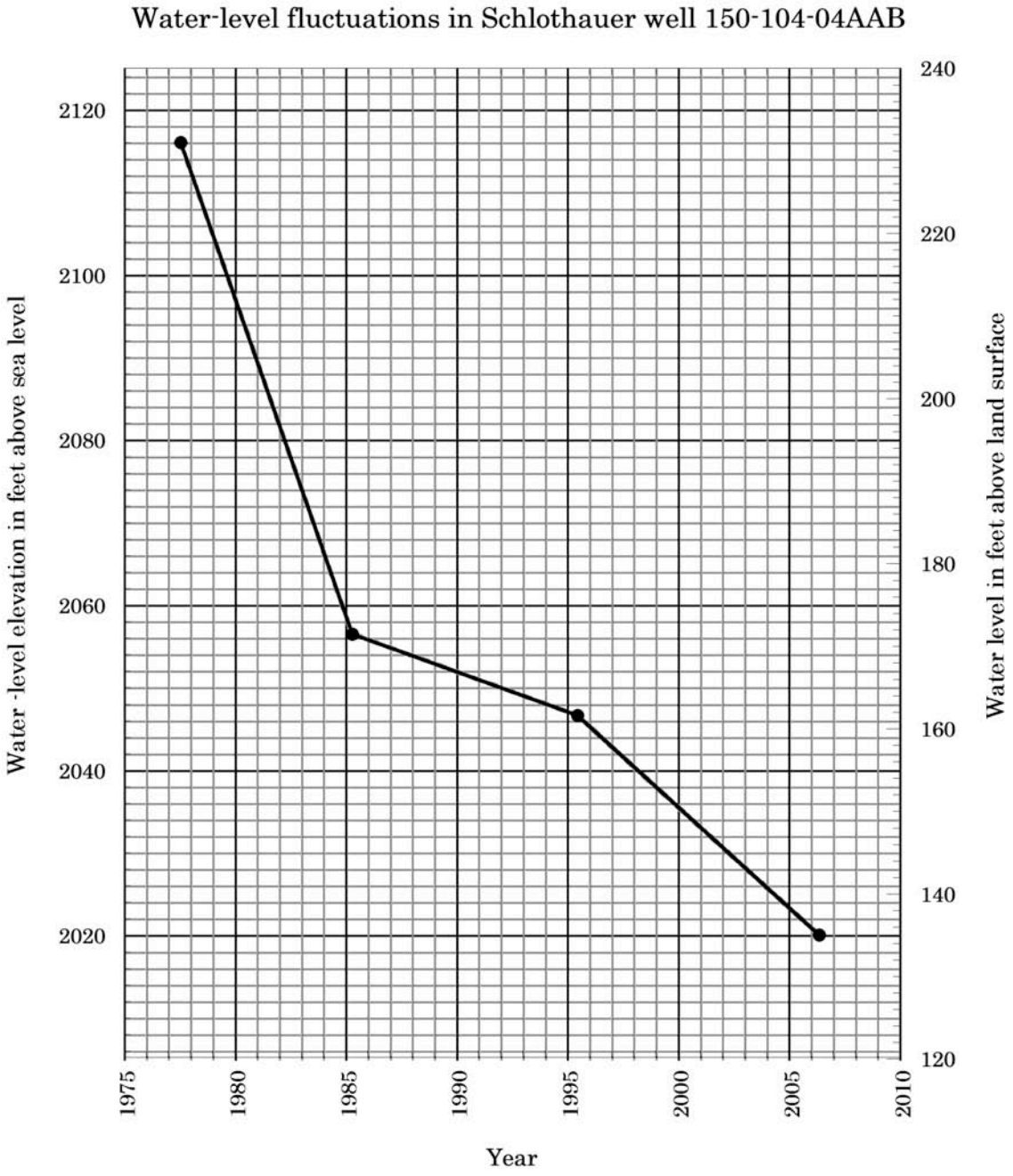
Date Completed:	07/25/1977	Purpose:	Domestic Well
L.S. Elevation (ft):	1885	Well Type:	2 in. - Steel
Depth Drilled (ft):	1385	Aquifer:	Fox Hills
Screen Int. (ft.):	1340-1380	Data Source:	Boyce Drilling, Inc.

Completion Info: 120 feet of 5 inch surface casing, 42 feet of pipe perforated, grouted to 1000 feet with neat cement

Remarks:

Lithologic Log

Depth (ft)	Unit	Description
0-85	SAND	Brown, with clay
85-97	GRAVEL	
97-118	SAND	Gray
118-125	LIGNITE	Coal
125-160	CLAY	Gray
160-170	LIGNITE	
170-200	CLAY	Gray
200-340	SAND	Gray, fine
340-405	CLAY	Gray
405-415	LIGNITE	
415-575	CLAY	Gray, with coal
575-576	SANDSTONE	
576-750	CLAY	Gray
750-752	SANDSTONE	
752-815	CLAY	Gray
815-817	SANDSTONE	
817-1340	CLAY	Gray, sandy
1340-1380	SAND	Water
1380-1385	CLAY	Gray


Water-level fluctuations in Schlothauer well 150-104-04AAB
Water -level elevation in feet above sea level
2120
2100
2080
2060
2040
2020
240
220
200
180
160
140
120
Water level in feet above land surface
1975
1980
1985
1990
1995
2000
2005
2010
Year

150-104-04AAB
No Water Quality Analysis

15010414BCA

Date Completed:	08/30/1967	*Purpose:*	Stock Well
L.S. Elevation (ft):	2092'	*Well Type:*	1.25" Steel
Depth Drilled (ft):	1270'	*Aquifer:*	Hell Creek
Screened Interval (ft):	943' - 960'	*Source:*	Boyce Drilling, Inc.

Owner:	Annie Walker and John Walker (son)
Address:	2741 Cheney Creek Road
Telephone #:	701-744-5772
Farmstead location:	3 miles south of Jalmer Nelson bridge, east side of Yellowstone River
Well Location:	Up in the breaks of the Yellowstone River Valley, 1 mile east of house
Directions to well:	From driveway/highway, 500 feet south along highway, approach to pasture, proceed ENE along faint trails, past trash dump, across draw, through fence, by pipeline path, through draw, & down into another draw, between small stock dams, old wooden tank by well
Wellhead description: (casing & plumbing)	2 feet out of ground, 4 in surface, T with top plugged, horizontal line to old wooden stock tank

*******Pressure head measurement was not taken due to poor condition of well*******

Long term pressure head measurements

Date	Flow rate (gpm)	Shut-in Time (min)	Pressure Head (ft)	Rate of change(ft/yr)	Measurement made by
06/26/80			+37.0		USGS
03/27/85		85	+25.5.5	-2.4	Allen Comeskey
06/23/1995	1.24	120	+29.0	+0.4	Alan Wanek
2006	NA	NA	NA	NA	NA

150-104-14BCA
Annie and John Walker

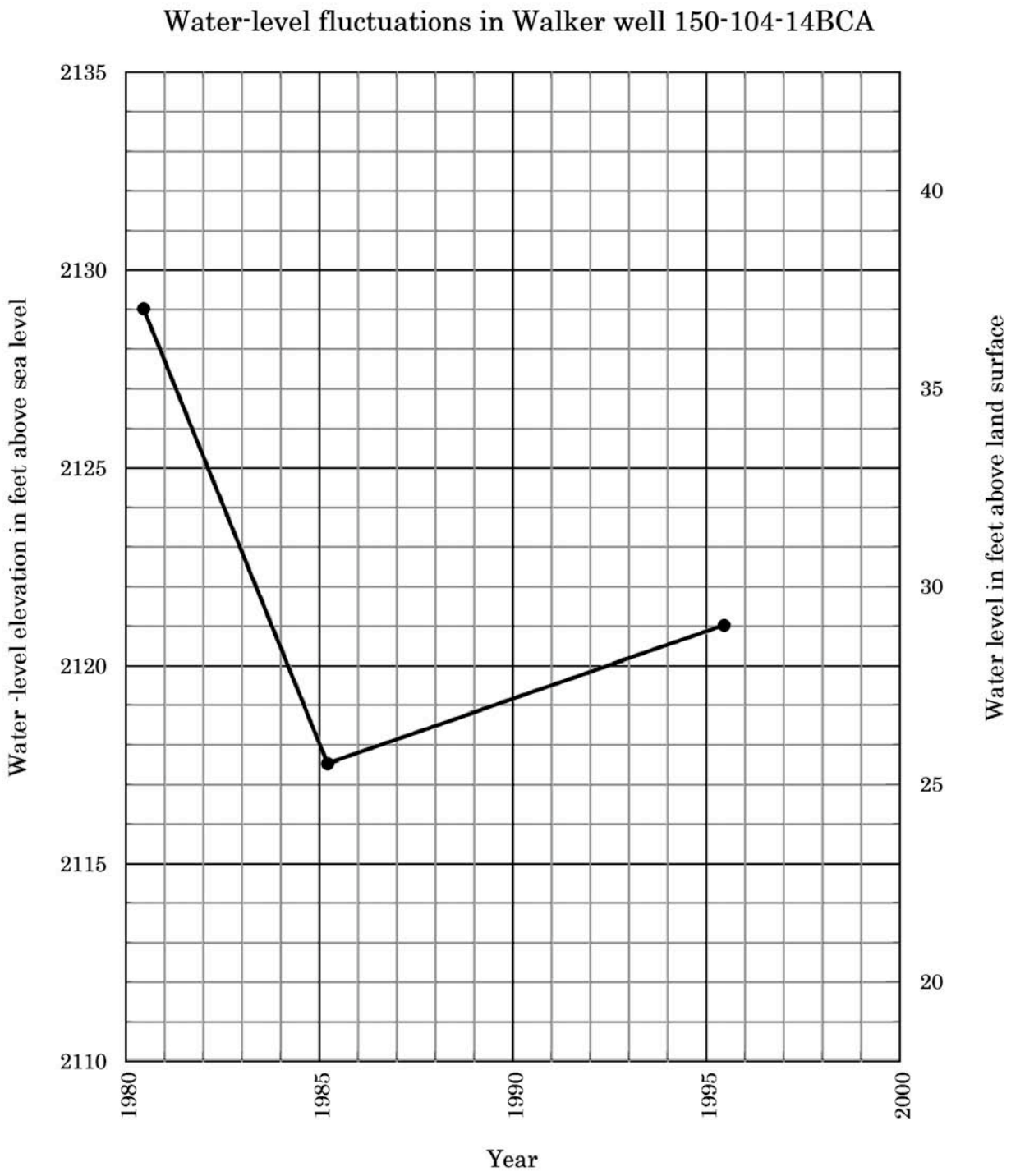
Date Completed:	8/1967	Purpose:	Stock Well
L.S. Elevation (ft):	2092	Well Type:	1.25 in. - Steel
Depth Drilled (ft):	1270	Aquifer:	Hell Creek
Screen Int. (ft.):	943-960	Data Source:	Francis Boyce Water Well

Completion Info:

Remarks:

Lithologic Log

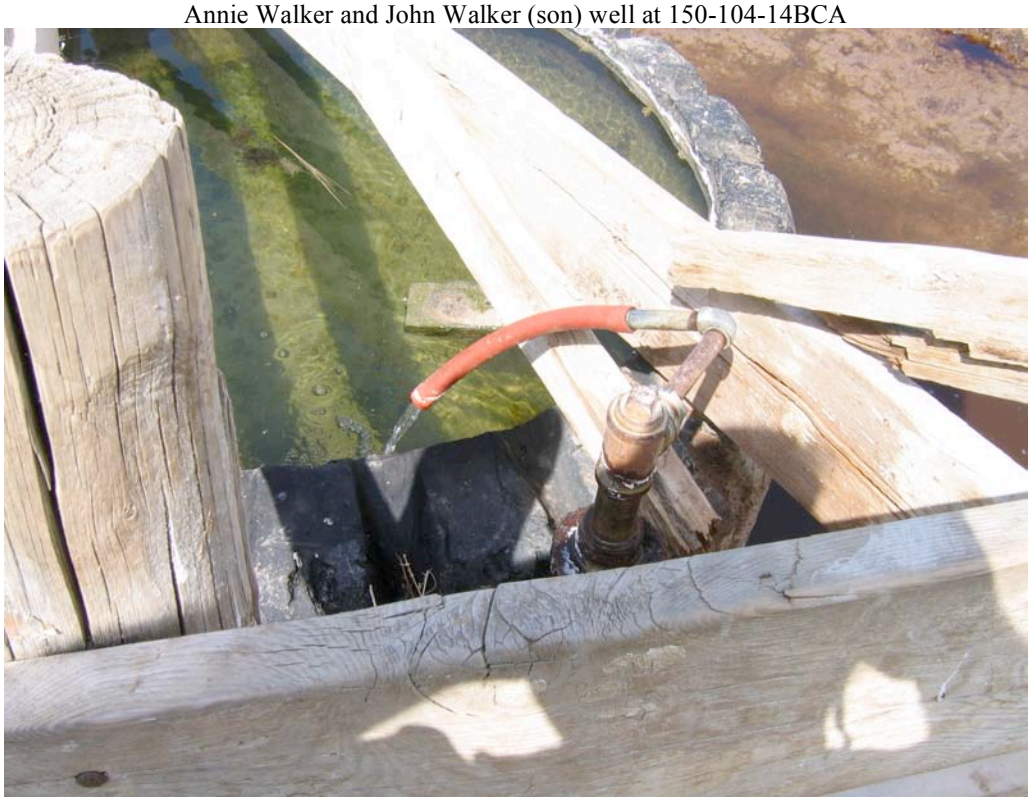
Depth (ft)	Unit	Description
0-3	TOPSOIL	
3-43	CLAY	Yellowish brown, sandy
43-303	SHALE	Gray, coal at 43-46, 122-125, 150-156, 255-263, sandy clay from 225-255
303-318	SANDSTONE	
318-394	SHALE	With interbedded sandstone, coal at 318-323, rock at 354-355
394-408	SANDSTONE	
408-431	SHALE	White, sandy, soft rock at 408-410, rock at 430-431
431-437	SHALE	
437-450	LIGNITE	
450-462	CLAY	?
462-626	SHALE	Coal at 462-470, rock at 470-478, hard shale to 542, soft shale to 570, interbedded with coal to 626
626-651	SANDSTONE	Coal at 636-641
651-953	SHALE	Hard, sandstone 662-684, indurated 684-693, rock at 796-807, 828-829, 869-871, 891-892, 930-935
953-990	SANDSTONE	
990-1270	SHALE	Hard


Water-level fluctuations in Walker well 150-104-14BCA
Water -level elevation in feet above sea level
2135
2130
2125
2120
2115
2110
Water level in feet above land surface
40
35
30
25
20
1980
1985
1990
1995
2000
Year

Water Quality

Location	150-104-14BCA
County	McKenzie
Screened Interval	943'-960'
Aquifer	Hell Creek
Purpose	Stock Well
Date Sampled	05/18/06
Time Sampled	11:46:00
Yield (gpm)	3/4
Field Temp(C)	17.10
Lab pH	8.19
Field Conductivity (um/cm)	3890
Lab Conductivity (um/cm)	3270
Total Dissolved Solids (mg/L)	2030
Calcium (mg/L)	3.68
Magnesium (mg/L)	2.0
Potassium (mg/L)	2.48
Sodium (mg/L)	762.0
Fluoride (mg/L)	2.41
Bicarbonate (mg/L)	2080
Carbonate (mg/L)	<1
Sulfate (mg/L)	0.35
Chloride (mg/L)	108.0
Hydroxide (mg/L)	<1
Nitrate(mg/L)	<0.09
Iron (mg/L)	0.097
Manganese (mg/L)	0.010
Hardness(mg/L)	17.0
Sodium Adsorption Ratio (SAR)	79.4
Residual Sodium Carbonate (Equiv/L)	34.0
Percent Sodium	99.0

Annie Walker and John Walker (son) well at 150-104-14BCA



View looking at well

View looking northwest

151-095-04DBD1
NDSWC 5939

Date Completed:	06/29/1981	Purpose:	Observation Well - Plugged
L.S. Elevation (ft):	2308	Well Type:	2 in. - Steel
Depth Drilled (ft):	1260	Aquifer:	Hell Creek
Screen Int. (ft.):	1178-1196	Data Source:	NDSWC - Allen Comeskey

Completion Info:

Remarks: Chimney Butte east well located in pasture southeast of butte, north of road and east of gate into pasture a few hundred feet, east well of twin set. Pumps poorly 1988.

Lithologic Log

Depth (ft)	Unit	Description
0-65	SILTSTONE	And claystone
65-75	LIGNITE	
75-95	SILTSTONE	Gray
95-115	LIGNITE	And claystone
115-200	SILTSTONE	And claystone, gray
200-210	LIGNITE	
210-290	SILTSTONE	And claystone, gray, carbonaceous
290-385	SANDSTONE	Silty, gray
385-440	SILTSTONE	And lignite, sandy, gray
440-555	SILTSTONE	Lignitic
555-590	LIGNITE	
590-665	SILTSTONE	And claystone, gray
665-680	Lignite	
680-800	SILTSTONE	Clayey, sandy
800-900	SILTSTONE	And claystone
900-920	SILTSTONE	Sandy
920-1060	SILTSTONE	And claystone
1060-1120	SILTSTONE	And sandstone
1120-1160	CLAYSTONE	Silty, gray
1160-1180	LIGNITE	
1180-1260	SILTSTONE	Sandy, gray
1260-1275	CLAYSTONE	Brown, carbonaceous; (One log written for holes 1 & 2, log from 1260 would apply only to hole 2)
1275-1380	SANDSTONE	Silty, fine, greenish gray
1380-1450	SANDSTONE	And siltstone, fine, gray
1450-1620	SILTSTONE	And claystone, gray

151-095-04DBD1
No Water Quality Analysis

151-095-04DBD2
NDSWC 6164

Date Completed:	05/26/1983	Purpose:	Observation Well
L.S. Elevation (ft):	2309	Well Type:	2 in. - Steel
Depth Drilled (ft):	1620	Aquifer:	Fox Hills
Screen Int. (ft.):	1407-1432	Data Source:	NDSWC - Allen Comeskey

Completion Info: 25 feet of 12 slot stainless steel screen

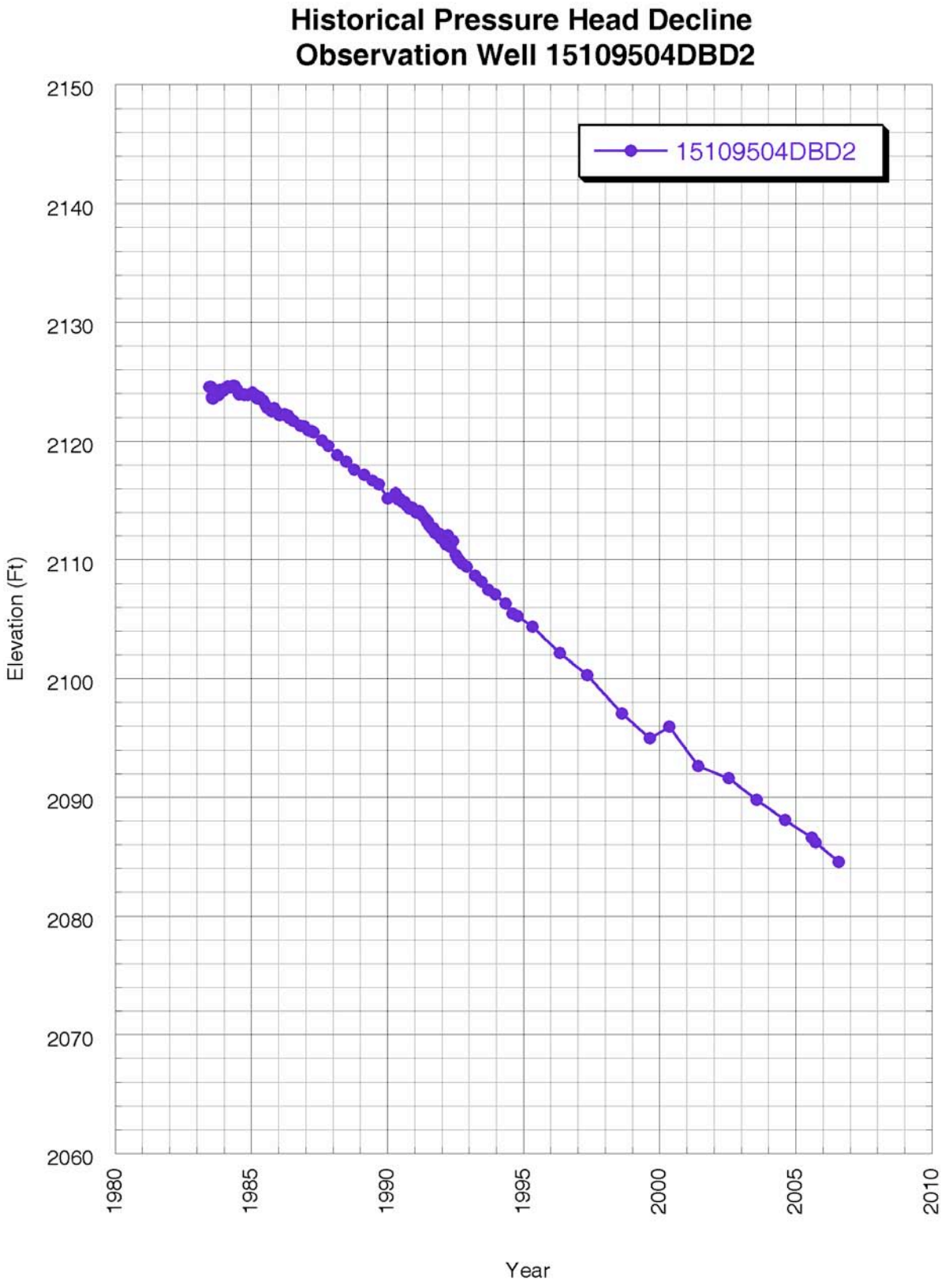
Remarks: Chimney Butte west well located in pasture SE of butte, NE of gate, west well of twin set, east well is 100 or so feet away

Lithologic Log

Depth (ft)	Unit	Description
0-65	SILTSTONE	And claystone
65-75	LIGNITE	
75-95	SILTSTONE	Gray
95-115	LIGNITE	And claystone
115-200	SILTSTONE	And claystone, gray
200-210	LIGNITE	
210-290	SILTSTONE	And claystone, gray, carbonaceous
290-385	SANDSTONE	Silty, gray
385-440	SILTSTONE	And lignite, sandy, gray
440-555	SILTSTONE	Lignitic
555-590	LIGNITE	
590-665	SILTSTONE	And claystone, gray
665-680	Lignite	
680-800	SILTSTONE	Clayey, sandy
800-900	SILTSTONE	And claystone
900-920	SILTSTONE	Sandy
920-1060	SILTSTONE	And claystone
1060-1120	SILTSTONE	And sandstone
1120-1160	CLAYSTONE	Silty, gray
1160-1180	LIGNITE	
1180-1260	SILTSTONE	Sandy, gray
1260-1275	CLAYSTONE	Brown, carbonaceous; (One log written for holes 1 & 2, log from 1260 would apply only to hole 2)
1275-1380	SANDSTONE	Silty, fine, greenish gray
1380-1450	SANDSTONE	And siltstone, fine, gray
1450-1620	SILTSTONE	And claystone, gray

Water Quality

Location	151-095-04DBD2
County	McKenzie
Screened Interval	1407'-1432'
Aquifer	Fox Hills
Purpose	Observation Well
Date Sampled	09/27/05
Time Sampled	12:30:00
Yield (gpm)	2.5
Field Temp(C)	
Lab pH	8.68
Field Conductivity (um/cm)	2048
Lab Conductivity (um/cm)	2510
Total Dissolved Solids (mg/L)	1450
Calcium (mg/L)	<2
Magnesium (mg/L)	1.0
Potassium (mg/L)	2.7
Sodium (mg/L)	570.0
Fluoride (mg/L)	5.36
Bicarbonate (mg/L)	1130
Carbonate (mg/L)	60.0
Sulfate (mg/L)	<0.3
Chloride (mg/L)	255.0
Hydroxide (mg/L)	<1
Nitrate(mg/L)	<0.09
Iron (mg/L)	0.042
Manganese (mg/L)	<0.01
Hardness(mg/L)	9.0
Sodium Adsorption Ratio (SAR)	82.1
Residual Sodium Carbonate (Equiv/L)	20.0
Percent Sodium	99.0


Historical Pressure Head Decline
Observation Well 15109504DBD2
15109504DBD2
Elevation (Ft)
2150
2140
2130
2120
2110
2100
2090
2080
2070
2060
1980
1985
1990
1995
2000
2005
2010
Year

151-103-11AAA
NDSWC 6279

Date Completed:	05/07/1985	Purpose:	Observation Well
L.S. Elevation (ft):	2186.7	Well Type:	4 in. - Steel
Depth Drilled (ft):	1920	Aquifer:	Fox Hills
Screen Int. (ft.):	1680-1753	Data Source:	NDSWC - Allen Comeskey

Completion Info: Open hole completion at 1680 feet

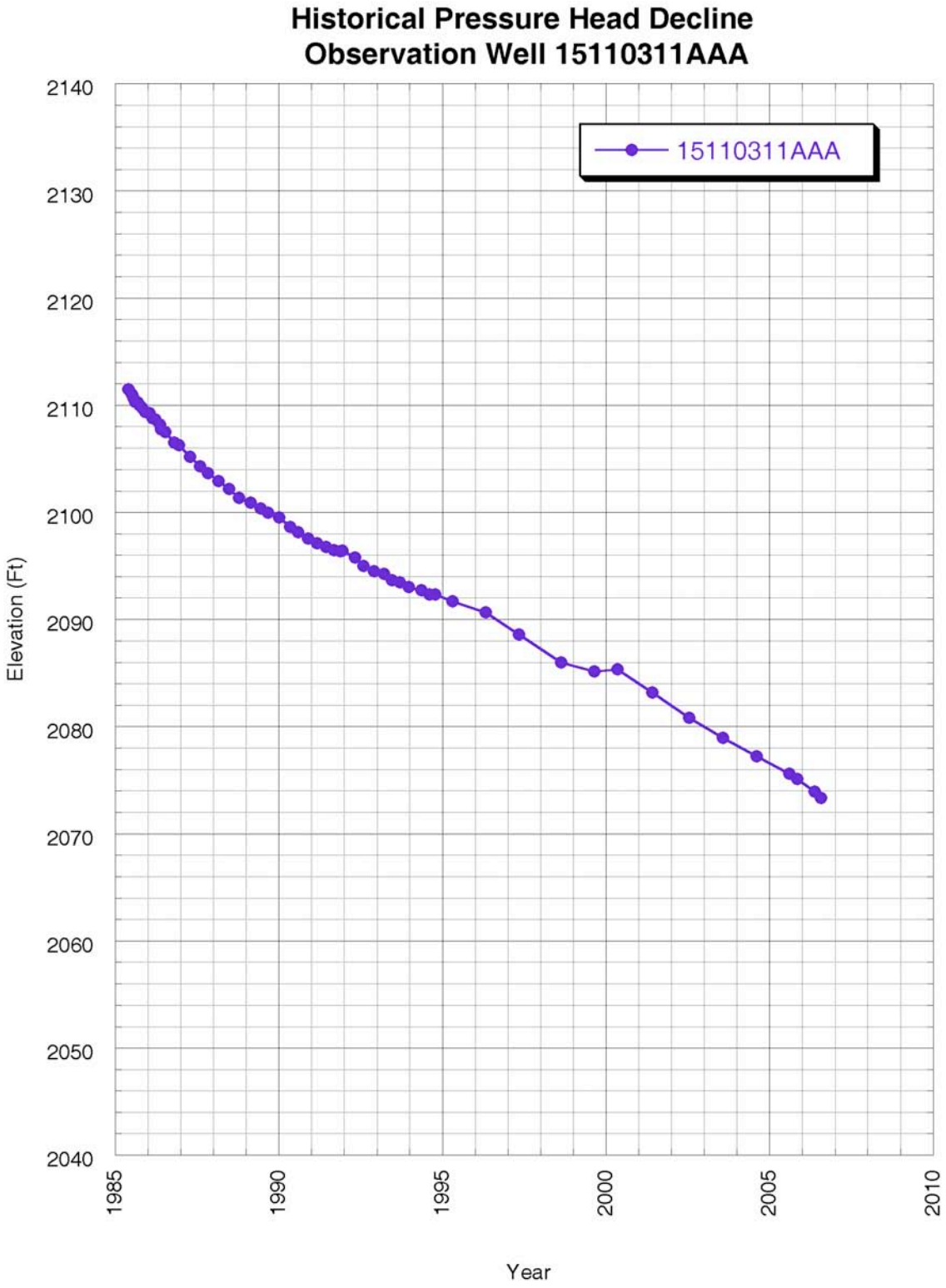
Remarks: Elk well,
located in pasture west of trail a bit south of road, named from oil field & probably township

Lithologic Log

Depth (ft)	Unit	Description
0-1	TOPSOIL	
1-15	CLAYSTONE	Dark yellowish orange, slightly sitly, poorly indurated, (oxidized)
15-35	CLAYSTONE	Greenish gray, slightly sitly, poorly indurated
35-130	SANDSTONE	Greenish gray, very fine grained, well sorted, argillaceous, poorly indurated, clayey 45-50, lignite bed 112-116, clayey 116-120
130-250	CLAYSTONE	Medium dark gray, poorly indurated, interbedded bentonite, lignite 138-140, silty 150-165, sandy 170-185, silty 220-230
250-314	SANDSTONE	Greenish to brownish gray, very fine grained to fine grained, argillaceous, interbedded clay, indurated 257-259, lignite 311-314
314-430	SILTSTONE	Brownish gray to greenish gray, argillaceous, limestone 345-355, indurated zone 421-425, clayey 425-430
430-450	SANDSTONE	Greenish gray, very fine to fine grained, argillaceous
450-715	CLAYSTONE	Greenish gray, slightly silty, poorly indurated, lignite at 458, 650, siltier at 460-480, 485-530, 580-650, 710-715
715-742	SANDSTONE	Very fine grained, well sorted, poor sample recovery
742-758	LIGNITE	
758-840	SILTSTONE	Greenish gray, argillaceous, interbedded clay
840-870	SANDSTONE	Greenish gray, very fine grained, silty
870-1030	SILTSTONE	Greenish gray, sometimes brownish gray, interbedded with clay zones 907-955, 960-980, 1000-1010
1030-1060	SANDSTONE	Greenish gray, fine grained, clayey, micaceous
1060-1400	SILTSTONE	And Claystone, interbedded, greenish gray, lignite bed 1304-1315
1400-1530	SANDSTONE	Greenish gray, very fine to medium grained, very clayey and tight, interbedded clay 1410-1420, 1440-1460, 1495-1500, 1510-1520, lignite at 1437-1440, 1483-1494
1530-1680	SILTSTONE	Greenish gray, brownish to light gray, bentonitic, interbedded lignite, indurated zones, carbonaceous zones, clay zones
1680-1790	SANDSTONE	Fine grained, clayey, clay zone 1710-1720, 1760-1780, (Fox Hills Formation)
1790-1920	CLAYSTONE	Greenish gray to black, interbedded siltstone, indurated zones (Lower Fox Hills Formation, possibly Pierre Fm. at 1885)

Water Quality

Location	151-103-11AAA
County	McKenzie
Screened Interval	1680'-1753'
Aquifer	Fox Hills
Purpose	Observation Well
Date Sampled	11/08/05
Time Sampled	14:39:00
Yield (gpm)	50
Field Temp(C)	
Lab pH	8.67
Field Conductivity (um/cm)	2011
Lab Conductivity (um/cm)	2140
Total Dissolved Solids (mg/L)	1280
Calcium (mg/L)	2.04
Magnesium (mg/L)	<1
Potassium (mg/L)	3.0
Sodium (mg/L)	578.0
Fluoride (mg/L)	5.58
Bicarbonate (mg/L)	1000
Carbonate (mg/L)	46.0
Sulfate (mg/L)	0.32
Chloride (mg/L)	153.0
Hydroxide (mg/L)	<1
Nitrate(mg/L)	<0.09
Iron (mg/L)	0.188
Manganese (mg/L)	<0.01
Hardness(mg/L)	9.0
Sodium Adsorption Ratio (SAR)	82.8
Residual Sodium Carbonate (Equiv/L)	18.0
Percent Sodium	99.0


Historical Pressure Head Decline
Observation Well 15110311AAA
15110311AAA
Elevation (Ft)
2140
2130
2120
2110
2100
2090
2080
2070
2060
2050
2040
1985
1990
1995
2000
2005
2010
Year

151-104-04AAA

Date Completed:	12/26/73	*Purpose:*	Domestic Well
L.S. Elevation (ft):	1879'	*Well Type:*	1.25"Steel
Depth Drilled (ft):	1405'	*Aquifer:*	Fox Hills
Screened Interval (ft):	1342' - 1405'	*Source:*	Boyce Drilling

Owner:	Harlow Bieber
Address:	Route 2, Box 2442, Fairview, MT 59221
Telephone #:	701-744-5724
Farmstead location:	1 mile west and 5 miles north of J. Nelson bridge
Well Location:	At house
Directions to well:	Located at SW corner of steel building, 300 feet west of house, east of row of steel bins, in 5 foot diameter inverted culvert, well covered with insulation, hydrant above, plumbed to house and yard hydrants
Wellhead description: (casing & plumbing)	

Shut in time vs. pressure head: 2006 measurements

Shut in time (minutes)	1	2	3	4	5	7	9	12	15	20	25	30	35	40
Pressure head (feet)	165.0	165.0	165.0	165.0	165.0	165.0	165.0	165.0	165.0	165.0	165.0	165.0		

Shut in time (minutes)	50	60	70	80	100	120
Pressure head (feet)						

Long term pressure head measurements

Date	Flow rate (gpm)	Shut-in Time (min)	Pressure Head (ft)	Rate of change(ft/yr)	Measurement made by
08/15/79			+242.6		USGS
04/23/1985			+208.5	-6.0	Allen Comeskey
06/29/95	shut in	+30	+182.5	-2.6	Alan Wanek
5/18/06	12	30	+165.0	-1.6	Merlyn Skaley

151-104-04AAA
Harlow Bieber

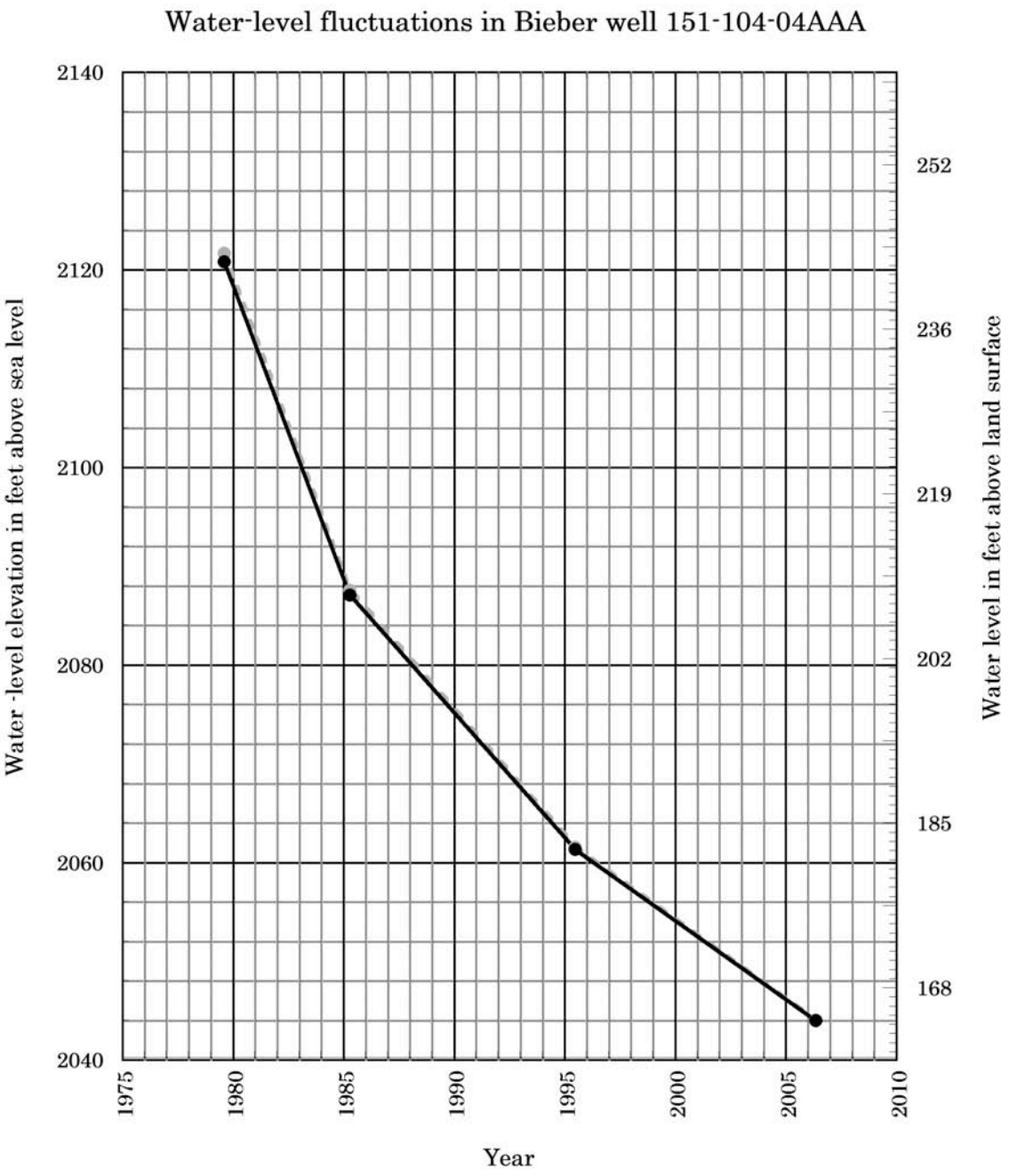
Date Completed:	12/26/1973	Purpose:	Domestic Well
L.S. Elevation (ft):	1879	Well Type:	1.25 in. - Steel
Depth Drilled (ft):	1405	Aquifer:	Fox Hills
Screen Int. (ft.):	1342-1405	Data Source:	Boyce Drilling

Completion Info: 5 inch surface casing set to 105 ft., 2 inch casing to surface to 147 feet, 1.25 inch casing to 1405 feet, bottom 63 ft. perforated, grouted with 133 bags of neat cement from surface to 1334 feet

Remarks:

Lithologic Log

Depth (ft)	Unit	Description
0-13	CLAY	Brown
13-95	SAND	Brown, scoria chips
95-491	CLAY	Gray, coal at 164-175, interbedded coal at 175-480, rock at 480-491
491-720	CLAY	Crumbly
720-1090	CLAY	Gray, sandy, rock at 870-873, 1018-1019, interbedded with coal 1019-1090
1090-1225	CLAY	
1225-1292	CLAY	Soft
1292-1314	CLAY	
1314-1404	SAND	Rock at 1314-1315, 1378-1382, 1387-1389
1404-1405	CLAY	Gray


Water-level fluctuations in Bieber well 151-104-04AAA
Water -level elevation in feet above sea level
2140
2120
2100
2080
2060
2040
Water level in feet above land surface
252
236
219
202
185
168
1975
1980
1985
1990
1995
2000
2005
2010
Year

Water Quality

Location	151-104-04AAA
County	McKenzie
Screened Interval	1342'-1405'
Aquifer	Fox Hills
Purpose	Domestic Well
Date Sampled	05/18/06
Time Sampled	14:00:00
Yield (gpm)	12
Field Temp(C)	14.20
Lab pH	8.46
Field Conductivity (um/cm)	1908
Lab Conductivity (um/cm)	2200
Total Dissolved Solids (mg/L)	1360
Calcium (mg/L)	<2
Magnesium (mg/L)	<1
Potassium (mg/L)	1.37
Sodium (mg/L)	501.0
Fluoride (mg/L)	5.45
Bicarbonate (mg/L)	1040
Carbonate (mg/L)	20.0
Sulfate (mg/L)	<0.3
Chloride (mg/L)	187.0
Hydroxide (mg/L)	<1
Nitrate(mg/L)	<0.09
Iron (mg/L)	<0.01
Manganese (mg/L)	<0.01
Hardness(mg/L)	9.0
Sodium Adsorption Ratio (SAR)	72.1
Residual Sodium Carbonate (Equiv/L)	18.0
Percent Sodium	99.2

Harlow Bieber well at 151-104-04AAA

View looking north

152-098-24CCC

Date Completed:	06/21/75	*Purpose:*	Stock Well
L.S. Elevation (ft):	2000'	*Well Type:*	2"Steel
Depth Drilled (ft):	1730'	*Aquifer:*	Fox Hills
Screened Interval (ft):	1680' - 1730'	*Source:*	Ralph Wold Well Drilling

Owner:	Madeline Miller/Cornell Wollan
Address:	106 Cactus Lane, Watford City, ND 58854
Telephone #:	701-842-2117
Farmstead location:	Along highway, 11 miles north of Watford City turn
Well Location:	One mile east of farm
Directions to well:	To get to well drive south along sec. line trail 1/4 mile beyond farm driveway at 1/4 line, bear east into pasture, take right fork where trail divides, proceed over hill to well along draw about 300 to 350 feet north and east of SW corner of section.
Wellhead description: (casing & plumbing)	2 inch casing extending 3 feet out of ground, reducer, "T" with line to faucet and line to valve to reducer to stock tank

Shut in time vs. pressure head: 2006 measurements

Shut in time (minutes)	1	2	3	4	5	7	9	12	15	20	25	30	35	40
Pressure head (feet)	19.00	19.50	19.75	19.75	19.00	19.00	19.00	19.00	20.00	19.00	19.00	21.00	21.00	19.00

Shut in time (minutes)	50	60	70	80	100	120
Pressure head (feet)	21.00	19.50	19.75	20.00	20.00	20.00

Long term pressure head measurements

Date	Flow rate (gpm)	Shut-in Time (min)	Pressure Head (ft)	Rate of change(ft/yr)	Measurement made by
06/25/80			+53.1		USGS
12/04/84			+35.0	-4.5	Allen Comeskey
06/29/95	1.04	30	+36.9	+0.2	Alan Wanek
5/18/06	3.00	120	+20.0	-1.5	Merlyn Skaley

152-098-24CCC
Madeline Miller/Cornell Wollan

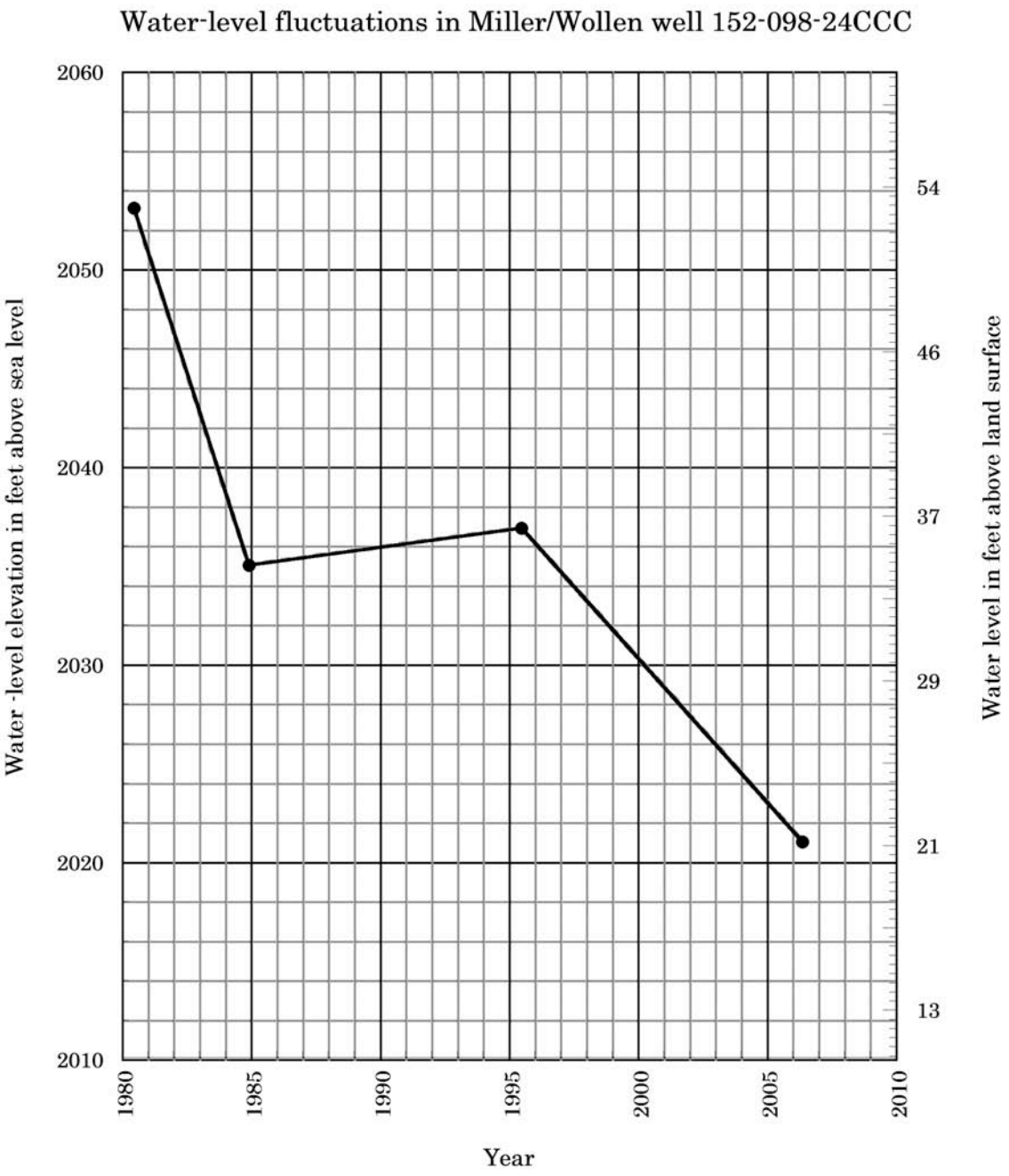
Date Completed:	06/21/1975	Purpose:	Stock Well
L.S. Elevation (ft):	2000	Well Type:	2 in. - Steel
Depth Drilled (ft):	1730	Aquifer:	Fox Hills
Screen Int. (ft.):	1680-1730	Data Source:	Ralph Wold Well Drilling

Completion Info: 50 feet of perforated casing, open end completion, grouted to 250 feet with puddled clay

Remarks:

Lithologic Log

Depth (ft)	Unit	Description
0-20	CLAY	
20-30	SAND & GRAVEL	
30-45	SAND	
45-250	CLAY	Coal 68-80, rock 114-116, 234-238
250-260	SAND	
260-290	CLAY	
290-298	SAND	
298-530	CLAY	Coal 470-482
530-540	SAND	
540-579	CLAY	575-579 rock
579-585	SAND	
585-620	CLAY	
620-650	LIGNITE	
650-705	CLAY	Sandy
705-730	LIGNITE	
730-810	CLAY	Sand streaks
810-855	CLAY	Rock streaks, rock at 810-814
855-889	LIGNITE	
889-1090	CLAY	
1090-1118	LIGNITE	
1118-1330	CLAY	Sand streaks, rock at 1327-1330
1330-1390	SHALE	With coal
1390-1405	LIGNITE	
1405-1445	SHALE	And clay
1445-1634	CLAY	Sandy streaks
1634-1673	SHALE	
1673-1730	SAND	


Water-level fluctuations in Miller/Wollen well 152-098-24CCC
Water -level elevation in feet above sea level
2060
2050
2040
2030
2020
2010
Water level in feet above land surface
54
46
37
29
21
13
1980
1985
1990
1995
2000
2005
2010
Year

Water Quality

Location	152-098-24CCC
County	McKenzie
Screened Interval	1680'-1730'
Aquifer	Fox Hills
Purpose	Stock Well
Date Sampled	05/23/06
Time Sampled	09:00:00
Yield (gpm)	3
Field Temp(C)	20.60
Lab pH	8.18
Field Conductivity (um/cm)	2930
Lab Conductivity (um/cm)	3180
Total Dissolved Solids (mg/L)	1970
Calcium (mg/L)	3.05
Magnesium (mg/L)	<1
Potassium (mg/L)	1.79
Sodium (mg/L)	689.0
Fluoride (mg/L)	4.01
Bicarbonate (mg/L)	1290
Carbonate (mg/L)	<1
Sulfate (mg/L)	<0.3
Chloride (mg/L)	430.0
Hydroxide (mg/L)	<1
Nitrate(mg/L)	<0.09
Iron (mg/L)	0.092
Manganese (mg/L)	<0.01
Hardness(mg/L)	12.0
Sodium Adsorption Ratio (SAR)	87.4
Residual Sodium Carbonate (Equiv/L)	21.0
Percent Sodium	99.2

Madeline Miller/Cornell Wollan well at 152-098-24CCC

View looking north

View looking west

152-099-03ABC

Date Completed:	08/19/74	*Purpose:*	Stock Well
L.S. Elevation (ft):	1920'	*Well Type:*	2"Steel
Depth Drilled (ft):	1610'	*Aquifer:*	Fox Hills
Screened Interval (ft):	1560' - 1610'	*Source:*	Ralph Wold Drilling

Owner:	Larry Widder
Address:	1211 163 Avenue SE, Minot, ND 58701
Telephone #:	701-722-3528
Farmstead location:	2 miles south of Banks School, 4 miles west of highway
Well Location:	In Missouri River breaks, about 4 miles NW of house
Directions to well:	Well reached from highway 1806 along Tobacco Garden Bay, taking gravel road west, then following trail just south of the Missouri River Valley farther west to the well along a draw about 25 feet south of the trail, by a tan stock tank with triangular bracing
Wellhead description: (casing & plumbing)	2 inch steel casing extends 2.5 feet with 4 inch surface casing around it, to reducer, elbow, valve, black plastic line to tank

Shut in time vs. pressure head: 2006 measurements

Shut in time (minutes)	1	2	3	4	5	7	9	12	15	20	25	30	35	40
Pressure head (feet)	19.00	19.50	19.75	19.75	19.00	19.00	19.00	19.00	20.00	19.00	19.00	21.00	21.00	19.00

Shut in time (minutes)	50	60	70	80	100	120
Pressure head (feet)	21.00	19.50	19.75	20.00	20.00	20.00

Long term pressure head measurements

Date	Flow rate (gpm)	Shut-in Time (min)	Pressure Head (ft)	Rate of change(ft/yr)	Measurement made by
06/25/80			+196.4		USGS
10/28/85		20	+158.0	-7.2	Allen Comeskey
06/29/95	6.8	120	+162.0	+0.3	Alan Wanek
05/23/06	12	60	+155.0	-0.6	Merlyn Skaley

152-099-03ABC
Larry Widder

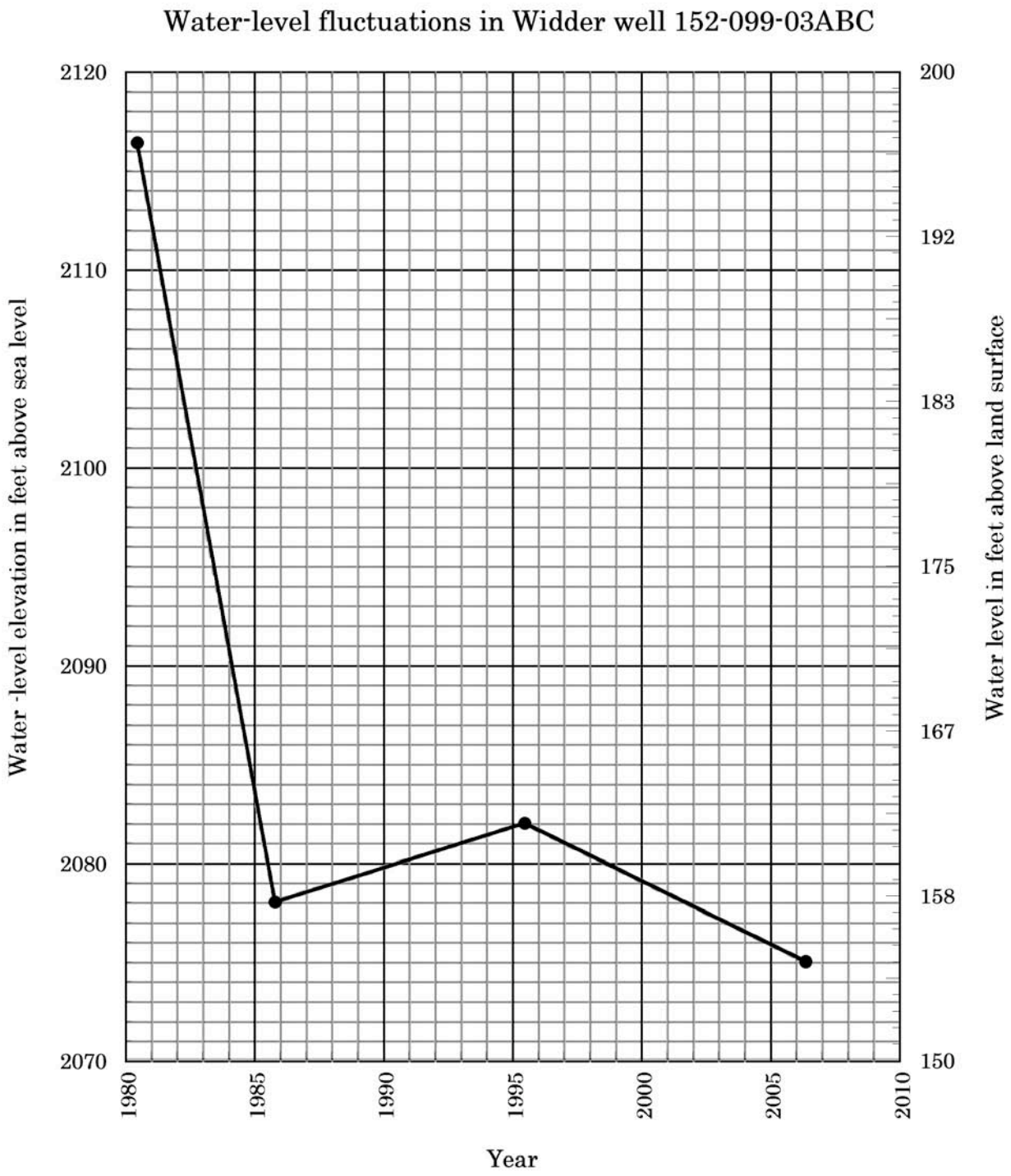
Date Completed:	08/19/1974	Purpose:	Stock Well
L.S. Elevation (ft):	1920	Well Type:	2 in. - Steel
Depth Drilled (ft):	1610	Aquifer:	Fox Hills
Screen Int. (ft.):	1560-1610	Data Source:	Ralph Wold Drilling

Completion Info: 50 feet of casing perforated, open ended casing, grouted to 400 feet with puddled clay

Remarks:

Lithologic Log

Depth (ft)	Unit	Description
0-20	SAND	
20-204	CLAY	Rock at 109-110, coal 200-204
204-235	SAND	
235-350	CLAY	Sand 273-280, 302-316, rock 321-326
350-432	SAND	
432-687	CLAY	rock 443-444, coal 520-530, 590-602, 615-623
687-715	SAND	
715-915	CLAY	Coal 820-830, rock 852-857
915-922	SAND	
922-1133	SHALE	Sand 992-997, 1128-1133
1133-1515	SHALE	And clay, rock 1145-1148
1515-1532	SAND	Streaks, rock at 1530-1532
1532-1545	CLAY	Sandy
1545-1560	SHALE	
1560-1610	SAND	


Water-level fluctuations in Widder well 152-099-03ABC
Water -level elevation in feet above sea level
Water level in feet above land surface
2120
2110
2100
2090
2080
2070
200
192
183
175
167
158
150
1980
1985
1990
1995
2000
2005
2010
Year

Water Quality

Location	15209903ABC
County	McKenzie
Screened Interval	1560'-1610'
Aquifer	Fox Hills
Purpose	Stock Well
Date Sampled	05/23/06
Time Sampled	12:13:00
Yield (gpm)	12
Field Temp(C)	22.00
Lab pH	8.36
Field Conductivity (um/cm)	2290
Lab Conductivity (um/cm)	2510
Total Dissolved Solids (mg/L)	1560
Calcium (mg/L)	2.24
Magnesium (mg/L)	<1
Potassium (mg/L)	1.45
Sodium (mg/L)	566.0
Fluoride (mg/L)	5.76
Bicarbonate (mg/L)	1190
Carbonate (mg/L)	13.0
Sulfate (mg/L)	<0.3
Chloride (mg/L)	242.0
Hydroxide (mg/L)	<1
Nitrate(mg/L)	<0.09
Iron (mg/L)	0.104
Manganese (mg/L)	<0.01
Hardness(mg/L)	10.0
Sodium Adsorption Ratio (SAR)	79.0
Residual Sodium Carbonate (Equiv/L)	20.0
Percent Sodium	99.2

Larry Widder well at 152-099-03ABC

View looking south

View looking west

152-101-14DAC

Date Completed:	07/03/76	*Purpose:*	Stock Well
L.S. Elevation (ft):	2016.9'	*Well Type:*	2"Steel
Depth Drilled (ft):	1855'	*Aquifer:*	Fox Hills
Screened Interval (ft):	1735' - 1855'	*Source:*	Ralph Wold Well Drilling

Owner:	Don Lindvig
Address:	14161 41st Street NW
Telephone #:	701-572-5089
Farmstead location:	3 miles east of Highway 85, 3 miles south of Pranger rest area
Well Location:	3 miles SE of house, on hill in pasture
Directions to well:	Beyond turn off to oil well/hay yard pad go into pasture, follow trail east, then east southeast about 1/2 to 3/4 mile to well on top of hill
Wellhead description: (casing & plumbing)	2 inch well extends 3 feet out of ground, with 5 inch surface casing around, reduced to 1.25 inch, elbow, valve, line to blue stock tank

Shut in time vs. pressure head: 2006 measurements

Shut in time (minutes)	1	2	3	4	5	7	9	12	15	20	25	30	35	40
Pressure head (feet)	12.50	12.75	12.75	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00

Shut in time (minutes)	50	60	70	80	100	120
Pressure head (feet)	13.00	13.00				

Long term pressure head measurements

Date	Flow rate (gpm)	Shut-in Time (min)	Pressure Head (ft)	Rate of change(ft/yr)	Measurement made by
04/22/83		10	+10.5		Allan Wanek
08/29/84		10	+10.5	0.0	Allan Wanek
07/12/95	0.70	120	+15.0	+0.3	Alan Wanek
05/25/06	0.75	60	+13.0	-0.2	Merlyn Skaley

152-101-14DAC
Don Lindvig

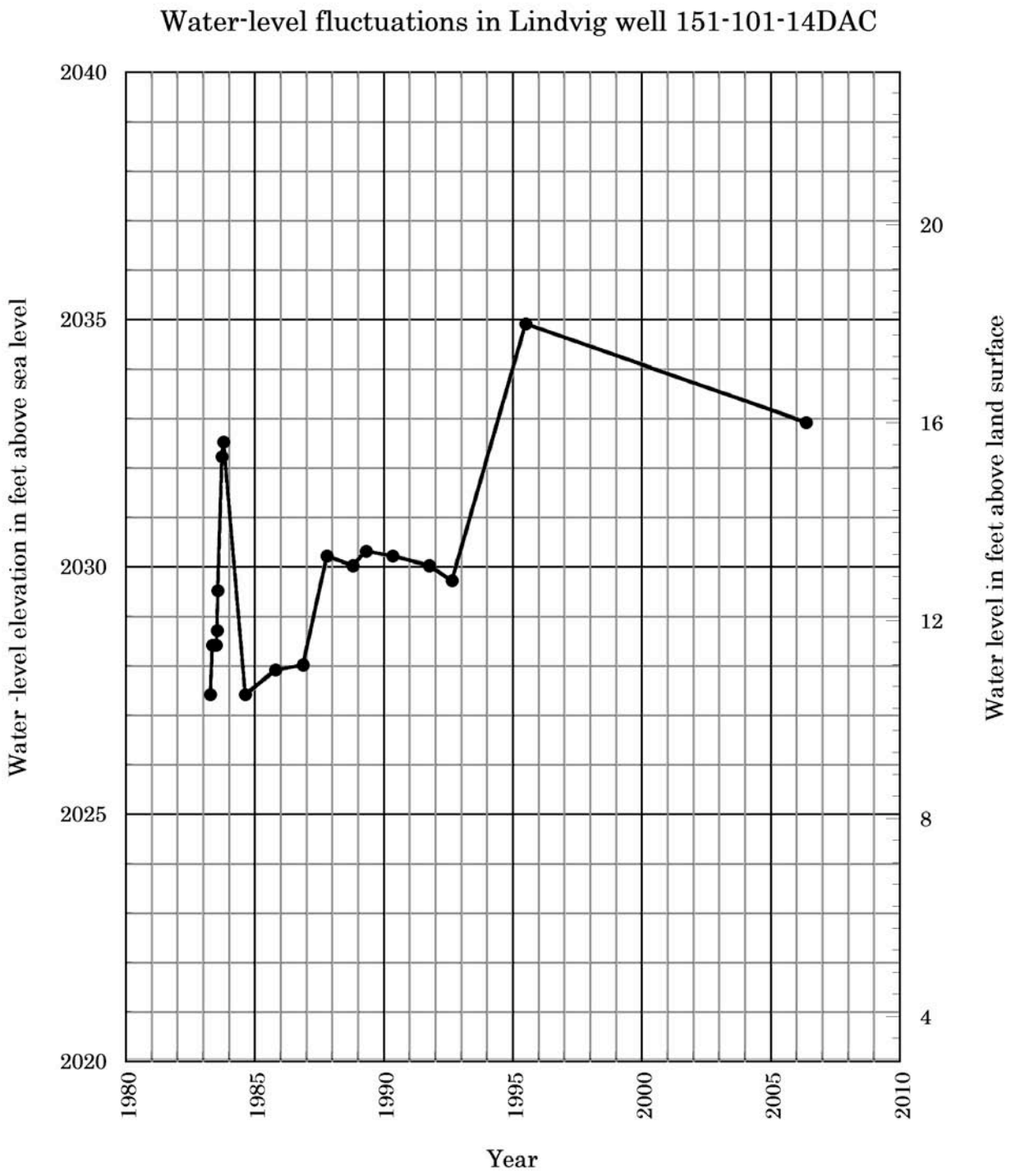
Date Completed:	07/03/1976	Purpose:	Stock Well
L.S. Elevation (ft):	2016.9	Well Type:	2 in. - Steel
Depth Drilled (ft):	1855	Aquifer:	Fox Hills
Screen Int. (ft.):	1735-1855	Data Source:	Ralph Wold Well Drilling

Completion Info: 120 feet of perforated pipe, grouted to 350 feet with puddled clay

Remarks:

Lithologic Log

Depth (ft)	Unit	Description
0-3	TOPSOIL	
3-18	SAND	
18-65	CLAY	Sandy
65-944	CLAY	Coal at 140-165, 185-188, 303-312, 340-368, 688-694, 925-938; rock at 230-233, 390-396, 587-592; sand at 836-851, 888-895
944-980	SAND	
980-989	SHALE	
989-996	LIGNITE	
996-1044	CLAY	Sandy
1044-1165	SHALE	
1165-1228	CLAY	Rock at 1165-1167, 1225-1228
1228-1322	SHALE	Coal at 1267-1276, 1284-1322
1322-1395	SAND	And coal streaks
1395-1640	SHALE	Sand at 1488-1500, rock at 1528-1533, coal at 1615-1625
1640-1672	SAND	
1672-1740	SHALE	
1740-1855	SAND	


Water-level fluctuations in Lindvig well 151-101-14DAC
Water -level elevation in feet above sea level
Water level in feet above land surface
Year
2040
2035
2030
2025
2020
20
16
12
8
4
1980
1985
1990
1995
2000
2005
2010

Water Quality

Location	152-101-14DAC
County	McKenzie
Screened Interval	1735'-1855'
Aquifer	Fox Hills
Purpose	Stock Well
Date Sampled	05/25/06
Time Sampled	12:50:00
Yield (gpm)	3/4
Field Temp(C)	15.20
Lab pH	8.26
Field Conductivity (um/cm)	2720
Lab Conductivity (um/cm)	3080
Total Dissolved Solids (mg/L)	1910
Calcium (mg/L)	3.05
Magnesium (mg/L)	<1
Potassium (mg/L)	2.06
Sodium (mg/L)	738.0
Fluoride (mg/L)	3.22
Bicarbonate (mg/L)	1650
Carbonate (mg/L)	<1
Sulfate (mg/L)	<0.3
Chloride (mg/L)	237.0
Hydroxide (mg/L)	<1
Nitrate(mg/L)	<0.09
Iron (mg/L)	0.105
Manganese (mg/L)	<0.01
Hardness(mg/L)	12.0
Sodium Adsorption Ratio (SAR)	93.6
Residual Sodium Carbonate (Equiv/L)	27.0
Percent Sodium	99.3

Don Lindvig well at 152-101-14DAC

View looking south

View looking west

152-101-15ADD

Date Completed:	06/22/82	*Purpose:*	Stock Well
L.S. Elevation (ft):	1995.2'	*Well Type:*	2.5"Steel
Depth Drilled (ft):	1547.2'	*Aquifer:*	Fox Hills
Screened Interval (ft):	1532' - 1547'	*Source:*	Himebaugh Drilling

Owner:	Don Lindvig
Address:	14161 41st Street NW
Telephone #:	701-572-5089
Farmstead location:	3 miles east of Highway 85, 3 miles south of Pranger rest area
Well Location:	Well in berm by last power pole, bottom of draw 500 feet north of road
Directions to well:	Located in bottom of draw, north of road, access from east, well has dirt bermed around it and is in a 6 feet diameter vertical cylindrical shelter with 4 lines leading from the well to stock tanks with float valves
Wellhead description: (casing & plumbing)	6 foot diameter upturned cylinder with dirt bermed around it, about 7 feet high, well with 4 lines from it, one has pump and pressure tank, lines valved, base of housing at approximate former land surface

Shut in time vs. pressure head: 2006 measurements

Shut in time (minutes)	1	2	3	4	5	7	9	12	15	20	25	30	35	40
Pressure head (feet)	95.00	95.00	95.00	95.00	95.00	95.00	95.00	95.00	95.00	95.00	95.00	95.0	95.00	95.00

Shut in time (minutes)	50	60	70	80	100	120
Pressure head (feet)	95.00	95.00				

Long term pressure head measurements

Date	Flow rate (gpm)	Shut-in Time (min)	Pressure Head (ft)	Rate of change(ft/yr)	Measurement made by
08/09/83	shut in	10	+121.8		Allan Wanek
07/12/95	shut in	20	+112.0	-0.8	Allan Wanek
05/25/06	3	60	+95.0	-1.6	Merlyn Skaley

152-101-15ADD
Don Lindvig

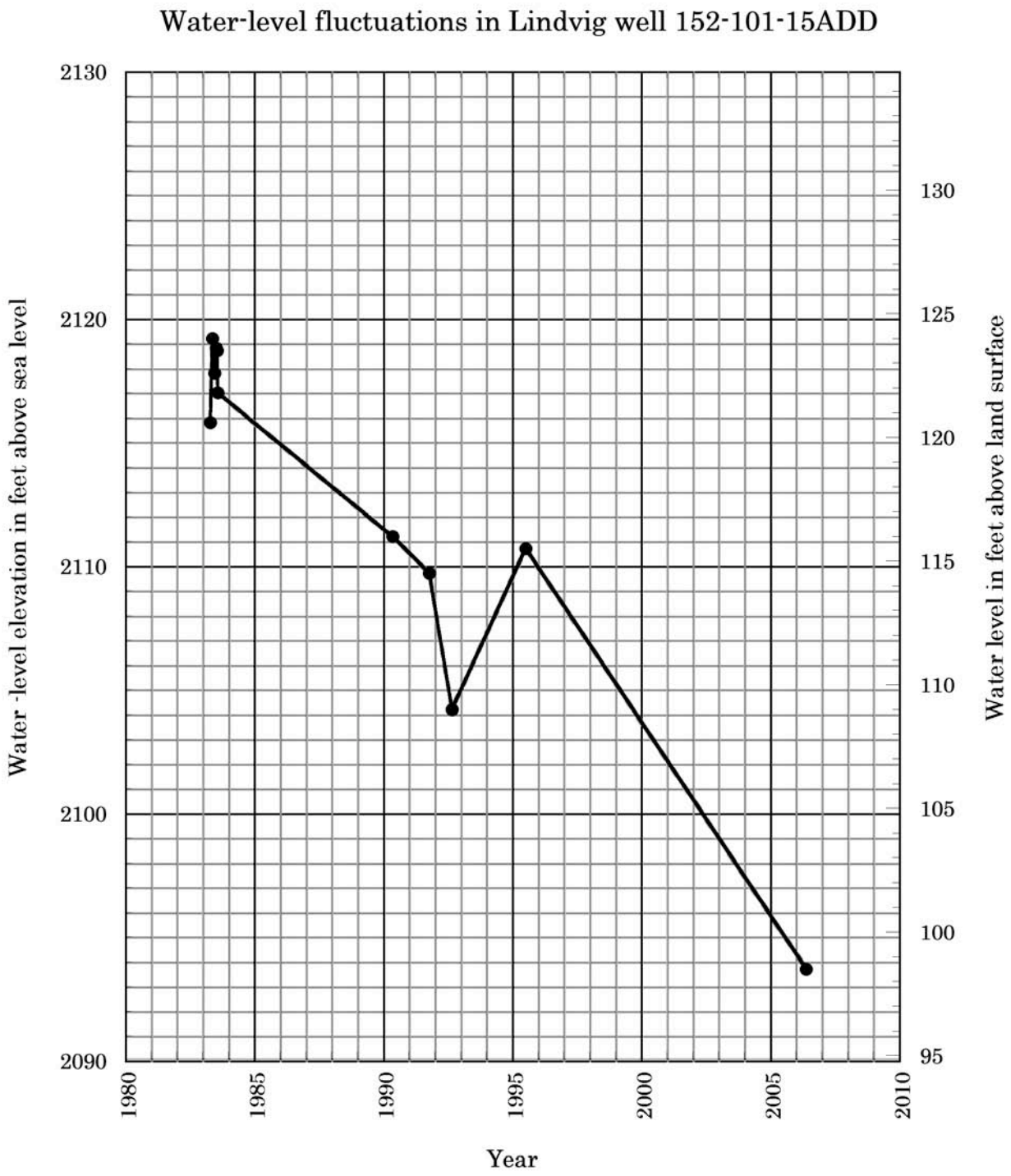
Date Completed:	06/22/1982	Purpose:	Stock Well
L.S. Elevation (ft):	1995.2	Well Type:	2.5 in. - Steel
Depth Drilled (ft):	1547.2	Aquifer:	Fox Hills
Screen Int. (ft.):	1532-1547	Data Source:	Himebaugh Drilling

Completion Info: 15 feet of casing perforated, open end, grouted with neat cement 0-210 feet

Remarks:

Lithologic Log

Depth (ft)	Unit	Description
0-20	CLAY	Brown, silty
20-40	CLAY	Olive gray, silty
40-55	CLAY	Lignitic
55-70	CLAY	Sandy
70-160	CLAY	Sandy
160-165	LIMESTONE	
165-190	SILT	Sandy, clayey
190-275	SAND	Gray, fine to medium grained
275-315	SILT	Gray, clayey, sandy
315-330	LIGNITE	And clay
330-355	CLAY	Gray, silty
355-360	LIGNITE	
360-415	CLAY	Gray, silty
415-420	LIMESTONE	
420-645	CLAY	Silty, carbonaceous
645-745	SAND	Fine to coarse grained
745-795	CLAY	Gray
795-925	SILT	Gray, sandy
925-1000	CLAY	Gray
1000-1005	LIMESTONE	
1005-1205	CLAY	Silty, carbonaceous
1205-1250	SILT	Sandy, with lignite
1250-1280	CLAY	Gray, silty
1280-1415	SILT	Sandy, clayey
1415-1495	CLAY	Silty, carbonaceous
1495-1610	SAND	Gray, fine to coarse grained
1610-1640	SILT	Sandy, clayey


Water-level fluctuations in Lindvig well 152-101-15ADD
Water -level elevation in feet above sea level
Water level in feet above land surface
2130
2120
2110
2100
2090
130
125
120
115
110
105
100
95
1980
1985
1990
1995
2000
2005
2010
Year

Water Quality

Location	152-101-15ADD
County	McKenzie
Screened Interval	1532'-1547'
Aquifer	Fox Hills
Purpose	Stock Well
Date Sampled	05/25/06
Time Sampled	11:10:00
Yield (gpm)	3
Field Temp(C)	
Lab pH	8.52
Field Conductivity (um/cm)	3170
Lab Conductivity (um/cm)	2370
Total Dissolved Solids (mg/L)	1470
Calcium (mg/L)	2.24
Magnesium (mg/L)	<1
Potassium (mg/L)	1.62
Sodium (mg/L)	538.0
Fluoride (mg/L)	5.45
Bicarbonate (mg/L)	1110
Carbonate (mg/L)	29.0
Sulfate (mg/L)	<0.3
Chloride (mg/L)	217.0
Hydroxide (mg/L)	<1
Nitrate(mg/L)	<0.09
Iron (mg/L)	0.109
Manganese (mg/L)	<0.01
Hardness(mg/L)	10.0
Sodium Adsorption Ratio (SAR)	75.0
Residual Sodium Carbonate (Equiv/L)	19.0
Percent Sodium	99.2

Don Lindvig well at 152-101-15ADD

Close-up view of well

Well located on the right side within the mound, tire tank to the left, view looking north

152-102-11ABC

Date Completed:	Unknown	*Purpose:*	Stock Well
L.S. Elevation (ft):	2073.4'	*Well Type:*	2"Steel
Depth Drilled (ft):	About 1600'	*Aquifer:*	Fox Hills
Screened Interval (ft):	Unknown	*Source:*	

Owner:	Don Lindvig
Address:	14161 41st Street NW
Telephone #:	701-572-5089
Farmstead location:	3 miles east of Highway 85, 3 miles south of Pranger rest area
Well Location:	West of house, 1.5 miles west of Highway 85
Directions to well:	Lindvig stock well, located in low south of stock dam, blue stock tank by well. Well surrounded by wooden guard
Wellhead description: (casing & plumbing)	6 inch surface casing to 1 foot, 2 inch casing 3 feet up to "T" with one line shut in w/valve, other line (vertical) to elbow, to reducer, to red plastic line to blue stock tank

Shut in time vs. pressure head: 2006 measurements

Shut in time (minutes)	1	2	3	4	5	7	9	12	15	20	25	30	35	40
Pressure head (feet)	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0

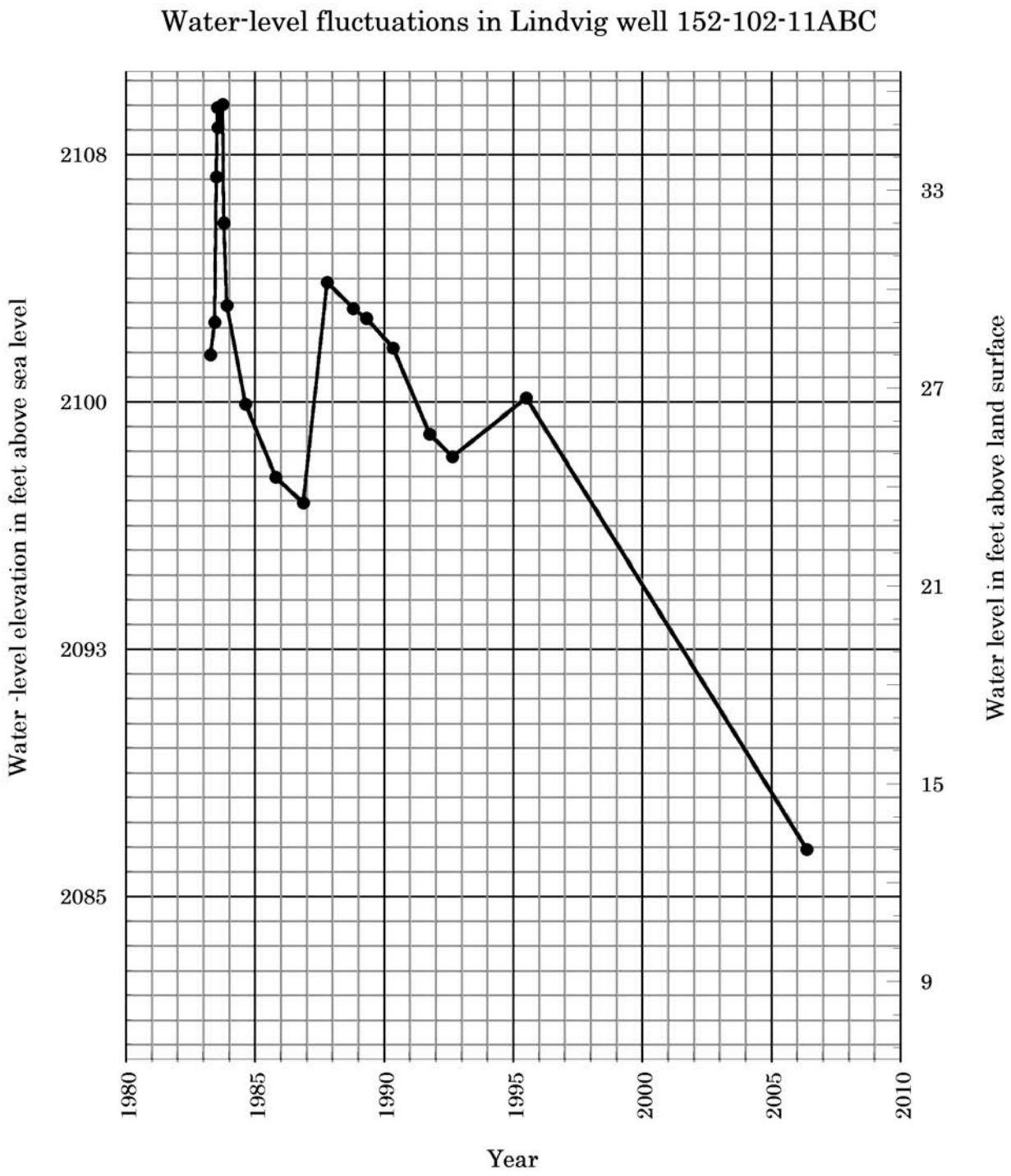
Shut in time (minutes)	50	60	70	80	100	120
Pressure head (feet)	10.0	10.0				

Long term pressure head measurements

Date	Flow rate (gpm)	Shut-in Time (min)	Pressure Head (ft)	Rate of change(ft/yr)	Measurement made by
08/29/84		10	+26.5		Allan Wanek
07/11/95	4	120	+23.6	-0.3	Allan Wanek
05/25/06	2	60	+10.0	-1.3	Merlyn Skaley

152-102-11ABC
Don Lindvig

No Lithologic log


Water-level fluctuations in Lindvig well 152-102-11ABC
Water -level elevation in feet above sea level
2108
2100
2093
2085
Water level in feet above land surface
33
27
21
15
9
1980
1985
1990
1995
2000
2005
2010
Year

Water Quality

Location	152-102-11ABC
County	McKenzie
Screened Interval	Unknown
Aquifer	Fox Hills
Purpose	Stock Well
Date Sampled	05/25/06
Time Sampled	07:50:00
Yield (gpm)	2
Field Temp(C)	17.00
Lab pH	8.52
Field Conductivity (um/cm)	2050
Lab Conductivity (um/cm)	2220
Total Dissolved Solids (mg/L)	1380
Calcium (mg/L)	<2
Magnesium (mg/L)	<1
Potassium (mg/L)	1.09
Sodium (mg/L)	507.0
Fluoride (mg/L)	5.56
Bicarbonate (mg/L)	1060
Carbonate (mg/L)	28.0
Sulfate (mg/L)	<0.3
Chloride (mg/L)	177.
Hydroxide (mg/L)	<1
Nitrate(mg/L)	<0.09
Iron (mg/L)	0.178
Manganese (mg/L)	<0.01
Hardness(mg/L)	9.0
Sodium Adsorption Ratio (SAR)	73.0
Residual Sodium Carbonate (Equiv/L)	18.0
Percent Sodium	99.2

Don Lindvig well at 152-102-11ABC

View looking south

View looking west

152-103-25CAB

Date Completed:	11/05/77	*Purpose:*	Stock Well
L.S. Elevation (ft):	1965'	*Well Type:*	2"Steel
Depth Drilled (ft):	1530'	*Aquifer:*	Fox Hills
Screened Interval (ft):	1485' - 1530'	*Source:*	Kieson Drilling

Owner:	Robert Erickson
Address:	Williston, ND 58801
Telephone #:	701-5722027
Farmstead location:	8 miles north and 4 miles west of Alexander
Well Location:	4 miles west of house, in Missouri Breaks
Directions to well:	Located at end of road, at old farmstead, in triangular bracing 100 feet south of stock tank
Wellhead description: (casing & plumbing)	5 inch surface casing extends 3 ft vertically, 2 inch well extends another foot, to elbow, "T", with valve on each line, one shut in, other to black plastic buried line to stock tank

Shut in time vs. pressure head: 2006 measurements

Shut in time (minutes)	1	2	3	4	5	7	9	12	15	20	25	30	35	40
Pressure head (feet)	112.0	112.0	112.0	112.0	112.0	112.0	112.0	112.0	112.0	112.0	112.0	112.0	112.0	112.0

Shut in time (minutes)	50	60	70	80	100	120
Pressure head (feet)	112.0	112.0				

Long term pressure head measurements

Date	Flow rate (gpm)	Shut-in Time (min)	Pressure Head (ft)	Rate of change(ft/yr)	Measurement made by
06/25/80			+161.7		USGS
04/23/85		10	+149.5	-2.5	Allen Comeskey
06/30/95	1.18	120	+131.8	-1.8	Alan Wanek
05/23/06	4	60	+112.0	-1.81	Merlyn Skaley

152-103-25CAB
Robert Erickson

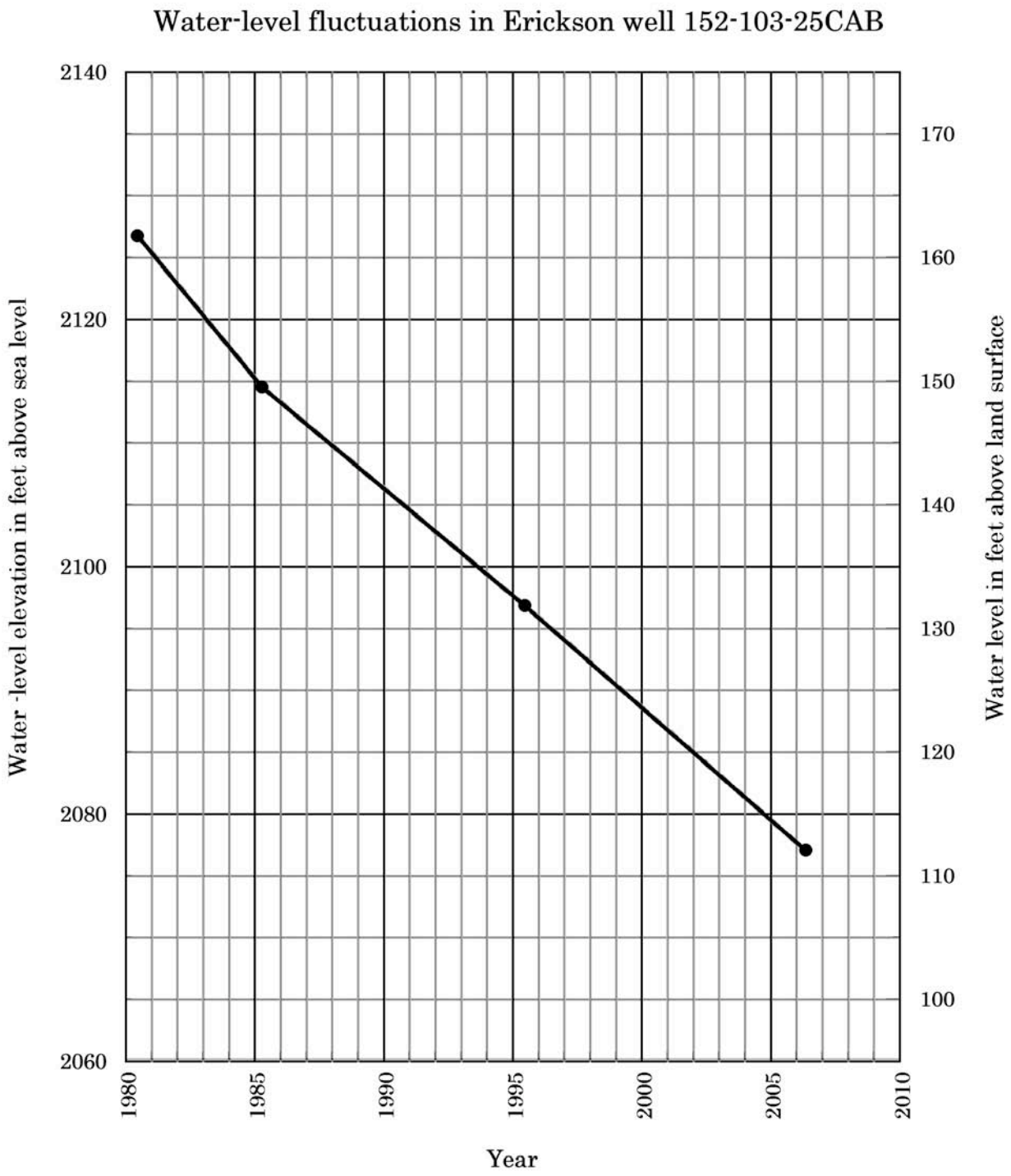
Date Completed:	11/05/1977	Purpose:	Stock Well
L.S. Elevation (ft):	1965	Well Type:	2 in. - Steel
Depth Drilled (ft):	1530	Aquifer:	Fox Hills
Screen Int. (ft.):	1485-1530	Data Source:	Keison Drilling

Completion Info: 45 feet of casing perforated, end left open

Remarks:

Lithologic Log

Depth (ft)	Unit	Description
0-8	TOPSOIL	
8-130	CLAY	Sandy, coal at 65-70, 125-130
130-294	CLAY	Coal at 136-146, 290-294
294-320	CLAY	Sandy
320-335	LIGNITE	
335-440	CLAY	Coal at 350-365
440-470	SAND	
470-608	CLAY	Coal at 485-504, 590-608
608-680	CLAY	Sandy
680-710	SAND	
710-980	CLAY	Sandy
980-1190	CLAY	Coal 1100-1110
1190-1220	CLAY	Sandy
1220-1250	CLAY	
1250-1280	CLAY	Sandy
1280-1315	SAND	
1315-1400	CLAY	
1400-1495	CLAY	Sandy, coal 1420-1425
1495-1528	SAND	
1528-1530	CLAY	


Water-level fluctuations in Erickson well 152-103-25CAB
Water -level elevation in feet above sea level
2140
2120
2100
2080
2060
Water level in feet above land surface
170
160
150
140
130
120
110
100
1980
1985
1990
1995
2000
2005
2010
Year

Water Quality

Location	152-103-25CAB
County	McKenzie
Screened Interval	1485'-1530'
Aquifer	Fox Hills
Purpose	Stock Well
Date Sampled	05/23/06
Time Sampled	17:17:00
Yield (gpm)	4
Field Temp(C)	21.50
Lab pH	8.02
Field Conductivity (um/cm)	1981
Lab Conductivity (um/cm)	2160
Total Dissolved Solids (mg/L)	1340
Calcium (mg/L)	<2
Magnesium (mg/L)	<1
Potassium (mg/L)	1.39
Sodium (mg/L)	502.0
Fluoride (mg/L)	5.64
Bicarbonate (mg/L)	1080
Carbonate (mg/L)	<1
Sulfate (mg/L)	<0.3
Chloride (mg/L)	166.0
Hydroxide (mg/L)	<1
Nitrate(mg/L)	<0.09
Iron (mg/L)	0.151
Manganese (mg/L)	<0.01
Hardness(mg/L)	9.0
Sodium Adsorption Ratio (SAR)	72.3
Residual Sodium Carbonate (Equiv/L)	18.0
Percent Sodium	99.2

Robert Erickson well at 152-103-25CAB

View looking east

View looking south

153-094-23CCC1
NDSWC 5781

Date Completed:	08/05/1980	Purpose:	Observation Well
L.S. Elevation (ft):	2186.3	Well Type:	2 in. - Steel
Depth Drilled (ft):	1855	Aquifer:	Fox Hills
Screen Int. (ft.):	1743-1767	Data Source:	NDSWC - Allen Comeskey

Completion Info:

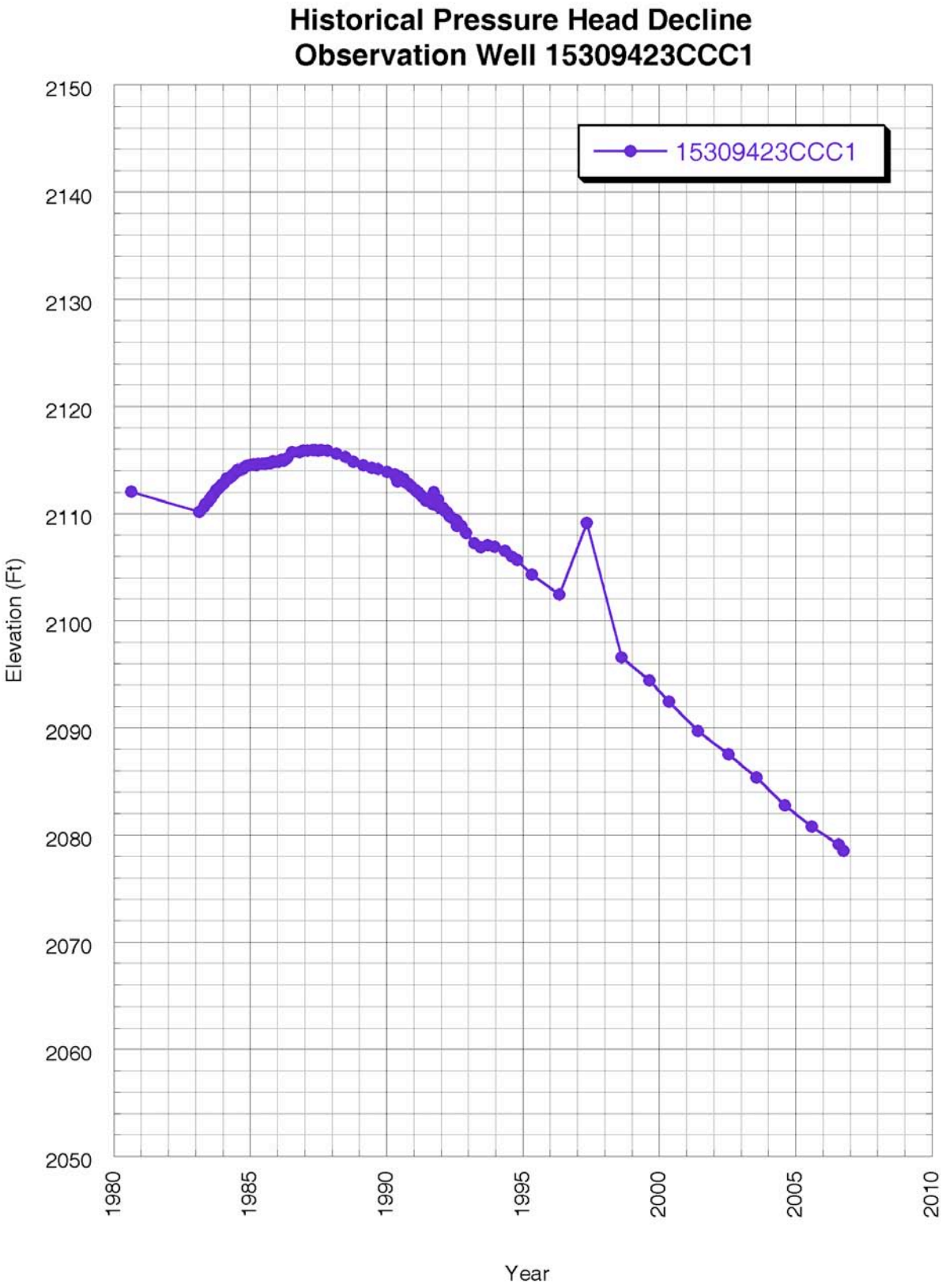
Remarks: Antelope south well; south well of triple set in SW corner of pasture, east of trail, south of cattle guard, formerly called Charlson wells (but quite a way from Charlson & in the Antelope oil & gas field)

Lithologic Log

Depth (ft)	Unit	Description
0-1	TOPSOIL	
1-15	CLAY	Yellowish brown, calcareous, very sandy, pebbly, bouldery, moderately cohesive, (oxidized till)
15-150	SILTSTONE	And claystone, sandy, brown, lignitic (Sentinel Butte)
150-220	SILTSTONE	And claystone, gray
220-245	SANDSTONE	And siltstone, fine to medium
245-365	LIGNITE	And claystone, sandy (Tongue River)
365-435	SILTSTONE	And claystone, gray
435-495	CLAYSTONE	And siltstone, lignitic
495-510	LIGNITE	
510-770	SILTSTONE	And claystone, gray, lignitic
770-780	LIGNITE	
780-925	SILTSTONE	And sandstone, fine to medium
925-1055	CLAYSTONE	And lignite, sandy, gray (Fort Union)
1055-1220	SILTSTONE	And sandstone, gray
1220-1260	SANDSTONE	Silty, fine to medium, gray
1260-1380	SILTSTONE	And claystone
1380-1445	SILTSTONE	And sandstone, fine to medium, gray
1445-1458	LIGNITE	
1458-1600	SILTSTONE	And sandstone, fine to medium, gray (Hell Creek-Fox Hills)
1600-1810	SANDSTONE	And siltstone, fine to medium, gray
1810-1845	SILTSTONE	Sandy, gray
1845-1856	SHALE	(Pierre shale)

Water Quality

Location	153-094-23CCC1
County	McKenzie
Screened Interval	1743'-1767'
Aquifer	Fox Hills
Purpose	Observation Well
Date Sampled	10/04/06
Time Sampled	16:36:00
Yield (gpm)	1.5
Field Temp(C)	
Lab pH	8.93
Field Conductivity (um/cm)	
Lab Conductivity (um/cm)	3110
Total Dissolved Solids (mg/L)	1930
Calcium (mg/L)	2.64
Magnesium (mg/L)	<1
Potassium (mg/L)	3.03
Sodium (mg/L)	742.0
Fluoride (mg/L)	4.15
Bicarbonate (mg/L)	970.0
Carbonate (mg/L)	95.0
Sulfate (mg/L)	<0.3
Chloride (mg/L)	440.0
Hydroxide (mg/L)	<1
Nitrate(mg/L)	0.09
Iron (mg/L)	0.501
Manganese (mg/L)	0.019
Hardness(mg/L)	11.0
Sodium Adsorption Ratio (SAR)	98.6
Residual Sodium Carbonate (Equiv/L)	19.0
Percent Sodium	99.3


Historical Pressure Head Decline
Observation Well 15309423CCC1
15309423CCC1
Elevation (Ft)
2150
2140
2130
2120
2110
2100
2090
2080
2070
2060
2050
1980
1985
1990
1995
2000
2005
2010
Year

153-096-11ADA
NDSWC 6339

Date Completed:	06/17/1987	Purpose:	Observation Well
L.S. Elevation (ft):	2339.8	Well Type:	4 in. - Steel
Depth Drilled (ft):	1520	Aquifer:	Fox Hills
Screen Int. (ft.):	1289-1370	Data Source:	NDSWC - Allen Comeskey

Completion Info: On 5/5/88 installed 320 feet of 1.25 inch PVC in well, top seal, to make measurements easier

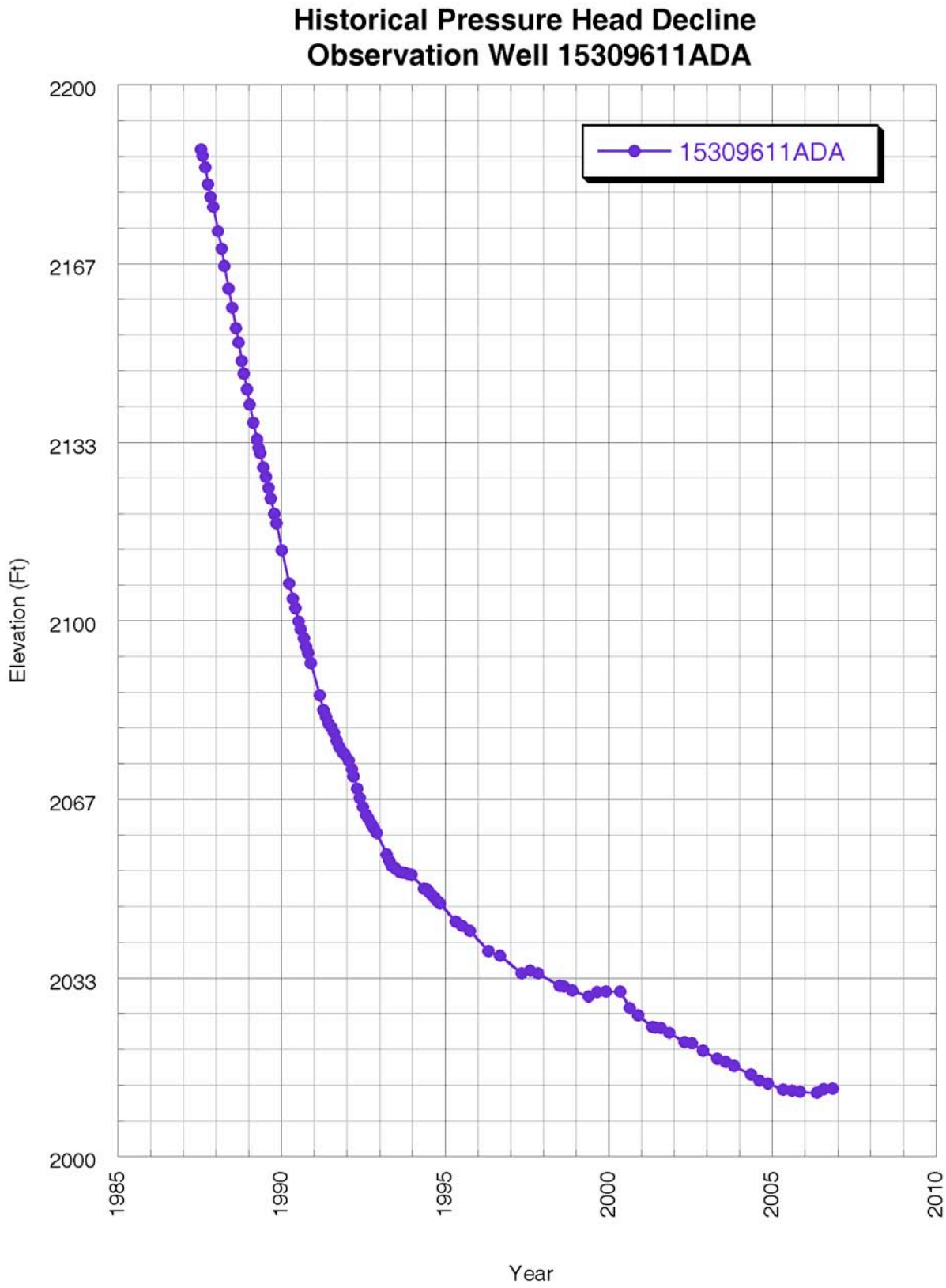
Remarks: Sand Creek well located south of Sand Creek road

Lithologic Log

Depth (ft)	Unit	Description
0-0.5	TOPSOIL	
0.5-20	CLAY	With silt, sand, and pebbles, (Oxidized till)
20-35	CLAYSTONE	Slightly sitly (Oxidized)
35-45	SANDSTONE	Very fine grained, silty
45-100	CLAYSTONE	With interbedded silt, 45-60, and sand 80-90
100-142	SANDSTONE	Very fine grained, clayey (oxidized)
142-152	LIGNITE	
152-228	CLAYSTONE	Greenish gray, occasionally silty
228-580	NO SAMPLE	Lost circulation
580-807	CLAYSTONE	With interbedded silt, lignite, indurated zones
807-880	SANDSTONE	Very fine grained, well sorted, clayey, indurated zones
880-1040	CLAYSTONE	As above
1040-1055	LIGNITE	
1055-1072	SANDSTONE	Very fine grained well sorted, clayey
1072-1118	CLAYSTONE	And interbedded lignite 1073-1077, 1090-1098, 1110-1118
1118-1126	SANDSTONE	As above
1126-1175	CLAYSTONE	Very sandy
1175-1200	SANDSTONE	Very vine to fine grained, clayey
1200-1214	CLAYSTONE	As above
1214-1236	SANDSTONE	As above
1236-1282	CLAYSTONE	Medium dark gray, very silty, brittle
1282-1394	SANDSTONE	Very fine to vine grained, clayey, greenish gray, faster drilling below 1314, coarser below 1350 (Fox Hills Fm.)
1394-1520	CLAYSTONE	Silty, waxy, greenish gray to dark greenish gray, indurated zones

Water Quality

Location	153-096-11ADA
County	McKenzie
Screened Interval	1289'-1370'
Aquifer	Fox Hills
Purpose	Observation Well
Date Sampled	09/09/87
Time Sampled	14:10:00
Yield (gpm)	25
Field Temp(C)	21
Lab pH	8.61
Field Conductivity (um/cm)	2710
Lab Conductivity (um/cm)	3460
Total Dissolved Solids (mg/L)	2020
Calcium (mg/L)	7.5
Magnesium (mg/L)	0
Potassium (mg/L)	3.2
Sodium (mg/L)	8100
Fluoride (mg/L)	4
Bicarbonate (mg/L)	1260
Carbonate (mg/L)	350
Sulfate (mg/L)	4.9
Chloride (mg/L)	5200
Hydroxide (mg/L)	
Nitrate(mg/L)	2.8
Iron (mg/L)	0.05
Manganese (mg/L)	0
Hardness(mg/L)	190
Sodium Adsorption Ratio (SAR)	81
Residual Sodium Carbonate (Equiv/L)	210
Percent Sodium	99


Historical Pressure Head Decline
Observation Well 15309611ADA
15309611ADA
Elevation (Ft)
2200
2167
2133
2100
2067
2033
2000
1985
1990
1995
2000
2005
2010
Year

153-096-20DCB1
NDSWC 6275A

Date Completed:	07/28/1984	Purpose:	Observation Well
L.S. Elevation (ft):	2282.1	Well Type:	4 in. - Steel
Depth Drilled (ft):	1700	Aquifer:	Fox Hills
Screen Int. (ft.):	1433-1500	Data Source:	NDSWC - Allen Comeskey

Completion Info: Open hole completion at 1433 feet

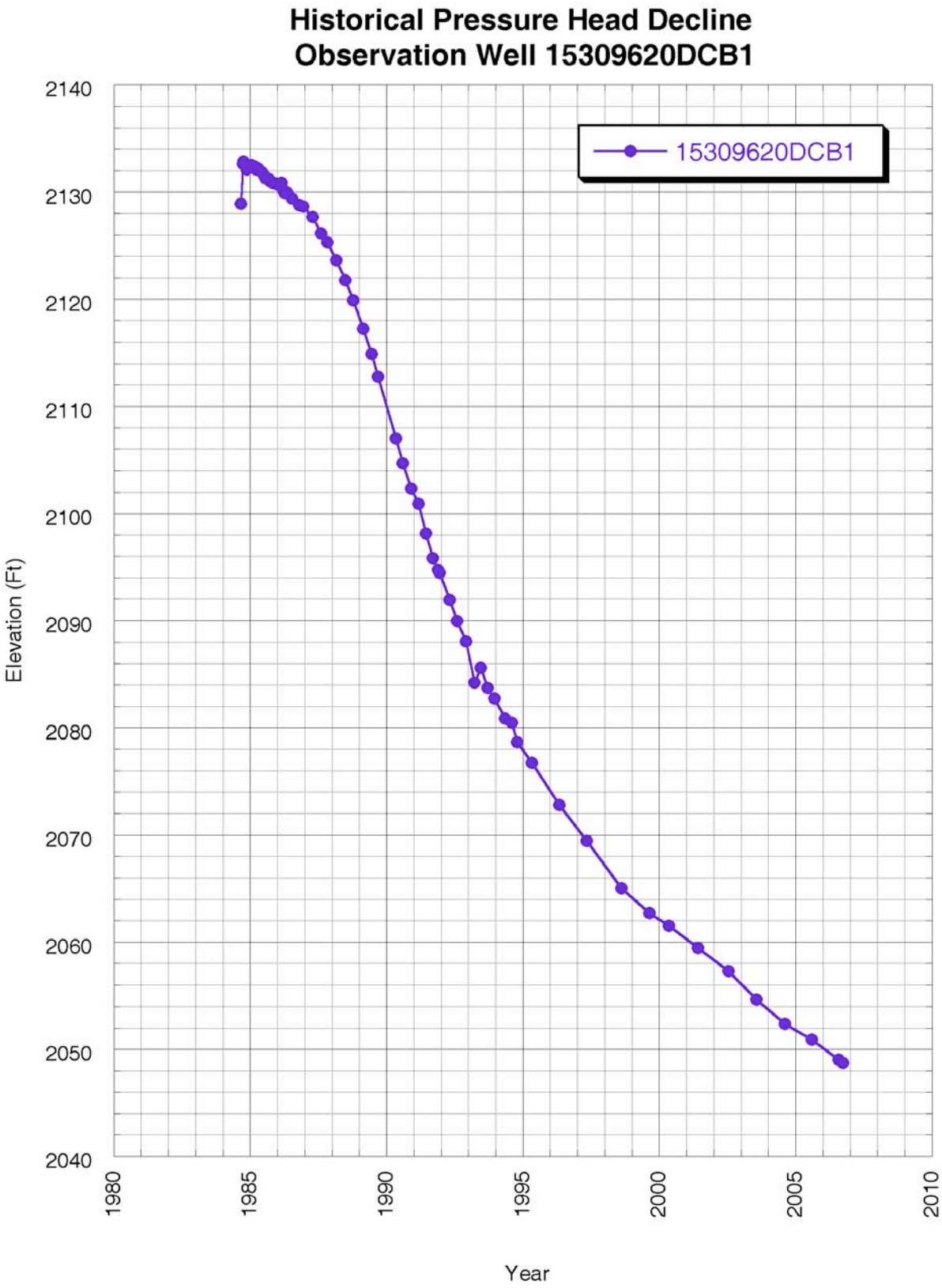
Remarks: Tobacco Garden well, south well located NE of road, NW of approach

Lithologic Log

Depth (ft)	Unit	Description
0-1	TOPSOIL	
1-4	CLAY	Yellowish brown, silty, cobbley (till)
4-18	CLAYSTONE	Yellowish brown to greenish gray, silty, lignite at 4-6 & 17-18
18-28	SILTSTONE	Greenish gray, clayey
28-35	CLAYSTONE	Bluish gray, lignite at 29-31, 33-35
35-75	SILTSTONE	Greenish to brownish gray, slightly clayey, clay 45-50, sand 54-61
75-155	SANDSTONE	Medium grained, yellowish brown (oxidized), clay 117-121, silt 130-135
155-180	CLAYSTONE	Bleu-greenish gray, silty, interbedded carbonaceous & bentonitic, lignite at 166-170
180-215	SILTSTONE	Greenish gray, clayey, limestone at 197-199, lignite at 214-215
215-270	SANDSTONE	Greenish gray, fine grained well sorted, carbonaceous, clayey 250-260
270-400	CLAYSTONE	Greenish gray, interbedded siltstone and lignite
400-450	SANDSTONE	Greenish gray, very fine grained, well sorted, silt 420-430
450-735	SILTSTONE	Interbedded with claystone and lignite beds
735-765	SANDSTONE	Very fine grained, well sorted
765-820	CLAYSTONE	Brownish gray, slightly silty
820-860	SANDSTONE	Medium grained, well sorted, clayey
860-877	CLAYSTONE	Silty
877-905	SANDSTONE	Very fine to fine grained, takes water
905-960	SILTSTONE	Greenish gray
960-1025	CLAYSTONE	Brown, waxy, slightly sitly, carbonaceous
1025-1180	SANDSTONE	Very fine grained, well sorted, interbedded indurated zones & clay/siltstone
1180-1247	CLAYSTONE	Greenish gray to brown, waxy, silty
1247-1265	SANDSTONE	Very fine grained, well sorted, poor recovery
1265-1440	CLAYSTONE	Greenish to brownish gray, slightly silty, poor recovery
1440-1500	SANDSTONE	Light greenish gray, medium grained, glauconitic (Fox Hills Formation)
1500-1591	CLAYSTONE	Brownish gray, interbedded siltstone
1591-1660	SILTSTONE	Greenish to brownish gray, interbedded with claystone
1660-1700	CLAYSTONE	Medium dark gray, waxy, noncalcareous, (Pierre Fm.)

Water Quality

Location	153-096-20DCB1
County	McKenzie
Screened Interval	1433'-1500'
Aquifer	Fox Hills
Purpose	Observation Well
Date Sampled	09/28/06
Time Sampled	16:45:00
Yield (gpm)	
Field Temp(C)	
Lab pH	8.63
Field Conductivity (um/cm)	
Lab Conductivity (um/cm)	3090
Total Dissolved Solids (mg/L)	1920
Calcium (mg/L)	3.24
Magnesium (mg/L)	<1
Potassium (mg/L)	2.39
Sodium (mg/L)	681.0
Fluoride (mg/L)	4.47
Bicarbonate (mg/L)	1180
Carbonate (mg/L)	62.0
Sulfate (mg/L)	3.81
Chloride (mg/L)	386.0
Hydroxide (mg/L)	<1
Nitrate(mg/L)	<0.09
Iron (mg/L)	0.105
Manganese (mg/L)	<0.01
Hardness(mg/L)	12.0
Sodium Adsorption Ratio (SAR)	84.7
Residual Sodium Carbonate (Equiv/L)	21.0
Percent Sodium	99.2


Historical Pressure Head Decline
Observation Well 15309620DCB1
15309620DCB1
Elevation (Ft)
2140
2130
2120
2110
2100
2090
2080
2070
2060
2050
2040
1980
1985
1990
1995
2000
2005
2010
Year