DEPARTMENT of ENVIRONMENT
and NATURAL RESOURCES

JOE FOSS BUILDING
523 EAST CAPITOL
PIERRE, SOUTH DAKOTA 57501-3182

denr.sd.gov

RECOMMENDATION OF CHIEF ENGINEER FOR WATER PERMIT APPLICATION NO. 8200-3, Don Schaefer

Pursuant to SDCL 46-2A-2, the following is the recommendation of the Chief Engineer, Water Rights Program, Department of Environment and Natural Resources concerning Water Permit Application No. 8200-3, Don Schaefer, 31435 149th Street, Hoven SD 57450.

The Chief Engineer is recommending APPROVAL of Application No. 8200-3 because 1) there is reasonable probability that there is unappropriated water available for the applicant's proposed use, 2) the proposed diversion can be developed without unlawful impairment of existing rights, 3) the proposed use is a beneficial use and 4) it is in the public interest with the following qualifications:

1. The wells approved under this Permit will be located near domestic wells and other wells which may obtain water from the same aquifer. The well owner under this Permit shall control his withdrawals so there is not a reduction of needed water supplies in adequate domestic wells or in adequate wells having prior water rights.

2. The wells authorized by Permit No. 8200-3 shall be constructed by a licensed well driller and construction of the well and installation of the pump shall comply with Water Management Board Well Construction Rules, Chapter 74:02:04 with the well casing pressure grouted (bottom to top) pursuant to Section 74:02:04:28.

3. This Permit is approved subject to the irrigation water use questionnaire being submitted each year.

See report on application for additional information.

Jeanne Goodman, Chief Engineer
March 21, 2016

REPORT TO THE CHIEF ENGINEER
ON
WATER PERMIT APPLICATION NO. 8200-3
DON SCHAEFER
MARCH 2, 2016

Water Permit Application No. 8200-3 proposes to appropriate water from the Hoven South management unit of the Bowdle aquifer for the irrigation of 160 acres. The application proposes to divert water from three wells located in the center of the NE¼, the NE¼NE¼, and the SE¼NE¼, respectively, of Sec. 21, T120N-R47W. Water is to be diverted at a maximum diversion rate of 2.28 cubic feet of water per second (cfs). The acreage to be irrigated is located in the NE¼ Sec. 21, T120N-R74W, in Potter County.

BOWDLE: HOVEN SOUTH

AQUIFER CHARACTERISTICS:

The Bowdle aquifer is a glacial outwash deposit consisting of sand and gravel that occurs at or near the land surface. The Hoven South management unit of the Bowdle aquifer extends south from Walworth/Potter County line six to seven miles, underlying an estimated 11,900 acres (Hedges and others, 1982). Hedges and others, (1982) estimated that the Hoven South management unit contains approximately 23,000 acre-feet of recoverable water in transient storage. The Hoven South management unit is hydrologically connected to the Hoven North management unit to the north, and to the Lebanon management unit to the south. The Hoven South management unit is under unconfined conditions with groundwater movement from south to north. The water table is expected to be approximately 30 feet below grade in the area of the well sites proposed by this application. The saturated thickness of the Hoven South management unit is typically less than 30 feet and generally high capacity irrigation wells can only be expected in those areas having 20 feet or more of saturated thickness (Hedges, 1977). Observation well data indicates the saturated thickness of the aquifer in the area of the proposed wells is currently 18 to 19 feet. This data indicates the water table has fluctuated with an amplitude of approximately 10 feet over the period of record, with highest water levels generally occurring in 1997, and lowest generally occurred in 1981-1983(Water Rights, 2016a). Consequently, during dryer periods, the saturated thickness near the well sites proposed by this application can be expected to be reduced to around 10 feet. A pump test was conducted in this area by the South Dakota Geological Survey and the Water Rights' Commission Staff in January of 1977. The test involved six observation wells monitored for 72 hours of drawdown and 72 hours of recovery. The results of the test showed a calculated transmissibility of 50,000 gallons per day per foot of aquifer (Selken, 1977).

History of controversy

The first water permit from the Bowdle: Hoven South aquifer was issued in 1968 to Mr. Willard Zweber. In 1976, Mr. Willard Zweber appeared before the Water Rights Commission to express his concerns about the additional water permits that had been approved from the aquifer between 1968 and 1976, declining water levels in the aquifer and decreased production from his irrigation wells. During the summer and fall of 1976, the South Dakota Geological Survey and Water Rights Commission Staff drilled test holes, installed observation wells, and conducted

aquifer pump tests in the Bowdle: Hoven South aquifer. On March 23-24, 1977, Water Rights Commission issued shut off orders to appropriators junior to Mr. Zweber's permits. The Commission's decision to shut off junior appropriators was appealed to the Sixth Judicial Circuit Court, and the court reversed the decision and remanded the matter back to the Commission for a new hearing. The Water Rights Commission reconsidered the matter on May 10, 1977, and Commission Staff testified that diminishment of Zweber's well yields was due to well construction/maintenance issues and lack of recharge to the aquifer and not interference from junior water permits. The Commission moved that pumping under junior water permits be allowed to continue with conditions that: 1) all permitted wells be metered, 2) the three junior appropriators pumping would be restricted based on certain water levels in two area observation wells, and 3) Water Rights Commission staff continue to study the area and present a report to the commission prior to the 1978 irrigation season. In 1979, the Commission raised the shut off water level established for the two observation wells by two feet. Mr. Zweber complained about water problems again in July 1980. Another complaint was filed in 1980 by Clifford and Robert Simon concerning the lowering of the water levels in their wells. After an investigation and drilling an additional observation well, it was determined that the Simon wells were not adequate. In 1981, the Water Management Board rescinded the Commission's action on using water levels in observation wells as shut-off of irrigation wells. Also in 1981, the Water Management Board denied a number of water permit applications proposing appropriations in the Hoven area. While most of the denied applications were from the Bowdle: Hoven North aquifer, the Board's action included denial of a water permit application (No. 3917-3, Robert L. Simon), proposing an appropriation from the Bowdle: Hoven South aquifer. The diversion points proposed by Application No. 3917-3 were to be located approximately two miles northwest of the well sites proposed by Application No. 8200-3. The application was denied due to past water availability issues in the area. Since 1981, the Water Management Board approved Future Use Permit No. 4860-3 for the City of Hoven in 1982, and Water Permit No. 5763-3, which corrected Water Right No. 1622-3, in 1993. There have not been any applications from the Hoven South management unit since 1993.

SOUTH DAKOTA CODIFIED LAW (SDCL) 46-2A-9

Pursuant to SDCL 46-2A-9, a permit to appropriate water may be issued only if there is reasonable probability that there is unappropriated water available for the applicant's proposed use, that the proposed diversion can be developed without unlawful impairment of existing rights and that the proposed use is a beneficial use and in the public interest. This report will address the availability of unappropriated water and existing rights from the aquifer.

WATER AVAILABILITY:

Water Permit Application No. 8200-3 proposes to appropriate water for the irrigation of 160 acres. If the permit is approved, the average annual water use that can be expected under this appropriation is estimated to be less than 106 acre-feet annually. The probability of unappropriated water available from an aquifer can be evaluated by considering SDCL 46-6-3.1, which requires "No application to appropriate groundwater may be approved if, according to the best information reasonably available, it is probable the quantity of water withdrawn annually from a groundwater source will exceed the quantity of the average estimated annual recharge of water to the groundwater source." If the source of the water is older or lower than the Greenhorn Formation and a water distribution system has applied for a permit, the Board need not consider

the recharge/withdrawal issue. Here, a water distribution system is not involved and the Bowdle: Hoven South aquifer is not older or lower than the Greenhorn Formation therefore withdrawal/recharge issue must be considered.

Recharge versus Discharge:
Recharge to the Bowdle aquifer occurs through infiltration of precipitation falling directly on the aquifer and runoff from surrounding areas. The average annual recharge to the Hoven South management unit was estimated in 1985, using observation well data, to be 2.5 inches per year (Hedges and others, 1985). Hedges and others (1985) also estimated recharge to the management unit by flow-net analysis to be 0.53 inches per year, although a disclaimer was included with this estimate that "...recharge rates calculated using flow-net analysis are suspect and conclusions based on this method are questionable" (Hedges and others, 1985). Given an areal extent of the Hoven South management unit of 11,900 acres, recharge to the management unit ranges from 525 of the flow net analysis estimate of recharge is used to 2479 of the more appropriate recharge estimate is used acre feet annually.

Discharge from the Hoven South management unit is from well withdrawals for domestic use and uses that require appropriations, evapotranspiration where the water table is near ground surface, and groundwater outflow to the Hoven North management unit. Although there are a number of domestic use wells completed into the Bowdle: Hoven South, the water use by domestic use wells is not expected to be significant to a hydrologic budget for the aquifer. There are five water rights and one future use reservation currently appropriating water from the Hoven South management unit of the Bowdle aquifer. Note: the source aquifer for Future Use Permit No. 4860-3 has been identified as the Hoven South management unit of the Bowdle aquifer, however given the location and well depth specified in the future use permit, the future use reservation may also involve the Onaka aquifer and/or the Hoven North management unit. Appropriations from the Bowdle: Hoven South aquifer are shown in Table 1.

Table 1. Appropriations from the Bowdle: Hoven South aquifer.

PERMIT NO	NAME	STATUS	USE	CFS	ACRES
1704-3	ALLEN TURNER	LC	IRR	1.11	96
2271A-3	DAVE HAGEMAN	LC	IRR	1.67	246
2598-3	JESSE FROST	LC	IRR	1.78	212
4063-3	FRANK & CAROL ZWEBER	LC	IRR	0.85	60
4860-3	CITY OF HOVEN	FU (410 ac-ft/yr)	MUN	na	na
5763-3	FRANK & CAROL ZWEBER	LC	IRR	1.44	201

Since 2000, when the City of Hoven switched to rural water, the water use from the Bowdle: Hoven South aquifer has been exclusively for irrigation use. Irrigation use reported from the management unit is shown in Table 2.

Table 2. Irrigation use reported from the Bowdle: Hoven South aquifer (Water Rights 1980-2015).

Year	Number of Appropriations	Total Appropriation (ac-ft/yr)	Reported Pumped (ac-ft/yr)	Application Rate * (in/ac/yr)
2014	4	1956	419.39	7.00
2013	4	1956	601.22	10.03
2012	4	1956	656.47	10.96
2011	4	1956	561.9	9.38
2010	4	1956	549.09	9.16
2009	4	1956	711.27	11.87
2008	4	1956	519.26	8.67
2007	4	1956	597.47	9.97
2006	4	1956	793.02	13.24
2005	4	1956	626.65	10.46
2004	4	1956	731.27	12.20
2003	4	1956	686.74	11.46
2002	4	1956	786.06	13.12
2001	4	1956	597.07	9.97
2000	4	1956	470.65	7.86
1999	4	1956	390.88	6.52
1998	4	1956	545.54	9.10
1997	4	1956	476	7.94
1996	4	1956	502.47	8.39
1995	4	1776	426.35	7.12
1994	5	1866	479.84	8.01
1993	7	2865	70	0.88
1992	8	3819	300	2.83
1991	8	3822	441	4.34
1990	8	3822	383	3.77
1989	8	3822	593	5.83
1988	8	3822	993.4	9.77
1987	8	3822	458	4.50
1986	8	3822	100	0.98
1985	6	3822	429	4.22
1984	6	3822	265	2.61
1983	8	3822	355.87	3.50
1982	8	3822	395.65	3.89
1981	6	3822	318	3.13
1980	7	3822	441	4.34
1979	7	3822	206	2.03
Average			*496.60*	*7.20*

* Application rate is in inches per permitted acre

A simple hydrologic budget comparing estimated average annual recharge to the Bowdle: Hoven South aquifer with the average annual well withdrawal from the aquifer indicates that it is probable that unappropriated water is available to satisfy the appropriation proposed by Application No. 8200-3.

Observation well analysis:

The DENR-Water Rights Program monitors 12 observation wells completed into the Bowdle: Hoven South aquifer. Hydrographs for the observation wells are shown in Figures 1-12. The hydrographs all document upward trending water levels throughout the aquifer. A rising water level in an aquifer indicates that recharge to the aquifer exceeds withdrawals from the aquifer.

An analysis of observation well hydrographs was used to quantify the change in volume of water in storage in the aquifer. The analysis involved determining the change of the water level in each observation well for every year (see Table 3). The amount of water represented by a change in water level was determined by multiplying the water level change by an estimated specific yield for the aquifer (0.15) (Hedges and others, 1982), and the aquifer area.

The average annual water level change for the 12 observation wells for the period of 1982-2015 was +0.19 feet. Although a number of the Bowdle: Hoven South aquifer observation wells have records older than 1982, a period beginning in 1982 was used to maximize the number of wells used for the analysis. Therefore, the water level for the aquifer increased an average of 0.19 feet per year from 1982-2015. The areal extent of the Hoven South management unit has been estimated to be 11,900 acres. Assuming a specific yield of 0.15, the annual change in volume in the aquifer has averaged:

(11,900 acres x 0.19 feet x 0.15)= 339.15 acre-feet/year

Therefore the observation well data indicates that recharge to the aquifer exceeded discharge from the aquifer by an average of 339 acre-feet per year for the period of 1982-2015. Since discharge from the aquifer included natural discharge (i.e. evapotranspiration and ground water outflow), and a portion of the natural discharges is available for capture for well withdrawals, 339 acre-feet per year should be considered a minimum amount of water that is available for additional well withdrawals.

The observation well analysis indicates that unappropriated water is available for this appropriation.

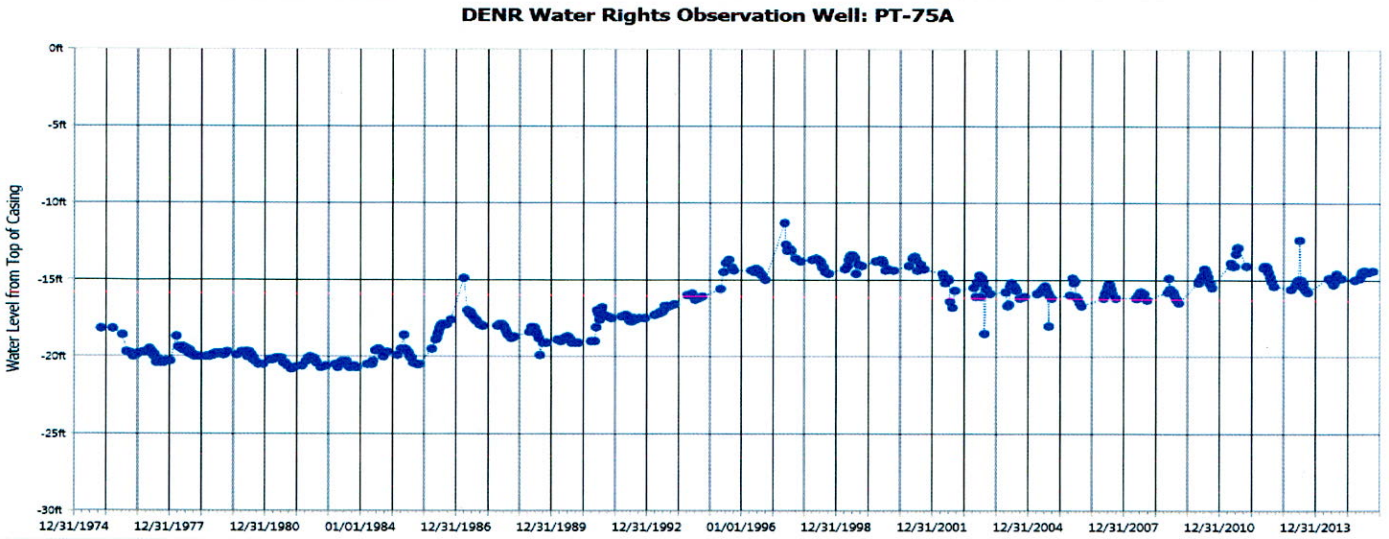


Figure 1. Hydrograph of observation well PT-75A which is completed into the Bowdle: Hoven South aquifer

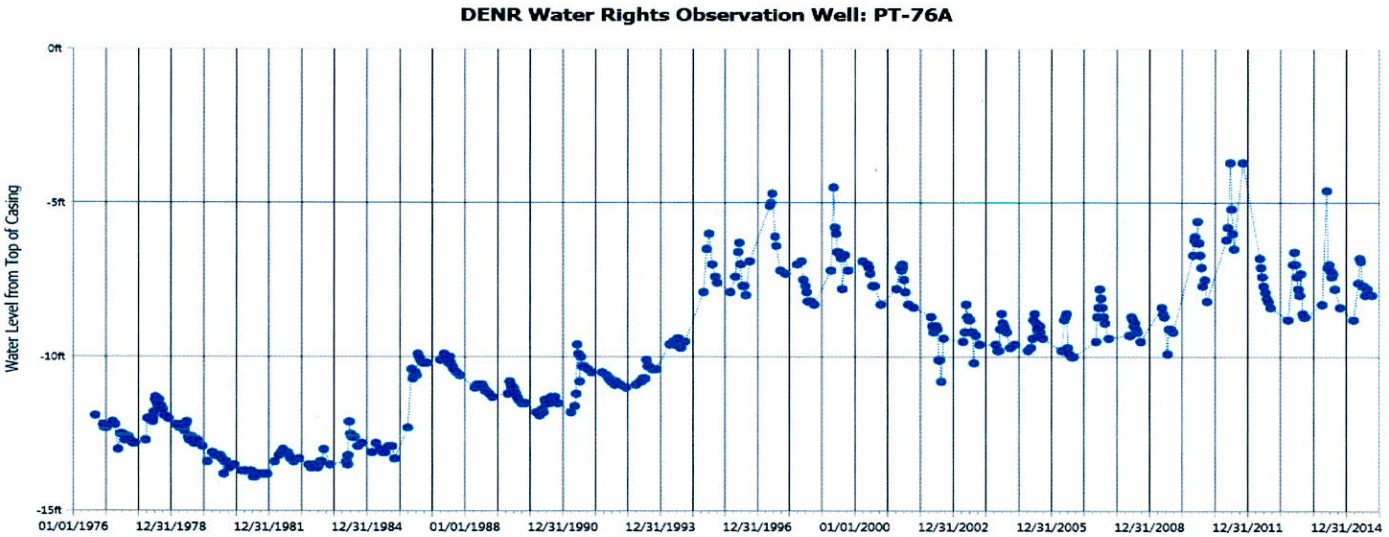


Figure 2. Hydrograph of observation well PT-76A which is completed into the Bowdle: Hoven South aquifer

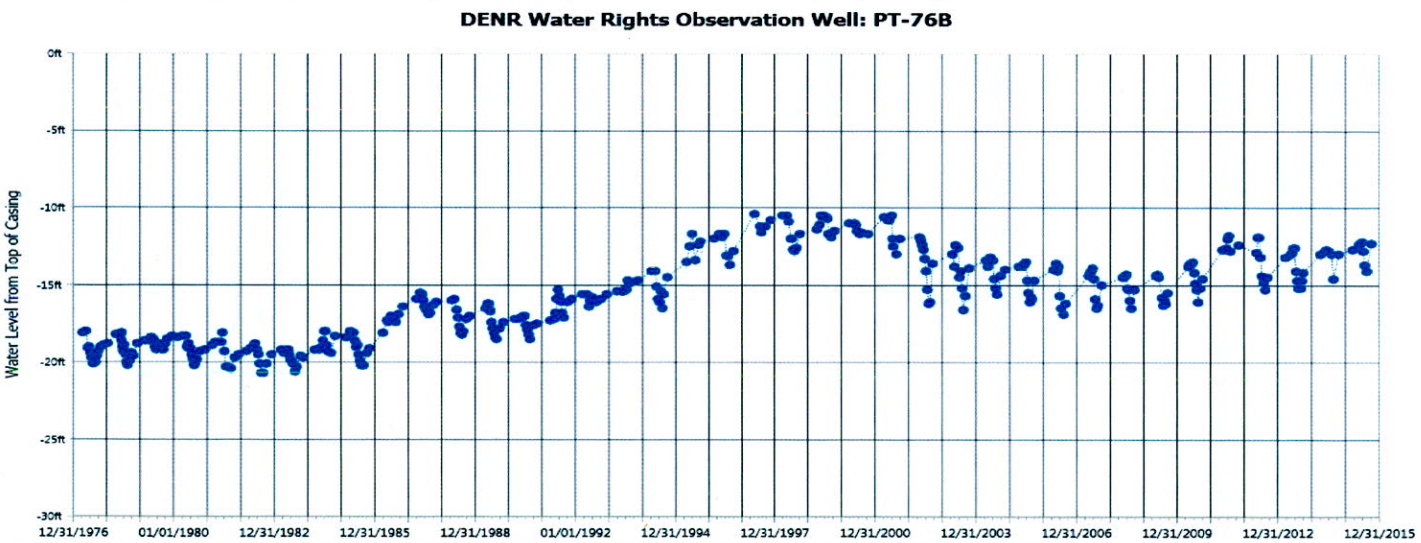


Figure 3. Hydrograph of observation well PT-76B which is completed into the Bowdle: Hoven South aquifer

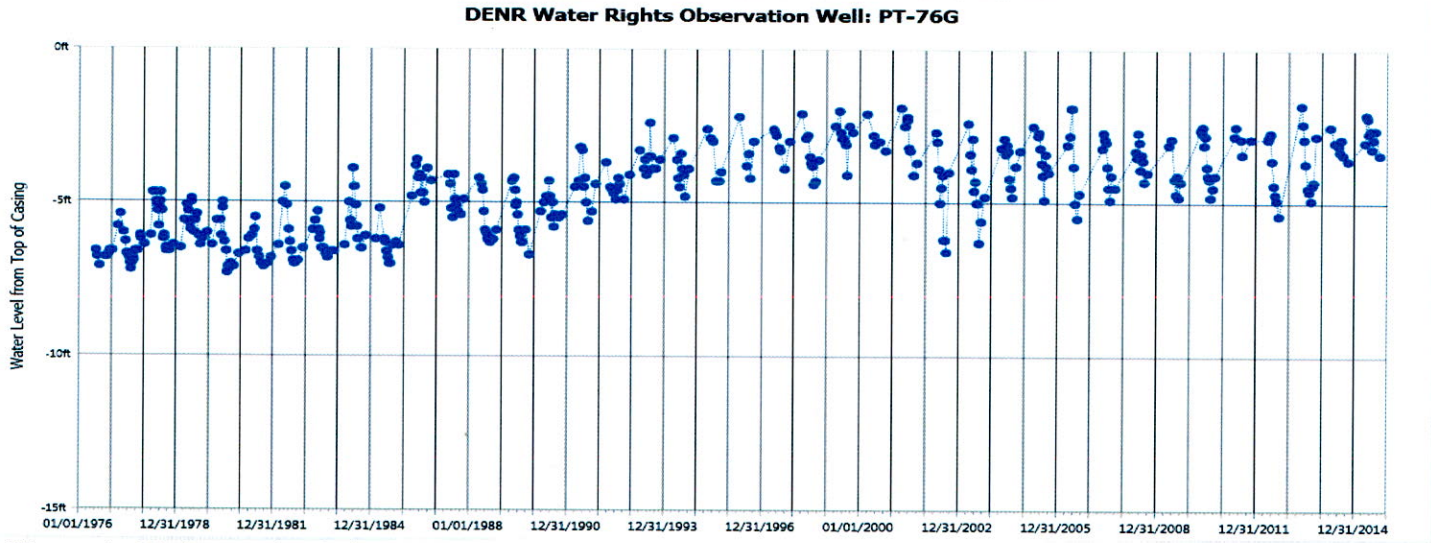


Figure 4. Hydrograph of observation well PT-76G which is completed into the Bowdle: Hoven South aquifer

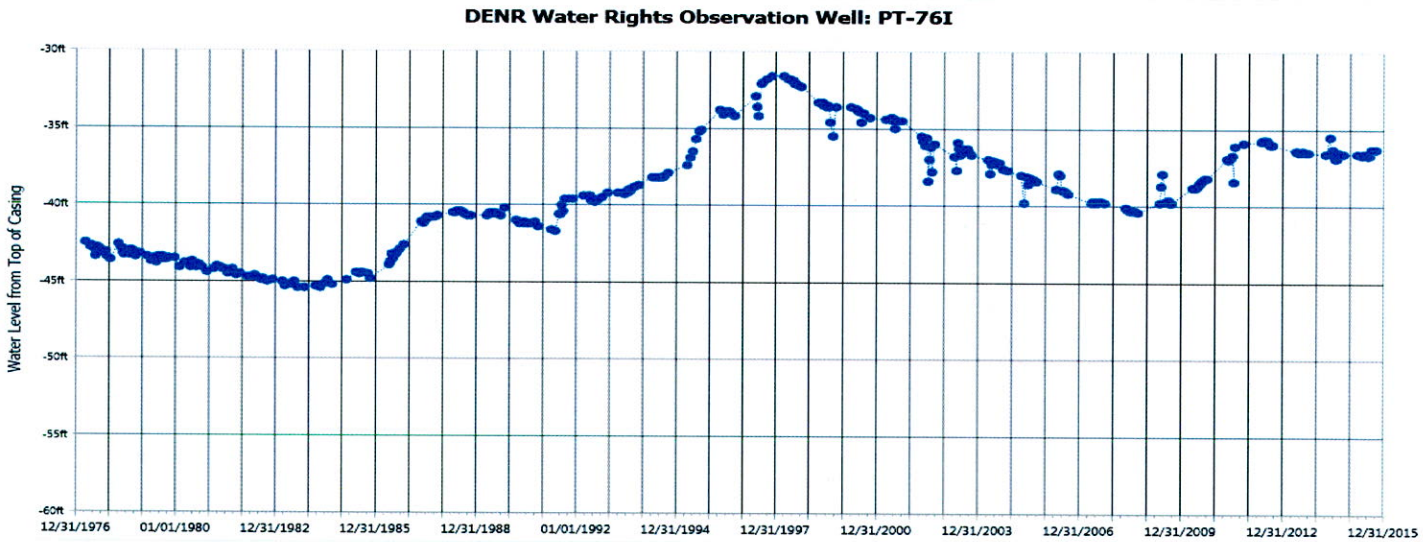


Figure 5. Hydrograph of observation well PT-76I which is completed into the Bowdle: Hoven South aquifer

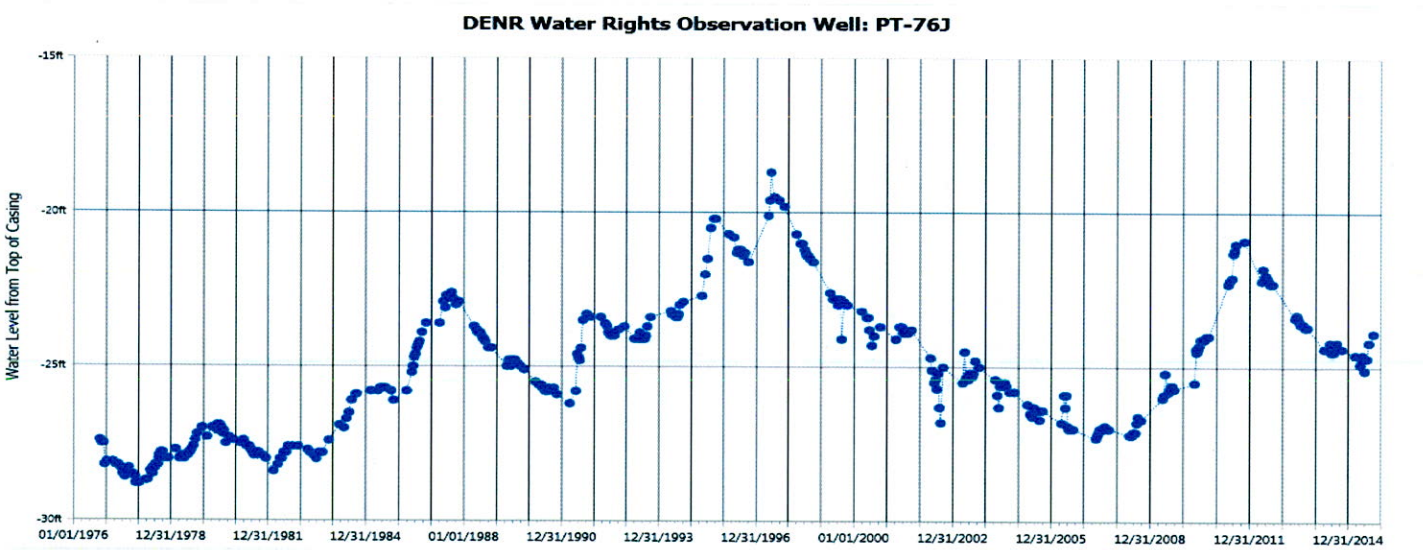


Figure 6. Hydrograph of observation well PT-76J which is completed into the Bowdle: Hoven South aquifer

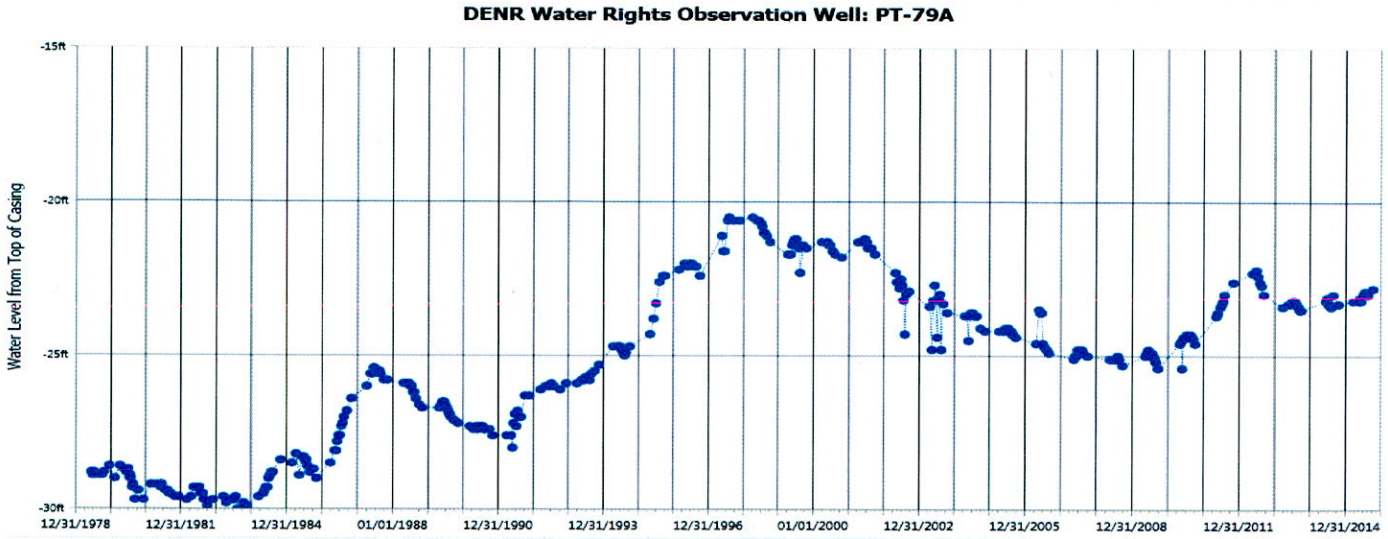


Figure 7. Hydrograph of observation well PT-79A which is completed into the Bowdle: Hoven South aquifer

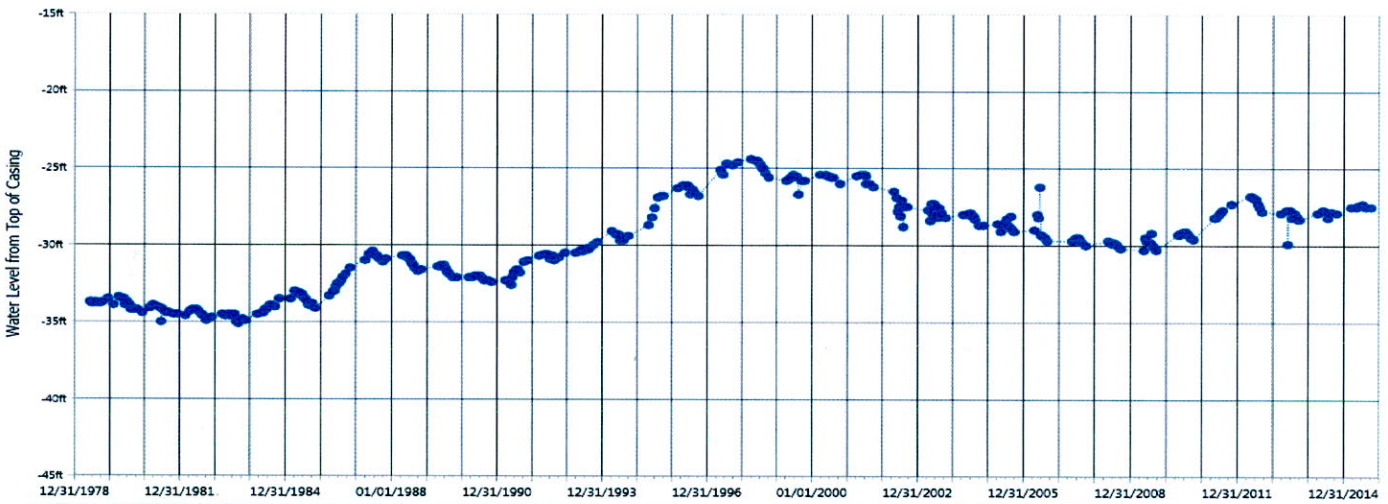


Figure 8. Hydrograph of observation well PT-79B which is completed into the Bowdle: Hoven South aquifer

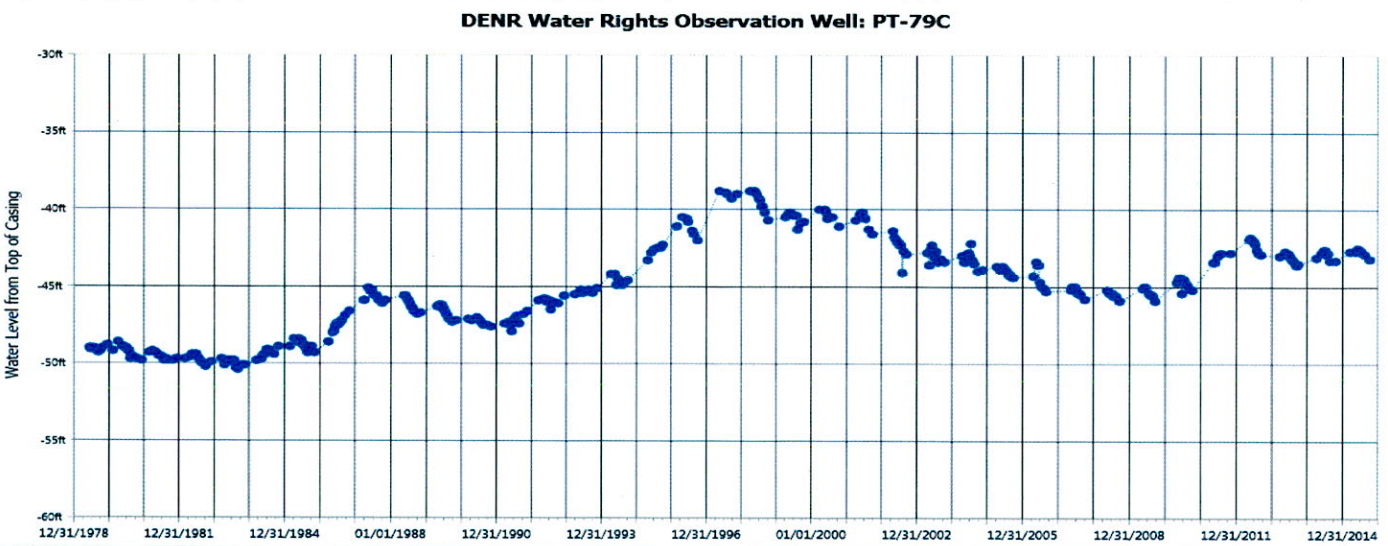


Figure 9. Hydrograph of observation well PT-79C which is completed into the Bowdle: Hoven South aquifer

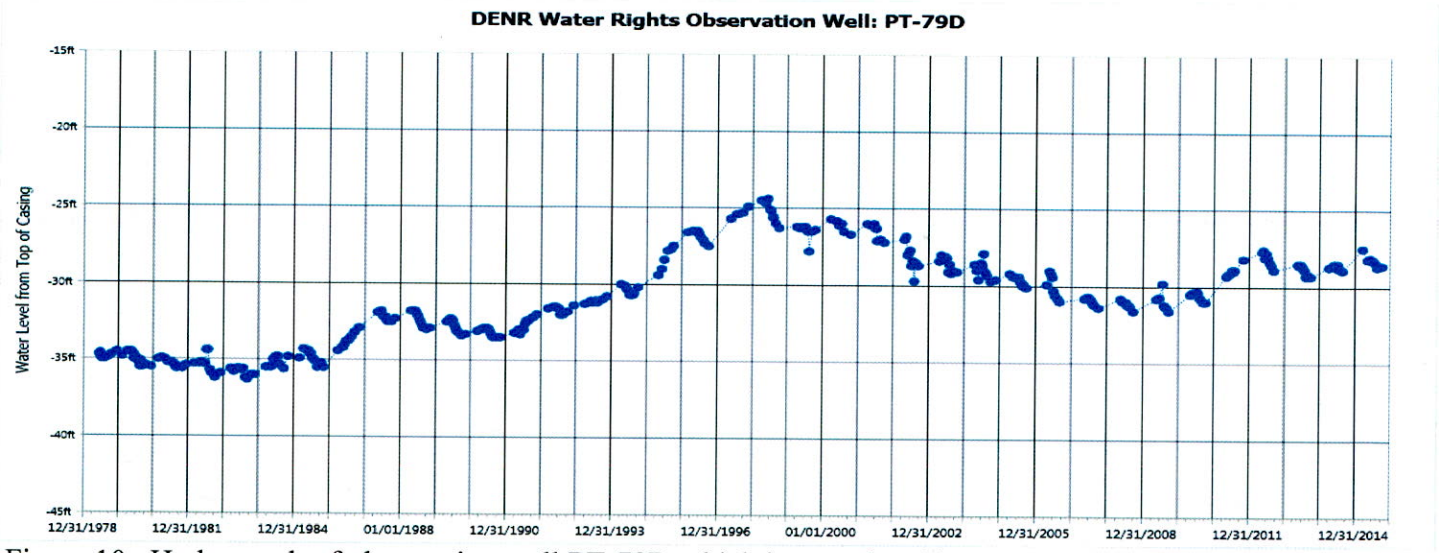


Figure 10. Hydrograph of observation well PT-79D which is completed into the Bowdle: Hoven South aquifer

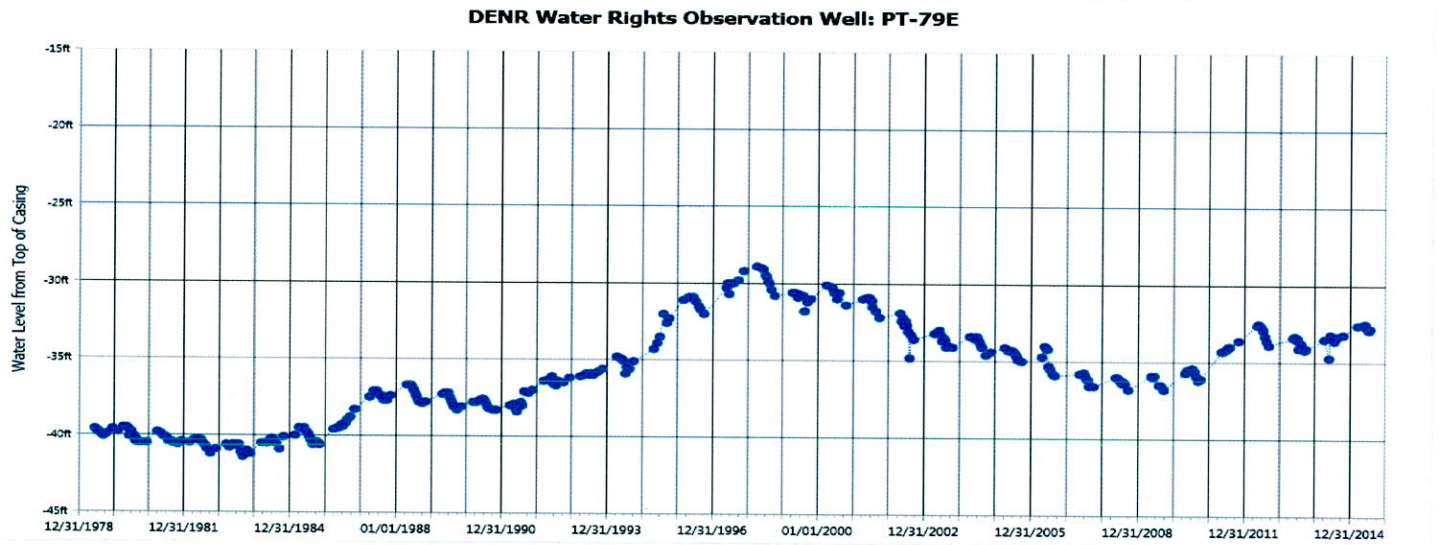


Figure 11. Hydrograph of observation well PT-79E which is completed into the Bowdle: Hoven South aquifer

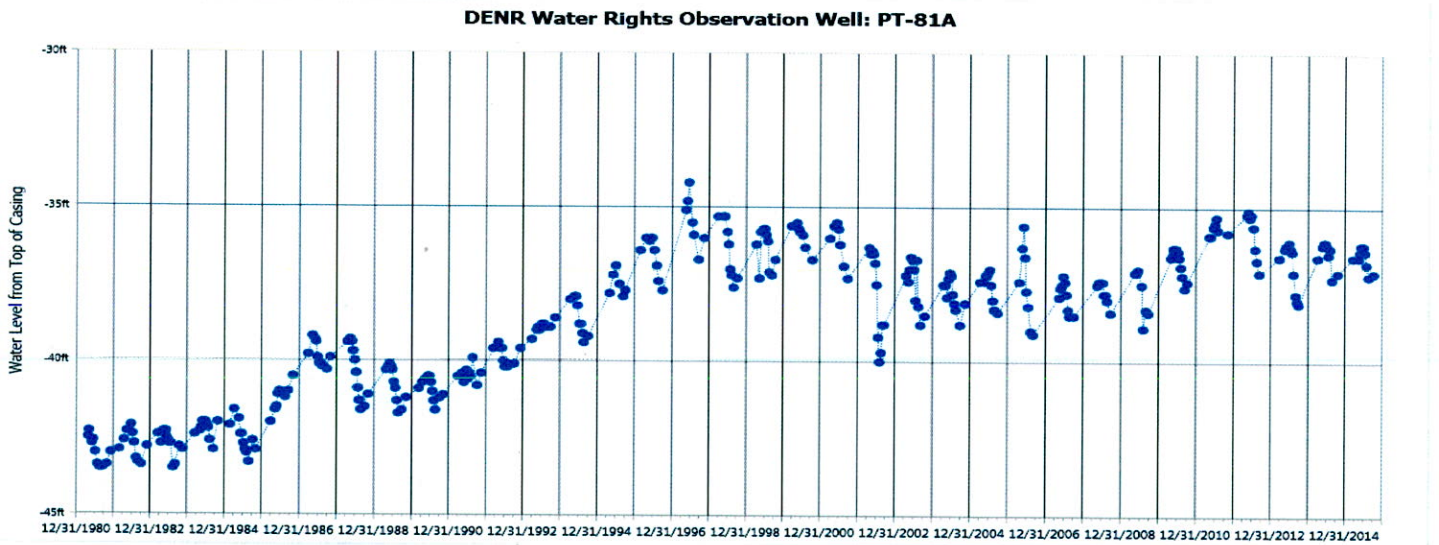


Figure 12. Hydrograph of observation well PT-81A which is completed into the Bowdle: Hoven South aquifer

Water Year	PT-75A	PT-76A	PT-76B	PT-76G	PT-76I	PT-76J	PT-79A	PT-79B	PT-79C	PT-79D	PT-79E	PT-81A	
1975													
1976	-1.6												
1977	-0.5	-0.8		-0.1		-1.1							
1978	0.4	1	-0.1	0.3	-0.1	0.7							
1979	0.1	-1.1	0.6	0.2	-0.4	0.4							
1980	-0.7	-0.8	-0.5	-0.7	-0.6	0.1	-0.5	-0.4	-0.5	-0.6	-0.5		
1981	-0.1	-0.2	-1.1	0	-0.5	-0.6	-0.1	-0.3	-0.1	-0.1	0		
1982	-0.1	0.4	0.3	0.2	-0.4	0.3	-0.4	-0.4	-0.4	-0.7	-0.7	0.1	
1983	0.1	0.4	0.5	0.3	-0.4	-0.2	0.1	0.1	0.1	0.2	0.2	0.6	
1984	0.6	0.1	0.2	0.5	0.2	1.9	1.4	0.8	0.7	0.4	0.1	-0.1	
1985	-0.5	0	0	-0.2	0.7	0.1	-0.3	0.2	0.5	0.4	0.5	0.3	
1986	2.6	2.7	2.5	2.4	1.6	1.9	1.9	1.9	2	2	1.6	1.6	
1987	0	-0.3	0.6	-1.5	2.1	0.9	1	0.8	0.8	0.7	1.1	0.7	
1988	-0.9	-0.7	-0.9	-0.8	0.1	-1.4	-0.8	-0.6	-0.7	-0.5	-0.2	-1.2	
1989	-0.3	-0.3	-0.6	0.3	0	-0.6	-0.5	-0.4	-0.5	-0.4	-0.4	-0.1	
1990	0	0.2	0.2	0.4	-0.4	-0.7	-0.3	-0.2	-0.2	-0.1	0	0.4	
1991	1.7	0.9	1.5	0.2	1.5	2.4	1.1	1.2	0.7	1.3	1.1	0.4	
1992	-0.1	-0.5	0.2	0.4	0.1	-0.5	0.2	0.3	0.7	0.4	0.7	0.7	
1993	0.8	0.5	1.1	1	0.7	0.4	0.6	0.8	0.7	0.8	0.7	1.2	
1994	0.6	0.9	0.3	0	0.9	0.5	0.8	0.6	0.8	0.8	0.7	-0.3	
1995	1.7	1.9	2.3	-0.1	2.8	2.7	2.3	2.6	2.3	2.5	2.8	1.5	
1996	-0.6	0.7	-0.6	1	0.9	-1.4	0	0	0.3	0.2	0.3	0	
1997	1.4	-0.3	1.6	-0.9	2.4	2	1.8	2	2.7	2.2	2.2	1	
1998	-1	-1.1	-0.5	0.3	-0.5	-2	-0.7	-0.8	-1.4	-1	-1	-0.6	
1999	0.5	1.1	0.2	0.9	-1.3	-1.4	-0.2	-0.2	-0.1	-0.1	-0.2	0.6	
2000	-0.3	-1.1	-0.2	-0.6	-0.7	-0.7	-0.3	-0.2	-0.3	-0.3	-0.4	0	
2001	0.1	-0.1	-0.3	-0.4	-0.2	-0.1	0.1	-0.2	-0.5	-0.5	-0.8	-0.6	
2002	-1.4	-1	-1.6	-0.3	-1.5	-1.2	-1.2	-1.3	-1.3	-1.5	-1.4	-1.5	
2003	-0.2	-0.2	-0.3	-0.8	-0.5	0	-0.7	-0.7	-0.5	-0.4	-0.5	0.3	
2004	-0.3	-0.1	-0.5	1	-1.1	-0.8	-0.5	-0.5	-0.6	-0.6	-0.5	-0.3	
2005	0	0.3	-0.3	-0.2	-0.8	-0.6	-0.3	-0.4	-0.4	-0.4	-0.4	0.4	
2006	-0.5	-0.6	-1.5	-0.7	-0.8	-0.6	-0.5	-0.6	-0.9	-0.9	-0.9	-0.7	
2007	0.5	0.6	1.2	0.2	-0.6	0	-0.1	-0.3	-0.5	-0.4	-0.7	0.6	
2008	-0.1	-0.1	-0.3	0.5	-0.6	0.3	-0.3	-0.2	-0.1	-0.2	-0.2	0.1	
2009	-0.2	0.3	-0.2	-0.3	0.6	1	-0.1	-0.1	0	0	0	0	
2010	1	1	0.9	0.2	1.6	1.7	1	0.7	0.7	0.6	0.7	1	
2011	1.4	4.5	2.2	1.2	2.3	3.1	1.8	2.3	2.4	2.8	2.5	1.6	
2012	-1.3	-4.7	-2.1	-2.5	-0.1	-1.4	-0.4	-0.5	-0.1	-0.7	-0.3	-1.3	
2013	-0.4	-0.3	0.3	1.1	-0.5	-1.4	-0.5	-0.5	-0.6	-0.4	-0.2	-1	
2014	0.9	0.3	1.2	0.7	-0.1	-0.7	0.2	0.4	0.2	0.4	0.9	1	
2015	0.5	0.4	0.7	0.2	0.3	0.5	0.5	0.4	0.1	0.3	0.4	0	
Ave	*0.182353*	*0.170588*	*0.238235*	*0.108824*	*0.244118*	*0.117647*	*0.197059*	*0.205882*	*0.194118*	*0.202941*	*0.226471*	*0.188235*	*0.189706*

Table 3. Annual water level fluctuations for observation wells completed in the Bowdle: Hoven South Aquifer. *1975-191 values are not included in the averages so all 12 observation wells can be incorporated into the analysis

EXISTING WATER RIGHTS/PERMITS

Existing water rights/permits in the vicinity of the well sites proposed by this application are shown in Table 4 and Figure 13.

Hydrographs of the observation wells completed into the Bowdle: Hoven South aquifer document that the aquifer responds to recharge and pumping. Since the aquifer is under unconfined conditions, the cone of influence that results from pumping a well is not expected to be significant very far from the well. Examination of the observation well hydrographs confirms this. For example, observation well PT-76B is located within approximately 700 feet of the four wells that supply Water Right 2271A-3, and the hydrograph for the observation well (Figure 3.) only shows 1-2 foot fluctuations during irrigation seasons (Water Rights 2016a). The combination of all irrigation pumping from the aquifer does have a minor effect on the water levels even beyond drawdown cones. Assuming all of the water pumped comes out of storage, (i.e. no recharge occurs during the irrigation season), and none of the natural discharges from the aquifer are captured, the impact of the maximum pumping from the management unit (786.06 acre-feet in 2002) would have been at maximum, 0.44 feet over the entire aquifer. This water level decline is minor in comparison with the natural water level fluctuations of the aquifer. The issuance of this appropriation will not adversely impact existing users.

As stated earlier, there has been a history of controversy in this area. The annual recharge to water in storage ratio of this management unit is fairly high, therefore, the aquifer is susceptible to drought conditions, and the saturated thickness of the aquifer can be reduced significantly. Given a transmissivity of 50,000 gallons per day per foot, each foot of water level decline can be expected to reduce a well's yield by approximately 35 gallons per minute. Considering the limited saturated thickness of the aquifer, during drought conditions, some wells may have production issues.

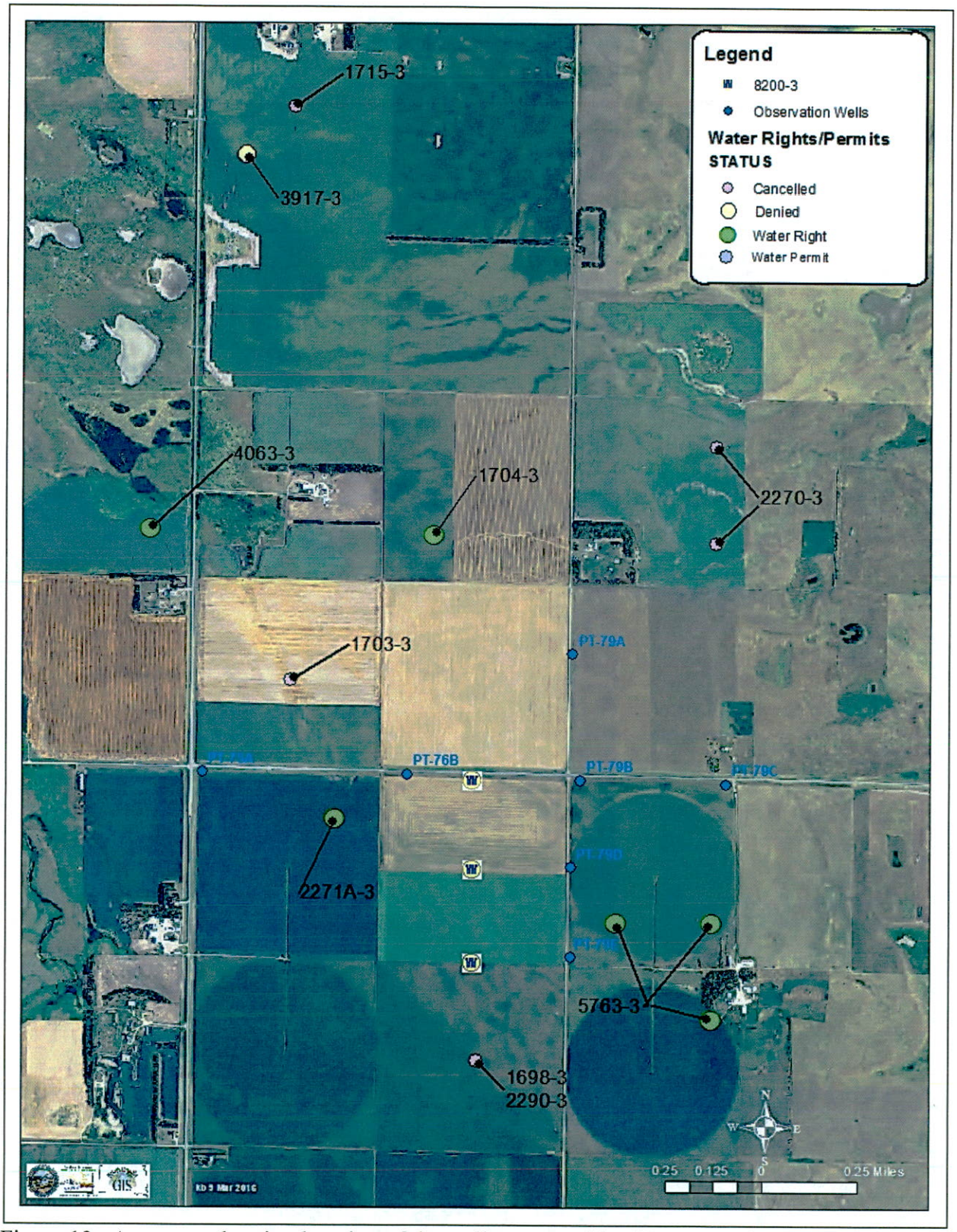


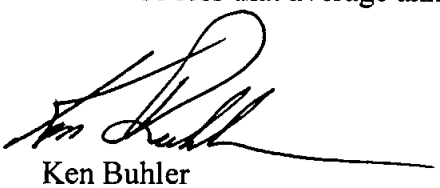
Figure 13. Area map showing location of the wells proposed by Water Permit Application No. 8200-3, DENR-Water Rights observation wells, and approximate location of diversion points proposed by previous applications.

Table 4. Water permit applications shown on Figure 13.

PERMIT NO	NAME	STATUS	CFS	ACRES
2270-3	ALLEN TURNER	CA	4.5	318
1698-3	RAY ZWEBER	CA	2.27	159
1703-3	DEAN GIESE	CA	2.28	160
1715-3	ROBERT L SIMON	CA	2.17	152
2290-3	BILL ZWEBER	CA	2.22	160
3917-3	ROBERT L SIMON	DN	0	0
1704-3	ALLEN TURNER	LC	1.11	96
2271A-3	DAVE HAGEMAN	LC	1.67	246
4063-3	FRANK & CAROL ZWEBER	LC	0.85	60
5763-3	FRANK & CAROL ZWEBER	LC	1.44	201

CONCLUSIONS:

1. The Hoven South management unit of the Bowdle aquifer is a relatively thin, surficial, glacial aquifer under unconfined conditions.
2. There has been a history of controversy involving the Bowdle: Hoven South aquifer with concerns about reduced well production during drought years.
3. There is a reasonable probability that average annual recharge to the Bowdle: Hoven South aquifer will exceed average annual withdrawals from the aquifer if Water Permit No. 8200-3 is approved.
4. Well interference is not expected to be a concern due to the unconfined conditions of the aquifer.
5. The average annual recharge/water in storage ratio is fairly high in the Bowdle: Hoven South aquifer so some wells completed in the aquifer may experience production problems during times of drought even though average annual withdrawal is expected to be less that average annual recharge.



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