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HYDROGEOLOGICAL EVALUATION AND ASSESSMENT
PAWNEE RIDGE SUBDIVISION
STERLING, COLORADO

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INTRODUCTION/OBJECTIVE AND PURPOSE

Kumar and Associates, Inc. (K+A) has been retained by the Pawnee Ridge Homeowners Association to provide hydrogeological evaluation and assessment services related to shallow ground water conditions in the subdivision. In addition K+A will provide mitigation alternatives to lower the ground water table in critical areas of the subdivision.

SITE HISTORY AND DESCRIPTION

Location

The Pawnee Ridge Subdivision near Sterling, Colorado consists of 106 homes of which 2 are not members of the Pawnee Ridge Homeowners Association. Pawnee Ridge is located northwest of the Sterling city limits in Logan County. The oldest homes in Pawnee Ridge were constructed in the early 1970's. A location map of the subdivision is provided on Figure 1. The site is situated in Section 19, Township 8 North, Range 52 West. The elevation of the subdivision ranges from approximately 3,975 feet above mean sea level in the southeastern and northeastern portions of the subdivision along Springdale Ditch to slightly over 4,000 feet in the northwestern portion of the subdivision. Overall relief across the subdivision is approximately 25 to 30 feet.

Geology

Pawnee Ridge is located in the Colorado Piedmont Section of the Great Plains Physiographic Province. The salient features of the Great Plains are large flat divides of rolling grassland that lie between and adjacent to the valleys of the South Platte and the Arkansas Rivers. These two major shallow rivers gradually rise from the eastern border of the state, at elevations around 3,500 feet, westward to the foothills of the Rocky Mountains.

In the vicinity of the Pawnee Ridge Subdivision Holocene age alluvium is present south and east of the Springdale Ditch comprising the South Platte Alluvial Valley. Figure 2 shows the topography and surficial geology of the Pawnee Ridge Subdivision. North and west of the Springdale Ditch Holocene and Pleistocene age eolian sand consisting of pale-brown, yellowish-brown, or dark yellowish brown locally silty well sorted loose wind-blown sand which contains calcareous brown soil in upper part underlies the Pawnee Ridge Subdivision. The eolian sand overlies the older alluvial deposits to a depth of approximately 30 to 60 feet in the Pawnee Ridge area. These alluvial deposits consist of poorly sorted gravel, sand and clay with caliche.

Underlying the alluvial deposits is the Upper Transition Member of the Pierre Shale of Upper Cretaceous Age. This unit consists of dark-gray marine calcareous silty shale or claystone,

shaley sandstone, and sandy shale. This formation is typically of low permeability and forms a hydrologic confining layer in most areas.

Hydrogeology

The hydrogeology or ground water occurrence in the vicinity of Pawnee Ridge is dominated by the alluvial deposits underlying the subdivision and the hydraulic connection (tributary) to the South Platte River. The alluvial aquifer underlying the subdivision is reportedly up to 60+ feet thick. Eighteen domestic water supply wells are present within the subdivision ranging in depth from approximately 40 to 70 feet. In addition, eight monitoring wells have been installed at the locations shown on Figure 2 to monitor shallow ground water conditions. The direction of ground water flow is generally from the west-northwest to the east-southeast. The depth to ground water within the Pawnee Ridge subdivision ranges from less than 5 feet to over 20 feet near the domestic wells.

Over the past several years water augmentation projects have changed the hydrogeological conditions in the vicinity of Pawnee Ridge. Colorado law provides for the adjudication of a "plan for augmentation" which is defined as a program to increase the supply of water available for beneficial use by the development of new or alternate means or points of diversion, by a pooling of water resources, by water exchange projects, by providing substitute supplies of water, by development of new sources of water, or by any other appropriate means.

A plan for augmentation is most often used to allow the out-of-priority diversion of water from the tributary stream system and the replacement of the depletion caused by that diversion from some other source. Sources of replacement water include senior direct flow water rights, non-tributary ground water, or water stored in priority and available for later release. The replacement water must be of a quality and quantity so as to meet the requirements for which the water of the senior appropriator has normally been used. Water court approval of a plan for augmentation will permit the applicant to continue diversions of water when curtailment would otherwise be required to meet a valid senior call for water.

The result of augmentation in the vicinity of Pawnee Ridge is the creation of augmentation ponds up gradient or west of the subdivision and the nearly continuous flow of the irrigation supply ditches both up gradient (North Sterling and Pawnee) and down gradient (Springdale and Sterling #1). The increased ground water recharge up gradient of the subdivision has resulted in increased water levels. The increase in water levels did not impact the Pawnee Ridge Subdivision until the last few years (2008 to 2009).

The continuous flow in the down gradient irrigation supply ditches, particularly the Springdale Ditch, has created a ground water barrier down gradient of the subdivision restricting the release of shallow ground water to the east and southeast from the subdivision.

CONCEPTUAL HYDROGEOLOGIC MODEL

A conceptual hydrogeologic model of Pawnee Ridge is shown on Figure 3. As shown on the Figure recharge to the alluvial aquifer occurs up gradient from ditch seepage and augmentation ponds. Additional recharge occurs from normal precipitation and irrigation of lawns/gardens within Pawnee Ridge. Ground water discharge occurs in the form of evapotranspiration and domestic well pumping within the subdivision. Recharge to the alluvial aquifer occurs immediately down gradient of the subdivision in the form of seepage from the Springdale Ditch.

Sump pump discharge from Pawnee Ridge homes with basement drains is discharged to the ground surface and re-infiltrates into the shallow aquifer, re-circulating the pumped water.

SUMMARY OF HOMEOWNER QUESTIONNAIRE RESPONSES

A questionnaire was sent to all 106 homes within the Pawnee Ridge Subdivision. At the time of this report 78 responses were received. Table 1 summarizes the responses from the homeowners. Fifty-six of the 78 responses (72%) reported having basements. Of the 78 owners responding, 12 or 15% reported wet or flooded basements and 3 (4%) reported wet crawl spaces. The responses also indicated that major basement water issues began in 2009 with some sumps initiating pumping in 2006.

Figures 4 and 5 present the distribution of homeowner responses, the distribution of basements and the distribution of impacted (wet) basements and crawl spaces. As shown on Figures 4 and 5 the shallow ground water problems are localized in the area of Dakota Road and to a lesser extent at the southeastern or down gradient area of the subdivision along Westwood Drive and Shawnee Place.

WELL DATA

Domestic Wells

According to the Sate Engineer's Office of the Colorado Division of Water Resources there are eighteen registered domestic wells within the Pawnee Ridge Subdivision. There are also five monitoring wells with "Notices of Intent" on file at the State Engineer's Office. In addition one permit application for a dewatering well is on file however a permit has not been issued for a dewatering the well located at 14327 Dakota Road. A summary of the registered well information is provided on Table 2. The domestic wells were installed from 1968 through 1977 and range in depth from 41 to 68 feet. The well yields are reported to range from 15 to 30 gpm.

The well logs were reviewed to evaluate the stratigraphy at Pawnee Ridge. Copies of the well permits and logs are provided in Appendix A. The logs indicate that the thickness of alluvium ranges from approximately 29 to 62 feet in depth. Underlying the alluvial deposits is shale of the Pierre Shale Formation. The alluvial deposits typically consist of fine to coarse sand and gravel with occasional boulders reported in the lower portion. Several of the well logs indicate

the presence of clay or clay lenses of up to 15 feet in thickness (Well Permit # 41428). The clay lenses likely act as local confining layers.

Static (non-pumping) water levels in these wells ranged from 11.5 to 25 feet in depth. These measurements reflect ground water levels in the late 1960s through the mid 1970s.

Monitoring Wells

In the fall of 2009 seven monitoring wells were installed at Pawnee Ridge to evaluate and monitor over time the shallow ground water conditions. The well locations a re shown on Figure 2 and a summary of the well readings is provided on Table 3. Hydrographs of the monitoring wells prepared by the Pawnee Ridge Homeowners Association are included in Appendix B. The data indicate that five of the seven wells (St. John, Meier, Milyard/Samber, Fast SE, and Fast SW) had ground water levels which ranged from approximately 5 to less than 7 feet in depth consistently from November 2009 through August 2010. In September 2010 three of these wells (St. John, Meier, and Milyard/Samber) decreased approximately 5 feet rather dramatically to depths of approximately 10 feet. The Fast SE and SW wells only showed a slight decrease of less than 1 foot.

The Boren and Libeig monitoring wells show ground water depths at approximately 10 and 15 feet, respectively. The Boren well did not exhibit a significant decrease in September 2010 while the Libeig well exhibited a decrease of approximately of over 2 feet to a depth below ground of 17.6 feet.

The shallow ground water levels at Pawnee Ridge appear to be responsive to precipitation and augmentation amounts as well as well pumping and ditch seepage from irrigation in the nearby area. For example, well pumping increased during the late summer 2010 dry period and the North Sterling inlet ditch did not run from July 13th thru September 15th. The nearby augmentation or recharge ponds also did not have much water in them since mid July. It appears that the aquifer in the area was extremely full due to precipitation and augmentation and when precipitation and at the same time augmentation decreased the aquifer dropped substantially as pressure was relieved.

MITIGATION ALTERNATIVES

There are three basic alternatives to mitigate the shallow ground water conditions at Pawnee Ridge and the resultant impacts on homeowners. They can be grouped into two categories; drains and wells.

Drains

Ground water drains designed to decrease or drain the ground water table can be either regional affecting a large area or local, for example, a foundation drain which would only affect

the immediate area of a structure. An example of a large regional drain is the Pioneer Drain located down gradient or east of Pawnee Ridge subdivision.

Large regional drains require land space and a depth that would regionally lower the water table. In addition, there has to be a cost effective way to discharge the drained water. At Pawnee Ridge, the area to install a large regional drain is not readily available and discharge from the drain would likely have to be pumped through a conveyance across the Springdale ditch to wetlands east of the subdivision. Capital costs to install a regional drain, pumps and conveyance would be the highest of all alternatives at several hundred thousand dollars not including operational and maintenance costs.

Local drains are those that drain the water at the source of impact. These would include perimeter foundation and/or subslab drains. Depending on the number of impacted residences local drains are typically the least expensive alternative. Carefull design of drains and discharge conveyance need to be considered for the local drains to be effective and minimize operational costs. Discharge of local drains in the vicinity of the residence results in local recharge of the shallow aquifer cycling water back to the drain resulting in nearly continuous operation of drain pumps. Local drain discharge water should be conveyed to a location that does not recharge the shallow aquifer in the vicinity of the drains. Typical local drains are estimated to cost approximately $8,000 to $10,000 for an effective system.

Wells

Large capacity wells designed to regionally lower the ground water levels could be effective when properly located and designed. Pump testing of the wells would be required to determine the appropriate pumping rate, drawdown, and radius of influence.

Again, the well discharge would have to be conveyed beyond the area of impact similar to the regional drain system. Based on the distribution of impacts previously described at Pawnee Ridge three to four wells may be required to effectively lower the water table.

These wells may not be able to be permitted as they likely will impact the existing domestic wells in the subdivision. Large capacity wells are estimated to cast from $25,000 to $30,000 each including drilling, pump, pump testing, and permitting. These costs do not include the conveyance for discharge or operational and maintenance costs, which would be higher than a regional or local drain(s).

CONCLUSIONS AND RECOMMENDATIONS

Shallow ground water conditions within the Pawnee Ridge Subdivision have resulted from increased water augmentation, increased periods of irrigation ditch flow, and are affected over the short term by precipitation events. The high permeability alluvial aquifer underlying Pawnee Ridge is confined by the low permeability Pierre Shale and by the down gradient Springdale

Ditch limiting natural discharge of the aquifer. This condition is anticipated to persist unless changes in augmentation rates and irrigation ditch flows are significantly reduced. This is not likely to occur in the foreseeable future.

Given the number and distribution of impacted residences within Pawnee Ridge the most cost effective mitigation alternative is properly designed local or individual perimeter and/or subslab drain systems. Two residences with basements located in the impacted area of Dakota Road have effective drain systems according to the homeowner questionnaires. We recommend, however, that the discharge from the individual drainage systems by conveyed away from the area of impact. This may require the installation of a pipe or some other conveyance that would discharge the pumped water across Springdale Ditch to the wetlands east of the subdivision.

Large capacity wells would likely be effective but their high capital and operation/maintenance costs as well as the likely impact on domestic wells within Pawnee Ridge.

It is also recommended that surface storm drainage within Pawnee Ridge be improved to facilitate runoff minimizing ground water recharge. Existing drainage within the subdivision is very poor with resulting high aquifer recharge rates.

LIMITATIONS

This study has been conducted in accordance with generally accepted hydrogeological practices in this area for exclusive use by the client. The conclusions and recommendations submitted in this report are based upon the data obtained from the referenced sources. This report may not reflect subsurface variations at the site. Kumar & Associates, Inc. is not responsible for liability associated with interpretation of subsurface data by others.

REFERENCES

Scott, Glenn R., Map Showing Geology, Structure, and Oil and Gas Fields in the Sterling $1^0 \times 2^0$ Quadrangle, Colorado, Nebraska, and Kansas, Map I-1092, Miscellaneous Investigation Series, U.S. Geological Survey, 1978

Topper, Ralf, et.al., Ground Water Atlas of Colorado, Special Publication 53, Colorado Geological Survey, 2003

Pawnee Ridge Homeowners Association, Monitoring Well Data, September 2010

Colorado Division of Water Resources, Permitted Well Database, September, 2010

DRG/ag
cc: book, file

Table 1
Pawnee Ridge Questionnaire Response Summary

Address/Location	Year Constructed	Year Occupied	Soils/GW Data	Well	Basement	Drain	Sump	Water Problems	Mon Wells	Irrigation	Notes
18187 C.R. 30	1975	1977	No	No	Yes	No	No	No	No	2-3 times/week 30 min	
18189 C.R. 30	1975	1976	No	No	No	No	No	No	No	2-3 times/week 30 min	
14250 C.R. 37	2006	2007	No	#3712F	Yes	No	No	No	No	2-3 times/week 30 min	Well water irrigation
14311 Dakota Rd	1998	1998	No	No	Yes	Yes	Yes	Yes	No	3 times/week 30 min	Problems began April 2009; Wet basement after sump pump failure
14318 Dakota Rd	1998	2007	No	No	Yes	Yes	Yes	Yes	No	2-3 times/week 30 min	Water problems started spring 2009; related to rainfall
14319 Dakota Rd	2001	2001	No	No	Yes	Yes	Yes	Yes	Yes	3 times/week 30 min	
14326 Dakota Rd	1997	2003	No	No	Yes	Yes	Yes	Yes	No	2-3 times/week 30 min	Problems began May 2009
14327 Dakota Rd	2001	2007	No	No	Yes	Yes	Yes	Yes	No	3 times/week 15 min	Wet Basement since April 2009; GW 45 inches below grade
14333 Dakota Rd	2001	2001	Yes	No	Yes	Yes	Yes	Yes	No	1-2 times/week 15 mi	Sumps began pumping 2006, basement flooding in summer 2009
14338 Dakota Rd	2001	2001	No	No	Yes	Yes	Yes	No	No	3 times/week 20 min	Sump began pumping in 2009
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
14348 Dakota Dr	2000	2001	No	No	Yes	Yes	Yes	No	Yes	3 times/week 15 min	Sump began running in May 2009
14354 Dakota Rd	1998	1998	No	No	Yes	Yes	Yes	Yes	No	3 times/week 10 min	Problems began August 2009
14362 Dakota Rd	1997	1997	No	No	Yes	Yes	Yes	Yes	No	2-3 times/week 30 min	Water problems began winter 2009, 2 years ago no water in sump
14363 Dakota Rd	1999	2010	No	No	Yes	Yes	Yes	Yes	No	2-3 times/week 30 min	Water problems only when float valve stuck; related to rainfall
14375 Dakota Rd	1996	1996	No	No	No	No	No	No	No	2-3 times/week 30 min	
14042 Greenway Dr	1973	1985	No	No	Yes	No	No	No	No	3 times/week 30 min	
14057 Greenway Dr	1971	1971	No	Yes	No	No	No	No	No	3-4 times/week 20 min	Well 20 ft deep
14066 Greenway Dr	1978	2007	No	No	Yes	No	No	No	No	2-3 times/week 30 min	
14085 Greenway Dr	1968	1969	No	Yes	No	No	No	No	No	2-3 times/week 30 min	
14092 Greenway Dr	2000	2000	No	No	Yes	No	No	No	No	2-3 times/week 30 min	
14113 Greenway Dr	1969	1969	No	Yes	Yes	No	No	No	No	2-3 times/week 30 min	Well provides water to house and lawn
14159 Greenway Dr	1981	1981	No	No	Yes	No	No	No	No	2-3 times/week 30 min	
14284 Greenway Dr	1979	2008	No	No	Yes	?	No	No	No	2 times/week 30 min	
14304 Greenway Dr	1978	1988	No	No	Yes	No	No	No	No	2 times/week 30 min	
14320 Greenway Dr	?	2004	No	No	Yes	?	Yes	Yes	No	No	Water problems began summer 2008
14347 Greenway Dr	1982	1982	No	No	Yes	No	No	No	No	2-3 times/week 30 min	
14360 Greenway Dr	2000	2004	No	No	Yes	Yes	No	No	No	No	
14402 Greenway Dr	1997	1997	No	No	Yes	Yes	Yes	No	Yes	2 times/week 30 min	Augmentation pond to east has raised water table
14408 Greenway Dr	1974	2010	No	Yes	Yes	No	No	No	No	3-4 times/week 20 min	
14415 Greenway Dr	1984	1984	No	No	Yes	No	No	No	No	2-3 times/week 30 min	
14421 Greenway Dr	1985	1985	No	No	Yes	No	No	No	No	2-3 times/week 30 min	
14435 Greenway Dr	1985	2005	No	No	Yes	No?	Yes	No	No	No	
14475 Greenway Dr	1999	2005	No	No	Yes	No	No	No	No	2-3 times/week 30 min	
18421 Shawnee Pl	1996	2007	No	No	Yes	No	No	No	No	No	
18433 Shawnee Pl	2001	2005	No	No	Yes	No	No	No	No	2-3 times/week 30 min	
18459 Shawnee Pl	1998	2005	No	No	Yes	No	No	Yes	No	4 times/week 60 min?	July 2010, water seeping from sewer drops (penetrations?)
18004 Shoshone Dr	1995	1995	No	No	Yes	No	No	No	No	2-3 times/week 30 min	
18006 Shoshone Dr	1995	1996	No	No	No	No	No	No	No	2-3 times/week 30 min	Three upgradient city wells shut down?
18008 Shoshone Dr	1997	1997	No	No	Yes	No	No	No	No	2-3 times/week 30 min	Related to augmentation ponds?
18110 Shoshone Dr	1999	2004	No	No	Yes	Yes	Yes	No	No	2-3 times/week 30 min	
18138 Shoshone Dr	1980	1991	No	No	Yes	No	No	No	No	2-3 times/week 30 min	Basement at least 6 ft below grade
14011 Summit Dr	1976	2005	No	No	Yes	No	No	No	No	2-3 times/week 30 min	
14020 Summit Dr	2007	2010	No	No	Yes	No	No	No	No	3 times/week 15 min	North side of property ditch flows continously? from sumps to the west
14118 Summit Dr	1972	2003	No	Yes	No	No	No	No	No	2-3 times/week 30 min	
14172 Summit Dr	1980	1984	No	No	Yes	No	No	No	No	2-3 times/week 30 min	
14182 Summit Dr	1996	1999	No	No	Yes	?	No	No	No	2-3 times/week 30 min	
14187 Summit Dr	1972	1972	No	#54991	Yes	No	No	No	No	3 times/week 30 min	
14205 Summit Dr	1974	2005	No	No	No	No	No	No	No	3 times/week 30 min	
14208 Summit Dr	1996	1996	No	No	Yes	No	No	No	No	3 times/week 15 min	
14241 Summit Dr	1973	1988	No	No	Yes	No	No	No	No	3 times/week 30 min	
14242 Summit Dr	1996	1996	No	No	Yes	No	No	No	No	3 times/week 30 min	
14344 Summit Dr	1969	1969	No	#248441	Yes	No	No	No	No	3 times/week 30 min	
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
18026 Westwood Dr	1989	1992	No	No	Yes	No	No	No	No	2-3 times/week 30 min	
18035 Westwood Dr	1980	2000	No	No	No	No	No	No	No	3 times/week 15 min	

Table 1
Pawnee Ridge Questionnaire Response Summary

Address/Location	Year Constructed	Year Occupied	Soils/GW Data	Well	Basement	Drain	Sump	Water Problems	Mon Wells	Irrigation	Notes
18035 Westwood Dr	1978	1984	No	No	Yes	No	No	No	No	3 times/week 15 min	
18037 Westwood Dr	1982	1998	No	No	No	No	No	No	No	several times /month	
18046 Westwood Dr	1990	1995	No	No	Yes	?	No	No	No	2-3 times/week 30 min	
18047 Westwood Dr	1983	2002	No	No	No	No	No	No	No	3 times/week 15 min	
18141 Westwood Dr	1978	2004	No	No	No	No	No	No	No	No	
18161 Westwood Dr	1975	2000	No	No	No	No	No	No	No	2-3 times/week 15 min	
18181 Westwood Dr	1978	2009	No	No	No	Yes	Yes	Yes	No	3 times/week 10 min	Water problems in crawl space began July 2009
18188 Westwood Dr	1976	2004	No	No?	Yes	Yes	No	Yes	No	No	Water problems in basement first appeared in April 2009
18209 Westwood Dr	1990	1990	No	No	Yes	Yes	Yes	Yes	No	3 times/week 40 min	Water problems began in 1997
18232 Westwood Dr	1978	1990	Yes	No	Yes	No	No	No	No	2-3 times/week 30 min	Damp spots in crawl space
18010 Willow Dr	1984	2004	No	No	Yes	No	No	No	No	3 times/week 30 min	
18018 Willow Dr	1984	1984	No	No	Yes	Yes	No	No	No	3 times/week 30 min	
18025 Willow Dr	1979	2005	No	#79519	No	No	No	No	No	3 times/week 30 min	Crawl space dry
18031 Willow Dr	1991	1991	No	No	Yes	No	No	No	No	2-3 times/week 30 min	
18046 Willow Dr	1978	1990	No	No	Yes	No	No	No	No	3 times/week 30 min	
18097 Willow D	1989	1996	No	No	Yes	No	No	No	No	3 times/week 15 min	
18137 Willow Dr	1970	1982	No	#42698	No	No	No	No	No	2-3 times/week 30 min	
18151 Willow Dr	1971	1973	No	#43896	No	No	No	No	No	2-3 times/week 30 min	
18156 Willow Dr	?	1986	No	No	No	No	No	No	No	2-3 times/week 30 min	
18180 Willow Dr	1977	1977	No	No	Yes	No	No	No	No	2-3 times/week 30 min	
18198 Willow Dr	1975	1975	No	No	No	No	No	No	No	3 times/week 15 min	
18231 Willow Dr	1971	1979	No	#45757	Yes	No	No	No	No	2-3 times/week 30 min	

Wet Basement Problems Reported

Wet Crawl Space Problems Reported

Table 2
Regsitered Wells in Pawnee Ridge

Permitted Wells-Domestic

Well Permit #	Owner	Date Completed	Depth (ft)	Yield (gpm)	Static Water Level (ft)	Depth to Shale (ft)	Address	Location	
3300	Jacob Hein	Denied 10/12/72	NA	NA		NA	NA	NWSW Sec 19	1360 from S; 1075 from W
36147	Myron House	12/20/1968	42	20	17	34	14085 Greenway Dr		
37630	Ed Leibig	5/5/1969	43	15	17	32	14113 Greenway Dr		
39448	Jack Hein	10/5/1969	52	25	20	40	NA	SWSW Sec 19	
39449	Wade Kallsen	10/4/1969	41	20	16	33	14175 Greenway Dr		
41427	Ernest Lewis	6/5/1970	41	30	20	35	14143 Greenway Dr		
41428	Ed Foos	6/4/1970	64	30	11.5	59	NA	SWSW Sec 19	1630 from S; 1080 from W
42698	Dan Muggli	8/26/1970	41	15	16	37	18137 Willow Dr		
42699	Jack Hein	8/27/1970	41	15	16	34.5	NA	SWSW Sec 19	
43895	Jack Hein	12/7/1970	60	30	15	48	NA	SWSW Sec 19	
43896	Francis Lambrecht	12/7/1970	60	30	22.5	40	18151 Willow Dr		
45756	Francis Bargeli	5/19/1971	42	15	13	29	14057 Greenway Dr		
48733	Dale Long	8/18/1976	68	15	12	62	14266 CR 30		
50408	Jacob Hein	12/29/1971	68	15	17	58	NA	NWSW Sec 19	
50409	Scott Rubottom	12/30/1971	41	15	17	30.5	18112 Shoshone Dr		
54990	Larry Bauder	7/17/1972	67	15	19	59	14265 Summit Dr		
54991	Ronald Ott	9/1/1972	60	15	25	40	NA	SWSW Sec 19	1040 from S; 1180 from W
65989	Jerry Williams	11/25/1972	67	15	12	55	NA	NWSW Sec 19	2500 from S; 350 from W
79519	Sam Kobayashi	6/20/1977	52	15	19	34	18025 Willow Dr	NWSW Sec 19	1360 from S; 200 from W

Permitted Wells-Monitoring

Well Permit #	Owner	Address
48944	Steve Meier	14348 Dakota Rd
48945	Kevin Milyard	14250 CR 37
48946	Dave Fast	14402 Greenway Dr
48947	Sandy St. John	14319 Dakota Rd
48948	Dave Fast	14402 Greenway Dr

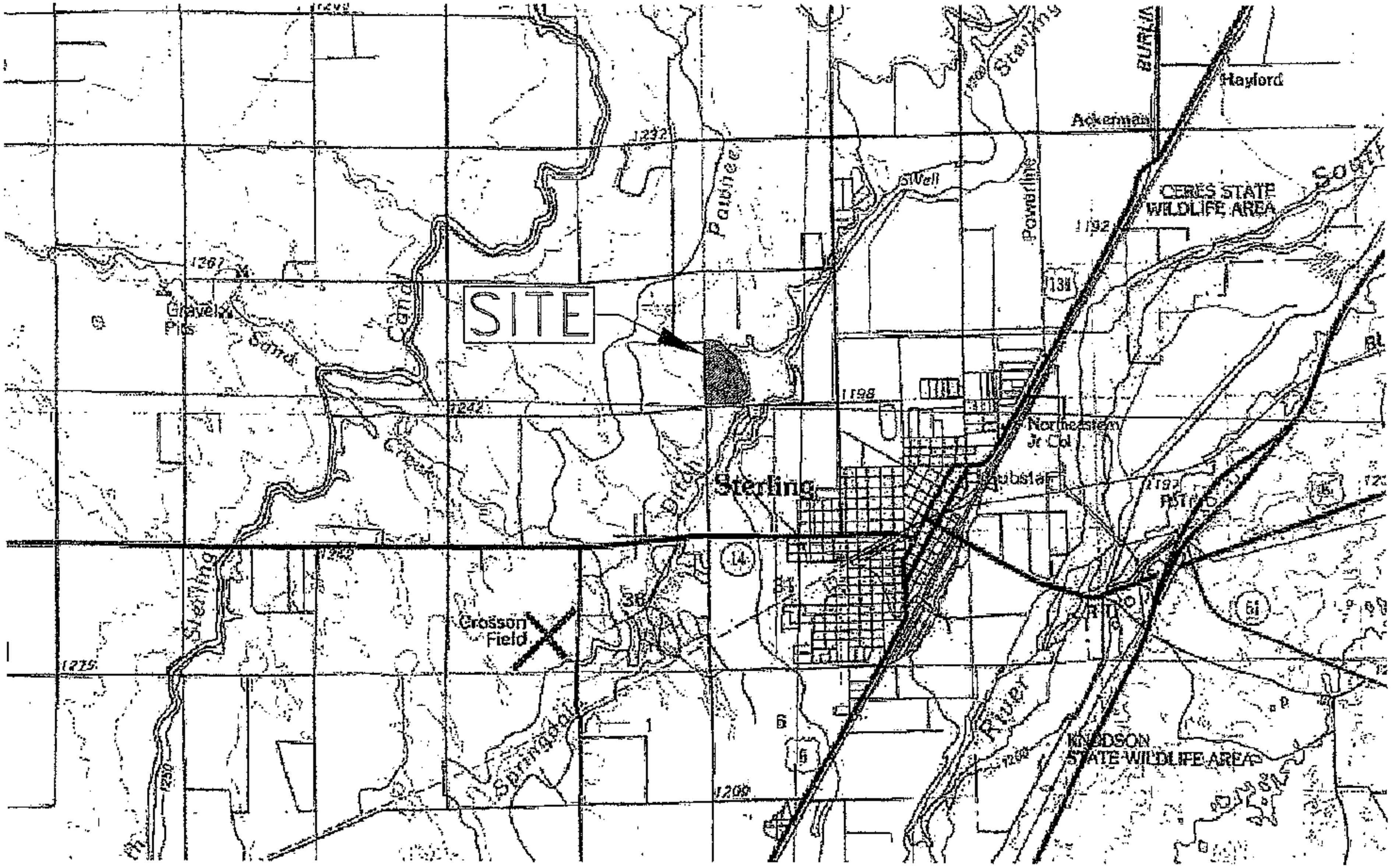
Well Permit Applications

Receipt #	Owner	Address
3646213	Gena Thim	14327 Dakota Rd

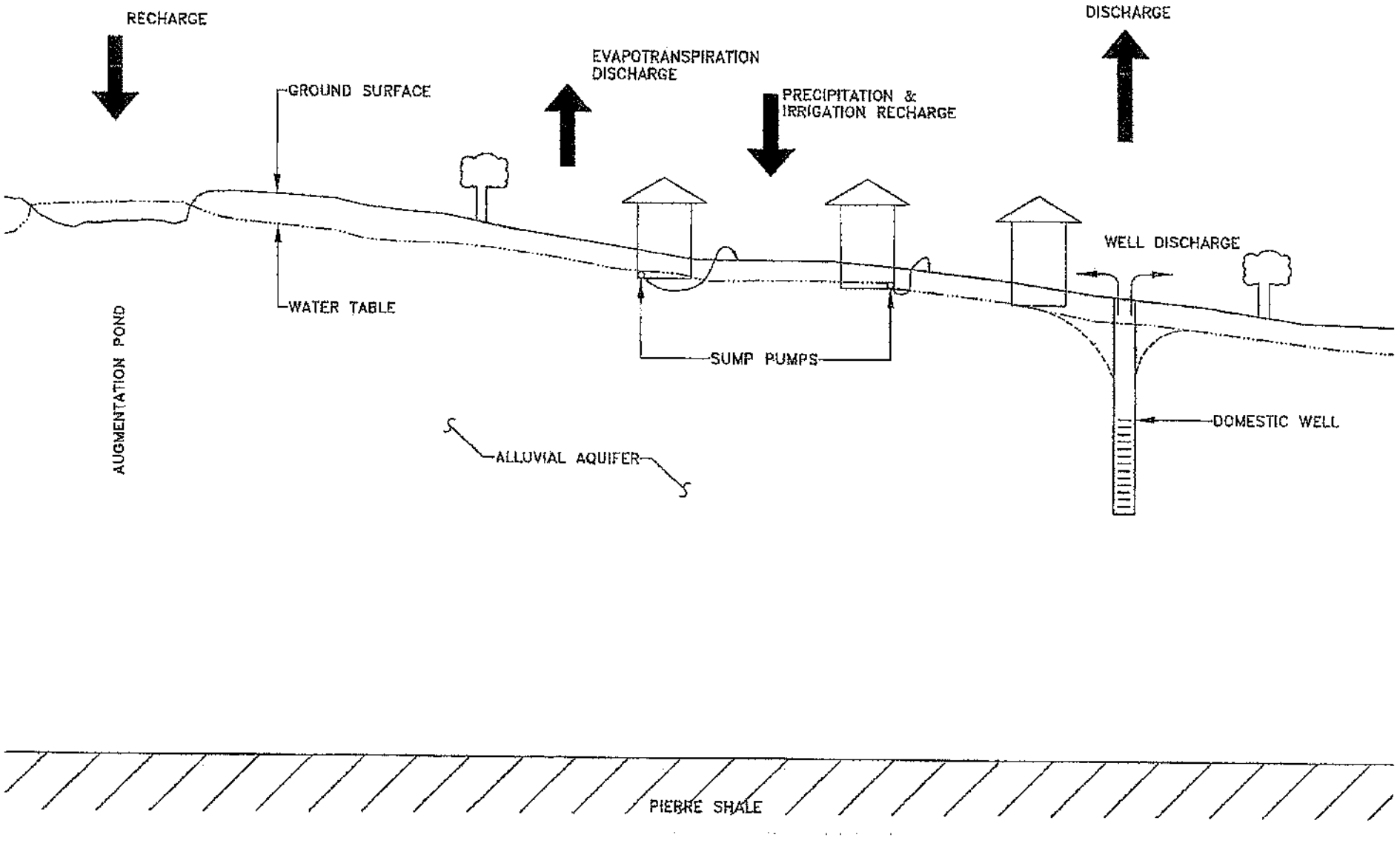
Table 3
Monitoring Well Data

	Location			11/25/2009		11/27/2009		2/12/2010		3/11/2010		4/21/2010		5/20/2010	
Well #	X	Y	Stickup	DTW	DBG	DTW	DBG	DTW	DBG	DTW	DBG	DTW	DBG	DTW	DBG
1-Meier	648869	4500818	0.4	7.9	7.5	6.16	5.75	5.95	5.55	5.4	5.0	5.85	5.45	5.55	5.15
2-Milyard/Sambler	648889	4500679	0.4	5.8	5.4	5.8	5.4	6.4	6.0	6.2	5.8	6.25	5.85	5.65	5.25
3-St John	648814	4500722	0.6	6.15	5.55	6.15	5.55	6.8	6.2	6.67	6.07	6.65	6.05	6.0	5.4
4-East SW	648800	4500952	0.6	7.45	6.85	7.44	6.84	7.35	6.75	7.45	6.85	7.3	6.7	7.3	6.7
5-East SE	648868	4500951	0.6	5.2	4.6	5.43	4.83	7.0	6.4	7.15	6.55	7.1	6.5	6.75	6.15
6-Boren	648954	4500774	3.3		9.4		9.4	12.7	9.4	13.65	10.35	13.8	10.5	13.7	10.4
7-Libelg	649015	4500177	0.7		15.9		15.9	16.6	15.9	16.5	15.8	16.4	15.7	15.8	15.1
8-Lauer			1.4		70.15		70.15		70.15	71.55	70.15	71.3	69.9	70.9	69.5

	Location			6/10/2010		6/17/2010		7/19/2010		8/13/2010		9/21/2010	
Well #	X	Y	Stickup	DTW	DBG	DTW	DBG	DTW	DBG	DTW	DBG	DTW	DBG
1-Meier	648869	4500818	0.4	5.5	5.1	5.3	4.9	5.4	5.0	5.3	4.9	10.1	9.7
2-Milyard/Sambler	648889	4500679	0.4	5.8	5.4	5.95	4.95	5.6	5.2	5.8	5.4	10.9	10.5
3-St John	648814	4500722	0.6	6.1	5.5	5.7	5.1	5.9	5.3	6.1	5.5	10.8	10.2
4-East SW	648800	4500952	0.6	7.3	6.7	7.15	6.55	7.1	6.5	6.95	6.35	7.7	7.1
5-East SE	648868	4500951	0.6	6.8	6.2	6.5	5.9	6.7	6.1	6.65	6.05	6.8	6.2
6-Boren	648954	4500774	3.3	15.6*	12.3	13.5	10.2	13.7	10.4	13.6	10.3	13.6	10.3
7-Libelg	649015	4500177	0.7	16.0	15.3	15.6	14.9	15.8	15.1	16.0	15.3	18.3*	17.6
8-Lauer			1.4	70.25	68.65	70.0	68.6	69.2	67.8	69.2	67.8	74.2	72.8


SITE
Sterling
Crosson Field
Gravel Pits
Hayford
Ackerman
CERES STATE WILDLIFE AREA
STATE WILDLIFE AREA
Northeastern Jr Col
Pawnee
Powerline
River
Springdale
Sand
Creek
Ditch

AERIAL IMARIGE DATE: JUNE 17, 2005


RECHARGE
GROUND SURFACE
EVAPOTRANSPIRATION
DISCHARGE
PRECIPITATION &
IRRIGATION RECHARGE
DISCHARGE
WELL DISCHARGE
WATER TABLE
AUGMENTATION POND
SUMP PUMPS
DOMESTIC WELL
ALLUVIAL AQUIFER
PIERRE SHALE

SEMENT)


14375
14475
GREENWAY
14360
14362
14435
14363
14354
14415
14345
14348
14421
14333
14338
18004
14350
14327
14326
18006
14347
14344
CR 37
SHOSHONE
14319
14318
18008
SUMMIT
14311
14320
18110
14304
14250
14241
14284
18138
14242
18025
18031
18097
14205
18137
18151
SUMMIT
WILLOW
14187
14208
18010
18018
18046
18231
14182
14159
18156
14172
18035
18037
18047
18180
18141
18196
14118
18459
WESTWOOD
18151
GREENWAY
18026
18036
14113
18181
SHAWNEE
14092
18209
18421
18046
14085
14066
18433
18188
18232
14042
14057
14011
14020
18187
18189
18233

PROBLEMS)


14375
14475
GREENWAY
14360
14362
14435
14363
14354
14415
14346
14348
14421
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14338
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SHOSHONE
CR 37
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SUMMIT
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WILLOW
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18018
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WESTWOOD
18161
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SHAWNEE
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GREENWAY
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14011
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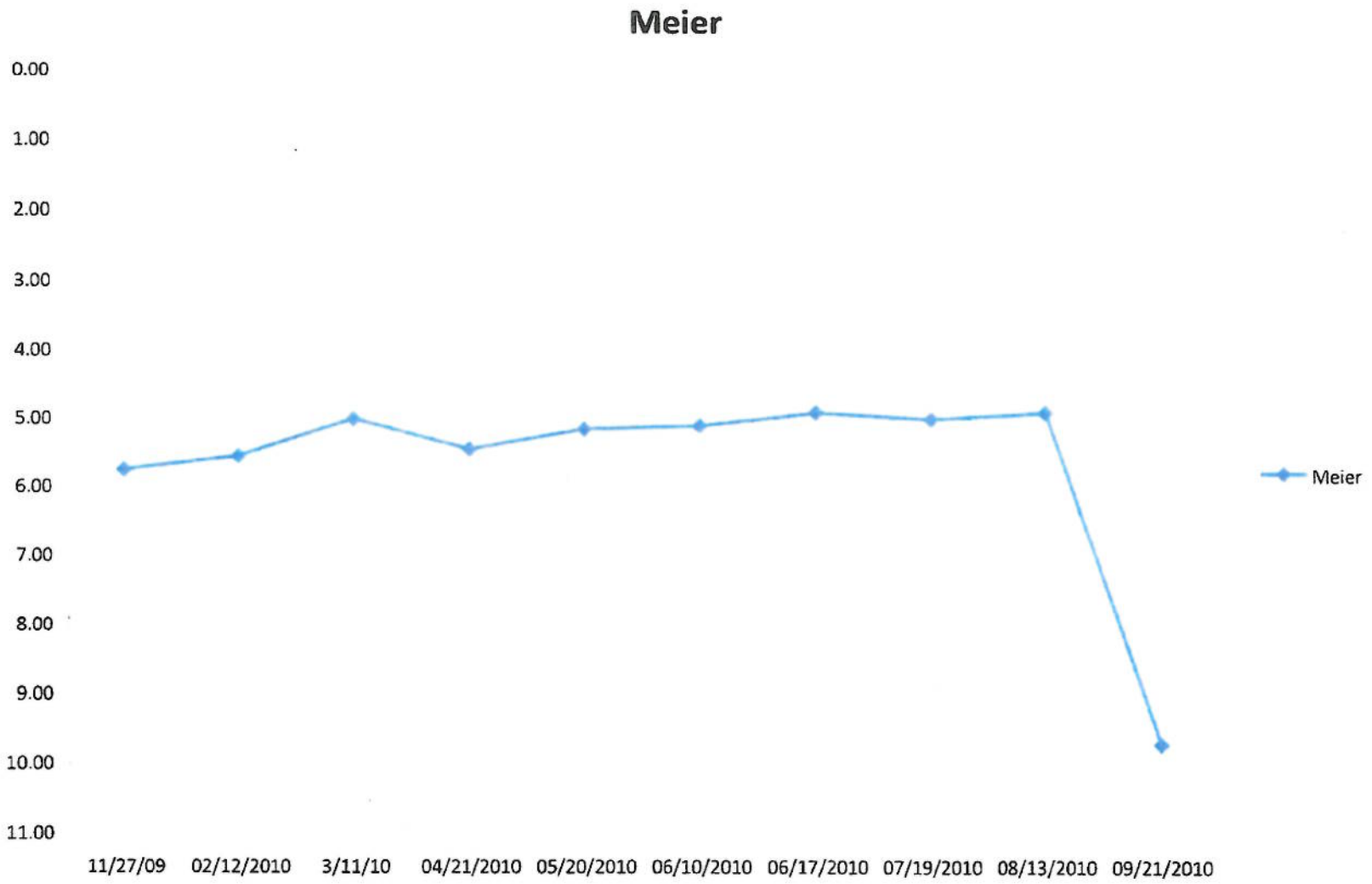
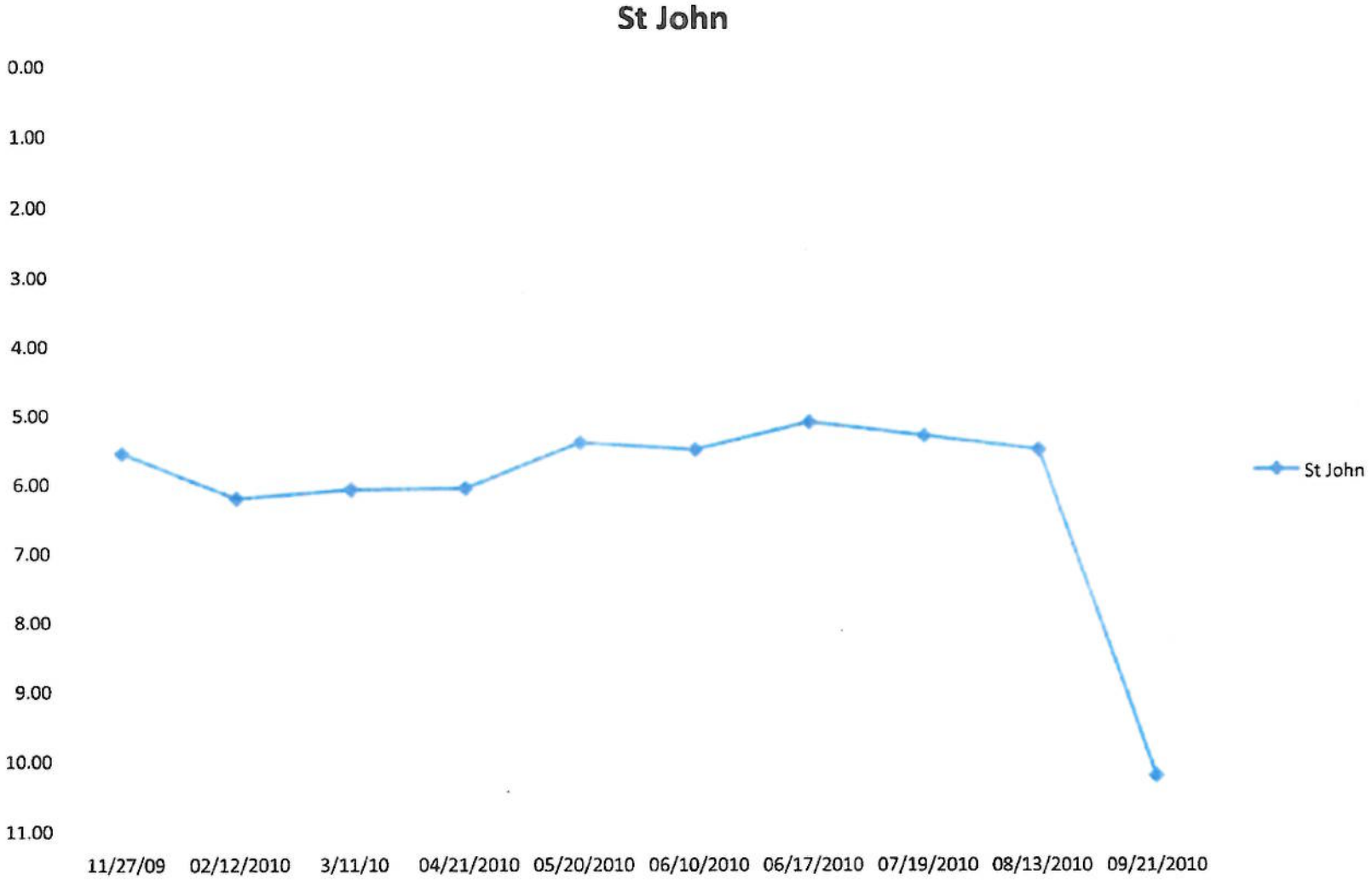
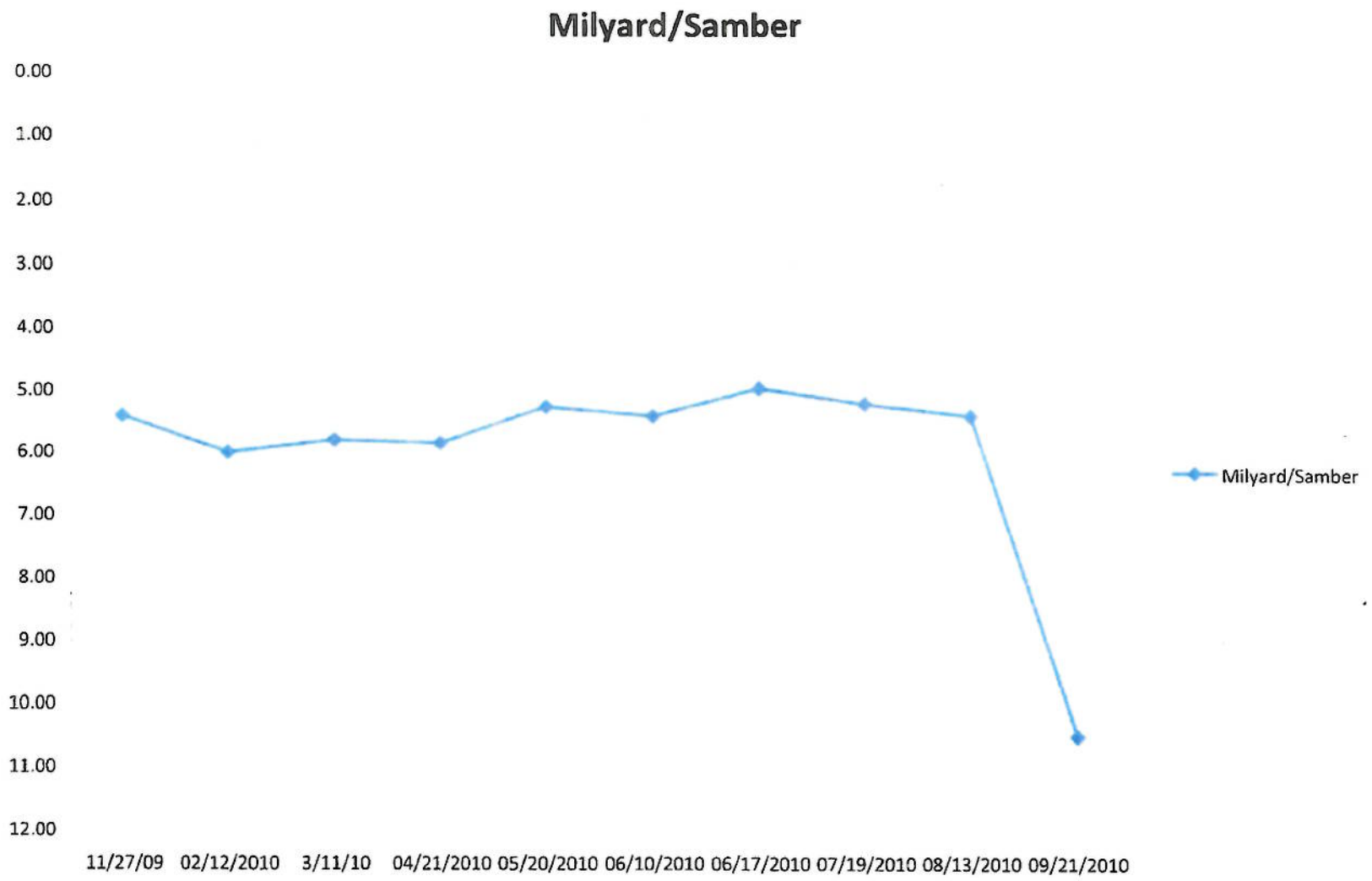
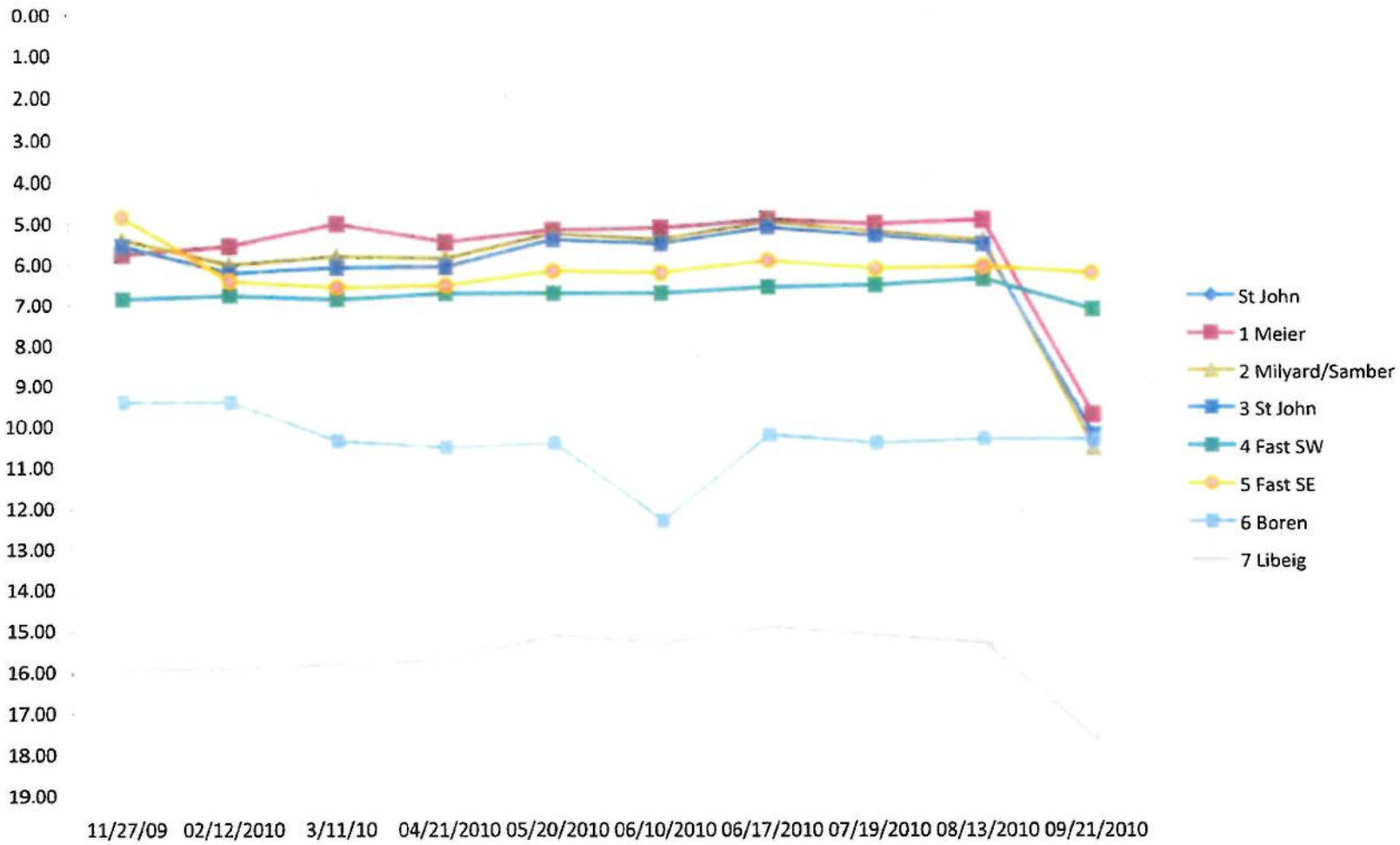
APPENDIX A


Meier
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
11/27/09
02/12/2010
3/11/10
04/21/2010
05/20/2010
06/10/2010
06/17/2010
07/19/2010
08/13/2010
09/21/2010
Meier


St John
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
11/27/09
02/12/2010
3/11/10
04/21/2010
05/20/2010
06/10/2010
06/17/2010
07/19/2010
08/13/2010
09/21/2010
St John


Milyard/Samber
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
11/27/09
02/12/2010
3/11/10
04/21/2010
05/20/2010
06/10/2010
06/17/2010
07/19/2010
08/13/2010
09/21/2010
Milyard/Samber

Pawnee Ridge Monitoring Wells




Fast SW
5.90
6.00
6.10
6.20
6.30
6.40
6.50
6.60
6.70
6.80
6.90
7.00
7.10
7.20
11/27/09
02/12/2010
3/11/10
04/21/2010
05/20/2010
06/10/2010
06/17/2010
07/19/2010
08/13/2010
09/21/2010
Fast SW