SPRINGS INVENTORY

TALLGRASS PRAIRIE NATIONAL PRESERVE

CHASE COUNTY, KANSAS

KGS OPEN-FILE
REPORT 2001-40
(Revised July 2008)

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Addendum

Kansas Geological Survey Open-file Report 2001-40 was revised in July 2008.

Changes:

Table 1. Spring Data by Drainage Areas.

- The column heading ‘FORMATION’ was changed to ‘GEOL. UNIT’ and the names in that column revised.

Table 2. Spring Data by Flow Rates.

- The column heading ‘FORMATION’ was changed to ‘GEOL. UNIT’ and the names in that column revised.

SPRINGS INVENTORY

TALLGRASS PRAIRIE NATIONAL PRESERVE
CHASE COUNTY, KANSAS

Robert Sawin and Rex Buchanan
Kansas Geological Survey

Introduction

The Tallgrass Prairie National Preserve, established in 1996, consists of 10,894 acres in Chase County, Kansas, all within the Flint Hills physiographic region (U.S. Dept. of the Interior, 2000, p. 1). Springs are an important feature of the preserve (a property once known as Spring Hill Ranch, and more recently, the Z Bar Ranch). Springs were the original source of water on the ranch; they continue to provide water to livestock and are important to the diverse flora and fauna on the property. Yet relatively little was known about their extent, flow rates, exact location, and water quality.

Knowledge about the preserve's springs will provide the National Park Service (NPS) and the National Park Trust (NPT) with basic, benchmark information about the nature of the preserve's water resources. One desired outcome in the preserve's General Management Plan is: "The preserve's seeps, springs, and streams are in good ecological condition and support a healthy and diverse aquatic community" (U.S. Dept. of the Interior, 2000, p. 11). However, the plan notes that "the preserve lacks long-term data sets on water quality, hydrology, and geomorphology" (U.S. Dept. of the Interior, 2000, p. 72). An accurate inventory of springs is necessary to measure the preserve's ability to achieve its long-term goals. The information should also be useful as the preserve's land-use patterns (such as burning regimes, grazing, and human visitation) change in the future.

In addition, development of the preserve as a new national resource offers a unique opportunity to gather baseline information on the various components of the natural system. Springs provide a rare opportunity to monitor groundwater conditions in a relatively pristine grassland environment, without using invasive hydrogeologic techniques. As a result, knowledge gained at the preserve will be useful throughout the Flint Hills region.

Scope

Based on a cooperative agreement between the Kansas Geological Survey (KGS) and the National Park Service (Cooperative Agreement Number H6067A00009), the KGS undertook a comprehensive inventory of springs on the preserve. Springs are generally defined as locations where "groundwater flows naturally from the earth into a body of surface water or onto the land surface, at a rate sufficient to form a current" (Buchanan, Sawin, and Lebsack, 1998). This differentiates springs from seeps, where water is discharged onto the surface at rates so low that no current or channel is created.

Previous Studies

Preliminary visits to the preserve in December 1998 and March 1999 found seven locations that met the definition of a spring. Both the NPS/NPT and the KGS were interested in examining seasonal changes in the basic water chemistry in these springs. As a result,

water from springs at the preserve was sampled and analyzed for basic constituents by the KGS every three months, for one year. In addition, the Kansas Department of Health and Environment did a full analysis (organic and inorganic components) at three of these springs. The results of both of these activities, made available to the NPS/NPT, showed that the quality of water in preserve springs was generally extremely high (Sawin and Buchanan, 2000). This work provided the NPS/NPT with water-quality data, over time, on an important component of the prairie ecosystem and provides a better understanding of the nature of springs in a relatively undisturbed Flint Hills environment.

KGS authors also published papers and abstracts on the springs of the Flint Hills region of Kansas (Sawin, Buchanan, and Lebsack, 1999a; Sawin, Buchanan, and Lebsack, 1999b; Buchanan and Sawin, 2000). Preserve springs were included in the discussions of Flint Hills springs in Sawin, Buchanan, and Lebsack (1999b) and Buchanan and Sawin (2000).

Methods

For the inventory, the preserve was divided into 17 drainage areas (see Plate 1, attached). The field procedure involved systematically walking each drainage and locating springs on a 1:24,000-scale U.S. Geological Survey topographic map (Strong City, Kansas quadrangle) and, electronically, with hand-held 12-channel Garmin Global Positioning System (GPS) units with an accuracy of 15 meters RMS (root mean square) or better. Springs were described and photographed, and flow rates estimated. The geologic unit from which each spring flowed was identified.

The initial survey was conducted April 9–18, 2001, when most prairie vegetation was dormant and immediately after most of the preserve pastures had been burned. Vegetation associated with the springs was green and contrasted sharply with the surrounding dormant plants and burned vegetation. General moisture conditions and rainfall at the preserve were estimated to be "normal" for that time of the year by NPS and KGS staff (see fig. 1). This initial inventory was completed prior to the annual springtime introduction of cattle onto the preserve's pastures.

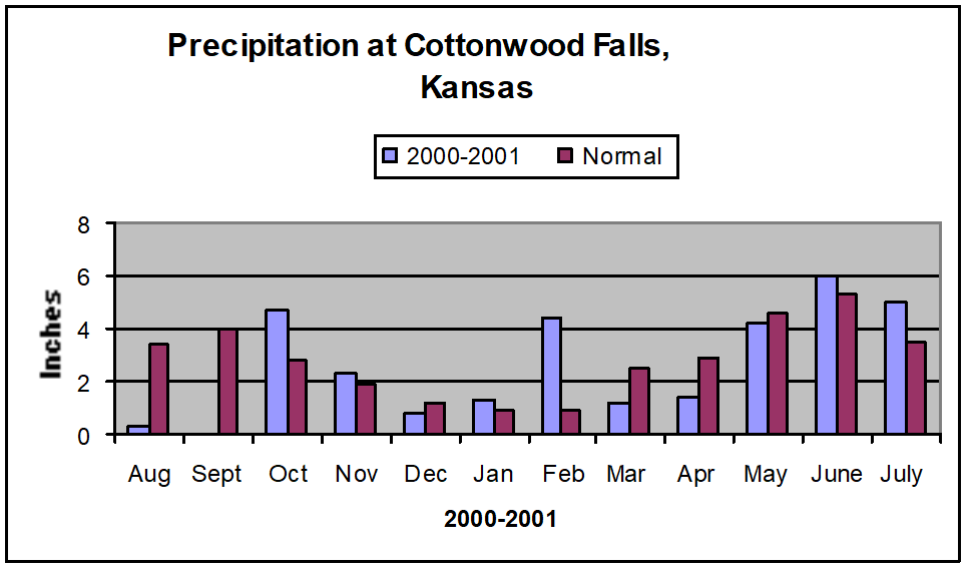

Figure 1. Precipitation at Cottonwood Falls, Kansas, from August 2000 through July 2001.

A geographically representative number of these springs was revisited on August 7–8, 2001. This follow-up survey was designed to observe springs during the driest time of the year, to generate information that would indicate the permanent or temporary nature of preserve springs. Springs revisited were selected to provide a geographic sampling of each drainage; to provide additional information on particularly large or significant springs; and to provide a sample of dry-weather flow rates at randomly selected locations. Again, NPS and KGS staff agreed general moisture and rainfall conditions were about normal. Nearly all cattle had been removed from the ranch by the time of this revisit.

Results

During the April survey, 237 springs were inventoried. As defined above, these were locations where moving water was observed emerging from the ground, regardless of the flow rate. The flow rate for 135 of these springs (57%) was estimated at 1 gallon per minute (gpm) or less. Almost all of these springs would be considered intermittent, or "wet weather," springs. Thirty-nine springs (16%) had flow rates estimated at 5 gpm or more.

In August, 61 springs were revisited (26% of the springs inventoried in April). As expected, flow rates were significantly less, and many of the low-flowing springs were dry or reduced to seeps. Of the 61 springs revisited, 22 (or about 36%) were dry in August. Twelve (or about 20%) were now seeps, and 14 (or about 23%) flowed less than 1 gpm. In total, nearly 80% of the springs observed in April were dry or flowing less than 1 gpm in August, including several springs that had significant (10–15 gpm) flows in April. Of the springs that were flowing in August, many had been reduced to about 20% of their April flow.

Nearly all the springs on the preserve that were inventoried in this study are classified as contact springs. Contact springs flow to the land surface from a permeable material (limestone) that lies directly on top of a less permeable layer (shale) that retards or prevents the downward movement of groundwater, causing it to be deflected laterally by gravity in the downdip direction. The water continues to move through fractures and pore space in the limestones along the contact between the permeable and less permeable layer until it is intersected by a stream valley or hillside, where it then issues onto the land surface.

Data from the April and August visits is shown by drainage (Table 1) and by flow rate, from highest to lowest (Table 2). Also included in the tables are the rock unit that produced water at each spring. Figure 2 is an idealized geologic section of the rock units that occur on the preserve. Spring locations are spotted on the Strong City, Kansas, 1:24,000-scale U.S.G.S. base (Plate 1). The GPS receivers datum was set to WGS 84. An ArcView file of the tables and map will be made available to NPS/NPT.

Summary

Historically, springs have been an important component at the Tallgrass Prairie National Preserve. Springs provide a window to the water resource at the preserve, and can be used to monitor water quality and quantity conditions through time. Water at the preserve is a critical resource upon which all other components (flora and fauna) rely. This comprehensive inventory of springs provides baseline information that will be useful in planning development at the preserve, evaluating past activities, and monitoring the impact

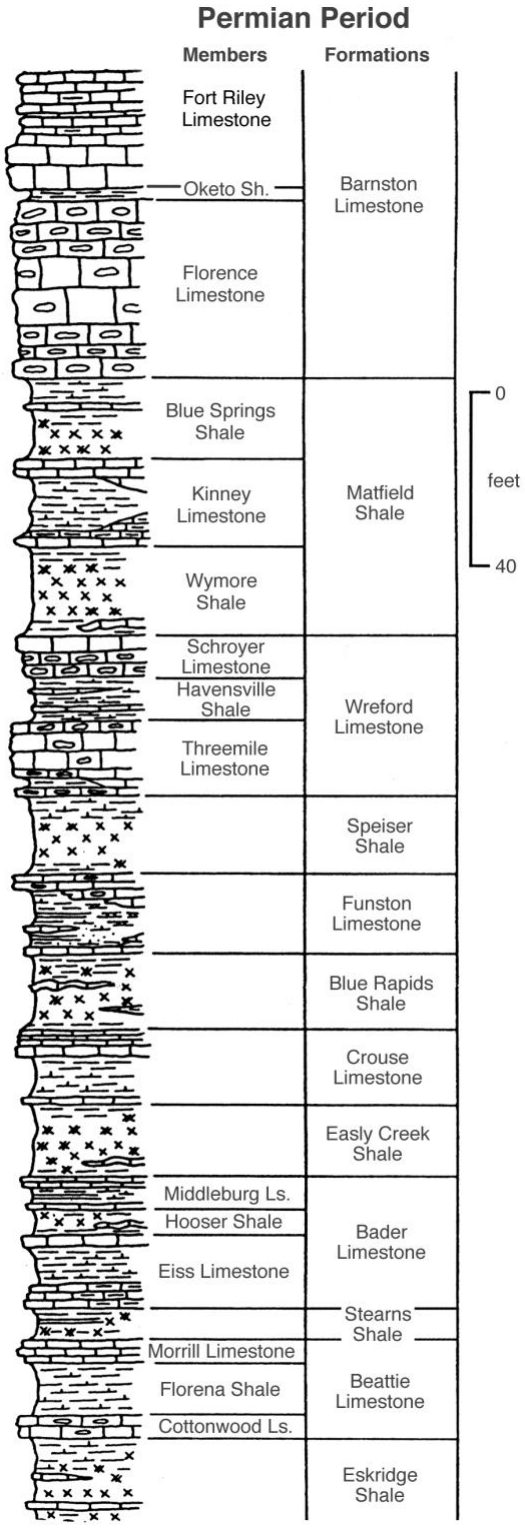

Figure 2. Idealized section of the rock units at Tallgrass Prairie National Preserve.

of future activities, such as livestock grazing, backcountry use, and burning. This information will also help guide future investigations of flora, fauna, and hydrologic systems.

This inventory showed that a substantial number of springs occur on the preserve, particularly in the wet weather of spring. Twenty-five of these springs produced large volumes of water, more than 10 gpm. As expected, dry conditions during summer had a substantial impact on many of these springs, particularly the lesser-producing springs. However, a significant number of springs continued to produce substantial amounts of water even in the dry weather of summer; because of their reliability, they are especially important water sources for livestock and flora and fauna on the preserve. Because springs are so important to the preserve, it is anticipated that the information in this report will be useful to resource managers, researchers, and other areas in the Flint Hills region.

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Table 1. Spring Data by Drainage Areas. Spring numbers in ( ) are from Sawin and Buchanan, 2000.

Spring No.	GPS (north)	GPS (west)	Est. Flow April	Est. Flow August	Geol. Unit	Misc
1-1	38.49592	96.56844	5		Funston	
1-2	38.49353	96.57417	<1		Funston	
1-3	38.49375	96.57684	4	seep	Funston	
1-4	38.49470	96.57671	2	<1	Threemile	
1-5	38.49533	96.57724	2	<1	Threemile	
1-6	38.49563	96.57728	2	<1	Threemile	
1-7	38.48694	96.58694	<1		Threemile	
1-8	38.48564	96.57862	<1		Funston	
1-9	38.48939	96.57813	<1		Crouse	
1-10	38.48944	96.57617	1		Funston	
1-11	38.48937	96.56897	1		Funston	
1-12	38.48822	96.57022	1		Funston	
1-13	38.48451	96.58178	<1		Funston	
1-14	38.48421	96.58268	5		Funston	
1-15	38.48333	96.58329	1		Threemile	
1-16	38.48613	96.59304	1		Threemile	
1-17	38.48490	96.59174	2		Threemile	
1-18	38.49408	96.59376	25	5	Threemile	
1-19	38.49445	96.59368	3		Threemile	
1-20	38.49530	96.58692	10		Threemile	
1-21 (CS-H)	38.49187	96.59001	2		Funston	
2-1	38.48362	96.57487	<1		Funston	
2-2	38.47724	96.56919	<1		Crouse	
2-3	38.47246	96.56893	15	seep	Easly Ck	
2-4	38.47241	96.57051	10	dry	Crouse	
2-5	38.47282	96.57238	<1		Funston	
2-6	38.47326	96.57340	<1		Funston	
2-7	38.47567	96.57272	1		Funston	
2-8	38.47546	96.57381	3		Funston	
2-9	38.48151	96.57676	3		Funston	
3-1	38.47750	96.58322	3		Threemile	
3-2	38.46958	96.57664	2	dry	Funston	
3-3	38.46872	96.57728	3	seep	Easly Ck	
3-4	38.47060	96.58290	1		Funston	
3-5	38.47386	96.58902	2		Threemile	
3-6	38.47071	96.58864	2		Threemile	
3-7	38.46862	96.58372	<1		Funston	
3-8	38.46504	96.57301	1		Middleburg	
3-9	38.46282	96.57688	2		Crouse	
3-10	38.46468	96.58656	<1		Threemile	

Spring No.	GPS (north)	GPS (west)	Est. Flow April	Est. Flow August	Geol. Unit	Misc
3-11	38.45914	96.58181	2		Threemile	
3-12	38.45958	96.57911	5		Funston	
3-13	38.45694	96.57997	5		Threemile	
3-14	38.46363	96.56648	3		Eiss	
3-15	38.46103	96.56637	1	seep	Eiss	
3-16	38.45945	96.56729	2	dry	Crouse	
3-17	38.45800	96.57670	<1		Threemile	
3-18	38.47427	96.57930	7		Funston	
4-1	38.46345	96.59527	<1	dry	Wymore	
5-1	38.43699	96.59535	<1	dry	Threemile	
5-2	38.43535	96.59683	2	<1	Threemile	
5-3	38.43693	96.59718	1	<1	Threemile	
5-4	38.44226	96.59269	<1		Threemile	
5-5	38.44241	96.59262	<1		Schroyer	
5-6	38.44366	96.59023	2		Threemile	
5-7	38.44498	96.59341	<1		Threemile	
5-8	38.44840	96.59322	<1		Threemile	
5-9	38.45159	96.59350	<1		Threemile	
5-10	38.45827	96.59153	<1		Kinney	
5-11	38.43103	96.59573	1		Threemile	
5-12	38.43080	96.59670	1		Threemile	
5-13	38.42730	96.59754	<1		Threemile	
6-1 (CS-F)	38.44256	96.56775	20		Eiss	Developed
6-2	38.44101	96.57104	<1		Crouse	
6-3	38.44141	96.57111	2		Crouse	
6-4	38.44111	96.57351	1		Funston	
6-5	38.43922	96.57171	2		Funston	
6-6	38.45254	96.58061	<1	dry	Threemile	
6-7	38.45119	96.58043	1	dry	Funston	
6-8	38.45107	96.57970	10	2	Funston	
6-9	38.45015	96.58174	1		Threemile	
6-10	38.44969	96.58427	1		Schroyer	
6-11	38.45515	96.58647	<1		Wymore	
6-12	38.45405	96.58493	<1		Schroyer	
6-13	38.45208	96.58165	3	<1	Threemile	
6-14	38.45095	96.57811	3	2	Funston	
6-15	38.44685	96.58347	<1		Schroyer	
6-16	38.44522	96.58210	2		Threemile	
6-17	38.44468	96.58209	1		Threemile	
6-18	38.44426	96.58007	4		Funston	
6-19	38.44128	96.57746	1		Funston	
6-20	38.44101	96.57855	<1		Threemile	
6-21 (CS-J)	38.43938	96.58066	<1		Schroyer	
6-22	38.44448	96.57325	2		Easly Ck	

Spring No.	GPS (north)	GPS (west)	Est. Flow April	Est. Flow August	Geol. Unit	Misc
6-23	38.44393	96.57369	20		Easly Ck	
6-24	38.44781	96.57548	25	4	Crouse	Developed
6-25	38.45047	96.57318	2		Funston	
6-26	38.45114	96.57017	<1		Funston	
6-27	38.45099	96.56781	<1		Funston	
6-28	38.44059	96.56565	<1		Eiss	
6-29	38.44171	96.56071	<1	dry	Eiss	
7-1	38.45592	96.56843	<1	dry	Funston	
7-2	38.45435	96.56332	1		Eiss	
7-3	38.45443	96.56753	1		Funston	
7-4	38.43785	96.55435	<1		Cottonwood	
8-1	38.41239	96.58337	<1		Easly Ck	
8-2	38.41375	96.58138	15	7	Crouse	Developed
8-3	38.42562	96.57697	<1		Funston	
8-4	38.42626	96.58315	<1		Crouse	
8-5	38.42700	96.58311	<1		Crouse	
8-6	38.42919	96.58154	<1		Funston	
8-7	38.43316	96.57993	<1		Threemile	
8-8	38.43396	96.58025	<1		Threemile	
8-9	38.41880	96.58626	<1		Crouse	
8-10	38.42197	96.58896	<1		Funston	
8-11	38.41886	96.59137	<1		Funston	
8-12	38.42218	96.59462	<1		Threemile	
8-13	38.41846	96.59503	<1		Threemile	
8-14	38.41803	96.59232	1		Funston	
8-15	38.41276	96.58818	2		Easly Ck	
8-16	38.41460	96.59145	1		Funston	
8-17	38.41481	96.59713	1		Threemile	
8-18	38.41074	96.58803	<1		Middleburg	
8-19	38.43658	96.58641	<1	seep	Schroyer	
8-20	38.43699	96.58782	<1	dry	Schroyer	
8-21 (CS-A)	38.42314	96.58554	100		Easly Ck	Developed
8-22	38.43505	96.58891	<1		Threemile	
8-23	38.43210	96.59140	<1		Threemile	
8-24	38.43375	96.59296	<1		Schroyer	
8-25	38.42807	96.59324	<1		Schroyer	
8-26	38.42691	96.59211	2		Threemile	
8-27	38.43018	96.58688	2		Funston	
8-28	38.42543	96.58569	2		Easly Ck	
8-29 (CS-C)	38.41365	96.57946	<1	<1	Threemile	
8-30 (CS-B)	38.41796	96.57846	10		Funston	Developed
8-31 (CS-G)	38.41478	96.58501	5	5	Easly Ck	Developed
9-1	38.43014	96.57487	<1		Threemile	
9-2	38.42912	96.57263	1		Funston	

Spring No.	GPS (north)	GPS (west)	Est. Flow April	Est. Flow August	Geol. Unit	Misc
9-3	38.42848	96.56739	<1		Crouse	
9-4	38.42784	96.57073	<1		Funston	
9-5	38.42810	96.57039	<1		Funston	
9-6	38.43057	96.56124	<1		Eiss	
9-7	38.42969	96.56059	35	16	Eiss	
9-8	38.42946	96.56311	2		Middleburg	
9-9	38.42909	96.56393	2		Middleburg	
9-10	38.43108	96.56796	2		Crouse	
9-11	38.43163	96.57199	1		Funston	
9-12	38.43319	96.57288	3		Funston	
9-13	38.43421	96.57259	5		Funston	
9-14	38.43639	96.56805	1		Funston	
9-15	38.43278	96.56235	10	<1	Middleburg	
10-1	38.40873	96.56434	3		Funston	
10-2	38.40818	96.56149	5	dry	Crouse	
10-3	38.40725	96.56357	<1		Funston	
10-4	38.40662	96.56106	6	dry	Crouse	
10-5	38.40740	96.55868	<1		Middleburg	
10-6	38.41240	96.55906	<1		Middleburg	
10-7	38.41179	96.55973	<1		Easly Ck	
10-8	38.41296	96.56134	15	dry	Eiss	
10-9	38.41219	96.56441	1		Funston	
10-10	38.41729	96.56689	1		Crouse	
10-11	38.41561	96.56720	<1		Funston	
10-12	38.41662	96.56575	2		Crouse	
10-13	38.41667	96.56595	1		Crouse	
10-14	38.41831	96.55981	<1		Eiss	
10-15	38.41788	96.56715	17		Crouse	
10-16	38.42215	96.56896	<1		Funston	
10-17	38.42276	96.56926	2		Funston	
10-18	38.42157	96.57163	5		Funston	
10-19	38.42065	96.57121	<1		Funston	
10-20	38.40900	96.55508	1	seep	Eiss	
11-1	38.43599	96.54855	2		Cottonwood	
11-2	38.43657	96.54461	2		Crouse	
11-3	38.43631	96.54268	1		Funston	
11-4	38.42955	96.53947	2		Middleburg	
11-5	38.42621	96.54156	1		Funston	
11-6	38.42647	96.54315	2		Easly Ck	
11-7	38.42846	96.54608	4	1	Eiss	
11-8	38.42867	96.54622	4	1	Eiss	
12-1	38.41853	96.54397	2		Crouse	
12-2	38.41795	96.54363	1		Funston	
12-3	38.41949	96.54483	7		Eiss	

Spring No.	GPS (north)	GPS (west)	Est. Flow April	Est. Flow August	Geol. Unit	Misc
12-4	38.42163	96.54450	15	3	Eiss	
12-5	38.41976	96.53937	1		Threemile	
12-6	38.42187	96.54182	2	seep	Middleburg	
12-7	38.42154	96.54251	5	dry	Eiss	
12-8	38.42145	96.54294	3	<1	Eiss	
12-9	38.42117	96.54334	8	1	Eiss	
12-10	38.42099	96.54377	10	1	Eiss	
13-1	38.40515	96.54308	2		Eiss	
13-2	38.40979	96.54337	5	dry	Morrill	
13-3	38.40912	96.54250	2	<1	Eiss	
13-4	38.40965	96.54138	2	1	Eiss	
13-5	38.40857	96.53979	1		Easly Ck	
13-6 (CS-E)	38.41359	96.53507	3	dry	Middleburg	
13-7	38.41274	96.53376	1		Funston	
13-8	38.41298	96.53076	1	seep	Funston	
13-9	38.41191	96.52565	1		Threemile	
13-10	38.41434	96.52440	<1		Threemile	
13-11	38.41376	96.52907	3	dry	Funston	
13-12 (CS-D)	38.41756	96.52693	15		Threemile	Developed
13-13	38.41816	96.52704	1		Funston	
13-14	38.41939	96.52796	<1		Funston	
13-15	38.41984	96.52993	12		Funston	
13-16	38.42036	96.53036	12		Funston	
13-17	38.41779	96.53053	1		Crouse	
13-18	38.41629	96.53265	4		Easly Ck	
13-19	38.41518	96.53458	1		Middleburg	
13-20	38.41277	96.54239	<1		Eiss	
13-21	38.41661	96.53948	1		Crouse	
13-22	38.41662	96.53883	2		Crouse	
13-23	38.41439	96.54336	2		Easly Ck	
13-24	38.41491	96.54573	2	seep	Funston	
13-25	38.41325	96.54703	10	seep	Eiss	
13-26	38.41706	96.54789	1		Eiss	
14-1	38.41495	96.51589	10	<1	Funston	
14-2	38.41546	96.51711	12	<1	Funston	
14-3	38.41692	96.51956	1	dry	Threemile	
14-4	38.41871	96.51343	<1		Funston	
14-5	38.41855	96.51194	2		Crouse	
14-6	38.41896	96.51072	<1		Crouse	
14-7	38.42046	96.51063	<1		Crouse	
14-8	38.42032	96.50648	10	<1	Eiss	
14-9	38.42032	96.50566	3	dry	Eiss	
14-10	38.41861	96.50591	2		Eiss	
14-11	38.41432	96.50885	<1		Crouse	

Spring No.	GPS (north)	GPS (west)	Est. Flow April	Est. Flow August	Geol. Unit	Misc
14-12	38.41221	96.51222	11		Easly Ck	
14-13	38.40753	96.50292	1		Crouse	
14-14	38.40685	96.50512	1		Funston	
14-15	38.41033	96.50687	1		Crouse	
15-1	38.40831	96.51520	1		Funston	
15-2	38.40880	96.51651	1		Funston	
15-3	38.40769	96.51757	4	<1	Funston	
15-4	38.40819	96.52157	1		Threemile	
16-1	38.40694	96.52596	<1	dry	Funston	
16-2	38.40910	96.52599	1	seep	Funston	
16-3	38.40925	96.52445	<1		Threemile	
16-4	38.40859	96.52804	<1	dry	Funston	
16-5	38.40983	96.53096	1		Funston	
16-7	38.40708	96.53391	4		Easly Ck	
16-8	38.40801	96.52738	<1	seep	Funston	
17-1	38.40642	96.56863	1		Speiser	
17-2	38.41117	96.57170	<1		Funston	
17-3	38.41152	96.57526	<1		Funston	
17-4	38.41389	96.57374	<1		Funston	
17-5	38.41414	96.57540	2		Funston	
17-6	38.41054	96.57743	1	dry	Funston	

Table 2. Spring Data by Flow Rates. Spring numbers in ( ) are from Sawin and Buchanan, 2000.

Spring No.	GPS (north)	GPS (west)	Est. Flow April	Est. Flow August	Geol. Unit	Misc
8-21 (CS-A)	38.42314	96.58554	100		Easly Ck	Developed
9-7	38.42969	96.56059	35	16	Eiss	
1-18	38.49408	96.59376	25	5	Threemile	
6-24	38.44781	96.57548	25	4	Crouse	Developed
6-1 (CS-F)	38.44256	96.56775	20		Eiss	Developed
6-23	38.44393	96.57369	20		Easly Ck	
10-15	38.41788	96.56715	17		Crouse	
2-3	38.47246	96.56893	15	seep	Easly Ck	
8-2	38.41375	96.58138	15	7	Crouse	Developed
10-8	38.41296	96.56134	15	dry	Eiss	
12-4	38.42163	96.54450	15	3	Eiss	
13-12 (CS-D)	38.41756	96.52693	15		Threemile	Developed
13-15	38.41984	96.52993	12		Funston	
13-16	38.42036	96.53036	12		Funston	
14-2	38.41546	96.51711	12	<1	Funston	
14-12	38.41221	96.51222	11		Easly Ck	
1-20	38.49530	96.58692	10		Threemile	
2-4	38.47241	96.57051	10	dry	Crouse	
6-8	38.45107	96.57970	10	2	Funston	
8-30 (CS-B)	38.41796	96.57846	10		Funston	Developed
9-15	38.43278	96.56235	10	<1	Middleburg	
12-10	38.42099	96.54377	10	1	Eiss	
13-25	38.41325	96.54703	10	seep	Eiss	
14-1	38.41495	96.51589	10	<1	Funston	
14-8	38.42032	96.50648	10	<1	Eiss	
12-9	38.42117	96.54334	8	1	Eiss	
3-18	38.47427	96.57930	7		Funston	
12-3	38.41949	96.54483	7		Eiss	
10-4	38.40662	96.56106	6	dry	Crouse	
1-1	38.49592	96.56844	5		Funston	
1-14	38.48421	96.58268	5		Funston	
3-12	38.45958	96.57911	5		Funston	
3-13	38.45694	96.57997	5		Threemile	
8-31 (CS-G)	38.41478	96.58501	5	5	Easly Ck	Developed
9-13	38.43421	96.57259	5		Funston	
10-2	38.40818	96.56149	5	dry	Crouse	
10-18	38.42157	96.57163	5		Funston	
12-7	38.42154	96.54251	5	dry	Eiss	
13-2	38.40979	96.54337	5	dry	Morrill	
1-3	38.49375	96.57684	4	seep	Funston	

Spring No.	GPS (north)	GPS (west)	Est. Flow April	Est. Flow August	Geol. Unit	Misc
6-18	38.44426	96.58007	4		Funston	
11-7	38.42846	96.54608	4	1	Eiss	
11-8	38.42867	96.54622	4	1	Eiss	
13-18	38.41629	96.53265	4		Easly Ck	
15-3	38.40769	96.51757	4	<1	Funston	
16-7	38.40708	96.53391	4		Easly Ck	
1-19	38.49445	96.59368	3		Threemile	
2-8	38.47546	96.57381	3		Funston	
2-9	38.48151	96.57676	3		Funston	
3-1	38.47750	96.58322	3		Threemile	
3-3	38.46872	96.57728	3	seep	Easly Ck	
3-14	38.46363	96.56648	3		Eiss	
6-13	38.45208	96.58165	3	<1	Threemile	
6-14	38.45095	96.57811	3	2	Funston	
9-12	38.43319	96.57288	3		Funston	
10-1	38.40873	96.56434	3		Funston	
12-8	38.42145	96.54294	3	<1	Eiss	
13-6 (CS-E)	38.41359	96.53507	3	dry	Middleburg	
13-11	38.41376	96.52907	3	dry	Funston	
14-9	38.42032	96.50566	3	dry	Eiss	
1-4	38.49470	96.57671	2	<1	Threemile	
1-5	38.49533	96.57724	2	<1	Threemile	
1-6	38.49563	96.57728	2	<1	Threemile	
1-17	38.48490	96.59174	2		Threemile	
1-21 (CS-H)	38.49187	96.59001	2		Funston	
3-2	38.46958	96.57664	2	dry	Funston	
3-5	38.47386	96.58902	2		Threemile	
3-6	38.47071	96.58864	2		Threemile	
3-9	38.46282	96.57688	2		Crouse	
3-11	38.45914	96.58181	2		Threemile	
3-16	38.45945	96.56729	2	dry	Crouse	
5-2	38.43535	96.59683	2	<1	Threemile	
5-6	38.44366	96.59023	2		Threemile	
6-3	38.44141	96.57111	2		Crouse	
6-5	38.43922	96.57171	2		Funston	
6-16	38.44522	96.58210	2		Threemile	
6-22	38.44448	96.57325	2		Easly Ck	
6-25	38.45047	96.57318	2		Funston	
8-15	38.41276	96.58818	2		Easly Ck	
8-26	38.42691	96.59211	2		Threemile	
8-27	38.43018	96.58688	2		Funston	
8-28	38.42543	96.58569	2		Easly Ck	
9-8	38.42946	96.56311	2		Middleburg	
9-9	38.42909	96.56393	2		Middleburg	

Spring No.	GPS (north)	GPS (west)	Est. Flow April	Est. Flow August	Geol. Unit	Misc
9-10	38.43108	96.56796	2		Crouse	
10-12	38.41662	96.56575	2		Crouse	
10-17	38.42276	96.56926	2		Funston	
11-1	38.43599	96.54855	2		Cottonwood	
11-2	38.43657	96.54461	2		Crouse	
11-4	38.42955	96.53947	2		Middleburg	
11-6	38.42647	96.54315	2		Easly Ck	
12-1	38.41853	96.54397	2		Crouse	
12-6	38.42187	96.54182	2	seep	Middleburg	
13-1	38.40515	96.54308	2		Eiss	
13-3	38.40912	96.54250	2	<1	Eiss	
13-4	38.40965	96.54138	2	1	Eiss	
13-22	38.41662	96.53883	2		Crouse	
13-23	38.41439	96.54336	2		Easly Ck	
13-24	38.41491	96.54573	2	seep	Funston	
14-5	38.41855	96.51194	2		Crouse	
14-10	38.41861	96.50591	2		Eiss	
17-5	38.41414	96.57540	2		Funston	
1-10	38.48944	96.57617	1		Funston	
1-11	38.48937	96.56897	1		Funston	
1-12	38.48822	96.57022	1		Funston	
1-15	38.48333	96.58329	1		Threemile	
1-16	38.48613	96.59304	1		Threemile	
2-7	38.47567	96.57272	1		Funston	
3-4	38.47060	96.58290	1		Funston	
3-8	38.46504	96.57301	1		Middleburg	
3-15	38.46103	96.56637	1	seep	Eiss	
5-3	38.43693	96.59718	1	<1	Threemile	
5-11	38.43103	96.59573	1		Threemile	
5-12	38.43080	96.59670	1		Threemile	
6-4	38.44111	96.57351	1		Funston	
6-7	38.45119	96.58043	1	dry	Funston	
6-9	38.45015	96.58174	1		Threemile	
6-10	38.44969	96.58427	1		Schroyer	
6-17	38.44468	96.58209	1		Threemile	
6-19	38.44128	96.57746	1		Funston	
7-2	38.45435	96.56332	1		Eiss	
7-3	38.45443	96.56753	1		Funston	
8-14	38.41803	96.59232	1		Funston	
8-16	38.41460	96.59145	1		Funston	
8-17	38.41481	96.59713	1		Threemile	
9-2	38.42912	96.57263	1		Funston	
9-11	38.43163	96.57199	1		Funston	
9-14	38.43639	96.56805	1		Funston	

Spring No.	GPS (north)	GPS (west)	Est. Flow April	Est. Flow August	Geol. Unit	Misc
10-9	38.41219	96.56441	1		Funston	
10-10	38.41729	96.56689	1		Crouse	
10-13	38.41667	96.56595	1		Crouse	
10-20	38.40900	96.55508	1	seep	Eiss	
11-3	38.43631	96.54268	1		Funston	
11-5	38.42621	96.54156	1		Funston	
12-2	38.41795	96.54363	1		Funston	
12-5	38.41976	96.53937	1		Threemile	
13-5	38.40857	96.53979	1		Easly Ck	
13-7	38.41274	96.53376	1		Funston	
13-8	38.41298	96.53076	1	seep	Funston	
13-9	38.41191	96.52565	1		Threemile	
13-13	38.41816	96.52704	1		Funston	
13-17	38.41779	96.53053	1		Crouse	
13-19	38.41518	96.53458	1		Middleburg	
13-21	38.41661	96.53948	1		Crouse	
13-26	38.41706	96.54789	1		Eiss	
14-3	38.41692	96.51956	1	dry	Threemile	
14-13	38.40753	96.50292	1		Crouse	
14-14	38.40685	96.50512	1		Funston	
14-15	38.41033	96.50687	1		Crouse	
15-1	38.40831	96.51520	1		Funston	
15-2	38.40880	96.51651	1		Funston	
15-4	38.40819	96.52157	1		Threemile	
16-2	38.40910	96.52599	1	seep	Funston	
16-5	38.40983	96.53096	1		Funston	
17-1	38.40642	96.56863	1		Speiser	
17-6	38.41054	96.57743	1	dry	Funston	
1-2	38.49353	96.57417	<1		Funston	
1-7	38.48694	96.58694	<1		Threemile	
1-8	38.48564	96.57862	<1		Funston	
1-9	38.48939	96.57813	<1		Crouse	
1-13	38.48451	96.58178	<1		Funston	
2-1	38.48362	96.57487	<1		Funston	
2-2	38.47724	96.56919	<1		Crouse	
2-5	38.47282	96.57238	<1		Funston	
2-6	38.47326	96.57340	<1		Funston	
3-7	38.46862	96.58372	<1		Funston	
3-10	38.46468	96.58656	<1		Threemile	
3-17	38.45800	96.57670	<1		Threemile	
4-1	38.46345	96.59527	<1	dry	Wymore	
5-1	38.43699	96.59535	<1	dry	Threemile	
5-4	38.44226	96.59269	<1		Threemile	
5-5	38.44241	96.59262	<1		Schroyer	

Spring No.	GPS (north)	GPS (west)	Est. Flow April	Est. Flow August	Geol. Unit	Misc
5-7	38.44498	96.59341	<1		Threemile	
5-8	38.44840	96.59322	<1		Threemile	
5-9	38.45159	96.59350	<1		Threemile	
5-10	38.45827	96.59153	<1		Kinney	
5-13	38.42730	96.59754	<1		Threemile	
6-2	38.44101	96.57104	<1		Crouse	
6-6	38.45254	96.58061	<1	dry	Threemile	
6-11	38.45515	96.58647	<1		Wymore	
6-12	38.45405	96.58493	<1		Schroyer	
6-15	38.44685	96.58347	<1		Schroyer	
6-20	38.44101	96.57855	<1		Threemile	
6-21 (CS-J)	38.43938	96.58066	<1		Schroyer	
6-26	38.45114	96.57017	<1		Funston	
6-27	38.45099	96.56781	<1		Funston	
6-28	38.44059	96.56565	<1		Eiss	
6-29	38.44171	96.56071	<1	dry	Eiss	
7-1	38.45592	96.56843	<1	dry	Funston	
7-4	38.43785	96.55435	<1		Cottonwood	
8-1	38.41239	96.58337	<1		Easly Ck	
8-3	38.42562	96.57697	<1		Funston	
8-4	38.42626	96.58315	<1		Crouse	
8-5	38.42700	96.58311	<1		Crouse	
8-6	38.42919	96.58154	<1		Funston	
8-7	38.43316	96.57993	<1		Threemile	
8-8	38.43396	96.58025	<1		Threemile	
8-9	38.41880	96.58626	<1		Crouse	
8-10	38.42197	96.58896	<1		Funston	
8-11	38.41886	96.59137	<1		Funston	
8-12	38.42218	96.59462	<1		Threemile	
8-13	38.41846	96.59503	<1		Threemile	
8-18	38.41074	96.58803	<1		Middleburg	
8-19	38.43658	96.58641	<1	seep	Schroyer	
8-20	38.43699	96.58782	<1	dry	Schroyer	
8-22	38.43505	96.58891	<1		Threemile	
8-23	38.43210	96.59140	<1		Threemile	
8-24	38.43375	96.59296	<1		Schroyer	
8-25	38.42807	96.59324	<1		Schroyer	
8-29 (CS-C)	38.41365	96.57946	<1	<1	Threemile	
9-1	38.43014	96.57487	<1		Threemile	
9-3	38.42848	96.56739	<1		Crouse	
9-4	38.42784	96.57073	<1		Funston	
9-5	38.42810	96.57039	<1		Funston	
9-6	38.43057	96.56124	<1		Eiss	
10-3	38.40725	96.56357	<1		Funston	

Spring No.	GPS (north)	GPS (west)	Est. Flow April	Est. Flow August	Geol. Unit	Misc
10-5	38.40740	96.55868	<1		Middleburg	
10-6	38.41240	96.55906	<1		Middleburg	
10-7	38.41179	96.55973	<1		Easly Ck	
10-11	38.41561	96.56720	<1		Funston	
10-14	38.41831	96.55981	<1		Eiss	
10-16	38.42215	96.56896	<1		Funston	
10-19	38.42065	96.57121	<1		Funston	
13-10	38.41434	96.52440	<1		Threemile	
13-14	38.41939	96.52796	<1		Funston	
13-20	38.41277	96.54239	<1		Eiss	
14-4	38.41871	96.51343	<1		Funston	
14-6	38.41896	96.51072	<1		Crouse	
14-7	38.42046	96.51063	<1		Crouse	
14-11	38.41432	96.50885	<1		Crouse	
16-1	38.40694	96.52596	<1	dry	Funston	
16-3	38.40925	96.52445	<1		Threemile	
16-4	38.40859	96.52804	<1	dry	Funston	
16-8	38.40801	96.52738	<1	seep	Funston	
17-2	38.41117	96.57170	<1		Funston	
17-3	38.41152	96.57526	<1		Funston	
17-4	38.41389	96.57374	<1		Funston	