Lower Poorman Creek Hydrologic Assessment

DNRC Report WR-3.C.2.LPC

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MONTANA DEPARTMENT OF NATURAL RESOURCES AND CONSERVATION

Helena, Montana
January 2002

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Introduction

During the summer of 2001, the Montana Department of Natural Resources and Conservation (DNRC) was requested by the Montana Department of Fish, Wildlife & Parks (DFWP) to assess surface and ground water hydrology of lower Poorman Creek near Lincoln, Montana. Poorman Creek, a tributary of the Blackfoot River, is periodically dewatered in its lower reaches. The cause of dewatering is believed to be a combination of natural seepage and streamflow diversion.

With the cooperation of DFWP, the U. S. Fish & Wildlife Service (FWS), Natural Resource and Conservation Service (NRCS), and local landowners, an irrigation change has been proposed to convert approximately 90 acres of historically flood-irrigated land to a sprinkler system. The conversion would likely result in more efficient delivery of water to the irrigated lands while leaving the unused portion of water that is historically diverted for irrigation in lower Poorman Creek. It is anticipated that increasing flows in lower Poorman Creek would lead to longer periods of surface connectivity with the Blackfoot River during low water periods of the year.

The objective of this study is to characterize timing and magnitude of instream flows in lower Poorman Creek. Ultimately this information will be used to evaluate the potential for implementation of the proposed project.

Study area

Poorman Creek, located in the upper Blackfoot River valley, flows north into Grantier Spring Creek, which after a quarter mile enters the Blackfoot River approximately one mile south of Lincoln, Montana (Figure 1). The study area includes the lower 1.4 miles of Poorman Creek, adjacent irrigated lands, and 0.7 miles of Grantier Spring Creek above its confluence with Poorman Creek. Figure 2 depicts typical dewatered conditions in this reach. The legal description is T14N R9W Sec. 25 and 36. Two diversions off Poorman Creek irrigate approximately 340 acres of pasture adjacent to the creek. The upper diversion services approximately 90 acres of flood-irrigated lands on the east side of the creek. The lower diversion conveys water to a pump site that services a mobile center pivot that can irrigate two fields on the west side totaling approximately 250 acres.

The Blackfoot River Valley is underlain by a sequence of unconsolidated Quaternary age alluvium and glacial deposits, and semi-consolidated Tertiary age deposits that fill a fault bounded depression of unknown depth in Precambrian age bedrock (Coffin and Wilke, 1971). Quaternary age alluvium along the Blackfoot River consists of poor to well-sorted deposits of sand, gravel, cobbles, silt, and clay. In comparison, similar age alluvial deposits along tributary streams like Poorman Creek are generally poorer sorted and contain larger percentages of clay (Coffin and Wilke, 1971). Glacial outwash and till deposits consist of poorly-sorted mixtures of clay, silt, sand, gravel, and boulders encountered beneath Quaternary age alluvium and at the surface around the perimeter of the valley. Tertiary age sediments are a mixture of alluvium, lake sediments, and volcanic deposits underlying Quaternary age alluvium and glacial sediments.

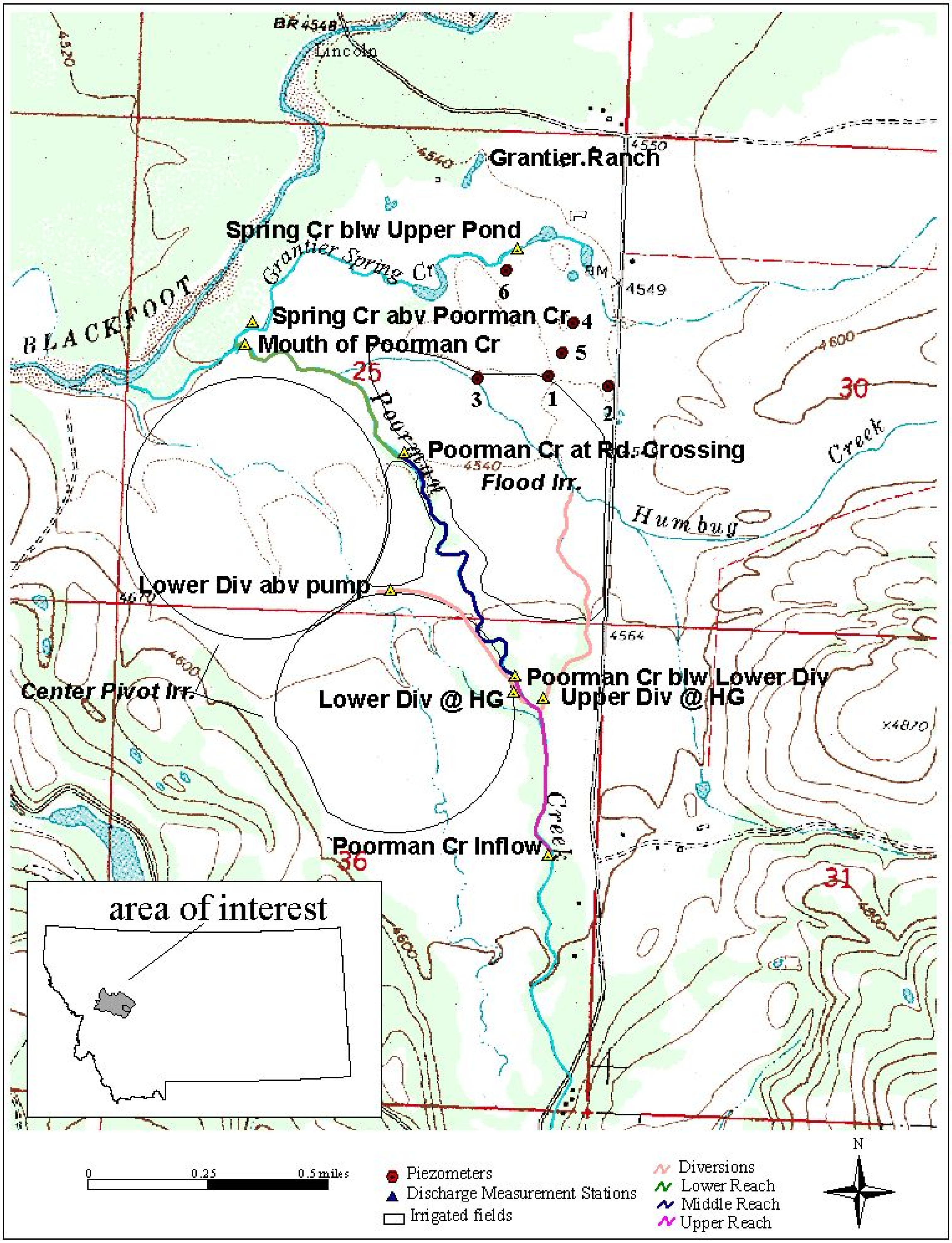

Figure 1. Poorman Creek study area.

A ridge of glacial outwash bounds the western edge of the study area, and glacial till deposits bound the eastern edge. Alluvium of the Poorman Creek drainage underlies the study area and merges with alluvium of the Blackfoot River drainage north of the study area (Coffin and Wilke, 1971). Ground-water contours plotted by Coffin and Wilke (1971) indicate that ground water flowing north from the Poorman Creek drainage merges with ground water flowing generally parallel to the Blackfoot River.

Figure 2. Lower Poorman Creek on June 21, 2001 (flowing) and July 19, 2001 (dry)

Water Year 2001

Based on provisional USGS flow data[*], water yield for the Blackfoot River basin was ranked 14th and 9th lowest on the 64-year record for water years 2000 and 2001, respectively. The cumulative effects of consecutive drought years on streamflow in the Blackfoot River and its tributaries can be seen in dry soil conditions, low snowpack, and consequently low runoff. Dewatering was exacerbated under these conditions and streams such as Poorman Creek may have dried up earlier than normal in 2001. During site visits on and after July 19, there was no flow observed in Poorman Creek between the lower diversion and its confluence with Grantiers Spring Creek.

Methods

Site hydrology was characterized by monitoring surface and ground water resources and examining local geologic conditions. The assessment focused on:

- gains and losses to Poorman and Grantier Spring Creek surface flow,
- fate of flood irrigation water, and
- ditch loss of the lower diversion.

Surface Water

To determine gains and losses in Poorman Creek, synoptic flow measurements were taken. Synoptic flow measurements provide existing flow conditions by gathering discharge data at several locations along the stream or ditch within a period of constant flow conditions. Synoptic runs were conducted on Poorman Creek, Grantier Spring

[*] 2001 USGS streamflow data obtained from the Blackfoot River at Bonner (12340000) is provisional.

Creek, and the lower of two diversions in the study reach. The following reaches within the study area were delineated by several measurement stations (Figure 1):

Poorman Creek

- Upper reach – between inflow station and a station 50 feet below lower diversion. The study reach inflow station was established at a bridge crossing near several homes and above both diversions. The upper reach is 0.4 miles long.
- Middle Reach – below lower diversion to culvert.
  The middle reach extends from the site below the lower diversion to a road crossing approximately 0.5 miles downstream.
- Lower Reach – culvert to confluence with Grantier Spring Creek.
  The lower reach includes the 0.5 miles between the road crossing and the confluence with Grantier Spring Creek.

Lower Diversion

- The lower diversion, which feeds a center pivot pump station on the west side of Poorman Creek, is approximately 0.4 miles in length. Measurement stations were established below the point of diversion and above the pump station.

Grantier Spring Creek

- Measurements on this 0.7-mile reach were taken below one of the upper ponds and above the confluence with Poorman Creek.

A portable flow meter (Marsh-McBirney Model 2000) and standard USGS methodology were used for gathering discharge measurements. Surface inflows and outflows were quantified during each synoptic run. Gains and losses were measured using the following equation:

$$\textit{Gain/Loss} = (\sum \textit{Basin Outflows} - \sum \textit{Basin Inflows}) + \sum \textit{Basin Diversions}$$

Surface water gains and losses determined in this calculation are assumed to result entirely from interaction with ground water. In other words, losses are due to seepage of surface water to ground water and gains are due to returns from ground water. Direct evaporative loss is assumed to be negligible.

Ground Water

The purpose of ground water monitoring for this study was to evaluate the potential for impacts of the proposed changes in irrigation practices on flows to Grantier Spring Creek and the spring-fed ponds located immediately north of the study area. Six piezometers consisting of five- to ten-foot long sections of ¾ inch diameter steel pipe were driven into sediments along the north edge of the study area and on adjacent land to the north on August 3, 2001. Two additional piezometers were installed at a later date to replace piezometers where ground water levels dropped below their bottoms (Figure 1).

Depths-to-water in each piezometer were measured approximately once a week between August 7 and October 28, 2001, and subtracted from elevations of piezometers surveyed from a nearby USGS benchmark to obtain ground-water elevations. Surveyed locations were used to plot water level elevation data and to create contour maps of water level elevations. The commercial software program Surfer© was used to create ground water elevation contours.

Results

Surface Water

Six synoptic flow measurement runs were conducted on Poorman Creek between June 21 and August 21 (Table 1). Seepage loss was observed on all six runs between the inflow station and the confluence of Poorman Creek and Grantiers Spring Creek. A surface water connection through this reach was maintained for the first three synoptic runs (i.e. 6/21/01 to 7/10/01). Dry conditions in the middle and lower reach that existed on the July 19 and August 3 synoptic run, were predominantly due to streamflow diversion. No diversions were running on the August 21 synoptic run, however inflows were extremely low and Poorman Creek was dry due entirely to seepage.

Table 1. Poorman Creek Synoptic Flow Data (cfs)

Station	6/21/2001	6/26/2001	7/10/2001	7/19/2001	8/3/2001	8/21/2001
Poorman Creek Inflow	24.3	19.7	10.3	8.8	4.7	2.9
Upper Div. Blw HG	6.6	4.6	2.5	3.1	1.3	0.0
Lower Div. blw HG	2.0	1.8	0.6	4.7	2.8	0.0
- Lower Div. Abv Pump	1.7	1.9	0.5	4.3	2.0	0.0
Poorman Cr blw Lower Div.	14.5	11.0	6.5	0.0	0.0	1.8
Road Crossing	9.4	6.4	3.0	0.0	0.0	0.0
Poorman Cr confl w/ Grantier Spring Cr	8.0	4.7	2.0	0.3	0.1	0.0
seepage (+ gain, - loss)						
Inflow to Lowest Diversion (cfs)	-1.3	-2.3	-0.7	-1.0	-0.7	-1.1
Lowest Diversion to Road Crossing	-5.1	-4.6	-3.5	0.0	0.0	-1.8
Road Crossing to Mouth	-1.4	-1.7	-1.0	0.3	0.1	0.0
Lowest Div to mouth	-6.5	-6.3	-4.5	0.3	0.1	-1.8
Inflow to mouth	**-7.7**	**-8.6**	**-5.3**	**-0.7**	**-0.6**	**-2.9**
Lower Diversion Efficiency						
net gain/loss (cfs)	-0.3	0.1	-0.1	-0.4	-0.8	n/a
% gain/loss (seepage)	14.1	6.7	16.3	8.1	27.7	n/a
Grantier Spring Cr blw Upper Pond				10.5	10.0	9.9
Grantier Spring Cr abv Poorman Cr				18.9	15.0	14.1
Gains (cfs)				8.4	5.0	4.2
Gains (%)				44.5	33.3	30.0

Upper Reach - Inflows receded from 24 cfs in late June to less than 3 cfs in late August (Figure 3). Measured diversions ranged between 8.6 and 3.1 cfs before ceasing in late August when inflows were between 4.7 and 2.9 cfs. During the first three synoptic runs when enough flow was present below the lower diversion to make it to the confluence, 19% of Poorman Creek seepage losses occurred in the upper reach.

Middle Reach – Greatest seepage losses during the first three synoptic runs were observed in the middle reach (57%). Figure 4 depicts the extent of dewatering in lower Poorman Creek.

Lower Reach – Seepage losses averaged 24% in the lower reach during the first three synoptic runs. Small gains in surface flow, due to ground water discharge, were measured on July 19 and August 3 near the mouth of Poorman Creek. The extent of this surface flow was estimated to cover the lower 500 feet of stream.

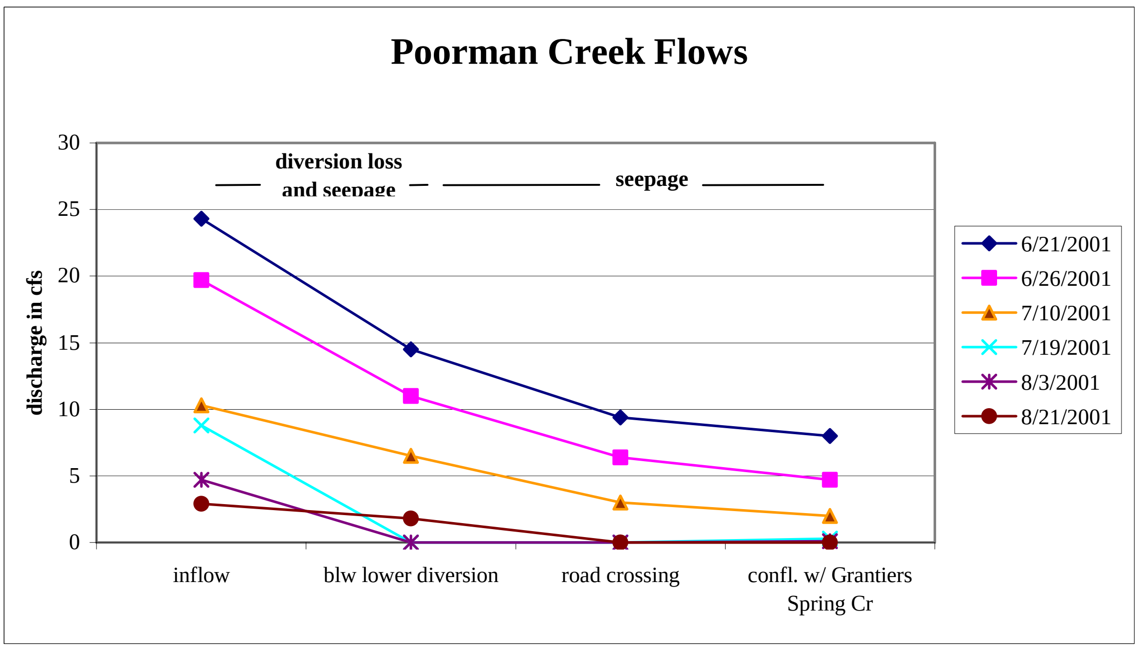

Figure 3. Poorman Creek synoptic flow measurement runs.

Lower Diversion - The lower diversion, a 0.5 mile open ditch that delivers water to a pump site that services two center pivots, was measured five times to determine delivery efficiency to the pump site. Gains or losses were negligible on two of the five runs (i.e. <50 gallons per minute) and losses between 135 and 360 gallons per minute were observed on the three other runs (Figure 5).

Grantier Spring Creek - Three measurement runs were conducted on Grantier Spring Creek. Streamflow gains between 4 and 8 cfs were measured over the reach (Figure 6). Streamflows in this reach are predominantly supplemented by Blackfoot River subsurface flow. Ground water data indicate contributions to surface flow from Humbug Creek subsurface flow, and the flood irrigated parcel are apparent near the confluence of Grantier Spring Creek and Poorman Creek.

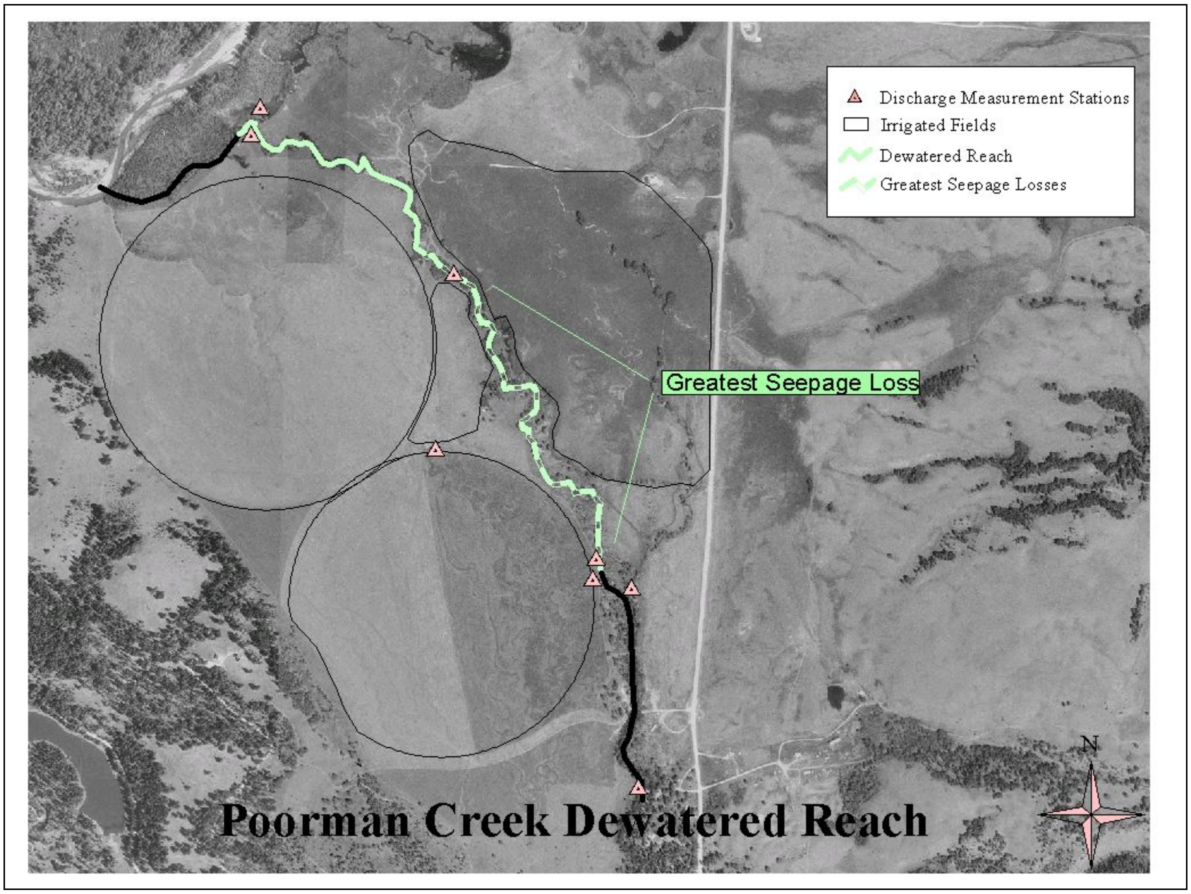

Figure 4. Dry reach of Poorman Creek (after July 19).

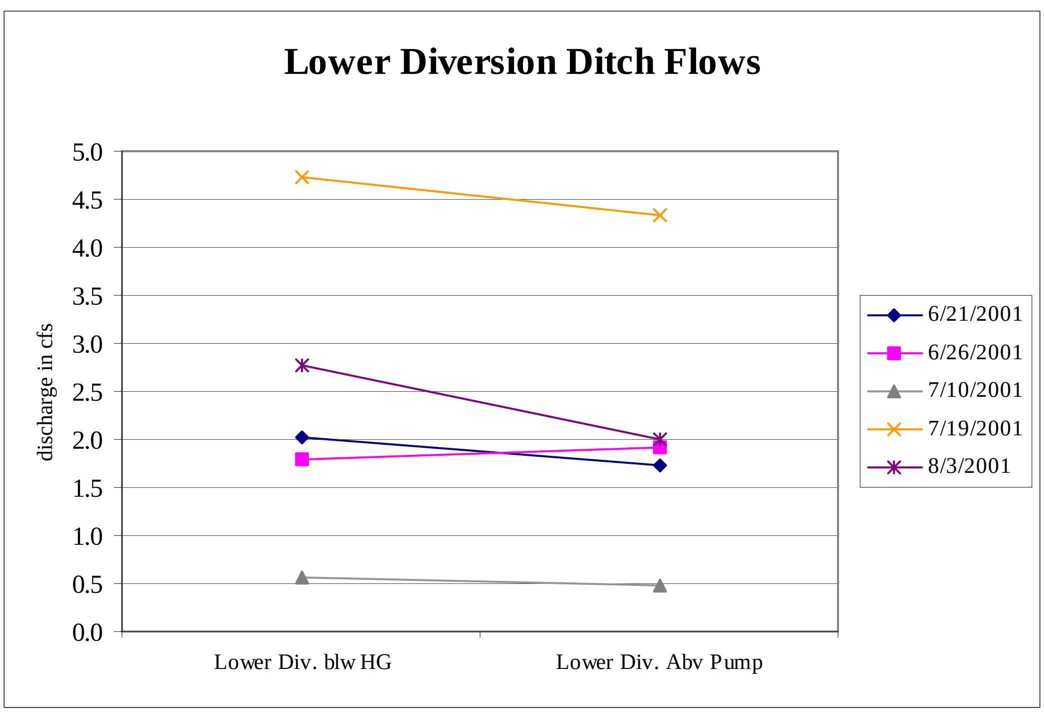

Figure 5. Lower diversion synoptic flow measurement runs.

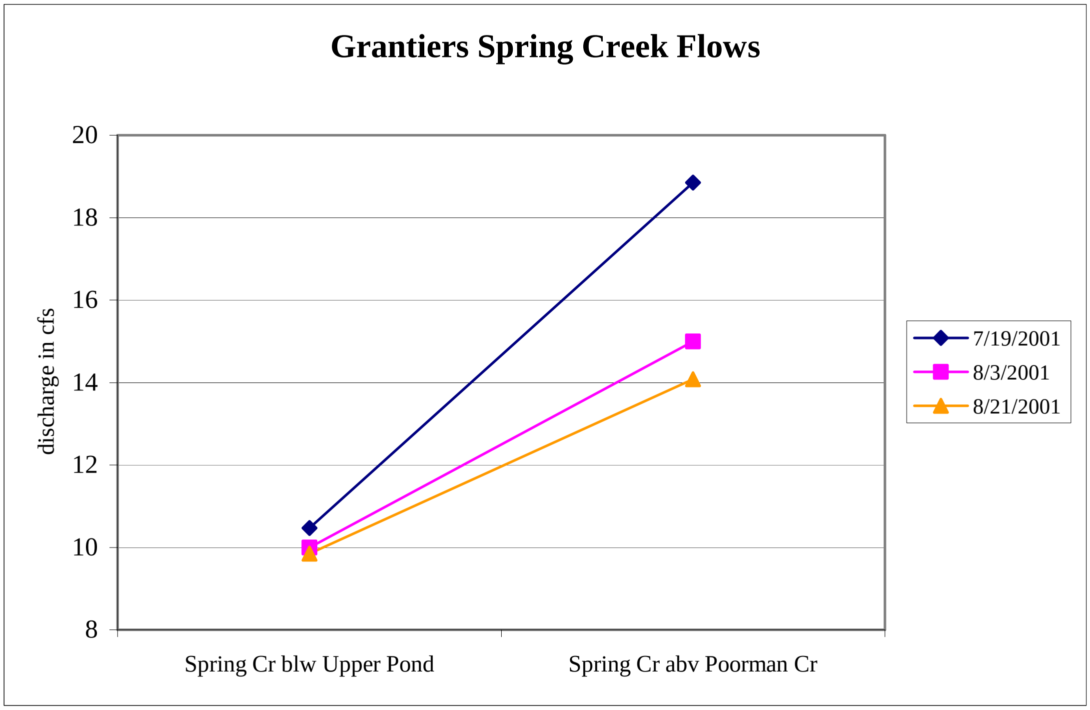

Figure 6. Grantiers Spring Creek synoptic flow measurement runs.

Exceedance flows for Poorman Creek at the Forest Service boundary (1.5 miles upstream from the study area inflow station) were estimated by the U.S. Forest Service (Sandy Kratville, personal communication) using USGS hydrologic modeling techniques (Parrott and Cartier 1989). These models estimate exceedance values by developing regional regresssion equations using gaged watersheds and basin characteristics such as drainage area and mean annual precipitation. The Q50 exceedance, for example, is a flow that would be met or exceeded in 5 out of 10 years. There is inherent variability associated with estimating streamflows using regional regression equations on ungaged watersheds like Poorman Creek, and the standard errors associated with these estimates can be high. However, values presented in Table 2 do provide a relative basis to conclude that during low flow years (i.e. Q70 and Q90), inflows to the study area in July and August are likely to be greater than those measured in 2001 (<11 cfs in July and <5 cfs in August).

Table 2. Poorman Creek Exceedance Flows

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Q90	5.3	5.5	4.9	4.2	4.9	5.6	10.2	33.1	65.4	17.9	10.4	7.2
Q70	7.7	8.2	7.2	6.6	7.1	8.1	16.3	58.7	103.5	25.3	13.1	9.8
Q50	10.6	11.7	10.2	9.0	8.7	9.9	24.7	89.8	152.9	37.3	16.0	11.4
Q10	31.7	26.2	21.7	17.1	18.9	19.2	65.3	212.7	290.2	88.9	28.3	21.9
QM	17.3	14.5	12.7	9.9	10.8	11.6	33.7	112.0	166.1	48.1	18.0	13.8

Ground Water
Water levels measured for this study confirm the general contour pattern presented by Coffin and Wilke (1971). Ground water flows generally north in alluvium of the Poorman Creek drainage and merges with ground water flowing parallel to the Blackfoot River immediately north of the study area. Water level data collected on August 3rd (Table 3) indicate that ground water from the Poorman Creek drainage, augmented by return flow from flood irrigation and flow from Humbug Creek, flowed from the study area toward the western most pond and lower reaches of Grantier Spring Creek near its confluence with Poorman Creek (Figure 7). Water level data collected on October 28th indicate a similar pattern, however the ground-water divide separating flow from the Poorman Creek Drainage and flow parallel to the Blackfoot River had shifted to the south. This shift indicates flow from the Poorman Creek drainage and that discharge is focused even farther to the west.

Table 3. Year 2001 Ground-Water Elevation Data (ft)

Piezometer	8/3	8/7	8/10	8/16	8/21	8/28	9/5	9/14	9/19	9/28	10/12
1	4540.91	4540.58				4539.14	4538.98	4538.75	4538.62	4538.17	
2	4542.20	4542.34	4542.41	4542.53	4542.61	4542.68	4542.74	4542.78	4542.81	4542.77	4542.69
3			4536.77	4536.36	4536.03	4535.79	4535.53	4535.41			
4	4542.56	4542.49	4542.43	4542.29	4542.19	4542.07	4541.93	4541.83	4541.76	4541.63	4541.29
5	4536.40	4536.51	4536.58	4536.69	4536.77	4536.89	4537.00	4537.15	4537.20	4537.31	4537.46
6	4533.36	4534.22	4534.81	4535.40	4535.64	4535.87	4536.00	4536.11	4536.15	4536.15	4536.16

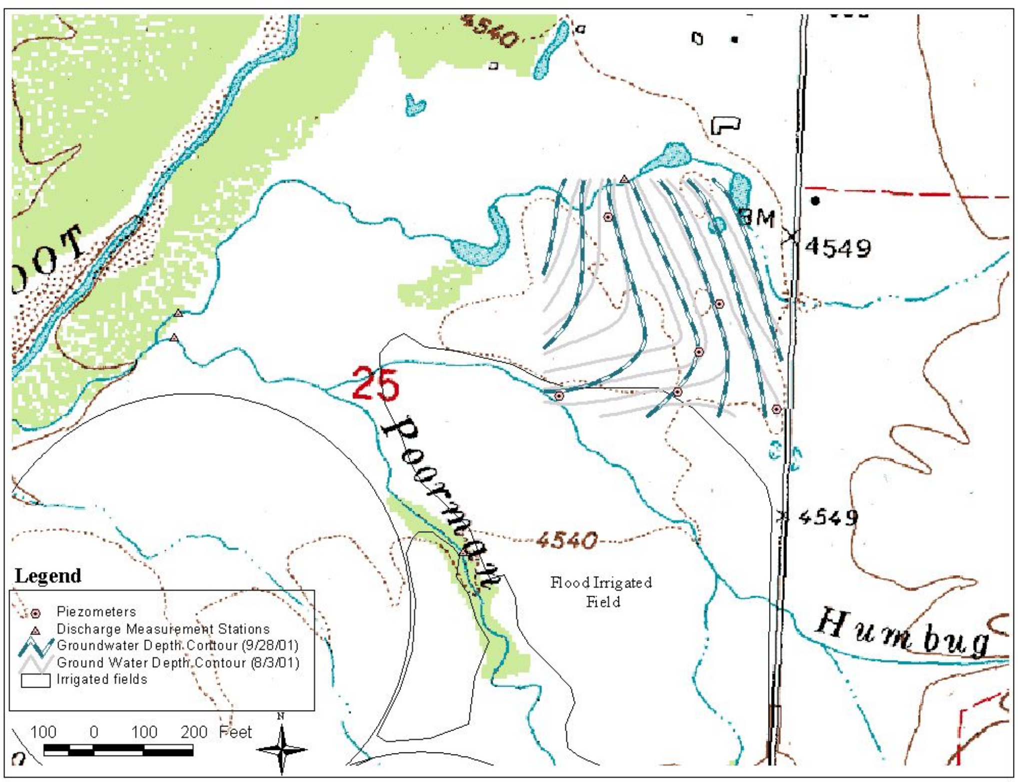

Figure 7. Ground water depth contours between the flood irrigated field and Grantier Spring Creek.

The pattern of water levels observed on October 28th might be indicative of what can be expected throughout the irrigation season if flood irrigation is stopped. The main effect would probably be to focus ground water discharge to the vicinity of the confluence of Poorman Creek and Grantier Spring Creek. Ground water from the Blackfoot River drainage will continue to feed the eastern most ponds north of the study area and, therefore, changing irrigation practices should not change flow to these ponds.

Discussion

Quantified streamflow losses indicate dewatering of Poorman Creek is caused by irrigation diversion and natural channel seepage. During the 2001 irrigation season, the amount diverted from the study reach was highly dependent on the amount of inflows available. Roughly one-third of inflows were diverted for irrigation purposes when inflows exceeded 10 cfs. As well, approximately 42% of inflows were lost to seepage under the same circumstances. When inflows were less than 10 cfs, irrigation demands exceeded the amount necessary to maintain instream flows throughout the dewatered reach of Poorman Creek.

The 0.9-mile section of Poorman Creek between the lower diversion and the confluence with Grantiers Spring Creek showed the greatest seepage losses in the study reach, approximately 81%.

Subsurface water, generated from flood irrigation on the eastside of Poorman Creek, flows generally north through alluvium and likely supplements surface water in the western most pond and lower reaches of Grantier Spring Creek near its confluence with Poorman Creek. Change to a more efficient irrigation system may result in a minor depletion on lower Grantier Spring Creek near its confluence with Poorman Creek.

Precise determination of a critical inflow value defining the threshold at which Poorman Creek dries up would require more detailed monitoring than was conducted in this study. However, based on the data collected some generalizations can be made. When 6.5 cfs was measured at the site below the lower diversion (7/10/01), surface flow was maintained to Poorman Creek's confluence with Grantier Spring Creek. When 1.8 cfs was measured on 8/21/01, the creek is dry for most of the same reach. So under drought conditions, the critical threshold below the lower diversion is between 1.8 and 6.5 cfs.

Estimates of exceedance flows on Poorman Creek at the forest boundary indicate that study area inflows on most years, including drought years, are likely to be greater than those measured in 2001.

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