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January 12, 2005

Mr. Gary Janosko, Chief
Fuel Cycle Facilities Branch
Division of Fuel Cycle Safety and Safeguards
Office of Nuclear Material Safety and Safeguards
U. S. Nuclear Regulatory Commission
11545 Rockville Pike
Rockville, Maryland 20852-2738

Re: Biotic and Physical Surveys of the Spring Creek Drainage System in the Vicinity of the Shirley Basin Mine Tailings Site, License No. SUA-442, Docket No. 40-6622

Dear Mr. Janosko:

Enclosed is a report on a stream survey conducted by consultants to Pathfinder Mines Corporation as outlined in our correspondence to the NRC dated June 3, 2004. The report consists of two separate sections: the first section is a presentation by Intermountain Resources of Laramie, Wyoming of the results of the biotic survey; the second section is a presentation by Hydro-Engineering of Casper, Wyoming of the results of the physical characterization (stream flows, water chemistry, and bottom sediment chemistry). The field work was conducted on July 17 and 18, 2004. The collected and preserved samples of primarily benthic organisms were identified and analyzed by Rhithron Associates, Inc., of Missoula, Montana, a subcontractor to Intermountain Resources. Chemical and radiological analyses of water and sediment samples were done by Energy Laboratories, Casper, Wyoming. Because different consultants did the two major components of the evaluation, Pathfinder felt it was simpler to present each primary consultant's report segregated from the other, as opposed to attempting to merge them.

Summarizing the results from the studies, the quantitative sampling of the aquatic organsims did not indicate a pattern that would lead to the conclusion that tailings seepage impacts on the ground water adjacent to the tailings has in turn led to degradation of the stream environment. Generally speaking, Spring Creek both above and below the Shirley Basin tailings site is marginal as an aquatic environment. The Wyoming DEQ indices for three upgradient sites, SP-1A, SP-1 and FC-1, rated "very poor", "poor", and "poor", respectively. With the exception of SP-5, sites downgradient from the tailings site rated "fair". Based on the flow measurements and general observation, it appears that the stream environment is primarily limited by the quantity of water, the natural abundance of fines in the stream bottom materials , and the effects

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of siltation aggravated by domestic livestock and wildlife impacts to the riparian habitat. Water chemistry results did not point to a significant problem, regardless of site location along Spring Creek.

While Mine Creek (MC-1) was part of these studies as well as earlier evaluations, it should be emphasized that the present surface water expression (a pond with a very minor overflow through a pipe to Spring Creek) is a short term, artificial environment. Once the corrective action plan fresh water injection ceases, the recharge source to the pond will disappear, and the pond itself will also disappear. The drainage will revert to a normally dry draw with only intermittent flows after significant precipitation events.

We see nothing in these latest evaluations that would diminish the appropriateness of Alternate Concentration Limits (ACL) for the Shirley Basin tailings site. We urge the NRC to proceed without further delay to approve the ACL request.

Sincerely,

Tom Hardgrove

T. W. Hardgrove
Manager, Reclamation Operations

Enclosure

Cc: J. Whitten, USNRC Region IV
J. Wagner, DEQ/WQD
D. L. Wichers

2004 SPRING CREEK AQUATIC STUDY

SHIRLEY BASIN MINE AREA

Prepared For

Pathfinder Mines Corporation

Shirley Basin Mine

Prepared By,

Intermountain Resources
PO Box 1589
Laramie, WY 82073

307-745-3803

October 2004

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1.0 INTRODUCTION

Intermountain Resources, located in Laramie, Wyoming, completed quantitative sampling of aquatic systems associated with Spring Creek on and adjacent to Pathfinder Mines Corporation, Shirley Basin Mine mill tailings site. These studies were completed to determine the presence of biotic organisms, primarily macroinvertebrates, at selected sample sites as described in this report.

2.0 DESCRIPTION OF THE STUDY AREA

The area sampled is located in the Shirley Basin area of Carbon County, Wyoming, approximately 45 miles south of Casper. Eleven sites were sampled on four drainages as listed below (see Figure 1 for map of locations):

SP-1A Murdock Creek above the confluence with Spring Creek

SP-1 Spring Creek above the area of impact by the mill tailings site at water quality sample site location SW-1A

SP-2 Spring Creek immediately below the confluence with Mine Creek

SP-2A Spring Creek between the Fox Creek and Mine Creek confluences

SP-3 Spring Creek in the diversion channel

SP-4 Spring Creek below the diversion channel

SP-5 Spring Creek above the confluence with the Little Medicine Bow River

FC-1 Fox Creek above the confluence with Spring Creek

MC-1 Mine Creek above the confluence with Spring Creek

MB-1 Little Medicine Bow River above the confluence with Spring Creek

MB-2 Little Medicine Bow River below the confluence with Spring Creek

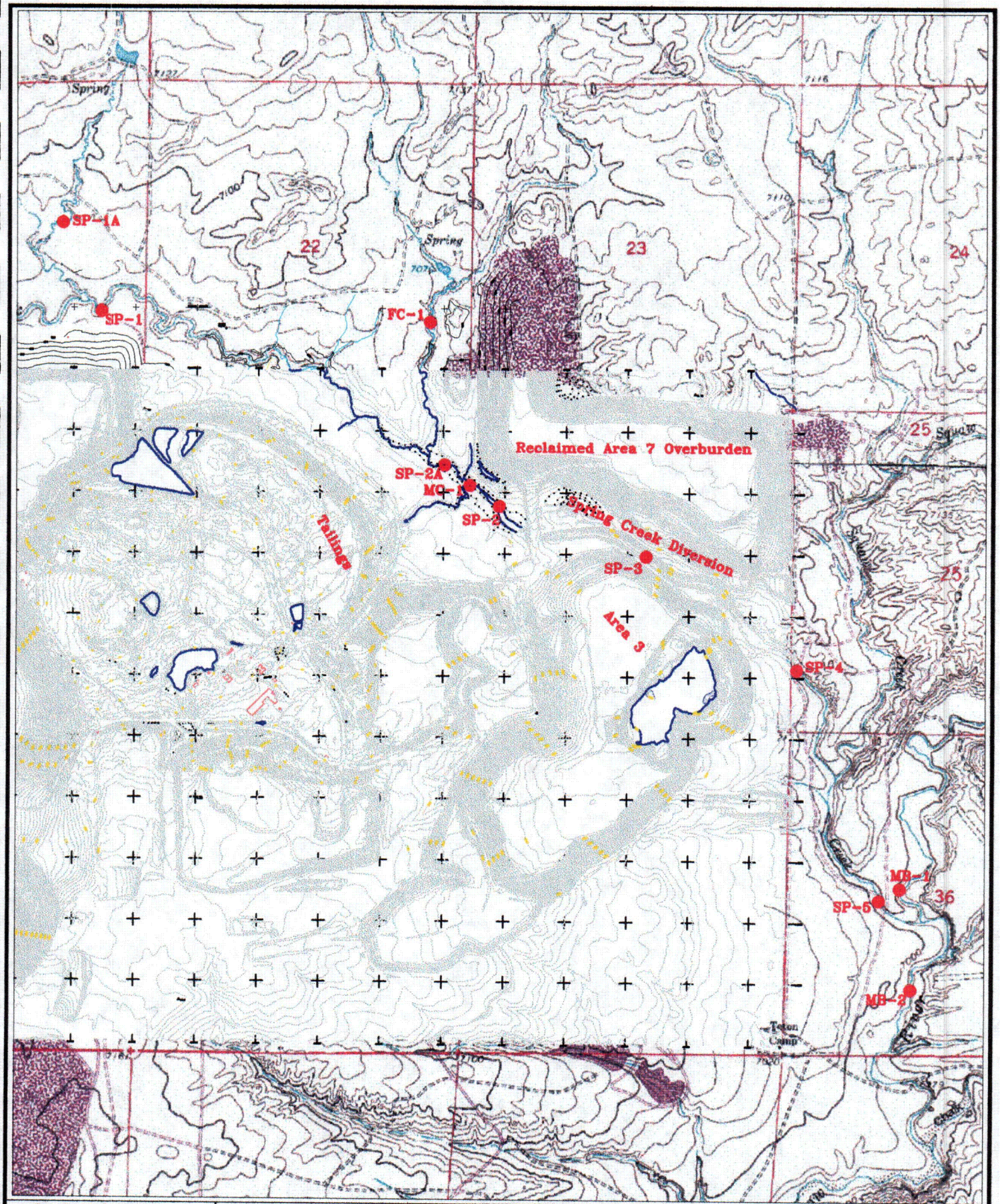

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FIGURE 1. SPRING CREEK STUDY SAMPLING SITES

DATE:12-2004	SCALE: 1"=1000'
	SAMPLE_FIGURE_2-1.DWG
	HYDRO-ENGINEERING L.L.C.

C-01

Sample sites SP-1, SP-1A, FC-1 and MB-1 are located above any water contributions from the Shirley Basin Mine tailings site and it will be assumed that these sample sites represent the natural conditions (unaffected by the Shirley Basin Mine tailings) of the drainages in the immediate area. Sample site MC-1 is assumed to have the most water quality impacts from the tailings site since flows in this drainage result primarily from tailings seepage waters related to the corrective action plan (CAP) clean water injection. Sample sites SP-2, SP-2A, SP-3, SP-4, SP-5 and MB-2 are assumed to have gradually lesser degrees of impact in the order listed based on distances from potential ground water contributions related to the tailings site.

3.0 METHODS

This study was designed to provide only quantitative information for the sites sampled.

Macroinvertebrates

Sampling for aquatic macroinvertebrates was conducted using a Surber Type Stream Bottom Sampler with a 12" x 12" sample area and 500 micron Nitex mesh net at all locations except MC-1 (Mine Creek). Mine Creek was less than 1 foot across, 2 inches deep, and had a very low flow. Mine Creek could not be sampled with the Surber Type Sampler. An Aquatic D-Shaped Dip Net with a 12" wide rim and a 500 micron nylon mesh bag was used for sampling at this location.

Eight macroinvertebrate samples were collected and composited at each location. Samples were field preserved with 10% formaldehyde. (Refer to the SOP Manual,

Wyoming Department of Environmental Quality, Water Quality Division, Watershed Program, Macroinvertebrate Sampling, August 1999).

Locations MB-2, MB-1, SP-5, SP-4, SP-3, and SP-2 were sampled on July 17, 2004. Locations SP-2A, FC-1, SP-1, SP-1A, and MC-1 were sampled on July 18, 2004.

The samples were sent to Rhithon Associates, Inc., Missoula, Montana, for identification and analysis.

4.0 RESULTS

This section presents the results of the aquatic sampling completed in 2004 at the eleven sites evaluated for the Pathfinder Mines Corporation Shirley Basin Mine.

Macroinvertebrates

Appendix A and Appendix B present the results of the macroinvertebrate sampling completed in 2004 for the Shirley Basin Mine. A total of 95 different aquatic macroinvertebrate species were identified in the study area. The average number of species per sample was 31 with the most being found at MB-2 (42 species) and the least being found at SP-1A (25 species). As discussed previously site MB-2, which exhibited the greatest number of species, is along the Medicine Bow River immediately below the confluence with Spring Creek and is assumed to have some impacts from the tailings site. Site SP-1A, which exhibited the least number of species, is located above the tailings site and is assumed to have no impacts related to tailings seepage.

Rhithron Associates analyzed and compared the samples and performed the Wyoming Stream Integrity Index or WSII, Macroinvertebrate Scoring (Wyoming Department of Environmental Quality, Water Quality Division Watershed Program) at each sample location. This information is included in Appendix A. The Wyoming Department of Environmental Quality has identified the Spring Creek Drainage as within the Wyoming Basin Ecoregion. The indices calculated by Rithron Associates using the Wyoming Basin Ecoregion are presented in Table 1.

Table 1 shows that MC-1 was identified as being 'Very Poor'. This was expected since this site contains water most directly or indirectly impacted by the tailings. However, this site also exhibited the lowest flows and could not be sampled with the Surber sampler but had to be sampled with a dip net. SP-1A was also identified as 'Very Poor'. This was somewhat unexpected because SP-1A is located on Murdock Creek above any tailings site activity and was assumed to represent natural conditions. SP-1, and FC-1 located upgradient of the tailings site and out of the area of impact were both rated 'Poor'. SP-2A and SP-3, respectively located adjacent to and downgradient from the tailings site were rated 'Fair'. Site SP-4, the first location downstream from the entire tailings/mine site rated 'Fair'; however, SP-5, the site on Spring Creek immediately above the confluence with the Little Medicine Bow River rated 'Poor'. Both locations on the Little Medicine Bow River, site MB-1 above the confluence with Spring Creek and MB-2 below the confluence with Spring Creek, rated 'Fair'.

Table 1.

Wyoming DEQ Indices - Site Ratings
Wyoming Basin

Site	SP-1A	SP-1	SP-2	FC-1	SP-2A	MC-1	SP-3	SP-4	SP-5	MB-1	MB-2
Rating	Very Poor	Poor	Poor	Poor	Fair	Very Poor	Fair	Fair	Poor	Fair	Fair

5.0 CONCLUSIONS

Quantitative macroinvertebrate aquatic sampling was completed on Murdock Creek, Spring Creek, Mine Creek, Fox Creek and the Little Medicine Bow River within, or adjacent to, Pathfinder Mines Corporation Shirley Basin Mine in the summer of 2004. Data from this sampling did not indicate any negative surface water impacts from the tailings. Using the Wyoming DEQ WSII ratings, it could be concluded that the Spring Creek Drainage stream quality was actually better within the area of impact of the tailings site than in drainages above the tailings site where there are no tailings related impacts.

6.0 REFERENCES

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APPENDIX A

SAMPLE ANALYSIS AND RESULTS

Intermountain Resources - Pathfinder Mine Project 2004
Determinations by Rhithron Associates, Inc.

	Sample date	7/18/2004	7/17/2004	7/17/2004	7/18/2004	7/18/2004	7/18/2004
	Site name	FC-1 8M	MB-1 2M	MB-2 1M	MC-1 11M	SP-1 9M	SP-1A 10M
Taxon							
	Nematoda		10	2	5	3	6
Enchytraeidae	Enchytraeidae						
Naididae	*Nais*	3				9	4
	Ophidonais serpentina			1	1		
Tubificidae	*Limnodrilus*		29	16	370	127	162
	Tubifex	40			28	33	22
Erpobdellidae	Erpobdellidae	4	3	2	1	1	
	Helobdella						
	Helobdella stagnalis	1	1	1	4	17	5
Glossiphoniidae	*Glossiphonia*			1			
Pisidiidae	Pisidiidae	63	10	5	312	48	14
Lymnaeidae	*Fossaria*		1	4			
Physidae	Physidae	20	10	17	31	4	1
Planorbidae	*Gyraulus*	16	3	7	36		
	Copepoda				6		
	Ostracoda				22		
Cragonyctidae	*Cragonyx*	173	9	5	5	12	10
Talitridae	*Hyalella*	127		2	133	24	
Acari	Acari	4	20	19	2	38	6
Coenagrionidae	*Argia*				1		
	Enallagma				4		
Gomphidae	Gomphidae - early instar		4	1			
	Ophiogomphus		1			1	
Baetidae	*Baetis tricaudatus*	3				3	185
	Fallceon quilleri	14	79	51		16	
Caenidae	*Caenis*					2	
Heptageniidae	*Heptagenia*			1			
Leptophlebiidae	*Paraleptophlebia*			1			
	Paraleptophlebia bicornuta			5			
Leptohyphidae	*Tricorythodes*	29	382	410	14	42	3
Capniidae	Capniidae		4	1			
Perlodidae	*Cultus*						
	Isoperla		1	2			
	Skwala		2	12			
Corixidae	Corixidae - early instar	8	2	4			
Sialidae	*Sialis*						
Brachycentridae	*Brachycentrus occidentalis*		1	3			
Helicopsychidae	*Helicopsyche borealis*		16	10		3	
Hydropsychidae	*Cheumatopsyche*	2	16	12		1	
	Hydropsyche		4	4			
Hydroptilidae	*Hydroptila*			1			
	Ochrotrichia	1				1	
Lepidostomatidae	*Lepidostoma*						
Leptoceridae	*Nectopsyche*			1			

Intermountain Resources - Pathfinder Mine Project 2004
Determinations by Rhithron Associates, Inc.

	Sample date	7/18/2004	7/18/2004	7/17/2004	7/17/2004	7/17/2004
	Site name	SP-2 6M	SP-2A 7M	SP-3 5M	SP-4 4M	SP-5 3M
	Taxon					
	Nematoda	17	7	22	7	1
Enchytraeidae	Enchytraeidae		1			
Naididae	*Nais*	2	25	8		10
	Ophidonais serpentina					
Tubificidae	*Limnodrilus*	40	52	42	42	37
	Tubifex					
Erpobdellidae	Erpobdellidae	1				
	Helobdella				1	
	Helobdella stagnalis	3	1	2		
Glossiphoniidae	*Glossiphonia*					
Physidae	Physidae	16	9	32	4	4
Lymnaeidae	*Fossaria*			2		
Physidae	Physidae	16	13	49		1
Planorbidae	*Gyraulus*	8	2	30		
	Copepoda					
	Ostracoda					
Crangonyctidae	*Crangonyx*	8	3		3	
Talitridae	*Hyalella*	4		2		
Acari	Acari	11	12	13	1	7
Coenagrionidae	*Argia*					
	Enallagma			9		
Gomphidae	Gomphidae - early instar	1			1	8
	Ophiogomphus	1		1		1
Baetidae	*Baetis tricaudatus*					
	Falloeon quilleri	19	61	61	30	10
Caenidae	*Caenis*					
Heptageniidae	*Heptagenia*					
Leptophlebiidae	*Paraleptophlebia*					
	Paraleptophlebia bicornuta					
Leptohyphidae	*Tricorythodes*	82	173	331	188	461
Capniidae	Capniidae					
Perlodidae	*Cultus*		1			
	Isoperla					1
	Skwala					
Corixidae	Corixidae - early instar			1		
Sialidae	*Sialis*			1		
Brachycentridae	*Brachycentrus occidentalis*		3	4	6	4
Helicopsychidae	*Helicopsyche borealis*		1	11	29	2
Hydropsychidae	*Cheumatopsyche*	21	14	9	44	4
	Hydropsyche	6	6	59	7	3
Hydroptilidae	*Hydroptila*	1	1		1	1
	Ochrotrichia		1			
Lepidostomatidae	*Lepidostoma*		1		2	
Leptoceridae	*Nectopsyche*					

Intermountain Resources - Pathfinder Mine Project 2004
Determinations by Rhithron Associates, Inc.

	Sample date	7/18/2004	7/17/2004	7/17/2004	7/18/2004	7/18/2004	7/18/2004
	Site name	FC-1 8M	MB-1 2M	MB-2 1M	MC-1 11M	SP-1 9M	SP-1A 10M
	Taxon						
	Oecetis		6				
Limnephilidae	*Onocosmoecus*						
Dryopidae	*Helichus*			1			
Dytiscidae	*Agabus*				1		
	Dytiscidae - early instar larva	2				3	4
	Nebrioporus			1			
Elmidae	*Cleptelmis*	1				1	
	Dubiraphia		4	3			
	Microcylloepus						
	Optioservus	45	47	44	2	115	44
	Zaitzevia		6	2			
Haliplidae	*Haliplus*				2		
Hydrophilidae	*Helophorus*				2		
	Hydrobius				1		
	Hydrophilidae - larva	1	2				
	Diptera - pupa					23	38
Ceratopogonidae	Ceratopogoninae	11	1	1	5	19	1
Muscidae	Muscidae						4
Psychodidae	*Pericoma*						1
Simuliidae	*Simulium*	32	9	4	4		
Stratiomyidae	*Nemotelus*						
Tabanidae	*Chrysops*				1		
Tipulidae	*Dicranota*		3	16			14
	Hexatoma		1				
	Tipula	1			1	1	18
Chironomidae	*Alotanypus*						1
	Cladotanytarsus		1		6		
	Corynoneura				1		
	Cricotopus (Cricotopus)	2			1		
	Cricotopus (Isocladius)						1
	Cricotopus bicinctus	1					
	Cricotopus trifascia			1			
	Cryptochironomus			1			
	Dicrotendipes					1	
	Eukiefferiella Brehmi Gr.						
	Eukiefferiella Brevicalcar Gr.					1	
	Eukiefferiella Devonica Gr.						
	Eukiefferiella Pseudomontana Gr.						
	Micropsectra		1	1	144		4
	Orthocladius	3				5	8
	Orthocladius rivicola						
	Parametriocnemus						1
	Polypedilum		1			2	

Intermountain Resources - Pathfinder Mine Project 2004
Determinations by Rhithron Associates, Inc.

	Sample date	7/18/2004	7/18/2004	7/17/2004	7/17/2004	7/17/2004
	Site name	SP-2 6M	SP-2A 7M	SP-3 5M	SP-4 4M	SP-5 3M
Taxon						
	Oecetis		1			
Limnephilidae	*Onocosmoecus*		1			
Dryopidae	*Helichus*					
Dytiscidae	*Agabus*					
	Dytiscidae - early instar larva					
	Nebrioporus					
Elmidae	*Cleptelmis*		2	2		
	Dubiraphia			16		
	Microcylloepus			2		
	Optioservus	293	140	351	135	33
	Zaitzevia		11	7	11	
Haliplidae	*Haliplus*					
Hydrophilidae	*Helophorus*					
	Hydrobius					
	Hydrophilidae - larva					
	Diptera - pupa					
Ceratopogonidae	Ceratopogoninae	4	4	6	1	4
Muscidae	Muscidae	1				
Psychodidae	*Pericoma*					
Simuliidae	*Simulium*	264	66	68	64	2
Stratiomyidae	*Nemotelus*			1		
Tabanidae	*Chrysops*					
Tipulidae	*Dicranota*	10	2		6	
	Hexatoma					
	Tipula		1	1	2	
Chironomidae	*Alotanypus*					
	Cladotanytarsus					5
	Corynoneura					1
	Cricotopus (Cricotopus)					
	Cricotopus (Isocladius)	3			1	5
	Cricotopus bicinctus	3				2
	Cricotopus trifascia	1				
	Cryptochironomus					
	Dicrotendipes	1				
	Eukiefferiella Brehmi Gr.	3		5		1
	Eukiefferiella Brevicalcar Gr.					
	Eukiefferiella Devonica Gr.	1				
	Eukiefferiella Pseudomontana Gr.				1	
	Micropsectra	1		2	1	
	Orthocladius			8		
	Orthocladius rivicola					1
	Parametriocnemus	6	3			
	Polypedilum			4		

Intermountain Resources - Pathfinder Mine Project 2004
Determinations by Rhithron Associates, Inc.

Sample date	7/18/2004	7/17/2004	7/17/2004	7/18/2004	7/18/2004	7/18/2004
Site name	FC-1 8M	MB-1 2M	MB-2 1M	MC-1 11M	SP-1 9M	SP-1A 10M
Taxon						
Psectrocladius					4	17
Radotanypus				1		
Rheotanytarsus		1	1	2		
Tanytarsus	1					
Thienemanniella			1			
Thienemannimyia Gr.		2		1		
Tvetenia Bavarica Gr.						
Tvetenia vitracies						
Total	608	693	678	1150	560	574

Intermountain Resources - Pathfinder Mine Project 2004
Determinations by Rhithron Associates, Inc.

Sample date	7/18/2004	7/18/2004	7/17/2004	7/17/2004	7/17/2004
Site name	SP-2 6M	SP-2A 7M	SP-3 5M	SP-4 4M	SP-5 3M
Taxon					
Psectrocladius			6		
Radotanypus					
Rheotanytarsus				1	
Tanytarsus					
Thienemanniella	1		8	1	1
Thienemannimyia Gr.		1	6	2	2
Tvetenia Bavarica Gr.		2		3	1
Tvetenia vitracies			3		
Total	849	621	1185	895	613

METRICS AND INDICES

Sample date / Site name	7/18/2004 FC-1 8M	7/17/2004 MB-1 2M	7/17/2004 MB-2 1M	7/18/2004 MC-1 11M	7/18/2004 SP-1 9M	7/18/2004 SP-1A 10M
Sample type		0	0	0	0	0
SUBSAMPLE TOTAL ORGANISMS	608	693	678	1150	560	574
Portion of sample used	13.33%	7.50%	16.67%	5.00%	5.83%	7.50%
Estimated number in total sample	4560	9240	4068	23000	9600	7653
Conversion factor	10.0875	17.93333333	8.07	26.9	23.05714286	17.93333333
Estimated number in 1 square meter	6133	12428	5471	30935	12912	10294
EPT abundance	49	511	514	14	68	188
Taxa richness	27	35	42	33	30	25
Number EPT taxa	5	10	14	1	7	2
Percent EPT	8.06%	73.74%	75.81%	1.22%	12.14%	32.75%
TAXONOMIC COMPOSITION - PERCENT						
GROUP						
Non-insect taxa	74.18%	13.85%	12.09%	83.13%	56.43%	40.07%
Odonata	0.00%	0.72%	0.15%	0.43%	0.18%	0.00%
Ephemeroptera	7.57%	66.52%	69.03%	1.22%	11.25%	32.75%
Plecoptera	0.00%	1.01%	2.21%	0.00%	0.00%	0.00%
Heteroptera	1.32%	0.29%	0.59%	0.00%	0.00%	0.00%
Megaloptera	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Trichoptera	0.49%	6.20%	4.57%	0.00%	0.89%	0.00%
Lepidoptera	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Coleoptera	8.06%	8.51%	7.52%	0.70%	21.25%	8.36%
Diptera	7.24%	2.02%	3.10%	0.96%	7.68%	13.24%
Chironomidae	1.15%	0.87%	0.74%	13.57%	2.32%	5.57%
TAXONOMIC COMPOSITION - ABUNDANCE						
GROUP						
Non-insect taxa	451	96	82	956	316	230
Odonata	0	5	1	5	1	0
Ephemeroptera	46	461	468	14	63	188
Plecoptera	0	7	15	0	0	0
Heteroptera	8	2	4	0	0	0
Megaloptera	0	0	0	0	0	0
Trichoptera	3	43	31	0	5	0
Lepidoptera	0	0	0	0	0	0
Coleoptera	49	59	51	8	119	48
Diptera	44	14	21	11	43	76
Chironomidae	7	6	5	156	13	32
TAXONOMIC COMPOSITION- # TAXA						
GROUP						
Non-insect taxa	10	10	13	14	11	9
Odonata	0	2	1	2	1	0
Ephemeroptera	3	2	5	1	4	2
Plecoptera	0	3	3	0	0	0
Heteroptera	1	1	1	0	0	0
Megaloptera	0	0	0	0	0	0
Trichoptera	2	5	6	0	3	0
Lepidoptera	0	0	0	0	0	0
Coleoptera	4	4	5	5	3	2
Diptera	3	4	3	4	3	6
Chironomidae	4	5	5	7	5	6

METRICS AND INDICES

Sample date	7/18/2004	7/18/2004	7/17/2004	7/17/2004	7/17/2004
Site name	SP-2 6M	SP-2A 7M	SP-3 5M	SP-4 4M	SP-5 3M
Sample type	0	0	0	0	
SUBSAMPLE TOTAL ORGANISMS	849	621	1185	595	613
Portion of sample used	5.00%	5.83%	10.00%	8.33%	5.00%
Estimated number in total sample	16980	10646	11850	7140	12260
Conversion factor	26.9	23.05714286	13.45	16.14	26.9
Estimated number in 1 square meter	22838	14318	15938	9603	16490
EPT abundance	129	264	475	307	486
Taxa richness	31	32	37	28	27
Number EPT taxa	5	12	6	8	8
Percent EPT	15.19%	42.51%	40.08%	51.60%	79.28%
TAXONOMIC COMPOSITION - PERCENT					
GROUP					
Non-insect taxa	14.84%	20.13%	17.05%	9.75%	9.79%
Odonata	0.24%	0.00%	0.84%	0.17%	1.47%
Ephemeroptera	11.90%	37.68%	33.08%	36.64%	76.84%
Plecoptera	0.00%	0.16%	0.00%	0.00%	0.16%
Heteroptera	0.00%	0.00%	0.08%	0.00%	0.00%
Megaloptera	0.00%	0.00%	0.08%	0.00%	0.00%
Trichoptera	3.30%	4.67%	7.00%	14.96%	2.28%
Lepidoptera	0.00%	0.00%	0.00%	0.00%	0.00%
Coleoptera	34.51%	24.64%	31.90%	24.54%	5.38%
Diptera	32.86%	11.76%	6.41%	12.27%	0.98%
Chironomidae	2.36%	0.97%	3.54%	1.68%	3.10%
TAXONOMIC COMPOSITION - ABUNDANCE					
GROUP					
Non-insect taxa	126	125	202	58	60
Odonata	2	0	10	1	9
Ephemeroptera	101	234	392	218	471
Plecoptera	0	1	0	0	1
Heteroptera	0	0	1	0	0
Megaloptera	0	0	1	0	0
Trichoptera	28	29	83	89	14
Lepidoptera	0	0	0	0	0
Coleoptera	293	153	378	146	33
Diptera	279	73	76	73	6
Chironomidae	20	6	42	10	19
TAXONOMIC COMPOSITION- # TAXA					
GROUP					
Non-insect taxa	11	10	10	6	6
Odonata	2	0	2	1	2
Ephemeroptera	2	2	2	2	2
Plecoptera	0	1	0	0	1
Heteroptera	0	0	1	0	0
Megaloptera	0	0	1	0	0
Trichoptera	3	9	4	6	5
Lepidoptera	0	0	0	0	0
Coleoptera	1	3	5	2	1
Diptera	4	4	4	4	2
Chironomidae	9	3	8	7	9

METRICS AND INDICES

Sample date / Site name	7/18/2004 FC-1 8M	7/17/2004 MB-1 2M	7/17/2004 MB-2 1M	7/18/2004 MC-1 11M	7/18/2004 SP-1 9M	7/18/2004 SP-1A 10M
TAXONOMIC RATIOS						
EPT/Chironomidae	7.00	85.17	102.80	0.09	5.23	5.88
Baetidae/Ephemeroptera	0.37	0.17	0.11	0.00	0.30	0.98
Hydropsychidae/Trichoptera	0.67	0.47	0.52	#DIV/0!	0.20	#DIV/0!
FUNCTIONAL COMPOSITION - PERCENT						
GROUP						
Predator	3.13%	3.03%	5.46%	1.48%	7.32%	4.88%
Parasite	0.00%	1.44%	0.29%	0.43%	0.54%	1.05%
Gatherer	54.77%	73.88%	74.34%	47.22%	38.21%	47.91%
Filterer	5.76%	4.33%	3.10%	0.52%	0.18%	0.00%
Herbivore	0.16%	0.00%	0.15%	0.17%	0.18%	0.00%
Piercer	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Scraper	13.32%	11.11%	12.24%	6.00%	21.79%	7.84%
Shredder	0.33%	0.58%	0.29%	0.09%	0.00%	0.17%
Omnivore	0.33%	1.15%	0.74%	0.09%	0.54%	3.14%
Unknown	22.20%	0.29%	0.88%	11.65%	8.39%	6.62%
FUNCTIONAL COMPOSITION - ABUNDANCE						
GROUP						
Predator	19	21	37	17	41	28
Parasite	0	10	2	5	3	6
Gatherer	333	512	504	543	214	275
Filterer	35	30	21	6	1	0
Herbivore	1	0	1	2	1	0
Piercer	0	0	0	0	0	0
Scraper	81	77	83	69	122	45
Shredder	2	4	2	1	0	1
Omnivore	2	8	5	1	3	18
Unknown	135	2	6	134	47	38
FUNCTIONAL COMPOSITION - # TAXA						
GROUP						
Predator	5	11	9	7	5	5
Parasite	0	1	1	1	1	1
Gatherer	10	9	12	12	13	12
Filterer	3	4	4	2	1	0
Herbivore	1	0	1	1	1	0
Piercer	0	0	0	0	0	0
Scraper	3	5	6	3	3	2
Shredder	1	1	2	1	0	1
Omnivore	2	3	3	1	2	1
Unknown	2	1	2	2	2	1
FUNCTIONAL RATIOS						
Scraper/Filterer	2.31	2.57	3.95	11.50	122.00	#DIV/0!
Scraper/Scraper + Filterer	0.70	0.72	0.80	0.92	0.99	1.00

METRICS AND INDICES

Sample date	7/18/2004	7/18/2004	7/17/2004	7/17/2004	7/17/2004
Site name	SP-2 5M	SP-2A 7M	SP-3 5M	SP-4 4M	SP-5 3M
TAXONOMIC RATIOS					
EPT/Chironomidae	6.45	44.00	11.31	30.70	25.58
Baetidae/Ephemeroptera	0.19	0.26	0.16	0.14	0.02
Hydropsychidae/Trichoptera	0.96	0.69	0.82	0.57	0.50
FUNCTIONAL COMPOSITION - PERCENT					
GROUP					
Predator	2.47%	1.45%	2.11%	1.85%	2.61%
Parasite	2.00%	1.13%	1.86%	1.18%	0.16%
Gatherer	17.67%	48.63%	42.36%	40.84%	81.89%
Filterer	34.28%	13.85%	11.48%	19.50%	1.47%
Herbivore	0.12%	0.32%	0.00%	0.17%	0.16%
Piercer	0.00%	0.00%	0.00%	0.00%	0.00%
Scraper	37.34%	25.12%	37.55%	27.56%	5.87%
Shredder	0.35%	0.16%	0.00%	0.50%	0.82%
Omnivore	0.47%	0.81%	0.76%	1.34%	0.98%
Unknown	0.59%	0.00%	0.34%	0.00%	0.00%
FUNCTIONAL COMPOSITION - ABUNDANCE					
GROUP					
Predator	21	9	25	11	16
Parasite	17	7	22	7	1
Gatherer	150	302	502	243	502
Filterer	291	86	136	116	9
Herbivore	1	2	0	1	1
Piercer	0	0	0	0	0
Scraper	317	156	445	164	36
Shredder	3	1	0	0	5
Omnivore	4	5	9	8	6
Unknown	5	0	4	0	0
FUNCTIONAL COMPOSITION - # TAXA					
GROUP					
Predator	7	5	6	5	5
Parasite	1	1	1	1	1
Gatherer	11	11	14	10	11
Filterer	3	3	3	4	3
Herbivore	1	2	0	1	1
Piercer	0	0	0	0	0
Scraper	3	4	6	2	3
Shredder	1	1	0	2	1
Omnivore	2	3	3	2	2
Unknown	2	0	3	0	0
FUNCTIONAL RATIOS					
Scraper/Filterer	1.09	1.81	3.27	1.41	4.00
Scraper/Scraper + Filterer	0.52	0.64	0.77	0.59	0.80

METRICS AND INDICES

Sample date / Site name	7/18/2004 FC-1 8M	7/17/2004 MB-1 2M	7/17/2004 MB-2 1M	7/18/2004 MC-1 11M	7/18/2004 SP-1 9M	7/18/2004 SP-1A 10M
COMMUNITY TOLERANCES						
Sediment tolerant taxa	3	6	4	3	3	3
Percent sediment tolerant	7.57%	56.42%	64.45%	4.43%	7.86%	6.10%
Sediment sensitive taxa	0	0	0	0	0	0
Percent sediment sensitive	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Metals tolerance index (McGuire)	3.67	4.06	3.94	2.67	4.28	4.66
Cold stenotherm taxa	0	0	0	0	0	0
Percent cold stenotherms	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
HABITUS MEASURES						
Hemoglobin bearer richness	2	3	2	4	4	2
Percent hemoglobin bearers	9.21%	4.76%	3.39%	37.83%	29.11%	32.06%
Air-breather richness	3	3	2	4	2	4
Percent air-breathers	0.66%	0.87%	2.51%	0.35%	0.71%	6.45%
Burrower richness	4	4	3	4	6	5
Percent burrowers	9.05%	1.01%	0.44%	3.04%	11.43%	8.01%
Swimmer richness	2	2	2	2	0	0
Percent swimmers	1.48%	0.58%	0.74%	0.26%	0.00%	0.00%
TOLERANCE/CONDITION INDICES						
Community Tolerance Quotient (CTQa)	96.80	84.07	81.88	101.30	94.35	91.11
Hilsenhoff Biotic Index	6.95	5.95	6.08	4.87	4.47	4.11
DIVERSITY						
Shannon H (loge)	3.18	2.56	2.46	2.46	3.66	2.77
Shannon H (log2)	2.21	1.78	1.71	1.71	2.54	1.92
Margalef D	4.05	5.35	6.28	4.54	4.58	3.77
Simpson D	0.15	0.33	0.38	0.21	0.12	0.20
Evenness	0.08	0.05	0.04	0.05	0.08	0.08
VOLTINISM - ABUNDANCE						
Multivoltine	29	115	78	191	74	229
Univoltine	526	510	543	950	365	297
Semivoltine	49	65	55	8	120	48
VOLTINISM - # TAXA						
Multivoltine	8	8	9	11	10	9
Univoltine	14	20	25	16	15	14
Semivoltine	4	7	7	5	4	2
VOLTINISM - PERCENT						
Multivoltine	4.77%	16.59%	11.50%	16.61%	13.21%	39.90%
Univoltine	86.51%	73.59%	80.09%	82.61%	65.18%	51.74%
Semivoltine	8.06%	9.38%	8.11%	0.70%	21.43%	8.36%
TAXA CHARACTERS - # TAXA						
Tolerant	9	13	13	8	13	7
Sensitive	0	0	0	0	0	0
Clinger	8	14	17	8	6	4
TAXA CHARACTERS - PERCENT						
Tolerant	8.06%	9.38%	8.11%	0.70%	21.43%	8.36%
Sensitive	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Clinger	14.47%	19.19%	16.81%	13.74%	28.57%	9.58%

METRICS AND INDICES

Sample date / Site name	7/18/2004 SP-2 6M	7/18/2004 SP-2A 7M	7/17/2004 SP-3 5M	7/17/2004 SP-4 4M	7/17/2004 SP-5 3M
COMMUNITY TOLERANCES					
Sediment tolerant taxa	4	4	5	3	2
Percent sediment tolerant	11.90%	28.66%	30.80%	32.94%	75.37%
Sediment sensitive taxa	0	0	0	0	0
Percent sediment sensitive	0.00%	0.00%	0.00%	0.00%	0.00%
Metals tolerance index (McGuire)	4.71	4.43	4.37	4.39	4.06
Cold stenotherm taxa	0	1	0	0	0
Percent cold stenotherms	0.00%	0.16%	0.00%	0.00%	0.00%
HABITUS MEASURES					
Hemoglobin bearer richness	3	2	3	1	1
Percent hemoglobin bearers	5.77%	8.70%	6.41%	7.06%	6.04%
Air-breather richness	1	2	2	2	0
Percent air-breathers	1.18%	0.48%	0.17%	1.34%	0.00%
Burrower richness	5	4	6	3	4
Percent burrowers	1.06%	4.99%	1.60%	0.67%	3.75%
Swimmer richness	0	0	1	0	0
Percent swimmers	0.00%	0.00%	0.08%	0.00%	0.00%
TOLERANCE/CONDITION INDICES					
Community Tolerance Quotient (CTQa)	102.10	85.93	97.29	86.91	94.45
Hilsenhoff Biotic Index	5.14	5.17	5.46	5.36	6.24
DIVERSITY					
Shannon H (loge)	2.51	3.07	3.12	2.85	1.52
Shannon H (log2)	1.74	2.13	2.17	1.98	1.05
Margalef D	4.59	4.82	5.08	4.22	4.20
Simpson D	0.23	0.16	0.18	0.18	0.57
Evenness	0.05	0.07	0.06	0.07	0.04
VOLTINISM - ABUNDANCE					
Multivoltine	68	88	138	49	38
Univoltine	485	377	664	393	529
Semivoltine	295	156	383	153	46
VOLTINISM - # TAXA					
Multivoltine	13	8	11	11	13
Univoltine	15	20	19	13	11
Semivoltine	3	4	7	4	4
VOLTINISM - PERCENT					
Multivoltine	8.01%	14.17%	11.65%	8.24%	6.20%
Univoltine	57.13%	60.71%	56.03%	66.05%	86.30%
Semivoltine	34.75%	25.12%	32.32%	25.71%	7.50%
TAXA CHARACTERS - # TAXA					
Tolerant	10	12	15	6	8
Sensitive	0	0	0	0	0
Clinger	10	12	12	12	11
TAXA CHARACTERS - PERCENT					
Tolerant	34.75%	25.12%	32.32%	25.71%	7.50%
Sensitive	0.00%	0.00%	0.00%	0.00%	0.00%
Clinger	71.14%	41.55%	46.08%	50.59%	10.44%

METRICS AND INDICES

Sample date	7/18/2004	7/17/2004	7/17/2004	7/18/2004	7/18/2004	7/18/2004
Site name	FC-1 8M	MB-1 2M	MB-2 1M	MC-1 11M	SP-1 9M	SP-1A 10M
BIOASSESSMENT INDICES						
B-IBI (Karr et al.) - VALUE						
Taxa richness	27	35	42	33	30	25
E richness	3	2	5	1	4	2
P richness	0	3	3	0	0	0
T richness	2	5	6	0	3	0
Long-lived	4	7	7	5	4	2
Sensitive richness	0	0	0	0	0	0
%tolerant	8.06%	9.38%	8.11%	0.70%	21.43%	8.36%
%predators	3.13%	3.03%	5.46%	1.48%	7.32%	4.88%
Clinger richness	8	14	17	8	6	4
%dominance (3)	59.70%	73.30%	74.48%	71.83%	51.79%	68.12%
B-IBI (Karr et al.) - TOTAL SCORE	20	26	30	22	18	18
WYOMING DEQ INDICES - VALUE						
Taxa richness	27	35	42	33	30	25
E richness	3	2	5	1	4	2
P richness	0	3	3	0	0	0
T richness	2	5	6	0	3	0
% E (no baetids)	4.77	55.12	61.50	1.22	7.86	0.52
%P	0.00	1.01	2.21	0.00	0.00	0.00
%T (no hydropsychids)	0.16	3.32	2.21	0.00	0.71	0.00
% 5 dominants	73.68	80.38	79.79	86.52	66.07	78.57
% non-insects	74.18	13.85	12.09	83.13	56.43	40.07
% scrapers	13.32	11.11	12.24	6.00	21.79	7.84
HBI	6.95	5.95	6.08	4.87	4.47	4.11
CTQa	96.80	84.07	81.88	101.30	94.35	91.11
SV richness	4	100	0	0	0	0
WYOMING DEQ INDICES - SITE RATINGS						
Western High Plains	fair	good	good	poor	fair	poor
Northwestern Great Plains	poor	fair	good	poor	poor	poor
Wyoming Basin	poor	fair	fair	very poor	poor	very poor
Middle Rockies West	very poor	poor	fair	very poor	poor	very poor
MRC Elevation > 6500	poor	fair	fair	very poor	poor	poor
MRC Elevation < 6500	very poor	poor	fair	very poor	poor	very poor
Southern Rockies	poor	poor	fair	very poor	poor	very poor
Black Hills	poor	fair	good	very poor	fair	poor

METRICS AND INDICES

Sample date	7/18/2004	7/18/2004	7/17/2004	7/17/2004	7/17/2004
Site name	SP-2 6M	SP-2A 7M	SP-3 5M	SP-4 4M	SP-5 3M
BIOASSESSMENT INDICES					
B-IBI (Karr et al.) - VALUE					
Taxa richness	31	32	37	28	27
E richness	2	2	2	2	2
P richness	0	1	0	0	1
T richness	3	9	4	6	5
Long-lived	3	4	7	4	4
Sensitive richness	0	0	0	0	0
%tolerant	34.75%	25.12%	32.32%	25.71%	7.50%
%predators	2.47%	1.45%	2.11%	1.85%	2.61%
Clinger richness	10	12	12	12	11
%dominance (3)	75.27%	61.03%	63.29%	65.04%	86.62%
B-IBI (Karr et al.) - TOTAL SCORE	16	22	22	22	22
WYOMING DEQ INDICES - VALUE					
Taxa richness	31	32	37	28	27
E richness	2	2	2	2	2
P richness	0	1	0	0	1
T richness	3	9	4	6	5
% E (no baetids)	9.66	27.86	27.93	31.60	75.20
%P	0.00	0.16	0.00	0.00	0.16
%T (no hydropsychids)	0.12	1.45	1.27	6.39	1.14
% 5 dominants	82.45	79.23	73.42	79.50	89.89
% non-insects	14.84	20.13	17.05	9.75	9.79
% scrapers	37.34	25.12	37.55	27.56	5.87
HBI	5.14	5.17	5.46	5.36	6.24
CTQa	102.10	85.93	97.29	86.91	94.45
SV richness	0	0	0	0	4
WYOMING DEQ INDICES - SITE RATINGS					
Western High Plains	good	good	good	good	good
Northwestern Great Plains	poor	fair	fair	fair	poor
Wyoming Basin	poor	fair	fair	fair	poor
Middle Rockies West	poor	poor	poor	poor	poor
MRC Elevation > 6500	poor	fair	fair	fair	poor
MRC Elevation < 6500	poor	poor	poor	poor	poor
Southern Rockies	poor	poor	poor	poor	poor
Black Hills	poor	fair	fair	fair	fair

Montana Plains ecoregions metrics (Bramblett and Johnson 2002)

Sample date / Site name	7/18/2004 FC-1 8M	7/17/2004 MB-1 2M	7/17/2004 MB-2 1M	7/18/2004 MC-1 11M	7/18/2004 SP-1 9M	7/18/2004 SP-1A 10M
Riffle						
EPT richness	5	10	14	1	7	2
Percent EPT	8.06%	73.74%	75.81%	1.22%	12.14%	32.75%
Percent Oligochaetes and Leeches	7.89%	4.76%	3.10%	35.13%	33.39%	33.62%
Percent 2 dominants	49.34%	66.52%	67.99%	59.30%	43.21%	60.45%
Filterer richness	3	4	4	2	1	0
Percent intolerant	0.00%	5.48%	5.31%	32.35%	22.86%	28.40%
Univoltine richness	14	20	25	16	15	14
Percent clingers	14.47%	19.19%	16.81%	13.74%	28.57%	9.58%
Swimmer richness	2	2	2	2	0	0
Pool						
E richness	3	2	5	1	4	2
T richness	2	5	6	0	3	0
Percent EPT	8.06%	73.74%	75.81%	1.22%	12.14%	32.75%
Percent non-insect	74.18%	13.85%	12.09%	83.13%	56.43%	40.07%
Filterer richness	3	4	4	2	1	0
Univoltine richness	14	20	25	16	15	14
Percent supertolerant	75.00%	8.66%	8.70%	50.43%	28.57%	18.47%

Montana Plains ecoregions metrics (Bramblett and Johnson 2002)

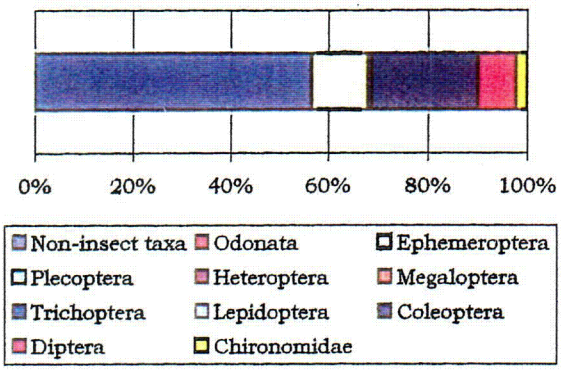
Sample date / Site name	7/18/2004 SP-2 6M	7/18/2004 SP-2A 7M	7/17/2004 SP-3 5M	7/17/2004 SP-4 4M	7/17/2004 SP-5 3M
Riffle					
EPT richness	5	12	6	8	8
Percent EPT	15.19%	42.51%	40.08%	51.60%	79.28%
Percent Oligochaetes and Leeches	5.42%	12.72%	4.39%	7.23%	7.67%
Percent 2 dominants	65.61%	50.40%	57.55%	54.29%	81.24%
Filterer richness	3	3	3	4	3
Percent intolerant	4.71%	9.34%	4.14%	8.40%	7.01%
Univoltine richness	15	20	19	13	11
Percent clingers	71.14%	41.55%	46.08%	50.59%	10.44%
Swimmer richness	0	0	1	0	0
Pool					
E richness	2	2	2	2	2
T richness	3	9	4	6	5
Percent EPT	15.19%	42.51%	40.08%	51.60%	79.28%
Percent non-insect	14.84%	20.13%	17.05%	9.75%	9.79%
Filterer richness	3	3	3	4	3
Univoltine richness	15	20	19	13	11
Percent supertolerant	9.54%	10.95%	13.00%	8.91%	3.26%

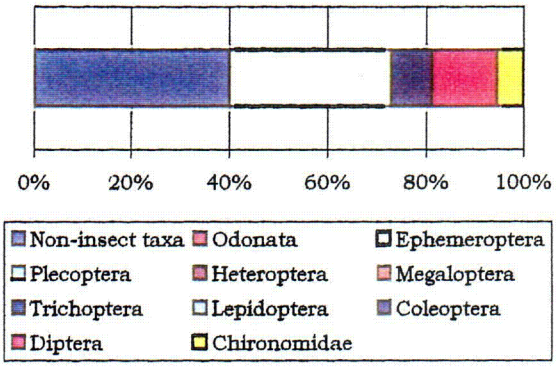
APPENDIX B

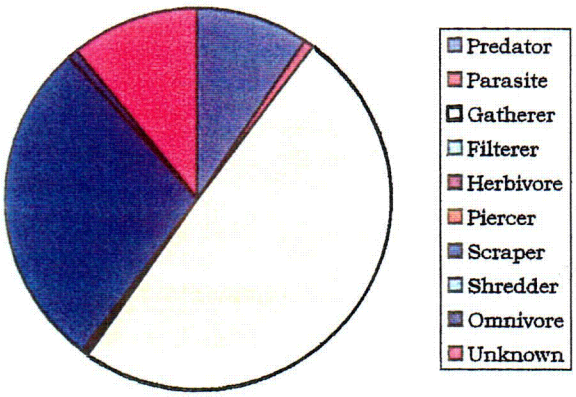
TAXONOMIC AND FUNCTIONAL COMPOSITION

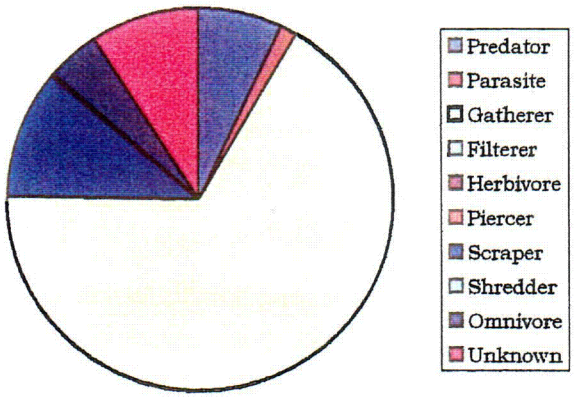
Taxonomic and Functional Composition

7/18/2004 SP-1 9M	7/18/2004 SP-1A 10M
Taxonomic composition - percent	Taxonomic composition - percent
Functional composition - percent	Functional composition - percent

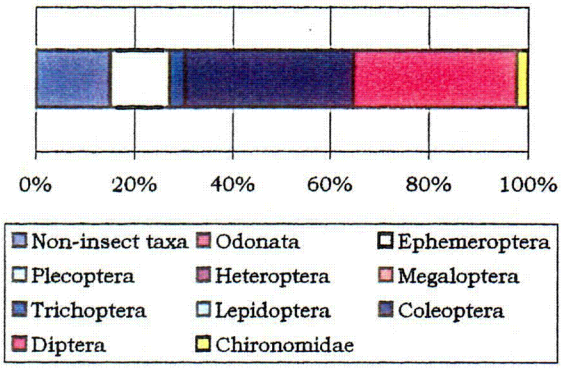
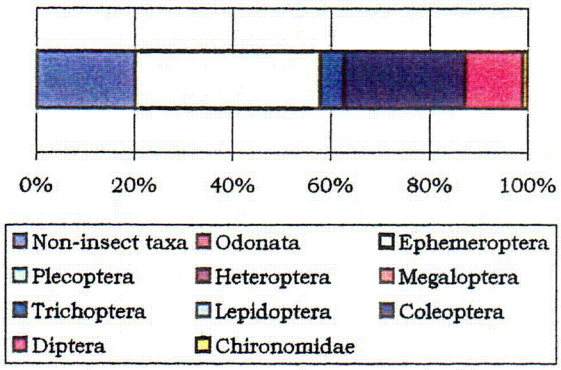
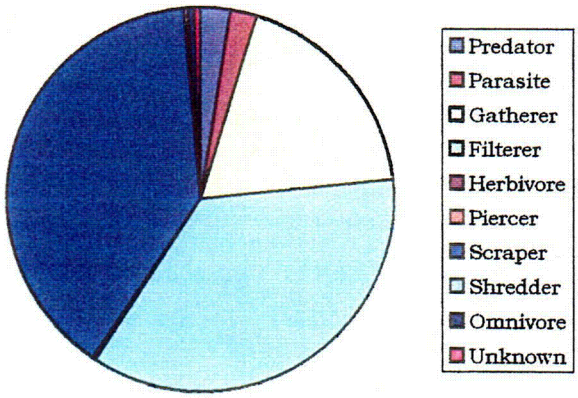
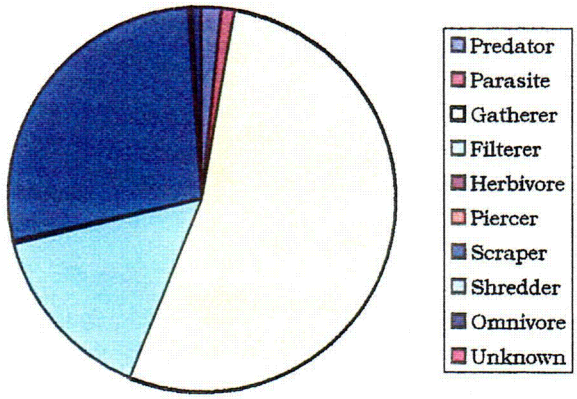








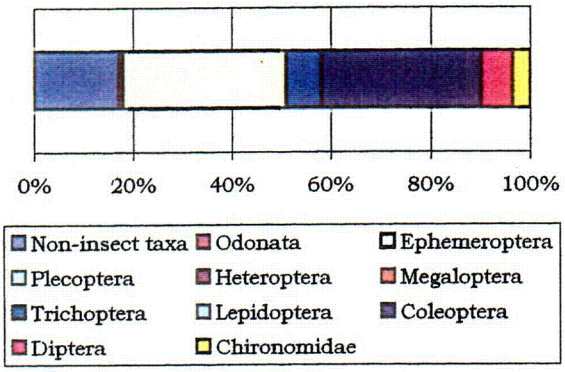
C-02

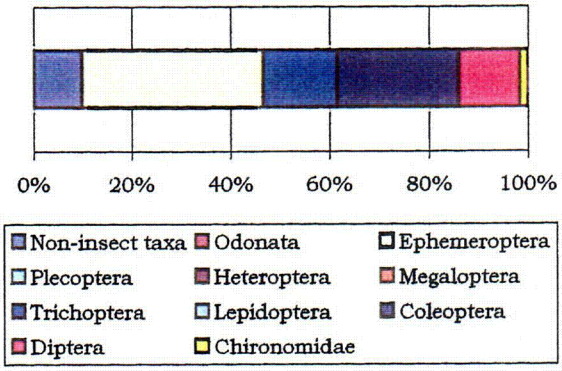
7/18/2004 SP-2 6M	7/18/2004 SP-2A 7M
Taxonomic composition - percent	**Taxonomic composition - percent**
	
Functional composition - percent	**Functional composition - percent**
	

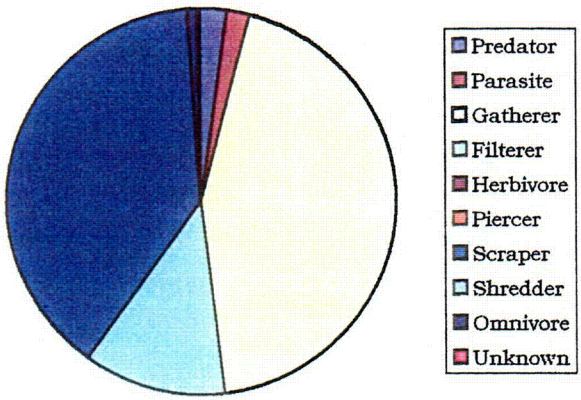
L-03

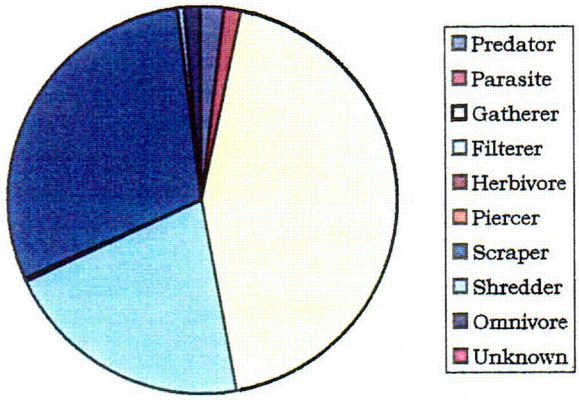
Taxonomic and Functional Composition

7/17/2004 SP-3 5M	7/17/2004 SP-4 4M
Taxonomic composition - percent	Taxonomic composition - percent
Functional composition - percent	Functional composition - percent





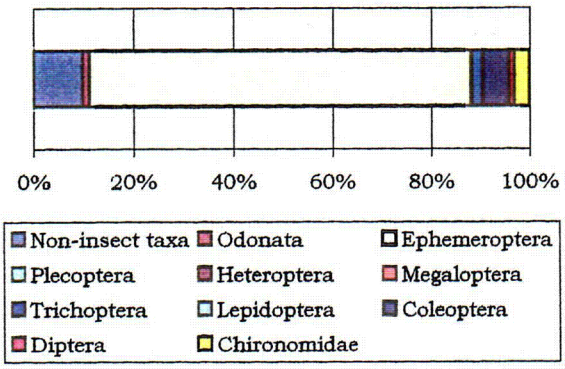




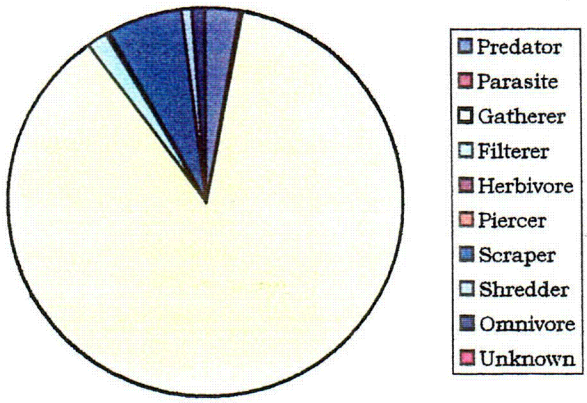
C-04

7/17/2004
SP-5 3M

Taxonomic composition - percent



Functional composition - percent



C-05

Taxonomic and Functional Composition

7/18/2004 FC-1 8M	7/17/2004 MB-1 2M
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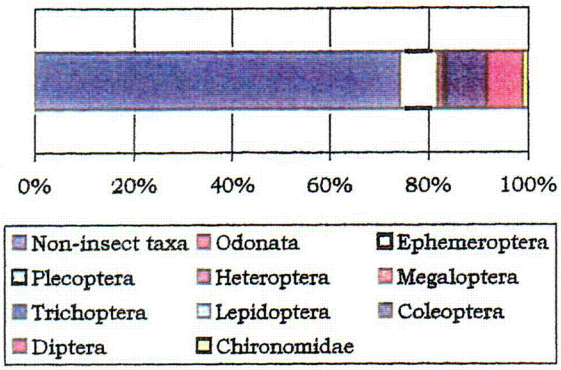
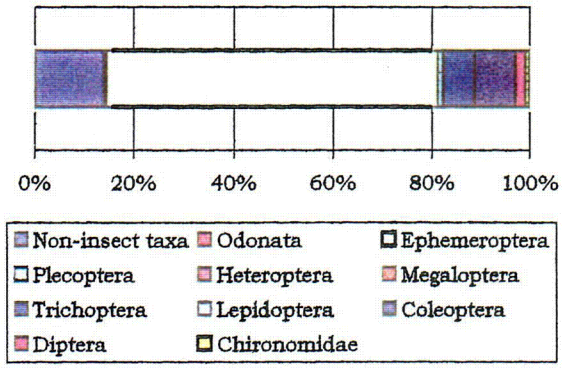
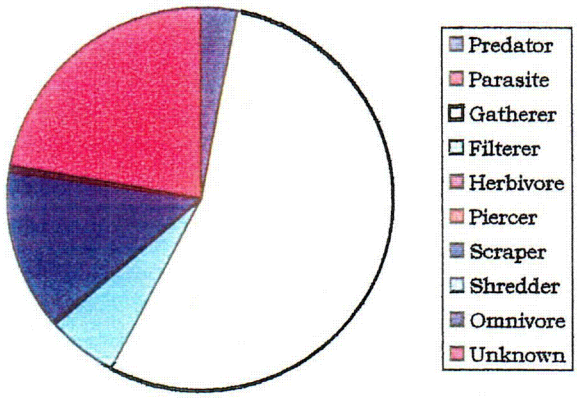
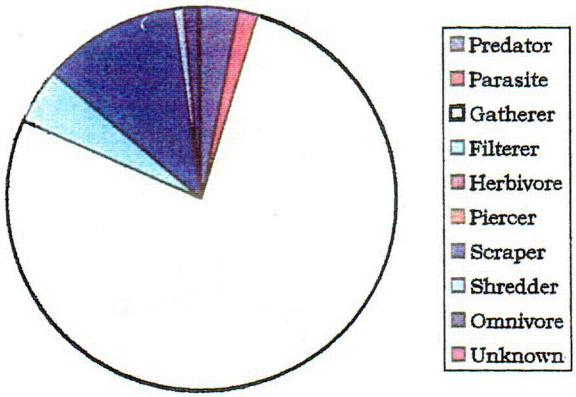
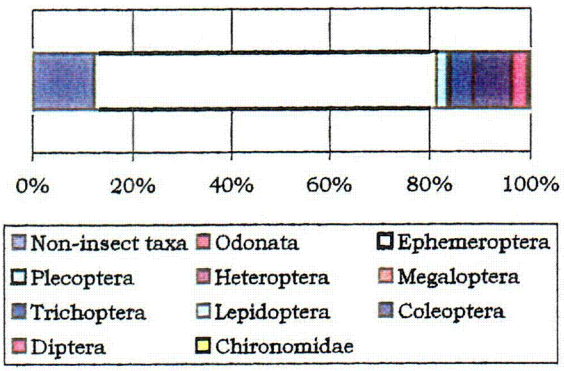
	
Functional composition - percent	**Functional composition - percent**
	

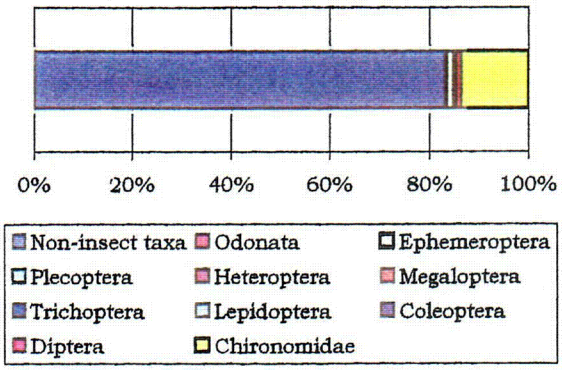
C-06

7/17/2004	7/18/2004
MB-2 1M	MC-1 11M

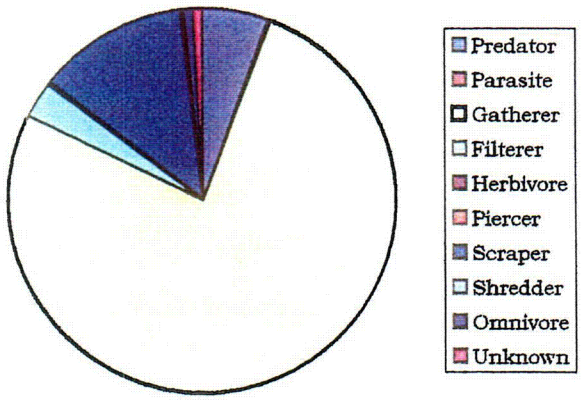
Taxonomic composition - percent



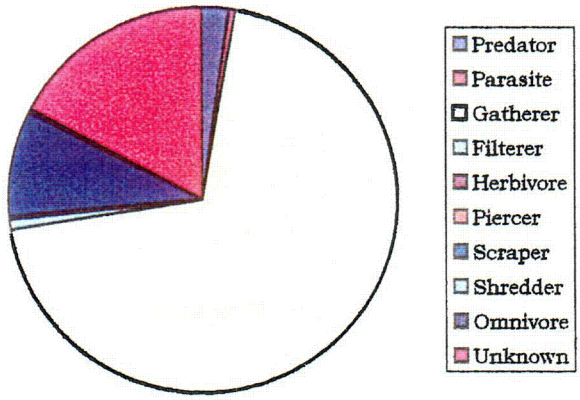
Taxonomic composition - percent



Functional composition - percent



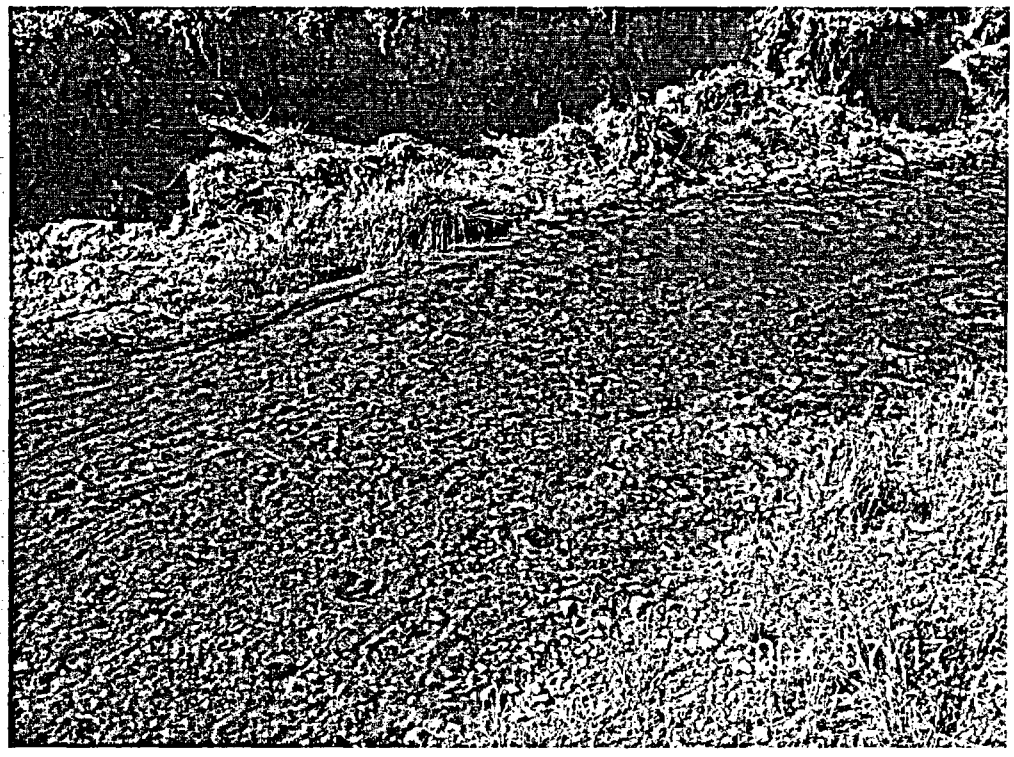
Functional composition - percent



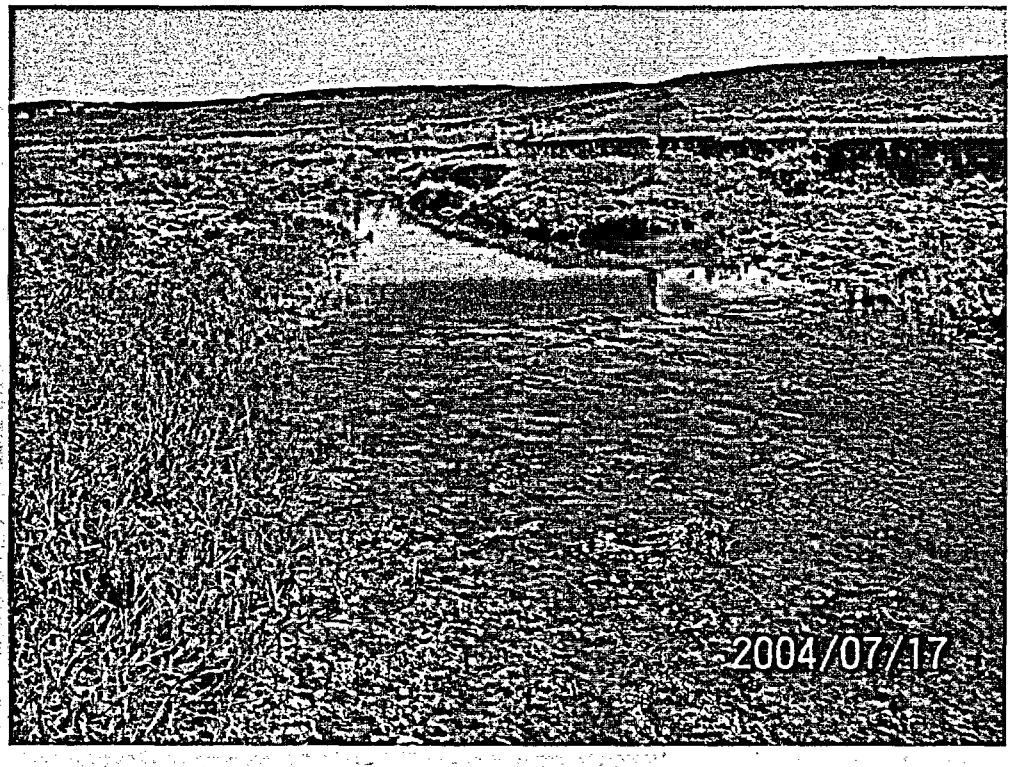
C-07

APPENDIX C

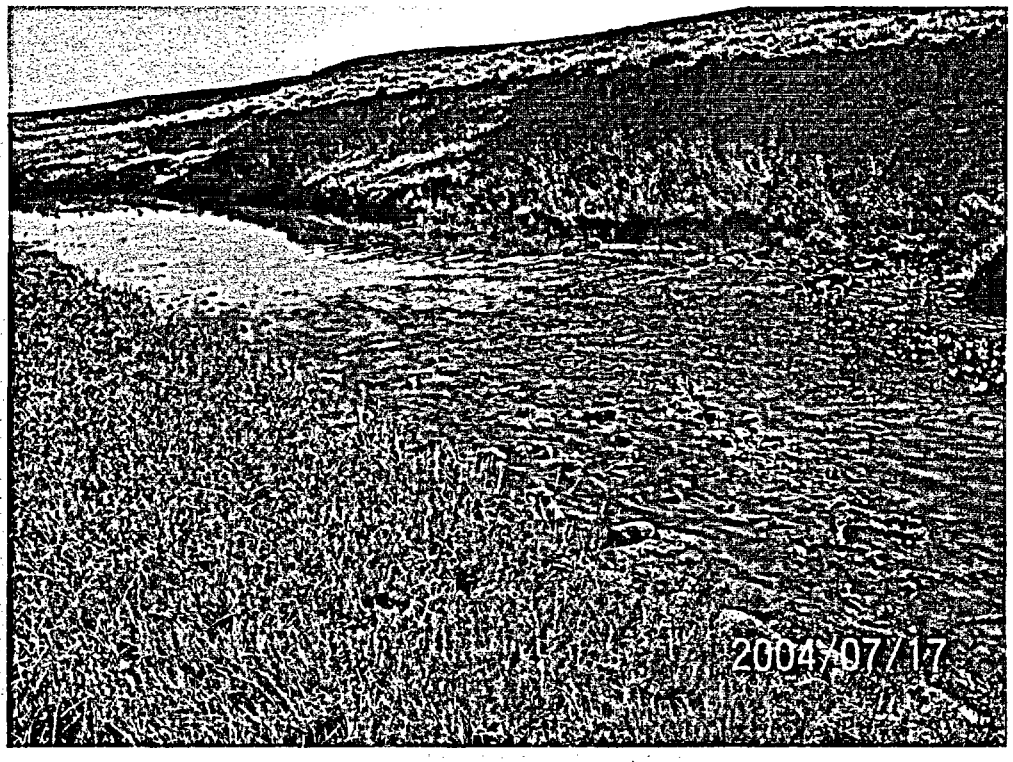
PHOTOGRAPHS OF SAMPLE LOCATIONS



Photograph C-1
Sample site MB-1

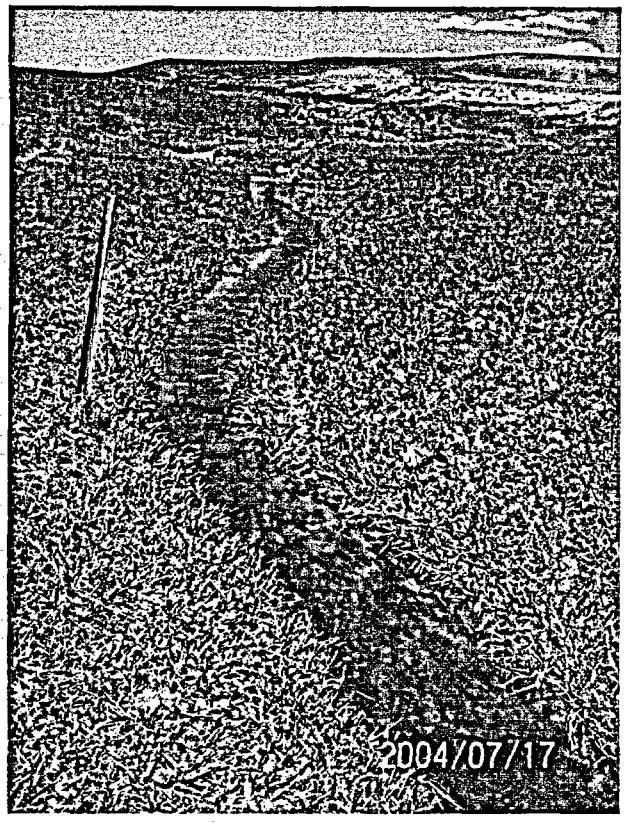


Photograph C-2
Sample site MB-1, looking upstream

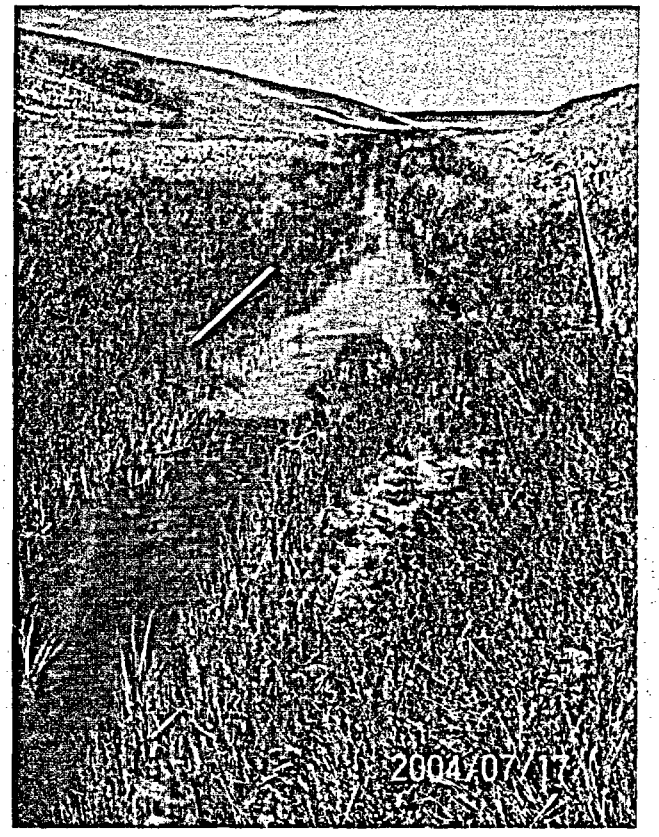


Photograph C-3
Sample site MB-2

Photograph C-4
Sample site SP-5



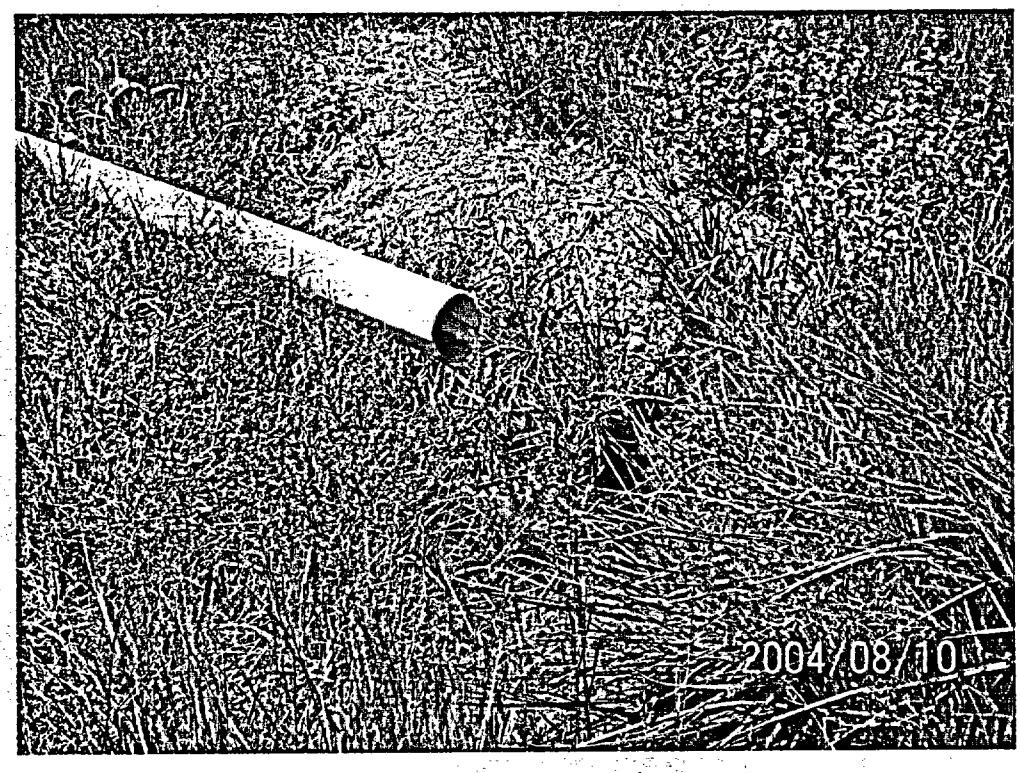
Photograph C-5
Sample site SP-4, looking upstream



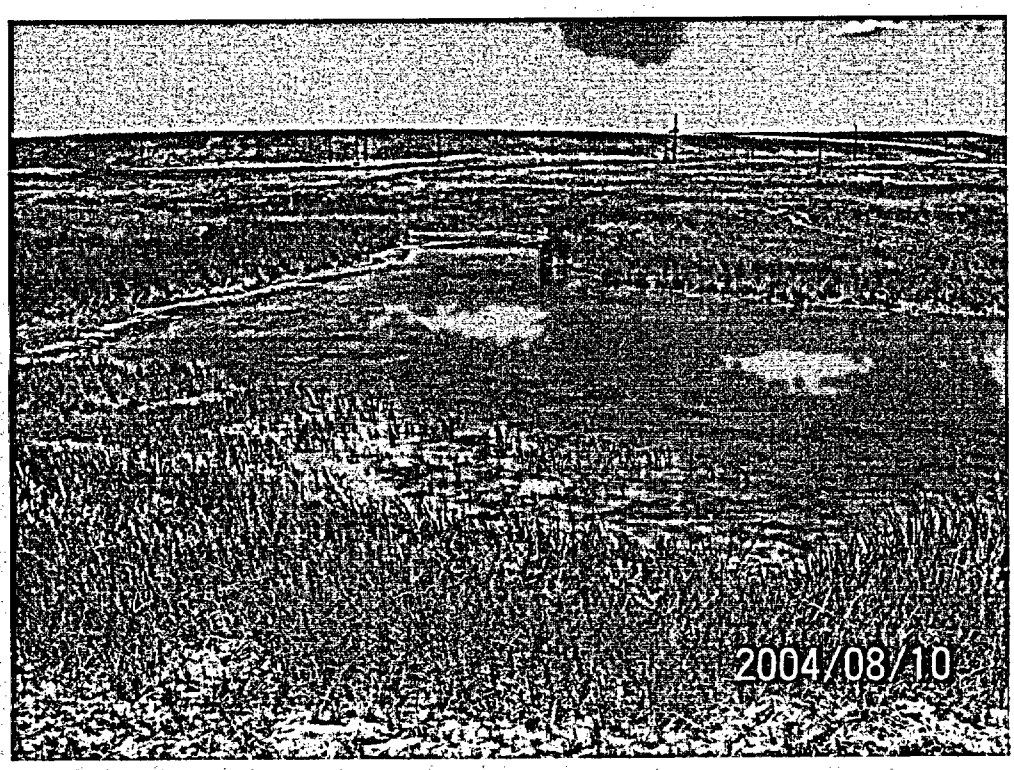
Photograph C-6
Sample site SP-3, looking downstream

Photograph C-7
Sample site SP-2

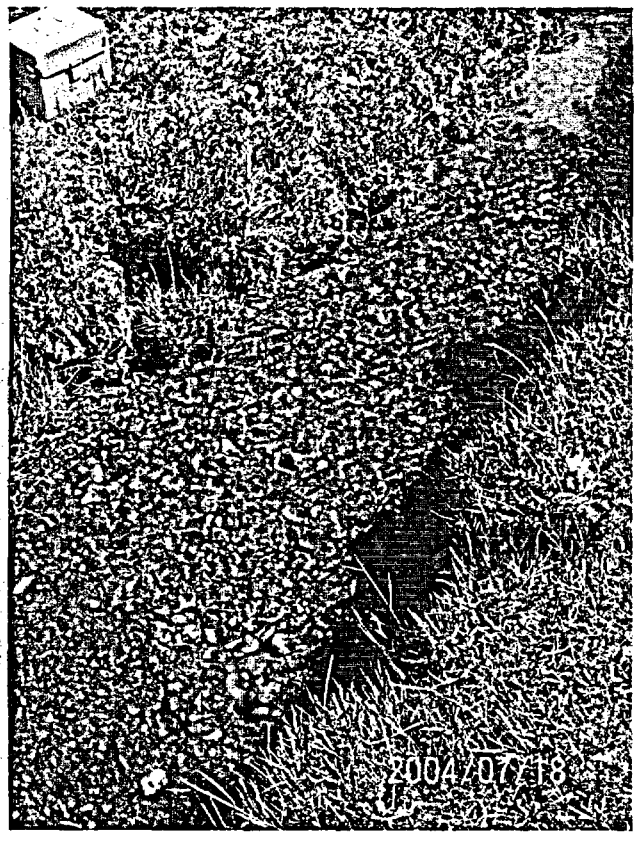
Photograph C-8
Sample site MC-1, looking downstream



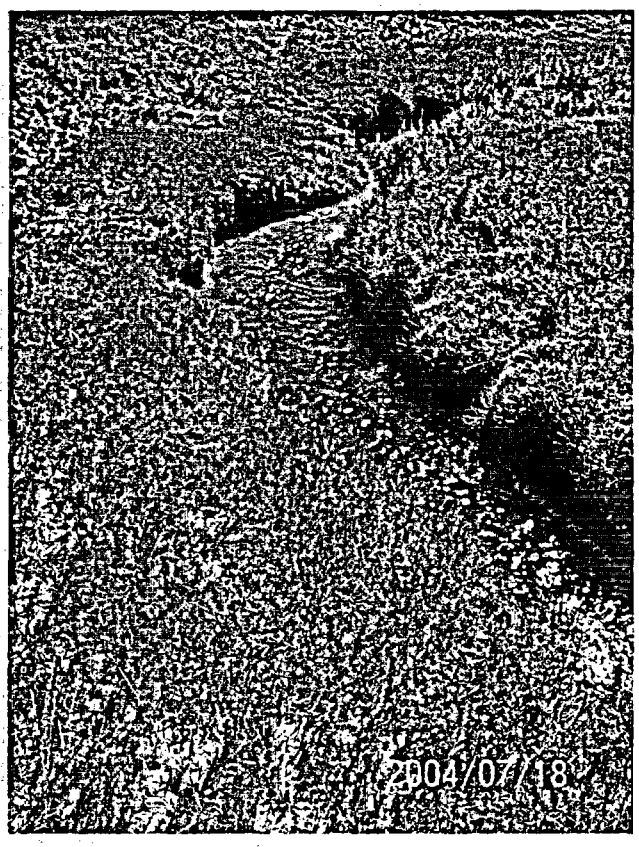
Photograph C-9
Pipe outlet just above sample site MC-1.



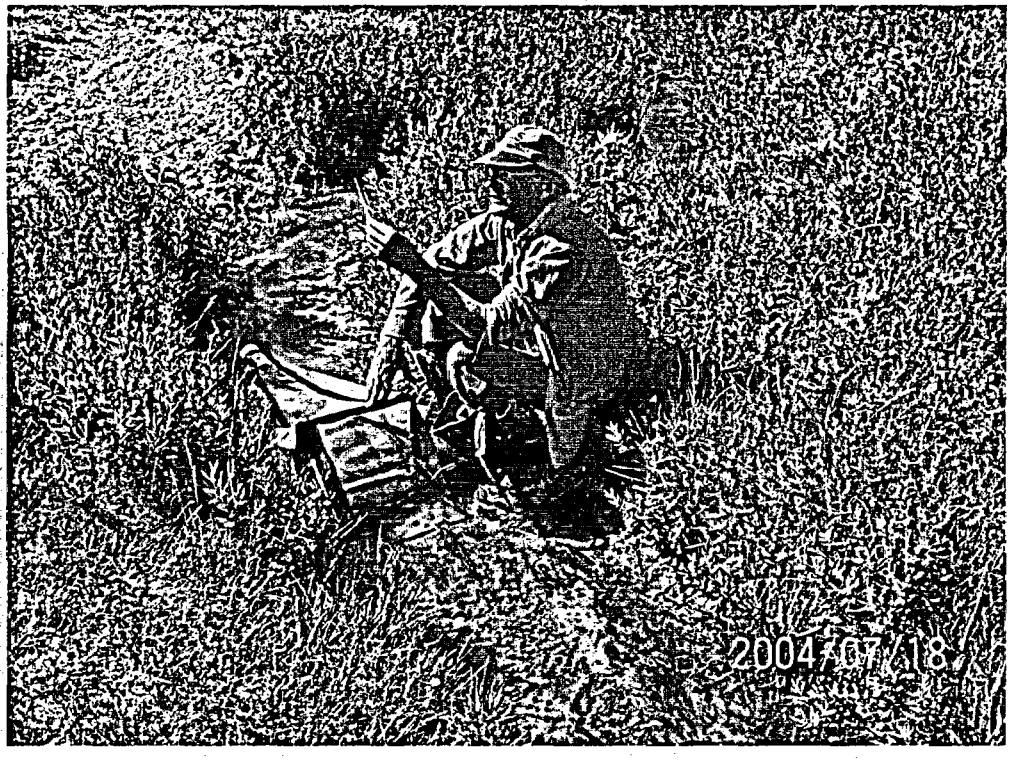
Photograph C-10
Ponded water on Mine Creek drainage above pipe outlet.



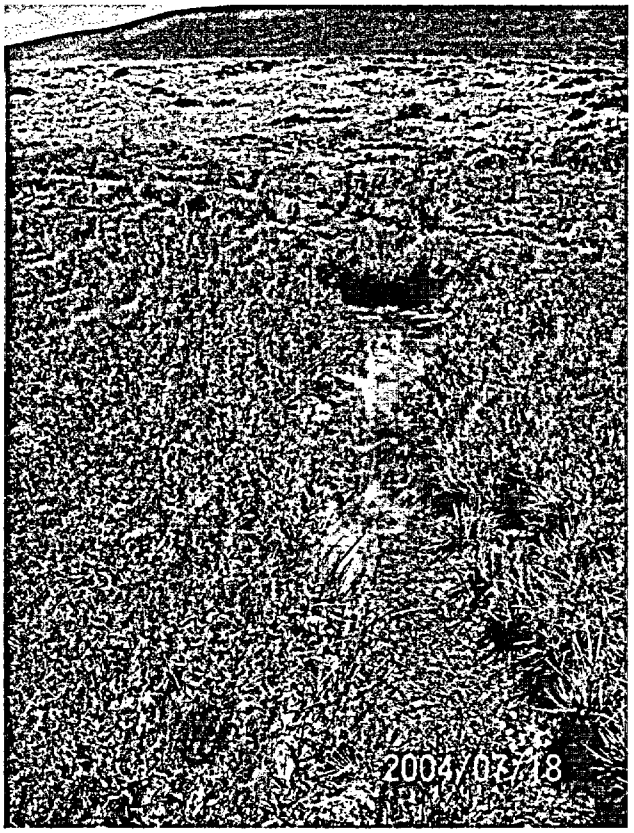
Photograph C-11
Sample site SP-2A



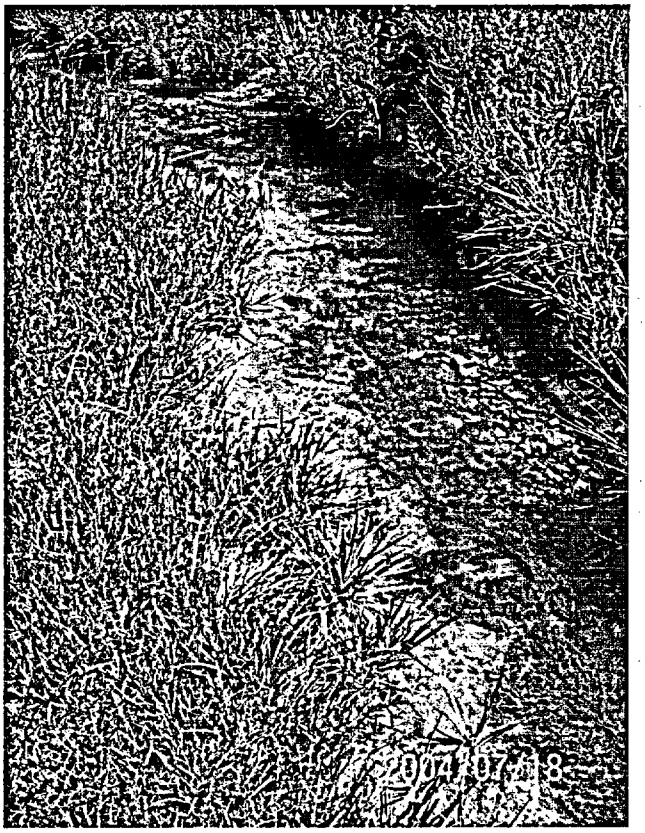
Photograph C-12
Sample site SP-2A, looking downstream



Photograph C-13
Sample site FC-1



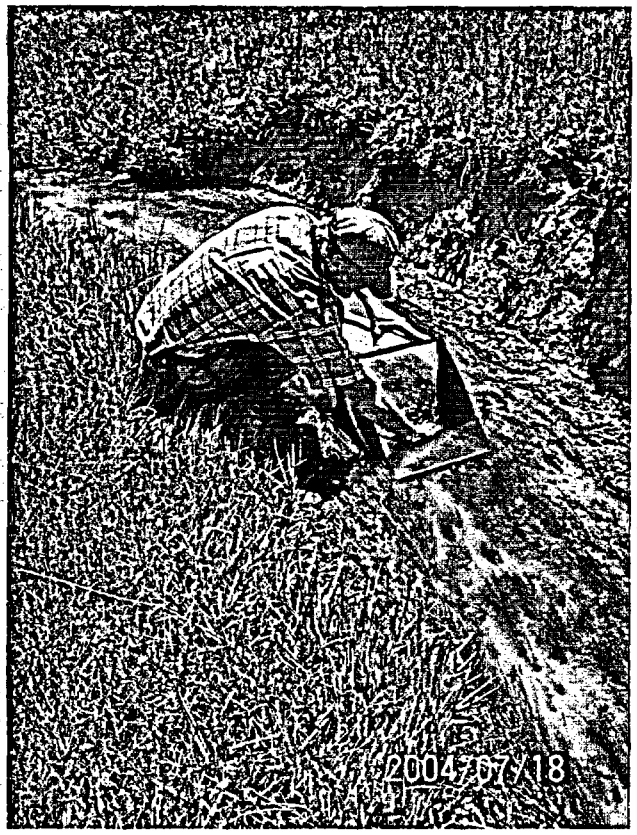
Photograph C-14
Sample site FC-1, looking upstream



Photograph C-15
Sample site SP-1

Photograph C-16
Sample site SP-1, looking upstream

Photograph C-17
Sample site SP-1A



Photograph C-18
Surber sampling at Site SP-1A

Photograph C-19
Sediment sampling with Eckman dredge at Site SP-1A

SPRING CREEK EVALUATION

FOR:

Pathfinder Mines Corporation
Shirley Basin Mine

BY:

Hydro-Engineering, L.L.C.
January, 2005

Professional Engineer (Civil)
Thomas G. Michel
8335
Date 1/18/05

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1.0 Executive Summary

The general findings of the field investigation of Spring Creek, Fox Creek and the reach of Little Medicine Bow River spanning the confluence with Spring Creek are that, at present, there are no significant negative impacts on the stream system resulting from seepage from the tailings. Flow rates in the creeks are smaller than normal and reflect the effects of the ongoing drought. Water quality in Spring Creek is relatively good and is consistent with past sampling. With the exception of Mine Creek, sediment samples taken from the stream bed contain relatively small concentrations or activities of radionuclides consistent with the natural presence of these constituents. The elevated radionuclide concentrations or activities in sediments from Mine Creek are attributed to the proportion of evaporation and the very small artificially-supported flow at the mouth of Mine Creek. There were noticeable impacts on the riparian zone from livestock and wildlife, particularly above and below the mine property.

2.0 Introduction

A field study and sampling of flow rates, water quality, sediments, and stream conditions in Spring Creek, Fox Creek and Little Medicine Bow River was conducted on July 16 and 17 of 2004. Eleven sample sites were selected (see Figure 2-1) including:

SP-1A	Murdock Creek above the confluence with Spring Creek
SP-1	Spring Creek upstream of the tailings area
SP-2	Spring Creek immediately below the confluence with Mine Creek
SP-2A	Spring Creek between the Fox Creek and Mine Creek confluences
SP-3	Spring Creek in the diversion channel
SP-4	Spring Creek below the diversion channel
SP-5	Spring Creek above the confluence with Little Medicine Bow River
FC-1	Fox Creek above the confluence with Spring Creek
MC-1	Mine Creek above the confluence with Spring Creek
MB-1	Little Medicine Bow River above the confluence with Spring Creek
MB-2	Little Medicine Bow River below the confluence with Spring Creek

At each location, sediment samples were taken for chemical analyses, stream cross sections were measured, the flow rate was measured or estimated, water samples were taken for chemical analysis, field water quality measurements were taken, and the general stream condition was noted. The sample locations coincided with those used for an aquatic study that was conducted simultaneously.

3.0 Study Limitations

A comparison of stream conditions between the MC-1 site at the mouth of Mine Creek and other sample sites was compromised by the fact that Mine Creek cannot be described as a stream. A more accurate description of site MC-1 would be a boggy area where a very small flow (<1 gpm) from a temporary impoundment along Mine Creek discharges to sediments at the base of the draw with additional saturation resulting from a surface expression of leakage from the small impoundment. The flow and the water level in the small impoundment are supported almost entirely by fresh water injection into the recharge lines as part of the site corrective action plan (CAP). Typical flows from this site do not exceed a few gpm and there is no defined channel.

4.0 Flow Measurement, Cross Sections and General Stream Condition

Cross sections were measured at each sample location. Where possible, a board was placed across the section approximately perpendicular to the flow and leveled. Measurements were then taken from the top of the board. In the case of Little Medicine Bow River sites MB-2 and MB-1, a line with a line level was stretched across the channel and measurements were taken from the line. Sinuosity of most reaches near the sample sites was great enough that it was not always possible to find a completely straight riffle section from which to take samples and measure cross sections.

A flow measurement was taken at each sample site. It did prove to be very difficult to get accurate measurements at many of the sites because flow depths were typically very small and the channel cross sections were highly non-uniform. There was also some moss growing in some reaches which effectively prevented use of a Pygmy flow meter. Because of the difficulties in measuring velocities in shallow flows for the complex cross sections, a temporary flume installation using one or two 3 inch flumes or a 6 inch flume was used to measure flows along Spring Creek and

Fox Creek. Measurement through a flume eliminates the problems of accurately measuring both the cross-sectional area of flow and the average velocity for the cross section where flow depth varies. Some disadvantages of a temporary flume installation include: it can be difficult to completely capture the flow in the flume without excessive disturbance of the reach, and the storage associated with increased flow depth through the flume can delay stabilization. Despite the disadvantages of and the additional effort necessary to install flumes, the measurements are considered more reliable. Since it was necessary to acquire the samples and measurements over the same sampling cycle for the aquatic study, the stabilization time for each flume installation was limited. Therefore, the measurement of flow rates at each site is interpreted with the storage effects. The presentation of flow measurements is from the downstream location on Little Medicine Bow River.

The general stream condition was also noted at each sample site. Photographs were taken at selected sites. Much of Spring Creek is open to grazing by livestock and downstream sections are also subject to modifications by the landowner to facilitate usage and access.

4.1 Little Medicine Bow River Site MB-2

Two cross sections were measured near the sample site with approximate flow measurements taken at the two locations. The downstream section, MB-2 Lower, was taken as a supplemental section while aquatic sampling was underway at the actual MB-2 site. Through this reach, Little Medicine Bow River is characterized by a sequence of pools and riffle sections with significant channel meandering (see Photograph 1). A tabulation of cross section information is included as Table A-1 in Appendix A. Current velocity at the MB-2 Lower site was measured with a Pygmy Current Meter. It was only possible to take measurements from a central section with larger flow depth and greater velocity. At other locations along the cross section, the flow was too shallow, too slow, or choked with moss and vegetation to the point where a current meter would not function properly. Even at the central location with moderate velocity, the flow depth was too small (0.27 to 0.29 feet) and the turbulence was too great to reliably operate the current meter. A tabulation of the flow measurements and cross section information is included in Table 4-1.

Table 4-1. Flow Measurements in Spring Creek

Site	Estimated Velocity (feet/second)	Measured Cross-sectional Area of Flow (square feet)	*Estimated Effective Cross-sectional Area of Flow (square feet)	Flumes Installed	Discharge Estimate (cfs)	Discharge Estimate (gpm)
MB-2 Lower	1.06	3.84	2.7	None	2.86	1284
MB-2	1.14	3.21	2.4	None	2.74	1228
MB-1	1.2	1.7	1.7	None	2.04	916
SP-5		0.53		2-3"Flumes	0.53 to 0.57	240 to 256
SP-4		0.63		6" Flume	0.49	219
SP-3		1.87		6" Flume	0.65	292
SP-2		0.7		6" Flume	0.60	271
MC-1		—		None		1-2 gpm
SP-2A		0.56		6" Flume	0.58	261
FC-1		0.18		3" Flume	0.11	48
SP-1		0.81		3" Flume	0.39	174
SP-1A		0.86		2-3"Flumes	0.50	226

*The total cross-sectional area of flow was reduced to an effective cross-sectional area of flow to reflect that portion where the flow velocity is significant. This excludes areas of very shallow flow and areas where the resistance to flow is great.

In order to discount areas of the channel where the flow was relatively stagnant, an effective cross-sectional area of flow was estimated in order to calculate discharge. In combination with the estimated current velocity of 1.06 feet/second (fps), the estimated flow at this section was 2.86 cfs (1284 gpm). Cross section MB-2 Lower was located on a channel bend and there was noticeable deviation from a level water surface across the section which clearly indicates flow acceleration. Channel bed materials through the riffle section ranged up to small cobbles. There was some degradation of the riparian area by livestock activity, although there is some stabilization of collapsed vertical banks by vegetation.

The tabulation of cross section MB-2 is included in Table A-2 of Appendix A. The current velocity was estimated using a floating strip of flagging tape because the flow depth and velocity was not sufficient to operate the Pygmy current meter across a reasonable section of the width. Photograph 2 shows a view of site MB-2 looking upstream. Like site MB-2 Lower, the effective flow area was reduced in order to discount the area where the contribution to total flow is not significant. The estimated flow at this section was 2.74 cfs (1228 gpm), and based on the fact that

the channel was straighter with a section that more closely approximated a parabola, the flow estimate for site MB-2 is considered more reliable than that for site MB-2 Lower. The channel bed at site MB-2 was armored with small gravel to small cobbles. There was significant degradation of the southern channel bank by livestock and wildlife activity.

4.2 Little Medicine Bow River Site MB-1

The flow measurements and the measurement of the cross section for site MB-1 were done in a manner similar to that for site MB-2. The cross section was measured using a line spanning the section and the results are included in Table A-2 of Appendix A. The width of flow for this section was narrower than that at site MB-2 and the current velocity was more uniform across the section. Therefore, the entire flow area was used in calculating the estimated flow of 2.04 cfs (916 gpm). The channel bed at site MB-1 was armored with small gravel to small cobbles, and there was minor livestock damage to a sandbar on the north side of the channel.

4.3 Spring Creek Site SP-5

Site SP-5 on Spring Creek is located just upstream of the confluence with Little Medicine Bow River. There is considerable evidence of livestock activity and disturbance in the area and there is an abandoned culvert crossing just downstream of the site (see Photograph 3). The cross section tabulation is presented in Table A-3 of Appendix A and the flow in the section was measured with a temporary installation of two 3-inch flumes. A flow ranging from 0.53 to 0.57 cfs (240 to 255 gpm) was measured at site SP-5 at a time of shortly after 13:00 MST. The time of day did appear to have an impact on flow rate because the rates of removal by evaporation and evapotranspiration during the middle of the day could constitute a measurable fraction of the flow in the creek. The depth of impoundment by the flumes was relatively small, but the flow may have been slightly underestimated due to incomplete stabilization of the storage upstream of the flumes. The channel bed material for the section was primarily sand to small gravel with some small cobble materials. Much of the material outside of the immediate channel area also appeared to be relatively coarse, so it is plausible that there was significant conveyance in the limited alluvial system.

4.4 Spring Creek Site SP-4

Site SP-4 on Spring Creek is located downstream of the end of the Spring Creek diversion. The channel banks are well vegetated and relatively stable, but the grass is cropped short due to grazing (see Photograph 4). The cross section tabulation is presented in Table A-3 of Appendix A and the flow in the section was measured with a temporary installation of a 6-inch flume. Flow was measured at 0.49 cfs (219 gpm). Slope of the channel segment upstream of the flume was relatively mild and there was a substantial storage in the temporary impoundment created by the flume (see Photograph 5). Unfortunately, this storage and the water loss to the stream banks with the increased water depth upstream of the flume resulted in a lag in flow stabilization and the flow is believed to be underestimated. Like site SP-5, the measurement was taken in early afternoon and there was the potential for significant abstraction by evaporation and evapotranspiration. The channel bed material for the section was primarily sand to small gravel with some small cobble materials.

4.5 Spring Creek Site SP-3

Site SP-3 is located within the Spring Creek diversion. The channel banks are well vegetated and relatively stable and the grass does not appear to have been grazed. The channel slope is mild throughout the diversion and the flow is lethargic with a lot of vegetation within the primary channel (see Photograph 6). The cross section tabulation is presented in Table A-4 of Appendix A and the flow in the section was measured with a temporary installation of a 6-inch flume (see Photograph 7). Flow was measured at 0.65 cfs (292 gpm). There was substantial storage in the temporary impoundment created by the flume, but the flume was set overnight to allow stabilization. There was a minor failure of a wing wall the following morning and this was corrected approximately 90 minutes before the reading was taken. The degree of underestimation in the flow is expected to be small, but the reading was taken at approximately 9:30 MST so the abstraction by evapotranspiration may have reduced flows slightly. The channel bed material for the section was much finer than sections outside of the diversion and had relatively little gravel and cobble sized particles.

4.6 Spring Creek Site SP-2

Site SP-2 is located upstream of the Spring Creek diversion. The channel banks are well vegetated and relatively stable and the grazing pressure is less pronounced than sections downstream of the diversion (see Photograph 8). The cross section tabulation is presented in Table A-4 of Appendix A and the flow in the section was measured with a temporary installation of a 6-inch flume. Flow was measured at 0.60 cfs (271 gpm). There was significant storage in the temporary impoundment created by the flume, but the stabilization of flow appeared to be nearly complete. The channel bed material for the section was primarily sand to small gravel with some small cobble materials. There was moss growing in the riffle and pool sections and the sinuosity of the channel downstream of site SP-2 was moderate while the channel was relatively straight immediately upstream of the site.

4.7 Mine Creek Site MC-1

Site MC-1 is located at the mouth of Mine Creek. As described in Section 3.0, MC-1 is not a stream flow and is primarily the surface expression of seepage from the small upstream impoundment combined with a fraction of a gpm discharge from the pipe outlet from the impoundment. There are no distinct channel banks and the sample site is basically a boggy area where the water collects into small rivulets with an estimated total flow of 1 to 2 gpm. No attempt was made to measure the flow because excavation to collect and capture the flow would have dramatically biased the flow measurement. There is considerable wildlife impact in the area (livestock are excluded). Much of the saturated area appears to be functioning under anoxic or anaerobic conditions.

4.8 Spring Creek Site SP-2A

Site SP-2A is located upstream of the confluence of Spring Creek and Mine Creek but downstream of the confluence with Fox Creek. The channel banks are well vegetated and relatively stable, but like sections downstream of the diversion, the grass is cropped short and the grazing pressure is significant (see Photograph 9). The cross section tabulation is presented in Table A-5 of Appendix A and the flow in the section was measured with a temporary installation of a 6-inch

flume. Flow was measured at 0.58 cfs (261 gpm). The setting of the 6-inch flume resulted in significant storage in the temporary impoundment, but like site SP-2, the stabilization of flow appeared to be nearly complete when the reading was taken. The channel bed material for the section was primarily sand to small gravel with some small cobble materials. There was very little moss at the site and the channel was relatively straight in the immediate reach of site SP-2A.

4.9 Fox Creek Site FC-1

Site FC-1 is located on Fox Creek well upstream of the confluence with Spring Creek. The channel banks are well vegetated and relatively stable, but like sections on Spring Creek, the area is utilized by livestock and the impacts are apparent in some degradation of the overbank area (see Photograph 10). The cross section tabulation is presented in Table A-6 of Appendix A and the flow in the section was measured with a temporary installation of a 3-inch flume. Flow was measured at 0.11 cfs (48 gpm). The sinuosity of the channel is relatively large and the thalweg slope is greater than that in Spring Creek. The channel bed material for the section was primarily sand to small cobble materials.

4.10 Spring Creek Site SP-1

Site SP-1 is located upstream of the tailings area and corresponds approximately with surface water sampling site SW-1A. Channel banks are well vegetated and relatively stable, but there are obvious impacts by grazing of livestock and wildlife. The cross section tabulation is presented in Table A-5 of Appendix A and the flow in the section was measured with a temporary installation of a 3-inch flume. Flow was measured at 0.39 cfs (174 gpm). Unfortunately, the available locations for setting of the flume were not favorable and the resulting measurements were compromised by incomplete stabilization and difficulty in capturing the flow. In light of a greater measured flow at upstream site SP-1A, the flow at site SP-1 is likely underestimated by roughly 30%. The sinuosity at the section is relatively large and the channel bed materials are slightly finer than downstream sections on Spring Creek but still range up to small cobble size.

4.11 Spring Creek Site SP-1A

Site SP-1A is located upstream of the tailings area on a tributary of Spring Creek that has been designated Murdock Creek. Channel banks are well vegetated and stable in some sections, but there is significant degradation by livestock on vertical banks on the outside of meanders (see Photograph 11). The cross section tabulation is presented in Table A-5 of Appendix A and the flow in the section was measured with a temporary installation of two 3-inch flumes (see Photograph 12). Flow was measured at 0.50 cfs (226 gpm). The sinuosity at the section is greater than downstream sections on Spring Creek and the channel bed materials are generally finer and range from sand to gravel with only a small fraction of cobbles. Unlike the major Spring Creek drainage, Murdock Creek is primarily a spring and ground-water fed stream with a smaller upland drainage area. Therefore, the erosion and aggradation of channel reaches by runoff flows is less pronounced at site SP-1A than it is on sections along Spring Creek.

4.12 General Spring Creek Drainage

The measured flow along the Spring Creek drainage was reasonably consistent with the composite flow of various contributing surface and ground-water flows with the exception of the sites SP-1 and SP-4. The measured flows at these two sites were compromised by a less than ideal location for flume installation and insufficient stabilization time, and flows at these sites are likely significantly underestimated. There may also be a slight underestimation of flows at other sites that were measured with a flume due to the idealized asymptotic approach to steady flow with storage upstream of the flume.

There was some evidence of diurnal cycling of the flow which is attributed to the high rates of evaporation and evapotranspiration during the sampling period. The largest flows were typically observed with measurements taken in the morning, and there also appeared to be a cumulative effect at downstream locations due to the cumulative abstractions from the flow. The night-time flows in Spring Creek, Fox Creek, and Little Medicine Bow River may be appreciably greater than the measured flows. The flow at site SP-1A in Murdock Creek may not change appreciably throughout the day because the site is relatively close to the source spring for the perennial flow.

5.0 Water and Sediment Sampling

Water and sediment samples were taken at each sampling site. The results of the water sample analyses are presented in Tables 5-1 and 5-2. The results of the sediment sampling are presented in Table 5-3.

Table 5-1. July 2004 Surface Water Quality Sample Results

Site	Field Conductivity (µmhos)	Field pH (std. units)	Dissolved Oxygen (ppm)	Alkalinity (mg/l)	Chloride (mg/l)	Nitrate & Nitrite (mg/l)	Sulfate (mg/l)
SP-1A	291	8.7	9.6	129	<1	0.31	17
SP-1	250	9.34	11.4	120	<1	0.26	18
FC-1	310	8.83	14.5	160	2	<0.1	19
SP-2A	362	8.53	8.1	144	7	<0.1	23
MC-1	724	10.31	9.6	106	21	<0.1	154
SP-2	307	9.03	11.1	132	8	<0.1	27
SP-3	329	9.13	10.6	138	8	<0.1	30
SP-4	317	8.8	8.4	122	10	<0.1	34
SP-5	362	8.15	7.4	143	10	<0.1	33
MB-1	292	9.12	10.6	120	5	<0.1	24
MB-2	304	8.59	7.65	128	7	<0.1	24

Table 5-2. July 2004 Surface Water Quality Sample Results

Site	TDS (mg/l)	TSS (mg/l)	Selenium (mg/l)	Uranium (mg/l)	Ra-226 (pCi/L)	Ra-228 (pCi/L)	Th-230 (pCi/L)
SP-1A	179	6.8	<0.001	0.0162	<0.2	<1.0	<0.2
SP-1	170	5	<0.001	0.0166	<0.2	<1.0	<0.2
FC-1	213	4.8	<0.001	0.0217	<0.2	<1.0	<0.2
SP-2A	206	25.8	<0.001	0.0195	<0.2	<1.0	<0.2
MC-1	381	15.1	0.011	0.0109	1	<1.0	<0.2
SP-2	199	10.8	0.001	0.0214	0.3	<1.0	<0.2
SP-3	209	25	0.001	0.0231	0.3	<1.0	<0.2
SP-4	201	52.5	<0.001	0.0203	0.4	<1.0	<0.2
SP-5	223	29.8	0.001	0.0198	0.2	<1.0	<0.2
MB-1	164	5	<0.001	0.0105	<0.2	<1.0	<0.2
MB-2	179	6.4	0.001	0.0133	<0.2	<1.0	<0.2

Table 5-3. Sediment Sample Analyses

Site	Samples Taken July 2004					Samples Taken November 2003				
	Selenium (mg/kg-dry)	Uranium (mg/kg-dry)	Ra-226 (pCi/g-dry)	Ra-228 (pCi/g-dry)	Th-230 (pCi/g-dry)	Selenium (mg/kg-dry)	Uranium (mg/kg-dry)	Ra-226 (pCi/g-dry)	Ra-228 (pCi/g-dry)	Th-230 (pCi/g-dry)
SP-1A	0.41	2.48	1.1	0.9	0.5	—	—	—	—	—
SP-1	1.4	6.17	1.5	0.6	0.9	0.79	6.28	1.2	1.2	0.8
FC-1	0.93	3.54	1.4	1	1.1	<0.05	3.1	1	2.4	1.7
SP-2A	0.49	4.13	1.4	0.7	1.1	—	—	—	—	—
MC-1	1.44	29.3	30	3.9	39	0.53	27.1	11	1.1	7.4
SP-2	0.36	9.18	4.6	1.9	4.7	0.26	10.8	3	3.4	2.2
SP-3	0.15	2.16	1.5	0.5	1	<0.05	3.4	1.3	0.8	1.3
SP-4	0.17	2.37	0.9	0.4	0.8	<0.05	3.83	1.1	0.7	1
SP-5	0.1	3.15	1.6	1.1	<0.2	<0.05	3.03	0.9	0.6	1.2
MB-1	0.12	0.96	0.6	0.4	0.3	0.49	16.9	1.3	0.6	1.2
MB-2	0.23	1.89	0.7	0.5	0.9	0.12	2.27	1.1	1.8	0.8

Measured field conductivities in the water were relatively small and were consistent with measured TDS concentrations. There was a very small increase in conductivity and TDS from the upstream Spring Creek site SP-1A to the downstream site SP-5, but the increase is less than the general variation within the measurements along the creek and there is no trend that reflects any tailings impacts. With the exception of Mine Creek site MC-1, the water quality results are very similar and reflect natural water quality with no measurable tailings impact. The sample from MC-1 had a conductivity, TDS concentration, and sulfate concentration that was modestly greater than other sample sites. The field pH of the samples was greater than 8.0 at all sites and the dissolved oxygen ranged from levels that were approaching saturation to super saturation.

The results of the sediment sampling from both the July 2004 sampling and the November 2003 sampling are included in Table 5-3. There was slightly more variability in constituent concentrations in sediment samples than the corresponding water samples. The results from the two sample sets were generally comparable with the exception of uranium concentration at site MB-1 where the concentration in the 2004 sample was dramatically lower. Constituent concentrations were elevated at site MC-1 and this is discussed in a following section. As with the flow

measurements in the Section 4.0, the discussion of water and sediment quality is presented from the downstream to the upstream sampling sites.

5.1 Little Medicine Bow River Site MB-2

The water quality at site MB-2 was consistent with a combination of Little Medicine Bow flow and the Spring Creek water which has slightly greater TDS and uranium concentrations. Concentrations of all constituents are well below levels of concern and there is no indication of measurable impacts by tailings seepage. The dissolved oxygen concentration is slightly below saturation and this may be related to the significant growth of moss in the area. The water had low turbidity and there was no noticeable odor.

The constituent concentrations in the two sediment samples for this site are reasonably similar and are below levels of concern. Sampling procedures for the July 2004 samples were more consistent so the more recent samples are used for comparisons between the sites. Although concentrations of radionuclides and selenium at site MB-2 are slightly greater than those at site MB-1, they are well within the range of natural sediment concentrations for the Spring Creek and Little Medicine Bow drainage.

5.2 Little Medicine Bow River Site MB-1

The water quality at site MB-1 was reasonably similar to that from upstream sites on Spring Creek. Water quality is generally consistent with the historic water quality from this site. Although concentration of radionuclides is slightly lower than those at site MB-2, concentrations at both sites are well within the range of natural concentrations from upgradient site MB-1. The measured dissolved oxygen concentration was super-saturated and may reflect additional turbulence in the extended riffle section at the sample site. There was very little moss at the sample site and the turbidity at the site was low.

The difference in constituent concentrations between the analytical results for the two sediment samples for site MB-1 is significant. The activities of Ra-226, Ra-228, and Th-230 are lower for the more recent sample but are at relatively low levels for both sample sets. There was also a decline in selenium concentration for the most recent sample, but again, the concentration for

both sample sets is relatively small and the difference may simply reflect natural variability in trace constituent concentrations. There was a dramatically lower uranium concentration in the most recent sediment sample when compared to the November, 2003 sample. The uranium concentration of 16.9 mg/kg-dry in the November, 2003 sample is plausible given the measured range in other samples, but is considered generally unrepresentative of site MB-1. There is also the potential for significant variability in uranium concentration in sediment depending on gradation, the nature of clay particles, organic matter, and redox conditions.

5.3 Spring Creek Site SP-5

The water quality at site SP-5, (see Tables 5-1 and 5-2) is consistent with past sampling and is similar to that for the two nearest upstream sites. There is no indication of measurable impacts by tailings seepage and the concentrations are within the range of natural background for Spring Creek. The water was slightly more turbid than Little Medicine Bow sites MB-1 and MB-2 and this was also reflected in a slightly elevated TSS concentration. There were numerous cattle utilizing the stream area upstream from the site and it is possible that livestock activity contributed to the increased TSS concentration. The measured dissolved oxygen concentration of 7.4 ppm is less than saturation and may also reflect the increased BOD caused by wildlife and livestock activity in the reach between site SP-5 and the downstream end of the Spring Creek diversion.

The analytical results for the two sediment samples for site SP-5 are very similar. All concentrations and activities are at levels within the range of natural background.

5.4 Spring Creek Site SP-4

The water quality at site SP-4 was very similar to that for upstream site SP-3 and downstream site SP-5. The water was slightly cloudy and it was noted that several head of cattle were utilizing the stream upstream of the site. The elevated TSS concentration likely reflected fine sediment disturbed by the livestock. The slight increase in dissolved oxygen concentration (8.4 ppm) over that at site SP-5 is a further indicator that the length of the reach where cattle are active may have an impact on the dissolved oxygen concentration. There is little or no livestock activity within the

5.7 Mine Creek Site MC-1

The general water quality at site MC-1, although different than that at sites along Spring Creek, is relatively good. The very small flow at MC-1 is supported by the fresh-water injection components of the corrective action program, and the surface expression of the flow is expected to disappear shortly after injection is discontinued. The water quality at MC-1 reflects the general water quality of injection water from supply wells WW20 and WW23 including a sulfate concentration in water from well WW20 that is slightly greater that typical Spring Creek water. The slightly greater TDS concentration and conductivity at site MC-1 is almost entirely a result of the slightly greater sulfate concentration in the injection water that was used until recently. Concentrations of all constituents are below levels of concern, and in the case of uranium, the concentration is lower than typical Spring Creek water. The turbidity of the water was low and the dissolved oxygen concentration was saturated or super-saturated.

The analytical results for the two sediment samples for site MC-1 differ for some constituents but both samples reflect higher concentrations or activities of constituents then Spring Creek sampling sites. The higher concentrations and activities in soils from the MC-1 site without attendant impacts on water quality can readily be explained. The soils that were included in the samples cannot really be described as sediment because the flow is not great enough to submerge the area of the sample. With a small artificial impoundment upstream of the site, there is significant emergent seepage from the pond that creates the boggy area at the mouth of Mine Creek. The evaporation from the soil surface at the seepage face will result in an accumulation of constituents within the soil, and it is hypothesized that the elevated constituent concentrations in the sediment samples result from this evaporation-driven sequestration process. There may be an occasional partial flushing of the near-surface soils with major precipitation events or overbank flows in Spring Creek, but there isn't a large enough steady flow for development of a pseudo-equilibration between concentrations in the water and sediments. This accumulation of salts and trace metals at the land surface at site MC-1 will continue as long as the fresh-water injection supports the small impoundment near the mouth of Mine Creek.

5.8 Spring Creek Site SP-2A

Water quality at site SP-2A is generally consistent with a combination of that at upstream site SP-1 and the contributing flow from Fox Creek. A slightly greater conductivity is not supported by a comparison of TDS concentrations with adjacent sites. The turbidity of the water was low and the dissolved oxygen concentration was approaching saturation.

Site SP-2A was added to the July, 2004 study, and thus there is only one sediment sample for the site. The constituent concentrations in the sediment are similar to those from upgradient sites SP-1A, SP-1 and FC-1. The concentrations and activities in the sediment do not give any indication of seepage impacts.

5.9 Fox Creek Site FC-1

Water quality in Fox Creek is very similar to the typical water quality in Spring Creek. The alkalinity, uranium, and TDS concentrations are slightly greater than those for upgradient sites on Spring Creek. Like the sites along Spring Creek and Little Medicine Bow River, there were no constituent concentrations that were at levels of concern or exceeding the natural range of background concentrations. The turbidity of the water was low and the dissolved oxygen concentration was super-saturated.

The analytical results for the two sediment samples for site FC-1 were reasonably similar for radionuclides. The selenium concentrations were markedly different in the two samples, but as was noted previously, the natural local variability in selenium concentration is fairly large. The FC-1 site was moved upstream on Fox Creek for the 2004 study to insure that it was well beyond potential impacts from windblown tailings. Based on a comparison between the results for the two samples, there are no perceptible tailings-related impacts at either the original or relocated FC-1 sites.

5.10 Spring Creek Site SP-1

Site SP-1 corresponds with the Spring Creek background surface water sampling site SW1A and it is located upstream of any plausible seepage impacts. Water quality was consistent with past samples for site SW1A and there were no constituent concentrations at levels of concern. The turbidity of the water was low and the dissolved oxygen concentration was super-saturated.

The analytical results for the two sediment samples for site SP-1 were reasonably similar for radionuclides. Selenium concentrations were slightly different in the two samples. The uranium concentration at this upgradient site was slightly greater than typical values for other sites along Spring Creek, and this reveals the natural variability in sediment concentrations.

5.11 Spring Creek Site SP-1A

Site SP-1A is located upstream on Murdock Creek which is the tributary to Spring Creek that supplies the majority of base flow in Spring Creek. Water quality was nearly identical to that from site SP-1. The turbidity of the water was low and the dissolved oxygen concentration was super-saturated.

The analytical results for the sediment sample for site SP-1A were reasonably similar to typical values for sites along Spring Creek. The uranium concentration at this upgradient site was slightly smaller than that at upgradient sites SP-1 and FC-1, and this further illustrates the natural variability.

6.0 Summary

The results of the study indicate that there are no measurable detrimental effects on the general environmental condition in Spring Creek from the tailings seepage. A major factor in the observed usage and condition of the creek is the flow rate with a significant increase in flow occurring just below the confluence of Spring Creek and Fox Creek. Another factor which has a dramatic impact on the condition of the stream and riparian area is the degree of utilization by livestock and wildlife. Livestock are partially excluded from the reaches extending from the downstream end of the diversion through that area directly east of the tailings. The degradation of channel banks and the periodic disturbance of channel sediments may have a dramatic effect on biological activity within the stream. There is also the cyclical nature of flows in Spring Creek that can dramatically impact channel erosion/aggradation processes, which will in turn impact the biological activity within the stream.

The measurement of flow rates and cross sections at the sample sites was reasonably consistent with the expected accumulated flow and the natural development of the stream channel.

The exceptions to a natural stream section include site MC-1 where the highly ephemeral channel has been temporarily and artificially converted to a miniscule perennial flow by the fresh-water injection, and site SP-3 in the Spring Creek diversion where the channel was relocated to a constructed channel section.

The constituent concentrations in the water samples from all sites were below levels of concern. The only site that had appreciably different water quality was site MC-1, and the slightly higher sulfate and TDS concentrations are attributable to the greater sulfate concentrations in the injection water from well WW20 which supports the flow at MC-1. Differences in the water quality of samples from the Spring Creek sites were very small and there were no trends or changes of sufficient magnitude to indicate impacts by the tailings.

Sediment samples from the sites along Spring Creek, Little Medicine Bow River, and Fox Creek had constituent concentrations that were generally similar. With the exception of sites MC-1 and SP-2, the concentrations of the five measured constituents were within the expected natural range. The observed variability can be attributed to differences in sediment gradation, organic matter, clay particles, redox conditions, etc. at the various sample locations. The elevated constituent concentrations in the soil samples at site MC-1 are attributed to the high rate of evaporation from the saturated soil surface. The sediment sample from site SP-2 likely shows a minor impact from the occasional flushing of sediments at the confluence of Mine Creek and Spring Creek.

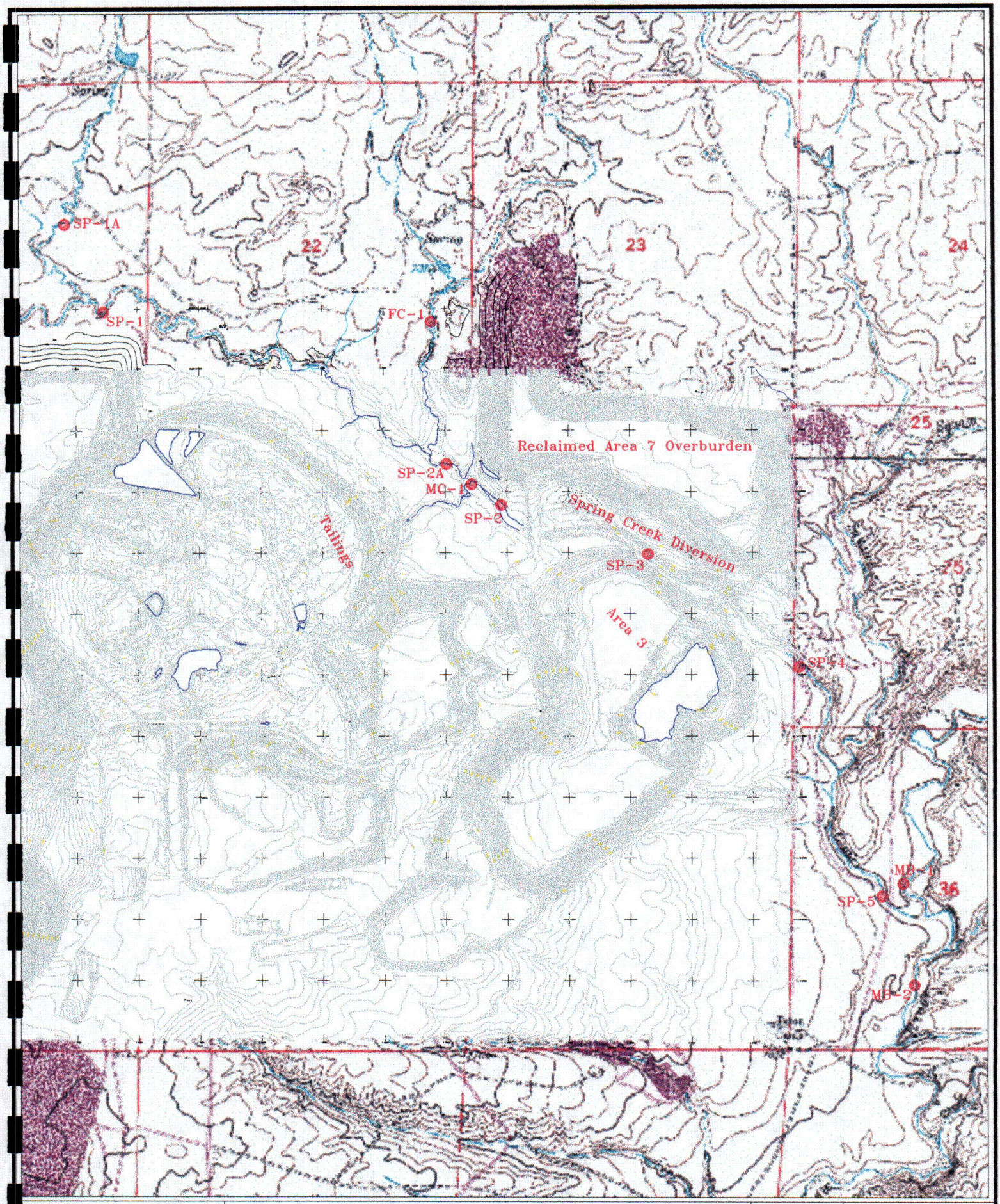

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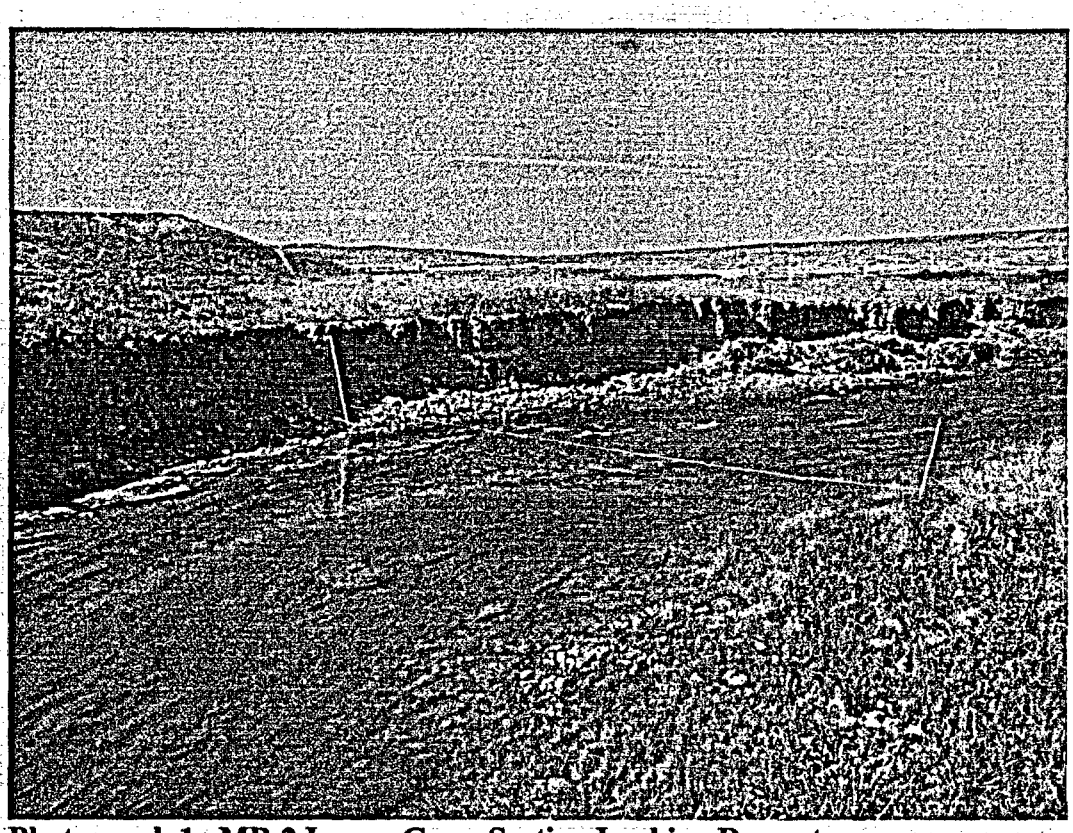
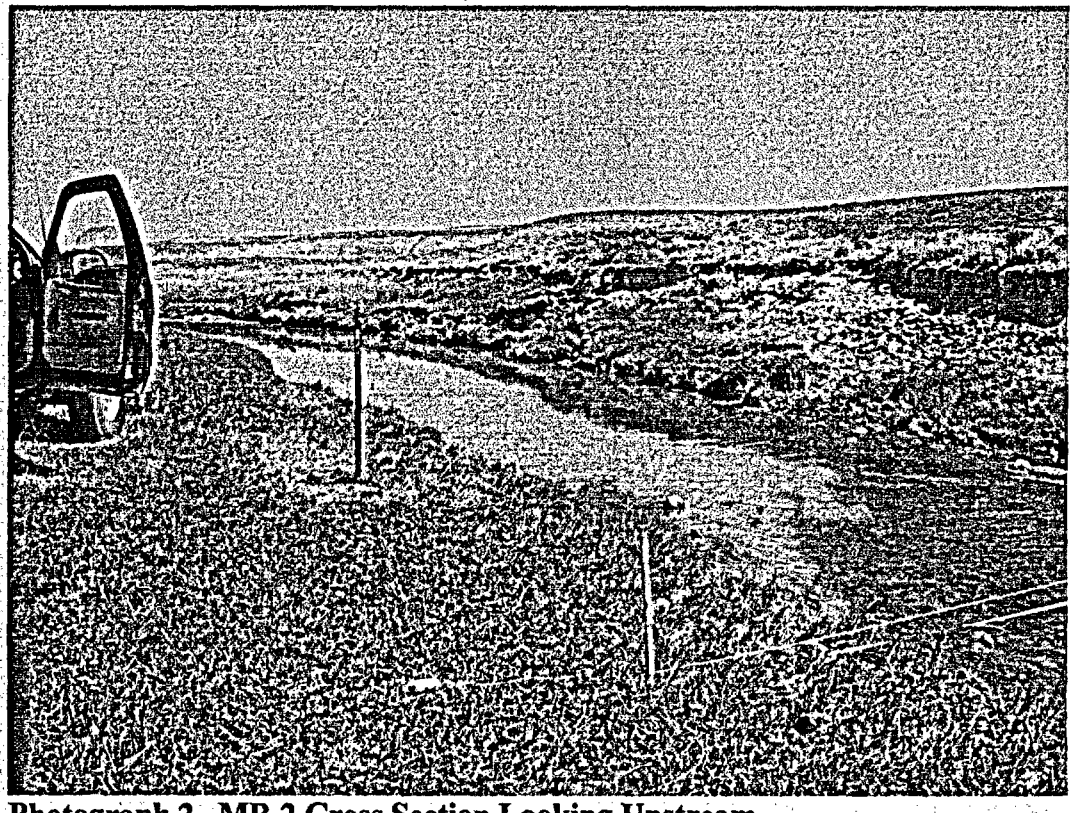
FIGURE 2-1. SPRING CREEK STUDY
SAMPLING SITES

DATE:12-2004
SCALE: 1"=1000'
SAMPLE_FIGURE_2-1.DWG
HYDRO-ENGINEERING L.L.C.

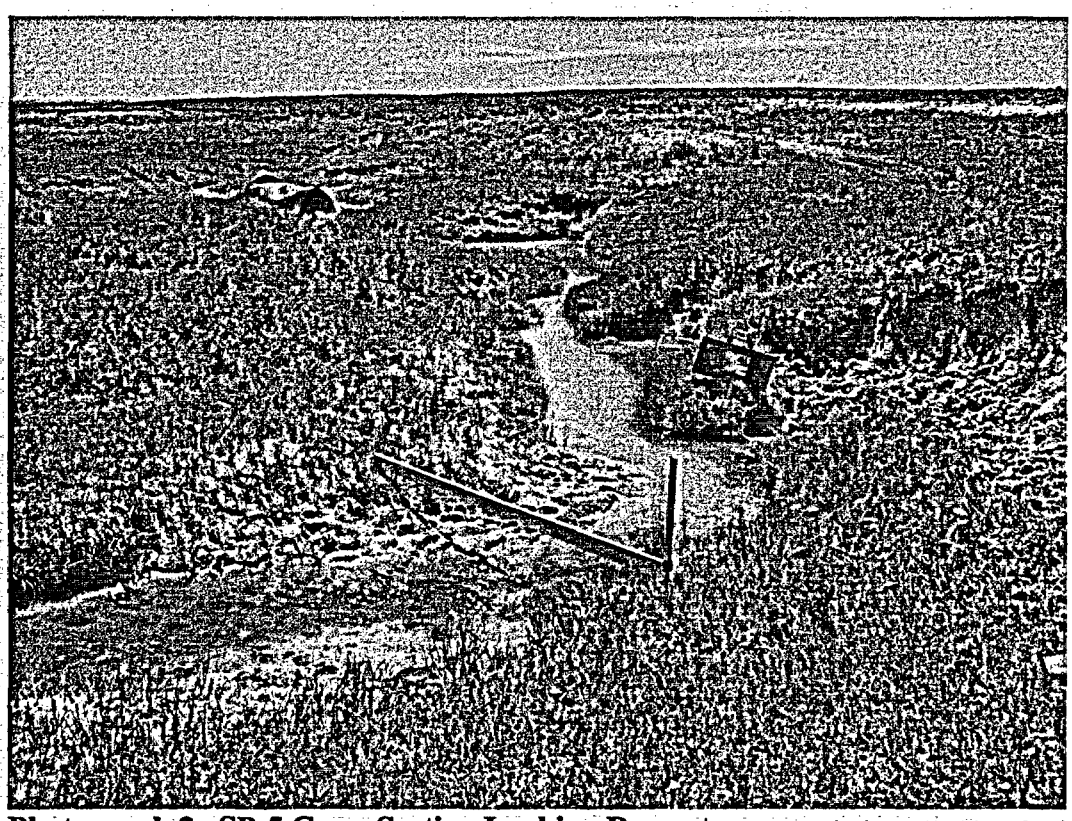
C-08



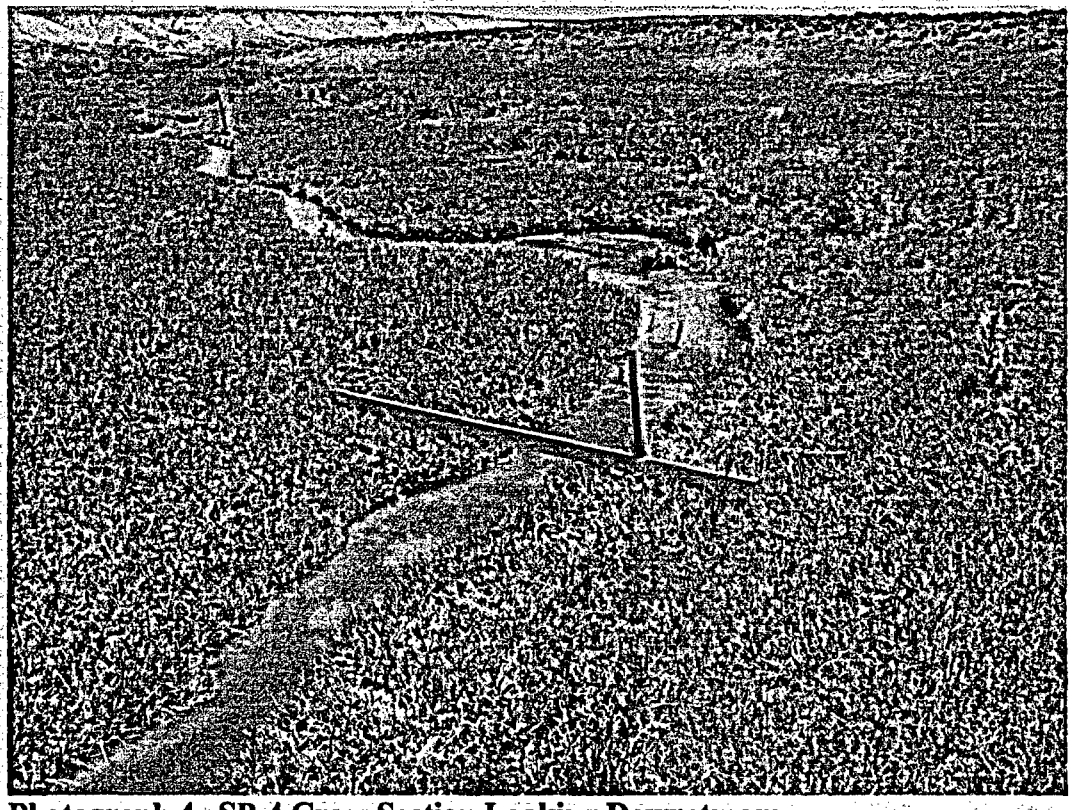
Photograph 1. MB-2 Lower Cross Section Looking Downstream



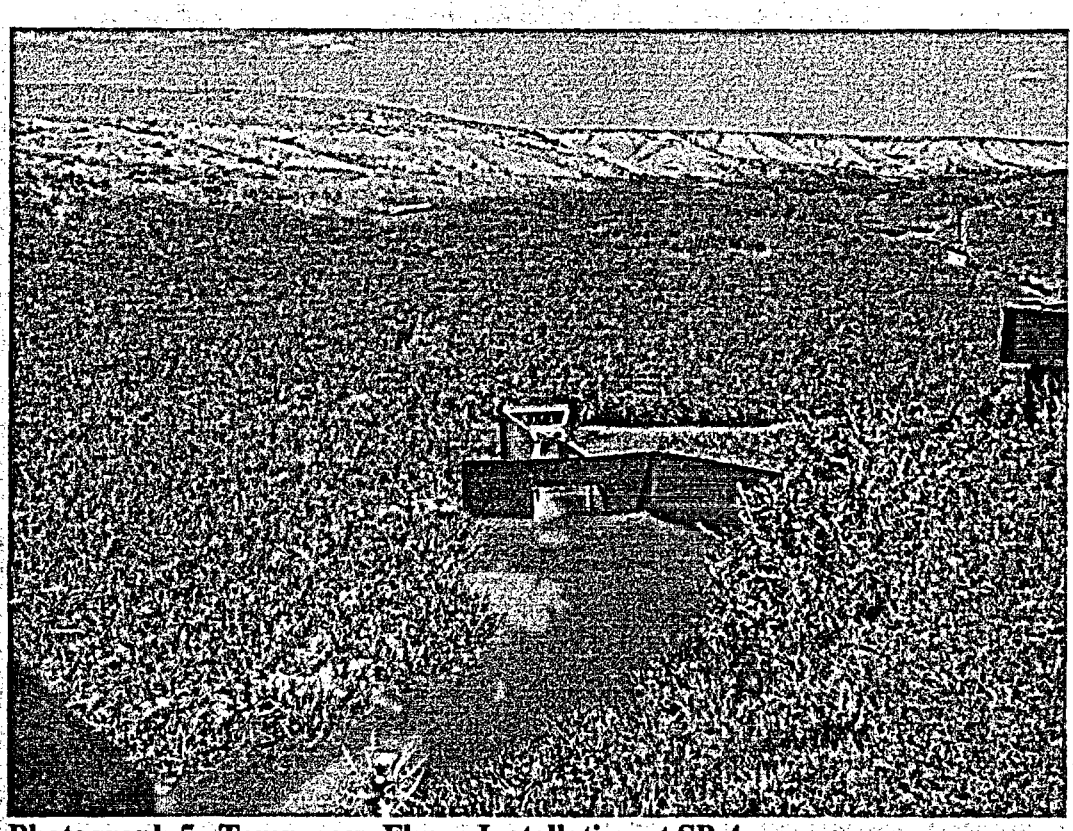
Photograph 2. MB-2 Cross Section Looking Upstream



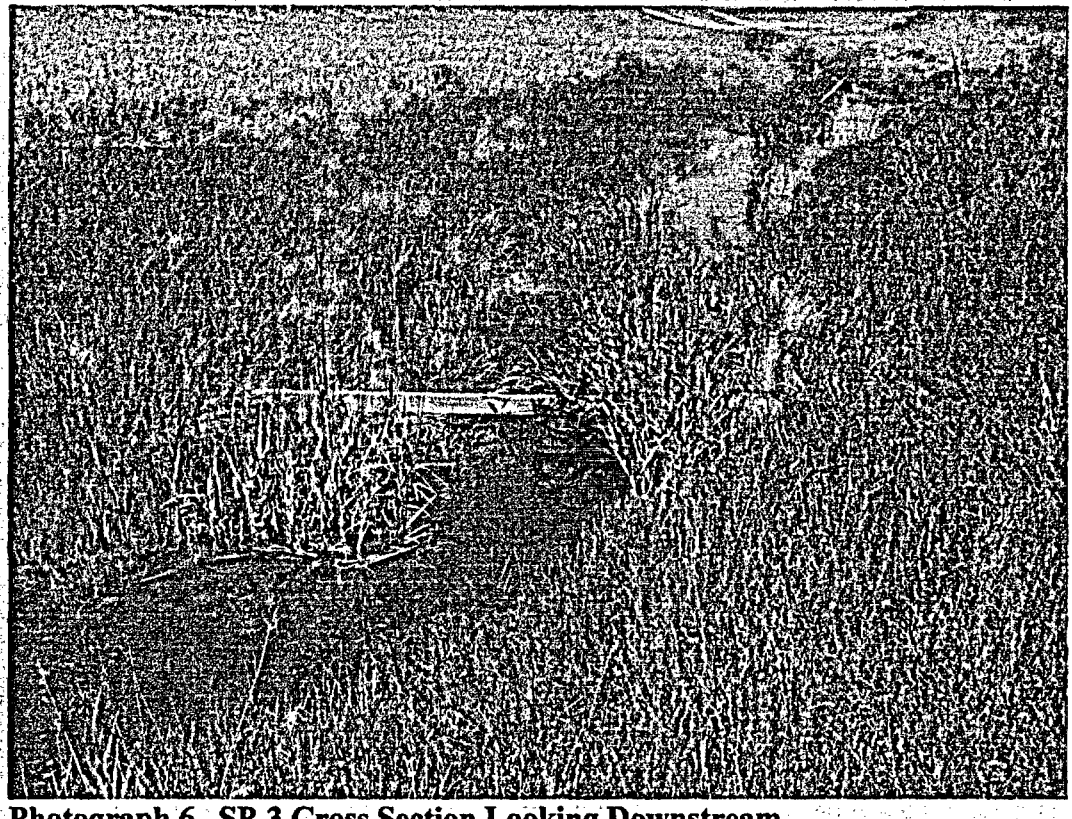
Photograph 3. SP-5 Cross Section Looking Downstream



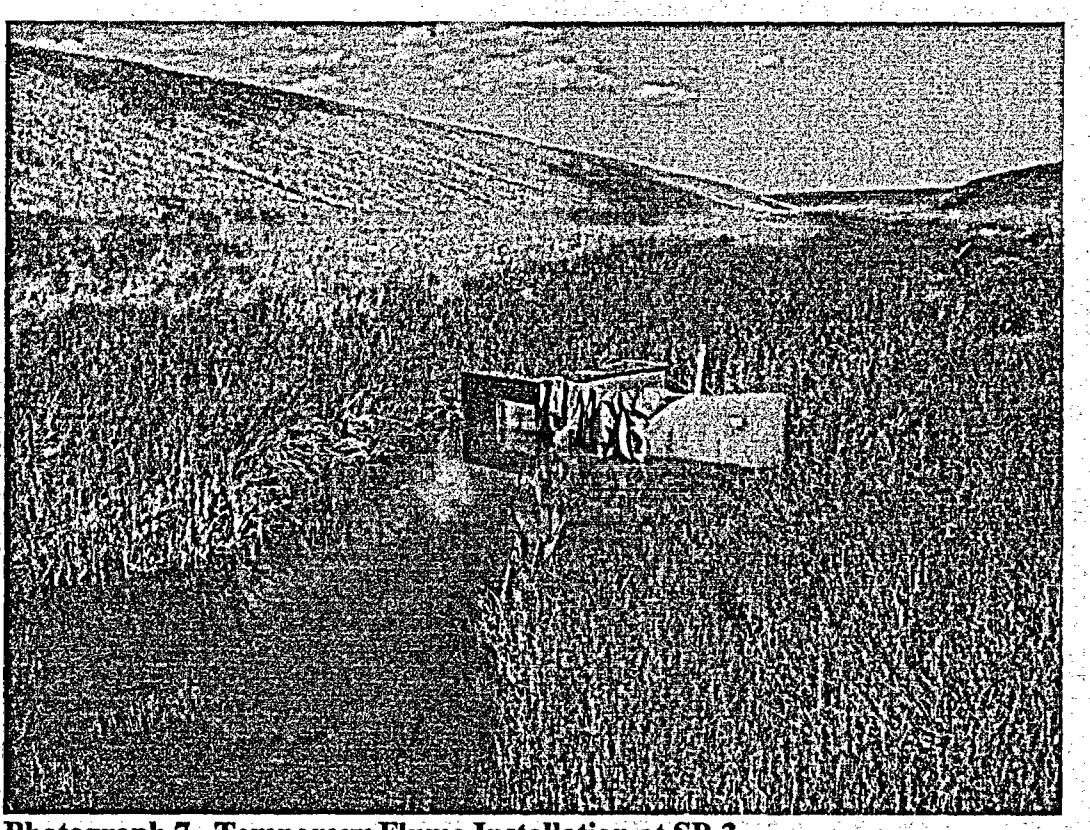
Photograph 4. SP-4 Cross Section Looking Downstream



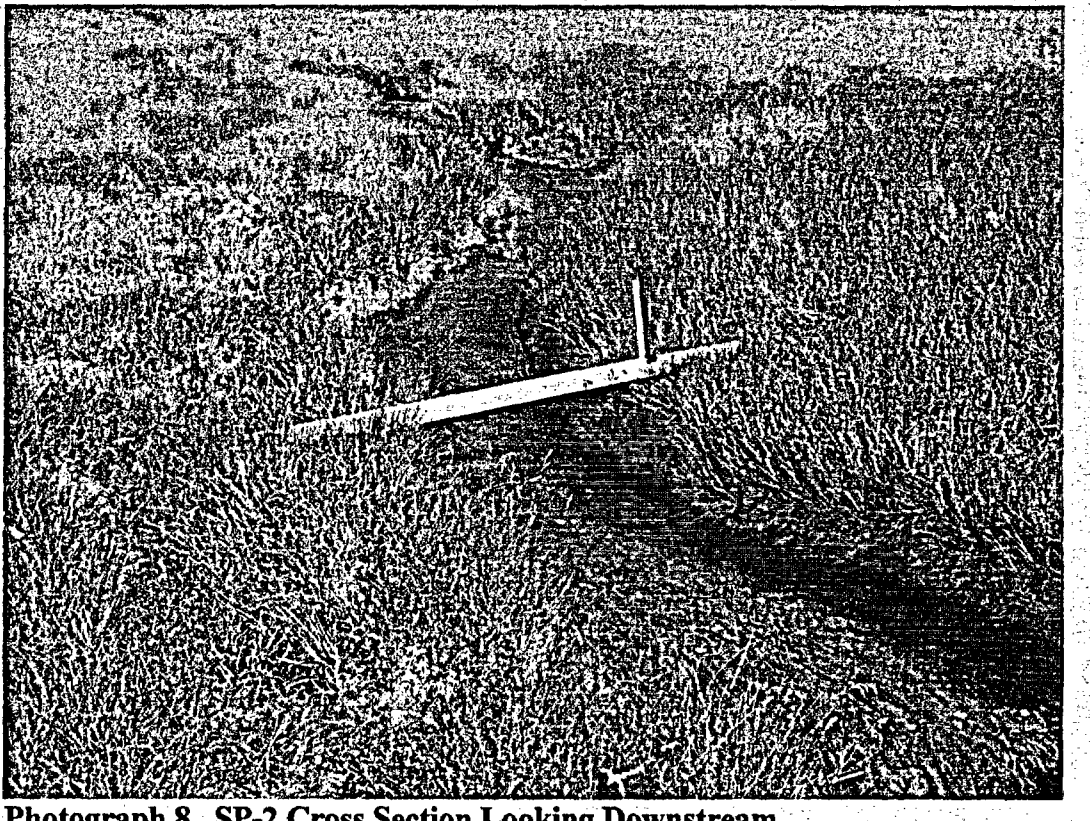
Photograph 5. Temporary Flume Installation at SP-4



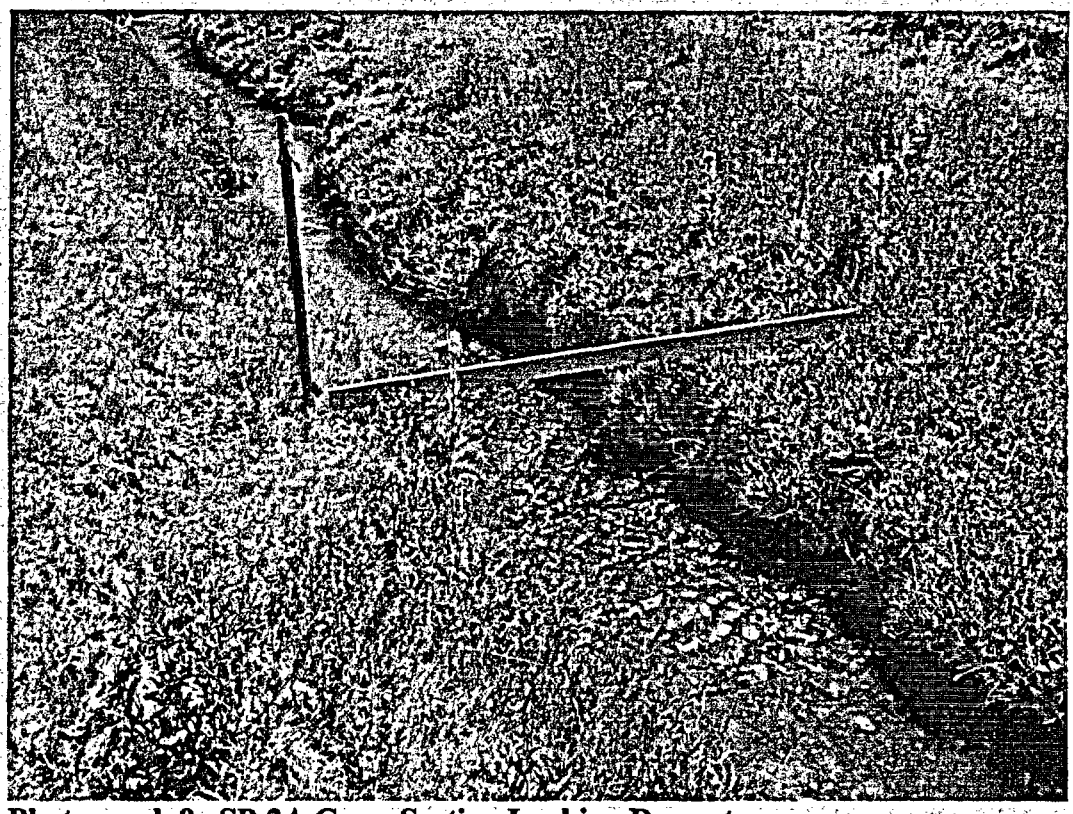
Photograph 6. SP-3 Cross Section Looking Downstream



Photograph 7. Temporary Flume Installation at SP-3



Photograph 8. SP-2 Cross Section Looking Downstream



Photograph 9. SP-2A Cross Section Looking Downstream

Photograph 10. Temporary Flume Installation at FC-1

Photograph 11. Channel Bend Near SP-1A

Photograph 12. Temporary Flume Installation at SP-1A

APPENDIX A

CROSS SECTION TABULATIONS

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TABLES

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A-3 Spring Creek Cross Sections
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A-4 Spring Creek Cross Sections
Cross Section SP-3 and Cross Section SP-2 ..... A-4

A-5 Spring Creek Cross Sections
Cross Section SP-2A, Cross Section SP-1 and Cross Section SP-1A A-5

A-6 Fox Creek Cross Section
Cross Section FC-1 ..... A-6

Table A-1. Little Medicine Bow River Cross Sections

Cross Section MB-2 Lower

Horizontal Location (inch)	Depth to Water (inch)	Depth to Bottom (inch)	Water Depth (inch)	Water Depth (ft)	Increment Flow Area (in^2)	Cumulative Flow Area (in^2)	Cumulative Flow Area (ft^2)
0		4.75					
6	4.5	4.625	0.125	0.010	0.75	0.75	0.01
12	4.25	4.375	0.125	0.010	0.75	1.50	0.01
18	4.375	4.5	0.125	0.010	0.75	2.25	0.02
24	4	5	1	0.083	6.00	8.25	0.06
30	4	6	2	0.167	12.00	20.25	0.14
36	3.875	7.25	3.375	0.281	20.25	40.50	0.28
42	3.875	7.875	4	0.333	24.00	64.50	0.45
48	3.875	7.875	4	0.333	36.00	100.50	0.70
60	4	6.625	2.625	0.219	31.50	132.00	0.92
72	4.375	8	3.625	0.302	43.50	175.50	1.22
84	4.375	7.5	3.125	0.260	37.50	213.00	1.48
96	4.875	6.5	1.625	0.135	19.50	232.50	1.61
108	5.125	6.5	1.375	0.115	16.50	249.00	1.73
120	5.5	7.5	2	0.167	24.00	273.00	1.90
132	5.75	8.75	3	0.250	36.00	309.00	2.15
144	6.25	8.875	2.625	0.219	31.50	340.50	2.36
156	6.5	9.25	2.75	0.229	33.00	373.50	2.59
168	7.125	9.875	2.75	0.229	33.00	406.50	2.82
180	7.25	10	2.75	0.229	33.00	439.50	3.05
192	8	9.125	1.125	0.094	13.50	453.00	3.15
204	8.75	10.125	1.375	0.115	16.50	469.50	3.26
216	9.25	12.5	3.25	0.271	39.00	508.50	3.53
228	9.5	12.625	3.125	0.260	37.50	546.00	3.79
240	10	10.75	0.75	0.063	6.75	552.75	3.84
246		9.5					

Table A-2. Little Medicine Bow River Cross Sections

Cross Section MB-2

Horizontal Location (inch)	Depth to Water (inch)	Depth to Bottom (inch)	Water Depth (inch)	Water Depth (ft)	Increment Flow Area (in^2)	Cumulative Flow Area (in^2)	Cumulative Flow Area (ft^2)
0		11.875					
12	12.125	14	1.875	0.156	22.50	22.50	0.16
24	12	13.375	1.375	0.115	16.50	39.00	0.27
36	12.125	14.125	2	0.167	24.00	63.00	0.44
48	12.125	14.375	2.25	0.188	27.00	90.00	0.63
60	12.375	14.375	2	0.167	24.00	114.00	0.79
72	12.625	14.875	2.25	0.188	27.00	141.00	0.98
84	12.75	16.375	3.625	0.302	43.50	184.50	1.28
96	13	17	4	0.333	48.00	232.50	1.61
108	13.5	17.75	4.25	0.354	51.00	283.50	1.97
120	14	17.875	3.875	0.323	46.50	330.00	2.29
132	14.125	17.25	3.125	0.260	37.50	367.50	2.55
144	14.75	17.75	3	0.250	36.00	403.50	2.80
156	15.25	17.5	2.25	0.188	27.00	430.50	2.99
168	15.5	16.5	1	0.083	12.00	442.50	3.07
180	15.125	16.5	1.375	0.115	19.25	461.75	3.21
196		15.375					

Cross Section MB-1

Horizontal Location (inch)	Depth to Water (inch)	Depth to Bottom (inch)	Water Depth (inch)	Water Depth (ft)	Increment Flow Area (in^2)	Cumulative Flow Area (in^2)	Cumulative Flow Area (ft^2)
0		7.5					
6		9.125					
12	9.5	9.75	0.25	0.021	2.25	2.25	0.02
24	9.375	10.75	1.375	0.115	16.50	18.75	0.13
36	9.875	10.375	0.5	0.042	6.00	24.75	0.17
48	10	12.5	2.5	0.208	30.00	54.75	0.38
60	10.125	13.25	3.125	0.260	37.50	92.25	0.64
72	10.25	13.625	3.375	0.281	40.50	132.75	0.92
84	10.375	14.875	4.5	0.375	54.00	186.75	1.30
96	10.5	14.625	4.125	0.344	49.50	236.25	1.64
108	10.5	11.25	0.75	0.063	9.00	245.25	1.70
120		10.75					

Table A-3. Spring Creek Cross Sections

Cross Section SP-5

Horizontal Location (inch)	Depth to Water (inch)	Depth to Bottom (inch)	Water Depth (inch)	Water Depth (ft)	Increment Flow Area (in^2)	Cumulative Flow Area (in^2)	Cumulative Flow Area (ft^2)
20		10					
22	14.125	18.375	4.25	0.354	12.75	12.75	0.09
26	14.375	18.375	4	0.333	16.00	28.75	0.20
30	14.25	17.5	3.25	0.271	13.00	41.75	0.29
34	14.25	17	2.75	0.229	11.00	52.75	0.37
38	14.125	17.25	3.125	0.260	12.50	65.25	0.45
42	14.25	16.375	2.125	0.177	8.50	73.75	0.51
46	14.25	14.875	0.625	0.052	2.50	76.25	0.53
50		14.125					
54		14.125					
60		13.875					
66		12.25					
72		12					
84		8.5					

Cross Section SP-4

Horizontal Location (inch)	Depth to Water (inch)	Depth to Bottom (inch)	Water Depth (inch)	Water Depth (ft)	Increment Flow Area (in^2)	Cumulative Flow Area (in^2)	Cumulative Flow Area (ft^2)
34		8					
36	10.25	13.125	2.875	0.240	8.63	8.63	0.06
40	10.25	14	3.75	0.313	15.00	23.63	0.16
44	10.25	13.75	3.5	0.292	14.00	37.63	0.26
48	10.25	14.375	4.125	0.344	16.50	54.13	0.38
52	10.25	14.625	4.375	0.365	17.50	71.63	0.50
56	10.25	14	3.75	0.313	11.25	82.88	0.58
58	10.25	14.125	3.875	0.323	7.75	90.63	0.63
60		8.5					

Table A-4. Spring Creek Cross Sections

Cross Section SP-3

Horizontal Location (inch)	Depth to Water (inch)	Depth to Bottom (inch)	Water Depth (inch)	Water Depth (ft)	Increment Flow Area (in^2)	Cumulative Flow Area (in^2)	Cumulative Flow Area (ft^2)
26		8					
30	7.5	11	3.5	0.292	14.00	14.00	0.10
34	7.25	14.25	7	0.583	28.00	42.00	0.29
38	7.25	16.125	8.875	0.740	62.13	104.13	0.72
48	7.25	16.5	9.25	0.771	37.00	141.13	0.98
46	7.25	15.875	8.625	0.719	8.63	149.75	1.04
50	7.25	15.875	8.625	0.719	34.50	184.25	1.28
54	7.25	13.25	6	0.500	24.00	208.25	1.45
58	7.25	12	4.75	0.396	19.00	227.25	1.58
62	7.125	10	2.875	0.240	11.50	238.75	1.66
66	7.125	9	1.875	0.156	9.38	248.13	1.72
72	7.125	9	1.875	0.156	9.38	257.50	1.79
76	7.125	8.5	1.375	0.115	5.50	263.00	1.83
80	7.125	8.625	1.5	0.125	6.00	269.00	1.87
84		4.5					

Cross Section SP-2

Horizontal Location (inch)	Depth to Water (inch)	Depth to Bottom (inch)	Water Depth (inch)	Water Depth (ft)	Increment Flow Area (in^2)	Cumulative Flow Area (in^2)	Cumulative Flow Area (ft^2)
29		10					
30	19.625	22.125	2.5	0.208	6.25	6.25	0.04
34	19.625	22	2.375	0.198	9.50	15.75	0.11
38	19.5	25.685	6.185	0.515	24.74	40.49	0.28
42	19.625	22.875	3.25	0.271	13.00	53.49	0.37
46	19.625	22.5	2.875	0.240	11.50	64.99	0.45
50	19.625	22.375	2.75	0.229	11.00	75.99	0.53
54	19.625	21.5	1.875	0.156	7.50	83.49	0.58
58	19.625	21.25	1.625	0.135	6.50	89.99	0.62
62	19.625	21	1.375	0.115	5.50	95.49	0.66
66	19.75	21.25	1.5	0.125	6.00	101.49	0.70
70		19.625					
72		18					
76		10					
78		10					

Table A-5. Spring Creek Cross Sections

Cross Section SP-2A

Horizontal Location (inch)	DTW (inch)	DTB (inch)	Water Depth (inch)	Water Depth (ft)	Increment Area (in^2)	Cumulative Area (in^2)	Cumulative Area (ft^2)
20		11					
22	23.875	24.875	1	0.083	3.00	3.00	0.02
26	23.875	25.375	1.5	0.125	6.00	9.00	0.06
30	23.875	26	2.125	0.177	10.63	19.63	0.14
36	23.875	25.875	2	0.167	12.00	31.63	0.22
42	23.875	26	2.125	0.177	12.75	44.38	0.31
48	24	26.25	2.25	0.188	13.50	57.88	0.40
54	23.875	27	3.125	0.260	18.75	76.63	0.53
60	23.875	24.625	0.75	0.063	3.75	80.38	0.56
64		24					
68		11					

Cross Section SP-1

Horizontal Location (inch)	DTW (inch)	DTB (inch)	Water Depth (inch)	Water Depth (ft)	Increment Area (in^2)	Cumulative Area (in^2)	Cumulative Area (ft^2)
22		10.25					
26		17.625					
34		18.125					
38		18.375					
42	18.375	19.375	1	0.083	4.00	4.00	0.03
46	18.375	20	1.625	0.135	6.50	10.50	0.07
50	18.375	21.25	2.875	0.240	14.38	24.88	0.17
56	18.375	21.5	3.125	0.260	18.75	43.63	0.30
62	18.375	22.5	4.125	0.344	24.75	68.38	0.47
68	18.375	22.25	3.875	0.323	23.25	91.63	0.64
74	18.375	21.5	3.125	0.260	15.63	107.25	0.74
78	18.375	21.375	3	0.250	9.00	116.25	0.81
80		10.75					

Cross Section SP-1A

Horizontal Location (inch)	DTW (inch)	DTB (inch)	Water Depth (inch)	Water Depth (ft)	Increment Area (in^2)	Cumulative Area (in^2)	Cumulative Area (ft^2)
14		8.25					
16		21.5					
18	22.375	23.25	0.875	0.073	2.63	2.63	0.02
22	22.375	23.25	0.875	0.073	3.50	6.13	0.04
26	22.375	23.625	1.25	0.104	5.00	11.13	0.08
30	22.375	25.875	3.5	0.292	17.50	28.63	0.20
36	22.375	26	3.625	0.302	21.75	50.38	0.35
42	22.375	26.5	4.125	0.344	24.75	75.13	0.52
48	22.375	26	3.625	0.302	21.75	96.88	0.67
54	22.375	26.75	4.375	0.365	21.88	118.75	0.82
58	22.375	24	1.625	0.135	4.88	123.63	0.86
60		21.5					
64		21.375					
70		19.125					

Table A-6. Fox Creek Cross Section

Cross Section FC-1

Horizontal Location (inch)	DTW (inch)	DTB (inch)	Water Depth (inch)	Water Depth (ft)	Increment Area (in^2)	Cumulative Area (in^2)	Cumulative Area (ft^2)
30		16.5					
32		19.375					
34		19.625					
36	19.75	20.125	0.375	0.031	1.13	1.13	0.01
40	19.75	21	1.25	0.104	5.00	6.13	0.04
44	19.75	21.5	1.75	0.146	7.00	13.13	0.09
48	19.75	21.375	1.625	0.135	6.50	19.63	0.14
52	19.75	20.875	1.125	0.094	4.50	24.13	0.17
56	19.75	20.5	0.75	0.063	2.25	26.38	0.18
58		11.625					