

Hydrologic and Water Quality Collection for Colorado's Upper Arkansas River Basin

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Summary

Field data collection and analysis activities for a study region in Chaffee County in the Upper Arkansas River Basin (UARB) (Gates et al, 2016) were conducted per the Scope of Work submitted to Colorado Water Conservation Board (CWCB) in September 2017. The activities and results are summarized below. Locations and methods of measurements and sampling are as described in Gates et al (2016). Data have been entered into the Arkansas River Basin SQL Database at Colorado State University and are summarized in an accompanying Excel file. Results reveal values for water table depth, flow rates, in-situ water quality parameters, and concentrations of selected water quality constituents, which are similar in magnitude and variability to those reported in Gates et al (2016) and in annual reports to Colorado Water Institute (CWI) and CWCB for fiscal years 2016 and 2017.

Monitoring events were conducted in November 2017 and April 2018. The average depth to the water table measured in 17 monitoring wells during the November 2017 sampling event was 6.6 meters, and the average electrical conductivity (EC) of the groundwater was 0.28 dS/m. During the sampling event in April 2018, depth to water table and EC were measured in 15 wells, with two additional wells found dry. Average water table depth was 5.6 meters and average EC of the groundwater was 0.23 dS/m. Groundwater quality samples taken from 13 wells in April 2018 revealed average uranium (U) and total dissolved solids (TDS) concentrations of 4.2 µg/L and 216.7 mg/L, respectively.

EC was measured in flows at three locations in the Arkansas River and at 18 locations in tributary streams in November 2017. Average EC in both the river and tributary streams was 0.12 dS/m. Acoustic Doppler velocimeters (ADV) were used to measure flow rates at gaging sites in eight tributaries. During the April 2018 sampling event, EC was measured in flows at three locations in the Arkansas River and at 19 locations in tributary streams. Average EC was 0.12 dS/m in the river and 0.13 dS/m in the tributary streams. ADVs were used to measure flow rates at gaging sites in seven tributaries. Water quality samples collected during the April event at three locations along the Arkansas River revealed average U and TDS concentrations of 1.7 µg/L and 100.7 mg/L, respectively. In the tributary streams, average measured U and TDS concentrations were 3.9 µg/L and 123.3 mg/L, respectively. Additional details are provided in the accompanying Excel file.

Activities

9 – 11 November 2017

- Measurement of water table level in 17 groundwater monitoring wells (manual readings and downloading of continuous water level loggers)
- Measurement of in-situ water quality parameters in 17 groundwater monitoring wells using an In-Situ smarTroll
 - Electrical conductivity (EC)
 - pH
 - Oxidation reduction potential (ORP)
 - Dissolved oxygen (DO)
 - Temperature (T)
- Measurement of stream flow at eight sites in tributaries to the Arkansas River using ADVs

- Measurement of in-situ water quality parameters at 19 sites in tributaries to the Arkansas River and at three sites in the Arkansas River an In-Situ smarTroll
 - EC
 - pH
 - ORP
 - DO
 - T

21 – 23 April 2018

- Measurement of water table level in 15 groundwater monitoring wells (manual readings and downloading of continuous water level loggers)
- Measurement of in-situ water quality parameters in 15 groundwater monitoring wells using an In-Situ smarTroll
 - EC
 - pH
 - ORP
 - DO
 - T
- Measurement of stream flow at seven sites in tributaries to the Arkansas River using ADVs
- Measurement of in-situ water quality parameters at 15 sites in tributaries to the Arkansas River and at three sites in the Arkansas River an In-Situ smarTroll
 - EC
 - pH
 - ORP
 - DO
 - T
- Extraction of water quality samples from 13 groundwater monitoring wells using bladder pump and low-flow sampling apparatus
 - Major salt ions
 - Uranium (U)

November 2017 – June 2018

- Entry of UARB data into Arkansas River Basin SQL database
- Processing of continuous groundwater level data
- Analysis of stage-discharge relationships for gaging locations within tributaries of the UARB (preliminary results are available upon request)

Reference

Gates, T. K., Steed, G. H., Niemann, J. D., and Labadie, J. W. 2016. "Data for improved water management in Colorado's Arkansas River Basin: Hydrological and water quality studies." Special Report No. 24, Colorado Water Institute, Colorado State University, Fort Collins, CO.

Status Legend				
W	Well was destroyed		L	Surface Point was frozen
B	Casing was destroyed. Still Readable		N	No Access
D	Site was dry		O	Object found in well. Unreadable
K	Surface Point was stagnant		Z	Well could not be found

Adjusted SAR	Adjusted SAR Duplicate	Lab EC (mmho/cm)	Lab EC Duplicate (mmho/cm)	Sodium (ppm)	Sodium Duplicate (ppm)	Potassium (ppm)	Potassium Duplicate (ppm)	Calcium (ppm)	Calcium Duplicate (ppm)	Magnesium (ppm)
0.00		0.09		2.00		0.00		16.00		2.00
0.60		0.28		13.00		2.00		43.00		9.00
0.18		0.15		4.85		0.70		23.45		3.90
0.86		0.29		0.58		0.82		0.29		0.45
Adjusted SAR	Adjusted SAR Duplicate	Lab EC (mmho/cm)	Lab EC Duplicate (mmho/cm)	Sodium (ppm)	Sodium Duplicate (ppm)	Potassium (ppm)	Potassium Duplicate (ppm)	Calcium (ppm)	Calcium Duplicate (ppm)	Magnesium (ppm)
0.4		0.19		9		1		26		6
0.1		0.14		4		0		19		5
0.2		0.16		5		1		23		5
0.2		0.21		6		1		32		6
0.2		0.15		5		1		23		4
0		0.17		3		1		29		3
0.1		0.13		3		0		22		2
0.6		0.19		13		1		27		3
0		0.19		3		1		34		3
0.3		0.14		6		1		21		3
0.2		0.14		5		1		21		3
0.2		0.14		6		1		21		3
0		0.1		2		0		16		3
0.1		0.09		2		0		16		2
0.1		0.11		3		0		17		2
0.1		0.11		2		0		18		3
0.2		0.16		5		1		20		5
0.2	0.2	0.14	0.14	4	3	0	0	22	21	5
0		0.11		2		1		19		3
0.4		0.28		9		2		43		9

Magnesium Duplicate (ppm)	Total Hardness (ppm)	Total Hardness Duplicate (ppm)	Nitrate (ppm)	Nitrate Duplicate (ppm)	Sulfate (ppm)	Sulfate Duplicate (ppm)	Chloride (ppm)	Chloride Duplicate (ppm)	Carbonate (ppm)
	48.00		0.00		0.00		2.00		0.00
	145.00		0.89		45.00		3.00		3.00
	74.90		0.31		17.18		2.10		0.15
	0.30		0.94		0.70		0.15		4.47
Magnesium Duplicate (ppm)	Total Hardness (ppm)	Total Hardness Duplicate (ppm)	Nitrate (ppm)	Nitrate Duplicate (ppm)	Sulfate (ppm)	Sulfate Duplicate (ppm)	Chloride (ppm)	Chloride Duplicate (ppm)	Carbonate (ppm)
	90		0		21		2		0
	68		0.44268		30		2		0
	78		0.44268		27		2		0
	105		0.88536		27		2		0
	74		0		12		2		0
					0				
	85		0		33		2		0
	63		0.88536		21		2		0
	80		0.44268		27		2		0
	98		0.44268		45		2		0
	65		0.44268		9		2		0
	65		0.44268		9		2		0
	65		0		9		2		0
	53		0.44268		6		2		0
	48		0.44268		9		2		0
	51		0.44268		30		2		0
					0				
	58		0.44268		6		2		0
	71		0		27		2		3
5	76	73	0	0	9	9	3	3	0
	60		0		9		2		0
	145		0		12		3		0

Carbonate Duplicate (ppm)	Bicarbonate (ppm)	Bicarbonate Duplicate (ppm)	Total Alkalinity (ppm)	Total Alkalinity Duplicate (ppm)	Boron (ppm)	Boron Duplicate (ppm)	TDS (ppm)
	23.00		19.00		0.00		78.7
	166.00		139.00		0.00		249.4
	71.90		59.65		0.00		130.0
	0.41		0.41		#DIV/0!		0.3
Carbonate Duplicate (ppm)	Bicarbonate (ppm)	Bicarbonate Duplicate (ppm)	Total Alkalinity (ppm)	Total Alkalinity Duplicate (ppm)	Boron (ppm)	Boron Duplicate (ppm)	TDS (ppm)
	102		84		0		167.9
	43		36		0		104.1
	62		51		0		127.2
	94		77		0		171.4
	78		64		0		130.9
	61		50		0		133.4
	46		38		0		99.6
	85		70		0		163.5
	50		41		0		140.0
	86		71		0		132.0
	80		66		0		126.5
	76		63		0		123.0
	62		52		0		94.7
	47		38		0		80.3
	23		19		0		78.7
	81		67		0		115.8
	60		54		0		139.0
0	73	75	61	62	0	0	120.3
	63		52		0		101.6
	166		139		0		249.4

Upper Arkansas River Basin (UARB)			Status Legend												
			W	Well was destroyed				L	Surface Point was frozen						
Ground Water Monitoring Data			B	Casing was destroyed. Still Readable				N	No Access						
			D	Site was dry				O	Object found in well. Unreadable						
			K	Surface Point was stagnant				Z	Well could not be found						
Sampling Event Information			In-Situ Readings							Pressure Transducer Reading				Atmospheric T	
Minimum		See status legend at top	WTD GroundSurface (m)	EC (dS/m)	T (°C)	pH	DO (mg/L)	ORP (mV)	T (°C)	Pressure (kPa)		Set Depth (M)	WTD (m)	T (°C)	
Maximum			1.2	0.11	7.9	5.21	0.42	28.8	Transducer readings are from time closest to In-Situ Measurement						Transducer readings In-Situ M
Average			17.9	0.59	24.0	8.12	9.38	120.2							
CV			6.5	0.27	13.2	7.10	4.87	56.2							
			4.5	0.11	4.3	0.78	2.51	20.2							
Monitoring Well Name	Reading Date/Time	Status													
127927-01	4/23/2018 12:00	Z										8.23			
	11/19/2017 9:40	Z													
137911-01	4/21/2018 15:03	D										5.64			
	11/19/2017 14:58		4.48	0.11	11.49	7.04	5.54	45.4							
137925-01	4/22/2018 8:28		9.91	0.14	12.59	5.24	5.89	100.4				14.27			
	11/19/2017 15:18		9.69	0.11	10.88	7.03	8.45	49.1							
147832-01	4/22/2018 12:01		3.30	0.1367	19.33	6.78	5.89	44.6				7.47			
	11/19/2017 10:57		2.08	0.16	10.71	7.38	6.86	43.9							
147878-01	11/19/2017 11:16		13.18	0.27	11.97	7.25	5.59	50.4							
147924-01	4/22/2018 11:02		4.33	0.179	14.48	5.81	6.41	75.4				7.59			
	11/19/2017 10:53		3.04	0.2	13.42	6.91	6.86	51.3							
147925-01	4/22/2018 10:00		9.56	0.2298	16.12	6.19	6.61	65.4				11.11			
	11/20/2017 9:51		8.14	0.25	10.05	6.92	8.17	82.3							
157815-01	4/22/2018 14:58		3.90	0.15	18.68	7.38	6.89	43.9				10.55			
	11/20/2017 13:03		5.56	0.18	10.9	7.47	6.21	60.0							
157823-01	4/22/2018 15:54		2.24	0.24	18.86	7.65	5.38	34.8				8.22			
	11/20/2017 13:18		1.39	0.39	9.12	7.74	1.25	50.7							
157824-01	4/22/2018 16:38		6.90	0.30	24	7.59	5.99	39.5				7.96			
	11/20/2017 13:32		5.61	0.36	10.76	7.68	3.27	58.8							
157826-01	4/22/2018 17:38		1.71	0.22	19	8.12	3.31	28.8				7.38			
	11/20/2017 13:53		5.88	0.25	10.81	7.49	2.91	59.1							
490804-01	4/23/2018 12:34	D										7.96			
	11/20/2017 9:52		13.91	0.37	7.94	7.34	4.67	57.4							
500811-01	4/23/2018 9:22		13.46	0.26	14.66	6.29	6.52	49.7				15.56			
	11/20/2017 16:57		9.78	0.32	8.55	7.72	9.38	62.1							
500814-01	4/23/2018 13:00	Z									23.15				
500822-01	11/20/2017 17:18		17.94	0.4	9.55	7.94	7.44	61.1							
	4/23/2018 14:06		1.91	0.24	18.55	7.71	3.87	35.9				8.7			
500822-02	11/21/2017 10:30		1.19	0.32	9.82	6.75	0.42	57.3							
	4/23/2018 14:47		4.33	0.36	22.97	7.79	5.51	29.2				24.41			
500929-01	11/21/2017 8:25		4.07	0.43	10.39	7.38	5.45	51.9							
	4/23/2018 13:43		13.70	0.48	15.05	7.87	0.81	32.7				18.07			
510808-01	11/21/2017 7:57		11.25	0.59	9	6.62	0.66	85.7							
	4/23/2018 8:19		3.73	0.16	11.29	5.21	5.67	120.2				16.74			
510808-02	4/23/2018 9:00		7.59	0.22	9.77	5.66	1.54	59.3				9.03			
	11/20/2017 10:41	N													
510810-01	4/22/2018 18:35		2.23	0.29	13.04	7.72	1.78	38.3				12.28			
	11/20/2017 14:14		1.92	0.31	9.78	7.63	0.48	73.0							

Transducer Reading	Solute Concentrations														
Pressure (kPa)	Se (ppb)	Se Duplicate (ppb)	U (µg/L)	U Duplicate (µg/L)	Lab pH	Lab pH Duplicate	SAR	SAR Duplicate	Adjusted SAR	Adjusted SAR Duplicate	Lab EC (mmho/cm)	Lab EC Duplicate (mmho/cm)	Sodium (ppm)	Sodium Duplicate (mg/L)	Potassium (ppm)
are from time closest to measurement			0.0		5.6		0.2		0.2		0.1		4.0		0.0
			16.0		7.8		2.5		2.6		0.4		56.0		3.0
			4.2		6.8		0.5		0.5		0.3		11.8		1.5
			5.7		0.7		0.6		0.6		0.1		13.6		1.0
			0		5.6		0.3		0.3		0.14		6		2
			0.63		7		0.2		0.2		0.16		4		0
			2.1		5.7		0.3		0.3		0.19		6		2
			1.5		6.3		0.2		0.2		0.25		5		0
			0.56		6.4		0.4		0.4		0.17		9		2
			1.7		7.2		0.5		0.5		0.28		13		2
			11		7.1		0.4		0.4		0.37		11		3
			13		7.5		0.4		0.4		0.28		10		0
			0.7		6.9		0.2		0.2		0.28		6		2
			1.7		7.3		0.3		0.4		0.28		9		2
			NR		7.8		2.5		2.6		0.43		56		1
			1.3		6.1		0.3		0.3		0.16		7		2
			16		7.1		0.4		0.5		0.32		12		2

Potassium Duplicate (ppm)	Calcium (ppm)	Calcium Duplicate (ppm)	Magnesium (ppm)	Magnesium Duplicate (ppm)	Total Hardness (ppm)	Total Hardness Duplicate (ppm)	Nitrate (ppm)	Nitrate N Duplicate (ppm)	Sulfate (ppm)	Sulfate S Duplicate (ppm)
	21.0		2.0		65.0		0.0		9.0	
	63.0		8.0		187.0		14.6		54.0	
	38.8		5.2		118.7		4.0		21.7	
	12.5		2.0		36.9		4.9		12.8	
	21		3		65		0.89		12	
	27		4		84		1.33		9	
	30		6		100		1.33		9	
	44		6		135		14.17		9	
	26		3		78		1.33		27	
	46		3		128		1.33		27	
	63		7		187		3.54		36	
	43		8		141		3.54		18	
	48		6		145		2.66		24	
	46		6		140		0.00		24	
	35		2		96		14.61		54	
	25		5		83		5.75		15	
	51		8		161		0.89		18	

Chloride (ppm)	Chloride Duplicate (ppm)	Carbonate (ppm)	Carbonate Duplicate (ppm)	Bicarbonate (ppm)	Bicarbonate Duplicate (ppm)	Total Alkalinity (ppm)	Total Alkalinity Duplicate (ppm)	Boron (ppm)	Boron Duplicate (ppm)	TDS (ppm)
2.0		0.0		62.0		51.0		0.00		117.9
22.0		0.0		194.0		159.0		0.01		320.6
4.1		0.0		125.7		103.1		0.00		216.7
5.5		0.0		41.4		34.1		0.00		71.9
2		0		71		57		0		117.9
2		0		97		80		0		145.0
2		0		113		92		0		171.4
2		0		136		112		0		217.7
2		0		62		51		0		132.9
2		0		139		114		0		235.0
3		0		183		150		0		320.5
4		0		147		121		0		246.5
6		0		129		106		0		224.4
2		0		155		127		0		245.7
22		0		136		112		0.01		320.6
2		0		72		59		0		135.1
2		0		194		159		0		303.9