Summary Report for the Water Supply, Use and Planning Study
Needs Assessment for the Little Thompson River/Watershed

May 25, 2016

Prepared for:
The Little Thompson Watershed Coalition
Colorado Water Conservation Board WSRA Contract 150707

Big Thompson Conservation District acting as fiscal agent for the project
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1.0 Introduction

This is the summary report for the Little Thompson Watershed Coalition, Water Supply, Use and Planning Study - Needs Assessment for the Little Thompson River/Watershed. The Little Thompson Watershed Coalition (LTWC) is made up of landowners within the watershed of the Little Thompson River, as well as stakeholders from various government agencies, businesses, and volunteer organizations. The work is funded by the Colorado Water Conservation Board WSRA Contract 150707 and the Big Thompson Conservation District is acting as the fiscal agent for the project.

This study will assist the communities and stakeholders in making informed choices and decisions regarding Little Thompson River water supplies. The mission of the LTWC includes additional goals related to floodplain restoration and engaging stakeholders to identify cooperative solutions to watershed management issues. The reporting provides characterization of the current water supply situation in the Little Thompson River watershed. The first objective of this study is to characterize water uses in the Little Thompson River watershed with emphasis on the river's "native" supplies. The native water supplies originate in the watershed. The water use characterization includes types of use, water supply sources, quantities, timing, and place of use. The reporting discusses agricultural, domestic, municipal, and industrial uses.

The second main objective of this study is to characterize the stream flows in the Little Thompson River. The stream flow information includes the timing and amount of native flows, water volumes imported into the watershed, and water diversions. The reporting describes stream flows with hydrographs, text, and water supply accounting methods.

Other stated objectives in the Scope of Work for this study are to identify gaps in water supplies, describe non-consumptive water needs, determine dry reaches, discuss impacts due to droughts, discuss impacts due to changes in use of Colorado Big-Thompson Project water supplies, determine supplies necessary to "stabilize" certain uses, and develop a stream monitoring plan.

A primary goal of this study is to develop initial water supply plans and processes for the watershed. The plans and processes are projects, studies, designs, and other actions meant to address consumptive and non-consumptive water supply needs/concerns. This study directs these evaluations to the "native" Little Thompson River sources and uses. This report provides a preliminary list of plans and processes to address the water supply needs/concerns. These suggested plans and processes were identified during the research for this study, based on discussions with the Project Management Team (PMT), or suggested by the public and other entities interested in the Needs Assessment.

This report includes a draft Scope of Work and Budget for Phase 2 Needs Assessment. At this time, the Phase 2 Scope is a work-in-progress. So for now, the report presents a "menu" of potential investigations and Phase 2 activities. The PMT and stakeholders must direct and prioritize any Phase 2 work. Since the information developed under this study is important in helping stakeholders evaluate and set priorities, the draft Phase 2 Scope of Work will be finalized as the process continues.

2.0 Characterization of Little Thompson River Water Uses

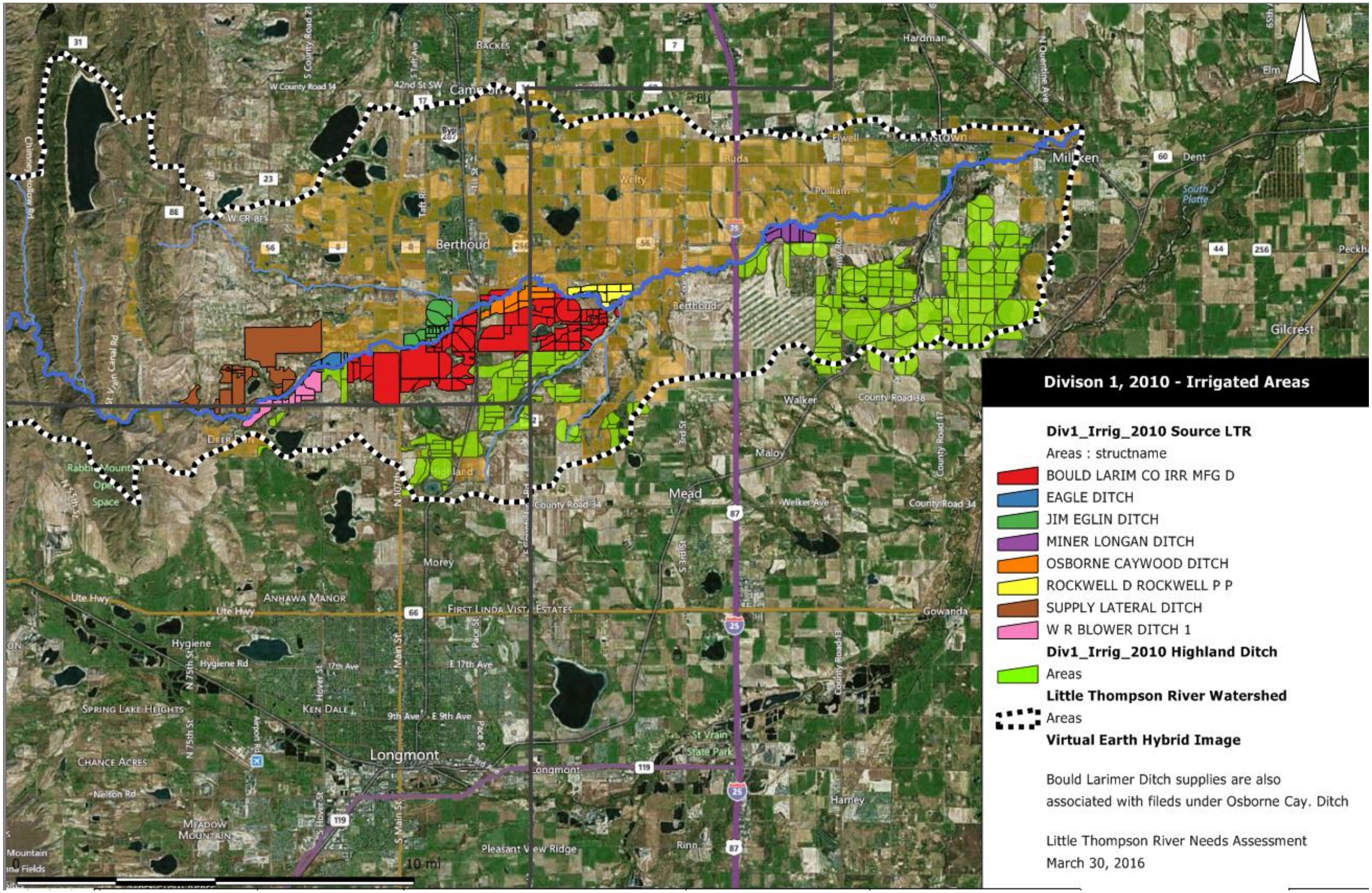
This section describes water uses in the Little Thompson River watershed with emphasis on the river's "native" supplies. The reporting discusses agricultural, domestic, municipal, and industrial uses. The water use information includes quantities, timing, and place of use. The data and information comes primarily from the State of Colorado Decision Support System (CDSS).

The largest use of native Little Thompson River water supplies is agricultural irrigation. In all, the agricultural diversions supply over 4,600 acres of irrigated area (predominantly grass pasture and based on the State's 2010 mapping of irrigated parcels (Figure 1). The vast majority of the diverted native supplies are associated with 10 diversion structures (bottom portion of Table 1). Since 2000, diversions of native Little Thompson River water supplies for irrigation average approximately 7,200 acre-feet per year (Table 2).

Some Little Thompson River structures also divert Colorado-Big Thompson Project (C-BT) water supplies, in addition to native diversions. Delivery of the C-BT supplies is possible from several different ditch or canal systems, but most often the C-BT conveys water in the Little Thompson Ditches No. 1 and/or No.2, releasing supplies from the St. Vrain Supply Canal to the Little Thompson River. Releases from the Ditches No. 1 and No. 2 enter the Little Thompson River just downstream of the gage near the Canyon mouth. Since 2000, the C-BT water supplies diverted by the Little Thompson River structures average approximately 2,500 acre-feet per year (Table 2).

The State's 2010 mapping of irrigated areas indicates that there are approximately 27,000 acres of potentially irrigated areas within the Little Thompson River watershed that receive solely "imported" water supplies (upper portion of Table 1). These imported supplies are conveyed from diversion structures on the Big Thompson River and St. Vrain River, and include supplies native to those watersheds and C-BT supplies. It is important to note that there is approximately 6 times more irrigated area in the Little Thompson watershed served by solely imported water than irrigated area associated with the Little Thompson River supplies.

Figure 1: Division 1, Year 2010 Irrigated Areas Associated with Native Little Thompson River Water Supplies



Note: Irrigation ditch service areas may be more extensive than indicated in the 2010 parcel mapping. Certain parcels associated with the Highland Ditch may be irrigated with Boulder Larimer "Old Ish" water supplies.

Table 1: Division 1, Year 2010 Irrigated Areas within the Little Thompson River Watershed

			Division 1 Year 2010 Irrigated Acreage within the Study Area by Crop Type									
8/14/2015	**WDID**	**Structure name**	**Total acres**	**ALFALFA**	**BARLEY**	**CORN**	**DRY_BEANS**	**GRASS_PASTURE**	**SMALL_GRAINS**	**SUGAR_BEETS**	**SUNFLOWER**	**WHEAT_FALL**
Water Source Not Little Thompson	400502	BIG T PLATTE R DITCH	184			75		109				
	400521	HANDY DITCH	5230	1174	253	805	22	2332	110	197		337
	400523	HILLSBOROUGH DITCH	2501	335	0	1169	65	417		269		246
	400524	HOME SUPPLY DITCH	9263	1740	1106	3455	291	1650	7	432	178	404
	400692	ST VRAIN SUPPLY CANAL	445					445				
	500523	SUPPLY DITCH	3213	146	230	1299		1299	6	185		48
	500526	HIGHLAND DITCH	6838	1252	534	1921	505	1509	115	424		578
		Total	**27674**	**4647**	**2123**	**8724**	**883**	**7761**	**238**	**1507**	**178**	**1613**
Water Source Little Thompson	400587	Beeline Ditch	No associated irrigated areas found in database									
	400588	BOULD LARIM CO IRR MFG D	2475	107	179	451	32	1319	97	117		173
	400592	EAGLE DITCH	70					70				
		Great Western Ind	No associated irrigated areas found in database									
	400596	JIM EGLIN DITCH	267	94		65		48			39	21
	400599	MINER LONGAN DITCH	162	146		16						
	400600	OSBORNE CAYWOOD DITCH	240	41	70	113	16					
	400601	ROCKWELL D ROCKWELL P P	176	44		38	16	20		21		37
	400602	SUPPLY LATERAL DITCH	1005					1005				
	400603	W R BLOWER DITCH 1	238					238				
		Total	**4633**	**432**	**249**	**683**	**64**	**2700**	**97**	**138**	**39**	**231**
		Combined Total	32307	5079	2372	9407	947	10461	335	1645	217	1844

Note: Irrigation ditch service areas may be more extensive than indicated in the 2010 parcel mapping. Certain parcels associated with the Highland Ditch may be irrigated with Boulder Larimer “Old Ish” water supplies.

Table 2: Diversion Volumes by Ditch Structure Years 2000 - 2014

2/12/2016	2010 Irrigated Area (acres)	Average Supply Volume for Irrigation Years 2000 - 2014 (acre-feet)															
Structure Name			Percent	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Total by Source (af)	Total
Beeline Ditch	none	Native	100%	0	0	0	0	0	98	248	431	368	162	222	117	1427	1427
		C-BT	0%	0	0	0	0	0	0	0	0	0	0	0	0	0	
BOULD LARIM CO IRR MFG D	2475	Native	63%	15	13	15	39	270	804	1132	288	105	62	19	37	2800	4459
		C-BT	37%	0	0	0	0	0	0	0	19	265	400	218	758	1659	
EAGLE DITCH	70	Native	83%	0	0	0	0	1	22	111	36	27	19	9	12	237	286
		C-BT	17%	0	0	0	0	0	0	10	5	12	13	6	3	49	
Great Western Ind	none	Diversion records not found in CDSS															
JIM EGLIN DITCH	267	No Diversion Records for 2000 - 2014															
MINER LONGAN DITCH	162	Native	53%	0	0	0	0	0	3	22	73	46	54	61	22	280	529
		C-BT	47%	0	0	0	0	0	0	9	40	91	91	18	0	249	
OSBORNE CAYWOOD DITCH	240	Native	95%	0	0	0	0	0	5	90	171	162	135	51	0	613	648
		C-BT	5%	0	0	0	0	0	0	3	9	8	11	2	2	35	
ROCKWELL D ROCKWELL P P	176	Native	71%	0	0	0	0	0	6	62	135	84	64	113	122	586	827
		C-BT	29%	0	0	0	0	0	0	9	14	76	92	40	10	241	
SUPPLY LATERAL DITCH	1005	Native	83%	0	0	0	0	6	79	360	214	87	65	33	10	855	1032
		C-BT	17%	0	0	0	0	0	0	15	26	21	30	36	50	177	
W R BLOWER DITCH 1	238	Native	87%	0	0	0	0	0	124	121	75	34	29	42	18	413	473
		C-BT	13%	0	0	0	0	0	0	12	11	14	10	7	10	60	
	4633	Native	74%											Total Native		7211	9681
		C-BT	26%											Total C-BT		2470	

Groundwater wells divert Little Thompson River water and provide supplies to domestic and household uses within the watershed. The domestic and household uses are associated with community water systems, exempt well permits, and wells that are part of the Milliken municipal water system. Groundwater supplies do not contribute significant volumes to agricultural uses within the watershed.

Wells with exempt well permits serve domestic, household only, stock, and commercial uses within the watershed. This study identified approximately 750 exempt well permits associated with constructed wells and locations within the watershed (Table 3 and Figure 2). Most of the exempt permitted wells, approximately 550, are in the foothills and mountains and outside of the Little Thompson Water District boundary (see page 9 for description of the Little Thompson Water District boundary).

This study estimated the water use volumes associated with the exempt wells. The estimate utilizes an average water use diversion factor of 0.42 acre-feet per well-year and an average consumptive use factor of 42%. With these factors the estimated annual consumptive use for 750 wells is approximately 130 acre-feet per year (average rate of 0.18 cfs).

This work evaluated the potential within the watershed for new exempt well permits. The State may permit new exempt wells on parcels with areas greater than or equal to 35 acres. An exempt well permit will not be issued where either a municipality or a water district can provide water to the property.

The analysis resulted in an estimate of approximately 680 parcels having areas of 35 acres or greater and not within the Little Thompson Water District or other municipal boundary. The 680 number represents an ultimate "high-end" estimate. Because of topography, economics, access, and other land use factors development of 680 individual parcels is probably not realistic.

Assuming 450 new (a conservatively large number) exempt well permits and a domestic/household diversion factor of 0.42 acre-feet per year per with 42% consumptive use results in a calculated well depletion volume of approximately 80 acre-feet per year. The example calculation indicates that potential new depletions from groundwater for domestic use are probably a relatively small volume of water.

Figure 2: Locations of Identified Exempt Wells within the Little Thompson River Watershed

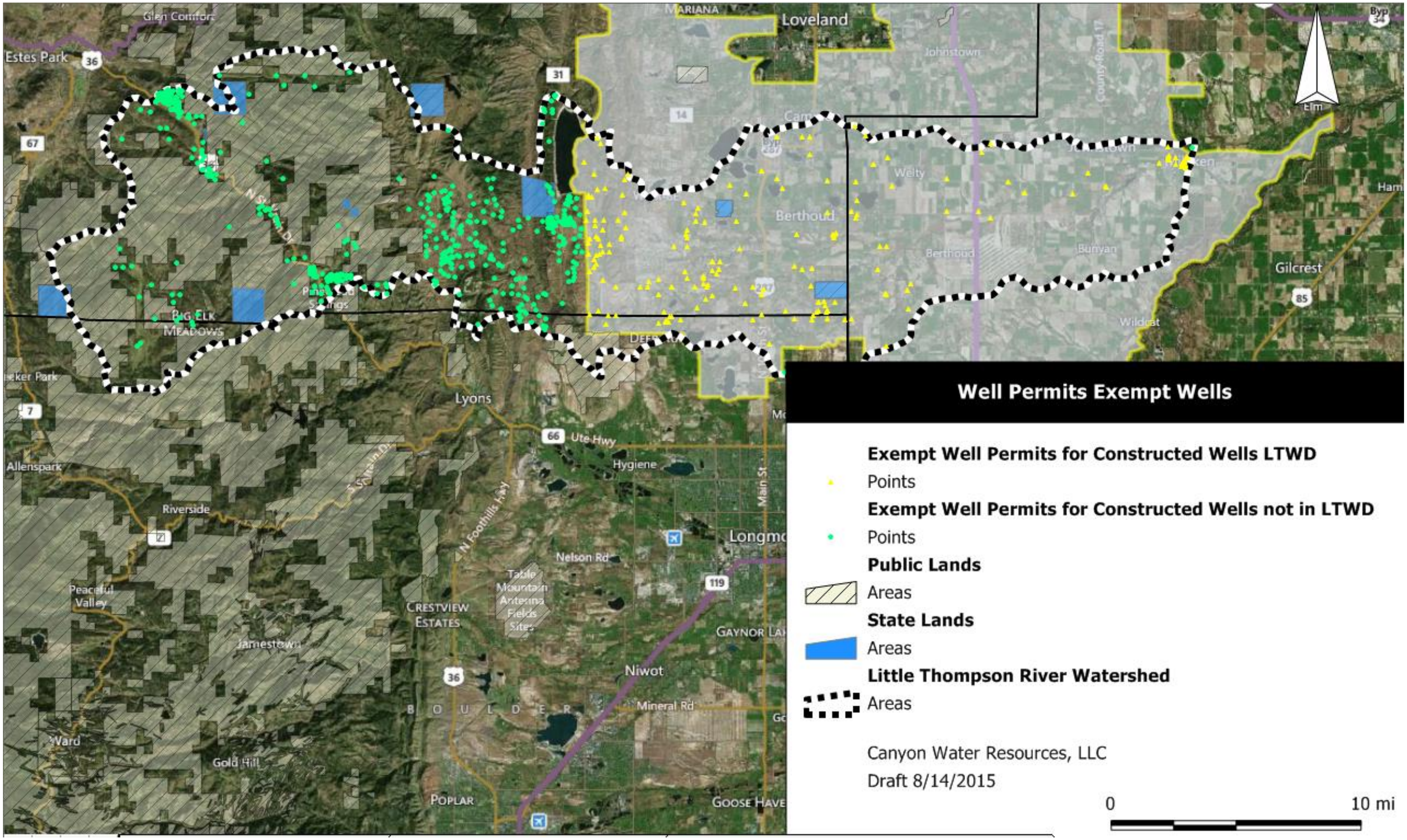


Table 3: Summary of Estimated Water Use Associated with Exempt Well Permits in the Little Thompson Watershed

8/14/2015							
Well Permit Use1 Code	**Not in LTWD (upper portion)**	**Within LTWD (lower portion)**	**Total**	**Well Usage Factor (af/year)**	**Well Usage (af/yr)**	**Consumptive Use Factor**	**Consumptive Use (af/yr)**
Commercial	6	0	6	0.25	negligible		
Domestic	241	145	386	0.6	232	50%	116
Household use only	296	34	330	0.25	83	20%	17
Industrial	0	0	0				
Irrigation	0	5	5	unknown			
Municipal	0	0	0				
Other	0	0	0				
Stock	8	13	21	15 gpd/head	negligible		
Total Count All Use Codes	**551**	**197**	**748**	**0.42**	**315**	**42%**	**133**

Note: Well usage factors modified from CDM, 2010.

There are some municipal uses of groundwater in the Little Thompson River watershed. This work identified 5 wells (Milliken, Knaub, 2 Oster, and the Seele wells) that may serve municipal uses in Milliken. The combined flow rate associated with the municipal wells is approximately 8 cfs. No diversion records are available for the wells.

The mountain community water districts evaluated in this study include the Pinewood Springs and Big Elk Meadows developments. The established developments are approaching full build-out (i.e., maximum water use). The water supplies serve indoor/in-house uses, and at Big Elk Meadows only, limited outdoor recreational uses. The information on water use for the developments indicates relatively small volumes of water use.

The water supply augmentation plan associated with Big Elk Meadows provides up to 31.4 acre-feet per year water depletions. The plan for Pinewood Springs provides up to 16.82 acre-feet per year depletions. Combined, the average depletion rate is 0.07 cfs. The water system development and water uses associated with the systems are shown below:

Water System	**Augmentation Plan Annual Consumptive Use Credit (acre-feet)**	**Development Build-Out Annual Consumptive Use (acre-feet)**	**Current Number of Units Served**	**Current Average Monthly Water Use Factor (gallons per Unit)**	**Estimated Build-Out Units Served**
Pinewood Springs	16.82[1]	9.38	Approx. 299	2,000 – 3,000	Approx. 320
Big Elk Meadows	31.4[2]	20.7	Approx. 160	Approx. 750[3]	Approx.166

[1] Minimum annual consumptive use based on dry year 1954.
[2] 10-year running average combined direct flow and storage.
[3] For 2015 – 2016, reflects seasonal residency.

The Pinewood Water District (PWD) manages the water system for the Pinewood Springs community. The water district's water system includes 17 wells, 3 springs, a collection gallery/diversion on the Little Thompson Reservoir, reservoirs (Culver Reservoir and Crow Lane Reservoir 1), storage tanks, and a water treatment facility. The Water District's rules and policies limits water use to indoor uses only and homeowners' use to a maximum of 6,000 gallons per month (these restrictions are included in subdivision covenants).

The Pinewood Springs system water uses average 2,000 – 3,000 gallons per month per tap. Since Crow Lane Reservoir 1 was built (circa 2009), the community's water supplies have been adequate. At full-build-out and if average water uses reach 6,000 gallons per month per tap, then the District would likely have water shortages[4].

Discussions with a representative of Pinewood Springs District indicated that the community is very conscientious about water conservation and water use. The relatively low water use factor of approximately 100 gallons per day per unit backs up that statement. Nonetheless, in dry years (like 2012) even with significant water conservation practices the physical supply to the system is not sufficient. In the driest years, the subdivision has purchased and trucked water from Lyons.

The Big Elk Water Association manages the water system for the Big Elk Meadows community. The water district's integrated water system includes 8 wells, a spring, 6 reservoirs, storage tanks, and a water treatment plant. The Big Elk Meadows water rights include an augmentation plan. The augmentation plan ensures that depletions from the water uses in the subdivision do not injure other water rights.

Since the 2013 flooding in the Little Thompson River, the Big Elk Meadows Water Association has completed reconstruction of Mirror Lake and the water supply infrastructure serving the subdivision. The approximate volume of the reservoir is 13 acre-feet. The community is working to re-establish the other reservoirs to return the recreational and fishery uses of the structures.

Other than the Pinewood Springs Water District and the Big Elk Meadow system, this study did not identify any Little Thompson River surface water supplies in use for municipal purposes. The Little Thompson Water District, the Town of Milliken, Johnstown, and Berthoud all have municipal supplies from sources other than the Little Thompson River. The Little Thompson Water District serves outside of the three town's municipal water service areas and east of approximately 23 Road (Larimer County)[5]. The water providers depend on Big Thompson River, C-BT, Windy Gap, St. Vrain River, and possibly other sources for municipal supplies.

The Little Thompson Water District owns 30 shares of the Boulder Larimer Irrigation and Manufacturing Company stock (aka Old-Ish). At this time, the District has no specific plans to change the supplies from irrigation to municipal use[6].

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[4] Personal communication 1/20/2016.

[5] See Figure 2. The general boundary for LTWD does not include areas served by the town's municipal systems.

[6] Personal communication, Mr. Michael Cook, February 2016.

The only identified historical industrial uses associated with Little Thompson River water supplies are for the Great Western Industrial Wells and the Great Western Industrial Ditch. The wells were decreed abandoned in Division 1, Case Number 11CW0263. No diversion records were available for the Great Western Industrial Ditch. This work did not identify any prospective industrial uses associated with the Little Thompson River water supplies.

3.0 Evaluation of Little Thompson River Stream Flows

The Little Thompson River is a relatively small and low elevation watershed. The watershed's total area is approximately 200 square miles (Figure 3). The drainage area upstream of the Little Thompson River at Canyon Mouth near Berthoud stream gage is approximately 100 square miles and the maximum elevation is around 10,000 feet. Consequently, the basin has a relatively low volume and early snow melt run-off.

3.1 Stream Gage Information for the Little Thompson River

Historical stream flow monitoring on the Little Thompson River includes 4 stream gages (Figure 3) and multiple single event or short-term flow observations. Over the years, two stream gages measured flow at essentially the same location near the canyon mouth. The combined record for these gages includes 43 years of stream flow records. Prior to the 1970's, there were periodic stream flow observations near the bottom of the watershed near Milliken and in the headwaters in the West Fork (Table 4). Since the 1960s, the only permanent Little Thompson stream gage records are for the river at the canyon mouth.

Table 4: Little Thompson River Stream Gages and Period of Records

Station Name (abbrev., USGS ID)	Data Records		No. Years
	From	To	
W. FK. LIT. THOM. R. B. BIG ELK MEAD. (LTCELKCO)	1955-10	1963-09	8
LITTLE THOMPSON RIVER NEAR BERTHOUD, CO. (LTCBERCO,06742000)	1929-05	1930-09	15
	1947-04	1952-09	
	1953-10	1961-09	
LITTLE THOMPSON RIVER AT CANYON MOUTH NEAR BERTHOUD (LTCANYCO)	1961-10	1969-09	28
	1993-04	2012-09	
LITTLE THOMPSON RIVER AT MILLIKEN, CO. (LTCMILCO,06743500)	1951-10	1957-03	14
	1959-10	1968-09	

Figure 3: Stream Flow Gaging Stations on the Little Thompson River

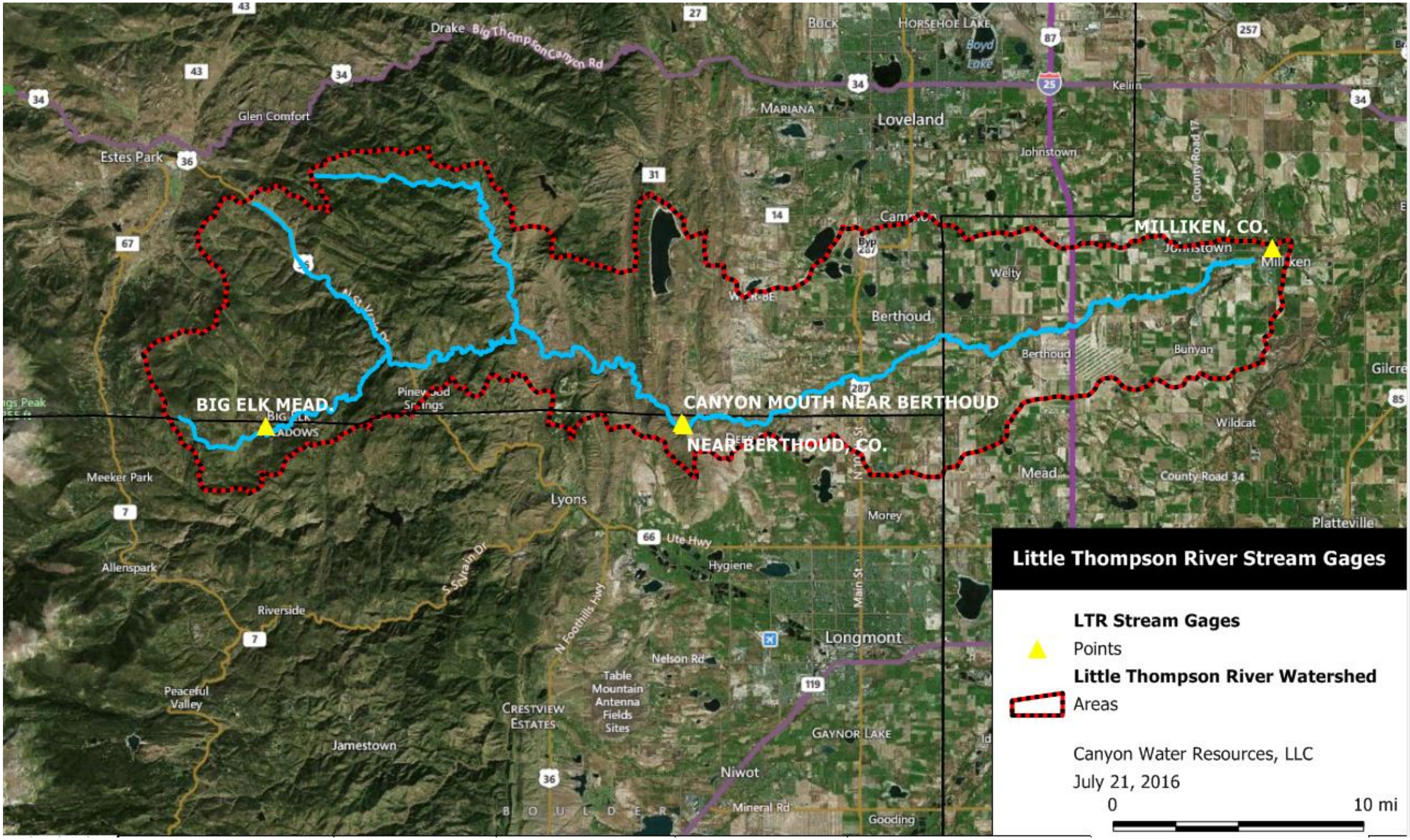
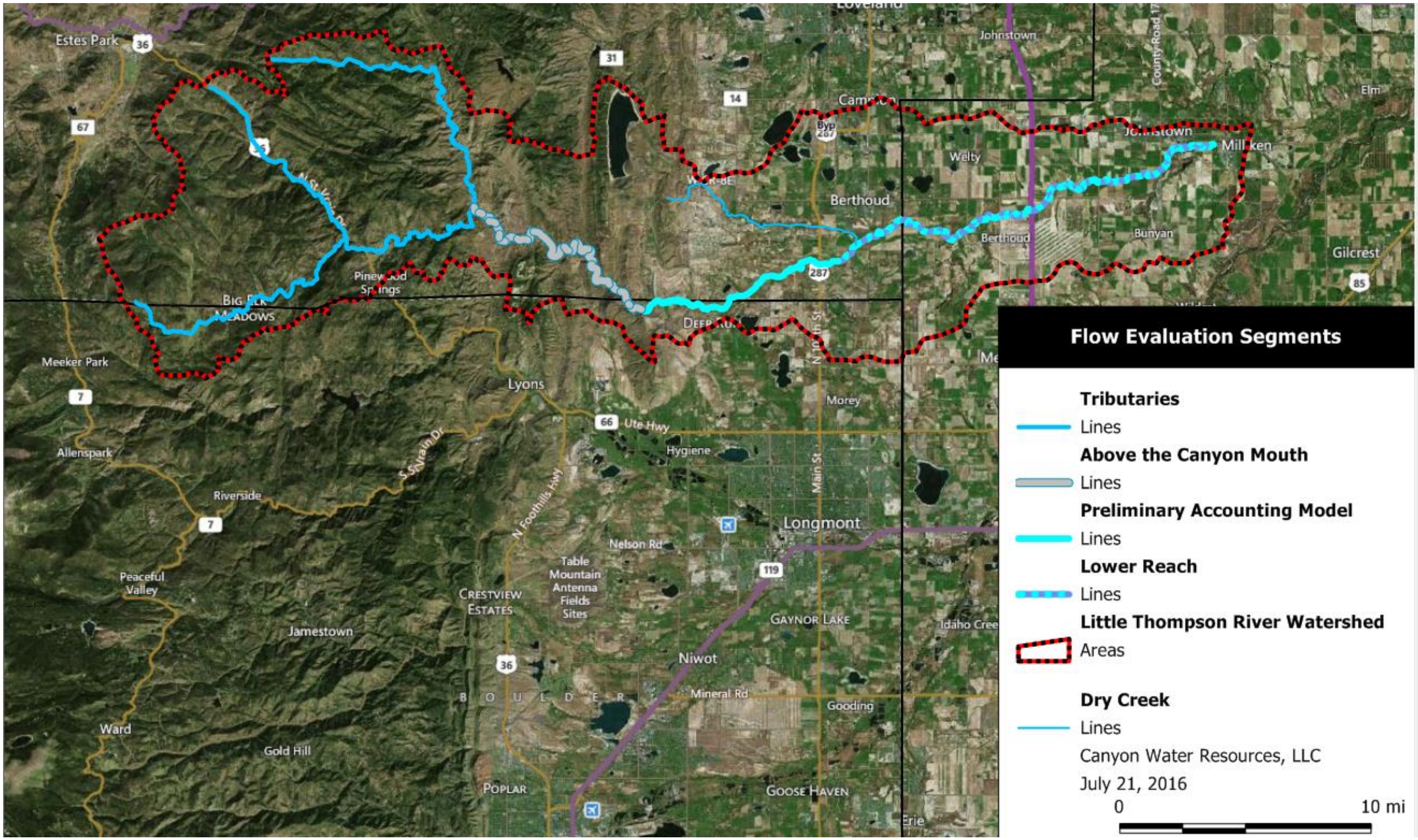


Figure 4: Stream Flow Evaluation Segments



Little Thompson River Stream Flows……..continued

For this discussion, the Little Thompson River is described with four segments (Figure 4). The tributary segment includes areas above the confluence of the North Fork tributary, the foothills segment extends from the confluence of the North Fork to the canyon mouth, the intermediate reach is the third segment from the Canyon mouth to approximately Dry Creek, and the fourth segment extends from approximately Dry Creek to the lower end of the watershed near Milliken.

For the available period of record, the average annual flow volume of the Little Thompson River at the Canyon Mouth is approximately 8,400 af (for the years with complete 12 months of records and for both gages). The run-off season March – June provides the bulk of the native water supply (Table 5). For the 43 years, the March – June[7] average annual flow volume is 8,200 af. The run-off peak monthly flows occur generally in May. After the run-off and in the winter-time, the stream flows volumes are small. Winter-time flow rates in the LTR at the canyon mouth are typically less than 1 cfs during the late summer and winter-time. In late summer and winter-time there may be zero observable surface water flow (Table 6).

There has historically only been one gaging station in the "tributary" reach of the Little Thompson River and that was in the West Fork for 8 years during the period from 1955 – 1963. The volume and timing of flows in the tributary reach can be estimated by proportioning the total flow (as recorded at the Canyon mouth gage location) between the three upper branches of the Little Thompson River. Detailed analyses may use estimates of the tributary catchment areas, elevations, topographical slope, aspect, hydrologic similar basins, stream gage correlations, and other techniques. However, for this Phase 1 of the Needs Assessment, the proportions are based on roughly estimating the area and average elevation of each tributary drainage area. For the purposes of this report, the rough proportions are 40% North Fork, 40% Upper Little Thompson River, and 20% West Fork.

The water supplies in the LTR from the confluence of the North Fork to the canyon mouth (i.e., the foothills reach above the Canyon mouth) are approximately the same in timing and volume of flows recorded at the canyon mouth. That is because the tributary area for the foothills reach is relatively low elevation and generally does not add significant volumes of flow for water supply. Since the 2013 flood, geomorphic changes may have impacted the expression of the surface water flows in this reach (as well as the other reaches). Site specific evaluations in the "foothills" reach may be evaluated in the next phase of work.

Stream flows in the lower reach (from approximately Dry Creek to Milliken) were historically recorded by the Little Thompson River near Milliken stream gage. The Milliken gage operated in the 1950's and 1960's. The historical gage data indicates winter-time base flows, probably resulting from delayed irrigation return flows. Currently, the Town of Berthoud's waste water treatment plant adds some volume to the stream at about County Road 1. Judging by the surrounding irrigated areas, the flows in the lower reach are heavily influenced by the irrigation practices associated with lands irrigated by the Handy, Home Supply, and Highland Ditches. More information on water uses in those systems and return flows may be evaluated in the next phase of work.

[7] The bulk of the annual water supply comes during the months March – June.

Table 5: Ranking of Little Thompson River near Canyon Mouth Run-off Season Water Volumes

4/6/2016	Little Thompson River near Canyon Mouth			
Rank (Dry to Wet)	Date	March-June Volume (af)	Comment	
9	1930	1750	LTCBERCO	
33	1947	14255	LTCBERCO	
26	1948	5695	LTCBERCO	
40	1949	24288	LTCBERCO	
11	1950	2705	LTCBERCO	
28	1951	8136	LTCBERCO	
34	1952	14285	LTCBERCO	
16	1954	3453	LTCBERCO	
13	1955	2749	LTCBERCO	
18	1956	3637	LTCBERCO	
43	1957	31945	LTCBERCO	
38	1958	18776	LTCBERCO	
30	1959	9227	LTCBERCO	
24	1960	5359	LTCBERCO	
36	1961	15755	LTCBERCO	
14	1962	3000	LTCANYCO	
5	1963	990	LTCANYCO	
7	1964	1040	LTCANYCO	
21	1965	4430	LTCANYCO	
4	1966	400	LTCANYCO	
25	1967	5400	LTCANYCO	
19	1968	3750	LTCANYCO	
41	1969	25180	LTCANYCO, no March records	
15	1993	3030	LTCANYCO, no March records	
23	1994	5290	LTCANYCO	
42	1995	28810	LTCANYCO	
22	1996	4800	LTCANYCO, no March records	
37	1997	16170	LTCANYCO	
32	1998	14140	LTCANYCO	
39	1999	20560	LTCANYCO	
6	2000	1020	LTCANYCO	
12	2001	2740	LTCANYCO	
1	2002	200	LTCANYCO, no March records	
31	2003	9860	LTCANYCO	
10	2004	2190	LTCANYCO	
27	2005	6250	LTCANYCO	
2	2006	200	LTCANYCO	
29	2007	8440	LTCANYCO	
8	2008	1350	LTCANYCO	
17	2009	3590	LTCANYCO	
35	2010	15380	LTCANYCO	
20	2011	3880	LTCANYCO	
3	2012	370	LTCANYCO, qualified as estimated	
No. of Years	Average	Median	Maximum	Minimum
43	8240	4800	31945	200
(shaded)	Little Thompson River near Berthoud gage records			
(boxed)	2009 - 2012 years with a preliminary water budget accounting			

Figure 5: Stream Flow Little Thompson River at Canyon Mouth near Berthoud

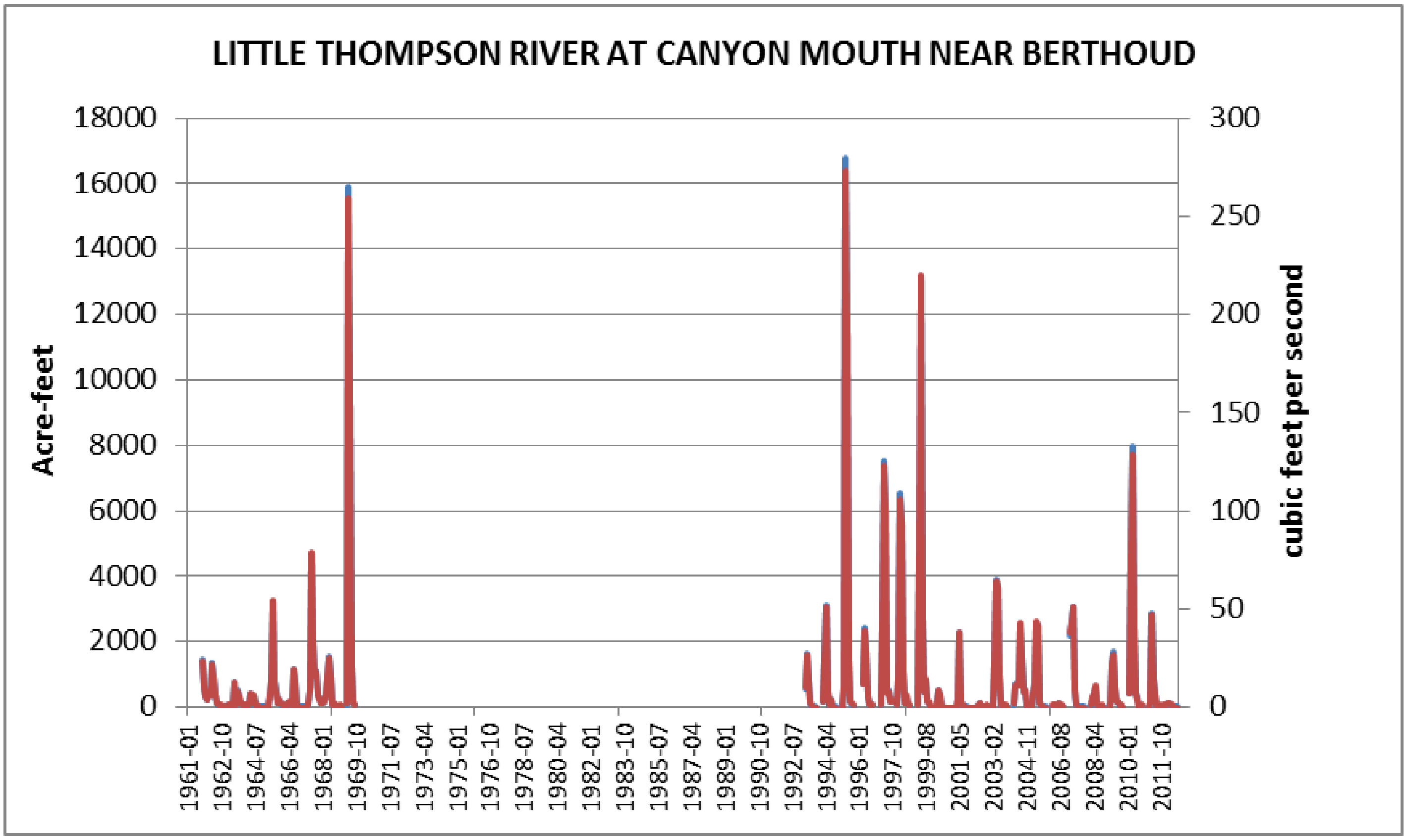


Table 6: Stream Flow Little Thompson River at Canyon Mouth near Berthoud

State of Colorado HydroBase

Description: LITTLE THOMPSON RIVER AT CANYON MOUTH NEAR BERTHOUD

Time Series Identifier:	LTCANYCO.DWR.Streamflow.Monthly	Data Source:	DWR
Located in Water Division, District:	4, 1	Measurement Type:	Streamflow
Located in County, State:	, CO	Data Interval:	Monthly
Located in HUC:	10190006	Data Units:	AF
Latitude, Longitude:	40.258038, -105.206386		
UTM X, UTM Y (zone 13 NAD 83):	482449.4 ,4456418.0		
Elevation (feet):	5206		
Time Series Creation History:			
Available Data:	1961 To 2012		
Selected Time Series From:	1961-01-01 To 2012-12-31		

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Total
1962	1428.12	592.87	301.49	245.95	388.77	361.79	1330.93	930.86	377.86	114.45	54.15	40.07	6167.30
1963	42.05	18.45	13.88	10.12	54.94	70.22	83.70	59.11	777.33	87.08	514.32	294.15	2025.35
1964	116.43	78.94	49.98	39.27	32.73	49.19	415.34	245.16	335.21	41.85	40.86	25.19	1470.17
1965	14.68	10.51	11.50	9.52	9.12	29.75	371.31	836.84	3193.44	790.62	459.18	128.53	5865.01
1966	223.94	94.41	37.88	24.60	10.51	104.73	151.94	102.55	38.68	1150.83	757.90	23.21	2721.16
1967	28.56	14.68	18.64	21.22	22.22	24.60	96.40	569.66	4704.86	2017.22	983.82	1094.89	9596.77
1968	352.86	251.90	147.37	122.98	191.61	382.82	934.82	1531.26	905.86	85.69	151.74	33.92	5092.83
1969	27.97	22.81	33.52	20.03	NC	NC	92.63	15901.52	9181.62	1211.32	107.11	56.53	26655.07
1993	NC	NC	NC	NC	NC	NC	575.22	1654.24	796.77	134.54	47.84	24.58	3233.18
1994	28.56	1.53	NC	NC	NC	200.93	1514.60	3120.05	453.43	41.67	221.18	27.73	5609.68
1995	27.17	18.03	NC	NC	NC	5.32	642.44	16802.23	11355.54	1421.77	164.23	102.94	30539.67
1996	48.60	NC	NC	NC	NC	NC	723.98	2421.46	1655.43	319.34	73.37	56.17	5298.35
1997	90.84	NC	NC	NC	NC	46.41	2606.52	7535.32	5986.20	453.63	503.02	178.08	17400.02
1998	219.77	197.36	NC	NC	44.63	941.17	6535.63	5565.70	1093.70	141.74	341.56	60.30	15141.56
1999	31.99	NC	NC	NC	NC	65.46	4738.58	13079.20	2675.74	465.73	832.08	199.34	NC
2000	173.95	0.00	0.00	0.00	0.00	127.54	524.24	340.77	27.87	10.02	4.46	4.03	1212.87
2001	2.98	0.73	0.00	0.00	0.00	4.90	258.31	2288.96	188.13	56.05	23.96	18.27	2842.30
2002	29.45	4.86	0.00	0.00	0.00	0.00	20.67	64.64	114.98	22.57	11.68	9.80	278.66
2003	39.27	6.33	0.00	0.00	0.00	1339.06	3915.43	3643.69	960.61	81.56	23.11	36.10	10045.16
2004	45.14	14.48	NC	NC	NC	98.50	702.16	690.46	701.37	2530.75	1493.58	471.87	NC
2005	529.79	33.92	0.00	0.00	0.00	375.67	756.90	2600.37	2517.26	134.06	47.50	24.91	7020.40
2006	15.87	14.46	NC	NC	NC	35.21	78.55	69.28	20.07	108.79	30.33	26.28	NC
2007	51.79	21.18	NC	NC	NC	2179.87	2665.82	3054.59	535.54	32.23	19.64	11.64	NC
2008	17.00	15.15	25.41	NC	NC	33.80	271.74	408.60	638.69	38.52	17.00	12.54	NC
2009	33.86	16.64	NC	NC	NC	25.13	1307.40	1689.94	567.88	192.90	161.38	38.50	NC
2010	33.88	4.09	NC	NC	NC	412.77	4649.32	7943.92	2374.25	412.77	259.70	15.59	16106.28
2011	15.31	32.71	NC	NC	NC	17.06	145.63	2891.55	829.10	359.81	46.85	12.08	NC
2012	35.82	27.65	48.38	73.17	84.70	145.59	134.48	55.24	32.07	21.70	8.03	6.96	673.79
Min:	2.98	0.00	0.00	0.00	0.00	0.00	20.67	55.24	20.07	10.02	4.46	4.03	278.66
Max:	1428.12	592.87	301.49	245.95	388.77	2179.87	6535.63	16802.23	11355.54	2530.75	1493.58	1094.89	30539.67
Mean:	137.25	62.24	45.87	40.49	59.95	283.10	1294.45	3432.04	1894.27	445.69	264.27	108.36	8333.12

Little Thompson River Stream Flows……..continued

The available stream gage data for the watershed includes some winter-time records. The historical data show that winter-time flows in the West Fork, the foothills reach, and the reach from the Canyon mouth to about Dry Creek were low (some records reporting 0 flows and others indicating less than 1 or 2 cfs). Irrigation return flows increase the volume of the Little Thompson stream flows downstream of about County Line Road 1. Based on data from the 1960's, water return flows added significant flow to the LTR at Milliken, where historical winter-time flows were in the range of 10 - 25 cfs.

Examination of the hydrology, water supply operations, and administration indicates the following general conclusions regarding the Little Thompson River water supplies and stream flows:

- The native LTR water supplies peak in April or May and flows decrease to just a few cubic feet per second by late July/early August. Stream flow records include reports of zero flow in the late fall and winter months at the West Fork and Canyon mouth gages.
- In all but the wettest years, the upper 5 LTR structures (i.e., Supply Lateral/Culver, Boulder Larimer, W R Blower, Eagle, and Osborne Caywood Ditches) appear to divert 100% of the available native supply.
- Return flows to the Little Thompson River contribute a significant portion of the stream flows and water supply to structures from the Rockwell Ditch (approximately Dry Creek) downstream to the eastern end of the watershed (i.e., Rockwell, Miner Longan, and Beeline Ditches).
- In the drier years, the Little Thompson River No. 1 and No. 2 Ditches historically delivered greater volumes of C-BT Project water supplies.
    - The deliveries of C-BT Project water supplies generally occur in the late summer (i.e., July and August), but occasionally supplement supplies earlier or later in the year.
    - On average for the period 2000 – 2014, approximately 75% of the C-BT Project supplies delivered via the Little Thompson River No. 1 and No. 2 Ditches were diverted by the Boulder Larimer system and the remainder was delivered to the Supply Lateral/Culver, Rockwell and Miner Longan Ditches.
    - The diversion records (2000 - 2014) indicate that the Beeline Ditch did not divert C-BT Project water supplies.
    - The diversion records (2000 – 2014) indicate that the Osborne Caywood Ditch diverted only a very small amount of C-BT Project water supplies.
- It appears that historically, in all but the wettest run-off seasons, the LTR was typically under water rights administration with an "internal" call (i.e., the calling diversion structure is located on the LTR).
    - The Osborne Caywood Ditch has the most senior water right on the Little Thompson River, 3.12 cfs with an appropriation date of 6/1/1861. For the period 2004 – 2014, the Osborne Caywood Ditch had the most days with a call (approximately 40% of the days when there was an internal call).
    - The Boulder Larimer system had the second most days on call with approximately 20% of the days when there was an internal call.
    - If the calling location is the Osborne Caywood Ditch, then the LTR is most likely "dried-up" downstream of the Ditch[8]. However, the lack of a call at Osborne Caywood does not necessarily indicate stream flow below the diversion structure.

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[8] In order for the Water Commissioner to administer a water right's priority, the calling structure must be efficiently diverting 100% of its in-priority physical water supply.

- The District 4 line diagram[9] indicates the Boulder Larimer ditch as a "dry-up" point on the stream.
- In many years, the LTR is under administration during the winter-time by a calling structure located on the South Platte River (i.e., South Platte River call).
- There is limited historical water availability to "free river" and relatively junior water rights. Based on information for 2010, for the watershed to produce supplies in excess of existing uses required a combination of a good winter snowpack and above normal precipitation in the spring (i.e., April, May and June). Recently, there have been winter-time periods without recorded river calls (e.g., 2010 – 2011, 2011 – 2012).
- Dry reaches on the Little Thompson River may occur in certain reaches and at certain times in the tributary reach, the foothills reach, in the reach from the canyon mouth to Dry Creek, and probably in the lower river below certain diversion structures. The occurrence of dry spots and dry reaches are most extensive during the low flow period (after the run-off through the next spring). During the irrigation season, dry reaches occur when water diversions are "sweeping" the stream. Often the administration point of the Little Thompson River is the Osborne Caywood Ditch; if the ditch is calling, than it is likely that the river is "dried-up" below the headgate.
- The Little Thompson River has constant flow below the Town of Berthoud's waste water treatment plant.

3.2 Evaluation of Impacts Associated with Water Supplies and Management of the Little Thompson River

This study addresses impacts in portions of the Scope of Work, including the Agricultural Water and Domestic Water Use Key Elements. For the agricultural impacts, the evaluation is to:

- Identify impacts of reduced diversion quantities due to drought (i.e., acreage adjustments and practice adjustments due to variation in river flow).
- Identify the volume of Northern Colorado Water Conservancy District (NCWCD) water usage and any potential impact of removing that water (i.e., C-BT water that uses the river as its delivery system).
- Determine the volume of water necessary to stabilize irrigated farm production.

The impact of drought on agriculture is significantly reduced farm production. Even with conditions of better than "average" hydrology, many front-range farms are "water-short", meaning the crops could use additional supplies to satisfy the full irrigation water requirement. Water users can anticipate droughts and adjust irrigation and farming practices[10].

[9]The line diagram may be accessed at http://dwrweblink.state.co.us/dwrweblink/DocView.aspx?id=2083919&page=1&dbid=0

[10] The Northern Colorado Water Conservation District's C-BT Project quota process exemplifies adjustments in water supplies in response to wetter and drier conditions. Working less acreage, acquiring supplemental water supplies, and planting different crops are a few of the on-farm adjustments.

This evaluation uses recent diversion records (2000 – 2014) and Little Thompson River flow information to describe the impacts of drought on Little Thompson River irrigation water supplies. Table 7 provides the annual diversion volume of native Little Thompson River water supplies for the structures. The second column on the table indicates that year's rank based on annual flow volume at the Canyon mouth. The rows associated with the 3 driest and the 3 wettest ranked years (for the 2000 – 2014 period) are shaded yellow and green, respectively.

Table 7: Little Thompson River Structures Annual Diversion Volumes for Recent Years

2/22/2016	Water Supply Year Rank (for 43 year Period of Record)	Senior - Listed by Priority - Junior							
Irrigation Year		Osborne Caywood	Supply Lateral/ Culver	WR Blower No. 1	Boulder Larimer	Eagle	Rockwell	Beeline	Miner Longan
		Total Diversions Native Supply in acre-feet							
2000	6	792	609	537	1066	182	813	685	533
2001	12	539	339	406	1990	1	772	1661	286
2002	1 - Driest	45	111	0	0	2	312	309	70
2003	31	480	1395	882	6531	0	788	452	210
2004	10	870	1923	891	2288	0	598	980	175
2005	27	866	691	459	4989	78	353	204	185
2006	2	301	37	47	0	0	260	1250	189
2007	29	866	1073	492	6825	356	540	0	220
2008	8	639	751	456	75	25	382	0	107
2009	17	615	1222	501	2174	162	406	1499	277
2010	35 - Wettest	826	1369	272	3835	77	910	3253	272
2011	20	1067	790	364	2912	127	1076	2861	569
2012	3	506	87	90	555	118	230	1485	257
2013		388	1032	393	3504	1032	220	1043	177
2014		401	1392	407	5258	1392	1137	5721	679
	Average								
	3 driest	280	80	50	190	40	270	1010	170
	3 wettest	720	1280	550	5730	140	750	1240	230
	% decrease	61%	94%	91%	97%	71%	64%	19%	26%
	9 other	690	970	490	2700	330	640	1630	330

Comparing the average annual diversions for 3 dry and wet water supply years indicates that all of the Little Thompson River diversion structures have significantly less volume of native supply diversions in the dry years. For the years shown, the Boulder-Larimer Ditch, Supply Lateral/Culver Ditch, and the W R Blower Ditch have the largest percentage decrease in supplies, greater than 90%. The Osborne Caywood, Eagle and Rockwell indicate 60 – 70% less supplies over the 3 year periods. The Miner Longan and Beeline indicate the least severe decrease in supplies with drought, probably because of their position lower in the watershed where historical return flows supply the diversions.

The SOW directs evaluation of "practice adjustments". Generally, practice adjustments may include changes in irrigated acreage, changes in the type of irrigation system (e.g., flood irrigation or sprinkler systems), and changes in crop types. The cropping mix area is mostly grass pasture. There may also be changes in the type of beneficial use of the native Little Thompson River water supplies.

In general, the changes in beneficial use of native Little Thompson River water supplies (e.g., changing from irrigation use to domestic use) should not impact stream flow conditions. The new uses are limited to the timing and volume of the water supply's historical consumptive use. The water rights adjudication process ensures that return flow volumes and timing for any new changed use is equivalent to the historical use.

Changes in the irrigation method, e.g., from flood irrigation to sprinklers, do not require a change of water use. Consequently, irrigators may switch irrigation methods without changing the water right. Nonetheless, depending on the site-specific situation, steam flows may be affected by changes in irrigation methods.

Going from flood irrigation to sprinkler irrigation generally results in increased irrigation efficiency (reduces field losses from deep percolation and tail-water run-off). In practice, there should be less volume of water diverted for the same amount of consumptive use. That change in irrigation method may result in more water left in the stream immediately below the diverting structure, but less tail-water runoff from the field. It may also result in less deep percolation, which may affect the timing of groundwater return flows.

In the LTR watershed, larger irrigated areas are being split into smaller but still irrigated parcels. This change in practice may result in less efficient use because of the lack of coordination between multiple water users. In this situation, water consumptive uses may decrease, but diversions may stay about the same.

Since 2000, the LTR structures diverted an average of approximately 2,500 af/yr of C-BT Project water supplies (Table 2). Since most of the carried C-BT water supplies are diverted at the Boulder Larimer Ditch system, the location of potential impacts of removing C-BT Project water supplies is in the reach from the Canyon mouth to the Boulder Larimer Ditch headgate. The timing of the changes in stream flows would generally correspond to the latter portion of the irrigation season in the drier than normal water supply years (Table 2).

The SOW includes direction to "determine the volume of water necessary to stabilize irrigated farm production". There are three general water supply outcomes that may be associated with goals to stabilize irrigated farm production:

1. No additional water supply required, current supplies represent stabilized conditions,
2. Less water supplies are needed (e.g., less irrigated farm production and that is an acceptable condition), or
3. New supplies are required. (e.g., current supplies not sufficient to stabilize irrigated farm production).

For the purpose of this study, the Project Management Team set a goal for conceptual water supply project/management options to supply up to approximately 2,500 acre-feet per year.

The irrigated areas mapped by the Division 1 State Engineer Office (SEO) for year 2010 indicate that 27,000 acres of the 32,000 acres potentially irrigated within the watershed have non-Little Thompson River water supplies (i.e., Big Thompson River, St. Vrain River, and C-BT Project sources). In other words, the water supplies "imported" to the watershed potentially serve approximately 6 times more irrigated area than the native supplies. Consequently, the largest impacts (by water volume) to stream flows and water supplies within the watershed may come from changes in operations associated with the Handy Ditch, the Home Supply Ditch, and the Highland Ditch, all which are outside of the watershed.

3.3 Water Availability

This analysis of Little Thompson River stream flows, water diversions, and call records indicates limited historical water availability for "free river" and to relatively junior water rights. The analysis is only for direct diversions from the Little Thompson River and does not evaluate exchanges or any changes of water supplies. For free-river and relatively junior water rights to divert in-priority, there must not be water right administration affecting the Little Thompson River and there must be sufficient physical supplies (for the intended beneficial use) at the prospective point of diversion.

At the time of this work, the call records database for Division 1 included over 6,800 records with dates ranging from the spring 1950 – summer of 2015. For the Little Thompson River, the call record database only included records from November 1, 2004 to July 31, 2014. The evaluation uses the recent data because the objectives of the Needs Assessment are focused on the current operations and administrative situation regarding the Little Thompson River.

For the period 2004 to 2014, the call records indicate no "internal" Little Thompson River or South Platte River call in only a few instances. This preliminary evaluation identified certain days during the winters of 2006 – 2007, 2007 – 2008, 2009 – 2010, 2010 – 2011, and 2011 – 2012 when the Little Thompson River was not under a call from senior water rights located on the Little Thompson River or downstream on the South Platte River. In addition, the records indicate 14 days from 6/11/10 – 6/24/2010 when the Little Thompson River was not under administration. The conclusion of very limited free river conditions agrees with the common understanding and knowledge of the South Platte River basin water supply availability (South Platte BIP reference).

3.4 Stream Gaging

This section addresses development of alternative reconnaissance-level stream gaging plans for the Little Thompson River. The process of planning and designing a gaging considers many issues. A gaging plan must establish objectives for the data collection, consider many site-specific factors, develop access agreements, assess equipment options, and define funding mechanisms. The Study is developing the information necessary for the PMT to prioritize gaging station locations and purposes. To begin the process, the Stream Gaging Technical Memorandum provides a comparison of equipment and operation and maintenance costs for conceptual planning of gaging stations.

In a public meeting discussing the results of this study held in Berthoud on April 9, 2016, stakeholders indicated that the priority for stream gaging within the Little Thompson River watershed is early warning of flooding. There was a strong consensus in support of new emergency warning precipitation and stream flow monitoring within the watershed. The Little Thompson Watershed Coalition strongly supports Larimer, Boulder, and Weld Counties efforts to identify and implement early flood warning and other emergency preparedness for the area.

The stakeholders have a priority to develop comprehensive flood and emergency warning system as a part of Boulder, Larimer, and Weld counties emergency systems. There are multiple local fire department individually serving the Big Elk Meadows, Pinewood Springs, Blue Mountain and Dakota Ridge areas, and the towns of Berthoud, Milliken and Johnstown. Homes are located in areas with single points of access at river crossings. Early warning is a crucial issue to the stakeholders so that evacuation routes may be accessible and emergency personnel can be notified.

The primary function of streamflow gaging stations is to estimate the flow rate (aka, discharge) of the water in the stream or canal. The flow rate is typically reported in cubic feet per second (cfs). Gaging stations measure the height of the stream's water surface relative to an established datum, i.e., the stage.

There are several methods to measure and record the stage elevation. Stage heights can be measured by observing the water level on a staff gage. If continuous monitoring is desired, than a pressure sensor, or similar device, is installed within a stilling basin to measure and record the stage Real-time monitoring involves data loggers and telemetry equipment to broadcast the data to the office or data service provider.

A stage-discharge relationship is developed through a series of measurements at multiple and different stage heights. Essentially, the method involves measuring the flow velocity at multiple small cross-sectional intervals of the channel. A discharge value is calculated by multiplying the estimated velocity in each sub-section by the area for each sub-section, and summing these values across the entire stream cross-section. This method provides a valid estimate of the stream discharge.

There are many factors that affect gaging station costs. Station design attributes that affect cost include:

- The period of measurements, i.e., seasonal or year-round data collection;
- The need for continuous data collection with data logging equipment vs. "spot" sampling or periodic monitoring;
- The need for real-time data access capabilities;
- The number of data parameters collected (i.e., stage only, streamflow, water quality parameters, etc.);
- Site specific conditions affecting station infrastructure/housing design;
- The need for flood hardening and/or flood stage monitoring; and,
- Any requirements for published and peer reviewed discharge data.

Stream flow gaging station options were reviewed for the purpose of preliminary planning. These options provide a range of data acquisition and reporting alternatives, along with their associated costs. The concepts range from permanent, real-time data and multiple water related parameter monitoring stations, to synoptic one-and-done flow observations. Table 8 presents a summary of the gaging station options and costs[11].

Table 8: Menu of Stream Flow Measurement Options and Costs

Station Option	Capital Costs Equipment and Installation	Annual O&M	Comments
Permanent Station with Year-around Operations and Real-time Provisional Data Reporting	$8,000 - $22,000	$9,000 - $25,000	Peer reviewed and published data. (upper range incls. WQ monitoring, 1 parameter)
Contracted Temporary Station with Seasonal Operations and Real-time Provisional Data Reporting	$5,000 - $7,500	$10,000	Includes data hosting, Up to 4 site visits to check observations and develop stage relationship, etc.
Contracted Temporary Seasonal without Real-time data	$2,500 - $5,000	$10,000	Up to 4 site visits to check observations and develop stage relationship
Contracted Periodic Observations	None	Up to $2,500 per observation	One-time report

[11] Concept-level cost estimates.

4.0 Little Thompson River Water Supply Issues and Concerns

The following description of Little Thompson River water supply issues and concerns was developed from discussions with the Project Management Team, identified in this work, or suggested by the public and other entities interested in the assessment of consumptive and non-consumptive water needs. The list is preliminary and additional topics will be added as stakeholders express new ideas and direction.

Issues/concerns associated with consumptive water uses and the Little Thompson River stream flows and water supply operations:

- Drought year supplies for the Pinewood Springs Water District. In past drought years, the Pinewood Springs Water District hauled treated water from the Town of Lyons to supplement the supplies available from the District's water supply system. Even though the community practices extensive water supply conservation, in recent drought years the physical supply was not sufficient to meet demands[12].

- New domestic uses from exempt wells. This study evaluates new uses by exempt wells and estimated the upper limit volume of new exempt well consumptive use to be 80 acre-feet per year. Any new exempt wells will be located in the foothills and mountains west of and outside of the Little Thompson Water District. As any new exempt wells come on-line, tributary stream flows may be slightly diminished. The small volumes associated with the exempt uses are not a significant impact considering the watershed's overall water budget.

- Water supplies for the Little Thompson Watershed Restoration Master Plan's revegetation and construction activities. The revegetation activities will establish new vegetation in restoration areas and may require 2 or 3 years of irrigation. The restoration plans are to be completed in multiple phases, so water supplies for revegetation could be necessary for several years and at various locations along the river. The initial restoration projects include the Berthoud neighborhood, the Blue Mountain neighborhood, 83rd Street reach in Boulder County, and several currently funded projects in Larimer County reaches (awards/allocations from the Natural Resource Conservation Service's (NRCS) Emergency Watershed Protection Program (EWP) , and Community Development Block Grant-Disaster Recovery (CDBG-DR), as well as future unfunded projects. The Little Thompson Watershed Coalition may consider plans implementing water supply projects to supply the demands of the restoration activities. It is unknown how other watershed restoration efforts (e.g., Big Thompson, St. Vrain Rivers, Left Hand, Poudre, and Four Mile) may provide water supplies for stream restoration efforts. The Little Thompson Watershed Coalition will consider coordinating with these entities regarding water supplies for restoration activities.

[12] Personal communication, Ms. Gabriel Benson, Manager, Pinewood Springs Water District, January 2016.

- Conversion of imported water supplies from agricultural uses to municipal uses. This study's preliminary streamflow evaluation analysis confirms the importance of return flows from non-LTR water supplies to LTR flows in the lower reaches. Stakeholders want to know how conversions of the Big Thompson River, St. Vrain River, and C-BT Project water supplies may affect the diversion and use of native Little Thompson River water supplies.

- Conversion of native Little Thompson water supplies from agricultural uses to municipal uses. Stakeholders want to develop alternatives for future use of native water supplies that may allow leasing, temporary uses, Alternative Transfer Methods, and flexibility to water right owners that avoid conversion of agricultural uses to municipal uses.

- Changing irrigation practices that may affect water supplies. Changes in the irrigation method, e.g., from flood irrigation to sprinklers, do not require a change of water use. Consequently, irrigators may switch irrigation methods without changing the water right. Nonetheless, depending on the site-specific situation, steam flows may be affected by changes in irrigation methods. These changes may offer water savings or supplies for other water uses.

- The PMT and stakeholder would like to develop additional data and information regarding water use reporting in the watershed.

Issues/concerns associated with <u>non-consumptive water uses</u> and the Little Thompson River stream flows and water supply operations:

- In-stream flows, low flows and river "dry-up". This study identifies locations and general timing of low flows within certain reaches of the Little Thompson River. Stakeholders want to find ways to supplement environmental flows in the watershed and particularly in the river above the canyon mouth. The Little Thompson River does not have any in-stream flow water rights to protect environmental flows. The PMT seeks additional information and data regarding the aquatic species and habitats of the Little Thompson River. This study is a first step in documenting timing and volumes of stream flows and may be useful to the Colorado Water Conservation Board for further evaluation of in-stream flows for the watershed.

- Colorado-Big Thompson Project operations in the North Fork of the Little Thompson River. Occasionally, C-BT Project operations release water into the North Fork of the Little Thompson River in order to bypass the Pole Hill power plant. These are unscheduled releases that occur when emergency or unforeseen circumstances arise at the power plant. The consequences of these operational releases are rapid increases of stream flow in the North Fork below Pole Hill for short periods of time. The stakeholders believe that there is potential safety issues associated with the releases. The PMT would like to initiate discussions among the Bureau of Reclamation, the Department of Water Resources, stakeholders, and NCWCD with the goal of developing consistent communications and readily available information pertaining to the by-pass operations.

5.0 Plans and Processes – Scope of Work for Phase 2 of the Needs Assessment

This section presents a draft Phase 2 scope of work and budget for discussion with the stakeholders and Project Management Team. The goal of the Phase 2 work is to identify effective solutions to the consumptive and non-consumptive water supply issues/concerns. This report is a reconnaissance phase, to seek data, input, and possible solutions for a Phase 2 that include but are not limited to those presented in the report. The scope of work is preliminary and additional information may be added as stakeholders express new ideas and direction.

The plans and processes identified by the stakeholders include:

1. Investigate water storage for multi-use water needs including municipal, domestic, irrigation, fire mitigation, and environmental uses. The additional storage would help to maintain irrigated agriculture served by the native Little Thompson River supplies, provide dry year water supplies for Pinewood Springs and possibly other domestic and municipal water users, and to supplement flow to maintain stream flow levels in the Little Thompson River. The next phase of study could determine goals for the project such as storage volume, reservoir location, and permitting requirements.
2. Coordinate with Larimer, Boulder, and Weld Counties to implement early flood warning stream and precipitation monitoring within the Little Thompson River watershed. Look for opportunities for stakeholder participation in streamflow monitoring at Milliken.
3. Evaluation of water supply operations and determine the feasibility of re-routing C-BT Project and possibly other supplies to benefit the Little Thompson River environmental flows. Initially, this work would evaluate the need and timing of environmental flows for late summer and early fall with emphasis on the reach from the confluence of the North Fork to Dry Creek. The next phase of the study would evaluate flow rates, water sources, locations, timing, and initial feasibility of re-routing.
4. As may be necessary, identify potential water supplies for various revegetation activities associated with the Little Thompson Watershed Restoration Master Plan. The potential sources may include leasing and temporary water supply plans.
5. Initiate a process to review the Division 1 Water Court Resume to identify and evaluate water right change applications and other activities within the Little Thompson River watershed.
6. Follow the progress of South Platte Basin Alternative Transfer Methods (ATMs) studies with a focus on how ATMs may be applied in the Little Thompson watershed. Investigate leasing programs that would encourage agricultural uses of native LTR water supplies while providing flexibility to water owners.
7. In conjunction with the Little Thompson Watershed Coalition and the Big Thompson Conservation District, develop a clearinghouse of educational opportunities for water users regarding water conservation practices and techniques that would also protect water rights.

Plans and Processes…..continued

The activities and proposed planning budgets associated with certain plans and processes are described below.

Investigate Developing Water Storage for Multiple Uses

Additional volumes of stored water supplies would help maintain certain stream flows for environmental purposes and serve multiple other human uses. The Project Management Team is interested in further investigations of storage reservoirs in the upper portion of the watershed. This work would investigate the preliminary feasibility of up to 3 reservoir sites.

For each of the three alternative reservoir sites, the study would determine land ownership, identify project water rights, potential participants, funding sources, and permitting requirements. The results would assist the Project Management Team and stakeholders in making decisions regarding the feasibility of new water storage in the watershed. This work would be reported in a technical memorandum. The planning budget for this work is $25,000.

Preliminary Evaluation of Water Supply Operations

This work would provide technical support to the Project Management Team regarding water supply operational alternatives that may re-route water deliveries such that certain reaches of the Little Thompson River have higher and more consistent flows. To pursue operational alternatives, the PMT initially plans to meet with representatives from the Bureau of Reclamation. If that meeting indicates any opportunities, then this element of the scope of work would help develop the technical aspects of the operational alternatives (e.g., sources, timing and amount of flows). The planning budget for this activity is $2,000 - $10,000[13].

Identify Potential Water Supplies for Master Plan Restoration Activities

This activity would develop alternative water supply sources for restoration activities within the Little Thompson River watershed. In addition, the work would evaluate regional watershed restoration activities to determine how other watershed restoration plans are dealing with water supplies for their restoration needs. If there is a regional need for restoration water supplies, then this work would initiate development of supplies for the larger area. The planning budget for this activity is $10,000.

Participate and Lead Stakeholder Meetings Associated with Phase II Activities

The scope for participating in Phase II stakeholder, agencies, and water user meetings will depend on the number and location of the meetings. The work involves planning the meetings inviting participants, outreach, reporting and follow-up to the meetings. Initially, there may need to be three or four meetings. The planning budget is $1,000 - $5,000 per meeting.

[13] The $2,000 budget item covers participation at the initial meeting with BOR. If the element continues, then the $10,000 budget would cover the next step activities.

6.0 References

CDM, 2010. South Platte SWSI Basin http://cwcb.state.co.us/water-management/basin-roundtables/Pages/SouthPlatteBasinRoundtable.aspx

Colorado Decision Support System. http://cdss.state.co.us/Pages/CDSSHome.aspx

HDR and Sage Consulting, 2015. South Platte Basin Implementation Plan, Metro Basin Roundtable and the South Platte Basin Roundtable. http://www.southplattebasin.com/pdfs/South-Platte-Basin-Implementation-Plan-April-17-2015.pdf

Tetra Tech, et al, 2014. Little Thompson Watershed Restoration Master Plan. http://www.ltwrc.org/master_plan_level_1.html

APPENDICES AND TECHNICAL MEMORANDA

to Summary Report for the Water Supply, Use and Planning Study and Needs Assessment for the Little Thompson River/Watershed

May 25, 2016

Prepared for:
The Little Thompson Watershed Coalition
Colorado Water Conservation Board WSRA Contract 150707

Big Thompson Conservation District acting as fiscal agent for the project
Prepared by: Canyon Water Resources, LLC and George Wear Consulting, LLC

Little Thompson Watershed Coalition • 435 High Street, Lyons, CO 80540 • 303-823-2370

To: Project Management Team, Little Thompson Watershed Coalition

From: Canyon Water Resources, LLC and George Wear Consulting, LLC

Subject: WSRA Contract 150707, Water Supply, Use and Planning Study - Needs Assessment Little Thompson River, **Key Element 1 - Agricultural Water Use Technical Memorandum**

Date: February 18, 2016 revised May 25, 2016

Introduction

The following Technical Memorandum (TM) is a portion of the Little Thompson Watershed Restoration Coalition, Water Supply, Use and Planning Study - Needs Assessment for the Little Thompson River/Watershed. The work is funded by the Colorado Water Conservation Board WSRA Contract 150707 and the Big Thompson Conservation District is acting as the fiscal agent for the project. This technical memorandum reports on the use of water for agricultural purposes within the Little Thompson River watershed (aka the study area).

This work describes the irrigated acreages, cropping patterns, and quantifies the agricultural water supply diversions for irrigated areas within the watershed. There are 8 primary irrigation diversion structures associated with Little Thompson River water supplies (i.e., the "native" supplies). These structures may also divert Colorado-Big Thompson Project (C-BT) water supplies. For the 10 diversion structures, the reporting quantifies the "native" and "imported" water supply diversions[14].

This technical memorandum is a portion of Key Element 1.0 of the Scope of Work and Response to Solicitation[15].

Discussion

The following evaluation of agricultural water diversions reports information from the Colorado Decision Support System Water Division 1 databases (CDSS). The irrigated areas and crop types are from the Division 1 year 2010 interpretation and mapping. The lists of wells, ditches, pipelines, and reservoirs are from the Administrative Structures database. Diversion records are summarized from the CDSS Diversions database. The estimates of consumptive use are from the South Platte StateCU tool.

Since 2009, there has been minimal to practically no use of groundwater supplies to irrigate land in the Little Thompson River watershed. Several irrigation wells were identified as included in augmentation plans, but given the relatively few wells and associated low diversion rates, the volume of any irrigation use is small as compared to the surface water diversions use. The Technical Memorandum – Evaluation

[14] In this study, imported water supplies include Colorado-Big Thompson Project, Big Thompson River, and St. Vrain River diversions.
[15] Key Element 1 includes identification of potential impacts of reduced water supplies from drought and reduction of imported water supplies. That evaluation is included in the Stream Flow Evaluation Technical Memorandum.

of Groundwater Well Domestic Uses includes a brief discussion of the limited agricultural groundwater uses (see Appendices).

The following sections quantifies agricultural water supplies diverted from the natural flow in the Little Thompson River (i.e., the "native" supplies) and water supplies that originate from outside the Little Thompson River watershed (i.e., "imported"). There are 8 primary irrigation diversion structures associated with Little Thompson River water supplies. The Little Thompson River structures may also divert imported water supplies (i.e., C-BT Project water supplies).

The imported water supplies include diversion structures on the Bit Thompson River and St. Vrain River. This work identified 7 structures that may deliver imported water supplies it irrigated areas within the watershed (aka non-Little Thompson River structures).

Irrigated Areas and Crop Types

The quantification of irrigated areas and crop type is based on the Division 1, Year 2010 interpretation and associated GIS coverage of irrigated areas (CDSS). The 2010 interpretation is the State's most recent "snapshot" of irrigated areas in the watershed. The irrigated area database includes various data fields that describe the irrigated areas. This evaluation utilizes the structure identification number, location and area of the fields, water source, and crop type.

The analysis first selected all irrigated areas contained within or touching the watershed. Figure 1 is a map of the year 2010 irrigated areas within or touching the study area. The mapping indicates there are approximately 32,300 acres of potentially irrigated areas in the Little Thompson River watershed.

Of the 32,300 acres, approximately 4,600 acres are associated with water supplies diverted from the natural flow of the Little Thompson River. Figure 2 is a map indicating the lands with native Little Thompson River water supplies. There are 8 ditches (structures) associated with the 4,600 acres. These ditches represent the primary use of the natural flows[16].

1. Boulder Larimer County Irrigation and Manufacturing Ditch
2. Eagle Ditch
3. Jim Eglin Ditch
4. Miner Logan Ditch
5. Osborne Caywood Ditch
6. Supply Lateral/Culver Ditch
7. Rockwell and Rockwell Pipeline
8. W R Blower Ditch

The irrigated crop types associated with the native supplies include alfalfa, barley, corn, dry beans, grass pasture, sugar beets, sunflowers and wheat. In 2010, alfalfa and grass pasture was the crop type on approximately 3,100 acres. Corn totaled about 700 acres. Barley, sugar beets, wheat, and sunflowers

[16] There are two other primary structures that divert native LTR water supplies; the Beeline Ditch and the Great Western Indus. These structures did not have 2010 irrigated areas either within or outside of the watershed.

comprised the balance of the total area. Table 1 provides a summary of the structures, crop types, and irrigated areas.

Of the 32,300 acres of potentially irrigated area within the watershed, approximately 27,700 acres are associated with diversion structures located on streams other than the Little Thompson River (i.e., the non-Little Thompson River structures). Figure 3 is a map of the irrigated areas served solely by imported water supplies. There are 7 ditches (structures) associated with the 27,700 acres.

1. Big T Platte River Ditch
2. Handy Ditch
3. Highland Ditch
4. Hillsborough Ditch
5. Home Supply Ditch
6. Supply Ditch
7. WDID 400692 – St. Vrain Supply Canal

The irrigated areas associated solely with imported water include approximately 15,500 acres of grass pasture and alfalfa. Corn totals approximately 9,400 acres and was the second largest single crop type. Barley, sugar beets, and fall wheat totaled about 5,900 acres, and dry beans, small grains, and sunflowers made up the remaining areas (approx. 1,500 acres). Table 1 provides a summary of the structures, crop types, and irrigated areas.

Figure 1: Division 1 Year 2010 Irrigated Areas within the Study Area

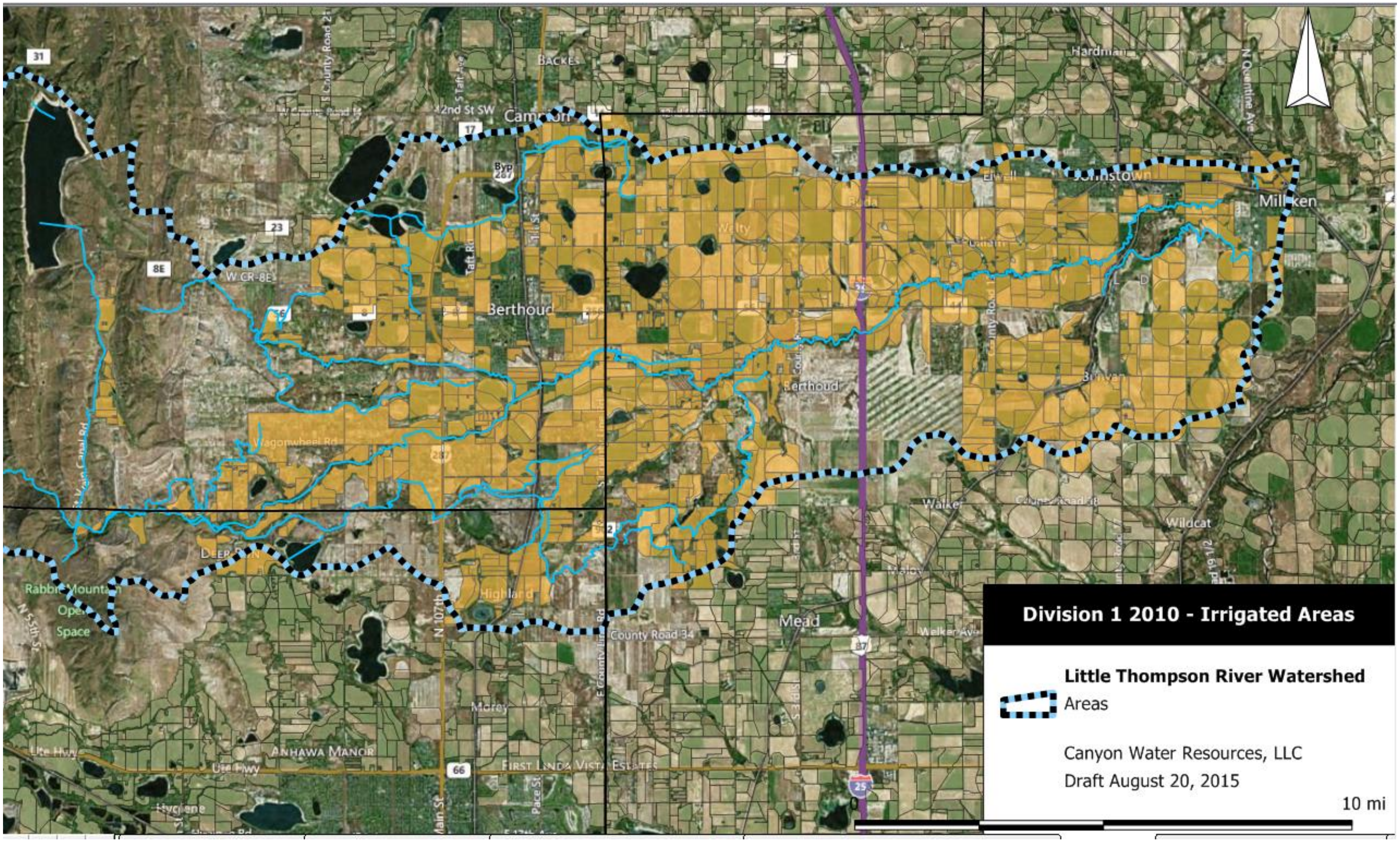
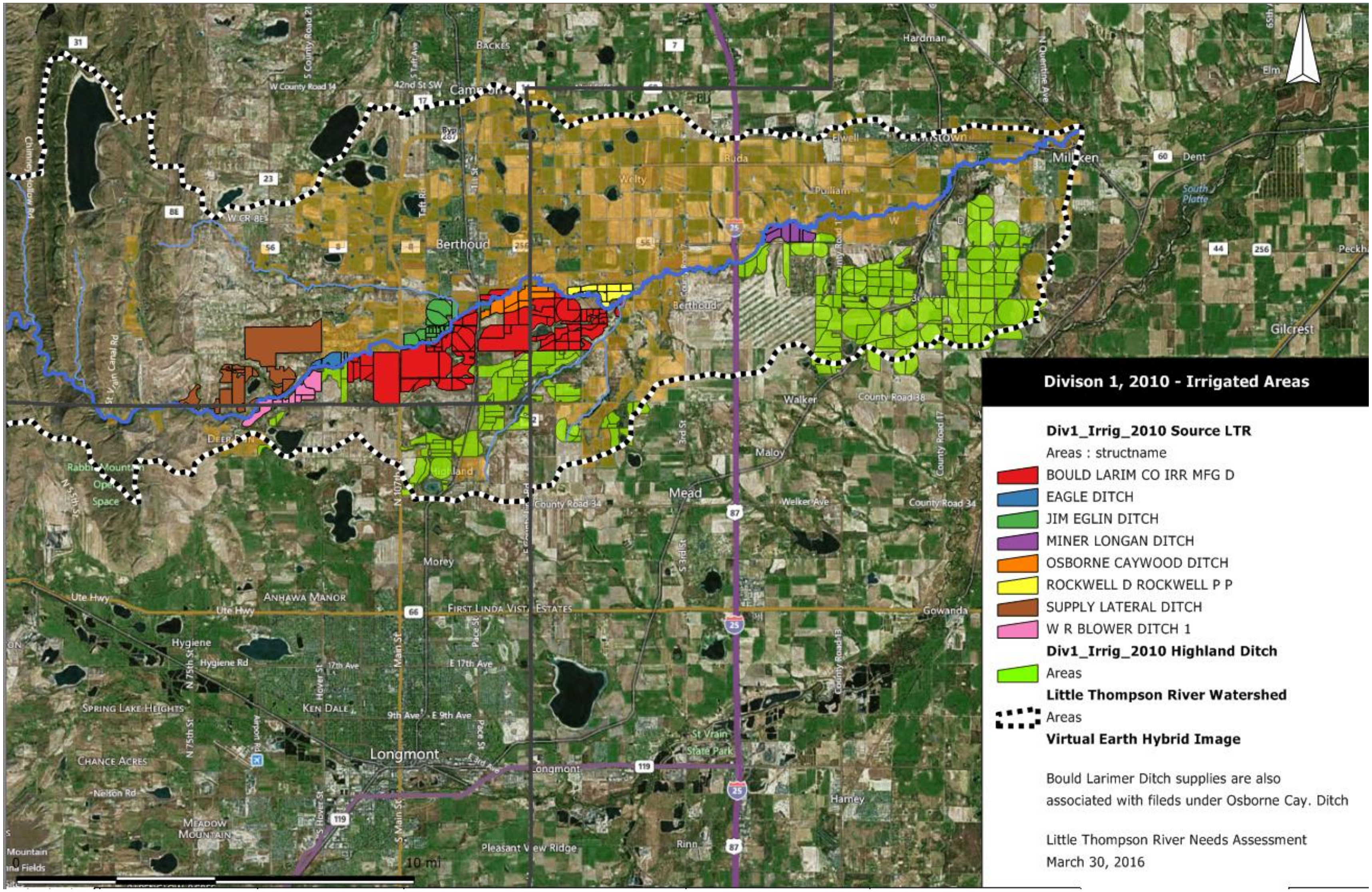


Figure 2: Division 1 Year 2010 Irrigated Areas Associated with Native Little Thompson River Water Supplies



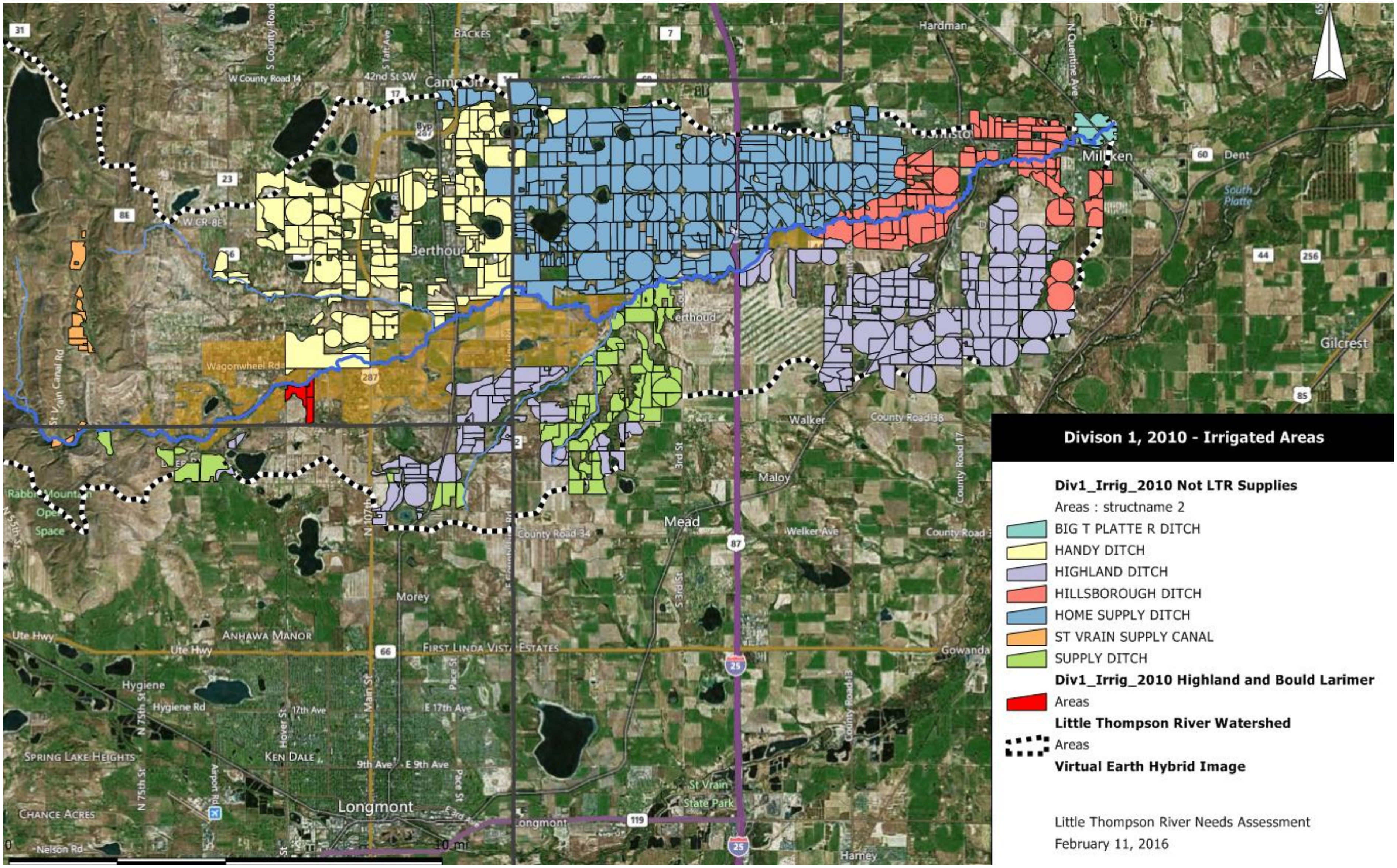
Note: Irrigation ditch service areas may be more extensive than indicated in the 2010 parcel mapping. Certain parcels associated with the Highland Ditch may be irrigated with Boulder Larimer "Old Ish" water supplies.

Table 1: Summary of Division 1 Year 2010 Irrigated Areas in the Little Thompson River Watershed

			Division 1 Year 2010 Irrigated Acreage within the Study Area by Crop Type									
8/14/2015	WDID	Structure name	Total acres	ALFALFA	BARLEY	CORN	DRY_BEANS	GRASS_PASTURE	SMALL_GRAINS	SUGAR_BEETS	SUNFLOWER	WHEAT_FALL
Water Source Not Little Thompson	400502	BIG T PLATTE R DITCH	184			75		109				
	400521	HANDY DITCH	5230	1174	253	805	22	2332	110	197		337
	400523	HILLSBOROUGH DITCH	2501	335	0	1169	65	417		269		246
	400524	HOME SUPPLY DITCH	9263	1740	1106	3455	291	1650	7	432	178	404
	400692	ST VRAIN SUPPLY CANAL	445					445				
	500523	SUPPLY DITCH	3213	146	230	1299		1299	6	185		48
	500526	HIGHLAND DITCH	6838	1252	534	1921	505	1509	115	424		578
		Total	**27674**	**4647**	**2123**	**8724**	**883**	**7761**	**238**	**1507**	**178**	**1613**
Water Source Little Thompson	400587	Beeline Ditch	No associated irrigated areas found in database									
	400588	BOULD LARIM CO IRR MFG D	2475	107	179	451	32	1319	97	117		173
	400592	EAGLE DITCH	70					70				
		Great Western Ind	No associated irrigated areas found in database									
	400596	JIM EGLIN DITCH	267	94		65		48			39	21
	400599	MINER LONGAN DITCH	162	146		16						
	400600	OSBORNE CAYWOOD DITCH	240	41	70	113	16					
	400601	ROCKWELL D ROCKWELL P P	176	44		38	16	20		21		37
	400602	SUPPLY LATERAL DITCH	1005					1005				
	400603	W R BLOWER DITCH 1	238					238				
		Total	**4633**	**432**	**249**	**683**	**64**	**2700**	**97**	**138**	**39**	**231**
		Combined Total	32307	5079	2372	9407	947	10461	335	1645	217	1844

Note: Irrigation ditch service areas may be more extensive than indicated in the 2010 parcel mapping. Certain parcels associated with the Highland Ditch may be irrigated with Boulder Larimer "Old Ish" water supplies.

Figure 3: Division 1 Year 2010 Irrigated Areas with Solely Imported Water Supplies



Diversion Records

This section summarizes the diversion records associated with the ditches and pipelines that have diversion records and identified irrigated areas within Little Thompson River watershed (Table 1). The evaluation includes diversion records for the period November 2000 – October 2014. The work quantifies the average monthly diversions by structure and water source.

The diversion records indicate that combined, the 8 Little Thompson River structures[17] diverted an average of approximately 9,700 acre-feet per year (af/yr) for the period 2000 – 2014. The total average volume coded as natural flow (i.e., native Little Thompson River water supplies) was approximately 7,200 af/yr. The average annual volume of imported water supplies associated with these structures was 2,500 af/yr. The diversion records indicate that the native supply represents about 75% of the total water volume diverted by the structures.

Most of the irrigated area within the Little Thompson River watershed is associated with "imported" water supplies (Table 1 and Figure 3). The non-Little Thompson River structures[18] convey Big Thompson River, St. Vrain River, and C-BT Project water supplies to irrigated areas within and outside of the watershed. This evaluation reports water from all of these sources as water supplies imported to the watershed.

The diversion records indicate that combined, the non- Little Thompson River structures diverted an average of approximately 111,000 acre-feet per year (af/yr) for the period 2000 – 2014 (Table 2). The 2010 estimate of irrigated acreage in the LTR watershed indicates that combined, the non-Little Thompson River structures served approximately 64,500 acres (Figure 4). As a preliminary estimate of diversions into the watershed, the supply is calculated based on the proportion of the area within the watershed to the total irrigated area. So on that basis, the calculated volume for the irrigated areas within the watershed is approximately 46,600 acre-feet.

Appendix A includes summaries of the diversion records.

[17] Beeline Ditch, Boulder Larimer Co. Irr. and Mfg. Ditch, Eagle Ditch, Jim Eglin Ditch, Miner Logan Ditch, Osborne Caywood Ditch, Rockwell and Rockwell Ditch, Supply Lateral Ditch, and W R Blower Ditch.
[18] Big T Platte River Ditch, Handy Ditch, Hillsborough Ditch, Home Supply Ditch, Supply Ditch, and Highland Ditch.

Table 2: Average Water Supply Volume for 2000 – 2014, Little Thompson River Diversion Structures

2/12/2016	2010 Irrigated Area (acres)	Average Supply Volume for Irrigation Years 2000 - 2014 (acre-feet)															
Structure Name			Percent	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Total by Source (af)	Total
Beeline Ditch	none	Native	100%	0	0	0	0	0	98	248	431	368	162	222	117	1427	1427
		C-BT	0%	0	0	0	0	0	0	0	0	0	0	0	0	0	
BOULD LARIM CO IRR MFG D	2475	Native	63%	15	13	15	39	270	804	1132	288	105	62	19	37	2800	4459
		C-BT	37%	0	0	0	0	0	0	0	19	265	400	218	758	1659	
EAGLE DITCH	70	Native	83%	0	0	0	0	1	22	111	36	27	19	9	12	237	286
		C-BT	17%	0	0	0	0	0	0	10	5	12	13	6	3	49	
Great Western Ind	none	Diversion records not found in CDSS															
JIM EGLIN DITCH	267	No Diversion Records for 2000 - 2014															
MINER LONGAN DITCH	162	Native	53%	0	0	0	0	0	3	22	73	46	54	61	22	280	529
		C-BT	47%	0	0	0	0	0	0	9	40	91	91	18	0	249	
OSBORNE CAYWOOD DITCH	240	Native	95%	0	0	0	0	0	5	90	171	162	135	51	0	613	648
		C-BT	5%	0	0	0	0	0	0	3	9	8	11	2	2	35	
ROCKWELL D ROCKWELL P P	176	Native	71%	0	0	0	0	0	6	62	135	84	64	113	122	586	827
		C-BT	29%	0	0	0	0	0	0	9	14	76	92	40	10	241	
SUPPLY LATERAL DITCH	1005	Native	83%	0	0	0	0	6	79	360	214	87	65	33	10	855	1032
		C-BT	17%	0	0	0	0	0	0	15	26	21	30	36	50	177	
W R BLOWER DITCH 1	238	Native	87%	0	0	0	0	0	124	121	75	34	29	42	18	413	473
		C-BT	13%	0	0	0	0	0	0	12	11	14	10	7	10	60	
	4633	Native	74%											Total Native		7211	9681
		C-BT	26%											Total C-BT		2470	

Note: The Boulder Larimer Reservoir occasionally stores C-BT Project water supplies that are delivered via the Highland Ditch. The available diversion records indicate diversions 2003, 140 af; 2005, 476 af; 2007, 506 af; 2008 357 af; and 2009, 1,428 af.

Figure 4: Division 1, 2010 Irrigated Areas for Structures without Little Thompson River Water Supplies

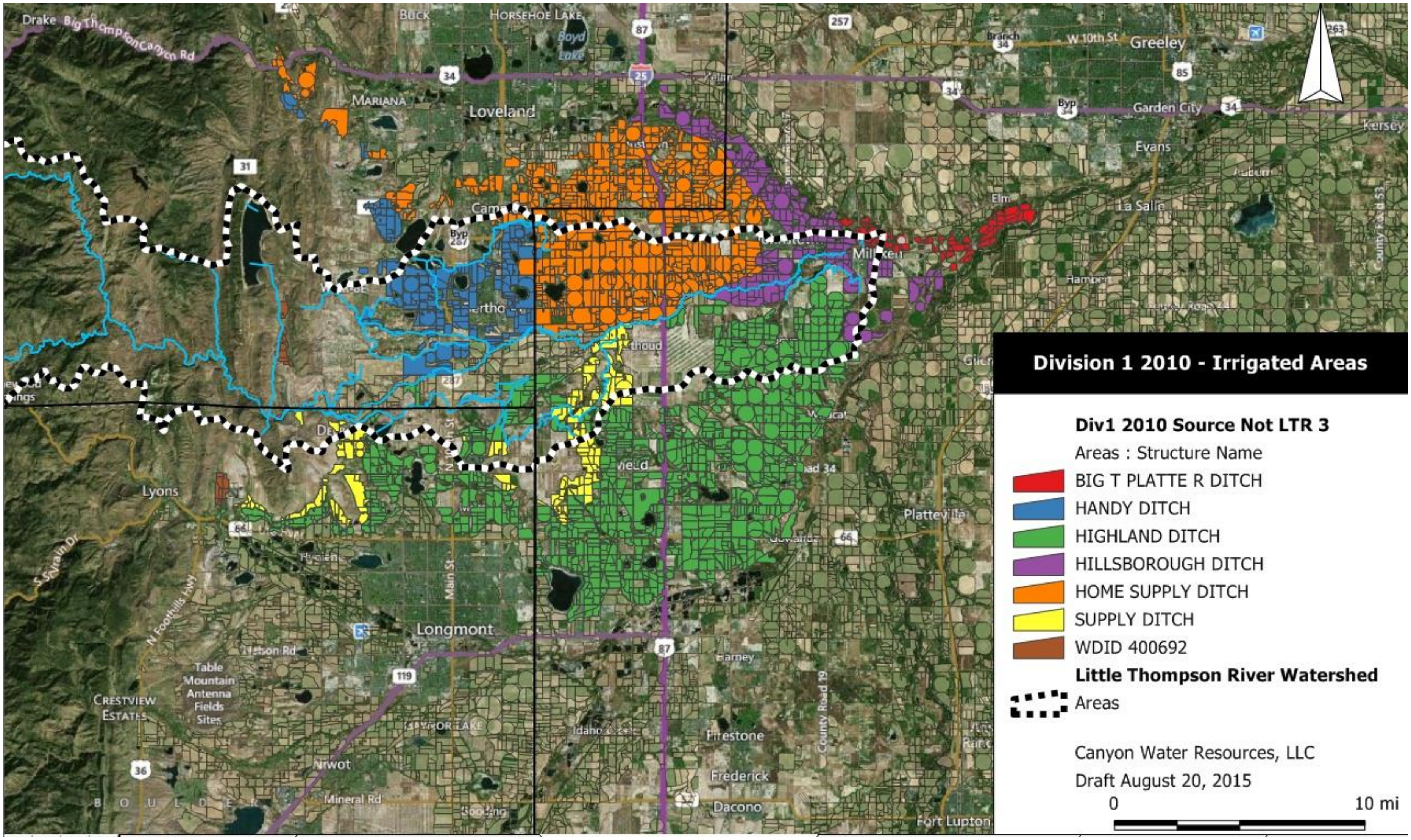


Table 3: Average Supply Volume 2000 – 2014, Non-Little Thompson River Structures

2/12/2016				Average Supply Volume for Irrigation Years 2000 - 2014 (acre-feet)												
Structure Name		Irrigated Area (acres)	Percent	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Total by Source (af)**
BIG T PLATTE R DITCH	Not in LTR	1166	86%													
	In LTR	184	14%													
	Total IA	1350		0	0	0	0	332	1137	1773	2166	1807	1364	1102	0	9680
HANDY DITCH	Not in LTR	855	14%													
	In LTR	5230	86%													
	Total IA	6085		0	0	0	0	0	915	3517	2631	2389	2074	522	0	12047
HILLSBOROUGH DITCH	Not in LTR	2400	49%													
	In LTR	2500	51%													
	Total IA	4900		0	0	0	0	276	1823	3261	4086	3659	2073	237	0	15415
HOME SUPPLY DITCH	Not in LTR	9347	50%													
	In LTR	9263	50%													
	Total IA	18610		1244	1031	803	1109	771	2096	4753	4706	3753	3170	1672	1207	26316
SUPPLY DITCH	Not in LTR	1087	25%													
	In LTR	3213	75%													
	Total IA	4300		27	0	0	21	706	1780	2025	2005	1527	898	416	73	9478
HIGHLAND DITCH	Not in LTR	22337	77%													
	In LTR	6838	23%													
	Total IA	29175		123	117	98	587	1156	4269	9746	10426	8029	4083	1062	159	39853
Combined Structures	Not in LTR	37192	58%													
	In LTR	27228	42%													
	Total IA	64420		1394	1148	901	1717	2909	12020	25075	26020	21164	13662	5011	1439	111021

StateCU Consumptive Use Data

The following discussion reports information and results from the Colorado Decision Support System State CU Tool (CDSS)[19], [20]. This evaluation is meant to provide a general indication of consumptive use for selected ditches and irrigation systems that divert native water supplies from the Little Thompson River within the watershed. The following discussion is not an engineering opinion of consumptive use for the ditches.

The StateCU tool includes data and calculations for the years 1950 – 2006. Since this study is focusing on the existing uses and current conditions, the evaluation reports the estimated water supply limited consumptive use for the years 2000 – 2006 (the available period that overlaps the reported diversion records). The tool utilizes the Blaney-Criddle method. The tool includes and uses diversion records to account for historically diverted supplies and calculates the so-called "water supply limited" consumptive use.

For the period 2000 – 2006 and for District 4, the StateCU tool uses the State's year 2001 description and mapping of the irrigated areas. The previous section discussed irrigated areas for 2010. A cursory comparison of irrigated areas for 2001 with 2010 showed only minor differences in areas and/or crop types. The 2001 irrigated areas available in StateCU are sufficient for this preliminary level of investigation.

The reported water supply limited consumptive use accounts for effective rainfall (i.e., the volume of rainfall taken up and transpired by the crop), winter-time precipitation, soil moisture, and the water supply (based on diversion records) available to the crop including conveyance losses and irrigation system efficiency. Generally for this area, the effective precipitation and winter-time precipitation may meet a significant portion of crop water uses in the early spring. Irrigation water supplies are the greatest portion of crop water uses in late June, July, and August.

Table 4 summarizes the StateCU consumptive use estimates for the primary Little Thompson River diversion structures. From the previous discussion, taken as a whole, diversions by the Little Thompson River structures are approximately 25% imported and 75% native supplies. The table indicates that for the combined acreage of approximately 4,600 acres, the 2000 – 2006 average annual total consumptive use is approximately 3,800 acre-feet, or a use factor of approximately 0.8 acre-foot per acre (af/ac).

[19] The documentation for the CDSS includes this disclaimer: This program is furnished by The State of Colorado (State) and is accepted and used by the recipient upon the expressed understanding that the State makes no warranties, express or implied, concerning the accuracy, completeness, reliability, usability, or suitability for any particular purpose of the information and data contained in this program or furnished in connection therewith, and the State shall be under no liability whatsoever to any person by reason of any use made thereof.

[20] As of July 2015, the most recent version of the StateCU tool for the South Platte River contains input data up through 2006

Table4: StateCU Supply Limited CU

Structure Name	Area (acres)	StateCU Supply Limited Consumptive Use Average for years 2000 - 2006 (acre-feet)													
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	AF/ac
BOULD LARIM CO IRR MFG D	2641	0	0	6	91	248	402	748	506	274	61	4	0	2340	0.89
EAGLE DITCH	69	0	0	0	0	7	7	8	6	0	0	0	0	29	0.41
JIM EGLIN DITCH	150	0	0	0	0	9	10	4	4	2	0	0	0	29	0.17
MINER LONGAN DITCH	184	0	0	0	4	23	59	61	49	15	1	0	0	212	1.14
OSBORNE CAYWOOD DITCH	131	0	0	0	5	31	50	44	26	12	1	0	0	168	1.29
ROCKWELL D ROCKWELL P P	229	0	0	0	8	34	69	91	59	34	9	0	0	304	1.32
SUPPLY LATERAL DITCH	1024	0	0	0	51	173	94	56	39	35	28	0	0	477	0.47
W R BLOWER DITCH 1	232	0	0	0	21	54	62	48	22	21	12	0	0	239	1.03
Total	**4660**	**0**	**0**	**6**	**180**	**579**	**753**	**1060**	**711**	**393**	**112**	**4**	**0**	**3798**	**0.84**

From StateCUMonthlyTimeSeriesChart1 - Microsoft Excel

Other Identified Water Uses

The uses discussed above represent the majority of agricultural surface water use within the watershed. However, there are numerous other diversion structures and water uses within the Little Thompson River watershed. Table 5 lists the all the structures (from the Administrative Structures database and not including wells) within the watershed. Later phases of study may further investigate other diversion structures and water uses.

Table 5: List of Administrative Structures in the Little Thompson River Watershed

In Use Code	WDID	Structure Type	Structure Name	County	Decreed Uses	Associated Case Numbers	Decreed Rate abs (cfs)	Decreed Rate cond (cfs)	Decreed Vol abs (af)	Decreed Vol cond (af)	Diversion Record Start	Diversion Record End
Active Structure with Contemporary Diversion Records	402750	Aug/Repl	BIG ELK MEADOWS AUG	LARIMER		95CW0238					2004	2005
	402533		JELLYSTONE AUG	LARIMER		07CW0336					0	0
	402578		MEADOWDALE RANCH AUG	LARIMER		87CW0061					0	0
	402501		PINEWOOD AUG	LARIMER		W8001					0	0
	402513		SPRING GULCH RANCH AUG	LARIMER		W6440					0	0
	400587	Ditch	BEELINE DITCH	WELD	irr	02CW0269, 05CW0331, CA4862	40	140	0	1000	1950	2014
	400588		BOULD LARIM CO IRR MFG D	BOULDER	storage, irr, aug	05/28/1883, 95CW0238, 97CW0363, CA4862, W8451	1136.72	0			1950	2014
	400592		EAGLE DITCH	LARIMER	irr	05/28/1883, 84CW0204	8	0			1950	2012
	400596		JIM EGLIN DITCH	LARIMER	irr	05/28/1883	3.642	0			1950	2002
	400599		MINER LONGAN DITCH	WELD	irr	01CW0273, 84CW0204, CA4862	8	0			1950	2014
	400600		OSBORNE CAYWOOD DITCH	LARIMER	irr	05/28/1883, 84CW0204	8.12	0			1950	2014
	400602		SUPPLY LATERAL DITCH	BOULDER	irr	05/28/1883, 91CW0121, CA4862, CA6629, W8001	58.59	0			1950	2014
	400603		W R BLOWER DITCH 1	BOULDER	irr	01CW0273, 05/28/1883	27.3	0			1950	2014
	400807	Pipeline	BIG ELK MEADOWS PL	BOULDER	irr, muni, rec, fish, dom	10CW0212, W1767	0.038	0.962			2000	2014
	400601		ROCKWELL D ROCKWELL P P	LARIMER	irr	CA4862	21	0			1950	2014
	400659	Pump	HAYMOND PORTABLE PUMP	LARIMER							2010	2012
	400781		JELLYSTONE POND DIVERSION 2	LARIMER	comm, rec, fish, dom	07CW0336	0	1			0	0
	400915		MCCARTY PUMPING PLANT	WELD	irr	06CW0073, 99CW0138	1.8	0			2011	2011
	404026	Reservoir	BAXTER LAKE RES	WELD	irr, dom	W8451			225.5	0	0	0
	404156		BOULDER LARIMER RES	BOULDER	stor, irr, aug	95CW0238, 97CW0363, CA4862			7650.8	1693	1993	2014
	403348		CROW LANE RESERVOIR 1	LARIMER	stor,muni, rec, fish, dom, aug, wildlife	02CW0347, 10CW0290	0	0	0	51	2008	2008
	404159		CULVER RES	LARIMER	stor, aug	79CW0331, 95CW0285, CA4862	0	0	148	0	2008	2014
	403502		KOOLSTRA PONDS 1-8	WELD	fish	01CW0182			0	42	0	0
	403506		KOOLSTRA STORAGE POND	WELD							0	0
	403610		MCCARTY POND	WELD	irr, fish, stock	11CW0005, 95CW0251			0	18	0	0
	403664		MEADOW LAKE	LARIMER	irr, muni, rec, fish, fire	95CW0238, W1768	0	0	64.6	0	0	0
	403665		MEADOWDALE RANCH POND 1	LARIMER	irr, rec, fish, fire, dom, stock	84CW0575			1.55	1.95	0	0
	403695		SPRAGUE POND 1	LARIMER	irr, rec, fish, fire, stock, wildlife	04CW0297, 97CW0360			50	0	2000	2006
	403707		SPRAGUE POND 2	LARIMER	irr, rec, fish, fire, stock, wildlife	97CW0360			0	50	0	0

Note: The shading indicates the structures diverting native Little Thompson River water supplies, with diversion records and included in the year 2010 irrigated areas as mapped by the SEO.

Table 5: (continued)

In Use Code	WDID	Structure Type	Structure Name	County	Decreed Uses	Associated Case Numbers	Decreed Rate abs (cfs)	Decreed Rate cond (cfs)	Decreed Vol abs (af)	Decreed Vol cond (af)	Diversion Record Start	Diversion Record End
Active Structure Diversion Records Not Maintained	400805	Ditch	BARRETT DITCH	LARIMER	irr	W7184	0.33	0			0	0
	400804		BOX CANYON DITCH	BOULDER	irr, stock	89CW0240	0.8	0			0	0
	400819		CUSHMAN LAND CO DITCH	LARIMER	irr, stock	W8765	5	0			0	0
	400832		FELSENHEIM DIVERSION	LARIMER	irr	86CW0201	0.037	0			0	0
	400837		GREAT WESTERN IND	WELD	ind	W0372	13	0			0	0
	400593		GRIFFITH DITCH	LARIMER	irr	CA4862	4	0			0	0
	400841		J B DITCH CO EAST	LARIMER	irr	79CW0135	0.065	0			0	0
	400842		J B DITCH CO WEST	LARIMER	irr	79CW0135	0.065	0			0	0
	400598		MEINING DITCH	BOULDER		05/28/1883, 91CW0121					1950	1956
	400790		PINEWOOD LAKE/POWELSON DIVERSION	LARIMER	muni	10CW0290	0	0			0	0
	400681		ROSE RANCH X-7	LARIMER							1961	1961
	400893		SPRING GARDEN DITCH	LARIMER	irr	W0341	3	0			0	0
	400900		VALHALLA DIVERSION	LARIMER	irr	86CW0201	0.037	0			0	0
	400731	Pipeline	BIG ELK MEADOW PL ALT PT	LARIMER	irr, muni, rec, fish, dom	02CW0251	0	0			0	0
	400843		JIMMY SPRING PL	LARIMER	irr, rec, fish, fire, dom, stock	84CW0575	0.2	0			0	0
	400874		ROBERTS PUMPING PLANT	LARIMER	irr	82CW0456	1	0			0	0
	400907	Pump	CUSHMAN LAND PUMPING PLA	LARIMER	irr, stock	W8765	0.5	0			0	0
	400829		DRY CREEK PUMPING PLANT	LARIMER	irr, other	81CW0173, W9186	1.33	3.67			0	0
	400671		LOUIS BREISCH(PUMP PLT)	LARIMER							1955	1969
	402006	Reach	BIG ELK MEADOWS AUG IMPACT REACH	LARIMER	aug	95CW0238	0	0			0	0
	402200		JELLYSTONE AUG IMPACT REACH	LARIMER	irr, muni, ind	07CW0336	0	0			0	0
	402211		MEADOWDALE RANCH AUG IMPACT REACH	LARIMER							0	0
	403609	Reservoir	BEAVER LAKE	LARIMER	stock	W1217			0.07	0	0	0
	404163		BENNETTS RES	LARIMER	irr	05/28/1883			29.09	0	0	0
	403349		CRESCENT LAKE/POWELSON RESERVOIR	LARIMER	stor, muni, rec, fish, dom, aug, wildlife	02CW0347, 10CW0290	0	0	0	18	0	0
	403346		CROW LANE RESERVOIR 2	LARIMER	stor, muni, rec, fish, dom, aug, wildlife	02CW0347, 10CW0290	0	0	0	39	0	0
	403631		CUSHMAN LAKE 1	LARIMER	irr, stock	W8765			20	0	0	0
	403632		CUSHMAN LAKE 2	LARIMER	irr, stock	W8765			0	20	0	0
	403633		CUSHMAN LAKE 3	LARIMER	irr, stock	W8765			20	0	0	0
	403691		EAGLE POND 2	LARIMER		08CW0086, 92CW0121					0	0
	403503		KOOLSTRA AQUACULTURE FACILITIY	WELD	fish	01CW0182			0.5	5.5	0	0
	403663		MARKHAM RES	WELD	irr	82CW0253			13.3	0	0	0
	403350		MAURE HOLLOW RESERVOIR	LARIMER	stor, muni, rec, fish, dom, aug, wildlife	02CW0347, 10CW0290	0	0	0	45	0	0
	403345		MCCARTY POND 2	LARIMER	stock	97CW0342			0	10	0	0
	403612		MEREDITH RES	BOULDER	irr, fire, dom, stock, other, wildlife	89CW0240			2	0	0	0
	403668		MIRROR LAKE	LARIMER	irr, muni, rec, fish, dom	95CW0238, W1772	0	0	34.294	0	0	0
	403677		RAINBOW LAKE	LARIMER	irr, muni, rec, fish, dom	95CW0238, W1771	0	0	56.266	0	0	0
	403700		WILLOW LAKE	LARIMER	irr, muni, rec, fish, dom	95CW0238, W1770	0	0	44.8	0	0	0
	401405	Spring	BLAIR SPRING	BOULDER	stock, wildlife	89CW0240	0.0067	0			0	0
	401419		BOB'S SPRING	LARIMER	stock	02CW0371	0.018	0			0	0
	401418		EDMONDS SPRING	LARIMER	stock	02CW0371	0.0044	0			0	0
	401420		NOTO SPRING	LARIMER	stock	02CW0371	0.0044	0			0	0
	401416		SASQUATCH SPRING	LARIMER	stock	02CW0371	0.018	0			0	0
	401417		THUNDERBYRD SPRING	LARIMER	stock	02CW0371	0.018	0			0	0

Conclusion

This technical memorandum describes the irrigated acreages, cropping patterns, quantifies the native Little Thompson River water supply diversions, and quantifies the "imported" water supply diversions associated with agriculture water uses in the Little Thompson River watershed. This technical memorandum is a portion of Key Element 1.0 of the Scope of Work and Response to Solicitation.

The available information indicates that in 2010, the Little Thompson River "native" water supplies were associated with approximately 4,600 acres of irrigated areas. Approximately 60% of the irrigated acreage has crop type grass pasture. The other significant irrigated areas have crop types corn, alfalfa, and barely. The following ditches as associated with the primary use of the native flows[21].

1. Beeline Ditch
2. Boulder Larimer County Irrigation and Manufacturing Ditch
3. Eagle Ditch
4. Jim Eglin Ditch
5. Miner Logan Ditch
6. Osborne Caywood Ditch
7. Supply Lateral/Culver Ditch
8. Rockwell and Rockwell Pipeline
9. W R Blower Ditch

For the period 2000 – 2014, the State's diversion records indicate that the LTR structures diverted approximately 7,200 acre-feet of native supplies and 2,500 acre-feet of "imported "C-BT Project water supplies.

[21] There are two other primary structures that divert native LTR water supplies; the Beeline Ditch and the Great Western Indus. These structures did not have 2010 irrigated areas either within or outside of the watershed.

Summary Irrigated Areas and Water Supplies for the Little Thompson River Structures

2/3/2016 Structure Name	2010 Irrigated Area (acres)	Average Supply Volume for Irrigation Years 2000 - 2014 (acre-feet)	Percent	Total by Source (af)	Total
Beeline Ditch	none	Native	100%	1427	1427
		Imported	0%	0	
BOULD LARIM CO IRR MFG D	2475	Native	63%	2800	4459
		Imported	37%	1659	
EAGLE DITCH	70	Native	83%	237	286
		Imported	17%	49	
Great Western Ind	none	Diversion records not found in CDSS			
JIM EGLIN DITCH	267	No Diversion Records for 2000 - 2014			
MINER LONGAN DITCH	162	Native	53%	280	529
		Imported	47%	249	
OSBORNE CAYWOOD DITCH	240	Native	95%	613	648
		Imported	5%	35	
ROCKWELL D ROCKWELL P P	176	Native	71%	586	827
		Imported	29%	241	
SUPPLY LATERAL DITCH	1005	Native	83%	855	1032
		Imported	17%	177	
W R BLOWER DITCH 1	238	Native	87%	413	473
		Imported	13%	60	
	4633	Native	74%	7211	9681
		Imported	26%	2470	

References

Colorado Decision Support System (CDSS). Accessed June, July, and August 2015 at http://cdss.state.co.us/Pages/CDSSHome.aspx

Attachments – Summaries of Little Thompson River Diversion Records

1. Beeline Ditch
2. Boulder Larimer County Irrigation and Manufacturing Ditch
3. Eagle Ditch
4. Jim Eglin Ditch
5. Miner Logan Ditch
6. Osborne Caywood Ditch
7. Supply Lateral/Culver Ditch
8. Rockwell and Rockwell Pipeline
9. W R Blower Ditch

Beeline Ditch

Volume Native						acre-feet						
IY	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Total**
2000	0	0	0	0	0	0	410	65	210	0	0	0	685
2001	0	0	0	0	0	0	81	239	544	0	797	0	1661
2002	0	0	0	0	0	309	0	0	0	0	0	0	309
2003	0	0	0	0	0	0	0	162	48	0	190	52	452
2004	0	0	0	0	0	0	0	0	0	0	565	415	980
2005	0	0	0	0	0	0	0	0	157	47	0	0	204
2006	0	0	0	0	0	0	561	625	0	64	0	0	1250
2007	ndr	ndr	ndr	ndr	ndr	ndr	ndr	ndr	ndr	ndr	ndr	ndr	0
2008	ndr	ndr	ndr	ndr	ndr	ndr	ndr	ndr	ndr	ndr	ndr	ndr	0
2009	0	0	0	0	0	0	43	605	297	272	282	0	1499
2010	0	0	0	0	0	0	0	837	1333	758	325	0	3253
2011	0	0	0	0	0	213	499	916	885	348	0	0	2861
2012	0	0	0	0	0	144	166	56	40	0	391	688	1485
2013	0	0	0	0	0	0	227	449	0	0	0	367	1043
2014	0	0	0	0	0	610	1242	1654	1267	614	334	0	5721
Median	**0**	**0**	**0**	**0**	**0**	**0**	**81**	**239**	**157**	**0**	**190**	**0**	**1043**
Max	**0**	**0**	**0**	**0**	**0**	**610**	**1242**	**1654**	**1333**	**758**	**797**	**688**	**5721**
Min	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Average	0	0	0	0	0	98	248	431	368	162	222	117	1427

Volume Imported						acre-feet							
IY	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Total**
2000	0	0	0	0	0	0	0	0	0	0	0	0	0
2001	0	0	0	0	0	0	0	0	0	0	0	0	0
2002	0	0	0	0	0	0	0	0	0	0	0	0	0
2003	0	0	0	0	0	0	0	0	0	0	0	0	0
2004	0	0	0	0	0	0	0	0	0	0	0	0	0
2005	0	0	0	0	0	0	0	0	0	0	0	0	0
2006	0	0	0	0	0	0	0	0	0	0	0	0	0
2007	ndr	ndr	ndr	ndr	ndr	ndr	ndr	ndr	ndr	ndr	ndr	ndr	0
2008	ndr	ndr	ndr	ndr	ndr	ndr	ndr	ndr	ndr	ndr	ndr	ndr	0
2009	0	0	0	0	0	0	0	0	0	0	0	0	0
2010	0	0	0	0	0	0	0	0	0	0	0	0	0
2011	0	0	0	0	0	0	0	0	0	0	0	0	0
2012	0	0	0	0	0	0	0	0	0	0	0	0	0
2013	0	0	0	0	0	0	0	0	0	0	0	0	0
2014	0	0	0	0	0	0	0	0	0	0	0	0	0
Median	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Max	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Min	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Average	0	0	0	0	0	0	0	0	0	0	0	0	0

ndr = no diversion record

Boulder Larimer Ditch

Volume Native						acre-feet						
IY	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Total**
2000	0	0	0	0	62	568	270	0	0	0	10	156	1066
2001	0	0	0	0	0	191	1799	0	0	0	0	0	1990
2002	0	0	0	0	0	0	0	0	0	0	0	0	0
2003	0	0	0	0	438	2483	3308	302	0	0	0	0	6531
2004	0	0	0	0	0	222	0	217	1173	278	42	356	2288
2005	130	104	79	110	479	769	1707	1611	0	0	0	0	4989
2006	0	0	0	0	0	0	0	0	0	0	0	0	0
2007	0	0	0	385	2160	2033	2100	147	0	0	0	0	6825
2008	0	0	0	0	0	0	0	75	0	0	0	0	75
2009	0	0	0	0	0	1175	853	146	0	0	0	0	2174
2010	0	0	0	0	422	2875	185	269	84	0	0	0	3835
2011	0	0	0	0	0	0	2260	509	143	0	0	0	2912
2012	102	88	139	92	134	0	0	0	0	0	0	0	555
2013	0	0	0	0	0	413	3036	55	0	0	0	0	3504
2014	0	0	0	0	361	1333	1468	984	177	659	234	42	5258
Median	**0**	**0**	**0**	**0**	**0**	**413**	**853**	**146**	**0**	**0**	**0**	**0**	**2288**
Max	**130**	**104**	**139**	**385**	**2160**	**2875**	**3308**	**1611**	**1173**	**659**	**234**	**356**	**6825**
Min	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Average	15	13	15	39	270	804	1132	288	105	62	19	37	2800

Volume Imported						acre-feet						
IY	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Total**
2000	0	0	0	0	0	0	0	0	2218	1111	172	367	3868
2001	0	0	0	0	0	0	0	94	169	0	0	422	685
2002	0	0	0	0	0	0	0	109	71	106	0	0	286
2003	0	0	0	0	0	0	0	0	0	465	38	460	963
2004	0	0	0	0	0	0	0	0	375	0	0	0	375
2005	0	0	0	0	0	0	0	0	43	1189	848	268	2348
2006	0	0	0	0	0	0	0	0	91	180	0	0	271
2007	0	0	0	0	0	0	0	0	0	647	371	550	1568
2008	0	0	0	0	0	0	0	0	381	0	422	2532	3335
2009	0	0	0	0	0	0	0	0	0	1051	34	2032	3117
2010	0	0	0	0	0	0	0	0	259	383	0	0	642
2011	0	0	0	0	0	0	0	0	0	580	1021	4359	5960
2012	0	0	0	0	0	0	0	62	366	254	0	0	682
2013	0	0	0	0	0	0	0	15	0	34	364	0	413
2014	0	0	0	0	0	0	0	0	0	0	0	378	378
Median	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**71**	**254**	**34**	**367**	**685**
Max	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**109**	**2218**	**1189**	**1021**	**4359**	**5960**
Min	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**271**
Average	0	0	0	0	0	0	0	19	265	400	218	758	1659

Eagle Ditch

Volume Native						acre-feet							
IY	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Total**
2000	0	0	0	0	0	0	177	5	0	0	0	0	182
2001	0	0	0	0	0	0	0	0	1	0	0	0	1
2002	0	0	0	0	0	2	0	0	0	0	0	0	2
2003	0	0	0	0	0	0	0	0	0	0	0	0	0
2004	0	0	0	0	0	0	0	0	0	0	0	0	0
2005	0	0	0	0	0	0	58	20	0	0	0	0	78
2006	0	0	0	0	0	0	0	0	0	0	0	0	0
2007	0	0	0	0	0	177	179	0	0	0	0	0	356
2008	0	0	0	0	0	13	12	0	0	0	0	0	25
2009	0	0	0	0	0	22	138	2	0	0	0	0	162
2010	0	0	0	0	0	0	0	0	0	0	0	77	77
2011	0	0	0	0	0	21	43	0	0	0	0	63	127
2012	0	0	0	0	18	74	5	0	0	0	9	12	118
2013	0	0	0	0	0	21	696	192	0	0	123	0	1032
2014	0	0	0	0	0	0	356	327	398	280	0	31	1392
Median	**0**	**0**	**0**	**0**	**0**	**0**	**12**	**0**	**0**	**0**	**0**	**0**	**78**
Max	**0**	**0**	**0**	**0**	**18**	**177**	**696**	**327**	**398**	**280**	**123**	**77**	**1392**
Min	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Average	0	0	0	0	1	22	111	36	27	19	9	12	237

Volume Imported						acre-feet							
IY	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Total**
2000	0	0	0	0	0	0	0	0	127	0	0	0	127
2001	0	0	0	0	0	0	0	0	48	0	0	0	48
2002	0	0	0	0	0	0	14	0	0	0	0	0	14
2003	0	0	0	0	0	0	0	0	0	0	0	0	0
2004	0	0	0	0	0	0	0	0	0	0	0	0	0
2005	0	0	0	0	0	0	0	0	0	51	0	0	51
2006	0	0	0	0	0	0	0	0	0	0	0	0	0
2007	0	0	0	0	0	0	0	0	10	0	0	0	10
2008	0	0	0	0	0	0	0	0	0	0	0	0	0
2009	0	0	0	0	0	0	0	0	0	0	0	0	0
2010	0	0	0	0	0	0	0	0	0	21	86	0	107
2011	0	0	0	0	0	0	132	0	0	103	0	44	279
2012	0	0	0	0	0	0	0	76	0	22	0	0	98
2013	0	0	0	0	0	0	0	0	0	0	0	0	0
2014	0	0	0	0	0	0	0	0	0	0	0	0	0
Median						**0**	**0**	**0**	**0**	**0**	**0**		**10**
Max						**0**	**132**	**76**	**127**	**103**	**86**	**44**	**279**
Min						**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Average	0	0	0	0	0	0	10	5	12	13	6	3	49

Jim Eglin Ditch

No diversion records for the period 2000 – 2014

Miner Longan Ditch

Volume Native							acre-feet						
IY	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Total**
2000	0	0	0	0	0	0	121	135	27	81	169	0	533
2001	0	0	0	0	0	0	0	203	20	0	63	0	286
2002	0	0	0	0	0	0	0	70	0	0	0	0	70
2003	0	0	0	0	0	0	210	0	0	0	0	0	210
2004	0	0	0	0	0	0	0	90	54	19	12	0	175
2005	0	0	0	0	0	0	0	0	44	26	115	0	185
2006	0	0	0	0	0	0	0	0	47	12	0	130	189
2007	0	0	0	0	0	0	0	138	3	79	0	0	220
2008	0	0	0	0	0	0	0	39	0	68	0	0	107
2009	0	0	0	0	0	0	0	0	66	115	96	0	277
2010	0	0	0	0	0	0	0	0	39	60	173	0	272
2011	0	0	0	0	0	0	0	72	332	31	130	4	569
2012	0	0	0	0	0	42	0	11	38	23	0	143	257
2013	0	0	0	0	0	0	0	163	0	14	0	0	177
2014	0	0	0	0	0	0	0	168	20	281	161	49	679
Median	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**70**	**27**	**26**	**12**	**0**	**220**
Max	**0**	**0**	**0**	**0**	**0**	**42**	**210**	**203**	**332**	**281**	**173**	**143**	**679**
Min	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**70**
Average	0	0	0	0	0	3	22	73	46	54	61	22	280

Volume Imported							acre-feet						
IY	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Total**
2000	0	0	0	0	0	0	0	42	168	72	0	0	282
2001	0	0	0	0	0	0	0	8	81	176	17	0	282
2002	0	0	0	0	0	0	0	20	106	100	0	0	226
2003	0	0	0	0	0	0	0	0	0	0	0	0	0
2004	0	0	0	0	0	0	0	101	54	62	0	0	217
2005	0	0	0	0	0	0	0	0	146	191	2	0	339
2006	0	0	0	0	0	0	53	138	18	29	0	0	238
2007	0	0	0	0	0	0	0	2	237	84	0	0	323
2008	0	0	0	0	0	0	0	78	152	43	36	0	309
2009	0	0	0	0	0	0	0	0	0	91	34	0	125
2010	0	0	0	0	0	0	0	0	136	138	67	0	341
2011	0	0	0	0	0	0	0	0	0	192	109	0	301
2012	0	0	0	0	0	0	86	131	73	61	0	0	351
2013	0	0	0	0	0	0	0	74	0	125	3	0	202
2014	0	0	0	0	0	0	0	0	192	0	0	0	192
Median						**0**	**0**	**8**	**81**	**84**	**0**	**0**	**282**
Max						**0**	**86**	**138**	**237**	**192**	**109**	**0**	**351**
Min						**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Average	0	0	0	0	0	0	9	40	91	91	18	0	249

Osborne Caywood Ditch

Volume Native						acre-feet						
IY	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Total**
2000	0	0	0	0	0	0	132	189	205	206	60	0	792
2001	0	0	0	0	0	0	99	162	164	114	0	0	539
2002	0	0	0	0	0	9	17	13	0	6	0	0	45
2003	0	0	0	0	0	0	112	227	99	42	0	0	480
2004	0	0	0	0	0	0	191	183	211	240	45	0	870
2005	0	0	0	0	0	0	119	182	199	208	158	0	866
2006	0	0	0	0	0	0	72	39	104	75	11	0	301
2007	0	0	0	0	0	0	152	252	199	166	97	0	866
2008	0	0	0	0	0	0	83	184	202	118	52	0	639
2009	0	0	0	0	0	0	129	20	202	177	87	0	615
2010	0	0	0	0	0	0	0	200	245	263	118	0	826
2011	0	0	0	0	0	64	58	304	261	259	121	0	1067
2012	0	0	0	0	0	1	131	174	113	87	0	0	506
2013	0	0	0	0	0	0	33	184	94	61	16	0	388
2014	0	0	0	0	0	0	19	245	137	0	0	0	401
Median	**0**	**0**	**0**	**0**	**0**	**0**	**99**	**184**	**199**	**118**	**45**	**0**	**615**
Max	**0**	**0**	**0**	**0**	**0**	**64**	**191**	**304**	**261**	**263**	**158**	**0**	**1067**
Min	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**13**	**0**	**6**	**0**	**0**	**45**
Average	0	0	0	0	0	5	90	171	162	135	51	0	613

Volume Imported						acre-feet						
IY	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Total**
2000	0	0	0	0	0	0	0	24	0	0	0	0	24
2001	0	0	0	0	0	0	0	17	10	50	0	0	77
2002	0	0	0	0	0	0	42	0	0	0	0	0	42
2003	0	0	0	0	0	0	0	0	0	0	0	0	0
2004	0	0	0	0	0	0	0	0	64	84	0	0	148
2005	0	0	0	0	0	0	0	0	0	0	0	0	0
2006	0	0	0	0	0	0	1	99	45	28	31	0	204
2007	0	0	0	0	0	0	0	0	0	0	0	0	0
2008	0	0	0	0	0	0	0	0	0	0	0	0	0
2009	0	0	0	0	0	0	0	0	0	0	0	0	0
2010	0	0	0	0	0	0	0	0	0	0	0	35	35
2011	0	0	0	0	0	0	0	0	0	0	0	0	0
2012	0	0	0	0	0	0	0	0	0	0	0	0	0
2013	0	0	0	0	0	0	0	0	0	0	0	0	0
2014	0	0	0	0	0	0	0	0	0	0	0	0	0
Median						**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Max						**0**	**42**	**99**	**64**	**84**	**31**	**35**	**204**
Min						**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Average	0	0	0	0	0	0	3	9	8	11	2	2	35

Rockwell and Rockwell Ditch

Volume Native						acre-feet						
IY	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Total**
2000	0	0	0	0	0	0	274	158	163	68	150	0	813
2001	0	0	0	0	0	0	24	219	136	0	199	194	772
2002	0	0	0	0	0	34	55	78	0	0	0	145	312
2003	0	0	0	0	0	0	185	285	0	0	164	154	788
2004	0	0	0	0	0	56	37	56	77	52	69	251	598
2005	0	0	0	0	0	0	0	131	21	32	48	121	353
2006	0	0	0	0	0	0	0	0	0	12	74	174	260
2007	0	0	0	0	0	0	120	221	16	63	120	0	540
2008	0	0	0	0	0	0	0	37	0	86	108	151	382
2009	0	0	0	0	0	0	177	177	52	0	0	0	406
2010	0	0	0	0	0	0	0	258	273	43	158	178	910
2011	0	0	0	0	0	0	0	185	275	267	259	90	1076
2012	0	0	0	0	0	0	0	12	28	2	65	123	230
2013	0	0	0	0	0	0	63	135	5	16	1	0	220
2014	0	0	0	0	0	0	0	75	220	314	281	247	1137
Median	**0**	**0**	**0**	**0**	**0**	**0**	**24**	**135**	**28**	**32**	**108**	**145**	**540**
Max	**0**	**0**	**0**	**0**	**0**	**56**	**274**	**285**	**275**	**314**	**281**	**251**	**1137**
Min	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**220**
Average	0	0	0	0	0	6	62	135	84	64	113	122	586
Volume Imported							acre-feet						
IY	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Total**
2000	0	0	0	0	0	0	0	0	101	212	10	0	323
2001	0	0	0	0	0	0	0	19	133	170	29	0	351
2002	0	0	0	0	0	0	0	6	111	81	0	0	198
2003	0	0	0	0	0	0	0	0	83	62	0	0	145
2004	0	0	0	0	0	0	0	0	85	86	0	0	171
2005	0	0	0	0	0	0	0	0	116	105	75	0	296
2006	0	0	0	0	0	0	85	60	16	29	34	0	224
2007	0	0	0	0	0	0	0	0	145	78	0	0	223
2008	0	0	0	0	0	0	33	22	180	30	33	0	298
2009	0	0	0	0	0	0	0	0	50	228	242	157	677
2010	0	0	0	0	0	0	0	0	10	147	62	0	219
2011	0	0	0	0	0	0	0	0	0	0	0	0	0
2012	0	0	0	0	0	0	15	96	42	101	60	0	314
2013	0	0	0	0	0	0	0	0	68	51	59	0	178
2014	0	0	0	0	0	0	0	0	0	0	0	0	0
Median						**0**	**0**	**0**	**83**	**81**	**29**	**0**	**223**
Max						**0**	**85**	**96**	**180**	**228**	**242**	**157**	**677**
Min						**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Average	0	0	0	0	0	0	9	14	76	92	40	10	241

Supply Lateral/ Culver Ditch

Volume Native						acre-feet							
IY	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Total
2000	0	0	0	0	0	117	454	28	0	0	0	10	609
2001	0	0	0	0	0	0	181	124	7	1	5	21	339
2002	0	0	0	0	0	0	30	68	13	0	0	0	111
2003	0	0	0	0	96	484	306	457	52	0	0	0	1395
2004	0	0	0	0	0	317	635	240	340	243	126	22	1923
2005	0	0	0	0	0	0	446	83	126	6	30	0	691
2006	0	0	0	0	0	0	6	0	21	0	0	10	37
2007	0	0	0	0	0	200	527	287	55	2	0	2	1073
2008	0	0	0	0	0	0	279	443	13	2	6	8	751
2009	0	0	0	0	0	0	633	393	41	97	56	2	1222
2010	0	0	0	0	0	12	551	306	99	286	115	0	1369
2011	0	0	0	0	0	0	261	259	134	57	41	38	790
2012	0	0	0	0	0	36	34	0	0	6	0	11	87
2013	0	0	0	0	0	21	696	192	0	0	123	0	1032
2014	0	0	0	0	0	0	356	327	398	280	0	31	1392
Median	**0**	**0**	**0**	**0**	**0**	**0**	**356**	**240**	**41**	**2**	**5**	**8**	**790**
Max	**0**	**0**	**0**	**0**	**96**	**484**	**696**	**457**	**398**	**286**	**126**	**38**	**1923**
Min	**0**	**0**	**0**	**0**	**0**	**0**	**6**	**0**	**0**	**0**	**0**	**0**	**37**
Average	0	0	0	0	6	79	360	214	87	65	33	10	855

Volume Imported						acre-feet							
IY	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Total
2000	0	0	0	0	0	0	0	98	70	177	91	98	534
2001	0	0	0	0	0	0	0	80	53	109	140	94	476
2002	0	0	0	0	0	0	3	37	39	0	0	0	79
2003	0	0	0	0	0	0	0	0	9	0	0	35	44
2004	0	0	0	0	0	0	0	0	0	0	12	0	12
2005	0	0	0	0	0	0	0	0	42	17	84	26	169
2006	0	0	0	0	0	0	76	107	22	0	0	80	285
2007	0	0	0	0	0	0	0	0	12	11	54	92	169
2008	0	0	0	0	0	0	12	26	55	29	17	58	197
2009	0	0	0	0	0	0	0	0	0	40	43	49	132
2010	0	0	0	0	0	0	0	0	0	13	22	57	92
2011	0	0	0	0	0	0	110	0	6	26	74	73	289
2012	0	0	0	0	0	0	17	37	0	30	0	88	172
2013	0	0	0	0	0	0	0	0	0	0	0	0	0
2014	0	0	0	0	0	0	0	0	0	0	0	0	0
Median						**0**	**0**	**0**	**9**	**13**	**17**	**57**	**169**
Max						**0**	**110**	**107**	**70**	**177**	**140**	**98**	**534**
Min						**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Average	0	0	0	0	0	0	15	26	21	30	36	50	177

W R Blower Ditch

Volume Native							acre-feet						
IY	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Total**
2000	0	0	0	0	0	249	107	1	24	100	56	0	537
2001	0	0	0	0	0	16	261	24	0	23	40	42	406
2002	ndr	ndr	ndr	ndr	ndr	ndr	ndr	ndr	ndr	ndr	ndr	ndr	0
2003	0	0	0	0	0	404	202	170	26	14	63	3	882
2004	0	0	0	0	0	113	36	221	177	166	143	35	891
2005	0	0	0	0	0	77	186	173	23	0	0	0	459
2006	0	0	0	0	0	34	13	0	0	0	0	0	47
2007	0	0	0	0	0	265	140	57	0	0	0	30	492
2008	0	0	0	0	0	145	113	129	0	0	0	69	456
2009	0	0	0	0	0	98	279	43	64	17	0	0	501
2010	0	0	0	0	0	0	0	0	39	60	173	0	272
2011	0	0	0	0	0	8	59	92	100	16	43	46	364
2012	0	0	0	0	4	53	3	0	5	6	17	2	90
2013	0	0	0	0	0	97	276	19	0	1	0	0	393
2014	0	0	0	0	0	171	19	117	23	0	53	24	407
Median	**0**	**0**	**0**	**0**	**0**	**97.5**	**110**	**50**	**23**	**10**	**28.5**	**2.5**	**407**
Max	**0**	**0**	**0**	**0**	**4**	**404**	**279**	**221**	**177**	**166**	**173**	**69**	**891**
Min	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Average	0	0	0	0	0	124	121	75	34	29	42	18	413
Volume Imported							**acre-feet**						
IY	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Total**
2000	0	0	0	0	0	0	0	26	16	8	0	0	50
2001	0	0	0	0	0	0	0	34	45	29	6	2	116
2002	ndr	ndr	ndr	ndr	ndr	ndr	ndr	ndr	ndr	ndr	ndr	ndr	0
2003	0	0	0	0	0	0	0	0	9	20	13	12	54
2004	0	0	0	0	0	0	2	0	0	0	0	0	2
2005	0	0	0	0	0	0	0	0	29	0	0	31	60
2006	0	0	0	0	0	0	29	73	23	0	12	0	137
2007	0	0	0	0	0	0	0	25	46	0	0	6	77
2008	0	0	0	0	0	0	4	0	15	3	26	21	69
2009	0	0	0	0	0	0	0	0	16	33	0	0	49
2010	0	0	0	0	0	0	0	0	0	0	29	21	50
2011	0	0	0	0	0	1	135	0	0	31	0	45	212
2012	0	0	0	0	0	0	0	0	0	4	0	0	4
2013	0	0	0	0	0	0	0	0	0	8	8	0	16
2014	0	0	0	0	0	0	0	0	0	0	0	0	0
Median						**0**	**0**	**0**	**12**	**3.5**	**0**		**50**
Max						**1**	**135**	**73**	**46**	**33**	**29**	**45**	**212**
Min						**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Average	0	0	0	0	0	0	12	11	14	10	7	10	60

— End of Agriculture Water Use Technical Memorandum —

To: Project Management Team, Little Thompson Watershed Coalition

From: Canyon Water Resources, LLC and George Wear Consulting, LLC

Subject: WSRA Contract 150707, Water Supply, Use and Planning Study - Needs Assessment Little Thompson River, **Key Element 2 - Evaluation of Groundwater Well Domestic Use Technical Memorandum**

Date: February 18, 2016 revised May 25, 2016

Introduction

The following Technical Memorandum (TM) is a portion of the Little Thompson Watershed Restoration Coalition, Water Supply, Use and Planning Study - Needs Assessment for the Little Thompson River/Watershed. The work is funded by the Colorado Water Conservation Board WSRA Contract 150707 and the Big Thompson Conservation District is acting as the fiscal agent for the project. This technical memorandum reports on the use groundwater for domestic uses within the Little Thompson River watershed (aka the watershed).

The work quantifies the number of exempt and non-exempt wells for household and domestic uses in the watershed; estimates the number of homes served by groundwater and water usage (including any stock use) and generally describes potential impact on stream flows. This evaluation also examines undeveloped acreage (USFS, BLM, State, and County lands and conservation easements on private lands) and estimates potential additional groundwater withdrawals.

Discussion

This evaluation of well groundwater use in the Little Thompson River watershed utilizes the Colorado Decision Support System (CDSS) Water Division 1 Well Permit and Administrative Structures databases[22] (CDSS). The Well Permit database includes recorded permits. The Administrative Structures database includes groundwater wells with corresponding structure IDs, water right case numbers, and identifies certain exempt wells. The key GIS information includes well locations, water uses, decreed amounts, and the Larimer, Weld, and Boulder County parcel databases.

The Well Permit and Administrative Structures databases include unique data and some overlapping data fields and attributes. Both databases have missing data (no data entered for particular data fields)

[22] For the wells within the watershed, the Administrative Structure and the Water Right Net Amount databases have almost the same list and number of structure IDs (the Administrative Structures database had a few more unique structure identifications). The Administrative Structures – Wells dataset includes the attribute "Water Source" which is coded with either Groundwater or Groundwater-Exempt. This evaluation utilizes the Administrative Structures – Wells database because it has more unique records and indicates the non-exempt wells.

and this analysis takes the data "as-is". The well information most pertinent to this work is the location of the well, whether the well is an exempt well or not, and the amount and type of water use.

The State Engineer distinguishes wells that are exempt from water rights administration and are not administered under the priority system. In general, exempt wells may serve household uses, limited irrigation, and stock watering. Exempt wells are typically associated with 35 acre or larger parcels or land subdivisions created prior to 1972. The exempt wells are generally limited to pumping rates of 15 gpm and unused water (i.e., return flows) must return to the same drainage as where the pumping occurs. So-called "non-exempt" wells (i.e., wells that are not permitted as exempt) are administered under the priority system and are usually associated with an augmentation plan that serves to replace all out-of-priority depletions caused by the well pumping (e.g., Big Elk Meadows and Pinewood Springs).

The following sections report on the non-exempt wells, the exempt wells, and the potential for development of new exempt wells within the Little Thompson River watershed.

Non-Exempt Wells

Non-exempt wells are administered under the priority system and usually have associated water right decrees. Non-exempt wells must replace any out-of-priority stream depletions in time, place, amount, and quality by having available augmentation water supplies. A plan for augmentation must be approved by the water court to prevent injury to senior water right holders by replacing the amount of water consumed by the non-exempt uses.

For this evaluation, the primary list of non-exempt wells comes from the State's Administrative Structures database. We screened the database selecting all records with the Structure Type = "Well", locations within the watershed, the Water Source attribute not coded as "GROUNDWATER-EXEMPT", and by location to determine which wells are geographically within the Little Thompson Conservation District and those outside of the District's boundaries. The result is a list of 118 non-exempt wells located within the watershed with 59 within and 59 wells outside of the Little Thompson Water District.

The Well Permit database includes permits for non-exempt wells. This work identified all permits within the watershed, and then selected only permits with "Status" = Well Constructed and "PermitSuf" = F or R[23]. The sorting procedure resulted in a list of 76 permits associated with non-exempt wells within the watershed

The evaluation compared the pared down lists from the Administrative Structures and Well Permit databases to try and identify records for wells appearing in both lists. The comparison indicated 67 well permit records that could be matched to well records in the Administrative Structures database.

[23] Generally, the Well Permits for non-exempt wells are indicated with an "F" or an "R" in the field "PermitSuf" (i.e., the suffix field).

Consequently, there are 9 records for well permits classified as well constructed that do not have an associated record in the Administrative Structures database. So, it appears that there could be as many as approximately 130 non-exempt wells in the watershed (i.e., 118 + 9 = 127).

Figure 1 shows the locations of the identified non-exempt wells, Tables 1, 2 and 3 summarize the well permit and structures databases.

This evaluation identified approximately 59 non-exempt wells within LTWD (i.e., within the lower portion of the watershed). The wells are associated with irrigation, stock, commercial, industrial, municipal, and domestic uses (Table 1). The following bullets summarize the information regarding the non-exempt wells:

- Eleven of the 59 wells have water rights that were abandoned in the Division 1 Water Court Case Number 11CW0263.
- The Milliken, Knaub, 2 Oster, and the Seele wells serve municipal uses under the Milliken augmentation plan.
- The Jordan Well No. 1 well is associated with irrigation uses and an augmentation plan (1.54 cfs).
- The Koolstra Wells (2 cfs total) for fishery are augmented.
- There are 42 non-exempt wells within the LTWD boundary and the watershed that are not associated with augmentation plans.

In the upper portion of the Little Thompson River watershed, the non-exempt wells are mostly associated with domestic, stock, and municipal uses (Table 2). Consequently, the associated uses and rates are relatively small. This work did not identify augmentation plans associated with 16 of the wells. Wells that are covered by augmentation plans are shaded in the table and include the Pinewood Springs, Smitherman, and Big Elk Meadows water systems[24]. The Brown, Jellystone, and Meadow Dale Ranch wells serve small domestic systems with augmentation plans.

Table 3 lists the well permits associated with the 9 non-exempt wells that were not matched up with data records in the Administrative Structures database. Five of the well permit records correspond to household use only the Spring Ranch Estates subdivision located in the upper portion of the watershed. Three of the well permits indicate commercial uses and one well permit indicates irrigation uses.

[24] The Pinewood Springs and Big Elk Meadows systems are discussed in a separate technical memorandum.

Figure 6: Administrative Structures, Wells Non-Exempt

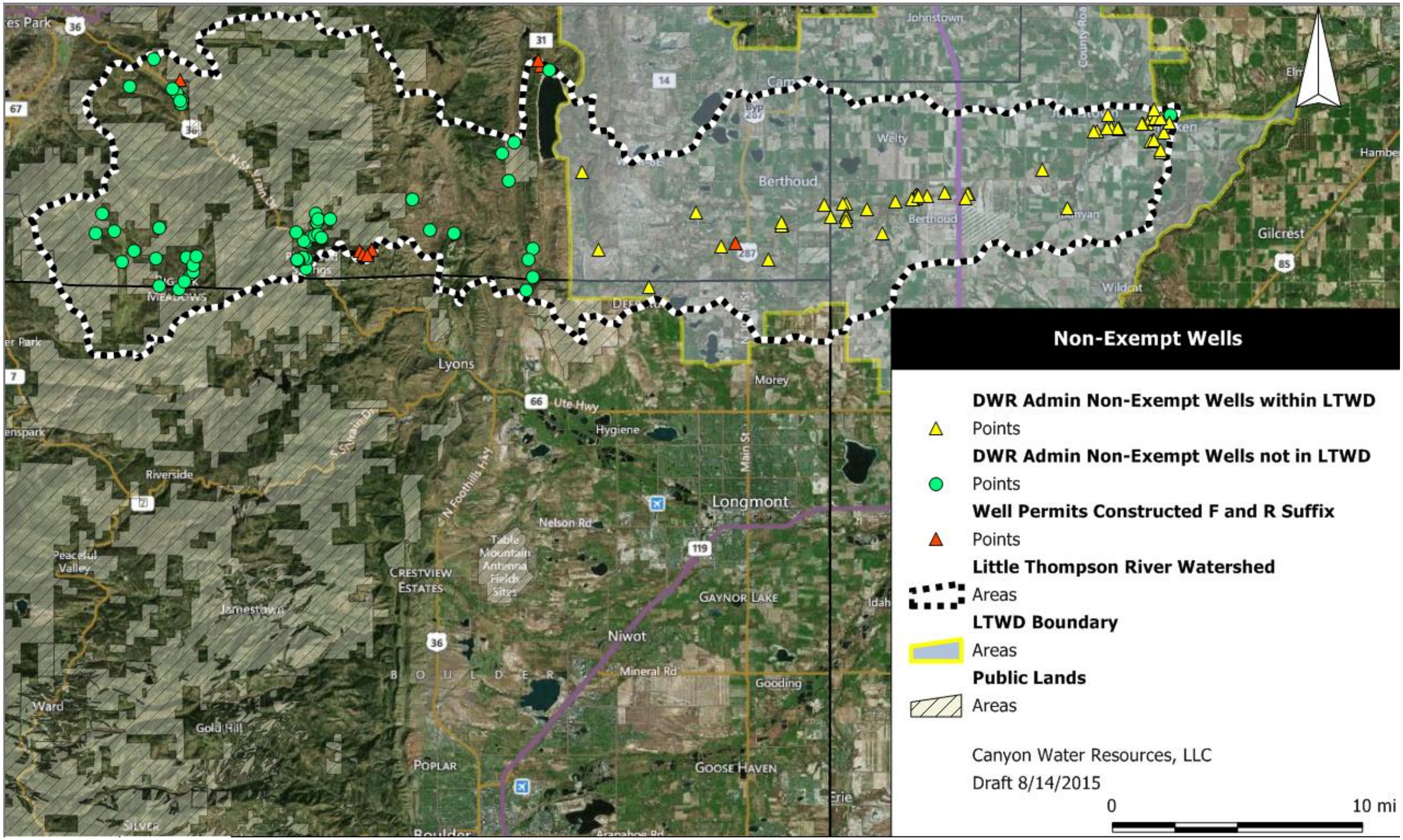


Table 1: DWR Administrative Non-Exempt Wells and within the Little Thompson Water District

2/17/2016 WDID	Structure name	Associated Case Numbers	Decreed Rate abs (cfs)	Decreed Rate cond (cfs)	Decreed Uses	Adjudication Date	Appropriation Date
405078	BINDER WELL 1	W3513	0.0333	0	stock	12/31/1972	12/31/1942
405079	BINDER WELL 2	W3513	0.0778	0	stock	12/31/1972	12/31/1947
405080	BINDER WELL 3	W3513	0.0222	0	dom	12/31/1972	12/31/1961
405077	BINDER WELL 4	W3513	0.0222	0	stock	12/31/1972	12/31/1949
405102	BROOKS WELL 12802	W0329	1.67	0	irr	12/31/1970	4/30/1953
405118	CARROLL WELL 1-10708-R	W2894	0.74	0	irr	12/31/1972	9/20/1940
405119	CARROLL WELL 2-10709	W2894	0.345	0	irr	12/31/1972	6/30/1940
405120	CARROLL WELL 3-11060	W2894	1.11	0	irr	12/31/1972	9/11/1936
405121	CARROLL WELL 4-10649-F	W2894	0.89	0	irr	12/31/1972	2/9/1966
405122	CARROLL WELL 5-10650-F	W2894	2.23	0	irr	12/31/1972	4/6/1966
405123	CARROLL WELL 6-10570-F	W2894	1.445	0	irr	12/31/1972	1/17/1966
405573	CHAMBERLIN WELL 1-5676-F	11CW0263, W4407				abandoned	
405135	COLO ALF PROD W 2-13447	W3210	0.111	0	stock	12/31/1972	12/3/1962
405136	COLO ALF PROD W 3-486	W3210	1.78	0	irr	12/31/1972	11/2/1955
405137	COLO ALF PROD WELL 1	W3210	0.142	0	stock	12/31/1972	4/29/1952
405772	FLYNN POND						
405196	GREAT WESTERN W 11-10145	11CW0263, W2902	*0.3*	from decree	ind	abandoned	
405197	GREAT WESTERN W 12-10146	11CW0263, W2902	*0.7*	from decree	ind	abandoned	
405198	GREAT WESTERN W 13-10147	11CW0263, W2902	*0.3*	from decree	ind	abandoned	
405199	GREAT WESTERN W 14-10148	11CW0263, W2902	*0.4*	from decree	ind	abandoned	
405200	GREAT WESTERN W 15-10837	11CW0263, W2902	*0.3*	from decree	ind	abandoned	
405201	GREAT WESTERN W 16-10838	11CW0263, W2902	*0.4*	from decree	ind	abandoned	
405203	GREAT WESTERN W 17-2465F	11CW0263, W2902	*0.6*	from decree	ind	abandoned	
405230	HART WELL 1627	11CW0263, W1001				abandoned	
405241	HERNLUND WELL 17004	11CW0263, W7307				abandoned	
405006	JORDAN WELL 1	W8140	1.54	0	irr	12/31/1976	7/2/1955
405263	JUDY WELL 1	W4185	0.0175	0	irr	12/31/1972	3/18/1972
405267	KERBS WELL 4	W2775	0.07	0	dom	12/31/1972	12/31/1958
405273	KNAUB WELL 456	02CW0339, W0420	1.7	0	irr, muni	12/31/1970	12/31/1934
405662	KOOLSTRA AQU WELL 1	01CW0182, 12CW0106	0.2228	3.0192	fishery	12/31/2001	10/25/2001
405663	KOOLSTRA AQU WELL 2	01CW0182, 12CW0106	0.2228	3.0192	fishery	12/31/2001	10/25/2001
405664	KOOLSTRA AQU WELL 3	01CW0182, 12CW0106	0.2228	3.1192	fishery	12/31/2001	10/25/2001
405665	KOOLSTRA AQU WELL 4	01CW0182, 12CW0106	0.2228	3.1192	fishery	12/31/2001	10/25/2001
405666	KOOLSTRA AQU WELL 5	01CW0182, 12CW0106	0.2228	3.1192	fishery	12/31/2001	10/25/2001
405667	KOOLSTRA AQU WELL 6	01CW0182, 12CW0106	0.2228	3.1192	fishery	12/31/2001	10/25/2001
405668	KOOLSTRA AQU WELL 7	01CW0182, 12CW0106	0.2228	3.1192	fishery	12/31/2001	10/25/2001
405669	KOOLSTRA AQU WELL 8	01CW0182, 12CW0106	0.2228	3.1192	fishery	12/31/2001	10/25/2001
405670	KOOLSTRA AQU WELL 9	01CW0182, 12CW0106	0.2228	3.1192	fishery	12/31/2001	10/25/2001
405352	MC CRAY WELL 1-42051	W6562	0.11	0	irr, dom	12/31/1972	10/15/1970
405353	MC CRAY WELL 2	W6562	0.06	0	irr	12/31/1972	8/1/1962
405354	MC CRAY WELL 3	W6562	0.11	0	irr	12/31/1972	7/1/1960
405366	MCNEELY WELL 1	W2319	0.11	0	irr, dom, stock	12/31/1972	5/30/1952
405660	MILLIKEN WELL 3-59961	02CW0339	0	2.228	muni	12/31/2002	12/11/2002
405596	MORGAN WELL	W8558	1.11	0	irr	12/31/1977	9/15/1952
405390	NOBLES WELL 1	W6955	0.11	0	fire, dom, stock	12/31/1972	12/31/1950
405400	OSTER WELL 13787	01CW0005, W1635	2.223	0	irr	12/31/1971	8/31/1940
405227	OSTER WELL 65727-F	02CW0339	0	0.0334	irr, comm	12/31/2005	3/30/2005
405437	QUASEBARTH WELL 11371	W5577	2	0	irr	12/31/1972	5/31/1941
405443	RIMBEY WELL P 41483	W0135	0.011	0	dom	12/31/1970	8/1/1927
405454	SCHAAL WELL 1-R-1954	79CW0337, W4293	0.39	0	irr	12/31/1972	12/31/1936
405463	SEELE WELL 11676	W2003	1.66	0	irr	12/31/1972	5/31/1940
405505	STROH WELL 1-0452	11CW0263, W2185				abandoned	
405550	WILSON WELL	W2543	0.088	0	irr, dom, stock	12/31/1972	4/7/1946
405016	WILSON WELL 1-6648	W0727	0.58	0	irr	12/31/1971	5/31/1948
405015	WILSON WELL 1-6652	W0728	1.23	0	irr	12/31/1971	3/31/1950
405017	WILSON WELL 2-6649	W0727	0.78	0	irr	12/31/1971	5/31/1948
405018	WILSON WELL 2-6653	W0728	0.45	0	irr	12/31/1971	5/31/1955
405019	WILSON WELL 3-6650	W0727	0.69	0	irr	12/31/1971	3/31/1950
405020	WILSON WELL 4-6651	W0727	0.78	0	irr	12/31/1971	3/31/1950

Shading indicates wells that are covered under augmentation plans.

Table 2: DWR Administrative Non-Exempt Wells not within the Little Thompson Water District

8/14/2015 WDID	Structure name	Associated Case Numbers	Decreed Rate abs (cfs)	Decreed Rate cond (cfs)	Decreed Uses	Adjudication Date	Appropriation Date
405069	BIG ELK MEADOWS 1-25172F	W6464	0.049	0	irr, dom, other	12/31/1972	11/10/1952
405070	BIG ELK MEADOWS 2-25173F	W6464	0.067	0	irr, dom, other	12/31/1972	11/10/1952
405071	BIG ELK MEADOWS 3-25174F	W6464	0.078	0	irr, dom, other	12/31/1972	11/10/1952
405073	BIG ELK MEADOWS 5-25176F	W6464	0.067	0	irr, dom, other	12/31/1972	11/10/1952
405074	BIG ELK MEADOWS 6-25177F	W6464	0.078	0	irr, dom, other	12/31/1972	10/31/1939
405075	BIG ELK MEADOWS 7-25178F	W6464	0.022	0	irr, dom, other	12/31/1972	12/31/1895
405076	BIG ELK MEADOWS 8-25179F	W6464	0.004	0	irr, dom, other	12/31/1972	11/10/1952
405072	BIG ELK MEADOWS WELL 4	W6463	0.073	0	irr, dom, other	12/31/1972	11/10/1952
405089	BRANUM WELL 1-013931F	W5395	0.0044	0	dom	12/31/1972	2/28/1972
405090	BRANUM WELL 2-41919	W5395	0.0011	0	dom	12/31/1972	7/6/1970
405103	BROWN WELL 1	07CW0336, W5855	0.033	0	comm, dom	12/31/1972	6/1/1966
405105	BROWN WELL 2-11016-F	07CW0336, W5855	0.0445	0	comm, dom	12/31/1972	6/28/1966
405107	BROWN WELL 3-014210-F	07CW0336, W5855	0.0445	0	comm, dom	12/31/1972	7/7/1969
405109	BROWN WELL 4-55371	W5855	0.033	0	comm, dom	12/31/1972	4/10/1972
405110	BROWN WELL 5-60443	W5855	0.033	0	comm, dom	12/31/1972	5/10/1972
405111	BROWN WELL 6-54664	W5855	0.0556	0	dom	12/31/1972	3/30/1972
405570	BUSTER BIG SPG WELL	81CW0266	0.015	0	irr, stock	12/31/1981	1/1/1958
400833	FIRKINS HOPE SUMP 1	12CW0165, W6170					
405207	GARVEY WELL 1-49367	W4299	0.03	0	dom	12/31/1972	10/22/1971
405226	H-P CO WELL 2-36652	W5998	0.0011	0	dom	12/31/1972	6/28/1969
405012	HANFT WELL 35180	W6564	0.002	0	irr, com	12/31/1972	10/25/1968
405679	JELLYSTONE WELL 4	07CW0336	0.122	0	comm, dom	12/31/1972	6/1/1966
405595	JONES WELL 40453	W8621	0.0004	0	irr, dom	12/31/1977	3/7/1970
405292	LINGER WELL 4	W8426	0.0044	0	dom	12/31/1976	12/31/1916
405293	LINGER WELL 5	W8426	0.0044	0	dom	12/31/1976	12/31/1916
405294	LINGER WELL 6	W8426	0.0044	0	dom	12/31/1976	12/31/1916
405630	MEADOWDALE RANCH 1-30320	87CW0061	0.0223	0	irr, dom	12/31/1987	10/26/1964
405631	MEADOWDALE RANCH 2-30319	87CW0061	0.0663	0	irr, dom	12/31/1987	6/12/1986
405373	MINE SPRING WELL	W7612	0.022	0	dom	12/31/1974	12/31/1952
405389	NIEDERMAYR WELL 1	W6600	0.044	0	irr, dom, stock	12/31/1972	6/20/1952
405409	PINEWOOD SPGS W 1-11070	W3526	0.0111	0	dom	12/31/1972	7/14/1966
405419	PINEWOOD SPGS W 10	W3526	0.0222	0	dom	12/31/1972	12/31/1962
405410	PINEWOOD SPGS W 11-12510	W3526	0.0155	0	dom	12/31/1972	12/20/1967
405411	PINEWOOD SPGS W 12-43460	W3526	0.0044	0	dom	12/31/1972	10/17/1970
405420	PINEWOOD SPGS W 13-17970	W8014	0.0067	0	muni, dom	12/31/1975	7/31/1973
405422	PINEWOOD SPGS W 14-17969	W8014	0.0044	0	muni, dom	12/31/1975	8/20/1973
405423	PINEWOOD SPGS W 15-17968	W8014	0.0089	0	muni, dom	12/31/1975	10/10/1973
405247	PINEWOOD SPGS W 19-46591	95CW0284	0.0055	0		12/31/1995	12/28/1995
405414	PINEWOOD SPGS W 2-46217	W3526	0.0044	0	dom	12/31/1972	12/31/1959
405248	PINEWOOD SPGS W 20-46592	95CW0284	0.0055	0		12/31/1995	12/28/1995
405412	PINEWOOD SPGS W 3-46216	W3526	0.0044	0	dom	12/31/1972	12/31/1959
405413	PINEWOOD SPGS W 4-11071	W3526	0.0022	0	dom	12/31/1972	7/13/1966
405415	PINEWOOD SPGS W 5-27923	W3526	0.0044	0	dom	12/31/1972	7/6/1966
405416	PINEWOOD SPGS W 6-12509F	W3526	0.0044	0	dom	12/31/1972	12/19/1967
405421	PINEWOOD SPGS W 7	W3526	0.0066	0	dom	12/31/1972	1/17/1969
405417	PINEWOOD SPGS W 8-14295F	W3526	0.0044	0	dom	12/31/1972	10/6/1969
405418	PINEWOOD SPGS W 9-13341	W3526	0.0066	0	dom	12/31/1972	9/4/1962
405633	PINEWOOD SPRINGS COLLECTION GALLERY	02CW0347, 10CW0290, 88CW0236	0.22	1	muni	12/31/1988	11/30/1989
405478	SMITHERMAN WELL 10-47364	W1216	0.002	0	dom, stock	12/31/1971	6/1/1918
405479	SMITHERMAN WELL 11-47365	W1216	0.001	0	dom, stock	12/31/1971	7/15/1915
405482	SMITHERMAN WELL 4-47358	W1216	0.304	0	dom, stock	12/31/1971	7/1/1916
405483	SMITHERMAN WELL 5-47359	W1216	0.273	0	dom, stock	12/31/1971	8/1/1916
405484	SMITHERMAN WELL 6-47360	W1216	0.419	0	dom, stock	12/31/1971	5/20/1914
405485	SMITHERMAN WELL 7-47361	W1216	0.011	0	dom, stock	12/31/1971	7/25/1913
405486	SMITHERMAN WELL 8-47362	W1216	0.003	0	dom, stock	12/31/1971	8/1/1913
405487	SMITHERMAN WELL 9-47363	W1216	0.004	0	dom, stock	12/31/1971	7/1/1917
405496	SPRING GARDEN SPG WELL 1	W7721	0.0089	0	irr, dom, stock	12/31/1974	12/31/1880
405497	SPRING GARDEN W 2-57455	W5484	0.11	0	irr, dom, stock	12/31/1972	12/31/1883
405498	SPRING GARDEN WELL 1	W5484	0.11	0	irr	12/31/1972	11/10/1954

Shading indicates wells are covered under augmentation plans.

Table 3: Well Permits Associated with Non-Exempt Wells and Not Found in the Administrative Structures Database

8/14/2015						
PermitNo	**PermitSuf**	**Well Name**	**Case No**	**Subdivision Name**	**Use1**	**Special Use**
12909	F			UNITED STATES	COMMERCIAL	
53191	F			SPRING GULCH RANCH ESTATES	HOUSEHOLD USE ONLY	
47089	F		W7689	SPRING GULCH RANCH ESTATES	HOUSEHOLD USE ONLY	AUGMENTED
37876	F		W7689	SPRING GULCH RANCH ESTATES	HOUSEHOLD USE ONLY	AUGMENTED
66645	F		W7689	SPRING GULCH RANCH ESTATES	HOUSEHOLD USE ONLY	AUGMENTED
45600	F		W7689	SPRING GULCH RANCH ESTATES	HOUSEHOLD USE ONLY	AUGMENTED
17913	F				COMMERCIAL	
12407	F				COMMERCIAL	
6593	F				IRRIGATION	

Exempt Wells

This section discusses exempt wells and quantifies the number of exempt wells within the watershed. The evaluation describes the types of uses and provides preliminary estimates of water uses associated with the exempt wells. For this study, the key points regarding exempt well permits are:

- In most cases, exempt wells are limited to 15 gpm and return flows from "non-evaporative" wastewater systems must return to the same stream drainage as where the well is located;
- Except in limited cases, an exempt well permit will not be issued where either a municipality or a water district can provide water to the property (i.e., within the Pinewood Springs, Big Elk Meadows and Little Thompson Water District boundaries[25]);
- Exempt wells may be "Household Use Only". These types of permits are issued for ordinary household uses in one single-family dwelling, and do not allow for outside water or livestock watering;
- Exempt wells may be "Domestic and Livestock Wells". These types of well permits are issued on tracts of land of 35 acres or more where the proposed well will be the only well on the tract, or on tracts of land of less than 35 acres in limited areas of the state where the surface drainage system is not over-appropriated, or where the well will produce from a deeper source;
- Because exempt wells divert and consume relatively small quantities of water, it is assumed that they will not have a significant impact on other water users and thus they are considered "exempt from the priority system of water rights."

[25] Pinewood Springs Water District serves the Pinewood Springs community near the confluence of the North Fork and the Little Thompson River. The Big Elk Meadows Water District serves that community in the West Fork of the Little Thompson River.

The list of exempt wells comes from the State's Well Permit database (CDSS). The database contains records for well permits associated with non-exempt wells, abandoned well permits, monitoring hole permits, and several other classes of well permits. Consequently, it requires several steps to sort out the well permits of interest in this study, exempt well permits for constructed wells.

First, the process mapped the locations of all well permits and selected the well permits with locations within the watershed (no. of records = 1375). The list was then sorted by the field "Current Status" = Well Constructed because this study focuses on current water uses (no. of records 938).

The next step sorted out and selected the records with a blank PermitSuf field. Generally, exempt wells have a blank PermitSuf field (i.e., nothing entered in the field). The resulting number of records was 809 and included some duplicate permit numbers. The duplicates were sorted out leaving only unique permits numbers and resulting in a list of 748 well permit records.

Figure 2 illustrates exempt well locations identified within the Little Thompson River watershed. Table 4 presents a summary of the exempt well permit records. The summary table indicates that the well permits are predominantly associated with domestic and household uses.

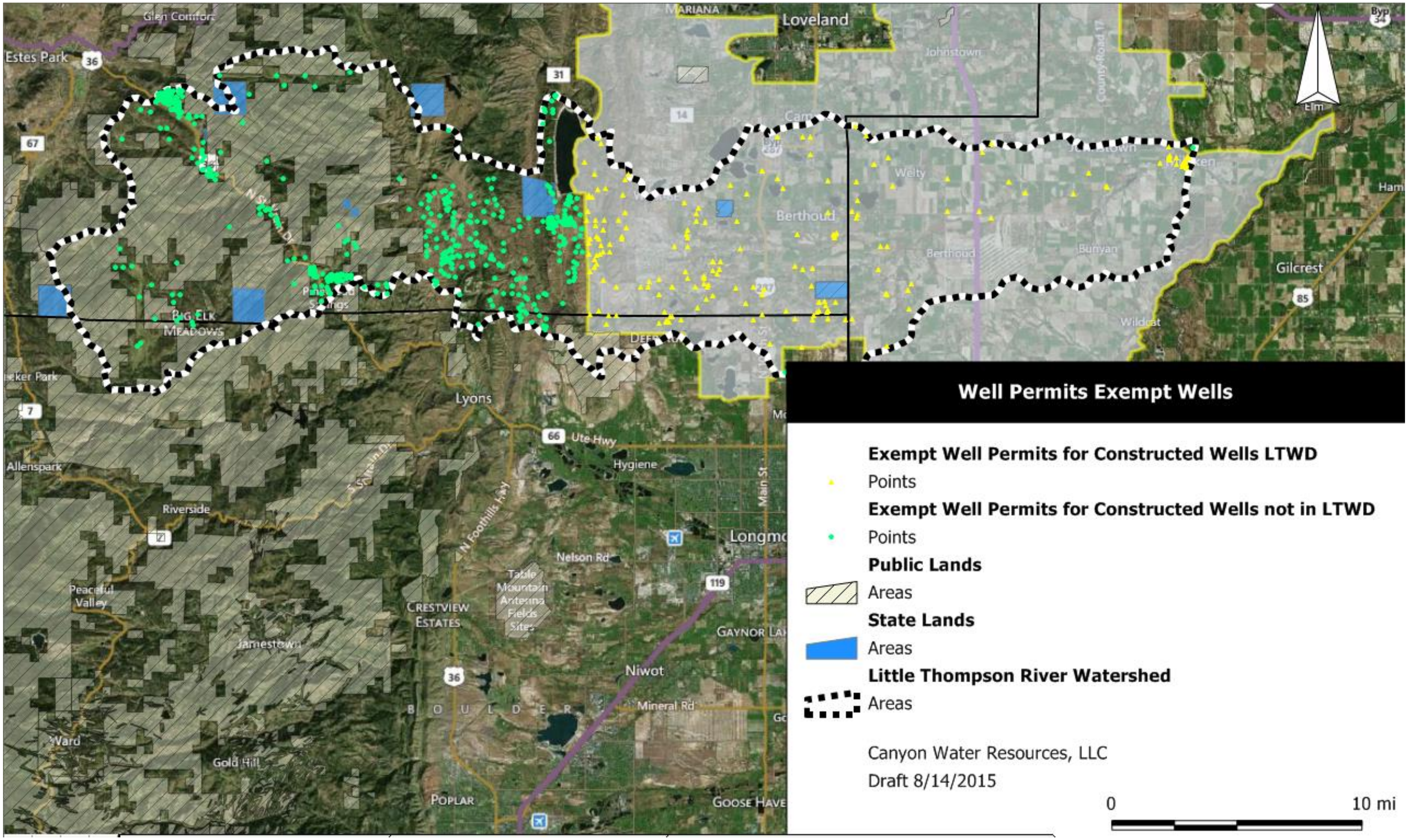
This evaluation uses water use factors to estimate water use volumes for the exempt wells. The use factor for domestic wells (which may include some outdoor uses) is 0.6 acre-feet per year (or approximately 550 gallons per day) and the household well use factor is 0.25 af/yr (or approximately 225 gpd) (CDM, 2010). For the purposes of this preliminary reporting, the consumptive use factors of 50% and 20% were used for the domestic and household diversions, respectively. Table 2 indicates that the estimated total diversion volume for the exempt wells is 315 acre-feet per year and the consumptive use portion is approximately130 af/yr.

Table 4: Summary of Estimated Water Use Associated with Exempt Well Permits in the Little Thompson Watershed

8/14/2015							
Well Permit Use1 Code	**Not in LTWD (upper portion)**	**Within LTWD (lower portion)**	**Total**	**Well Usage Factor (af/year)**	**Well Usage (af/yr)**	**Consumptive Use Factor**	**Consumptive Use (af/yr)**
Commercial	6	0	6	0.25	negligible		
Domestic	241	145	386	0.6	232	50%	116
Household use only	296	34	330	0.25	83	20%	17
Industrial	0	0	0				
Irrigation	0	5	5	unknown			
Municipal	0	0	0				
Other	0	0	0				
Stock	8	13	21	15 gpd/head	negligible		
Total Count All Use Codes	**551**	**197**	**748**	**0.42**	**315**	**42%**	**133**

Note: Well usage factors modified from CDM, 2010.

Figure 7: Well Permits Constructed Exempt Wells



Estimate Water Use Volume for Development of New Exempt Wells

The State well permit process may issue exempt well permits when the parcel area is greater than 35 acres, the parcel is not within a water service district, and uses only include domestic, limited irrigation, and stock watering. Parcels outside of the Little Thompson River Water District and with areas greater than or equal to 35 acres potentially qualify for exempt well permits. This section estimates a potential "high-end" number of new exempt wells and develops a rough estimate of water use volume associated with development of new exempt wells.

To estimate the potential number of new exempt wells, this analysis identified privately owned land (parcels) with areas greater than or equal to 35 acres and not within the Little Thompson Water District. The work sorted through the Larimer and Boulder County parcel databases[26] removing areas with Federal and State ownership, areas less than 35 acres, and any parcel containing location(s) of existing well permits associated with constructed well or administrative wells. Figure 3 maps the parcels meeting the selection criteria.

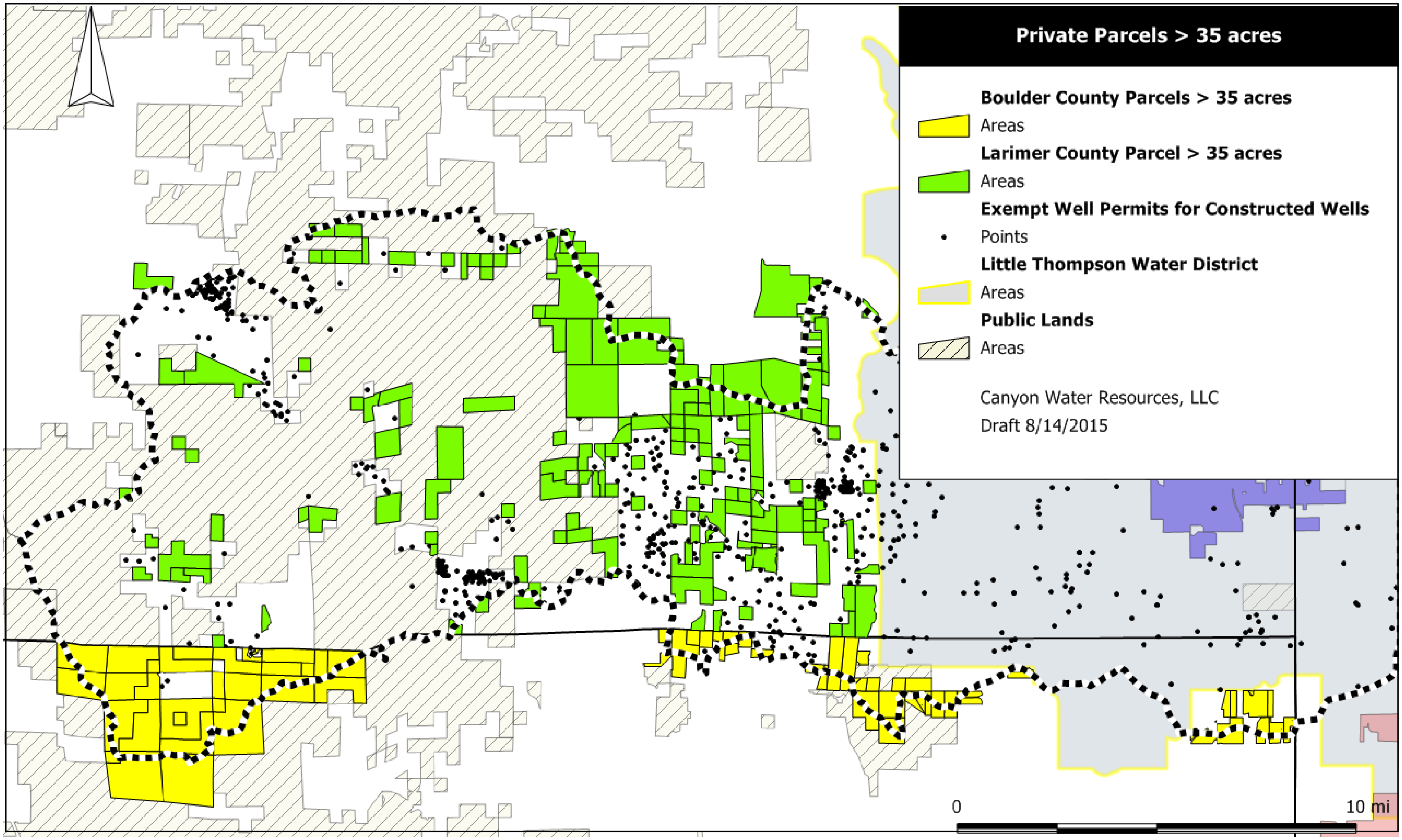
Once all the private parcels with areas greater than or equal to 35 acres were identified, the individual parcel areas were divided by 35 and the result rounded down to the nearest whole number. For example, if the parcel area is 69 acres, then 1 exempt well is assigned to the area. A 70 acre parcel would be assigned 2 exempt wells.

The analysis resulted in an estimate of approximately 680 parcels having areas of 35 acres or greater and not within the LTWD. The 680 number represents an ultimate "high-end" estimate. Because of topography, economics, access, and other land use factors development of 680 individual parcels is not realistic.

If we assume 450 new exempt well permits and a domestic consumptive use factor of 0.3 acre-feet per year per, then the well depletion volume is approximately 130 acre-feet per year. We believe that even 450 new exempt well permits is probably a relatively high and conservative number.

[26] Parcels greater than 35 acres and within the Little Thompson Conservation District were not included in this portion of the analysis because new wells in this area would probably not qualify for an exempt well permit.

Figure 8: Potential Locations for New Exempt Wells



Conclusions

This evaluation identified approximately 130[27] non-exempt groundwater wells and 750 exempt groundwater permits (constructed) within the Little Thompson River watershed. About half of the non-exempt wells are located in the upper portion of the watershed (i.e., the western portion of the area and outside of the Little Thompson Conservation District boundaries). The non-exempt wells are primarily associated with commercial, domestic, household, and municipal uses in subdivisions, and most of these are covered under augmentation plans (i.e., Big Elk Meadows, Pinewood Springs, and the Brown (aka Jellystone) and Smitherman wells/water systems)[28].

The non-exempt wells in the eastern portion of the watershed are generally associated with irrigation and municipal uses, although the well information describes some commercial, fishery, domestic and stock uses as well. The municipal and fishery wells are covered under augmentation plans, but most of the irrigation wells are not. Irrigation wells without augmentation plans are not likely to be in use currently because they have junior water rights and would be subject to a river call. The evaluation indicates that most of the non-exempt wells do not have diversion records or other use data and more detailed quantification of the current water uses requires additional investigation outside of this Scope of Work.

This work identified and mapped approximately 750 exempt well permits associated with constructed wells within the Little Thompson River watershed. Approximately 600 of the exempt wells are located south and west of Carter Reservoir in the foothills and mountains within the watershed. The other 150 exempt wells are located within the Little Thompson Water District. Domestic, household, commercial and stock are the primary uses associated with the exempt wells.

For the exempt wells, assuming an average water use factor of 350 gallons per day per well and a consumptive use factor of 15%, the calculated water diversions are about 315 acre-feet per year (af/yr) and the calculated consumptive use is approximately 130 af/yr.

This evaluation includes a preliminary estimate of the potential number of new exempt wells that could theoretically be permitted within the watershed. Because of topography, economics, access, and other land use factors development to "full build-out" is not realistic. Nonetheless, assuming that 2/3red are developed (i.e., 450 new wells) and a domestic consumptive use factor of 0.3 acre-feet per year per well results in an estimated consumptive use volume of approximately 130 acre-feet per year.

[27] After Subtracting the 11 wells that have been decreed abandoned in 11CW02____

[28] A separate technical memorandum (a portion of this Needs Assessment Phase I SOW) reports on the Big Elk Meadows and Pinewood Springs water uses. The Brown, Smitherman and other non-exempt uses in the upper portion of the watershed may be investigated in a later Scope of Work.

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To: Project Management Team, Little Thompson Watershed Coalition

From: Canyon Water Resources, LLC and George Wear Consulting, LLC

Subject: WSRA Contract 150707, Water Supply, Use and Planning Study - Needs Assessment Little Thompson River, **Key Element 3 –Gaging Station Options and Costs Technical Memorandum**

Date: March 1, 2016 revised on May 25, 2016

Introduction

The following Technical Memorandum (TM) is a portion of the Little Thompson Watershed Restoration Coalition, Water Supply, Use and Planning Study - Needs Assessment for the Little Thompson River/Watershed. The work is funded by the Colorado Water Conservation Board WSRA Contract 150707 and the Big Thompson Conservation District is acting as the fiscal agent for the project. This technical memorandum describes stream gaging options and costs for purposes of water supply management and operations within the Little Thompson River watershed (aka the study area).

This Technical Memorandum (TM) begins planning for alternative reconnaissance-level stream gaging for the Little Thompson River. The process of planning and designing a gaging plan considers many issues. A gaging plan must establish objectives for the data collection, consider many site-specific factors, develop access agreements, assess equipment options, and define funding mechanisms. The Study is developing the information necessary for the Stakeholders to prioritize gaging station locations and purposes. To begin the process, this TM provides a comparison of equipment and operation and maintenance costs for conceptual planning of gaging stations.

In a public meeting discussing the results of this study held in Berthoud on April 9, 2016, stakeholders indicated that the priority for stream gaging within the Little Thompson River watershed is early warning of flooding. There was a strong consensus in support of new emergency warning precipitation and stream flow monitoring within the watershed. The Little Thompson River Watershed Coalition strongly supports Larimer County's efforts to identify and implement early flood warning and other emergency preparedness for the area.

The stakeholders have a priority to develop comprehensive flood and emergency warning system as a part of the three counties emergency systems (Boulder, Larimer and Weld). There are several separate local fire departments individually serving the Big Elk Meadows, Pinewood Springs, Blue Mountain, Dakota Ridge, Berthoud, Johnstown, and Milliken areas. Homes are located in areas with single point at certain river crossings. Early warning is critically important to stakeholders so that evacuation routes may be accessible and emergency personnel notified.

Discussion

The primary function of stream flow gaging stations is to estimate the flow rate (aka, discharge) of the water in the stream or canal. The flow rate is typically reported in cubic feet per second (cfs). Gaging stations measure the height of the stream's water surface relative to an established datum, i.e., the stage, and then determine the flow rate using a stage-discharge curve unique to each station.

There are several methods to measure and record the stage elevation. Stage heights can be measured by observing the water level on a staff gage. If continuous monitoring is desired, than a pressure sensor, or similar device, is installed within a stilling basin to measure and record the stage. Real-time monitoring involves data loggers and telemetry equipment to broadcast the data to the office or data service provider.

A stage-discharge relationship is established for each individual gaging station. The relationship is typically a mathematical power function developed by graphing the stage height versus the estimated discharge at different flow rates. The function converts the stage data into discharge (i.e., flow rate) data.

A stage-discharge relationship is developed through a series of measurements at multiple, different stage heights. Essentially, the method involves measuring the flow velocity at multiple small cross-sectional intervals of the channel. A discharge value is calculated by multiplying the estimated velocity in each sub-section by the area for each sub-section, and summing these values across the entire stream cross-section. This method provides a valid estimate of the stream discharge.

There are many factors that affect gaging station costs. Station design attributes that affect cost include:

- The period of measurements, i.e., seasonal or year-round data collection;
- The need for continuous data collection with datalogging equipment vs. "spot" sampling or periodic monitoring;
- The need for real-time data access capabilities;
- The number of data parameters collected (i.e., stage only, stream flow, water quality parameters, etc.);
- Site specific conditions affecting station infrastructure/housing design;
- The need for flood hardening and/or flood stage monitoring; and,
- Any requirements for published and peer reviewed discharge data.

The following sections discuss conceptual gaging design options and their associated costs.

Gaging Station Options and Planning Costs

The following sections describe gaging station options for the purpose of preliminary planning. These options provide a range of data acquisition and reporting alternatives, along with their associated costs. The concepts range from permanent, real-time data, and multiple water quality parameter monitoring stations, to synoptic one-and-done flow observations. Table 1 presents a summary of the gaging station options and costs[29].

[29] Concept-level cost estimates.

Permanent Real-time Stream Gages

A permanent gaging station operated year-round with real-time data access capability represents the most advanced stream flow measuring system. These stations typically measure river stage on a near-continuous basis (e.g., sample stage height every 15 minutes) and have telemetry capability that allows for near-real-time viewing of the stream discharge data, usually via internet portals. For stations where data quality and accountability are paramount, exacting operations and data management protocols are followed and the stream flow data are published with peer review each year. Both the USGS and Colorado Division of Water Resources (DWR) build and operate these advanced stations.

The USGS may cooperate on new stream gaging stations through their Cooperative Water Program. The agency prioritizes all the new gage proposals and there can be a federal cost match for the higher ranking priority projects[30]. Once matching funds are approved, they are very likely to continue indefinitely.

USGS gage stations are almost always "permanent" stations (i.e., establishing an extended period of record). These stations typically report real-time discharge data. The USGS monitoring includes peer- reviewed stream flow records that are published annually. USGS stream flow records are considered the objective "standard" and their gaging station protocols are followed by others such as DWR. The permanent stations installed and operated by the USGS are the most expensive option available. Preliminary local average cost estimates follow[31]:

- Construction costs, stream flow station: $20,000; approximately half in equipment costs and the other half in construction labor/machinery and development costs;
- O&M: $16,600 for year-round operation; O&M typically includes about 12 visits per year;
- Water quality monitoring for water temperature only: capital cost < $2,000; approximately $4,300 for year-round O&M (monitoring of additional water quality parameters increases these costs);and,
- Costs include development of the stage-discharge curve, publishing data annually, and real-time data access using satellite monitoring and internet portals.

Colorado DWR constructs and operates gaging stations throughout the state. Many stream gaging stations have local cooperators. DWR stations primarily collect stream and ditch discharge data for real-time water administration purposes. Very few DWR stations measure water quality or are equipped to provide flood stage monitoring.

Typically, the DWR does not develop a new gaging station unless there is an imperative need for water administration purposes. The DWR will construct new stations where construction material and equipment costs are funded by a cooperating entity and there is a demonstrable purpose for water administration.

[30] Priority is given to state and regional studies, NWS flood monitoring, and water quality (WQ) monitoring. Smaller projects can gain the "medium" match category (i.e., 30% match) if WQ monitoring is included with a stream flow station.

[31] Cost estimates provided herein are average costs, but there can be significant variation in station construction costs, especially related to the station housing design which is a product of the individual site conditions. Difficult physical access to the site and host easement agreements can increase construction and/or operation costs.

However, DWR workloads often limit the number of new stations that can be maintained and operated by the staff.

For the permanent, year-round gaging station described above, average DWR costs are as follows:

- Equipment costs range from $6,500 to $9,000 depending on measurement technology selected;
- Shelter construction is additional, and can range from $1,000 to $5,000 depending on design, and the cooperator may be able to reduce these costs by assisting with the shelter installation using their own manpower and equipment;
- Annual O&M costs for a year-round, published station can vary from $9,000 to $12,000 per year, largely dependent on the travel distance for the hydrographer; and,
- Costs include development of the stage-discharge curve, publishing data annually, and real-time data access using satellite monitoring and internet portals.

Many gaging stations are not operated year-round (i.e., real-time stage data are not collected) in Colorado because of winter conditions where icing and low flows can make accurate data collection difficult. The USGS typically, and the DWR sometimes, will use a winter estimating procedure that includes several site visits throughout the winter to conduct stream discharge measurements. Some stations may have equipment that is able to operate throughout the winter and freezing conditions.

The DWR operates some gaging stations on a seasonal basis (i.e., irrigation season) where the flow data are used for real-time water administration. These stations are located both on natural streams and ditch diversions. DWR publishes an annual record for most of their stations, but does not usually estimate winter flows. This type of operation results in reduced annual O&M costs.

Temporary Stream Gages

Temporary gaging stations can be established for limited periods of data collection (e.g., 1-10 years). Temporary stations usually have reduced construction costs compared with permanent stations. For a temporary station the gage house is typically less substantial (or, not required) and less expensive data logging and telemetry equipment options may be selected. However, operation and maintenance costs for temporary stations may not vary substantially versus more permanent stations.

The costs associated with temporary stations depend on the key design parameters, including operational season, real-time monitoring, publishing/quality control, and number of data parameters. Since long-term monitoring is not an objective, an official record may not be important and, therefore, publishing the record may not be a requirement. The DWR will sometimes participate in the construction, operation, and/or funding of temporary gaging stations, whereas the USGS typically does not.

Watershed monitoring and research efforts may not require establishing a gaging station. For example, a transit loss analysis may utilize synoptic discharge measurements at several locations down the watercourse. Consulting contracts for these types of monitoring and sampling projects would typically have costs estimated based on hourly rates and expenses.

For temporary stream gaging the estimated costs are as follow:

- Equipment costs, including the shelter, range from $2,500 to $7,500 depending on the measurement technology that is selected. The cooperator may be able to reduce these costs by assisting with the shelter installation using their own manpower and equipment;
- Estimated annual O&M costs for a year-round station are about $10,000 assuming up to 6 visits by the contracting hydrographer;
- Costs include development of the stage-discharge curve and reporting the data.

Table 1: Menu of Stream flow Measurement Options and Costs

Station Option	Capital Costs Equipment and Installation	Annual O&M	Comments
Permanent Station with Year-around Operations and Real-time Provisional Data Reporting	$8,000 - $22,000	$9,000 - $25,000	Peer reviewed and published data. (upper range incls. WQ monitoring, 1 parameter)
Contracted Temporary Station with Seasonal Operations and Real-time Provisional Data Reporting	$5,000 - $7,500	$10,000	Includes data hosting, Up to 4 site visits to check observations and develop stage relationship, etc.
Contracted Temporary Seasonal without Real-time data	$2,500 - $5,000	$10,000	Up to 4 site visits to check observations and develop stage relationship
Contracted Periodic Observations	None	Up to $2,500 per observation	One-time report

"Ad hoc" Monitoring and Sampling

There are several options for involving local community volunteers in streamflow monitoring or sampling efforts. These types of projects can provide opportunities for community engagement and produce useful watershed monitoring data and information at low cost. Of course, consideration must be given to data quality requirements, training of data collection protocols, and quality control.

Water quality monitoring utilizing community volunteers is already being undertaken in the mid- and lower reaches of the watershed. The Big Thompson Watershed Forum (BTWF) has had a water quality monitoring program in place for many years, covering many locations throughout the Big Thompson watershed including within the CBT network. This program utilizes USGS for its "cooperative monitoring program" and citizens and staff for its "volunteer monitoring program."

The volunteer program has been collecting water quality data six times a year at three locations on the Little Thompson River: above the Berthoud WWTP discharge, below the Berthoud WWTP discharge, and below the Johnstown WWTP discharge (above Milliken and the confluence with the Big Thompson River.)

At this last station above Milliken, labeled "VT05" by BTWF, the USGS has established a staff gage and a rating table to facilitate stream flow estimating in conjunction with WQ monitoring. It is in the vicinity of a historic USGS stream gaging station that was operated in the 1950's and 1960's. The Town of Milliken cooperates with the BTWF for operations at this location, per a conversation with the USGS Denver Data Chief, Greg Smith. There is interest in re-establishing this station as a permanent stream gage and LTWRC may want to consider becoming a cooperator on this project. In addition, there could be further opportunities to cooperate with the BTWF, including possible expansion of the water quality monitoring program to locations in the upper watershed, or to cooperate on the establishment of additional new stream gage stations. Costs to the LTWRC would have to be assessed on a case-by-case basis.

In addition to the BTWF, the Colorado River Watch program has done water quality monitoring and stream flow estimating at over a dozen locations on the Little Thompson River from the canyon mouth to the confluence, as recent as 2009. This program is run by the Colorado Watershed Assembly, in cooperation with Colorado Parks and Wildlife, and typically partners with local middle and high school science programs. The LTWRC might endeavor to reestablish River Watch monitoring in the watershed and engaging local students. Costs to the LTWRC for their role in a program should be minimal.

Finally, given the LTWRC's focus on identifying dry reaches on the Little Thompson River, a simple community reporting effort could be undertaken where citizens would be asked to report dry conditions by posting the day/time/location and a picture to the LTWRC website or by email, for example. This is already occurring on a small scale, but could be formalized and, in the near term, could provide good anecdotal information while raising community awareness and engagement. Administration and data compilation costs could be estimated and shouldn't be substantial.

Conclusions

Defining clear objectives and data requirements is necessary in order to properly design a new gaging station and to select from the range of gaging options available. As discussed, many factors will influence gaging station design and selection. Costs will be highest to build and operate permanent stations with real-time data access, multiple parameter collection (e.g., water quality monitoring) and annual data publication. Basically, the more field visits required, the more sophisticated and permanent the equipment installed, and the more rigorous reporting needed, the higher the gaging station costs. The goal is to balance the appropriate data objectives with these cost demands.

To: Project Management Team, Little Thompson Watershed Restoration Coalition

From: Canyon Water Resources, LLC and George Wear Consulting, LLC

Subject: WSRA Contract 150707, Water Supply, Use and Planning Study, Needs Assessment Little Thompson, **Key Element 4 - Industrial Water Uses Technical Memorandum**

Date: March 1, 2016 revised May 25, 2016

The following Technical Memorandum (TM) is a portion of the Little Thompson Watershed Restoration Coalition, Water Supply, Use and Planning Study - Needs Assessment for the Little Thompson River/Watershed. The work is funded by the Colorado Water Conservation Board WSRA Contract 150707 and the Big Thompson Conservation District is acting as the fiscal agent for the project. This technical memorandum addresses industrial water uses in the Little Thompson River watershed. The Scope of Work directs emphasis on the use of Little Thompson river water supplies and a cursory review of only oil and gas industry uses.

This work did not identify any oil and gas industrial uses associated with "native" Little Thompson River Water Supplies. Inquiries with local water users, the Water Commissioner, and the Project Management Team for this project did not identify Little Thompson River water supply change of use applications for oil and gas purposes. The industry is reaching a point where most of the oil and gas operators have their water sources secured. The supplies include groundwater that doesn't have to be changed (Denver Basin water in particular), NCWCD water (particularly leases with area towns) and water rights that already have an industrial decree.

During the summer of 2015, there were reports of oil and gas operators diverting NCWCD supplies from the river near (Koolstras)[32]. Apparently, flow rates were planned at 3 – 7 cubic feet per second.

[32] Personal communication with Mr. Larry Lempka

Preliminary Stream Flow Evaluation for the Little Thompson River

Water Supply, Use and Planning Study – Needs Assessment for the Little Thompson River/Watershed, WRSA Contract 150707

Prepared for Little Thompson Watershed Coalition
and Big Thompson Conservation District, acting as Fiscal Agent

Prepared by Canyon Water Resources, LLC and George Wear Consulting, LLC
February 26, 2016 revised May 25, 2016

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Introduction

The following report is a portion of the Little Thompson Watershed Restoration Coalition, Water Supply, Use and Planning Study - Needs Assessment for the Little Thompson River/Watershed. The work is funded by the Colorado Water Conservation Board WSRA Contract 150707 and the Big Thompson Conservation District is acting as the fiscal agent for the project. This report presents a preliminary stream flow evaluation for the Little Thompson River (LTR). It includes SOW Key Elements concerning dry reaches, impacts due to drought and water management practices, and timing and location of water supplies.

The data reported herein primarily comes from the Colorado Decision Support System (CDSS) databases. The evaluation uses data for the period of 2000 – 2014, since this study is concerned with the current and some future water uses[33]. The data includes Little Thompson River stream flow records, irrigation diversion records, and Division 1 call records. The characterization of stream flows incorporates information from interviews and common knowledge of the Little Thompson River water supplies and operations. This study's Agricultural Use Technical Memorandum (see appendices) provides data and background to supplement the discussion in this Technical Memorandum.

An important determination of the Agricultural Technical Memorandum is that within the Little Thompson River watershed, irrigated areas served by the non-Little Thompson River diversion structures (i.e., the Handy, Home Supply, Highland ditches, etc.) are approximately 6 times greater than the irrigated areas associated with the Little Thompson River structures[34]. Consequently, for the watershed as a whole, the water imported (i.e., Big Thompson River, St. Vrain River, and Colorado Big Thompson Project water supplies) into the basin makes up the bulk of the watershed's overall water supply budget[35].

The Scope of Work for this Study directs emphasis on the Little Thompson River structures (i.e., Supply Lateral/Culver, Boulder Larimer, W R Blower, Eagle, Jim Eglin, Osborne Caywood, Rockwell, Miner Longan, Great Western, and Beeline ditches). These structures divert the natural flow of the Little Thompson River "native" supplies and may divert "imported" Colorado-Big Thompson Project (C-BT) water supplies.

The following sections present and discuss the Little Thompson River (LTR) stream gage data, a preliminary water supply accounting spreadsheet, the stream flow evaluation, and preliminary discussions of impacts from certain changes in agricultural water supplies and water management practices.

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[33] Evaluating the last 15 years of data is appropriate at this time because the datasets are more complete and the SOW is primarily concerned with the existing and some certain future water supply conditions. As discussed later in this section, hydrology for longer periods is presented to show how the last 15 years compares to the longer period of available records.

[34] The Little Thompson River structures are the headgates and ditch systems that divert the natural flows i.e., "native" Little Thompson River water supplies

[35] Phase 2 may develop more information on the non-LTR structures diversions, water use, and return flows. For now, this Study recognizes that the tributary areas and lower portions of the watershed need additional evaluation and data to more fully describe and characterize the flows and water supplies.

Stream Gage Data

Historical stream flow monitoring on the Little Thompson River includes 4 stream gages and multiple single event or short-term flow observations. Since the 1960s, the only Little Thompson stream gage records are for the river at the Canyon mouth. Prior to the 1970's, there were periodic stream flow observations near the bottom of the watershed near Milliken and in the headwaters in the West Fork (Table 1 and Figure 1).

Over the years, two stream gages measured flow at essentially the same location near the Canyon mouth. Prior to 1961, the Little Thompson River near Berthoud gage recorded stream flows at the Canyon mouth. The Little Thompson River at Canyon Mouth near Berthoud gage replaced the Little Thompson River near Berthoud gage in 1961. The combined record for these gages includes 43 years of stream flow records.

Table 9: Little Thompson River Stream Gages and Period of Records

Station Name (abbrev., USGS ID)	Data Records		No. Years
	From	To	
W. FK. LIT. THOM. R. B. BIG ELK MEAD. (LTCELKCO)	1955-10	1963-09	8
LITTLE THOMPSON RIVER NEAR BERTHOUD, CO. (LTCBERCO,06742000)	1929-05	1930-09	15
	1947-04	1952-09	
	1953-10	1961-09	
LITTLE THOMPSON RIVER AT CANYON MOUTH NEAR BERTHOUD (LTCANYCO)	1961-10	1969-09	28
	1993-04	2012-09	
LITTLE THOMPSON RIVER AT MILLIKEN, CO. (LTCMILCO,06743500)	1951-10	1957-03	14
	1959-10	1968-09	

The Little Thompson River is a relatively small and low elevation watershed. The watershed's total area is approximately 200 square miles. The drainage area upstream of the Little Thompson River at Canyon Mouth near Berthoud stream gage is approximately 100 square miles and the maximum elevation is approximately 10,000 feet.

The average annual flow volume of the Little Thompson River at the Canyon mouth is approximately 8,400 acre-feet (af) (for the years with complete 12 months of records). The run-off season March – June provides the bulk of the native water supply. For the 43 years, the March – June average annual flow volume is 8,200 af (Table 2). After the run-off and in the winter-time the stream flow volumes are small. Winter-time flow rates in the Little Thompson River at the Canyon mouth are typically less than 1 cfs during the late summer and winter-time.

Figures 2- 5, provide graphical and tabular summaries of the stream flow records. The graphs show the stream flow monthly volumes (i.e., acre-feet per month) on the primary axis and the secondary axis indicates the average flow rate (cubic feet per second per month). Gaps in the line connecting the monthly values indicate no available data record (as opposed to zero values that are published in the data). Note that the scale and historical period vary between all the graphs.

Figure 9: Little Thompson River Stream Gage Locations

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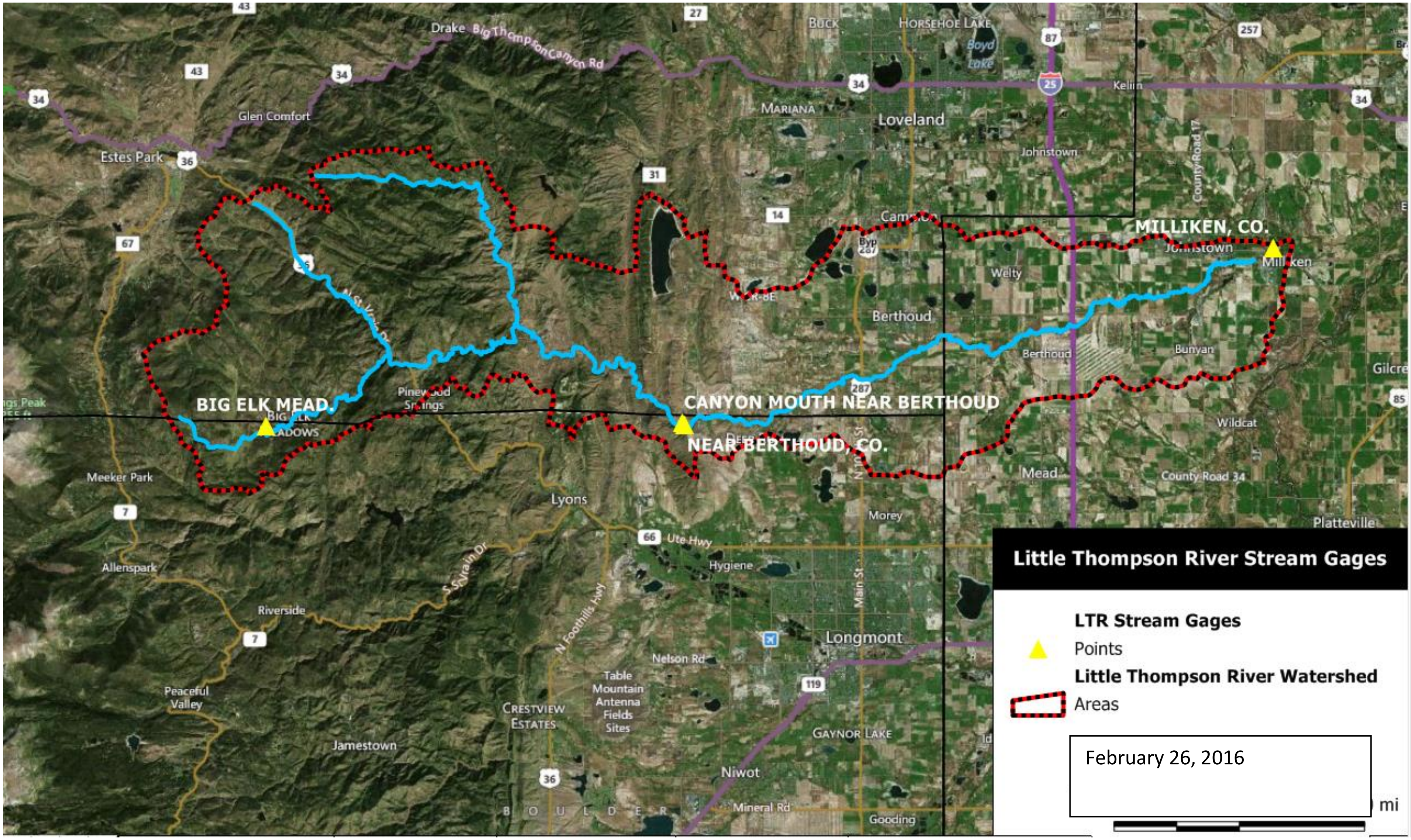
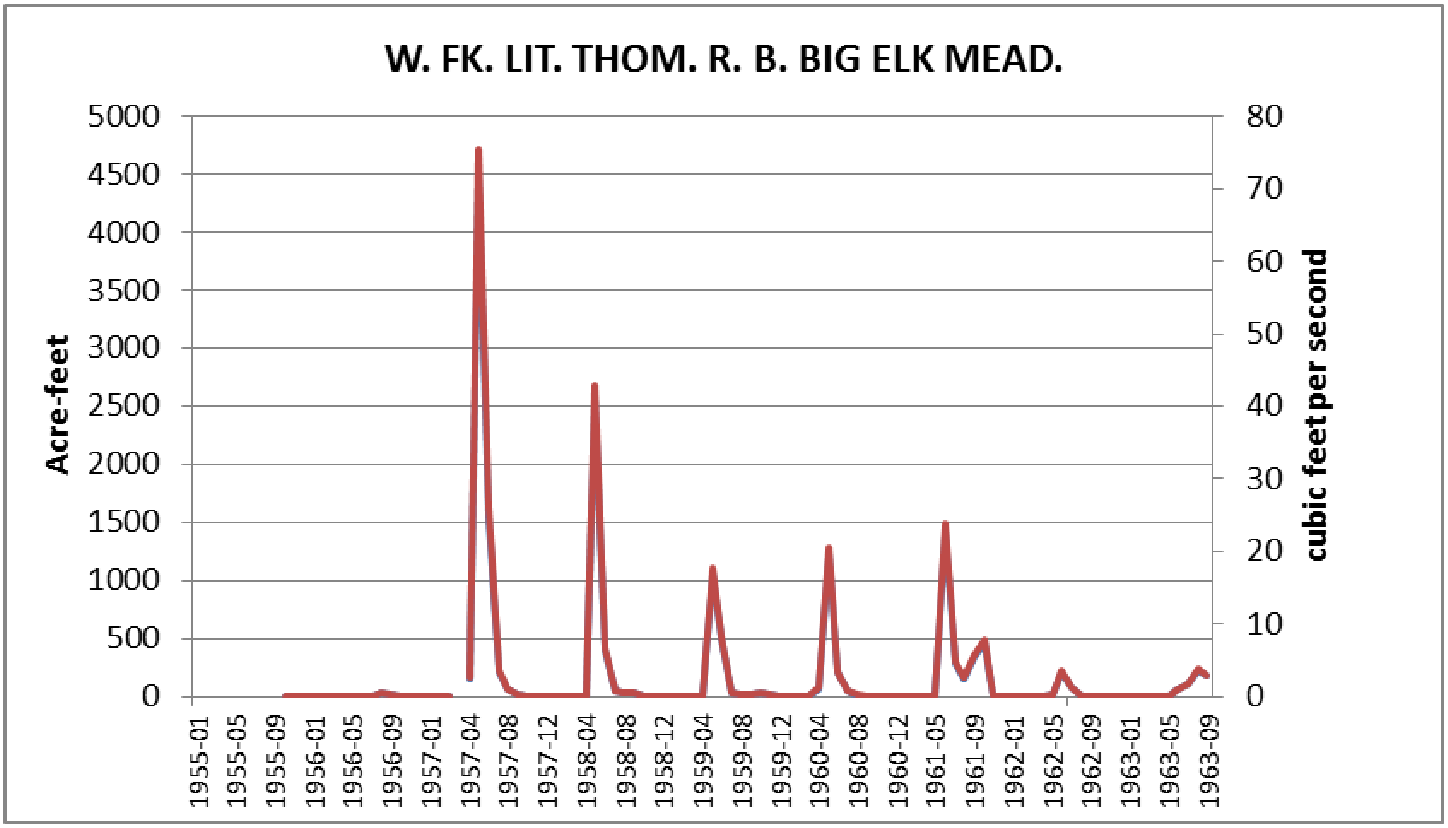


Figure 10: West Fork Little Thompson River below Big Elk Meadows



State of Colorado | HydroBase

Description: W. FK. LIT. THOM. R. B. BIG ELK MEAD.

Time Series Identifier:	LTCELKCO.DWR.Streamflow.Monthly	Data Source:	DWR
Located in Water Division, District:	4, 1	Measurement Type:	Streamflow
Located in County, State:	, CO	Data Interval:	Monthly
Located in HUC:	10190006	Data Units:	AF
Latitude, Longitude:	40.256929, -105.446394		
UTM X, UTM Y (zone 13 NAD 83):	462039.1 ,4456370.0		
Elevation (feet):			
Time Series Creation History:			
Available Data:	1955 To 1963		
Selected Time Series From:	1955-01-01 To 1963-12-31		

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Total
1956	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	26.18	20.43	46.61
1957	0.00	0.00	0.00	0.00	0.00	0.00	156.70	4484.69	1541.77	213.23	55.14	14.28	6465.81
1958	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2556.73	401.06	45.03	37.49	31.74	3072.04
1959	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1060.97	498.65	31.93	11.11	12.10	1614.77
1960	35.31	11.50	0.00	0.00	0.00	0.00	67.24	1223.42	203.71	43.04	9.32	0.79	1594.34
1961	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1416.62	282.45	153.72	340.96	2193.75
1962	465.53	0.00	0.00	0.00	0.00	0.00	0.00	20.03	212.23	75.17	0.79	0.00	773.76
1963	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.17	54.15	98.18	229.29	172.37	558.16
Min:	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.79	0.00	46.61
Max:	465.53	11.50	0.00	0.00	0.00	0.00	156.70	4484.69	1541.77	282.45	229.29	340.96	6465.81
Mean:	62.61	1.44	0.00	0.00	0.00	0.00	27.99	1168.75	541.02	98.63	65.38	74.08	2039.91

Figure 11: Little Thompson River near Berthoud, Colorado

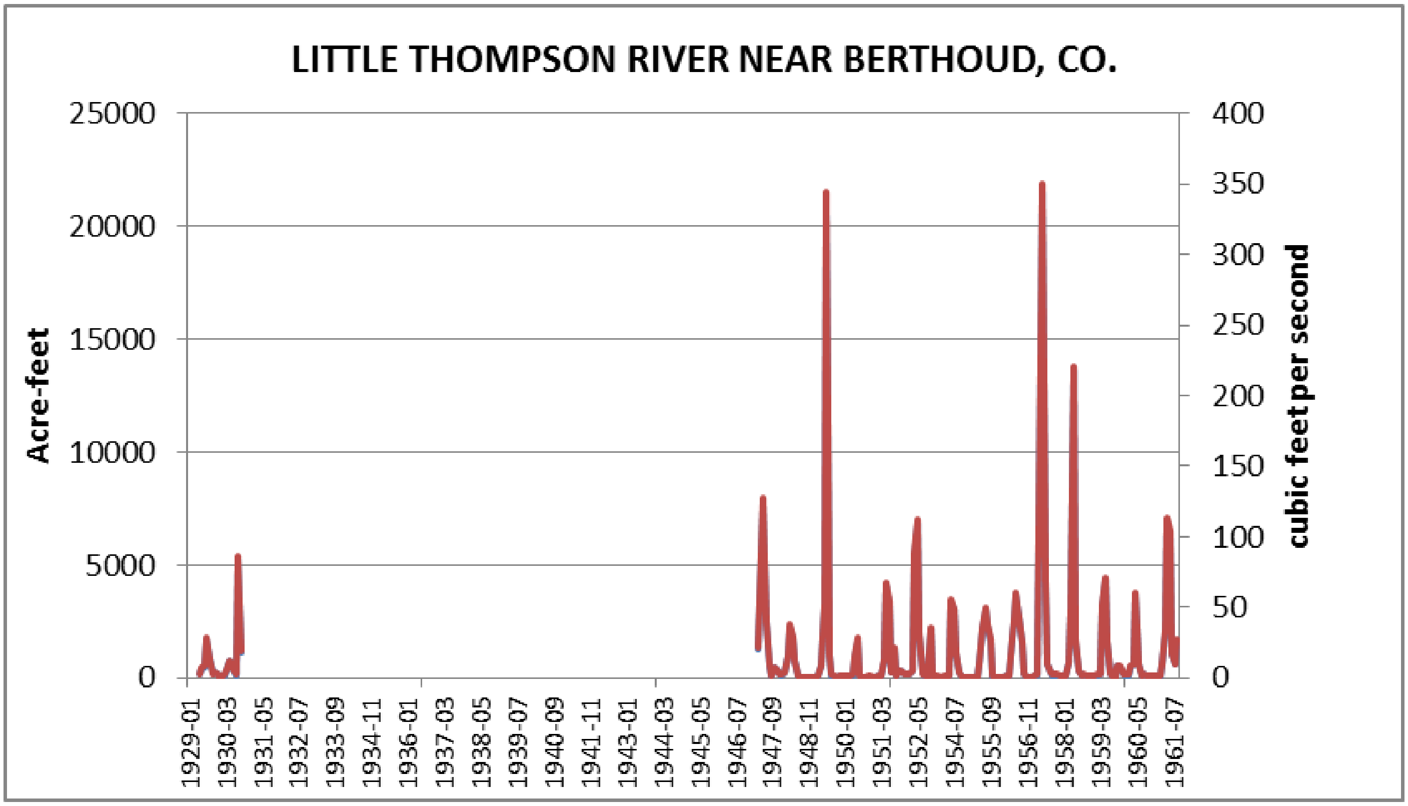


Figure 3: continued

State of Colorado HydroBase

Description: LITTLE THOMPSON RIVER NEAR BERTHOUD, CO.

Time Series Identifier:	**06742000.USGS.Streamflow.Monthly**	**Data Source:**	**USGS**
Located in Water Division, District:	**4, 1**	**Measurement Type:**	**Streamflow**
Located in County, State:	**BOULDER, CO**	**Data Interval:**	**Monthly**
Located in HUC:	**10190006**	**Data Units:**	**AF**
Latitude, Longitude:	**40.257207, -105.204709**		
UTM X, UTM Y (zone 13 NAD 83):	**482591.8 ,4456325.4**		
Elevation (feet):	**5223.37**		
Time Series Creation History:			
Available Data:	**1929 To 1961**		
Selected Time Series From:	**1929-01-01 To 1961-12-31**		

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Total
1929	NC	NC	NC	NC	NC	NC	NC	194.38	393.72	475.84	1717.31	792.21	NC
1930	205.49	257.46	184.47	24.60	55.54	117.22	516.70	729.93	386.58	106.51	5274.72	1120.68	8979.90
1947	NC	NC	NC	NC	NC	NC	1229.77	5403.05	7622.59	2413.52	463.94	68.63	NC
1948	428.83	378.06	151.74	104.13	256.07	996.91	2249.29	1719.69	729.13	87.67	17.85	6.55	7125.92
1949	12.30	13.88	13.29	5.36	13.09	76.36	510.75	3232.71	20467.74	947.52	113.46	32.73	25439.18
1950	24.40	48.60	50.78	32.13	28.96	33.12	94.02	919.35	1658.01	92.03	23.80	11.11	3016.31
1951	35.50	31.74	12.50	24.40	60.30	85.09	757.90	4109.81	3183.52	248.53	1297.80	88.27	9935.35
1952	303.28	289.59	132.70	136.86	127.14	289.59	5244.37	6872.83	1878.37	209.06	38.48	25.79	15548.06
1954	2178.28	72.79	65.65	43.44	21.82	41.85	59.51	61.49	3290.63	3030.79	1076.25	251.31	10193.80
1955	11.31	3.57	6.55	12.10	9.12	9.12	5.95	609.53	2124.33	3068.47	2331.01	1595.33	9786.39
1956	33.32	7.93	11.50	11.70	17.26	65.46	72.40	971.91	2526.98	3659.56	2653.92	1480.88	11512.83
1957	175.94	28.17	22.61	26.18	69.82	120.40	6364.65	21497.17	3963.03	593.66	254.68	109.09	33225.41
1958	112.07	117.22	92.23	56.73	78.94	646.62	2935.58	13614.74	1579.06	337.20	88.46	93.62	19752.49
1959	64.27	85.29	84.70	87.08	102.15	193.19	3080.77	4377.58	1575.49	165.03	65.06	25.98	9906.59
1960	534.16	476.83	144.60	93.62	94.61	472.67	585.73	3715.10	585.73	85.49	136.86	54.74	6980.13
1961	37.09	35.70	49.19	49.19	42.05	596.64	2033.09	6932.33	6192.49	1035.78	621.43	1635.59	19260.58
Min:	11.31	3.57	6.55	5.36	9.12	9.12	5.95	61.49	386.58	85.49	17.85	6.55	3016.31
Max:	2178.28	476.83	184.47	136.86	256.07	996.91	6364.65	21497.17	20467.74	3659.56	5274.72	1635.59	33225.41
Mean:	296.87	131.92	73.04	50.54	69.78	267.45	1716.03	4685.10	3634.84	1034.79	1010.94	462.03	13618.78

Figure 12: Little Thompson River at Canyon Mouth near Berthoud, CO

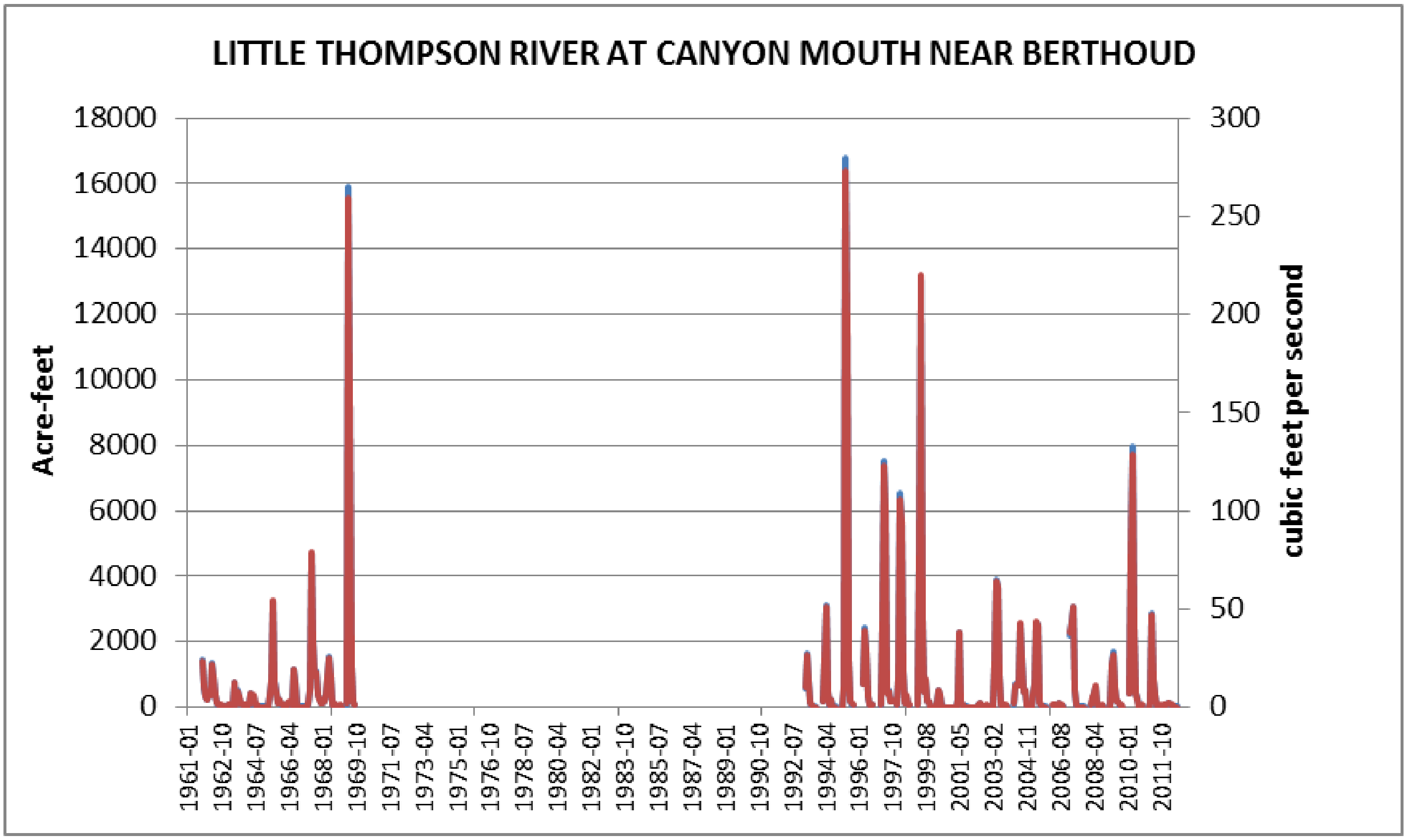


Figure 4 continued

State of Colorado | HydroBase

Description: LITTLE THOMPSON RIVER AT CANYON MOUTH NEAR BERTHOUD

Time Series Identifier:	LTCANYCO.DWR.Streamflow.Monthly	Data Source:	DWR
Located in Water Division, District:	4, 1	Measurement Type:	Streamflow
Located in County, State:	, CO	Data Interval:	Monthly
Located in HUC:	10190006	Data Units:	AF
Latitude, Longitude:	40.258038, -105.206386		
UTM X, UTM Y (zone 13 NAD 83):	482449.4 ,4456418.0		
Elevation (feet):	5206		

Time Series Creation History:

Available Data:	1961 To 2012
Selected Time Series From:	1961-01-01 To 2012-12-31

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Total
1962	1428.12	592.87	301.49	245.95	388.77	361.79	1330.93	930.86	377.86	114.45	54.15	40.07	6167.30
1963	42.05	18.45	13.88	10.12	54.94	70.22	83.70	59.11	777.33	87.08	514.32	294.15	2025.35
1964	116.43	78.94	49.98	39.27	32.73	49.19	415.34	245.16	335.21	41.85	40.86	25.19	1470.17
1965	14.68	10.51	11.50	9.52	9.12	29.75	371.31	836.84	3193.44	790.62	459.18	128.53	5865.01
1966	223.94	94.41	37.88	24.60	10.51	104.73	151.94	102.55	38.68	1150.83	757.90	23.21	2721.16
1967	28.56	14.68	18.64	21.22	22.22	24.60	96.40	569.66	4704.86	2017.22	983.82	1094.89	9596.77
1968	352.86	251.90	147.37	122.98	191.61	382.82	934.82	1531.26	905.86	85.69	151.74	33.92	5092.83
1969	27.97	22.81	33.52	20.03	NC	NC	92.63	15901.52	9181.62	1211.32	107.11	56.53	26655.07
1993	NC	NC	NC	NC	NC	NC	575.22	1654.24	796.77	134.54	47.84	24.58	3233.18
1994	28.56	1.53	NC	NC	NC	200.93	1514.60	3120.05	453.43	41.67	221.18	27.73	5609.68
1995	27.17	18.03	NC	NC	NC	5.32	642.44	16802.23	11355.54	1421.77	164.23	102.94	30539.67
1996	48.60	NC	NC	NC	NC	NC	723.98	2421.46	1655.43	319.34	73.37	56.17	5298.35
1997	90.84	NC	NC	NC	NC	46.41	2606.52	7535.32	5986.20	453.63	503.02	178.08	17400.02
1998	219.77	197.36	NC	NC	44.63	941.17	6535.63	5565.70	1093.70	141.74	341.56	60.30	15141.56
1999	31.99	NC	NC	NC	NC	65.46	4738.58	13079.20	2675.74	465.73	832.08	199.34	NC
2000	173.95	0.00	0.00	0.00	0.00	127.54	524.24	340.77	27.87	10.02	4.46	4.03	1212.87
2001	2.98	0.73	0.00	0.00	0.00	4.90	258.31	2288.96	188.13	56.05	23.96	18.27	2842.30
2002	29.45	4.86	0.00	0.00	0.00	0.00	20.67	64.64	114.98	22.57	11.68	9.80	278.66
2003	39.27	6.33	0.00	0.00	0.00	1339.06	3915.43	3643.69	960.61	81.56	23.11	36.10	10045.16
2004	45.14	14.48	NC	NC	NC	98.50	702.16	690.46	701.37	2530.75	1493.58	471.87	NC
2005	529.79	33.92	0.00	0.00	0.00	375.67	756.90	2600.37	2517.26	134.06	47.50	24.91	7020.40
2006	15.87	14.46	NC	NC	NC	35.21	78.55	69.28	20.07	108.79	30.33	26.28	NC
2007	51.79	21.18	NC	NC	NC	2179.87	2865.82	3054.59	535.54	32.23	19.64	11.64	NC
2008	17.00	15.15	25.41	NC	NC	33.80	271.74	408.60	638.69	38.52	17.00	12.54	NC
2009	33.86	16.64	NC	NC	NC	25.13	1307.40	1689.94	567.88	192.90	161.38	38.50	NC
2010	33.88	4.09	NC	NC	NC	412.77	4649.32	7943.92	2374.25	412.77	259.70	15.59	16106.28
2011	15.31	32.71	NC	NC	NC	17.06	145.63	2891.55	829.10	359.81	46.85	12.08	NC
2012	35.82	27.65	48.38	73.17	84.70	145.59	134.48	55.24	32.07	21.70	8.03	6.96	673.79
Min:	2.98	0.00	0.00	0.00	0.00	0.00	20.67	55.24	20.07	10.02	4.46	4.03	278.66
Max:	1428.12	592.87	301.49	245.95	388.77	2179.87	6535.63	16802.23	11355.54	2530.75	1493.58	1094.89	30539.67
Mean:	137.25	62.24	45.87	40.49	59.95	283.10	1294.45	3432.04	1894.27	445.69	264.27	108.36	8333.12

Figure 13: Little Thompson River at Milliken

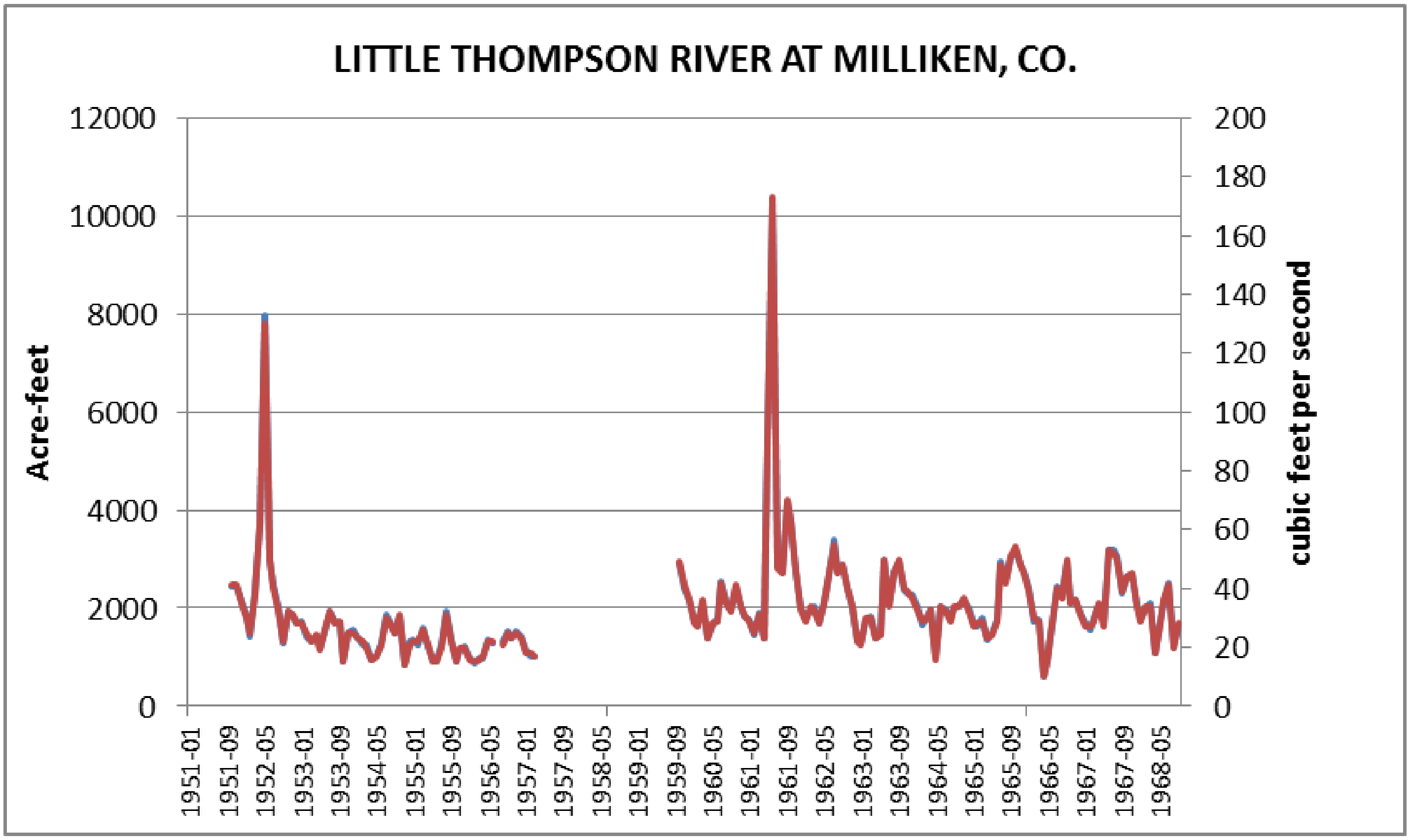


Figure 5: continued

State of Colorado HydroBase

Description: LITTLE THOMPSON RIVER AT MILLIKEN, CO.

Time Series Identifier:	**06743500.DWR.Streamflow.Monthly**	**Data Source:**	**DWR**
Located in Water Division, District:	**4, 1**	**Measurement Type:**	**Streamflow**
Located in County, State:	**WELD, CO**	**Data Interval:**	**Monthly**
Located in HUC:	**10190006**	**Data Units:**	**AF**
Latitude, Longitude:	**40.335260, -104.865250**		
UTM X, UTM Y (zone 13 NAD 83):	**511445.7 ,4464977.5**		
Elevation (feet):	**4737.96**		
Time Series Creation History:			
Available Data:	**1951 To 1968**		
Selected Time Series From:	**1951-01-01 To 1968-12-31**		

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Total
1952	2455.57	2455.57	2152.10	1826.80	1436.05	2350.45	3707.16	7963.75	2973.27	2485.33	2023.17	1287.69	33116.91
1953	1929.75	1834.74	1699.86	1719.69	1434.07	1334.90	1406.30	1191.69	1540.39	1945.42	1735.56	1707.20	19479.56
1954	918.56	1473.74	1551.10	1394.40	1247.62	1247.62	949.50	1031.42	1275.39	1870.44	1739.53	1499.53	16198.85
1955	1842.67	859.25	1305.14	1348.78	1245.64	1582.83	1221.84	924.31	898.53	1246.03	1920.03	1338.86	15733.92
1956	912.81	1163.92	1231.75	983.82	862.82	983.82	987.78	1338.86	1281.34	NC	1317.04	1509.44	12573.41
1957	1388.45	1509.44	1408.29	1128.61	1025.47	1029.44	NC	NC	NC	NC	NC	NC	7489.70
1958	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
1959	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
1960	2931.61	2411.94	2169.95	1741.51	1685.97	2058.87	1383.89	1652.26	1793.08	2526.98	2148.13	1981.52	24485.71
1961	2411.94	2039.04	1826.80	1755.40	1459.86	1900.19	1378.14	5469.10	10266.60	2911.78	2784.83	4167.33	38371.01
1962	3758.73	2745.16	2001.35	1801.02	1961.68	2025.15	1689.94	2142.18	2695.58	3407.65	2786.82	2874.09	29889.36
1963	2400.03	2001.35	1334.90	1301.18	1751.43	1834.74	1392.42	1493.58	2999.05	2078.71	2739.21	2963.35	24289.94
1964	2364.33	2292.93	2265.16	2048.96	1676.06	1816.89	1967.63	1010.20	2037.05	1967.63	1781.18	1997.38	23225.40
1965	2021.19	2185.82	1985.48	1676.06	1624.49	1789.12	1366.63	1499.53	1747.46	2954.22	2560.70	3024.84	24435.53
1966	3195.42	2870.12	2741.20	2417.89	1721.68	1767.30	606.36	952.08	1676.06	2443.67	2279.04	2963.35	25634.16
1967	2088.63	2169.95	1914.08	1683.99	1551.10	1808.95	2075.93	1687.96	3175.58	3171.62	3062.52	2298.88	26689.18
1968	2640.04	2665.82	2076.72	1804.98	1979.53	2094.58	1094.10	1743.10	2114.41	2497.23	1216.08	1644.32	23570.92
Min:	912.81	859.25	1231.75	983.82	862.82	983.82	606.36	924.31	898.53	1246.03	1216.08	1287.69	7489.70
Max:	3758.73	2870.12	2741.20	2417.89	1979.53	2350.45	3707.16	7963.75	10266.60	3407.65	3062.52	4167.33	38371.01
Mean:	2217.32	2045.25	1844.26	1642.21	1510.90	1708.32	1516.26	2150.00	2605.27	2423.59	2149.56	2232.70	23012.24

Preliminary Water Supply Accounting

The following evaluation is for the reach of the Little Thompson River from the Canyon mouth to approximately Dry Creek- County Road 1 (the intermediate reach). The Phase 1 SOW directs emphasis on this segment because the majority of the diversions of native Little Thompson river water supplies are in the reach. The subsequent section of this report addresses flows in the other river segments. The other river segments are the tributaries (i.e., above the confluence of the North Fork and the LTR), the Little Thompson River from the confluence of the North Fork to the canyon mouth (the foothills reach), and the "lower" segment from about County Road 1 to Milliken (Figure 6).

The preliminary water supply accounting utilizes the daily streamflow records for the Little Thompson River at the Canyon mouth, Division of Water Resources daily diversion records, and the call records. There are 6 LTR diversion structures located west (i.e., upstream) of Dry Creek: Supply Lateral/Culver, Boulder Larimer, W R Blower, Eagle, Jim Eglin[36], and Osborne Caywood Ditches. The Little Thompson River Ditches No. 1 and No. 2 deliver C B-T Project water supplies from the St. Vrain Supply Canal to the LTR between the Canyon mouth gage and the headgate of the Supply Lateral/Culver Ditch. The call records used in this analysis include the "internal" LTR calls and the South Platte River calls originating from structures located downstream of the confluence of the Little Thompson and Big Thompson Rivers. The periods without calls and with supplies in excess of the demands may generally indicate potential historical water availability.

The preliminary water budget accounting spreadsheet compares the daily flow at the canyon mouth (native supply) plus contributions from the Little Thompson Ditches No. 1 and No. 2 (imported supply) to the total daily diversions recorded at the LTR structures[37]. For now, the spreadsheet does not explicitly account or quantify any return flows. Return flows may be added to the accounting in a later phase.

The primary data for this evaluation is the 2000 – 2012 period and particularly the years 2009 – 2012 (4 run-off seasons). The 2009 - 2012 run-off seasons are the only years with complete daily data records for the gage, the Little Thompson River Ditches No. 1 and No. 2, and the primary Little Thompson River diversion structures. As discussed next, the 4 years exhibit a range in run-off hydrology from dry to wet and generally illustrate the current water supply operations.

Table 2 provides the March – June total water supply volume for the 43 years of gage records at the Canyon mouth . The table indicates the rank of the seasonal volumes from the driest (1) to the wettest (43). The average, median, maximum, and minimum values for the 43 years are shown at the bottom of Table 2.

For the thirteen run-off seasons 2000 – 2012, nine of the 13 years are in the driest 50% of ranked years. So, the recent 13 years represent a drier period as compared to the 43 years of record. For the period 2009 – 2012, the data includes 3 years (2009, 2011, and 2012) with flow volumes less than the median for the 43-years (4,800 acre-feet) and only one year (2010) with flows above the median. So, the data utilized in the preliminary water supply accounting spreadsheet indicates drier hydrologic years with less volume of supplies as compared to the 43 year historical record.

The following sections describe the water supply accounting, flow conditions and water rights administration situation for the years 2009 – 2012.

[36] There are no CDSS diversion records for the Jim Eglin Ditch during the period 2000 - 2014.

[37] Supply Lateral/Culver, Boulder Larimer, W R Blower, Eagle, Osborne Caywood Ditches, Miner Longan, and Beeline Ditches. The CDSS database does not contain Jim Eglin Ditch or Great Western Industrial diversion records for the period 2000 – 2014.

Figure 14: Stream Flow Evaluation Segments

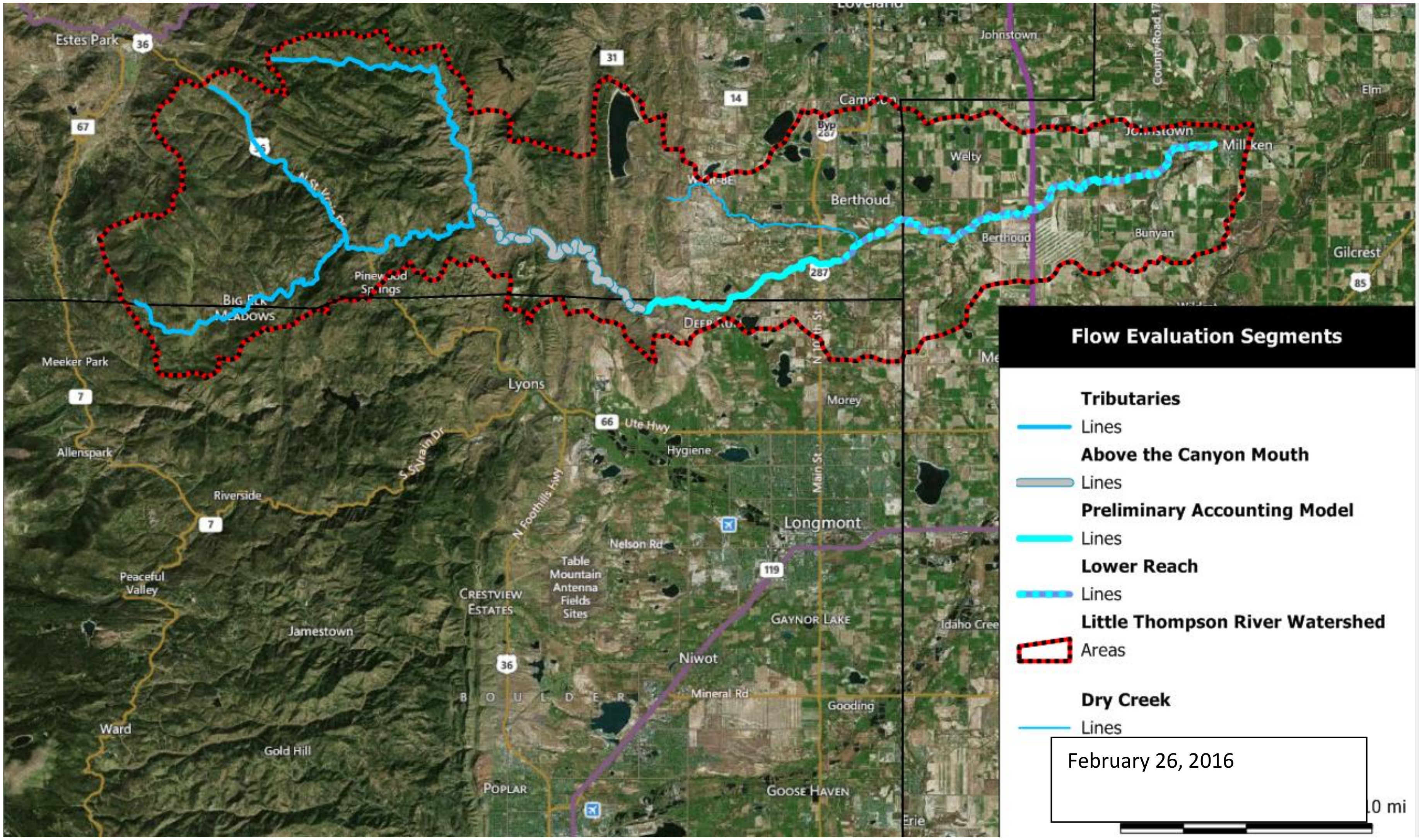


Table 10: Ranking of Little Thompson River near Canyon Mouth Run-off Season Water Volumes

4/6/2016	Little Thompson River near Canyon Mouth			
Rank (Dry to Wet)	Date	March-June Volume (af)	Comment	
9	1930	1750	LTCBERCO	
33	1947	14255	LTCBERCO	
26	1948	5695	LTCBERCO	
40	1949	24288	LTCBERCO	
11	1950	2705	LTCBERCO	
28	1951	8136	LTCBERCO	
34	1952	14285	LTCBERCO	
16	1954	3453	LTCBERCO	
13	1955	2749	LTCBERCO	
18	1956	3637	LTCBERCO	
43	1957	31945	LTCBERCO	
38	1958	18776	LTCBERCO	
30	1959	9227	LTCBERCO	
24	1960	5359	LTCBERCO	
36	1961	15755	LTCBERCO	
14	1962	3000	LTCANYCO	
5	1963	990	LTCANYCO	
7	1964	1040	LTCANYCO	
21	1965	4430	LTCANYCO	
4	1966	400	LTCANYCO	
25	1967	5400	LTCANYCO	
19	1968	3750	LTCANYCO	
41	1969	25180	LTCANYCO, no March records	
15	1993	3030	LTCANYCO, no March records	
23	1994	5290	LTCANYCO	
42	1995	28810	LTCANYCO	
22	1996	4800	LTCANYCO, no March records	
37	1997	16170	LTCANYCO	
32	1998	14140	LTCANYCO	
39	1999	20560	LTCANYCO	
6	2000	1020	LTCANYCO	
12	2001	2740	LTCANYCO	
1	2002	200	LTCANYCO, no March records	
31	2003	9860	LTCANYCO	
10	2004	2190	LTCANYCO	
27	2005	6250	LTCANYCO	
2	2006	200	LTCANYCO	
29	2007	8440	LTCANYCO	
8	2008	1350	LTCANYCO	
17	2009	3590	LTCANYCO	
35	2010	15380	LTCANYCO	
20	2011	3880	LTCANYCO	
3	2012	370	LTCANYCO, qualified as estimated	
No. of Years	Average	Median	Maximum	Minimum
43	8240	4800	31945	200
(grey)	Little Thompson River near Berthoud gage records			
(boxed)	2009 - 2012 years with a preliminary water budget accounting			

Stream Flow Accounting for Year 2011

The year 2011 represents water supply conditions slightly drier that the median run-off volume. The 2011 March – June water supply volume of 3,850 acre-feet ranks 20th driest out of the 43 years of data. The long-term median volume is 4,800 af. The DWR call records indicate that for the entire irrigation year, the Little Thompson River was under administration from either an internal call or South Platte River administration (i.e., no periods of "free river"). The accounting results indicate full diversion of the available supplies by the 7 Little Thompson River structures.

The accounting begins at the canyon mouth gage and proceeds downstream, first adding the Little Thompson Ditch No. 1 and No. 2 deliveries and then subtracting the daily diversion amounts for each subsequent ditch. The accounting matrix includes 11 primary columns for the gages and ditches and approximately 180 rows, one for each day March 1 – October 30, 2011. For each diversion (i.e., node) the accounting indicates the inflow, the diversion amount, and outflow.

Graphing the daily water supply operations summarizes and helps to explain the data (Figure 8a). The daily supplies equal the flow at the canyon mouth gage plus the C-BT Project deliveries. On the graph, the gage flows are indicated by the solid line and the additional C-BT Project deliveries are indicated by the dotted line. The imported water supplies are shown as being in addition to the native flows. The graph indicates that beginning in late August, native flows were almost zero and water supplies in the LTR were predominantly Project deliveries.

The graph also includes the river water rights administration timing and general location. The LTR internal calls are indicated near the horizontal axis by a red line. The black line marks the South Platte calls. The 2011 accounting example shows that the LTR was under administration March 10 through the end of October.

Continuing with the 2011 example, Figure 8b includes the daily demands. The dark green trace represents the sum of the daily diversions for the five upstream LTR irrigation structures (i.e., the Supply Lateral/Culver, Boulder Larimer, W R Blower, Eagle, and Osborne Caywood). The light green trace indicates the sum of all of the diversions (i.e., adding in the lower structures; Rockwell, Miner Longan, and Beeline Ditches diversion volumes). If the light and dark green traces are coincident, then the structures below the Osborne Caywood Ditch are not diverting. Gaps between the green traces represent the total flow rate for diversions by structures downstream of the Osborne Caywood Ditch.

Figure 8b indicates that with some exceptions, the sum of the year 2011 demands is about equal to the total supplies. The graphs implicitly estimate volumes of return flows. When the diversion trace exceeds the total supply trace, the difference in the daily values is equal to the amount of the diverted return flows. So the gaps between the green traces and the supply traces indicate the amount of the diverted return flows.

The relative size of the gaps between the supply trace and the diversion traces indicates the volumes of the return flows. The larger the gap, the more reliance on return flows for the particular day's water supply. Essentially, downstream of County Road 1 return flows become a more important factor to the water supply.

Stream Flow Accounting for Year 2010

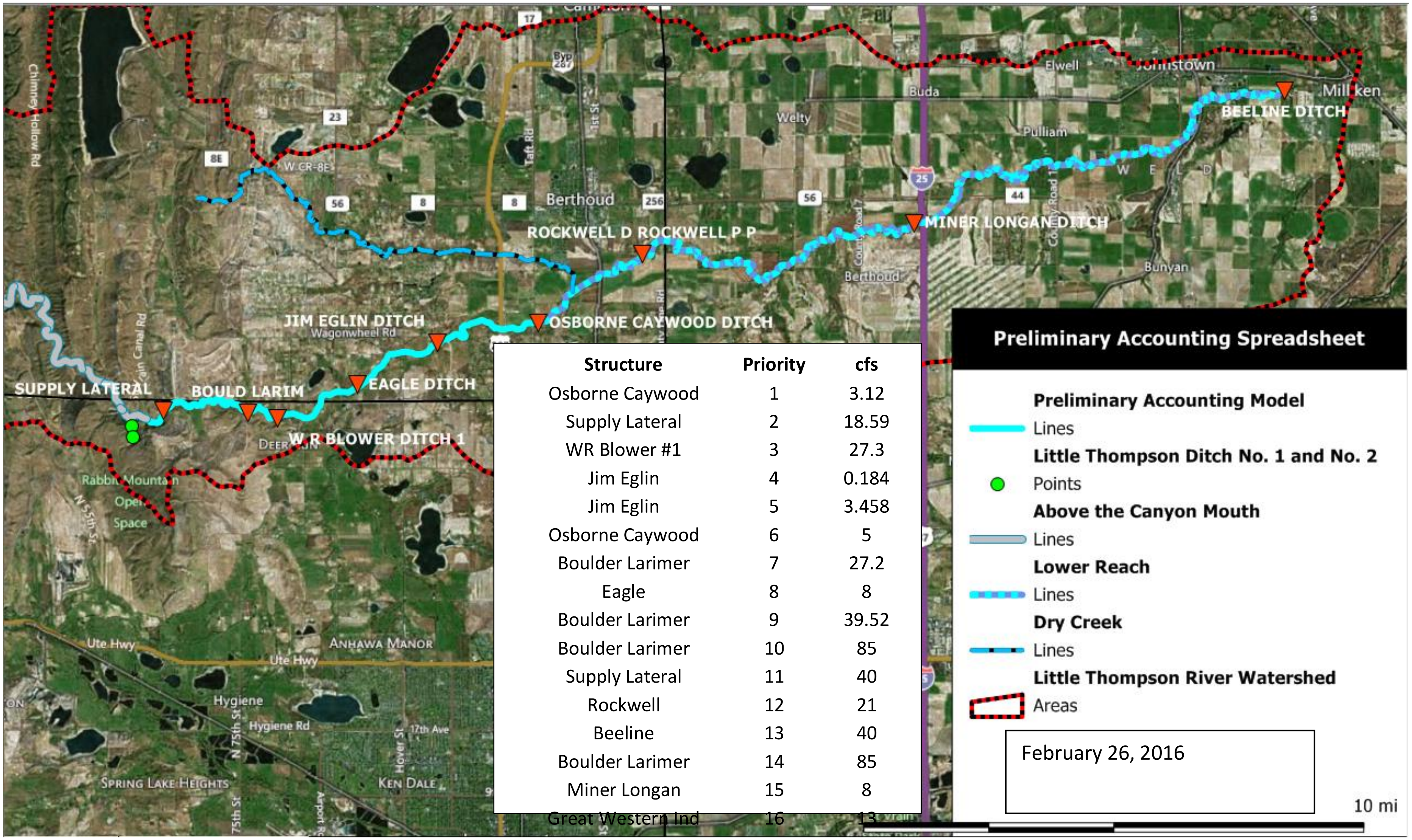
The year 2010 represents relatively wet water supply conditions. For the 43 years with records, the 2010 March – June volume of 15,380 acre-feet ranks 35th driest and is about the 75% wettest year ranking. The DWR call records indicate that there was not an internal call or a South Platte River call from about April 22 through June 28, 2010. The accounting results indicate that water supplies are in excess of historical diversions by the 7 LTR structures from April 4 to approximately June 1 (Figures 9a and 9b).

Stream Flow Accounting for 2009 and 2012

The run-off season for 2009 was relatively dry with a volume of 3,590 acre-feet, ranking just slightly drier than 2011. The 2012 gage records for the Canyon gage are qualified in the database as "estimated". The qualified records indicate a very low volume run-off. As an example, the 2012 water supply accounting represents very dry conditions with the estimated native run-off flows at the Canyon mouth totaling approximately 400 acre-feet.

Figures 10 and 11 provide graphs of the supply and demand accounting for 2009 and 2012.

Figure 15: Water Supply Accounting Reach



Structure	Priority	cfs
Osborne Caywood	1	3.12
Supply Lateral	2	18.59
WR Blower #1	3	27.3
Jim Eglin	4	0.184
Jim Eglin	5	3.458
Osborne Caywood	6	5
Boulder Larimer	7	27.2
Eagle	8	8
Boulder Larimer	9	39.52
Boulder Larimer	10	85
Supply Lateral	11	40
Rockwell	12	21
Beeline	13	40
Boulder Larimer	14	85
Miner Longan	15	8
Great Western Ind	16	13

Notes: There are no diversion records for Jim Elgin Ditch or the Great Western for the period 2000 – 2014.

Figure 16a: Year 2011 LTR Water Supply Accounting

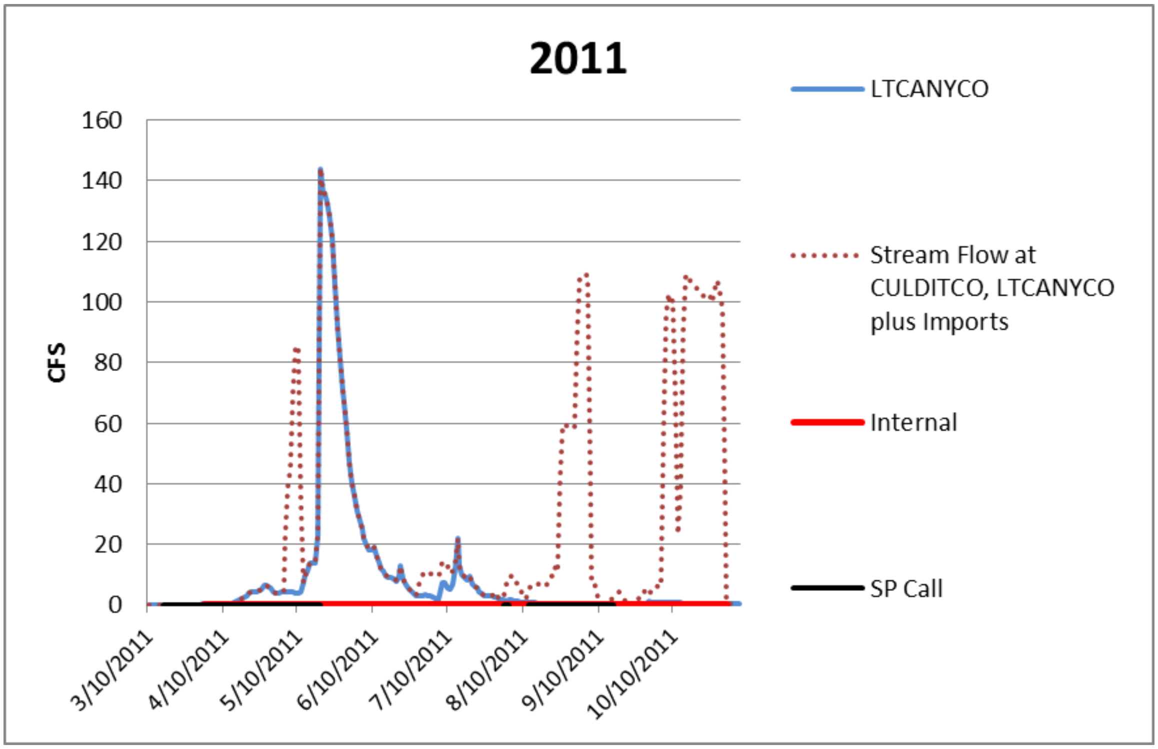


Figure 8b: Year 2011 LTR Water Supply Accounting

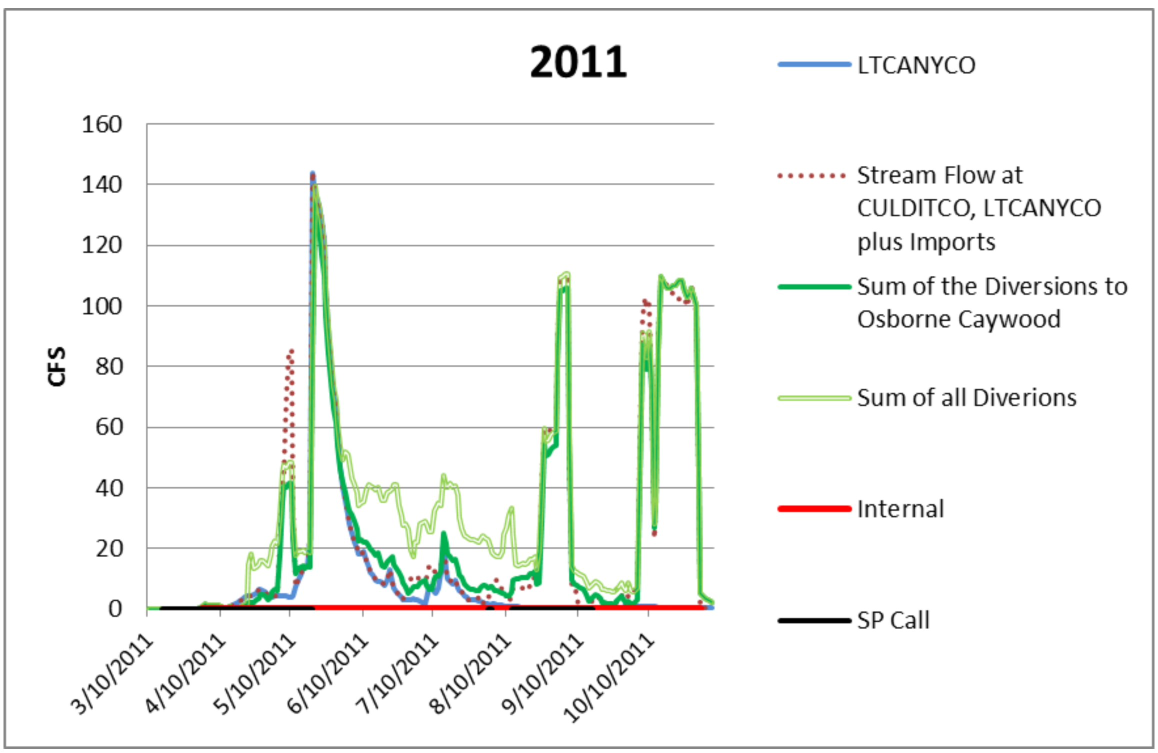


Figure 17a: Year 2010 LTR Water Supply Accounting

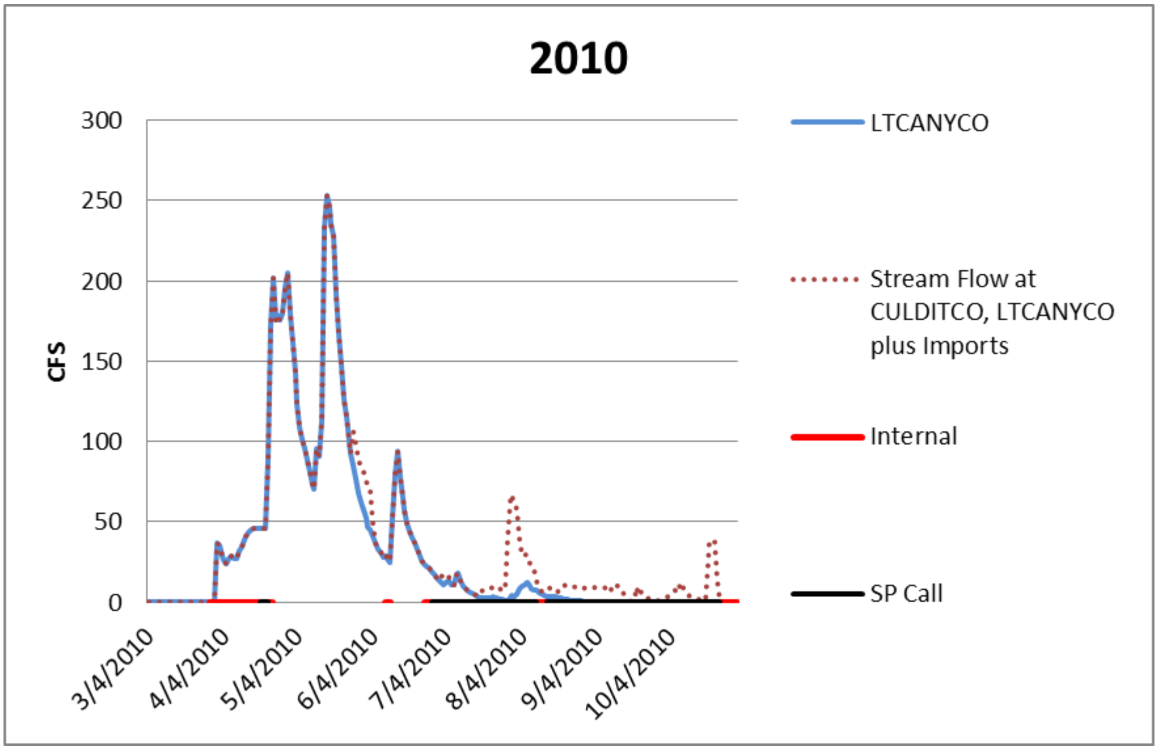


Figure 9b: Year 2010 LTR Water Supply Accounting

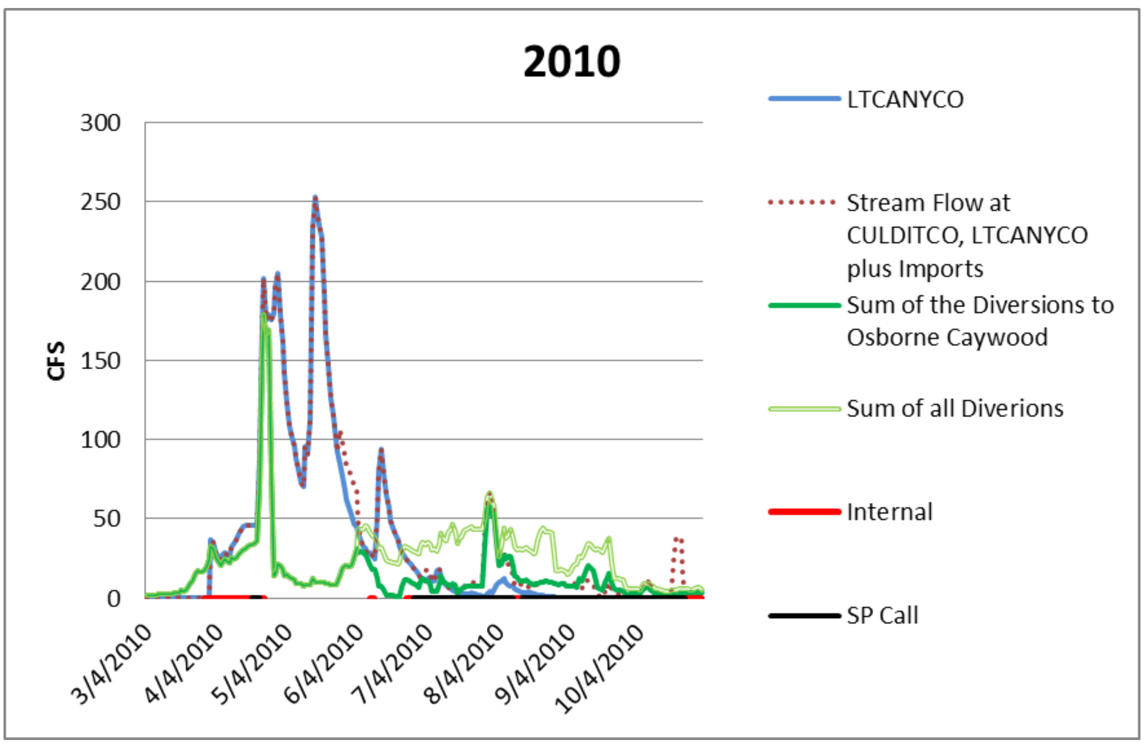


Figure 18: Year 2009 LTR Water Supply Accounting

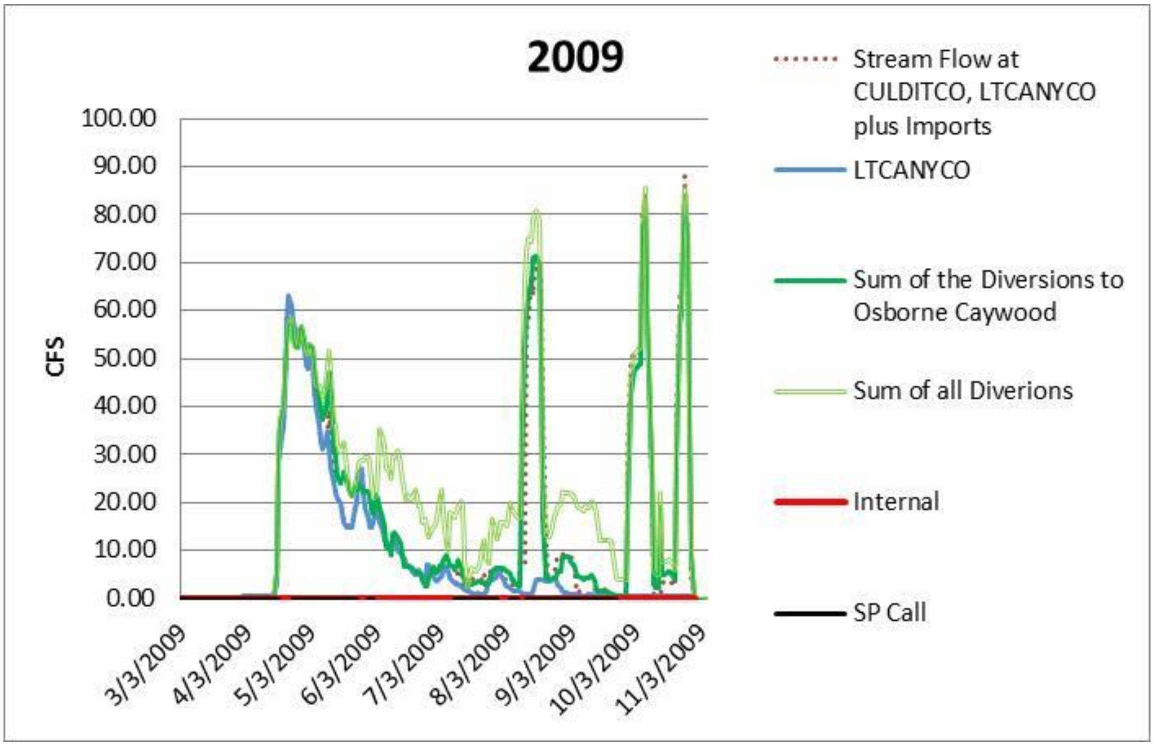
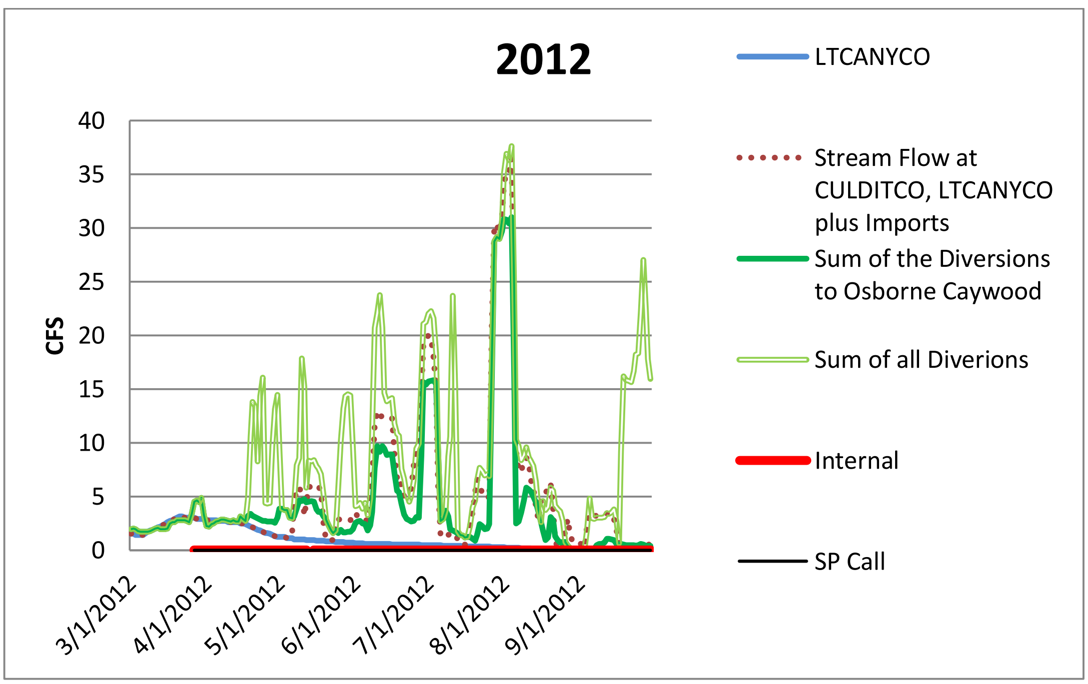


Figure 19: Year 2012 LTR Water Supply Accounting



Stream Flow Evaluation

This section describes general stream flow conditions for the Little Thompson River. The evaluation focuses on the reach from the Canyon mouth to about Dry Creek and the primary water supply season, i.e., the spring and early summer run-off hydrology. The evaluation includes information developed in the Agricultural Use Technical Memorandum. The stream flow evaluation addresses the Scope of Work key elements regarding locations of stream “dry-up” and sets the stage for describing impacts due to changing water supplies and operations.

For this discussion, the Little Thompson River is described with four segments; the tributary, foothills, intermediate, and lower. The tributary segment includes areas above the confluence of the North Fork, the foothills segment extends from the confluence of the North Fork and the Little Thompson River to the Canyon mouth, the intermediate reach is from the Canyon mouth to approximately Dry Creek, the lower segment extends from approximately Dry Creek to the bottom of the watershed near Milliken (Figure 6).

The volume and timing of flows in the tributaries may be estimated by proportioning the total flow (as recorded at the Canyon mouth gage locations) between the three upper branches of the Little Thompson River. Each tributary contributes a share and detailed analyses may use estimates of the watershed catchment areas, elevations, topographical slope aspect, hydrological-similar basins, stream gage correlations, and other techniques. However, for this Phase 1 of the Needs Assessment, the proportions are based on roughly estimating the area and average elevation of each tributary drainage area. For the purposes of this report, the rough proportions are 40% North Fork, 40% Upper Little Thompson River, and 20% West Fork.

The water supplies in the Little Thompson River from the confluence of the North Fork to the canyon mouth (i.e., the foothills reach above the Canyon mouth) are approximately the same in timing and volume of flows recorded at the canyon mouth. That is because the tributary area for the intermediate reach is relatively low elevation and generally does not add significant volumes of flow for water supply. Since the 2013 flood, geomorphic changes may have impacted the expression of the surface water flows in this reach (as well as the other reaches). Site specific evaluations in the “intermediate” reach may be evaluated in the next phase of work.

Stream flows in the lower reach (from approximately Dry Creek to Milliken) were historically recorded by the Little Thompson River near Milliken stream gage. The Milliken gage operated in the 1950’s and 1960’s. The historical gage data indicates winter-time base flows, probably resulting from delayed irrigation return flows. Currently, the Town of Berthoud’s waste water treatment plant adds some volume to the stream at about County Road 1. Judging by the surrounding irrigated areas, the flows in the lower reach are heavily influenced by the irrigation practices associated with lands potentially irrigated by the Handy, Home Supply, and Highland Ditches. More information on water uses in those systems and return flows may be evaluated in the next phase of work.

The available stream gage data includes some winter-time records. The available historical data show that winter-time flows in the West Fork, the foothills reach, and the reach from the Canyon mouth to about Dry

Creek were low (some records reporting 0 flows and others indicating less than 1 or 2 cfs). Irrigation return flows increase the volume of the Little Thompson stream flows downstream of about County Line Road 1. Based on data from the 1960's, return flows added significant flow to the LTR at Milliken, where historical winter-time flows were in the range of 10 - 25 cfs.

Examination of the hydrology, water supply operations, and administration for the example years indicates the following general conclusions regarding the Little Thompson River water supplies and stream flows:

- The native LTR water supplies peak in April or May and flows decrease to just a few cubic feet per second or so by late July/early August. Stream flow records include reports of zero flow in the late fall and winter months at the West Fork and Canyon mouth gages.
- In all but the wettest years, the upper 5 LTR structures (i.e., Supply Lateral/Culver, Boulder Larimer, W R Blower, Eagle, and Osborne Caywood Ditches) appear to divert 100% of the available native supply.
- Return flows to the Little Thompson River contribute a significant portion of the stream flows and water supply to structures from the Rockwell Ditch (approximately Dry Creek) downstream to the eastern end of the watershed (i.e., Rockwell, Miner Longan, and Beeline Ditches).
- In the drier years, the Little Thompson River No. 1 and No. 2 Ditches historically delivered greater volumes of C-BT Project water supplies.
    - The deliveries of C B-T Project water supplies generally occur in the late summer (i.e., July and August), but occasionally supplement supplies earlier or later in the year.
- On average for the period 2000 – 2014, approximately 75% of the C-BT Project supplies delivered via the Little Thompson River No. 1 and No. 2 Ditches were diverted by the Boulder Larimer system and the remainder was delivered to the Supply Lateral/Culver, Rockwell and Miner Longan Ditches.
    - The diversion records (2000 - 2014) indicate that the Beeline Ditch did not divert C-BT Project water supplies.
    - The diversion records (2000 – 2014) indicate that the Osborne Caywood Ditch diverted only a very small amount of C-BT Project water supplies.
- It appears that historically, in all but the wettest run-off seasons, the LTR was typically under water rights administration with an "internal" call (i.e., the calling diversion structure is located on the LTR).
    - The Osborne Caywood Ditch has the most senior water right on the Little Thompson River, 3.12 cfs with an appropriation date of 6/1/1861. For the period 2004 – 2014, the Osborne Caywood Ditch had the most days with a call (approximately 40% of the days when there was an internal call).
    - The Boulder Larimer system had the second most days on call with approximately 20% of the days when there was an internal call.
    - If the calling location is the Osborne Caywood Ditch, then the LTR is most likely "dried-up" downstream of the Ditch[38]. However, the lack of a call at Osborne Caywood does not necessarily indicate stream flow below the diversion structure.
- The District 4 line diagram indicates the Boulder Larimer ditch as a "dry-up" point on the stream. In many years, the LTR is under administration during the winter-time by a calling structure located on the South Platte River (i.e., South Platte River call).
- There is limited historical water availability to free river and relatively junior water rights. Based on information for 2010, for the watershed to produce supplies in excess of existing uses required a combination of a good winter snowpack and above normal precipitation in the spring (i.e., April, May and June).
- Dry reaches on the Little Thompson River may occur in certain reaches and at certain times in the tributary areas, the foothills reach, in the reach from the Canyon mouth to Dry Creek, and probably in

[38] In order for the Water Commissioner to administer a water right's priority, the calling structure must be efficiently diverting 100% of its in-priority physical water supply.

the lower river below diversion structures. The occurrence of dry spots and dry reaches are most extensive during the low flow period (after the run-off through the next spring). During the irrigation season, dry reaches occur when water diversions are “sweeping” the stream. Often the administration point of the Little Thompson is the Osborne Caywood Ditch; if the ditch is calling, than it is likely that the river is “dried-up” below the headgate.

Evaluation of Impacts from Changes in Agricultural Water Supplies and Water Management Practices

The Scope of Work for this Study directs its emphasis on the Little Thompson River structures that use native Little Thompson River water supplies. Nonetheless, the irrigated areas mapped by the SEO for year 2010 indicate that 27,000 acres of the 32,000 acres potentially irrigated within the watershed have non-Little Thompson River water supplies (i.e., Big Thompson River, St. Vrain River, and C-BT Project sources). In other words, the water supplies “imported” to the watershed potentially serve approximately 6 times more irrigated area than the native supplies. Consequently, the largest impacts (by water volume) to stream flows and water supplies within the watershed may come from changes in operations associated with the Handy Ditch, the Home Supply Ditch, and the Highland Ditch.

The SOW includes tasks to address impacts in portions of the Agricultural Water and Domestic Water Use Key Elements. For the agricultural impacts, the evaluation is to:

- Identify impacts of reduced diversion quantities due to drought (i.e., acreage adjustments and practice adjustments due to variation in river flow).
- Identify the volume of NCWCD water usage and any potential impact of removing that water (i.e., C-BT water that uses the river as its delivery system).
- Determine the volume of water necessary to stabilize irrigated farm production.

The impact of drought on agriculture is significantly reduced farm production. Even with conditions of better than “average” hydrology, many front-range farms are “water-short”, meaning the crops could use additional supplies to satisfy the full irrigation water requirement. Water users can anticipate droughts and adjust irrigation and farming practices[39]. The Northern Colorado Water Conservation District’s C-BT Project quota process exemplifies adjustments in water supplies in response to wetter and drier conditions. Working less acreage, acquiring supplemental water supplies, and planting different crops are a few of the on-farm adjustments.

This evaluation uses recent diversion records (2000 – 2014) and Little Thompson River flow information to describe the impacts of drought on Little Thompson River irrigation water supplies. Table 3 provides the annual diversion volume of native Little Thompson River water supplies for the structures. The second column on the table indicates that year’s rank based on annual flow volume at the Canyon mouth. The rows associated with the 3 driest and the 3 wettest ranked years (for the 2000 – 2014 period) are shaded yellow and green, respectively.

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[39] The Northern Colorado Water Conservation District’s C-BT Project quota process exemplifies adjustments in water supplies in response to wetter and drier conditions. Working less acreage, acquiring supplemental water supplies, and planting different crops are a few of the on-farm adjustments.

Table 11: Little Thompson River Structures Annual Diversion Volumes for Recent Years

2/22/2016 Irrigation Year	Water Supply Year Rank (for 43 year Period of Record)	Senior - Listed by Priority - Junior							
		Osborne Caywood	Supply Lateral/ Culver	WR Blower No. 1	Boulder Larimer	Eagle	Rockwell	Beeline	Miner Longan
		Total Diversions Native Supply in acre-feet							
2000	6	792	609	537	1066	182	813	685	533
2001	12	539	339	406	1990	1	772	1661	286
2002	1 - Driest	45	111	0	0	2	312	309	70
2003	31	480	1395	882	6531	0	788	452	210
2004	10	870	1923	891	2288	0	598	980	175
2005	27	866	691	459	4989	78	353	204	185
2006	2	301	37	47	0	0	260	1250	189
2007	29	866	1073	492	6825	356	540	0	220
2008	8	639	751	456	75	25	382	0	107
2009	17	615	1222	501	2174	162	406	1499	277
2010	35 - Wettest	826	1369	272	3835	77	910	3253	272
2011	20	1067	790	364	2912	127	1076	2861	569
2012	3	506	87	90	555	118	230	1485	257
2013		388	1032	393	3504	1032	220	1043	177
2014		401	1392	407	5258	1392	1137	5721	679
	Average								
	3 driest	280	80	50	190	40	270	1010	170
	3 wettest	720	1280	550	5730	140	750	1240	230
	% decrease	61%	94%	91%	97%	71%	64%	19%	26%
	9 other	690	970	490	2700	330	640	1630	330

Comparing the average annual diversions for 3 dry and wet water supply years indicates that all of the Little Thompson River diversion structures have significantly less volume of native supply diversions in the dry years. For the years shown, the Boulder-Larimer Ditch, Supply Lateral/Culver Ditch, and the W R Blower Ditch have the largest percentage decrease in supplies, greater than 90%. The Osborne Caywood, Eagle and Rockwell indicate 60 – 70% less supplies over the 3 year periods. The Miner Longan and Beeline indicate the less sever decrease in supplies with drought, probably because of their position lower in the watershed where historical return flows supply the diversions.

The SOW directs evaluation of "practice adjustments". Generally, practice adjustments may include changes in irrigated acreage, changes in the type of irrigation system (e.g., flood irrigation or sprinkler systems), and changes in crop types. There may also be changes in the type of beneficial use of the native Little Thompson River water supplies.

The changes in beneficial use of native Little Thompson River water supplies (e.g., changing from irrigation use to domestic use) should not impact stream flow conditions. The new uses are limited to the timing and volume of the water supply's historical consumptive use. The water rights adjudication process ensures that return flow volumes and timing for any new changed use is equivalent to the historical use.

Changes in the irrigation method, e.g., from flood irrigation to sprinklers, do not require a change of water use. Consequently, irrigators may switch irrigation methods without changing the water right. Nonetheless, depending on the site-specific situation, steam flows may be affected by changes in irrigation methods.

Going from flood irrigation to sprinkler irrigation generally results in increased irrigation efficiency (reduces field losses from deep percolation and tail-water run-off). In practice, there should be less volume of water diverted for the same amount of consumptive use. That change in irrigation method may result in more water left in the stream immediately below the diverting structure, but less tail-water runoff from the field. It may also result in less deep percolation, which may affect the timing of groundwater return flows.

In the LTR watershed, larger irrigated areas are being split into smaller but still irrigated parcels. This change in practice may result in less efficient use because of the lack of coordination between multiple water users. In this situation, water consumptive uses may decrease, but diversions may stay about the same.

Since 2000, the LTR structures diverted an average of approximately 2,500 af/yr C-BT Project supplies (Table 4). Since most of the carried C-BT water supplies are diverted at the Boulder Larimer Ditch system, the location of potential impacts of removing C-BT Project water supplies is in the reach from the Canyon mouth to the Boulder Larimer Ditch headgate. The timing of the changes in stream flows would generally correspond to the latter portion of the irrigation season in the drier than normal water supply years (Table 4).

The SOW includes direction to "determine the volume of water necessary to stabilize irrigated farm production". There are three general water supply outcomes that may be associated with goals to stabilize irrigated farm production:

4. No additional water supply required, current supplies represent stabilized conditions,
5. Less water supplies are needed (e.g., less irrigated farm production and that is an acceptable condition), or
6. New supplies are required. (e.g., current supplies not sufficient to stabilize irrigated farm production).

For the purpose of this study, the Project Management Team set a goal for the conceptual water supply project/management options to supply up to approximately 2,500 acre-feet per year.

Table 12: Average Annual Supply Volumes for the Primary Little Thompson River Diversion Structures

2/12/2016	2010 Irrigated Area (acres)	Average Supply Volume for Irrigation Years 2000 - 2014 (acre-feet)														
Structure Name			Percent	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Total by Source (af)	Total
Beeline Ditch	none	Native	100%	0	0	0	0	0	98	248	431	368	162	222	117	1427	1427
		C-BT	0%	0	0	0	0	0	0	0	0	0	0	0	0	0	
BOULD LARIM CO IRR MFG D	2475	Native	63%	15	13	15	39	270	804	1132	288	105	62	19	37	2800	4459
		C-BT	37%	0	0	0	0	0	0	0	19	265	400	218	758	1659	
EAGLE DITCH	70	Native	83%	0	0	0	0	1	22	111	36	27	19	9	12	237	286
		C-BT	17%	0	0	0	0	0	0	10	5	12	13	6	3	49	
Great Western Ind	none	Diversion records not found in CDSS															
JIM EGLIN DITCH	267	No Diversion Records for 2000 - 2014															
MINER LONGAN DITCH	162	Native	53%	0	0	0	0	0	3	22	73	46	54	61	22	280	529
		C-BT	47%	0	0	0	0	0	0	9	40	91	91	18	0	249	
OSBORNE CAYWOOD DITCH	240	Native	95%	0	0	0	0	0	5	90	171	162	135	51	0	613	648
		C-BT	5%	0	0	0	0	0	0	3	9	8	11	2	2	35	
ROCKWELL D ROCKWELL P P	176	Native	71%	0	0	0	0	0	6	62	135	84	64	113	122	586	827
		C-BT	29%	0	0	0	0	0	0	9	14	76	92	40	10	241	
SUPPLY LATERAL DITCH	1005	Native	83%	0	0	0	0	6	79	360	214	87	65	33	10	855	1032
		C-BT	17%	0	0	0	0	0	0	15	26	21	30	36	50	177	
W R BLOWER DITCH 1	238	Native	87%	0	0	0	0	0	124	121	75	34	29	42	18	413	473
		C-BT	13%	0	0	0	0	0	0	12	11	14	10	7	10	60	
	4633	Native	74%											Total Native		7211	9681
		C-BT	26%											Total C-BT		2470	

Notes: From Water Supply, Use and Planning Study - Needs Assessment Little Thompson River, Draft Final Agricultural Water Use Technical Memorandum.

Conclusion

The Little Thompson River is a relatively small and low elevation watershed. The watershed's total area is approximately 200 square miles. The drainage area upstream of the Little Thompson River at Canyon Mouth near Berthoud stream gage is approximately 100 square miles and the maximum elevation is approximately 10,000 feet.

For this discussion, the Little Thompson River is described with four segments. The tributary segment includes areas above the confluence of the North Fork tributary, the foothills segment extends from the confluence of the North Fork to the Canyon mouth, the third segment is the intermediate reach from the Canyon mouth to approximately Dry Creek, the lower segment extends from approximately Dry Creek to the lower end of the watershed near Milliken (Figure 6).

The volume and timing of flows in the tributaries may be estimated by proportioning the total flow (as recorded at the Canyon mouth gage locations) between the three upper branches of the Little Thompson River. Detailed analyses may use estimates of the tributary catchment areas, elevations, topographical slope aspect, hydrologic similar basins, stream gage correlations, and other techniques. However, for this Phase 1 of the Needs Assessment, the proportions are based on roughly estimating the area and average elevation of each tributary drainage area. For the purposes of this report, the rough proportions are 40% North Fork, 40% Upper Little Thompson River, and 20% West Fork.

Historical stream flow monitoring on the Little Thompson River includes 4 stream gages and multiple single event or short-term flow observations. Since the 1960s, the only Little Thompson stream gage records are for the river at the Canyon mouth. Over the years, two stream gages measured flow at essentially the same location near the Canyon mouth. The combined record for these gages includes 43 years of stream flow records. Prior to the 1970's, there were periodic stream flow observations near the bottom of the watershed near Milliken and in the headwaters in the West Fork (Table 1 and Figure 1).

For the available period or record, the average annual flow volume of the Little Thompson River at the Canyon mouth is approximately 8,400 af (for the years with complete 12 months of records). The run-off season March – June provides the bulk of the native water supply (Table Yellow table). For the 43 years, the March – June[40] average annual flow volume is 8,200 af. With peak monthly flows generally in May. After the run-off and in the winter-time, the stream flows volumes are small. Winter-time flow rates in the LTR at the Canyon mouth are typically less than 1 cfs during the late summer and winter-time. In the late summer and winter-time there may be zero observable surface water flow.

The water supplies in the LTR from the confluence of the North Fork to the Canyon mouth (i.e., the foothills reach above the Canyon mouth) are approximately the same in timing and volume of flows recorded at the Canyon mouth. That is because the tributary area for the intermediate reach is relatively low elevation and generally does not add significant volumes of flow for water supply. Since the 2013 flood, geomorphic changes may have impacted the expression of the surface water flows in this reach (as well as the other reaches). Site specific evaluations in the "intermediate" reach may be evaluated in the next phase of work.

Stream flows in the lower reach (from approximately Dry Creek to Milliken) were historically recorded by the Little Thompson River near Milliken stream gage. The Milliken gage operated in the 1950's and 1960's. The historical gage data indicates winter-time base flows, probably resulting from delayed irrigation return flows. Judging by the surrounding irrigated areas, the flows in the lower reach are heavily influenced by the irrigation practices associated with lands potentially irrigated by the Handy, Home Supply, and Highland Ditches. More information on water uses in those systems and return flows may be evaluated in the next phase of work.

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[40] The bulk of the annual water supply comes during the months March – June.

To: Project Management Team, Little Thompson Watershed Coalition

From: Canyon Water Resources, LLC and George Wear Consulting, LLC

Subject: WSRA Contract 150707, Water Supply, Use and Planning Study, Needs Assessment Little Thompson, **Key Element 2 - Review of Pinewood Springs and Big Elk Meadows Water Systems Technical Memorandum**

Date: February 4, 2016 revised March 25, 2016

Introduction

This technical memorandum reports on the Pinewood Springs and Big Elk Meadows communities domestic water systems. The memorandum is a portion of Key Element 2.0 of the Scope of Work. Pinewood Springs and Big Elk Meadows are the two private domestic water systems in the foothill and mountain areas within the Little Thompson River watershed. There are numerous domestic exempt groundwater wells in the foothills and mountains. A separate Technical Memorandum - Evaluation of Groundwater Well Water Use describes those uses. This report includes discussion of the Pinewood Springs and Big Elk Meadows systems water supply portfolios, existing use, and anticipated growth for the two systems.

The water system development and water uses associated with the systems are shown below:

Water System	Augmentation Plan Annual Consumptive Use Credit (acre-feet)	Development Build-Out Annual Consumptive Use (acre-feet)	Current Number of Units Served	Current Average Monthly Water Use Factor (gallons per Unit)	Estimated Build-Out Units Served
Pinewood Springs	16.82[41]	9.38	Approx. 299	2,000 – 3,000	Approx. 320
Big Elk Meadows	31.4[42]	20.7	Approx. 160	Approx. 750[43]	Approx. 166

The two water systems divert and consume relatively small volumes of water. In the summer, the diversions and depletions increase because of reservoir evaporation and limited outdoor recreational uses. The current units served and estimated build-out units served indicate that the sub-divisions are 90% or so developed. The communities combined build-out annual consumptive use volume of 30 acre-feet per year represents an average flow rate of 0.04 cubic feet per second. The low flows are important because they sustain vibrant communities and the volumes are relatively small compared with the average daily flows in the Little Thompson River.

[41] Minimum annual consumptive use based on dry year 1954.
[42] 10-year running average combined direct flow and storage.
[43] For 2015 – 2016, reflects seasonal residency.

Pinewood Springs

The Pinewood Water District (PWD) manages the water system for the Pinewood Springs community. The water district's water system includes 17 wells, 3 springs, a collection gallery/diversion on the Little Thompson Reservoir, reservoirs (Culver Reservoir and Crow Lane Reservoir 1), storage tanks, and a water treatment facility. The Water District's rules and policies limits water use to indoor uses only and homeowners' use to a maximum of 6,000 gallons per month (these restrictions are included in subdivision covenants).

Pinewood Springs water supply includes an augmentation plan originally decreed in 1976, Division 1, Case Number W8001. This augmentation plan has been modified over the years, including Division 1 Case Numbers 79CW0331, 95CW0285, and 10CW0290. The plan ensures that depletions from the water uses in Pinewood Springs do not injure other water rights.

The original plan of augmentation (W8001) covered the depletions associated with 15 wells (absolute water rights decreed in Case Numbers W3526 and W8014), three springs (absolute water rights decreed in Case Number W3526), and Pinewood Springs Reservoir (conditional water rights decreed in Case Number W8017.) Additional diversion structures were added later to the Pinewood Springs water system including 2 more wells (absolute water rights decreed in Case Number 95CW284) and a collection gallery diverting directly from the Little Thompson River (absolute water rights decreed in Case Number 88CW236). These new diversions were made subject to the original plan of augmentation in W8001.

Decree W8001 indicates that at full development a maximum of 350 single-family equivalent residential units could be served by the water system. At that time, 131 single –family equivalents were connected to the water system. Currently, the Pinewood Water district serves 299 taps and 14 "paid tap" lots. The District expects build-out to approximately 320 taps. The Pinewood Springs system water uses average 2,000 – 3,000 gallons per month per tap. Since Crow Lane Reservoir 1 was built (circa 2009), the community's water supplies have been adequate. At full-build-out and if average water uses reach 6,000 gallons per month per tap, then the District would likely have water shortages[44].

Per W8001, out-of-priority depletions from Pinewood's uses are replaced by consumptive use credits from a decreed change of use of 7 shares (of a total 150 shares outstanding) of the Culver Ditch and Irrigation Company (W8001). The 7 shares represent a minimum annual consumptive use of 16.32 acre-feet based on the dry year of record (1954). At full development, the Pinewood water system was projected to have annual consumptive use of 9.86 acre-feet. The supplies are available during the 150-day historical irrigation season associated with the Culver Ditch and Irrigation Company water rights.

The original augmentation plan indicates that depletions by the subdivision during the 150-day irrigation season would be replaced by comparable reduced diversions at the headgate of the Culver Lateral (aka Supply Lateral). The remainder of the annual consumptive use credits each year (i.e., the amount by

[44] Personal communication 1/20/2016.

which 16.32 acre-feet exceeds the subdivision's irrigation season depletions for that year) would be stored by exchange in Pinewood Springs Reservoir. According to this original augmentation plan decree, depletions by the subdivision during the non-irrigating season each year would be replaced by releases from Pinewood Springs Reservoir at the direction of the Division 1 Engineer. Pinewood Springs Reservoir has not been constructed to date and, as noted below, later decrees modified the augmentation plan such that the non-irrigation season replacement releases were accomplished elsewhere.

In 1982, the Pinewood Springs augmentation plan was modified in Case Number 79CW0331. Culver Reservoir was added as an alternate place for storage of the 7 shares of the Culver Ditch and Irrigation Company. Culver Reservoir was also added as an alternate release point to operate the exchange during the non-irrigation season. This non-irrigation season replacement has an appropriative right of exchange with a downstream terminus at the Culver Reservoir outlet and upstream termini at the water system's diversion points (i.e., wells, springs, and reservoir). The appropriation date for this exchange is July 31, 1975.

In Division 1 Water Court Case Number 95CW0285 Pinewood Springs confirmed the appropriation date for both appropriative rights of exchange, irrigation season and non-irritation season, to be July 31, 1975.

In 2004, new conditional storage rights for several reservoirs to serve the Pinewood Springs water system were adjudicated in Case Number 02CW347[45]. These new rights included Crow Lane Reservoir 1 (51 af), Crow Lane Reservoir 2 (39 af), Maure Hollow Reservoir (45 af), Crescent Lake/Powelson Reservoir (18 af), and Pinewood Springs Reservoir (20 af.) The new reservoirs are located on tributaries to the Little Thompson River and are to be filled either with runoff from their respective drainage basins or with new direct flow diversions of 1 cfs from the Little Thompson River. All the reservoirs are to be filled from the same diversion point on the river, with the exception of Crescent Lake/Powelson Reservoir, and this diversion location is the same as the Pinewood Springs Collection Gallery (decreed in 88CW236 as noted above.) Crescent Lake/Powelson Reservoir has a different diversion point location on the river.

Since these new reservoir water rights were not explicitly covered under the original plan for augmentation, new appropriative rights of exchange for 1 cfs to fill each of these reservoirs were decreed in Case Number 10CW290. The new exchanges use the same 7 shares of Culver Ditch and Irrigation Company, including storage in Culver Reservoir. The downstream termini of these exchanges are at the Supply Lateral headgate and at the Culver Reservoir outlet, while the upstream termini are at each reservoir location and at the two surface diversions on the Little Thompson River. The appropriation date for these exchanges is December 9, 2010.

[45] The previously decreed water rights in Pinewood Springs Reservoir were abandoned by the court in Case Number 80CW5.

In 2006, PWD completed construction of their first reservoir, Crow Lane Reservoir with a storage capacity of 39 acre-feet (reference?). A new diversion on the Little Thompson Creek and a pipeline to the reservoir was also constructed. The reservoir can fill with runoff from the local drainage basin or from the new pipeline. As noted above, the reservoir water rights are filled by exchange from either bypass at the Supply Lateral Ditch or releases from Culver Reservoir (Case Number 10CW290.)

Prior to completion of Crow Lane Reservoir, PWD was forced to truck water to fill its' storage tanks during extended drought periods. At those times, their decreed exchanges were out of priority or unable to operate per Division 1 administration. Residents were assessed additional fees to cover the costs of water hauling.

Table 1 lists the structures, amounts, decrees, and priorities associated with the Pinewood Springs water system.

Preliminary Identification of Pinewood Springs Water Supply Concerns

Discussions with a representative of Pinewood Springs District indicated that the community is very conscientious about water conservation and water use. The relatively low water use factor of approximately 100 gallons per day per unit backs up that statement. Nonetheless, in dry years (like 2012) even with significant water conservation practices the physical supply to the system is not sufficient. In the driest years, the subdivision has purchased and trucked water from Lyons. It appears that the District could use more storage, but at this time, planning to truck water is a more practical alternative.

Table 1: Pinewood Springs Water Supply Portfolio

	DIST 4 ID	EXISTING STRUCTURES (with absolute water rights)	ADJUDICATION DATE	APPROPRIATION DATE	ADMIN NUMBER	NET AMOUNT	UNITS (cfs or af)	USES	ASSOCIATED CASE NUMBERS
Aug/Repl Plan	602	Supply Lateral Ditch (aka Culver Lateral)	1883-05-28	1867-04-15	6314.00000	0.9	cfs	augmentation	W8001,79CW331,95CW285,10CW290
	602	Supply Lateral Ditch (aka Culver Lateral)	1883-05-28	1875-04-30	9251.00000	0.9	cfs	augmentation	W8001,79CW331,95CW285,10CW290
	4159	Culver Reservoir	1883-05-28	1867-04-15	6314.00000	4.896	af	augmentation	W8001,79CW331,95CW285,10CW290
	4159	Culver Reservoir	1883-05-28	1875-04-30	9251.00000	4.896	af	augmentation	W8001,79CW331,95CW285,10CW290
Surface Diversions	5633	Pinewood Springs Collection Gallery	1988-12-31	1989-11-30	51103.00000	0.2200	cfs	muni	88CW236,95CW285,10CW290
	1650	Pinewood Springs Spring 1	1972-12-31	1964-06-30	44559.41819	0.0022	cfs	domestic	W3526,W8001,79CW331,95CW285
	1570	Pinewood Springs Spring 2	1972-12-31	1959-06-30	44559.39992	0.0044	cfs	domestic	W3526,W8001,79CW331,95CW285
	1651	Pinewood Springs Spring 3	1972-12-31	1961-06-30	44559.40723	0.0044	cfs	domestic	W3526,W8001,79CW331,95CW285
Wells	5409	Pinewood Springs Well 1	1972-12-31	1966-07-14	42563.00000	0.0111	cfs	domestic	W3526,W8001,79CW331,95CW285
	5414	Pinewood Springs Well 2	1972-12-31	1959-12-31	40176.00000	0.0044	cfs	domestic	W3526,W8001,79CW331,95CW285
	5412	Pinewood Springs Well 3	1972-12-31	1959-12-31	40176.00000	0.0044	cfs	domestic	W3526,W8001,79CW331,95CW285
	5413	Pinewood Springs Well 4	1972-12-31	1966-07-13	42562.00000	0.0022	cfs	domestic	W3526,W8001,79CW331,95CW285
	5415	Pinewood Springs Well 5	1972-12-31	1966-07-06	42555.00000	0.0044	cfs	domestic	W3526,W8001,79CW331,95CW285
	5416	Pinewood Springs Well 6	1972-12-31	1967-12-19	43086.00000	0.0044	cfs	domestic	W3526,W8001,79CW331,95CW285
	5421	Pinewood Springs Well 7	1972-12-31	1969-01-17	43481.00000	0.0066	cfs	domestic	W3526,W8001,79CW331,95CW285
	5417	Pinewood Springs Well 8	1972-12-31	1969-10-06	43743.00000	0.0044	cfs	domestic	W3526,W8001,79CW331,95CW285
	5418	Pinewood Springs Well 9	1972-12-31	1962-09-04	41154.00000	0.0066	cfs	domestic	W3526,W8001,79CW331,95CW285
	5419	Pinewood Springs Well 10	1972-12-31	1962-12-31	41272.00000	0.0222	cfs	domestic	W3526,W8001,79CW331,95CW285
	5410	Pinewood Springs Well 11	1972-12-31	1967-12-20	43087.00000	0.0155	cfs	domestic	W3526,W8001,79CW331,95CW285
	5411	Pinewood Springs Well 12	1972-12-31	1970-10-17	44119.00000	0.0044	cfs	domestic	W3526,W8001,79CW331,95CW285
	5420	Pinewood Springs Well 13	1975-12-31	1973-07-31	45655.45137	0.0067	cfs	muni, domestic	W8001,W8014,79CW331,95CW285
	5422	Pinewood Springs Well 14	1975-12-31	1973-08-20	45655.45157	0.0044	cfs	muni, domestic	W8001,W8014,79CW331,95CW285
	5423	Pinewood Springs Well 15	1975-12-31	1973-10-10	45655.45208	0.0089	cfs	muni, domestic	W8001,W8014,79CW331,95CW285
	5247	Pinewood Springs Well 19	1995-12-31	1995-12-28	53322.00000	0.0055	cfs	muni, HUO	95CW284,95CW285
	5248	Pinewood Springs Well 20	1995-12-31	1995-12-28	53322.00000	0.0055	cfs	muni, HUO	95CW284,95CW285
		CONDITIONAL WATER RIGHTS							
Surface Diversions	5633	Pinewood Springs Collection Gallery	2002-12-31	2002-07-30	55728.00000	1	cfs	muni	02CW247,10CW290
Reservoirs	3348	Crow Lane Reservoir 1	2002-12-31	2002-07-30	55728.00000	51	af	muni, storage, aug, etc	10CW290
	3346	Crow Lane Reservoir 2	2002-12-31	2002-07-30	55728.00000	39	af	muni, storage, aug, etc	10CW290
	3349	Crescent Lake/Powelson Reservoir	2002-12-31	2000-09-27	55517.55057	18	af	muni, storage, aug, etc	10CW290
	3350	Maure Hollow Reservoir	2002-12-31	2002-07-30	55728.00000	45	af	muni, storage, aug, etc	10CW290
	3676	Pinewood Springs Reservoir	2002-12-31	2002-07-30	55728.00000	20	af	muni, storage, aug, etc	W8001,79CW331,80CW5,95CW285,02CW347,10CW290

Notes: Crow Lane Reservoir 1 has been constructed and is integrated into the domestic water system.

Big Elk Meadows

The Big Elk Water Association manages the water system for the Big Elk Meadows community. The water district's integrated water system includes 8 wells, a spring, 6 reservoirs, storage tanks, and a water treatment plant. The Big Elk Meadows water rights include an augmentation plan. The augmentation plan ensures that depletions from the water uses in the subdivision do not injure other water rights.

The augmentation plan was originally decreed in February 1997, Division 1, Case Number 95CW238. The decree indicates that the water system may serve up to approximately 175 homes. There are also uses associated with recreation, municipal swimming pool, turf and garden irrigation, livestock, and lake evaporation. At this time, 160 sfe's (single family residential equivalent) are served by the Association. The development has more than half of these homes as seasonal residency.

The Decree 95CW238 indicates that the water uses at Big Elk Meadows are replaced by consumptive use credits from a decreed change of use of water supplies associated with 12 shares of stock in the Boulder Larimer County Irrigation and Manufacturing Company (BLCIMC, aka Old Ish). The 12 shares represent an average annual consumptive use of 31.4 acre-feet per year (10-year running average, combined direct flow and storage).

The augmentation decree states that the maximum estimated water use for the subdivision is 38.45 acre-feet per year, with a consumptive use loss to the stream system of 20.7 acre-feet per year, including net evaporation from the lakes. The decree restricts lawn irrigation to "existing conditions" (unless otherwise augmented) and Paragraph 14 provides equations/water use factors to calculate household, swimming pool, turf and garden irrigation, livestock, and lake evaporation uses.

The augmentation plan indicates that each year a determination will be made of the amount of augmentation water available that year, broken into direct flow and storage components. Paragraphs no. 16. F. and 16. D. of the decree specifies the calculations to determine the direct flow and storage available from the 12 shares of stock in the BLCIMC. If the full amount decreed to the Boulder Larimer priorities is not available, then the entitlement shall be reduced in the proportion of that amount of water actually available to the decreed amount (i.e., the 12 shares pro-rata amount).

Big Elk Meadows provides replacement of the annual consumptive use with:

- Release of water stored in Ish Reservoir (releases must flow to the Little Thompson River),
- Release of water stored by exchange to the lakes,
- Release of water stored by priority in the lakes, and
- Bypass of water at the BLCIMC headgate to which BEM would be entitled. Accomplished by diverting water to the ditch and releasing back to the river through a flume.

The appropriative right of exchange has its downstream terminus as the Boulder Larimer headgate. The upper terminus of the exchange includes the wells and the lakes. The appropriation date for the exchange is September 5, 1995.

The maximum rate of exchange for the direct flow rights is 0.72 cubic feet per second (cfs) and a maximum diversion of 3.6 acre-feet. The maximum rate for exchange to storage is 85 cfs limited to an annual fill of 42.07 acre-feet and the storage volume shall not exceed a running average of 31.4 acre-feet.

Big Elk Meadows will exchange water from the BLCIMC headgate to the reservoirs and wells only when water is available under the BLCIMC priorities at the headgate. Also such an exchange to storage or to use must be made without causing flow immediately downstream of Meadow Lake to go below the amount necessary to meet any senior call of Pinewood Springs Water District under rights decreed. The decree includes other terms and conditions including record keeping and release schedule.

Table 1 lists the structures, water rights, amounts, decrees, priorities associated with the Big Elk Meadows water system.

Preliminary Identification of Big Elk Meadows Water Supply Concerns

The Big Elk Meadows Water Association has completed reconstruction of Mirror Lake and the water supply infrastructure serving the subdivision. The approximate volume of the reservoir is 13 acre-feet. The community is working to re-establish the other reservoirs to return the recreational and fishery uses of the structures.

One issue brought up at the November 9, 2015 public presentation in Longmont, at the Little Thompson Watershed Coalition's Steering Committee meeting with members of this Water Use Study's Advisory Committee participating, is that residents downstream of the Big Elk Meadows system noticed that the stream sometimes dried-up and questioned if Big Elk Meadows system was potentially responsible for the condition. Our investigations indicate that the very low flow and dry conditions are most likely resulting from the surface water yield of the upstream area dropping to practically zero. Big Elk Meadows system has water volume and flow monitoring as required by their decrees and the Division 1 Reservoir Accounting guidelines.

Table 1: Big Elk Meadows Water Supply Portfolio

	DIST 4 ID	Water Right Name	Adj Date	Appr Date	Admin No	Use Type	Net Amount	Units	Case No
Aug/Repl Plan	2750	BIG ELK MEADOWS AUG	1995-12-31			A			95CW0238
	2006	BIG ELK MEADOWS AUG IMPACT REACH	1995-12-31	1995-09-05	53208.00000	A	0.7200	CFS	95CW0238
	588	BOULD LARIM CO IRR MFG D	1883-05-28	1875-06-30	9312.00000	A0	0.3300	CFS	95CW0238
	588	BOULD LARIM CO IRR MFG D	1883-05-28	1877-05-20	10002.00000	A0	0.4300	CFS	95CW0238
	4156	BOULDER LARIMER RES	1916-06-29	1875-06-30	14691.09312	A0	14.9000	AF	95CW0238
	4156	BOULDER LARIMER RES	1916-06-29	1877-05-20	14691.10002	A0	6.6400	AF	95CW0238
	4156	BOULDER LARIMER RES	1916-06-29	1890-09-16	14869.00000	A0	9.0200	AF	95CW0238
	4156	BOULDER LARIMER RES	1916-06-29	1904-01-04	19726.00000	A0	11.5100	AF	95CW0238
Surface Diversions	1402	BIG ELK M PASTURE SPRING	1995-12-31	1952-11-10	52960.37569	9	0.0110	CFS	95CW0238
	807	BIG ELK MEADOWS PL	1971-12-31	1971-10-13	44480.00000	12568	1.0000	CFS	W1767
	807	BIG ELK MEADOWS PL	1971-12-31	1971-10-13	44480.00000	12568	0.0380	CFS	10CW0212
	731	BIG ELK MEADOW PL ALT PT	1971-12-31	1971-10-13	44480.00000	12568	1.0000	CFS	02CW0251
Wells	5069	BIG ELK MEADOWS 1-25172F	1972-12-31	1952-11-10	44559.37569	18Q	0.0490	CFS	W6464
	5070	BIG ELK MEADOWS 2-25173F	1972-12-31	1952-11-10	44559.37569	18Q	0.0670	CFS	W6464
	5071	BIG ELK MEADOWS 3-25174F	1972-12-31	1952-11-10	44559.37569	18Q	0.0780	CFS	W6464
	5073	BIG ELK MEADOWS 5-25176F	1972-12-31	1952-11-10	44559.37569	18Q	0.0670	CFS	W6464
	5074	BIG ELK MEADOWS 6-25177F	1972-12-31	1939-10-31	44559.32810	18Q	0.0780	CFS	W6464
	5075	BIG ELK MEADOWS 7-25178F	1972-12-31	1895-12-31	44559.16801	18Q	0.0220	CFS	W6464
	5076	BIG ELK MEADOWS 8-25179F	1972-12-31	1952-11-10	44559.37569	18Q	0.0040	CFS	W6464
	5072	BIG ELK MEADOWS WELL 4	1972-12-31	1952-11-10	44559.37569	18Q	0.0730	CFS	W6463
Reservoirs	3677	RAINBOW LAKE	1971-12-31	1952-11-10	44194.37569	12568	28.1330	AF	W1771
	3677	RAINBOW LAKE	1995-12-31	1995-09-05	53208.00000	A	85.0000	CFS	95CW0238
	3677	RAINBOW LAKE	1995-12-31	1995-09-05	53208.00000	A0	28.1330	AF	95CW0238
	3668	MIRROR LAKE	1971-12-31	1952-11-10	44194.37569	12568	17.1470	AF	W1772
	3668	MIRROR LAKE	1995-12-31	1995-09-05	53208.00000	A0	85.0000	CFS	95CW0238
	3668	MIRROR LAKE	1995-12-31	1995-09-05	53208.00000	A0	17.1470	AF	95CW0238
	3688	SUNSET LAKE	1971-12-31	1953-08-13	44194.37845	1	8.6000	AF	W1766
	3688	SUNSET LAKE	1995-12-31	1995-09-05	53208.00000	A0	85.0000	CFS	95CW0238
	3688	SUNSET LAKE	1995-12-31	1995-09-05	53208.00000	A0	8.6000	AF	95CW0238
	3700	WILLOW LAKE	1971-12-31	1953-08-13	44194.37845	12568	22.0000	AF	W1770
	3700	WILLOW LAKE	1995-12-31	1995-09-05	53208.00000	A0	85.0000	CFS	95CW0238
	3700	WILLOW LAKE	1995-12-31	1995-09-05	53208.00000	A0	22.8000	AF	95CW0238
	3664	MEADOW LAKE	1971-12-31	1953-08-13	44194.37845	12568	32.3000	AF	W1768
	3664	MEADOW LAKE	1995-12-31	1995-09-05	53208.00000	A0	85.0000	CFS	95CW0238
	3664	MEADOW LAKE	1995-12-31	1995-09-05	53208.00000	A0	32.3000	AF	95CW0238
		Conditional							
Reservoirs	3621	CANYON LAKE	1971-12-31	1971-10-13	44480.00000	12568	300.0000	AF	W1769
	3621	CANYON LAKE	1995-12-31	1995-09-05	53208.00000	A0	85.0000	CFS	95CW0238
	3621	CANYON LAKE	1995-12-31	1995-09-05	53208.00000	A0	300.0000	AF	95CW0238

From the CDSS Transaction List

At this time only Mirror Lake is reconstructed.

— End of Pinewood Springs and Big Elk Meadows Report —

END OF APPENDICES AND TECHNICAL MEMORANDA TO WATER USE STUDY AND NEEDS ASSESSMENT