GSI Water Solutions, Inc.

November 10, 2016

Mr. John Martin
General Manager
Tehachapi-Cummings County Water District
PO Box 326
Tehachapi, CA 93581

Subject: Supplemental Report to *Groundwater Model Update, Cummings Groundwater Basin*

Dear Mr. Martin,

The purpose of this Supplemental Report is to provide additional information and clarify some of the discussions contained in the Fugro Consultants (2015) report titled *Groundwater Model Update, Cummings Groundwater Basin*. The original report was prepared for the Tehachapi-Cummings County Water District (District) in order to evaluate recent changes in the quantity of groundwater storage in the basin, assess changes in the sources and volumes of recharge and discharge, and update and recalibrate the existing numerical groundwater flow model of the basin.

One of the components of the report was a discussion of the perennial yield of the Cummings Basin under then-current conditions versus the concept of an operational yield (or “native yield”). As discussed in the report, the perennial yield of a groundwater basin is specific to a period of time (base period), and accounts for all sources of recharge to the basin (e.g., natural recharge, artificial recharge, return flows). Thus, the perennial yield of a groundwater basin can change over time as cultural conditions change (e.g., the amount of agricultural irrigation affects return flows). By the standard definition of perennial yield used in the report, the perennial yield of the Cummings Groundwater Basin, under then-current conditions and over the time period of 1981 to 2013, is 3,750 acre-feet per year (AFY).

The Fugro (2015) report also presented the concept of an operational yield of a groundwater basin (or “native yield”), that is, the amount of groundwater discharge that can occur (pumping and natural outflow) on an average annual basis while maintaining no net change in groundwater storage and not requiring any supplemental (artificial) recharge. As described in the report, the operational yield of the Cummings Basin accounts for natural recharge (precipitation recharge, streamflow infiltration, and bedrock inflow) and return flows (from agricultural irrigation from groundwater pumping and domestic water use). The report concluded that the operational yield (native yield) of the Cummings Basin is approximately 2,990 AFY (equivalent to the perennial yield of 3,750 AFY less the annual volume of imported water recharge, which equaled 753 AFY). Therefore, the report concluded that pumping in excess of 2,990 AFY must be compensated by the same amount of artificial recharge (after accounting for evaporative losses) to keep the basin in balance.

The discussion of the native yield and how the volume of 753 AFY was derived was relatively brief, and questions have subsequently been raised as to the origin of the 753 AFY volume and its relationship to the perennial yield of the basin. The purpose of this Supplemental Report, therefore, is to provide additional information on the issue and present modified data tables intended to help clarify some of the questions.

You are referred directly to the Fugro (2015) report for the following discussions on select sections of the report.

Section 3.4 Agricultural Irrigation Return Flows

On page 12 of the Fugro (2015) report is a discussion of the calculation of irrigation return flows. The methodology of calculating irrigation return flows is described, and the reader is referred to Tables 6 and 7 for presentation of the data. The irrigation return flows were calculated by multiplying the total applied irrigation water (both imported water plus groundwater) by 15 percent (established by convention in the District Annual Reports). Thus, over the base period of 1981 to 2013, irrigation return flows equaled an average of 554 AFY. Table 6 of the Fugro (2015) report is attached to this Supplemental Report for reference.

The discussion further states that of the annual return flow volume of 554 AFY, 273 AFY of the return flow is from pumping native groundwater and 281 AFY is from applied imported water. The derivation of these volumes is shown on the attached Table 6a (see Columns 8a and 8b).

Also of note on Table 6a is Column 9, the volume of basin recharge attributed to artificial recharge of imported water. For the base period 1981 through 2013, the volume of artificial recharge of imported water averaged 472 AFY.

Table 6b (attached) is a summary of the groundwater recharge components (similar to Table 6a), but the contribution of imported water has been removed, that is, all irrigation return flow volumes from ag imported water (281 AFY) and all artificial (imported water) recharge (472 AFY) is removed from the inventory. Thus, Table 6b describes the recharge components of the basin water balance inventory as if the 753 AFY of imported water contribution (281 + 472) did not exist. The significance of these volumes and separate accounting of these irrigation return flow volumes will be discussed in following sections.

Section 3.5 CCI and Domestic Return Flows

Apart from the discussion of perennial yield and native yield, it is worthwhile noting a minor discrepancy in the Fugro (2015) report related to the accounting of return flows from the California Correctional Institute (CCI). On page 12 of the Fugro (2015) report is a discussion of the return flow volumes attributed to CCI and to domestic water use. The original Fugro (2003, 2004, and 2015) reports did not separately account for the volume of CCI return flows attributable solely to the CCI imported water supply. This return flow volume is noted, but is considered minor and is not considered further.

Section 3.10 Summary of Recharge and Discharge Components (Basin Inventory)

As described in Section 3.10 of the Fugro (2015) report (page 14), groundwater recharge in Cummings Basin is derived from several different sources, including precipitation, stream flows, return flows, bedrock inflow, and artificial recharge. The majority of groundwater discharge from Cummings Basin is from pumping with a minor component of groundwater outflow through the bedrock. The average annual contribution of each component based on the basin water balance inventory is summarized in Table 9 of the original report, and is attached to this Supplemental Report for reference.

Table 9a (attached) is a modified version of Table 9, showing the 33-year average annual groundwater component recharge vs. discharge with the removal of the imported water contribution. Over the course of the entire 1981 to 2013 time period, basin recharge, including the imported water supply, exceeded basin discharge by an average of approximately 156 AFY. However, if the 753 AFY of imported water supply is removed (no irrigation return flow of imported water 281 AFY and no artificial recharge of 472 AFY), basin discharge exceeds basin native recharge by 597 AFY.

Section 4.5 Estimate of Perennial Yield

Section 4.5 of the Fugro (2015) report is a discussion of perennial yield and the results of the modeling effort. However, the last paragraph of the section (bottom of page 27) includes a discussion of contribution of the imported water supply to basin recharge. There are two typographical errors in this paragraph that are worthy of correction.

The second sentence of the last paragraph of Section 4.5 states that "For the base period, irrigation return flows from imported water amounted to an average annual recharge of *273* AFY." As described above and shown on Table 6a, the irrigation return flow from imported water is equal to 281 AFY. Further on in the paragraph, the fourth sentence states "Averaged over the 33-year base period, the direct artificial recharge program accounted for an additional *473* AFY." As shown in Table 6a, the volume of direct artificial recharge averaged 472 AFY. These two amounts, 281 AFY and 472 AFY, account for the total volume of 753 AFY attributable to imported water within the overall basin water balance.

Section 4.6 Additional Discussion of Perennial Yield (Operational Yield)

The Fugro (2015) report describes that the perennial yield of a groundwater basin is specific to a period of time (base period), and accounts for all sources of recharge to the basin (e.g., natural recharge, artificial recharge, return flows). In simple terms, a basin water balance states that the recharge of the basin equals basin discharge, plus or minus the change in groundwater in storage.

As calculated in the Fugro (2015) report, the perennial yield of the Cummings Groundwater Basin, under then-current conditions and over the time period of 1981 to 2013, is 3,750 AFY.

The report goes on to discuss that the operational yield of a groundwater basin (or "native yield") is the amount of groundwater discharge that can occur (pumping and natural outflow) on an average annual basis while maintaining no net change in groundwater storage and not requiring any supplemental (artificial) recharge. The native, operational yield of the Cummings Basin takes into account natural recharge (precipitation recharge, streamflow infiltration, and bedrock inflow) and return flows from native sources (agricultural irrigation from groundwater pumping and domestic water use).

The native yield can be estimated two ways. One method is to take the total net basin recharge of the water balance, without the contribution of imported water (2,701 AFY; column 14 of Table 6b), and add the average annual gain in groundwater in storage of 90 AFY (see Section 4.2.2 – Water Balance Update, page 16 of the Fugro (2015) report). By this methodology, a native yield value of 2,791 AFY could be argued.

The preferred methodology to estimate the operational yield (native yield) of the Cummings Basin is by taking the perennial yield of 3,750 AFY less the volume of basin recharge attributed to imported water (753 AFY), or approximately 2,990 AFY. As described in earlier sections of this Supplemental Report, the derivation of the volume of 753 AFY of imported water basin recharge is shown on Table 6a.

Therefore, pumping in excess of the native yield value of 2,990 AFY must be compensated by the same amount of artificial recharge (after accounting for evaporative losses) to keep the basin in balance.

I trust that this Supplemental Report and attached modified tables provides clarification of the discussion of the native yield of Cummings Basin, and adequately illustrates the derivation of the underlying values of imported water contribution to the basin over the years.

If you have any questions, please do not hesitate to contact me.

Sincerely,
GSI Water Solutions, Inc.

Paul Sorensen. PG, CHG
Principal Hydrogeologist
California Professional Geologist
California Certified Hydrogeologist

Attachments

Table 6. Summary of Groundwater Recharge Components

Year	Total Rainfall	Rainfall Recharge	Cummings Creek Streamflow	Cummings Creek Streamflow Recharge	Other Streamflow	Other Streamflow Recharge	Irrigation Return Flow	Artificial Recharge	Bedrock Inflow	CCI/Domestic Return Flow	Total Potential Recharge	Streamflow Out of Basin	Total Net Recharge
Col.1	Col. 2	Col. 3	Col. 4	Col. 5	Col. 6	Col. 7	Col. 8	Col. 9	Col. 10	Col. 11	Col. 12	Col. 13	Col. 14
											=3+4+6+8+9 +10+11	=(4+6)-(5+7)	=12-13
1981	18.56	1,302	909	909	720	720	227	0	530	137	3,825	0	3,825
1982	16.85	971	613	613	486	486	236	0	530	152	2,988	0	2,988
1983	22	1,522	2,272	1,000	1,799	1,000	193	0	530	127	6,443	2,071	4,372
1984	12.95	883	364	364	288	288	189	0	530	137	2,391	0	2,391
1985	15.62	927	568	568	450	450	192	0	530	140	2,807	0	2,807
1986	13.73	883	500	500	396	396	199	0	530	165	2,673	0	2,673
1987	14.68	905	523	523	414	414	202	0	530	205	2,779	0	2,779
1988	19.16	1,390	1,136	1,000	899	899	325	0	530	274	4,554	136	4,418
1989	10.89	728	227	227	180	180	401	0	530	240	2,306	0	2,306
1990	7.46	243	23	23	18	18	378	0	530	241	1,433	0	1,433
1991	8.15	530	45	45	36	36	317	0	530	242	1,700	0	1,700
1992	17.04	1,103	727	727	576	576	333	0	530	249	3,518	0	3,518
1993	24.85	1,721	3,635	1,000	2,878	1,000	336	0	530	257	9,357	4,513	4,844
1994	8.4	618	68	68	54	54	439	0	530	266	1,975	0	1,975
1995	24.86	1,897	3,635	1,000	2,878	1,000	480	0	530	233	9,653	4,513	5,140
1996	9.95	640	91	91	72	72	383	41	530	405	2,162	0	2,162
1997	9.26	662	80	80	63	63	440	41	530	407	2,223	0	2,223
1998	25.81	2,912	6,816	1,000	5,397	1,000	349	333	530	410	16,747	10,213	6,534
1999	10.45	684	136	136	108	108	568	108	530	302	2,436	0	2,436
2000	10.21	684	102	102	81	81	685	81	530	295	2,458	0	2,458
2001	11.11	860	250	250	198	198	779	701	530	295	3,613	0	3,613

Table 6. Summary of Groundwater Recharge Components

Year	Total Rainfall	Rainfall Recharge	Cummings Creek Streamflow	Cummings Creek Streamflow Recharge	Other Streamflow	Other Streamflow Recharge	Irrigation Return Flow	Artificial Recharge	Bedrock Inflow	CCI/Domestic Return Flow	Total Potential Recharge	Streamflow Out of Basin	Total Net Recharge
Col.1	Col. 2	Col. 3	Col. 4	Col. 5	Col. 6	Col. 7	Col. 8	Col. 9	Col. 10	Col. 11	Col. 12	Col. 13	Col. 14
											=3+4+6+8+9 +10+11	=(4+6)-(5+7)	=12-13
2002	8.67	512	100	100	79	79	1,028	404	530	336	2,990	0	2,990
2003	7.46	424	25	25	20	20	1,028	1,056	530	335	3,418	0	3,418
2004	7.85	452	25	25	20	20	1,106	877	530	327	3,337	0	3,337
2005	18.11	1,297	718	718	568	568	969	940	530	345	5,367	0	5,367
2006	8.12	472	43	43	34	34	994	1,695	530	350	4,118	0	4,118
2007	8.78	520	107	107	85	85	1,034	1,193	530	337	3,806	0	3,806
2008	7.89	455	36	36	28	28	936	961	530	322	3,267	0	3,267
2009	8.46	497	57	57	45	45	755	1,634	530	301	3,820	0	3,820
2010	13.05	858	368	368	291	291	717	1,951	530	275	4,990	0	4,990
2011	19.67	1,439	2,540	1,000	2,010	1,000	423	1,459	530	329	8,730	2,549	6,180
2012	6.91	385	21	21	17	17	737	714	530	295	2,699	0	2,699
2013	3.76	179	21	21	17	17	921	1,389	530	340	3,397	0	3,397
Total		29,554	26,781	12,748	21,205	11,243	18,298	15,578	17,490	9,073	137,979	23,995	113,984
Average 1981-2013	13.05	896	812	386	643	341	554	472	530	275	4,181	727	3,454
Average 1981-2001	14.86	1,051	1,082	487	857	430	364	62	530	247	4,192	1,021	3,171
Average 2002-2013	9.89	624	338	210	268	184	887	1,189	530	325	4,162	212	3,949

Table 6a. Summary of Groundwater Recharge Components

Year	Total Rainfall	Rainfall Recharge	Cummings Creek Streamflow	Cummings Creek Streamflow Recharge	Other Streamflow	Other Streamflow Recharge	Irrigation Return Flow from Ag Pumping Native Groundwater	Irrigation Return Flow from Ag Imported Water	Artificial Recharge	Bedrock Inflow	CCI/Domestic Return Flow from Native and Imported Water	Total Potential Recharge	Streamflow Out of Basin	Total Net Recharge
Col.1	Col. 2	Col. 3	Col. 4	Col. 5	Col. 6	Col. 7	Col. 8a	Col. 8b	Col. 9	Col. 10	Col. 11	Col. 12	Col. 13	Col. 14
												=3+4+6+8a+8b+9 +10+11	=(4+6)-(5+7)	=12-13
1981	18.56	1,302	909	909	720	720	216	11	0	530	137	3,825	0	3,825
1982	16.85	971	613	613	486	486	216	20	0	530	152	2,988	0	2,988
1983	22	1,522	2,272	1,000	1,799	1,000	188	5	0	530	127	6,443	2,071	4,372
1984	12.95	883	364	364	288	288	188	2	0	530	137	2,391	0	2,391
1985	15.62	927	568	568	450	450	188	5	0	530	140	2,807	0	2,807
1986	13.73	883	500	500	396	396	188	12	0	530	165	2,673	0	2,673
1987	14.68	905	523	523	414	414	188	14	0	530	205	2,779	0	2,779
1988	19.16	1,390	1,136	1,000	899	899	263	62	0	530	274	4,554	136	4,418
1989	10.89	728	227	227	180	180	285	116	0	530	240	2,306	0	2,306
1990	7.46	243	23	23	18	18	153	225	0	530	241	1,433	0	1,433
1991	8.15	530	45	45	36	36	153	164	0	530	242	1,700	0	1,700
1992	17.04	1,103	727	727	576	576	153	179	0	530	249	3,518	0	3,518
1993	24.85	1,721	3,635	1,000	2,878	1,000	153	183	0	530	257	9,357	4,513	4,844
1994	8.4	618	68	68	54	54	153	287	0	530	266	1,976	0	1,976
1995	24.86	1,897	3,635	1,000	2,878	1,000	239	242	0	530	233	9,654	4,513	5,141
1996	9.95	640	91	91	72	72	71	311	41	530	405	2,161	0	2,161
1997	9.26	662	80	80	63	63	71	368	41	530	407	2,222	0	2,222
1998	25.81	2,912	6,816	1,000	5,397	1,000	71	278	333	530	410	16,748	10,213	6,535
1999	10.45	684	136	136	108	108	71	499	108	530	302	2,438	0	2,438
2000	10.21	684	102	102	81	81	181	504	81	530	295	2,458	0	2,458
2001	11.11	860	250	250	198	198	486	293	701	530	295	3,613	0	3,613

Table 6a. Summary of Groundwater Recharge Components

Year	Total Rainfall	Rainfall Recharge	Cummings Creek Streamflow	Cummings Creek Streamflow Recharge	Other Streamflow	Other Streamflow Recharge	Irrigation Return Flow from Ag Pumping Native Groundwater	Irrigation Return Flow from Ag Imported Water	Artificial Recharge	Bedrock Inflow	CCI/Domestic Return Flow from Native and Imported Water	Total Potential Recharge	Streamflow Out of Basin	Total Net Recharge
Col.1	Col. 2	Col. 3	Col. 4	Col. 5	Col. 6	Col. 7	Col. 8a	Col. 8b	Col. 9	Col. 10	Col. 11	Col. 12	Col. 13	Col. 14
												=3+4+6+8a+8b+9 +10+11	=(4+6)-(5+7)	=12-13
2002	8.67	512	100	100	79	79	539	489	404	530	336	2,990	0	2,990
2003	7.46	424	25	25	20	20	447	581	1,056	530	335	3,418	0	3,418
2004	7.85	452	25	25	20	20	461	646	877	530	327	3,337	0	3,337
2005	18.11	1,297	718	718	568	568	385	584	940	530	345	5,367	0	5,367
2006	8.12	472	43	43	34	34	455	539	1,695	530	350	4,118	0	4,118
2007	8.78	520	107	107	85	85	451	583	1,193	530	337	3,806	0	3,806
2008	7.89	455	36	36	28	28	473	462	961	530	322	3,267	0	3,267
2009	8.46	497	57	57	45	45	528	227	1,634	530	301	3,820	0	3,820
2010	13.05	858	368	368	291	291	461	256	1,951	530	275	4,990	0	4,990
2011	19.67	1,439	2,540	1,000	2,010	1,000	293	129	1,459	530	329	8,730	2,549	6,180
2012	6.91	385	21	21	17	17	297	441	714	530	295	2,699	0	2,699
2013	3.76	179	21	21	17	17	376	545	1,389	530	340	3,397	0	3,397
Total		29,554	26,781	12,748	21,205	11,243	9,039	9,261	15,578	17,490	9,073	137,981	23,995	113,985
Average 1981-2013	13.05	896	812	386	643	341	273	281	472	530	275	4,181	727	3,454
Average 1981-2001	14.86	1,051	1,082	487	857	430	184	180	62	530	247	4,192	1,021	3,171
Average 2002-2013	9.89	624	338	210	268	184	430	457	1,189	530	325	4,162	212	3,949

GSI Water Solutions, Inc.

Table 6b. Summary of Groundwater Recharge Components without Imported Water

Year	Total Rainfall	Rainfall Recharge	Cummings Creek Streamflow	Cummings Creek Streamflow Recharge	Other Streamflow	Other Streamflow Recharge	Irrigation Return Flow from Ag Pumping Native Groundwater	Bedrock Inflow	CCI/Domestic Return Flow from Native and Imported Water	Total Potential Recharge	Streamflow Out of Basin	Total Net Recharge
Col.1	Col. 2	Col. 3	Col. 4	Col. 5	Col. 6	Col. 7	Col. 8a	Col. 10	Col. 11	Col. 12	Col. 13	Col. 14
										=3+4+6+8a+10+11	=(4+6)-(5+7)	=12-13
1981	18.56	1,302	909	909	720	720	216	530	137	3,814	0	3,814
1982	16.85	971	613	613	486	486	216	530	152	2,968	0	2,968
1983	22	1,522	2,272	1,000	1,799	1,000	188	530	127	6,438	2,071	4,367
1984	12.95	883	364	364	288	288	188	530	137	2,390	0	2,390
1985	15.62	927	568	568	450	450	188	530	140	2,803	0	2,803
1986	13.73	883	500	500	396	396	188	530	165	2,662	0	2,662
1987	14.68	905	523	523	414	414	188	530	205	2,765	0	2,765
1988	19.16	1,390	1,136	1,000	899	899	263	530	274	4,492	136	4,356
1989	10.89	728	227	227	180	180	285	530	240	2,190	0	2,190
1990	7.46	243	23	23	18	18	153	530	241	1,208	0	1,208
1991	8.15	530	45	45	36	36	153	530	242	1,536	0	1,536
1992	17.04	1,103	727	727	576	576	153	530	249	3,338	0	3,338
1993	24.85	1,721	3,635	1,000	2,878	1,000	153	530	257	9,174	4,513	4,661
1994	8.4	618	68	68	54	54	153	530	266	1,689	0	1,689
1995	24.86	1,897	3,635	1,000	2,878	1,000	239	530	233	9,412	4,513	4,899
1996	9.95	640	91	91	72	72	71	530	405	1,809	0	1,809
1997	9.26	662	80	80	63	63	71	530	407	1,813	0	1,813
1998	25.81	2,912	6,816	1,000	5,397	1,000	71	530	410	16,136	10,213	5,923
1999	10.45	684	136	136	108	108	71	530	302	1,831	0	1,831
2000	10.21	684	102	102	81	81	181	530	295	1,873	0	1,873
2001	11.11	860	250	250	198	198	486	530	295	2,619	0	2,619

GSI Water Solutions, Inc.

Table 6b. Summary of Groundwater Recharge Components without Imported Water

Year	Total Rainfall	Rainfall Recharge	Cummings Creek Streamflow	Cummings Creek Streamflow Recharge	Other Streamflow	Other Streamflow Recharge	Irrigation Return Flow from Ag Pumping Native Groundwater	Bedrock Inflow	CCI/Domestic Return Flow from Native and Imported Water	Total Potential Recharge	Streamflow Out of Basin	Total Net Recharge
Col.1	Col. 2	Col. 3	Col. 4	Col. 5	Col. 6	Col. 7	Col. 8a	Col. 10	Col. 11	Col. 12	Col. 13	Col. 14
										=3+4+6+8a+10+11	=(4+6)-(5+7)	=12-13
2002	8.67	512	100	100	79	79	539	530	336	2,097	0	2,097
2003	7.46	424	25	25	20	20	447	530	335	1,781	0	1,781
2004	7.85	452	25	25	20	20	461	530	327	1,815	0	1,815
2005	18.11	1,297	718	718	568	568	385	530	345	3,843	0	3,843
2006	8.12	472	43	43	34	34	455	530	350	1,884	0	1,884
2007	8.78	520	107	107	85	85	451	530	337	2,030	0	2,030
2008	7.89	455	36	36	28	28	473	530	322	1,844	0	1,844
2009	8.46	497	57	57	45	45	528	530	301	1,959	0	1,959
2010	13.05	858	368	368	291	291	461	530	275	2,783	0	2,783
2011	19.67	1,439	2,540	1,000	2,010	1,000	293	530	329	7,141	2,549	4,592
2012	6.91	385	21	21	17	17	297	530	295	1,545	0	1,545
2013	3.76	179	21	21	17	17	376	530	340	1,463	0	1,463
Total		29,554	26,781	12,748	21,205	11,243	9,039	17,490	9,073	113,142	23,995	89,146
Average 1981-2013	13.05	896	812	386	643	341	274	530	275	3,429	727	2,701
Average 1981-2001	14.86	1,051	1,082	487	857	430	184	530	247	3,950	1,021	2,929
Average 2002-2013	9.89	624	338	210	268	184	430	530	325	2,515	212	2,303

GSI Water Solutions, Inc.

Table 7. Cummings Basin Water Use (acre feet)

Year	Irrigated Crop (ac)	Imported Water (af)				Groundwater Pumped (af)						Total Ag Use (af)	Ag Duty Factor (af/ac)
		Ag	CCI	Other M&I	Total	Ag	CCI	Other M&I	Domestic	Other	Total		
1981	483	70	0	188	258	1,440	585	0	40	0	2,065	1,510	3.13
1982	510	133	0	179	312	1,440	660	0	40	0	2,140	1,573	3.08
1983	481	35	0	81	116	1,250	560	0	30	0	1,840	1,285	2.67
1984	407	12	0	103	115	1,250	560	0	50	0	1,860	1,262	3.10
1985	433	30	0	133	163	1,250	575	0	50	0	1,875	1,280	2.96
1986	385	79	0	166	245	1,250	700	0	50	0	2,000	1,329	3.45
1987	472	96	198	181	475	1,250	700	0	50	0	2,000	1,346	2.85
1988	871	415	258	183	856	1,750	986	0	50	129	2,915	2,165	2.49
1989	909	771	248	556	1,575	1,900	700	0	100	271	2,971	2,671	2.94
1990	1,267	1,500	256	574	2,330	1,021	700	0	100	48	1,869	2,521	1.99
1991	1,348	1,092	256	576	1,924	1,021	702	0	100	131	1,954	2,113	1.57
1992	945	1,196	270	560	2,026	1,021	700	0	110	0	1,831	2,217	2.35
1993	1,019	1,219	298	513	2,030	1,021	710	0	110	0	1,841	2,240	2.20
1994	1,149	1,914	357	550	2,821	1,021	700	0	110	0	1,831	2,935	2.55
1995	1,046	1,614	389	247	2,250	1,590	500	0	110	0	2,200	3,204	3.06
1996	1,284	2,074	393	426	2,893	475	1,355	0	110	0	1,940	2,549	1.99
1997	1,496	2,450	404	346	3,200	475	1,355	159	110	0	2,099	2,925	1.96
1998	1,582	1,856	419	200	2,475	475	1,355	55	110	0	1,995	2,331	1.47
1999	1,660	3,328	433	308	4,069	475	800	221	110	0	1,606	3,803	2.29
2000	1,586	3,358	347	332	4,037	1,206	821	537	122	0	2,686	4,564	2.88
2001	1,828	1,956	360	343	2,659	3,237	829	671	114	0	4,851	5,193	2.84

Table 7. Cummings Basin Water Use (acre feet)

Year	Irrigated Crop (ac)	Imported Water (af)				Groundwater Pumped (af)						Total Ag Use (af)	Ag Duty Factor (af/ac)
		Ag	CCI	Other M&I	Total	Ag	CCI	Other M&I	Domestic	Other	Total		
2002	2,321	3,259	343	377	3,979	3,594	942	852	159	0	5,547	6,853	2.95
2003	2,918	3,871	247	198	4,316	2,983	942	781	195	0	4,901	6,854	2.35
2004	2,507	4,304	19	331	4,654	3,072	1,128	908	195	0	5,304	7,376	2.94
2005	2,727	3,893	0	222	4,115	2,565	1,125	959	240	0	4,889	6,458	2.37
2006	2,741	3,594	0	200	3,794	3,034	1,155	1,144	239	0	5,572	6,628	2.42
2007	2,909	3,886	0	245	4,131	3,004	1,140	1,184	219	0	5,547	6,890	2.37
2008	2,062	3,083	0	254	3,337	3,154	1,058	1,262	220	0	5,695	6,237	3.02
2009	1,584	1,512	0	250	1,762	3,522	913	997	238	0	5,670	5,034	3.18
2010	1,317	1,707	0	198	1,905	3,072	799	907	231	0	5,008	4,779	3.63
2011	1,418	863	0	196	1,059	1,956	1,018	765	251	0	3,991	2,819	1.99
2012	3,332	2,937	0	34	2,971	1,977	784	946	277	0	3,984	4,914	1.47
2013	2,873	3,633	0	9	3,642	2,506	1,009	1,107	276	0	4,898	6,139	2.14
Total	49,870	61,740	5,495	9,259	76,494	60,257	28,566	13,455	4,516	579	107,373	121,997	
Average 1981-2013	1,511	1,871	167	281	2,318	1,826	866	408	137	18	3,254	3,697	2.56
Average 1981-2001	1,008	1,200	233	321	1,754	1,229	788	78	85	28	2,208	2,429	2.56
Average 2002-2013	2,392	3,045	51	210	3,305	2,870	1,001	984	228	0	5,084	5,915	2.57

Table 9. Average Annual Groundwater Recharge and Discharge by Component, Basin Inventory Methodology

Water Balance Component	Calculation Method	21-Year Average Annual Amount 1981-2001 (AFY)	12-Year Average Annual Amount 2002-2013 (AFY)	33-Year Average Annual Amount 1981-2013 (AFY)	Comments
Precipitation Recharge	10% of precipitation	1,051	624	896	–
Cummings Creek Stream flow Recharge	2.1 inches over 6,182 acres minus excess stream flow	487	210	386	2.1 inches derived from Tehachapi Project Report
Other Stream flow Recharge	1.2 inches over 8,566 acres minus excess stream flow	430	184	341	1.2 inches derived from Tehachapi Project Report
Irrigation Return Flow	15% of applied irrigation water (sw and gw)	364	887	554	15% based on TCCWD value for return flow
Artificial Recharge	Per TCCWD records	62	1,189	472	Artificial recharge occurred from 1995-2013
Bedrock Inflow	Darcy's Law	530	530	530	-
CCI/Domestic Return Flow	20% and 50% of Total Use	247	325	275	Avg Ann Dom Use = 137 AFY (69 AFY return flow) Avg Ann CCI GW Pumping = 866 AFY (173 AFY return flow) Avg Ann CCI Import = 167 AFY (33 return flow)
Recharge Totals	**–**	**3,171**	**3,949**	**3,454**	**–**
Groundwater Pumping	District Records	2,208	5,084	3,254	Includes Agricultural, Municipal/Industrial, Domestic, and Other
Bedrock Outflow	Darcy's Law	44	44	44	–
Discharge Totals	**–**	**2,254**	**5,128**	**3,298**	**–**

GSI Water Solutions, Inc.

Table 9a. Average Annual Groundwater Recharge and Discharge by Component, Basin Inventory Methodology

Water Balance Component	Calculation Method	21-Year Average Annual Amount 1981-2001 (AFY)	12-Year Average Annual Amount 2002-2013 (AFY)	33-Year Average Annual Amount 1981-2013, with imported water supply (AFY)	33-Year Average Annual Amount 1981-2013, without imported water supply (AFY)	Comments
Precipitation Recharge	10% of precipitation	1,051	624	896	896	–
Cummings Creek Stream flow Recharge	2.1 inches over 6,182 acres minus excess stream flow	487	210	386	386	2.1 inches derived from Tehachapi Project Report
Other Stream flow Recharge	1.2 inches over 8,566 acres minus excess stream flow	430	184	341	341	1.2 inches derived from Tehachapi Project Report
Irrigation Return Flow from Ag Pumping Native Groundwater	15% of applied irrigation water	184	430	274	274	15% based on TCCWD value for return flow
Irrigation Return Flow from Ag Imported Water	15% of applied irrigation water	180	457	281	--	15% based on TCCWD value for return flow
Artificial Recharge	Per TCCWD records	62	1,189	472	--	Artificial recharge occurred from 1995-2013
Bedrock Inflow	Darcy's Law	530	530	530	530	–
CCI/Domestic Return Flow from Native and Imported Water	20% and 50% of Total Use	247	325	275	275	Avg Ann Dom Use = 137 AFY (69 AFY return flow) Avg Ann CCI GW Pumping = 866 AFY (173 AFY return flow) Avg Ann CCI Import = 167 AFY (33 return flow)
Recharge Totals	**–**	**3,171**	**3,949**	**3,454**	**2,701**	**–**
Groundwater Pumping	District Records	2,208	5,084	3,254	3,254	Includes Agricultural, Municipal/Industrial, Domestic, and Other
Bedrock Outflow	Darcy's Law	44	44	44	44	–
Discharge Totals	**–**	**2,254**	**5,128**	**3,298**	**3,298**	**–**

GSI Water Solutions, Inc.