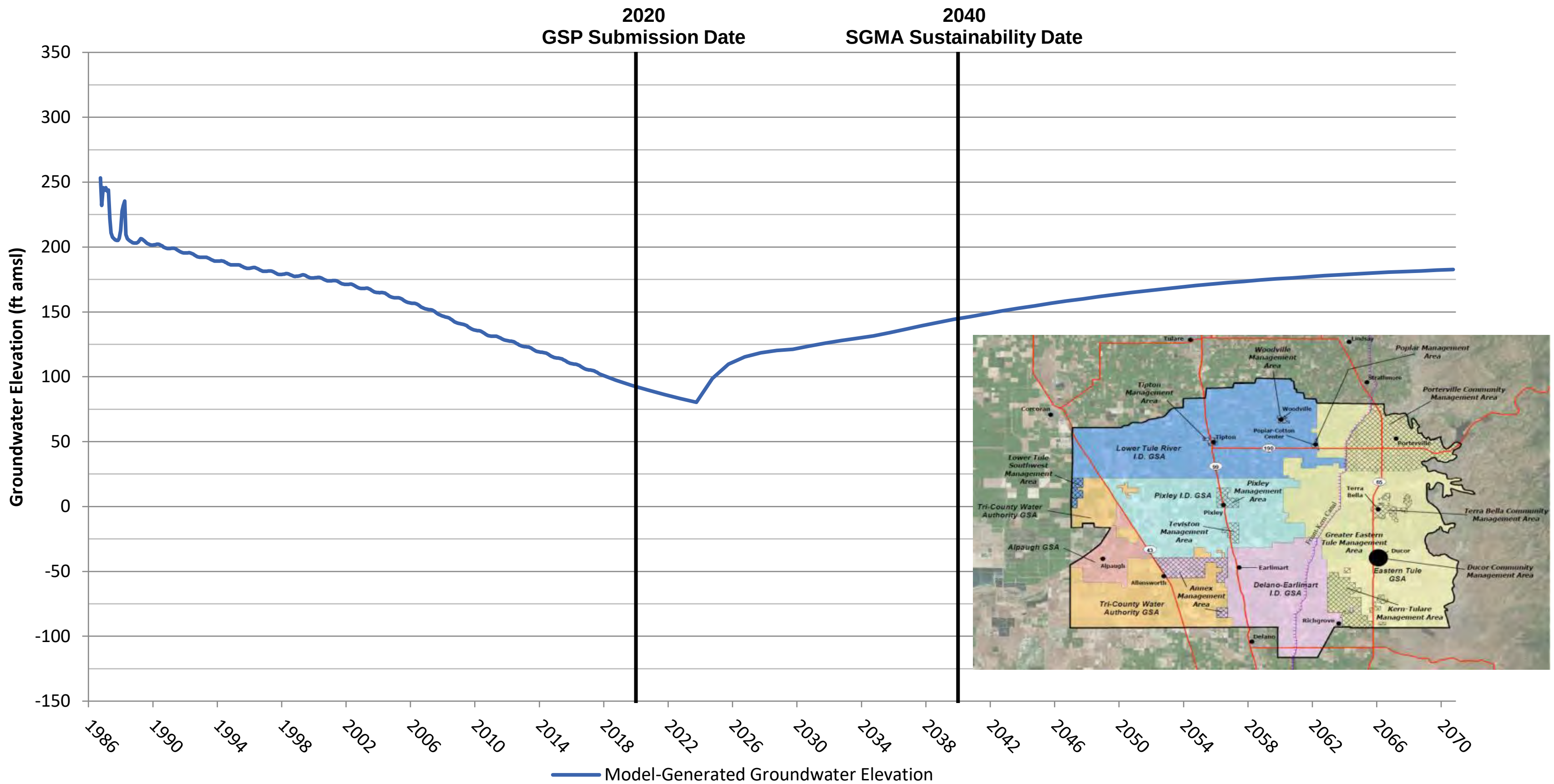
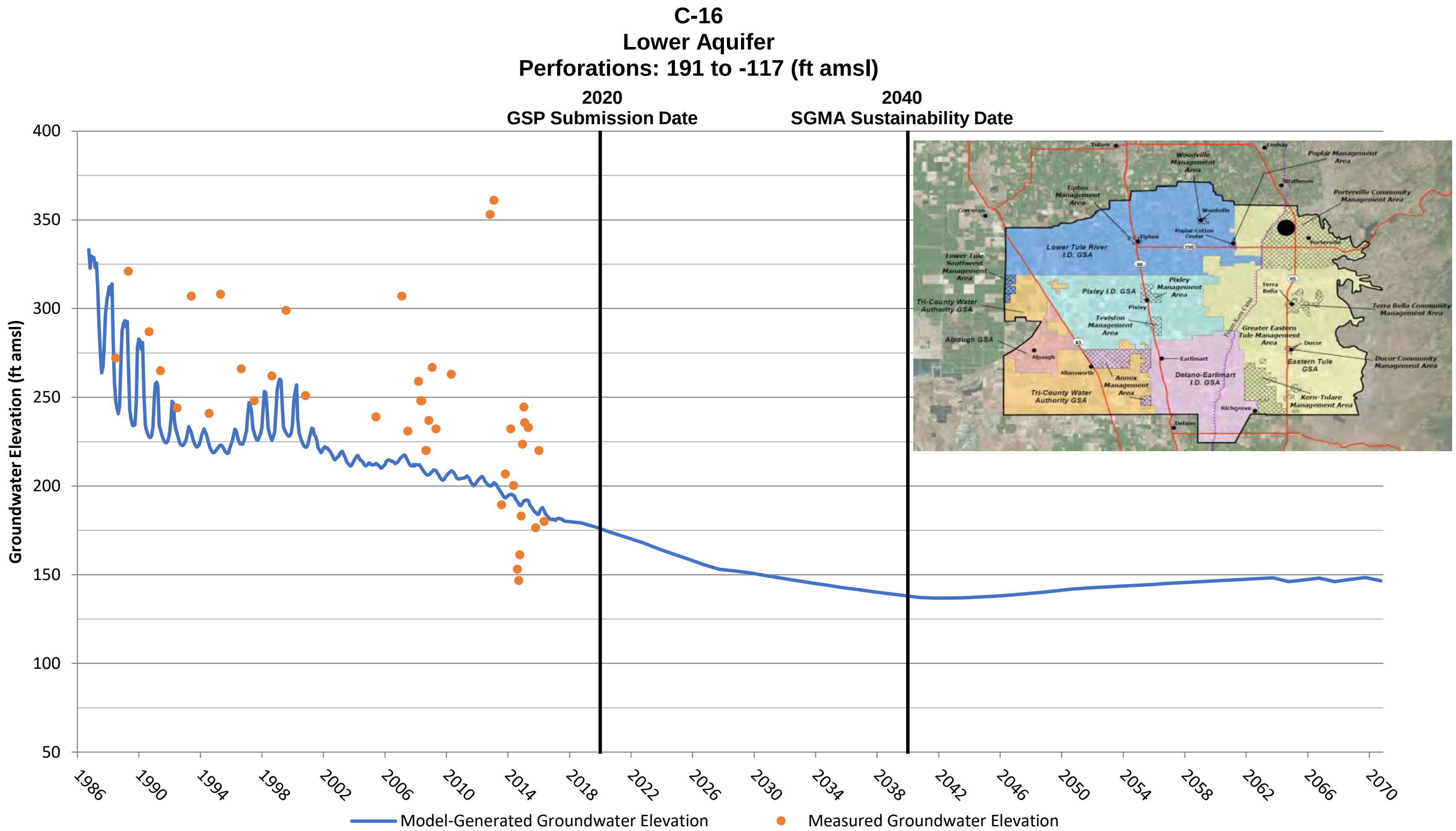
Eastern Tule GSA
Representative Monitoring Site

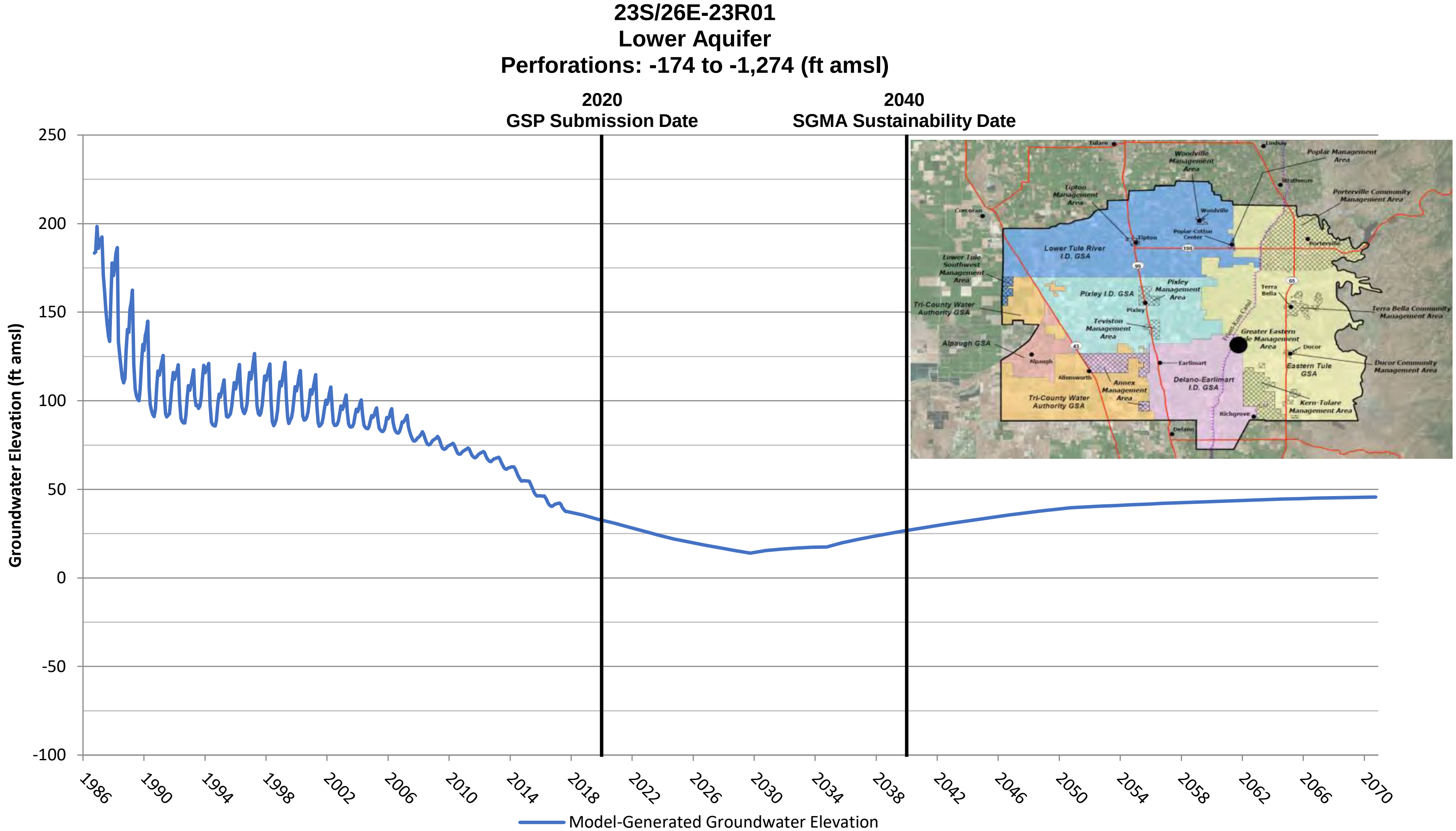
23S/27E-27
Lower Aquifer
Perforations: -505 to -855 (ft amsl)



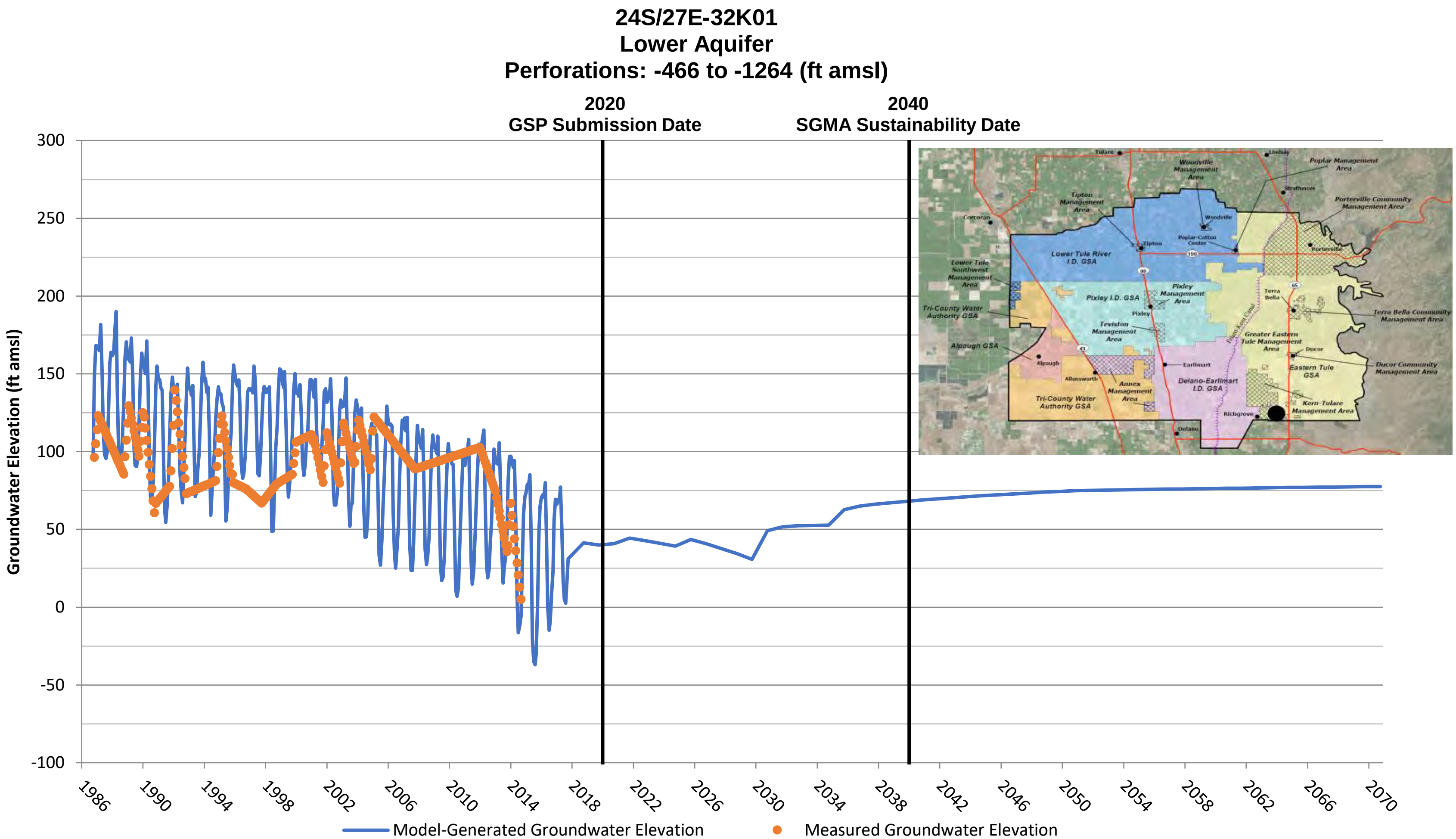
Eastern Tule GSA
Representative Monitoring Site



Eastern Tule GSA
Representative Monitoring Site

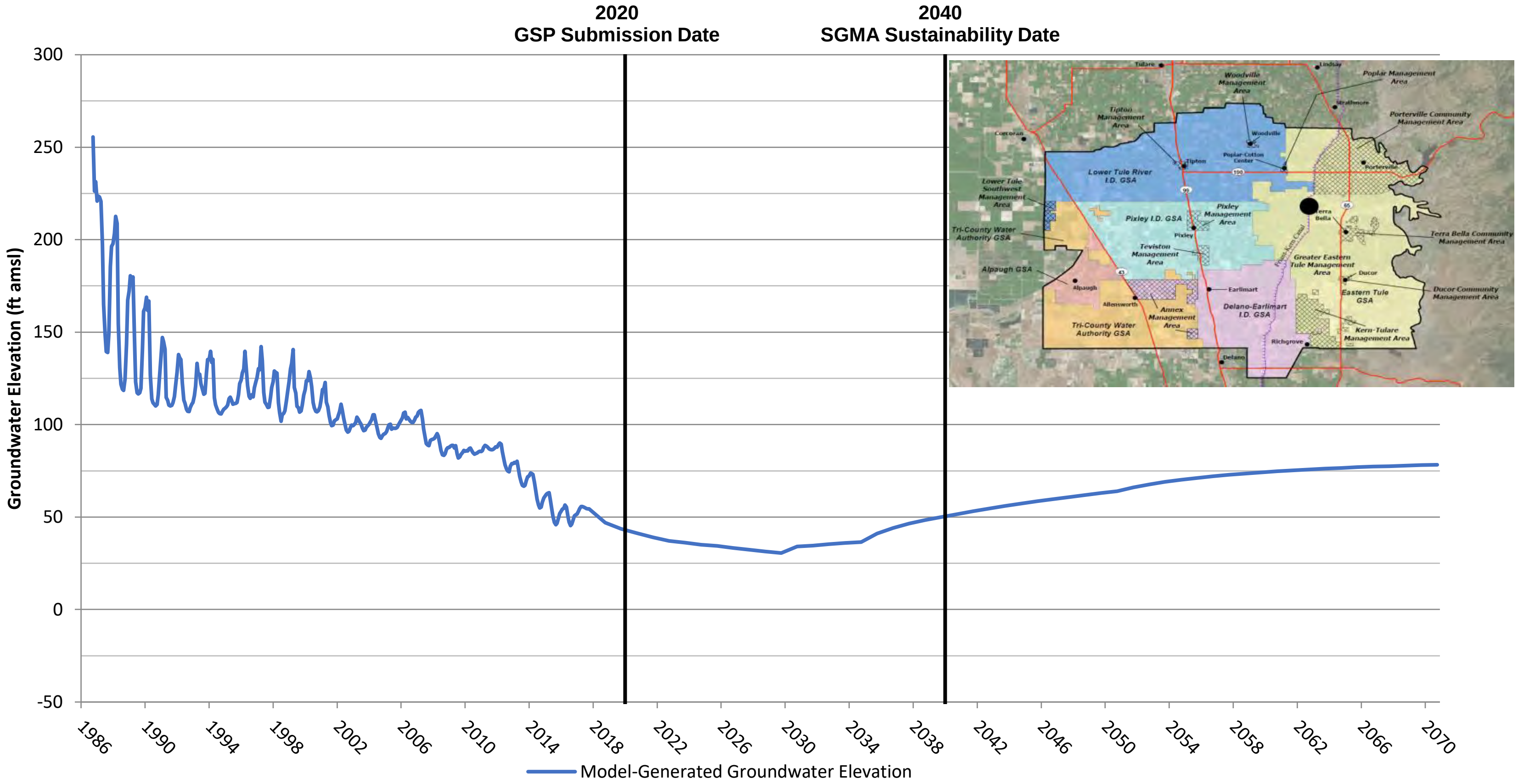


Eastern Tule GSA
Representative Monitoring Site



Eastern Tule GSA
Representative Monitoring Site

22S/26E-24
Lower Aquifer
Perforations: -263 to -813 (ft amsl)



Appendix C

Delano-Earlimart Irrigation District GSA

Water Budgets and Hydrographs

Delano-Earlimart Irrigation District GSA
Historical Surface Water Budget 1986/87 to 2016/17

Water Year	Surface Water Inflow (acre-ft)					Total In
	Precipitation	Stream Inflow	Imported Water	Discharge from Wells		
		White River	Delano-Earlimart ID	Agricultural	Municipal	
1986 - 1987	27,000	0	114,782	51,000	1,600	194,000
1987 - 1988	39,000	0	110,345	52,000	1,600	203,000
1988 - 1989	32,000	0	105,980	56,000	1,700	196,000
1989 - 1990	30,000	0	83,837	78,000	1,700	194,000
1990 - 1991	41,000	0	106,877	53,000	1,700	203,000
1991 - 1992	36,000	0	92,567	70,000	1,700	200,000
1992 - 1993	58,000	0	133,359	33,000	1,700	226,000
1993 - 1994	36,000	0	92,394	72,000	1,800	202,000
1994 - 1995	76,000	3,867	124,388	40,000	1,800	246,000
1995 - 1996	40,000	1,276	144,069	35,000	1,800	222,000
1996 - 1997	56,000	6,659	153,967	34,000	1,800	252,000
1997 - 1998	91,000	27,100	119,815	56,000	1,800	296,000
1998 - 1999	46,000	205	124,051	48,000	1,900	220,000
1999 - 2000	44,000	626	134,272	42,000	1,900	223,000
2000 - 2001	33,000	296	117,746	53,000	1,900	206,000
2001 - 2002	31,000	1,067	126,747	44,000	2,000	205,000
2002 - 2003	31,000	646	121,277	43,000	2,000	198,000
2003 - 2004	26,000	0	127,364	35,000	2,100	190,000
2004 - 2005	49,000	1,298	119,847	39,000	2,100	211,000
2005 - 2006	50,000	2,384	121,005	38,000	2,200	214,000
2006 - 2007	21,000	0	79,111	77,000	2,200	179,000
2007 - 2008	24,000	0	106,470	46,000	2,300	179,000
2008 - 2009	25,000	0	111,556	47,000	2,400	186,000
2009 - 2010	41,000	0	118,671	43,000	2,400	205,000
2010 - 2011	60,000	6,543	127,447	36,000	2,500	232,000
2011 - 2012	38,000	0	114,108	39,000	2,500	194,000
2012 - 2013	17,000	0	87,302	64,000	2,600	171,000
2013 - 2014	12,000	0	38,106	111,000	2,600	164,000
2014 - 2015	18,000	0	18,591	129,000	2,700	168,000
2015 - 2016	27,000	0	93,806	57,000	2,800	181,000
2016 - 2017	28,000	10,216	137,773	34,000	2,800	213,000
86/87-16/17 Avg	38,000	2,000	109,900	53,000	2,100	205,000

Appendix C
Table 1b

Delano-Earlimart Irrigation District GSA
Historical Surface Water Budget 1986/87 to 2016/17

Water Year	Surface Water Outflow (acre-ft)										Total Out
	Areal Recharge of Precipitation	Streambed Infiltration	Recharge in Basins	Deep Percolation of Applied Water			Evapotranspiration				
		White River	Imported Water	Imported Water	Agricultural Pumping	Municipal Pumping	Precipitation Crops/Native	Imported Water Agricultural Cons. Use	Ag. Cons. Use from Pumping	Municipal (Landscape ET)	
1986 - 1987	0	0	0	27,100	10,200	1,100	27,000	87,600	41,000	600	195,000
1987 - 1988	0	0	0	23,200	10,300	1,100	39,000	87,100	41,000	600	202,000
1988 - 1989	0	0	0	22,400	11,200	1,100	32,000	83,600	45,000	600	196,000
1989 - 1990	0	0	0	18,000	15,200	1,100	30,000	65,900	63,000	600	194,000
1990 - 1991	0	0	0	20,900	10,600	1,100	41,000	86,000	43,000	600	203,000
1991 - 1992	0	0	0	19,900	13,700	1,100	36,000	72,700	56,000	600	200,000
1992 - 1993	4,000	0	5,600	25,400	6,800	1,100	53,000	102,400	26,000	600	225,000
1993 - 1994	0	0	700	21,400	14,100	1,100	36,000	70,300	58,000	600	202,000
1994 - 1995	15,000	3,900	4,500	23,700	8,100	1,200	61,000	96,300	32,000	600	246,000
1995 - 1996	0	1,300	1,300	37,100	7,700	1,200	40,000	105,800	27,000	600	222,000
1996 - 1997	4,000	6,700	5,300	42,100	7,600	1,200	52,000	106,500	26,000	600	252,000
1997 - 1998	25,000	27,100	2,900	28,200	11,700	1,200	66,000	88,700	44,000	700	296,000
1998 - 1999	0	200	2,700	26,600	10,300	1,200	46,000	94,700	38,000	700	220,000
1999 - 2000	0	600	4,400	29,900	9,100	1,200	44,000	100,000	33,000	700	223,000
2000 - 2001	0	300	600	26,800	11,300	1,200	33,000	90,400	42,000	700	206,000
2001 - 2002	0	1,100	0	28,400	9,500	1,300	31,000	98,300	34,000	700	204,000
2002 - 2003	0	600	0	23,800	7,500	1,300	31,000	97,500	35,000	700	197,000
2003 - 2004	0	0	0	27,700	6,300	1,300	26,000	99,700	29,000	700	191,000
2004 - 2005	1,000	1,300	100	23,700	6,900	1,400	48,000	96,100	32,000	800	211,000
2005 - 2006	1,000	2,400	1,200	23,200	6,800	1,400	49,000	96,700	32,000	800	215,000
2006 - 2007	0	0	100	15,800	12,400	1,500	21,000	63,200	65,000	800	180,000
2007 - 2008	0	0	0	16,500	7,900	1,500	24,000	90,000	38,000	800	179,000
2008 - 2009	0	0	2,500	19,500	7,900	1,500	25,000	89,600	39,000	800	186,000
2009 - 2010	0	0	5,800	20,200	7,400	1,600	41,000	92,600	36,000	900	206,000
2010 - 2011	5,000	6,500	9,400	22,100	6,300	1,600	54,000	96,000	30,000	900	232,000
2011 - 2012	0	0	1,100	21,000	6,800	1,600	38,000	92,000	32,000	900	193,000
2012 - 2013	0	0	0	16,300	10,400	1,700	17,000	71,000	54,000	900	171,000
2013 - 2014	0	0	0	7,100	17,100	1,700	12,000	31,000	94,000	900	164,000
2014 - 2015	0	0	0	2,700	19,700	1,700	18,000	15,900	109,000	1,000	168,000
2015 - 2016	0	0	3,600	13,000	9,400	1,800	27,000	77,100	48,000	1,000	181,000
2016 - 2017	0	10,200	16,400	23,100	6,000	1,800	28,000	98,200	28,000	1,000	213,000
86/87-16/17 Avg	2,000	2,000	2,200	22,500	9,900	1,400	36,000	85,300	44,000	700	206,000

Groundwater Inflows to be Included in Sustainable Yield Estimates
Groundwater Inflows to be Excluded from the Sustainable Yield Estimates
Surface Water or ET Outflows Not Included in Groundwater Recharge or Sustainable Yield Estimates

Appendix C
Table 2

Delano-Earlimart Irrigation District GSA
Historical Groundwater Budget 1986/87 to 2016/17

Water Year	Groundwater Inflows (acre-ft): Areal Recharge from Precipitation	Groundwater Inflows (acre-ft): White River Streamed Infiltration	Groundwater Inflows (acre-ft): Imported Water Deliveries Recharge in Basins	Groundwater Inflows (acre-ft): Imported Water Deliveries Return Flow	Groundwater Inflows (acre-ft): Agricultural Pumping Return Flow	Groundwater Inflows (acre-ft): Municipal Pumping Return Flow	Groundwater Inflows (acre-ft): Release of Water from Compression of Aquitards	Groundwater Inflows (acre-ft): Sub-surface Inflow From Outside Subbasin	Groundwater Inflows (acre-ft): Sub-surface Inflow From Other GSAs	Total In	Groundwater Outflows (acre-ft): Groundwater Pumping Municipal	Groundwater Outflows (acre-ft): Groundwater Pumping Agricultural	Groundwater Outflows (acre-ft): Groundwater Pumping Groundwater Banking Extraction	Groundwater Outflows (acre-ft): Sub-surface Outflow To Outside Subbasin	Groundwater Outflows (acre-ft): Sub-surface Outflow To Other GSAs	Total Out	Change in Storage (acre-ft)
1986 - 1987	0	0	0	27,100	10,200	1,100	11,000	3,000	23,000	75,000	1,600	51,000	0	23,000	47,000	123,000	-48,000
1987 - 1988	0	0	0	23,200	10,300	1,100	8,000	3,000	26,000	72,000	1,600	52,000	0	19,000	50,000	123,000	-51,000
1988 - 1989	0	0	0	22,400	11,200	1,100	8,000	4,000	26,000	73,000	1,700	56,000	0	18,000	51,000	127,000	-54,000
1989 - 1990	0	0	0	18,000	15,200	1,100	18,000	5,000	27,000	84,000	1,700	78,000	0	20,000	47,000	147,000	-63,000
1990 - 1991	0	0	0	20,900	10,600	1,100	8,000	5,000	29,000	75,000	1,700	53,000	0	22,000	52,000	129,000	-54,000
1991 - 1992	0	0	0	19,900	13,700	1,100	12,000	7,000	29,000	83,000	1,700	70,000	0	16,000	49,000	137,000	-54,000
1992 - 1993	4,000	0	5,600	25,400	6,800	1,100	2,000	5,000	30,000	80,000	1,700	33,000	0	17,000	52,000	104,000	-24,000
1993 - 1994	0	0	700	21,400	14,100	1,100	12,000	8,000	27,000	84,000	1,800	72,000	0	13,000	44,000	131,000	-47,000
1994 - 1995	15,000	3,900	4,500	23,700	8,100	1,200	3,000	6,000	26,000	91,000	1,800	40,000	0	13,000	47,000	102,000	-11,000
1995 - 1996	0	1,300	1,300	37,100	7,700	1,200	2,000	6,000	34,000	91,000	1,800	35,000	0	14,000	50,000	101,000	-10,000
1996 - 1997	4,000	6,700	5,300	42,100	7,600	1,200	2,000	6,000	33,000	108,000	1,800	34,000	0	17,000	51,000	104,000	4,000
1997 - 1998	25,000	27,100	2,900	28,200	11,700	1,200	3,000	7,000	37,000	143,000	1,800	56,000	0	14,000	48,000	120,000	23,000
1998 - 1999	0	200	2,700	26,600	10,300	1,200	2,000	6,000	37,000	86,000	1,900	48,000	0	14,000	47,000	111,000	-25,000
1999 - 2000	0	600	4,400	29,900	9,100	1,200	2,000	6,000	35,000	88,000	1,900	42,000	0	15,000	50,000	109,000	-21,000
2000 - 2001	0	300	600	26,800	11,300	1,200	6,000	6,000	36,000	88,000	1,900	53,000	0	17,000	50,000	122,000	-34,000
2001 - 2002	0	1,100	0	28,400	9,500	1,300	5,000	6,000	36,000	87,000	2,000	44,000	0	18,000	55,000	119,000	-32,000
2002 - 2003	0	600	0	23,800	7,500	1,300	4,000	6,000	34,000	77,000	2,000	43,000	0	15,000	52,000	112,000	-35,000
2003 - 2004	0	0	0	27,700	6,300	1,300	5,000	6,000	30,000	76,000	2,100	35,000	0	17,000	51,000	105,000	-29,000
2004 - 2005	1,000	1,300	100	23,700	6,900	1,400	4,000	6,000	33,000	77,000	2,100	39,000	0	16,000	49,000	106,000	-29,000
2005 - 2006	1,000	2,400	1,200	23,200	6,800	1,400	3,000	7,000	29,000	75,000	2,200	38,000	0	13,000	44,000	97,000	-22,000
2006 - 2007	0	0	100	15,800	12,400	1,500	18,000	7,000	32,000	87,000	2,200	77,000	0	14,000	40,000	133,000	-46,000
2007 - 2008	0	0	0	16,500	7,900	1,500	8,000	6,000	36,000	76,000	2,300	46,000	0	20,000	51,000	119,000	-43,000
2008 - 2009	0	0	2,500	19,500	7,900	1,500	10,000	6,000	35,000	82,000	2,400	47,000	600	21,000	54,000	125,000	-43,000
2009 - 2010	0	0	5,800	20,200	7,400	1,600	7,000	6,000	39,000	87,000	2,400	43,000	100	21,000	56,000	123,000	-36,000
2010 - 2011	5,000	6,500	9,400	22,100	6,300	1,600	5,000	6,000	33,000	95,000	2,500	36,000	0	18,000	52,000	109,000	-14,000
2011 - 2012	0	0	1,100	21,000	6,800	1,600	9,000	6,000	29,000	75,000	2,500	39,000	3,900	19,000	50,000	114,000	-39,000
2012 - 2013	0	0	0	16,300	10,400	1,700	18,000	6,000	31,000	83,000	2,600	64,000	6,000	17,000	49,000	139,000	-56,000
2013 - 2014	0	0	0	7,100	17,100	1,700	26,000	7,000	35,000	94,000	2,600	111,000	5,600	17,000	44,000	180,000	-86,000
2014 - 2015	0	0	0	2,700	19,700	1,700	20,000	7,000	38,000	89,000	2,700	129,000	1,200	15,000	40,000	188,000	-99,000
2015 - 2016	0	0	3,600	13,000	9,400	1,800	11,000	7,000	41,000	87,000	2,800	57,000	100	16,000	45,000	121,000	-34,000
2016 - 2017	0	10,200	16,400	23,100	6,000	1,800	6,000	6,000	37,000	107,000	2,800	34,000	0	16,000	51,000	104,000	3,000
86/87-16/17 Avg	2,000	2,000	2,200	22,500	9,900	1,400	8,000	6,000	32,000	86,000	2,100	53,000	600	17,000	49,000	122,000	-36,000
Cumulative Change in Storage																	-1,109,000

Legend:
- (light blue) Groundwater Inflows or Outflows to be Included in Sustainable Yield Estimates
- (pink) Groundwater Inflows to be Excluded from the Sustainable Yield Estimates
- (yellow) Groundwater Outflows Not Included in Sustainable Yield Estimates

Appendix C
Table 3a

Projected Future Delano-Earlimart Irrigation District GSA Surface Water Budget

Water Year	Surface Water Inflow (acre-ft)						Total In
	Precipitation	Stream Inflow	Imported Water	Discharge from Wells			
		White River	Delano-Earlimart ID	Agricultural	Municipal	Water Bank	
2017 - 2018	38,000	2,224	116,902	36,000	3,700	2,200	197,000
2018 - 2019	38,000	2,224	116,902	36,000	3,700	2,200	197,000
2019 - 2020	38,000	2,224	116,902	36,000	3,700	2,200	197,000
2020 - 2021	38,000	2,224	116,902	36,000	3,700	2,200	197,000
2021 - 2022	38,000	2,224	116,902	36,000	3,700	2,200	197,000
2022 - 2023	38,000	2,224	116,902	36,000	3,700	2,200	197,000
2023 - 2024	38,000	2,224	116,902	36,000	3,700	2,200	197,000
2024 - 2025	38,000	2,224	117,661	33,000	3,700	2,200	195,000
2025 - 2026	38,000	2,224	118,420	31,000	3,700	2,200	193,000
2026 - 2027	38,000	2,224	119,180	29,000	3,700	2,200	192,000
2027 - 2028	38,000	2,224	119,939	27,000	3,700	2,200	191,000
2028 - 2029	38,000	2,224	120,698	25,000	3,700	2,200	190,000
2029 - 2030	38,000	2,224	121,457	23,000	3,700	2,200	188,000
2030 - 2031	38,000	2,224	121,457	21,000	3,700	2,200	186,000
2031 - 2032	38,000	2,224	121,457	20,000	3,700	2,200	185,000
2032 - 2033	38,000	2,224	121,457	18,000	3,700	2,200	183,000
2033 - 2034	38,000	2,224	121,457	17,000	3,700	2,200	182,000
2034 - 2035	38,000	2,224	121,457	15,000	3,700	2,200	180,000
2035 - 2036	38,000	2,224	121,457	15,000	3,700	2,200	180,000
2036 - 2037	38,000	2,224	121,457	15,000	3,700	2,200	180,000
2037 - 2038	38,000	2,224	121,457	15,000	3,700	2,200	180,000
2038 - 2039	38,000	2,224	121,457	15,000	3,700	2,200	180,000
2039 - 2040	38,000	2,224	121,457	15,000	3,700	2,200	180,000
2040 - 2041	38,000	2,224	121,457	15,000	3,700	2,200	180,000
2041 - 2042	38,000	2,224	121,457	15,000	3,700	2,200	180,000
2042 - 2043	38,000	2,224	121,457	15,000	3,700	2,200	180,000
2043 - 2044	38,000	2,224	121,457	15,000	3,700	2,200	180,000
2044 - 2045	38,000	2,224	121,457	15,000	3,700	2,200	180,000
2045 - 2046	38,000	2,224	121,457	15,000	3,700	2,200	180,000
2046 - 2047	38,000	2,224	121,457	15,000	3,700	2,200	180,000
2047 - 2048	38,000	2,224	121,457	15,000	3,700	2,200	180,000
2048 - 2049	38,000	2,224	121,457	15,000	3,700	2,200	180,000
2049 - 2050	38,000	2,224	121,457	15,000	3,700	2,200	180,000
2050 - 2051	38,000	2,152	112,046	25,000	3,700	2,200	181,000
2051 - 2052	38,000	2,152	112,046	25,000	3,700	2,200	181,000
2052 - 2053	38,000	2,152	112,046	25,000	3,700	2,200	181,000
2053 - 2054	38,000	2,152	112,046	25,000	3,700	2,200	181,000
2054 - 2055	38,000	2,152	112,046	25,000	3,700	2,200	181,000
2055 - 2056	38,000	2,152	112,046	25,000	3,700	2,200	181,000
2056 - 2057	38,000	2,152	112,046	25,000	3,700	2,200	181,000
2057 - 2058	38,000	2,152	112,046	25,000	3,700	2,200	181,000
2058 - 2059	38,000	2,152	112,046	25,000	3,700	2,200	181,000
2059 - 2060	38,000	2,152	112,046	25,000	3,700	2,200	181,000
2060 - 2061	38,000	2,152	112,046	25,000	3,700	2,200	181,000
2061 - 2062	38,000	2,152	112,046	25,000	3,700	2,200	181,000
2062 - 2063	38,000	2,152	112,046	25,000	3,700	2,200	181,000
2063 - 2064	38,000	2,152	112,046	25,000	3,700	2,200	181,000
2064 - 2065	38,000	2,152	112,046	25,000	3,700	2,200	181,000
2065 - 2066	38,000	2,152	112,046	25,000	3,700	2,200	181,000
2066 - 2067	38,000	2,152	112,046	25,000	3,700	2,200	181,000
2067 - 2068	38,000	2,152	112,046	25,000	3,700	2,200	181,000
2068 - 2069	38,000	2,152	112,046	25,000	3,700	2,200	181,000
2069 - 2070	38,000	2,152	112,046	25,000	3,700	2,200	181,000
17/18-69/70 Avg	38,000	2,200	117,100	23,000	3,700	2,200	184,000

Projected Future Delano-Earlimart Irrigation District GSA Surface Water Budget

Water Year	Surface Water Outflow (acre-ft)										Total Out
	Areal Recharge of Precipitation	Streambed Infiltration	Recharge in Basins	Deep Percolation of Applied Water			Evapotranspiration				
		White River	Imported Water	Imported Water	Agricultural Pumping	Municipal Pumping	Precipitation Crops/Native	Imported Water Agricultural Cons. Use	Ag. Cons. Use from Pumping	Municipal (Landscape ET)	
2017 - 2018	2,000	2,200	2,200	21,400	6,300	2,400	36,000	95,500	29,000	1,300	198,000
2018 - 2019	2,000	2,200	2,200	21,400	6,300	2,400	36,000	95,500	29,000	1,300	198,000
2019 - 2020	2,000	2,200	2,200	21,400	6,300	2,400	36,000	95,500	29,000	1,300	198,000
2020 - 2021	2,000	2,200	2,200	21,400	6,300	2,400	36,000	95,500	29,000	1,300	198,000
2021 - 2022	2,000	2,200	2,200	21,400	6,300	2,400	36,000	95,500	29,000	1,300	198,000
2022 - 2023	2,000	2,200	2,200	21,400	6,300	2,400	36,000	95,500	29,000	1,300	198,000
2023 - 2024	2,000	2,200	2,200	21,400	6,300	2,400	36,000	95,500	29,000	1,300	198,000
2024 - 2025	2,000	2,200	2,200	21,500	5,900	2,400	36,000	96,100	28,000	1,300	198,000
2025 - 2026	2,000	2,200	2,200	21,600	5,500	2,400	36,000	96,800	26,000	1,300	196,000
2026 - 2027	2,000	2,200	2,200	21,700	5,100	2,400	36,000	97,400	24,000	1,300	194,000
2027 - 2028	2,000	2,200	2,200	21,800	4,700	2,400	36,000	98,100	22,000	1,300	193,000
2028 - 2029	2,000	2,200	2,200	22,000	4,200	2,400	36,000	98,700	20,000	1,300	191,000
2029 - 2030	2,000	2,200	2,200	22,100	3,800	2,400	36,000	99,400	19,000	1,300	190,000
2030 - 2031	2,000	2,200	2,200	22,100	3,500	2,400	36,000	99,400	18,000	1,300	189,000
2031 - 2032	2,000	2,200	2,200	22,100	3,200	2,400	36,000	99,400	16,000	1,300	187,000
2032 - 2033	2,000	2,200	2,200	22,100	2,900	2,400	36,000	99,400	15,000	1,300	186,000
2033 - 2034	2,000	2,200	2,200	22,100	2,600	2,400	36,000	99,400	14,000	1,300	184,000
2034 - 2035	2,000	2,200	2,200	22,100	2,300	2,400	36,000	99,400	13,000	1,300	183,000
2035 - 2036	2,000	2,200	2,200	22,100	2,300	2,400	36,000	99,400	13,000	1,300	183,000
2036 - 2037	2,000	2,200	2,200	22,100	2,300	2,400	36,000	99,400	13,000	1,300	183,000
2037 - 2038	2,000	2,200	2,200	22,100	2,300	2,400	36,000	99,400	13,000	1,300	183,000
2038 - 2039	2,000	2,200	2,200	22,100	2,300	2,400	36,000	99,400	13,000	1,300	183,000
2039 - 2040	2,000	2,200	2,200	22,100	2,300	2,400	36,000	99,400	13,000	1,300	183,000
2040 - 2041	2,000	2,200	2,200	22,100	2,300	2,400	36,000	99,400	13,000	1,300	183,000
2041 - 2042	2,000	2,200	2,200	22,100	2,300	2,400	36,000	99,400	13,000	1,300	183,000
2042 - 2043	2,000	2,200	2,200	22,100	2,300	2,400	36,000	99,400	13,000	1,300	183,000
2043 - 2044	2,000	2,200	2,200	22,100	2,300	2,400	36,000	99,400	13,000	1,300	183,000
2044 - 2045	2,000	2,200	2,200	22,100	2,300	2,400	36,000	99,400	13,000	1,300	183,000
2045 - 2046	2,000	2,200	2,200	22,100	2,300	2,400	36,000	99,400	13,000	1,300	183,000
2046 - 2047	2,000	2,200	2,200	22,100	2,300	2,400	36,000	99,400	13,000	1,300	183,000
2047 - 2048	2,000	2,200	2,200	22,100	2,300	2,400	36,000	99,400	13,000	1,300	183,000
2048 - 2049	2,000	2,200	2,200	22,100	2,300	2,400	36,000	99,400	13,000	1,300	183,000
2049 - 2050	2,000	2,200	2,200	22,100	2,300	2,400	36,000	99,400	13,000	1,300	183,000
2050 - 2051	2,000	2,200	2,200	20,700	3,700	2,400	36,000	91,300	21,000	1,300	183,000
2051 - 2052	2,000	2,200	2,200	20,700	3,700	2,400	36,000	91,300	21,000	1,300	183,000
2052 - 2053	2,000	2,200	2,200	20,700	3,700	2,400	36,000	91,300	21,000	1,300	183,000
2053 - 2054	2,000	2,200	2,200	20,700	3,700	2,400	36,000	91,300	21,000	1,300	183,000
2054 - 2055	2,000	2,200	2,200	20,700	3,700	2,400	36,000	91,300	21,000	1,300	183,000
2055 - 2056	2,000	2,200	2,200	20,700	3,700	2,400	36,000	91,300	21,000	1,300	183,000
2056 - 2057	2,000	2,200	2,200	20,700	3,700	2,400	36,000	91,300	21,000	1,300	183,000
2057 - 2058	2,000	2,200	2,200	20,700	3,700	2,400	36,000	91,300	21,000	1,300	183,000
2058 - 2059	2,000	2,200	2,200	20,700	3,700	2,400	36,000	91,300	21,000	1,300	183,000
2059 - 2060	2,000	2,200	2,200	20,700	3,700	2,400	36,000	91,300	21,000	1,300	183,000
2060 - 2061	2,000	2,200	2,200	20,700	3,700	2,400	36,000	91,300	21,000	1,300	183,000
2061 - 2062	2,000	2,200	2,200	20,700	3,700	2,400	36,000	91,300	21,000	1,300	183,000
2062 - 2063	2,000	2,200	2,200	20,700	3,700	2,400	36,000	91,300	21,000	1,300	183,000
2063 - 2064	2,000	2,200	2,200	20,700	3,700	2,400	36,000	91,300	21,000	1,300	183,000
2064 - 2065	2,000	2,200	2,200	20,700	3,700	2,400	36,000	91,300	21,000	1,300	183,000
2065 - 2066	2,000	2,200	2,200	20,700	3,700	2,400	36,000	91,300	21,000	1,300	183,000
2066 - 2067	2,000	2,200	2,200	20,700	3,700	2,400	36,000	91,300	21,000	1,300	183,000
2067 - 2068	2,000	2,200	2,200	20,700	3,700	2,400	36,000	91,300	21,000	1,300	183,000
2068 - 2069	2,000	2,200	2,200	20,700	3,700	2,400	36,000	91,300	21,000	1,300	183,000
2069 - 2070	2,000	2,200	2,200	20,700	3,700	2,400	36,000	91,300	21,000	1,300	183,000
17/18-69/70 Avg	2,000	2,200	2,200	21,400	3,700	2,400	36,000	95,600	19,000	1,300	186,000

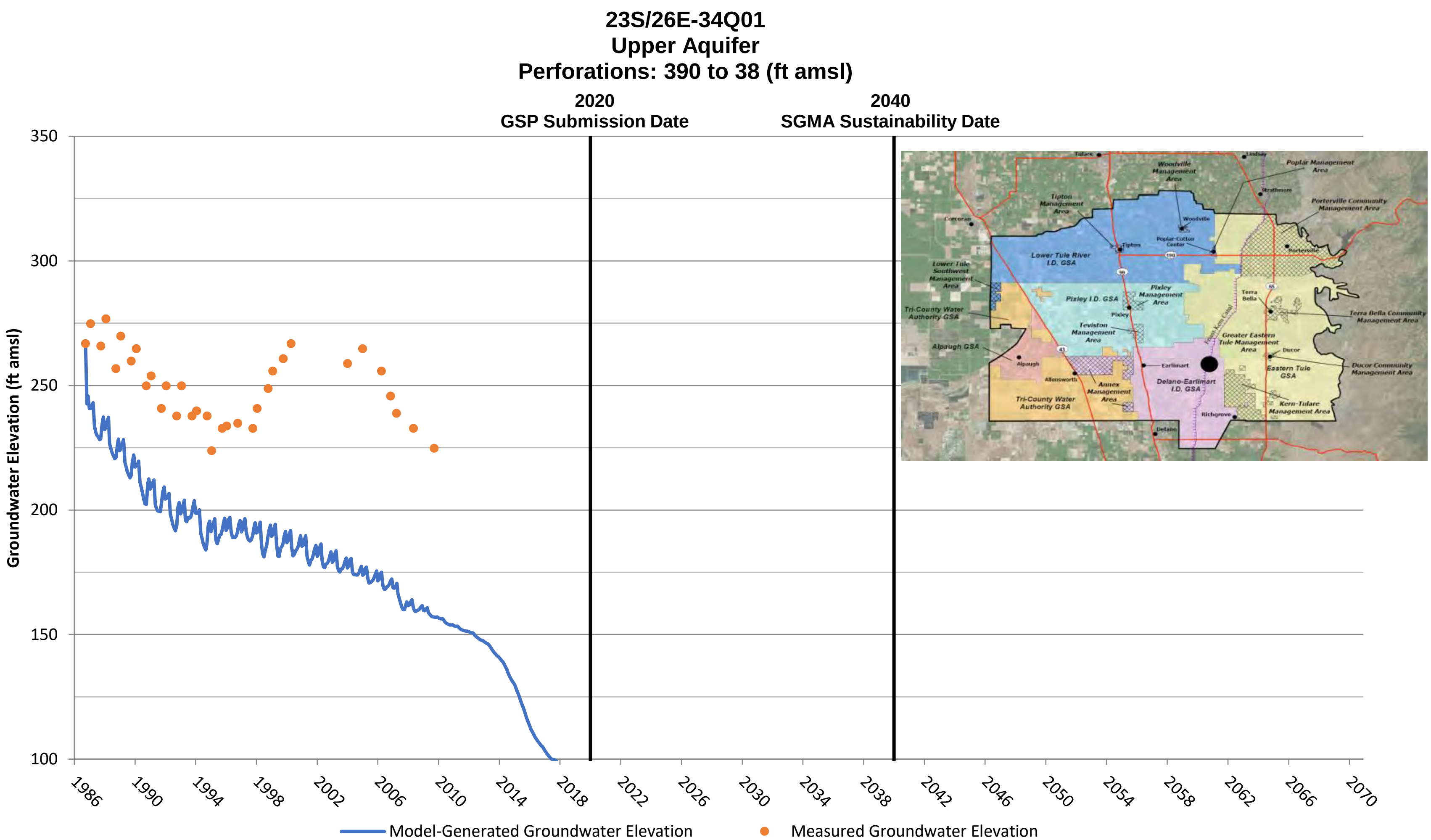
Appendix C
Table 4

Projected Future Delano-Earlimart Irrigation District GSA Groundwater Budget

Water Year	Groundwater Inflows (acre-ft)										Groundwater Outflows (acre-ft)						Change in Storage (acre-ft)
	Areal Recharge from Precipitation	White River	Imported Water Deliveries		Agricultural Pumping	Municipal Pumping	Release of Water from Compression of Aquitards	Sub-surface Inflow		Total In	Groundwater Pumping			Sub-surface Outflow		Total Out	
		Streambed Infiltration	Recharge in Basins	Return Flow	Return Flow	Return Flow		From Outside Subbasin	From Other GSAs		Municipal	Agricultural	Groundwater Banking Extraction	To Outside Subbasin	To Other GSAs		
2017 - 2018	2,000	2,200	2,200	21,400	6,300	2,400	6,000	5,000	28,000	76,000	3,700	36,000	2,200	19,000	52,000	113,000	-37,000
2018 - 2019	2,000	2,200	2,200	21,400	6,300	2,400	7,000	5,000	28,000	77,000	3,700	36,000	2,200	19,000	50,000	111,000	-34,000
2019 - 2020	2,000	2,200	2,200	21,400	6,300	2,400	7,000	5,000	28,000	77,000	3,700	36,000	2,200	19,000	49,000	110,000	-33,000
2020 - 2021	2,000	2,200	2,200	21,400	6,300	2,400	7,000	5,000	28,000	77,000	3,700	36,000	2,200	19,000	48,000	109,000	-32,000
2021 - 2022	2,000	2,200	2,200	21,400	6,300	2,400	7,000	5,000	27,000	76,000	3,700	36,000	2,200	18,000	47,000	107,000	-31,000
2022 - 2023	2,000	2,200	2,200	21,400	6,300	2,400	7,000	5,000	26,000	75,000	3,700	36,000	2,200	18,000	45,000	105,000	-30,000
2023 - 2024	2,000	2,200	2,200	21,400	6,300	2,400	8,000	5,000	26,000	76,000	3,700	36,000	2,200	17,000	46,000	105,000	-29,000
2024 - 2025	2,000	2,200	2,200	21,500	5,900	2,400	7,000	5,000	25,000	73,000	3,700	33,000	2,200	17,000	43,000	99,000	-26,000
2025 - 2026	2,000	2,200	2,200	21,600	5,500	2,400	6,000	5,000	22,000	69,000	3,700	31,000	2,200	16,000	40,000	93,000	-24,000
2026 - 2027	2,000	2,200	2,200	21,700	5,100	2,400	6,000	5,000	20,000	67,000	3,700	29,000	2,200	16,000	39,000	90,000	-23,000
2027 - 2028	2,000	2,200	2,200	21,800	4,700	2,400	5,000	5,000	18,000	63,000	3,700	27,000	2,200	16,000	37,000	86,000	-23,000
2028 - 2029	2,000	2,200	2,200	22,000	4,200	2,400	5,000	5,000	16,000	61,000	3,700	25,000	2,200	15,000	36,000	82,000	-21,000
2029 - 2030	2,000	2,200	2,200	22,100	3,800	2,400	4,000	5,000	15,000	59,000	3,700	23,000	2,200	14,000	32,000	75,000	-16,000
2030 - 2031	2,000	2,200	2,200	22,100	3,500	2,400	4,000	5,000	14,000	57,000	3,700	21,000	2,200	14,000	31,000	72,000	-15,000
2031 - 2032	2,000	2,200	2,200	22,100	3,200	2,400	3,000	5,000	13,000	55,000	3,700	20,000	2,200	14,000	31,000	71,000	-16,000
2032 - 2033	2,000	2,200	2,200	22,100	2,900	2,400	3,000	4,000	12,000	53,000	3,700	18,000	2,200	13,000	30,000	67,000	-14,000
2033 - 2034	2,000	2,200	2,200	22,100	2,600	2,400	3,000	4,000	12,000	53,000	3,700	17,000	2,200	13,000	31,000	67,000	-14,000
2034 - 2035	2,000	2,200	2,200	22,100	2,300	2,400	2,000	5,000	12,000	52,000	3,700	15,000	2,200	13,000	29,000	63,000	-11,000
2035 - 2036	2,000	2,200	2,200	22,100	2,300	2,400	2,000	5,000	13,000	53,000	3,700	15,000	2,200	13,000	28,000	62,000	-9,000
2036 - 2037	2,000	2,200	2,200	22,100	2,300	2,400	2,000	5,000	13,000	53,000	3,700	15,000	2,200	13,000	28,000	62,000	-9,000
2037 - 2038	2,000	2,200	2,200	22,100	2,300	2,400	2,000	5,000	13,000	53,000	3,700	15,000	2,200	13,000	27,000	61,000	-8,000
2038 - 2039	2,000	2,200	2,200	22,100	2,300	2,400	2,000	5,000	14,000	54,000	3,700	15,000	2,200	13,000	27,000	61,000	-7,000
2039 - 2040	2,000	2,200	2,200	22,100	2,300	2,400	2,000	5,000	14,000	54,000	3,700	15,000	2,200	13,000	25,000	59,000	-5,000
2040 - 2041	2,000	2,200	2,200	22,100	2,300	2,400	2,000	5,000	14,000	54,000	3,700	15,000	2,200	12,000	25,000	58,000	-4,000
2041 - 2042	2,000	2,200	2,200	22,100	2,300	2,400	1,000	5,000	14,000	53,000	3,700	15,000	2,200	12,000	24,000	57,000	-4,000
2042 - 2043	2,000	2,200	2,200	22,100	2,300	2,400	1,000	5,000	14,000	53,000	3,700	15,000	2,200	12,000	24,000	57,000	-4,000
2043 - 2044	2,000	2,200	2,200	22,100	2,300	2,400	1,000	5,000	14,000	53,000	3,700	15,000	2,200	12,000	24,000	57,000	-4,000
2044 - 2045	2,000	2,200	2,200	22,100	2,300	2,400	1,000	5,000	15,000	54,000	3,700	15,000	2,200	12,000	24,000	57,000	-3,000
2045 - 2046	2,000	2,200	2,200	22,100	2,300	2,400	1,000	5,000	15,000	54,000	3,700	15,000	2,200	12,000	24,000	57,000	-3,000
2046 - 2047	2,000	2,200	2,200	22,100	2,300	2,400	1,000	5,000	15,000	54,000	3,700	15,000	2,200	12,000	24,000	57,000	-3,000
2047 - 2048	2,000	2,200	2,200	22,100	2,300	2,400	1,000	5,000	15,000	54,000	3,700	15,000	2,200	12,000	24,000	57,000	-3,000
2048 - 2049	2,000	2,200	2,200	22,100	2,300	2,400	1,000	5,000	15,000	54,000	3,700	15,000	2,200	12,000	24,000	57,000	-3,000
2049 - 2050	2,000	2,200	2,200	22,100	2,300	2,400	1,000	5,000	15,000	54,000	3,700	15,000	2,200	12,000	24,000	57,000	-3,000
2050 - 2051	2,000	2,200	2,200	20,700	3,700	2,400	2,000	5,000	16,000	56,000	3,700	25,000	2,200	11,000	23,000	65,000	-9,000
2051 - 2052	2,000	2,200	2,200	20,700	3,700	2,400	2,000	5,000	17,000	57,000	3,700	25,000	2,200	11,000	22,000	64,000	-7,000
2052 - 2053	2,000	2,200	2,200	20,700	3,700	2,400	2,000	5,000	17,000	57,000	3,700	25,000	2,200	11,000	22,000	64,000	-7,000
2053 - 2054	2,000	2,200	2,200	20,700	3,700	2,400	2,000	5,000	17,000	57,000	3,700	25,000	2,200	11,000	22,000	64,000	-7,000
2054 - 2055	2,000	2,200	2,200	20,700	3,700	2,400	2,000	5,000	17,000	57,000	3,700	25,000	2,200	11,000	22,000	64,000	-7,000
2055 - 2056	2,000	2,200	2,200	20,700	3,700	2,400	2,000	5,000	18,000	58,000	3,700	25,000	2,200	11,000	21,000	63,000	-5,000
2056 - 2057	2,000	2,200	2,200	20,700	3,700	2,400	2,000	5,000	18,000	58,000	3,700	25,000	2,200	11,000	21,000	63,000	-5,000
2057 - 2058	2,000	2,200	2,200	20,700	3,700	2,400	1,000	5,000	18,000	57,000	3,700	25,000	2,200	10,000	21,000	62,000	-5,000
2058 - 2059	2,000	2,200	2,200	20,700	3,700	2,400	1,000	5,000	18,000	57,000	3,700	25,000	2,200	10,000	21,000	62,000	-5,000
2059 - 2060	2,000	2,200	2,200	20,700	3,700	2,400	1,000	5,000	18,000	57,000	3,700	25,000	2,200	10,000	21,000	62,000	-5,000
2060 - 2061	2,000	2,200	2,200	20,700	3,700	2,400	1,000	5,000	19,000	58,000	3,700	25,000	2,200	10,000	21,000	62,000	-4,000
2061 - 2062	2,000	2,200	2,200	20,700	3,700	2,400	1,000	5,000	19,000	58,000	3,700	25,000	2,200	10,000	21,000	62,000	-4,000
2062 - 2063	2,000	2,200	2,200	20,700	3,700	2,400	1,000	5,000	19,000	58,000	3,700	25,000	2,200	10,000	21,000	62,000	-4,000
2063 - 2064	2,000	2,200	2,200	20,700	3,700	2,400	1,000	5,000	19,000	58,000	3,700	25,000	2,200	10,000	21,000	62,000	-4,000
2064 - 2065	2,000	2,200	2,200	20,700	3,700	2,400	1,000	5,000	19,000	58,000	3,700	25,000	2,200	10,000	21,000	62,000	-4,000
2065 - 2066	2,000	2,200	2,200	20,700	3,700	2,400	1,000	5,000	19,000	58,000	3,700	25,000	2,200	10,000	21,000	62,000	-4,000
2066 - 2067	2,000	2,200	2,200	20,700	3,700	2,400	1,000	5,000	19,000	58,000	3,700	25,000	2,200	10,000	21,000	62,000	-4,000
2067 - 2068	2,000	2,200	2,200	20,700	3,700	2,400	1,000	5,000	19,000	58,000	3,700	25,000	2,200	10,000	21,000	62,000	-4,000
2068 - 2069	2,000	2,200	2,200	20,700	3,700	2,400	1,000	5,000	19,000	58,000	3,700	25,000	2,200	10,000	21,000	62,000	-4,000
2069 - 2070	2,000	2,200	2,200	20,700	3,700	2,400	1,000	5,000	19,000	58,000	3,700	25,000	2,200	10,000	21,000	62,000	-4,000
17/18-69/70 Avg	2,000	2,200	2,200	21,400	3,700	2,400	3,000	5,000	18,000	60,000	3,700	23,000	2,200	13,000	29,000	71,000	-11,000

Delano-Earlimart Irrigation District GSA
Representative Monitoring Site

Appendix **C**
Figure **1**

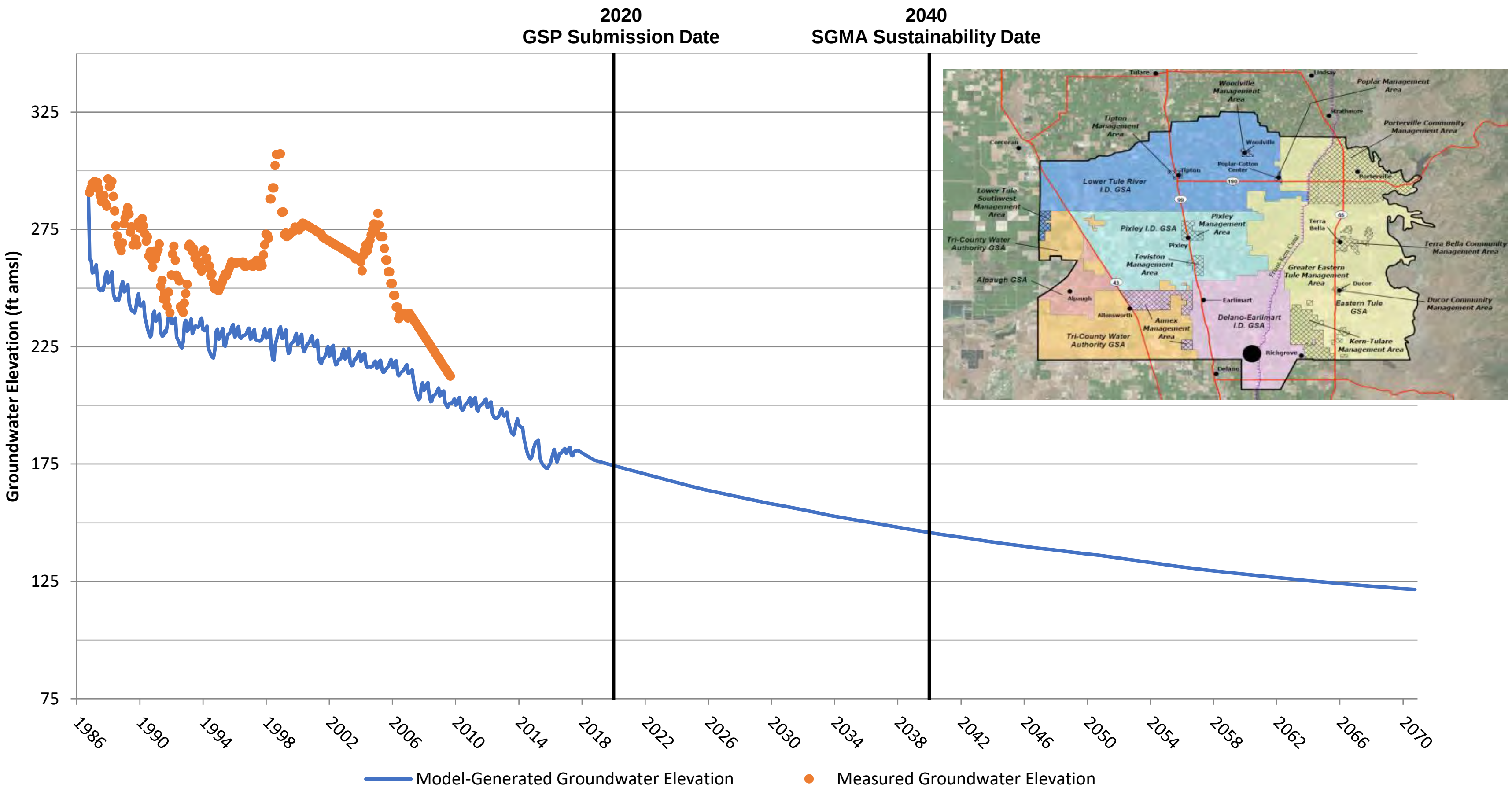


Thomas Harder & Co.
Groundwater Consulting

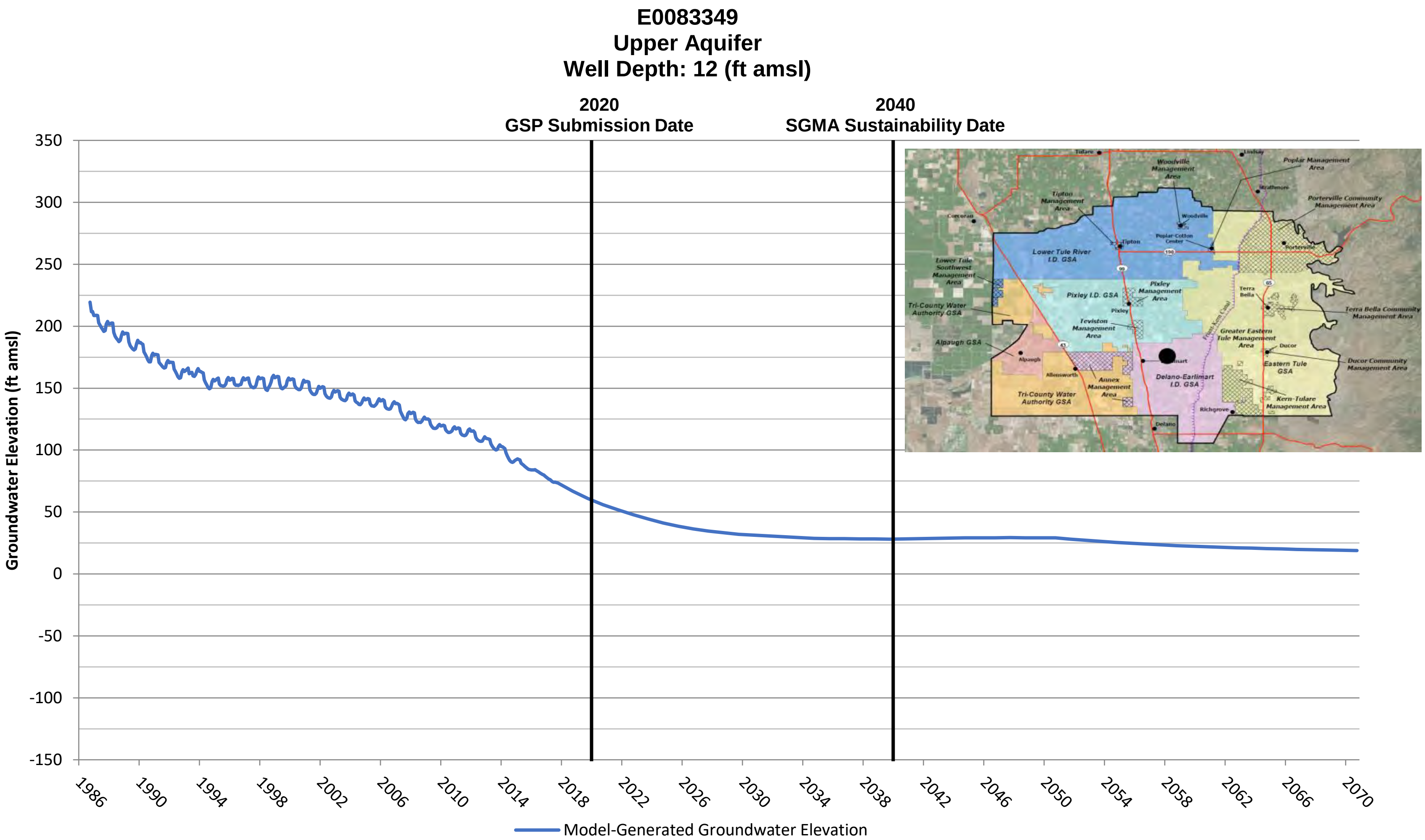
January 2020

Delano-Earlimart Irrigation District GSA
Representative Monitoring Site

24S/26E-32G01
Upper Aquifer
Bore Depth: -69 (ft amsl)

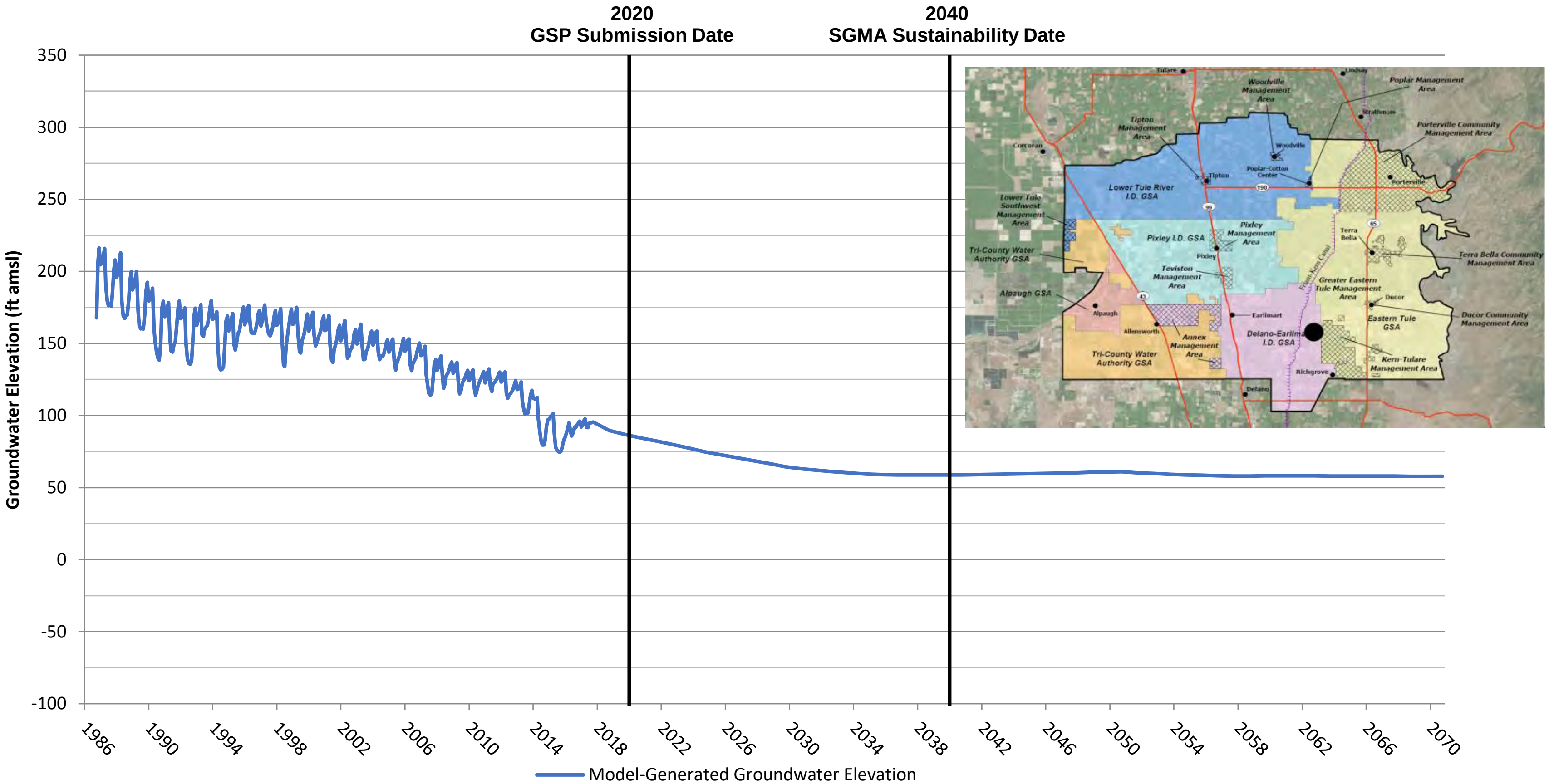


Delano-Earlimart Irrigation District GSA
Representative Monitoring Site

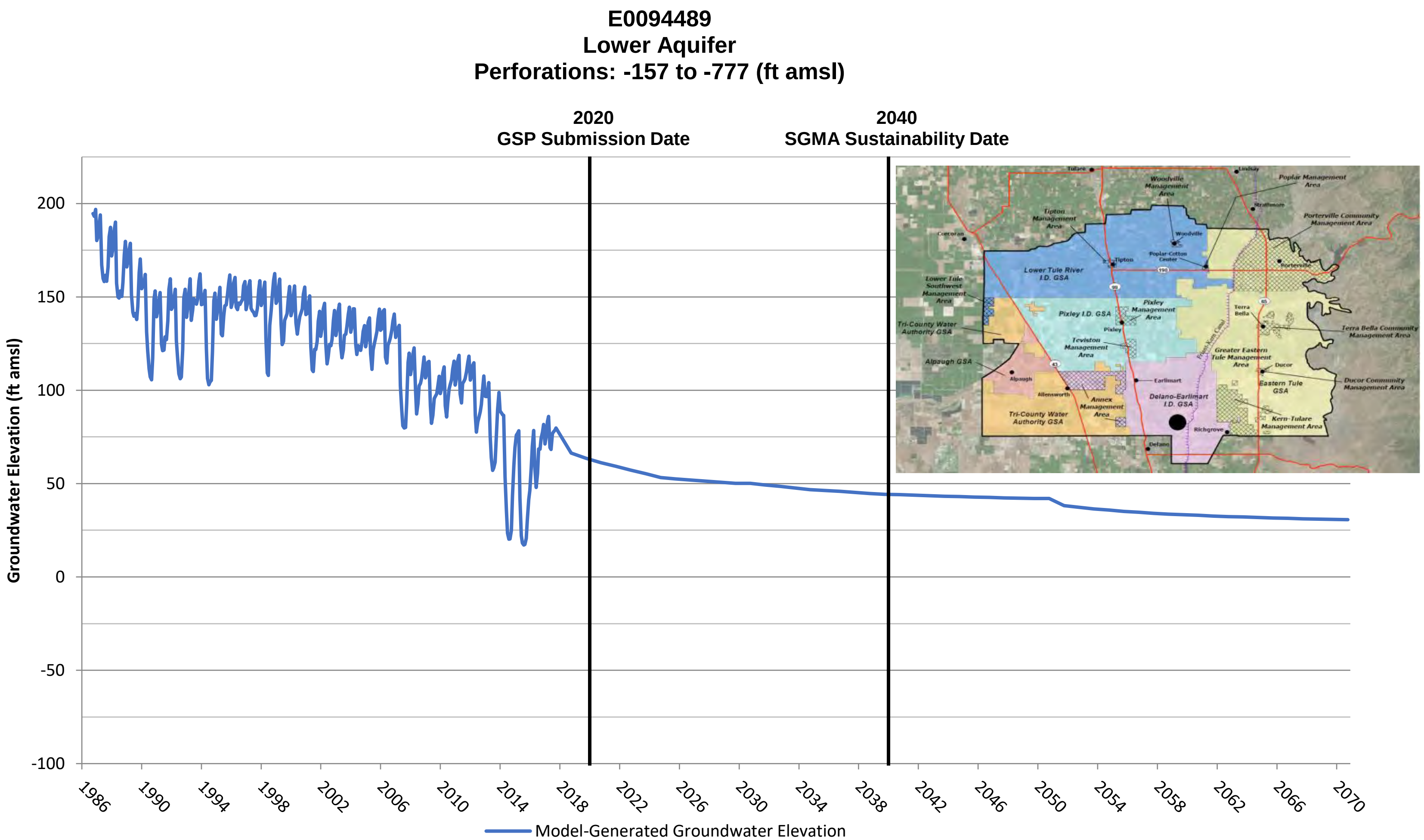


Delano-Earlimart Irrigation District GSA
Representative Monitoring Site

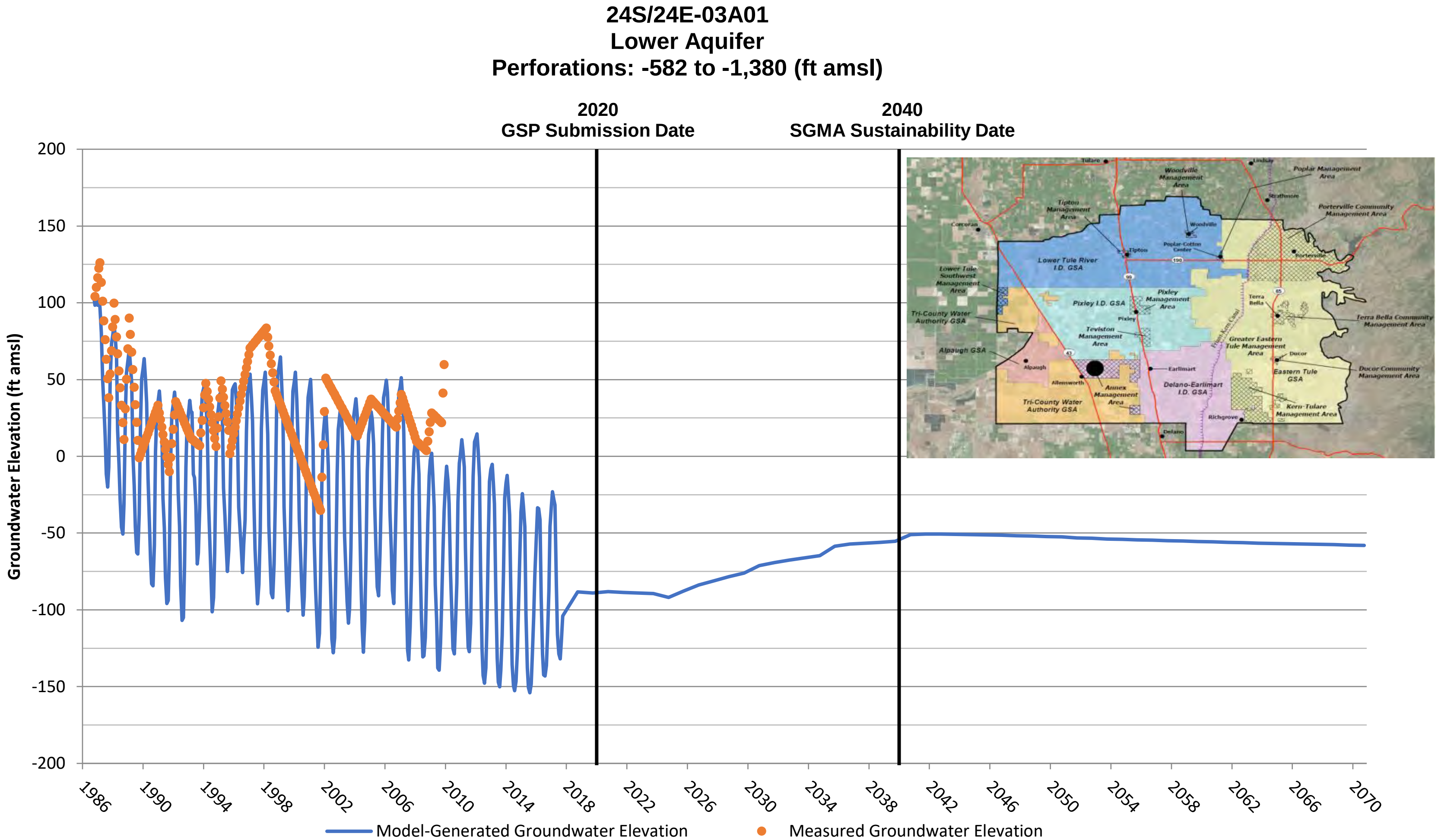
E0070434
Lower Aquifer
Well Depth: -323 (ft amsl)



Delano-Earlimart Irrigation District GSA
Representative Monitoring Site



Delano-Earlimart Irrigation District GSA
Representative Monitoring Site



Appendix D

Pixley Irrigation District GSA

Water Budgets and Hydrographs

Pixley Irrigation District GSA
Historical Surface Water Budget 1986/87 to 2016/17

Water Year	Surface Water Inflow (acre-ft)					Total In
	Precipitation	Stream Inflow	Imported Water	Discharge from Wells		
		Deer Creek	Pixley ID	Agricultural	Municipal	
1986 - 1987	28,000	0	9,356	153,000	700	191,000
1987 - 1988	40,000	0	0	154,000	700	195,000
1988 - 1989	32,000	0	5,289	150,000	700	188,000
1989 - 1990	31,000	0	0	174,000	700	206,000
1990 - 1991	42,000	0	0	177,000	700	220,000
1991 - 1992	36,000	0	0	167,000	700	204,000
1992 - 1993	58,000	0	96,890	112,000	700	268,000
1993 - 1994	37,000	0	7,793	177,000	700	222,000
1994 - 1995	77,000	10,445	55,365	148,000	700	292,000
1995 - 1996	41,000	8,989	60,931	120,000	700	232,000
1996 - 1997	57,000	13,322	37,048	143,000	700	251,000
1997 - 1998	92,000	74,587	41,823	138,000	700	347,000
1998 - 1999	47,000	4,770	34,736	156,000	700	243,000
1999 - 2000	45,000	4,791	40,076	160,000	700	251,000
2000 - 2001	33,000	0	9,098	159,000	700	202,000
2001 - 2002	32,000	0	13,588	150,000	800	196,000
2002 - 2003	31,000	1,697	32,195	131,000	800	197,000
2003 - 2004	26,000	0	9,839	137,000	800	174,000
2004 - 2005	50,000	7,994	59,211	104,000	800	222,000
2005 - 2006	51,000	9,156	60,634	132,000	900	254,000
2006 - 2007	21,000	0	7,200	143,000	900	172,000
2007 - 2008	24,000	0	12,243	126,000	900	163,000
2008 - 2009	26,000	0	23,620	142,000	900	193,000
2009 - 2010	41,000	0	32,972	115,000	900	190,000
2010 - 2011	61,000	20,157	48,391	132,000	1,000	263,000
2011 - 2012	38,000	0	5,914	179,000	1,000	224,000
2012 - 2013	18,000	0	5,012	179,000	1,000	203,000
2013 - 2014	12,000	0	0	184,000	1,000	197,000
2014 - 2015	18,000	0	0	184,000	1,000	203,000
2015 - 2016	27,000	0	3,442	119,000	1,100	151,000
2016 - 2017	29,000	13,754	82,363	92,000	1,100	218,000
86/87-16/17 Avg	39,000	5,500	25,600	146,000	800	217,000

Appendix D
Table 1b

Pixley Irrigation District GSA
Historical Surface Water Budget 1986/87 to 2016/17

Water Year	Surface Water Outflow (acre-ft)																Total Out
	Areal Recharge of Precipitation	Streambed Infiltration	Canal Loss		Recharge in Basins		Deep Percolation of Applied Water				Evapotranspiration					Surface Outflow	
		Deer Creek										Deer Creek	Imported Water				
		Trenton Weir to Homeland Canal Infiltration	Deer Creek	Imported Water	Deer Creek	Imported Water	Deer Creek	Imported Water	Agricultural Pumping	Municipal Pumping	Precipitation Crops/Native	Agricultural Cons. Use	Agricultural Cons. Use	Ag. Cons. Use from Pumping	Municipal (Landscape ET)	Deer Creek	
1986 - 1987	0	0	0	8,200	0	0	0	300	38,900	500	28,000	0	900	114,000	200	0	191,000
1987 - 1988	0	0	0	0	0	0	0	0	39,200	500	40,000	0	0	115,000	200	0	195,000
1988 - 1989	0	0	0	1,700	0	0	0	900	38,300	500	32,000	0	2,700	112,000	200	0	188,000
1989 - 1990	0	0	0	0	0	0	0	0	44,400	500	31,000	0	0	130,000	200	0	206,000
1990 - 1991	0	0	0	0	0	0	0	0	45,000	500	42,000	0	0	132,000	300	0	220,000
1991 - 1992	0	0	0	0	0	0	0	0	42,500	500	36,000	0	0	124,000	300	0	203,000
1992 - 1993	3,000	0	0	43,400	0	0	0	13,600	28,400	500	56,000	0	39,900	83,000	300	0	268,000
1993 - 1994	0	0	0	7,800	0	0	0	0	45,100	500	37,000	0	0	132,000	300	0	223,000
1994 - 1995	13,000	1,000	3,800	19,700	1,800	5,900	1,000	7,600	37,800	500	64,000	2,900	22,200	111,000	300	0	293,000
1995 - 1996	0	700	2,800	18,100	700	4,500	1,200	9,800	30,700	500	41,000	3,600	28,600	90,000	300	0	233,000
1996 - 1997	2,000	1,800	6,900	12,900	1,900	1,900	700	5,700	36,500	500	55,000	2,000	16,600	107,000	300	0	252,000
1997 - 1998	23,000	12,700	48,800	14,900	900	2,400	3,100	6,200	35,300	500	69,000	9,100	18,200	103,000	300	0	347,000
1998 - 1999	0	600	2,500	12,300	400	1,200	300	5,400	39,700	500	47,000	1,000	15,800	116,000	300	0	243,000
1999 - 2000	0	600	2,400	13,000	500	700	300	6,700	40,800	500	45,000	900	19,600	119,000	300	0	250,000
2000 - 2001	0	0	0	2,600	0	100	0	1,600	40,500	500	33,000	0	4,800	119,000	300	0	202,000
2001 - 2002	0	0	0	4,000	0	0	0	2,400	38,300	500	32,000	0	7,100	112,000	300	0	197,000
2002 - 2003	0	100	400	10,900	300	1,700	200	4,400	29,500	500	31,000	700	15,200	102,000	300	0	197,000
2003 - 2004	0	0	0	3,000	0	0	0	1,500	30,500	500	26,000	0	5,300	107,000	300	0	174,000
2004 - 2005	0	400	1,500	14,900	2,900	8,400	700	8,000	23,200	500	50,000	2,500	27,900	81,000	300	0	222,000
2005 - 2006	0	900	3,400	15,400	3,200	8,500	400	8,200	29,300	600	50,000	1,300	28,500	102,000	300	0	252,000
2006 - 2007	0	0	0	2,800	0	0	0	1,000	31,800	600	21,000	0	3,500	111,000	300	0	172,000
2007 - 2008	0	0	0	3,800	0	1,000	0	1,700	28,100	600	24,000	0	5,800	98,000	300	0	163,000
2008 - 2009	0	0	0	7,400	0	1,300	0	3,300	31,700	600	26,000	0	11,600	111,000	300	0	193,000
2009 - 2010	0	0	0	11,000	0	9,000	0	3,700	25,600	600	41,000	0	12,900	89,000	300	0	193,000
2010 - 2011	4,000	1,300	5,000	9,200	9,700	8,500	1,400	7,000	29,300	600	57,000	4,700	24,300	102,000	300	0	264,000
2011 - 2012	0	0	0	1,800	0	1,800	0	500	39,900	600	38,000	0	1,800	139,000	300	0	224,000
2012 - 2013	0	0	0	1,700	0	100	0	700	39,900	600	18,000	0	2,500	139,000	400	0	203,000
2013 - 2014	0	0	0	0	0	0	0	0	41,000	700	12,000	0	0	143,000	400	0	197,000
2014 - 2015	0	0	0	0	0	0	0	0	41,000	700	18,000	0	0	143,000	400	0	203,000
2015 - 2016	0	0	0	1,200	0	100	0	500	26,500	700	27,000	0	1,700	92,000	400	0	150,000
2016 - 2017	0	800	3,100	20,600	3,700	10,600	1,400	11,400	20,600	700	29,000	4,800	39,800	72,000	400	0	219,000
36/87-16/17 Avg	1,000	700	2,600	8,500	800	2,200	300	3,600	35,100	600	37,000	1,100	11,500	111,000	300	0	216,000

Groundwater Inflows to be Included in Sustainable Yield Estimates
Groundwater Inflows to be Excluded from the Sustainable Yield Estimates
Surface Water or ET Outflows Not Included in Groundwater Recharge or Sustainable Yield Estimates

Appendix D
Table 2

Pixley Irrigation District GSA
Historical Groundwater Budget 1986/87 to 2016/17

Water Year	Groundwater Inflows (acre-ft)													Total In	Groundwater Outflows (acre-ft)				Total Out	Change in Storage (acre-ft)
	Areal Recharge from Precipitation	Native Deer Creek				Imported Water Deliveries			Agricultural Pumping	Municipal Pumping	Release of Water from Compression of Aquitards	Sub-surface Inflow			Groundwater Pumping		Sub-surface Outflow			
		Trenton Weir to Homeland Canal Infiltration	Canal Loss	Recharge in Basins	Return Flow	Canal Loss	Recharge in Basins	Return Flow	Return Flow	Return Flow		From Outside Subbasin	From Other GSAs		Municipal	Agricultural	To Outside Subbasin	To Other GSAs		
1986 - 1987	0	0	0	0	0	8,200	0	300	38,900	500	23,000	0	136,000	207,000	700	153,000	0	54,000	208,000	-1,000
1987 - 1988	0	0	0	0	0	0	0	0	39,200	500	21,000	0	131,000	192,000	700	154,000	0	62,000	217,000	-25,000
1988 - 1989	0	0	0	0	0	1,700	0	900	38,300	500	22,000	0	128,000	191,000	700	150,000	0	64,000	215,000	-24,000
1989 - 1990	0	0	0	0	0	0	0	0	44,400	500	39,000	0	124,000	208,000	700	174,000	0	60,000	235,000	-27,000
1990 - 1991	0	0	0	0	0	0	0	0	45,000	500	39,000	0	134,000	219,000	700	177,000	0	65,000	243,000	-24,000
1991 - 1992	0	0	0	0	0	0	0	0	42,500	500	39,000	0	132,000	214,000	700	167,000	0	70,000	238,000	-24,000
1992 - 1993	3,000	0	0	0	0	43,400	0	13,600	28,400	500	4,000	0	144,000	237,000	700	112,000	0	78,000	191,000	46,000
1993 - 1994	0	0	0	0	0	7,800	0	0	45,100	500	20,000	0	135,000	208,000	700	177,000	0	62,000	240,000	-32,000
1994 - 1995	13,000	1,000	3,800	1,800	1,000	19,700	5,900	7,600	37,800	500	4,000	0	146,000	242,000	700	148,000	0	62,000	211,000	31,000
1995 - 1996	0	700	2,800	700	1,200	18,100	4,500	9,800	30,700	500	1,000	0	144,000	214,000	700	120,000	0	72,000	193,000	21,000
1996 - 1997	2,000	1,800	6,900	1,900	700	12,900	1,900	5,700	36,500	500	3,000	0	154,000	228,000	700	143,000	0	72,000	216,000	12,000
1997 - 1998	23,000	12,700	48,800	900	3,100	14,900	2,400	6,200	35,300	500	0	0	150,000	298,000	700	138,000	0	81,000	220,000	78,000
1998 - 1999	0	600	2,500	400	300	12,300	1,200	5,400	39,700	500	2,000	0	159,000	224,000	700	156,000	0	82,000	239,000	-15,000
1999 - 2000	0	600	2,400	500	300	13,000	700	6,700	40,800	500	3,000	0	156,000	225,000	700	160,000	0	79,000	240,000	-15,000
2000 - 2001	0	0	0	0	0	2,600	100	1,600	40,500	500	8,000	0	147,000	200,000	700	159,000	0	82,000	242,000	-42,000
2001 - 2002	0	0	0	0	0	4,000	0	2,400	38,300	500	14,000	0	144,000	203,000	800	150,000	0	85,000	236,000	-33,000
2002 - 2003	0	100	400	300	200	10,900	1,700	4,400	29,500	500	7,000	0	146,000	201,000	800	131,000	0	82,000	214,000	-13,000
2003 - 2004	0	0	0	0	0	3,000	0	1,500	30,500	500	17,000	0	130,000	183,000	800	137,000	0	68,000	206,000	-23,000
2004 - 2005	0	400	1,500	2,900	700	14,900	8,400	8,000	23,200	500	1,000	0	129,000	191,000	800	104,000	0	67,000	172,000	19,000
2005 - 2006	0	900	3,400	3,200	400	15,400	8,500	8,200	29,300	600	1,000	0	138,000	209,000	900	132,000	0	58,000	191,000	18,000
2006 - 2007	0	0	0	0	0	2,800	0	1,000	31,800	600	14,000	0	115,000	165,000	900	143,000	0	61,000	205,000	-40,000
2007 - 2008	0	0	0	0	0	3,800	1,000	1,700	28,100	600	23,000	0	122,000	180,000	900	126,000	0	82,000	209,000	-29,000
2008 - 2009	0	0	0	0	0	7,400	1,300	3,300	31,700	600	33,000	0	128,000	205,000	900	142,000	0	86,000	229,000	-24,000
2009 - 2010	0	0	0	0	0	11,000	9,000	3,700	25,600	600	14,000	0	143,000	207,000	900	115,000	0	94,000	210,000	-3,000
2010 - 2011	4,000	1,300	5,000	9,700	1,400	9,200	8,500	7,000	29,300	600	7,000	0	146,000	229,000	1,000	132,000	0	77,000	210,000	19,000
2011 - 2012	0	0	0	0	0	1,800	1,800	500	39,900	600	27,000	0	141,000	213,000	1,000	179,000	0	71,000	251,000	-38,000
2012 - 2013	0	0	0	0	0	1,700	100	700	39,900	600	40,000	0	126,000	209,000	1,000	179,000	0	70,000	250,000	-41,000
2013 - 2014	0	0	0	0	0	0	0	0	41,000	700	45,000	0	116,000	203,000	1,000	184,000	0	68,000	253,000	-50,000
2014 - 2015	0	0	0	0	0	0	0	0	41,000	700	47,000	0	115,000	204,000	1,000	184,000	0	69,000	254,000	-50,000
2015 - 2016	0	0	0	0	0	1,200	100	500	26,500	700	35,000	0	115,000	179,000	1,100	119,000	0	79,000	199,000	-20,000
2016 - 2017	0	800	3,100	3,700	1,400	20,600	10,600	11,400	20,600	700	11,000	0	130,000	214,000	1,100	92,000	0	78,000	171,000	43,000
86/87-16/17 Avg	1,000	700	2,600	800	300	8,500	2,200	3,600	35,100	600	18,000	0	136,000	209,000	800	146,000	0	72,000	219,000	-10,000

Cumulative Change in Storage -306,000

Color	Legend
Light blue	Groundwater Inflows or Outflows to be Included in Sustainable Yield Estimates
Pink	Groundwater Inflows to be Excluded from the Sustainable Yield Estimates
Yellow	Groundwater Outflows Not Included in Sustainable Yield Estimates

Thomas Harder & Co.
Groundwater Consulting

January 2020

Appendix D
Table 3a

Projected Future Pixley Irrigation District GSA Surface Water Budget

Water Year	Surface Water Inflow (acre-ft)					Total In
	Precipitation	Stream Inflow	Imported Water	Discharge from Wells		
		Deer Creek	Pixley ID	Agricultural	Municipal	
2017 - 2018	39,000	6,678	31,763	130,000	1,100	209,000
2018 - 2019	39,000	6,678	31,763	130,000	1,100	209,000
2019 - 2020	39,000	6,678	31,763	119,000	1,100	198,000
2020 - 2021	39,000	6,678	31,763	119,000	1,100	198,000
2021 - 2022	39,000	6,678	31,763	119,000	1,100	198,000
2022 - 2023	39,000	6,678	31,763	119,000	1,100	198,000
2023 - 2024	39,000	6,678	31,763	119,000	1,100	198,000
2024 - 2025	39,000	6,678	31,763	108,000	1,100	187,000
2025 - 2026	39,000	6,678	31,763	108,000	1,100	187,000
2026 - 2027	39,000	6,678	31,763	108,000	1,100	187,000
2027 - 2028	39,000	6,678	31,763	108,000	1,100	187,000
2028 - 2029	39,000	6,678	31,763	108,000	1,100	187,000
2029 - 2030	39,000	6,678	31,763	97,000	1,100	176,000
2030 - 2031	39,000	6,678	31,763	97,000	1,100	176,000
2031 - 2032	39,000	6,678	31,763	97,000	1,100	176,000
2032 - 2033	39,000	6,678	31,763	97,000	1,100	176,000
2033 - 2034	39,000	6,678	31,763	97,000	1,100	176,000
2034 - 2035	39,000	6,678	31,763	67,000	1,100	146,000
2035 - 2036	39,000	6,678	31,763	67,000	1,100	146,000
2036 - 2037	39,000	6,678	31,763	67,000	1,100	146,000
2037 - 2038	39,000	6,678	31,763	67,000	1,100	146,000
2038 - 2039	39,000	6,678	31,763	67,000	1,100	146,000
2039 - 2040	39,000	6,678	31,763	45,000	1,100	124,000
2040 - 2041	39,000	6,678	31,763	45,000	1,100	124,000
2041 - 2042	39,000	6,678	31,763	45,000	1,100	124,000
2042 - 2043	39,000	6,678	31,763	45,000	1,100	124,000
2043 - 2044	39,000	6,678	31,763	45,000	1,100	124,000
2044 - 2045	39,000	6,678	31,763	45,000	1,100	124,000
2045 - 2046	39,000	6,678	31,763	45,000	1,100	124,000
2046 - 2047	39,000	6,678	31,763	45,000	1,100	124,000
2047 - 2048	39,000	6,678	31,763	45,000	1,100	124,000
2048 - 2049	39,000	6,678	31,763	45,000	1,100	124,000
2049 - 2050	39,000	6,678	31,763	45,000	1,100	124,000
2050 - 2051	39,000	6,517	31,763	45,000	1,100	123,000
2051 - 2052	39,000	6,517	31,763	45,000	1,100	123,000
2052 - 2053	39,000	6,517	31,763	45,000	1,100	123,000
2053 - 2054	39,000	6,517	31,763	45,000	1,100	123,000
2054 - 2055	39,000	6,517	31,763	45,000	1,100	123,000
2055 - 2056	39,000	6,517	31,763	45,000	1,100	123,000
2056 - 2057	39,000	6,517	31,763	45,000	1,100	123,000
2057 - 2058	39,000	6,517	31,763	45,000	1,100	123,000
2058 - 2059	39,000	6,517	31,763	45,000	1,100	123,000
2059 - 2060	39,000	6,517	31,763	45,000	1,100	123,000
2060 - 2061	39,000	6,517	31,763	45,000	1,100	123,000
2061 - 2062	39,000	6,517	31,763	45,000	1,100	123,000
2062 - 2063	39,000	6,517	31,763	45,000	1,100	123,000
2063 - 2064	39,000	6,517	31,763	45,000	1,100	123,000
2064 - 2065	39,000	6,517	31,763	45,000	1,100	123,000
2065 - 2066	39,000	6,517	31,763	45,000	1,100	123,000
2066 - 2067	39,000	6,517	31,763	45,000	1,100	123,000
2067 - 2068	39,000	6,517	31,763	45,000	1,100	123,000
2068 - 2069	39,000	6,517	31,763	45,000	1,100	123,000
2069 - 2070	39,000	6,517	31,763	45,000	1,100	123,000
17/18-69/70 Avg	39,000	6,600	31,800	68,000	1,100	147,000

Projected Future Pixley Irrigation District GSA Surface Water Budget

Water Year	Surface Water Outflow (acre-ft)																Total Out
	Areal Recharge of Precipitation	Streambed Infiltration	Canal Loss		Recharge in Basins		Deep Percolation of Applied Water				Evapotranspiration					Surface Outflow	
		Deer Creek: Trenton Weir to Homeland Canal Infiltration	Deer Creek	Imported Water	Deer Creek	Imported Water	Deer Creek	Imported Water	Agricultural Pumping	Municipal Pumping	Precipitation Crops/Native	Deer Creek: Agricultural Cons. Use	Imported Water: Agricultural Cons. Use	Ag. Cons. Use from Pumping	Municipal (Landscape ET)	Deer Creek	
2017 - 2018	1,000	600	2,100	12,700	500	2,300	800	3,700	28,900	700	37,000	2,700	13,000	101,000	400	0	207,000
2018 - 2019	1,000	600	2,100	12,700	500	2,300	800	3,700	28,900	700	37,000	2,700	13,000	101,000	400	0	207,000
2019 - 2020	1,000	600	2,100	12,700	500	2,300	800	3,700	26,400	700	37,000	2,700	13,000	92,000	400	0	196,000
2020 - 2021	1,000	600	2,100	12,700	500	2,300	800	3,700	26,400	700	37,000	2,700	13,000	92,000	400	0	196,000
2021 - 2022	1,000	600	2,100	12,700	500	2,300	800	3,700	26,400	700	37,000	2,700	13,000	92,000	400	0	196,000
2022 - 2023	1,000	600	2,100	12,700	500	2,300	800	3,700	26,400	700	37,000	2,700	13,000	92,000	400	0	196,000
2023 - 2024	1,000	600	2,100	12,700	500	2,300	800	3,700	26,400	700	37,000	2,700	13,000	92,000	400	0	196,000
2024 - 2025	1,000	600	2,100	12,700	500	2,300	800	3,700	24,000	700	37,000	2,700	13,000	84,000	400	0	186,000
2025 - 2026	1,000	600	2,100	12,700	500	2,300	800	3,700	24,000	700	37,000	2,700	13,000	84,000	400	0	186,000
2026 - 2027	1,000	600	2,100	12,700	500	2,300	800	3,700	24,000	700	37,000	2,700	13,000	84,000	400	0	186,000
2027 - 2028	1,000	600	2,100	12,700	500	2,300	800	3,700	24,000	700	37,000	2,700	13,000	84,000	400	0	186,000
2028 - 2029	1,000	600	2,100	12,700	500	2,300	800	3,700	24,000	700	37,000	2,700	13,000	84,000	400	0	186,000
2029 - 2030	1,000	600	2,100	12,700	500	2,300	800	3,700	21,500	700	37,000	2,700	13,000	75,000	400	0	174,000
2030 - 2031	1,000	600	2,100	12,700	500	2,300	800	3,700	21,500	700	37,000	2,700	13,000	75,000	400	0	174,000
2031 - 2032	1,000	600	2,100	12,700	500	2,300	800	3,700	21,500	700	37,000	2,700	13,000	75,000	400	0	174,000
2032 - 2033	1,000	600	2,100	12,700	500	2,300	800	3,700	21,500	700	37,000	2,700	13,000	75,000	400	0	174,000
2033 - 2034	1,000	600	2,100	12,700	500	2,300	800	3,700	21,500	700	37,000	2,700	13,000	75,000	400	0	174,000
2034 - 2035	1,000	600	2,100	12,700	500	2,300	800	3,700	15,000	700	37,000	2,700	13,000	52,000	400	0	145,000
2035 - 2036	1,000	600	2,100	12,700	500	2,300	800	3,700	15,000	700	37,000	2,700	13,000	52,000	400	0	145,000
2036 - 2037	1,000	600	2,100	12,700	500	2,300	800	3,700	15,000	700	37,000	2,700	13,000	52,000	400	0	145,000
2037 - 2038	1,000	600	2,100	12,700	500	2,300	800	3,700	15,000	700	37,000	2,700	13,000	52,000	400	0	145,000
2038 - 2039	1,000	600	2,100	12,700	500	2,300	800	3,700	15,000	700	37,000	2,700	13,000	52,000	400	0	145,000
2039 - 2040	1,000	600	2,100	12,700	500	2,300	800	3,700	10,000	700	37,000	2,700	13,000	35,000	400	0	123,000
2040 - 2041	1,000	600	2,100	12,700	500	2,300	800	3,700	10,000	700	37,000	2,700	13,000	35,000	400	0	123,000
2041 - 2042	1,000	600	2,100	12,700	500	2,300	800	3,700	10,000	700	37,000	2,700	13,000	35,000	400	0	123,000
2042 - 2043	1,000	600	2,100	12,700	500	2,300	800	3,700	10,000	700	37,000	2,700	13,000	35,000	400	0	123,000
2043 - 2044	1,000	600	2,100	12,700	500	2,300	800	3,700	10,000	700	37,000	2,700	13,000	35,000	400	0	123,000
2044 - 2045	1,000	600	2,100	12,700	500	2,300	800	3,700	10,000	700	37,000	2,700	13,000	35,000	400	0	123,000
2045 - 2046	1,000	600	2,100	12,700	500	2,300	800	3,700	10,000	700	37,000	2,700	13,000	35,000	400	0	123,000
2046 - 2047	1,000	600	2,100	12,700	500	2,300	800	3,700	10,000	700	37,000	2,700	13,000	35,000	400	0	123,000
2047 - 2048	1,000	600	2,100	12,700	500	2,300	800	3,700	10,000	700	37,000	2,700	13,000	35,000	400	0	123,000
2048 - 2049	1,000	600	2,100	12,700	500	2,300	800	3,700	10,000	700	37,000	2,700	13,000	35,000	400	0	123,000
2049 - 2050	1,000	600	2,100	12,700	500	2,300	800	3,700	10,000	700	37,000	2,700	13,000	35,000	400	0	123,000
2050 - 2051	1,000	500	2,100	12,700	500	2,300	800	3,700	10,000	700	37,000	2,700	13,000	35,000	400	0	122,000
2051 - 2052	1,000	500	2,100	12,700	500	2,300	800	3,700	10,000	700	37,000	2,700	13,000	35,000	400	0	122,000
2052 - 2053	1,000	500	2,100	12,700	500	2,300	800	3,700	10,000	700	37,000	2,700	13,000	35,000	400	0	122,000
2053 - 2054	1,000	500	2,100	12,700	500	2,300	800	3,700	10,000	700	37,000	2,700	13,000	35,000	400	0	122,000
2054 - 2055	1,000	500	2,100	12,700	500	2,300	800	3,700	10,000	700	37,000	2,700	13,000	35,000	400	0	122,000
2055 - 2056	1,000	500	2,100	12,700	500	2,300	800	3,700	10,000	700	37,000	2,700	13,000	35,000	400	0	122,000
2056 - 2057	1,000	500	2,100	12,700	500	2,300	800	3,700	10,000	700	37,000	2,700	13,000	35,000	400	0	122,000
2057 - 2058	1,000	500	2,100	12,700	500	2,300	800	3,700	10,000	700	37,000	2,700	13,000	35,000	400	0	122,000
2058 - 2059	1,000	500	2,100	12,700	500	2,300	800	3,700	10,000	700	37,000	2,700	13,000	35,000	400	0	122,000
2059 - 2060	1,000	500	2,100	12,700	500	2,300	800	3,700	10,000	700	37,000	2,700	13,000	35,000	400	0	122,000
2060 - 2061	1,000	500	2,100	12,700	500	2,300	800	3,700	10,000	700	37,000	2,700	13,000	35,000	400	0	122,000
2061 - 2062	1,000	500	2,100	12,700	500	2,300	800	3,700	10,000	700	37,000	2,700	13,000	35,000	400	0	122,000
2062 - 2063	1,000	500	2,100	12,700	500	2,300	800	3,700	10,000	700	37,000	2,700	13,000	35,000	400	0	122,000
2063 - 2064	1,000	500	2,100	12,700	500	2,300	800	3,700	10,000	700	37,000	2,700	13,000	35,000	400	0	122,000
2064 - 2065	1,000	500	2,100	12,700	500	2,300	800	3,700	10,000	700	37,000	2,700	13,000	35,000	400	0	122,000
2065 - 2066	1,000	500	2,100	12,700	500	2,300	800	3,700	10,000	700	37,000	2,700	13,000	35,000	400	0	122,000
2066 - 2067	1,000	500	2,100	12,700	500	2,300	800	3,700	10,000	700	37,000	2,700	13,000	35,000	400	0	122,000
2067 - 2068	1,000	500	2,100	12,700	500	2,300	800	3,700	10,000	700	37,000	2,700	13,000	35,000	400	0	122,000
2068 - 2069	1,000	500	2,100	12,700	500	2,300	800	3,700	10,000	700	37,000	2,700	13,000	35,000	400	0	122,000
2069 - 2070	1,000	500	2,100	12,700	500	2,300	800	3,700	10,000	700	37,000	2,700	13,000	35,000	400	0	122,000
17/18-69/70 Avg	1,000	600	2,100	12,700	500	2,300	800	3,700	15,100	700	37,000	2,700	13,000	53,000	400	0	146,000

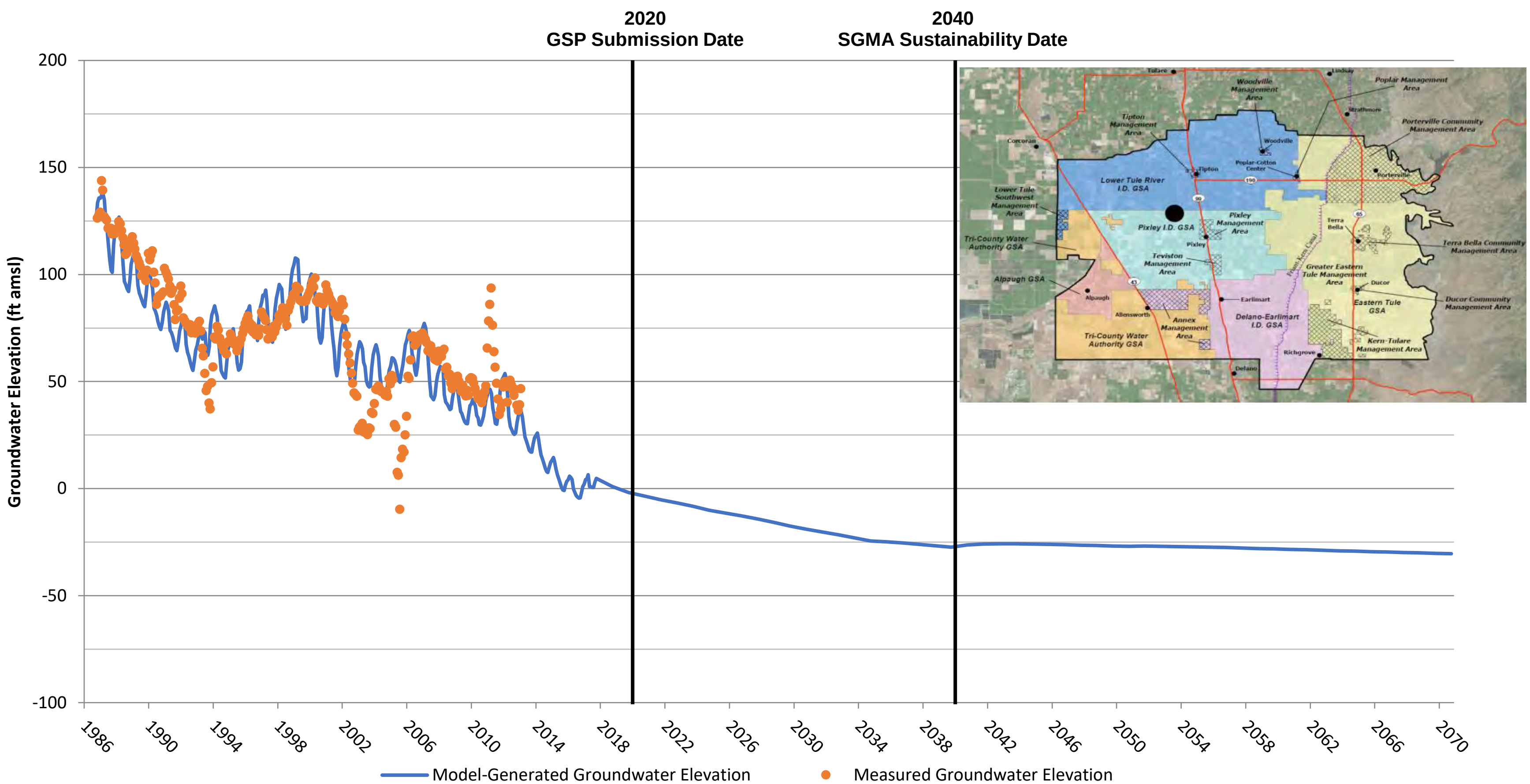
Projected Future Pixley Irrigation District GSA Groundwater Budget

Water Year	Groundwater Inflows (acre-ft): Areal Recharge from Precipitation	Native Deer Creek: Trenton Weir to Homeland Canal Infiltration	Native Deer Creek: Canal Loss	Native Deer Creek: Recharge in Basins	Native Deer Creek: Return Flow	Imported Water Deliveries: Canal Loss	Imported Water Deliveries: Recharge in Basins	Imported Water Deliveries: Return Flow	Agricultural Pumping: Return Flow	Municipal Pumping: Return Flow	Release of Water from Compression of Aquitards	Sub-surface Inflow: From Outside Subbasin	Sub-surface Inflow: From Other GSAs	Total In	Groundwater Outflows (acre-ft): Groundwater Pumping: Municipal	Groundwater Pumping: Agricultural	Sub-surface Outflow: To Outside Subbasin	Sub-surface Outflow: To Other GSAs	Total Out	Change in Storage (acre-ft)
2017 - 2018	1,000	600	2,100	500	800	12,700	2,300	3,700	28,900	700	9,000	0	123,000	185,000	1,100	130,000	0	70,000	201,000	-16,000
2018 - 2019	1,000	600	2,100	500	800	12,700	2,300	3,700	28,900	700	11,000	0	121,000	185,000	1,100	130,000	0	69,000	200,000	-15,000
2019 - 2020	1,000	600	2,100	500	800	12,700	2,300	3,700	26,400	700	12,000	0	116,000	179,000	1,100	119,000	0	70,000	190,000	-11,000
2020 - 2021	1,000	600	2,100	500	800	12,700	2,300	3,700	26,400	700	13,000	0	114,000	178,000	1,100	119,000	0	69,000	189,000	-11,000
2021 - 2022	1,000	600	2,100	500	800	12,700	2,300	3,700	26,400	700	14,000	0	112,000	177,000	1,100	119,000	0	69,000	189,000	-12,000
2022 - 2023	1,000	600	2,100	500	800	12,700	2,300	3,700	26,400	700	15,000	0	111,000	177,000	1,100	119,000	0	68,000	188,000	-11,000
2023 - 2024	1,000	600	2,100	500	800	12,700	2,300	3,700	26,400	700	16,000	0	110,000	177,000	1,100	119,000	0	69,000	189,000	-12,000
2024 - 2025	1,000	600	2,100	500	800	12,700	2,300	3,700	24,000	700	14,000	0	104,000	166,000	1,100	108,000	0	68,000	177,000	-11,000
2025 - 2026	1,000	600	2,100	500	800	12,700	2,300	3,700	24,000	700	13,000	0	102,000	163,000	1,100	108,000	0	65,000	174,000	-11,000
2026 - 2027	1,000	600	2,100	500	800	12,700	2,300	3,700	24,000	700	13,000	0	99,000	160,000	1,100	108,000	0	63,000	172,000	-12,000
2027 - 2028	1,000	600	2,100	500	800	12,700	2,300	3,700	24,000	700	13,000	0	98,000	159,000	1,100	108,000	0	61,000	170,000	-11,000
2028 - 2029	1,000	600	2,100	500	800	12,700	2,300	3,700	24,000	700	13,000	0	95,000	156,000	1,100	108,000	0	59,000	168,000	-12,000
2029 - 2030	1,000	600	2,100	500	800	12,700	2,300	3,700	21,500	700	11,000	0	90,000	147,000	1,100	97,000	0	58,000	156,000	-9,000
2030 - 2031	1,000	600	2,100	500	800	12,700	2,300	3,700	21,500	700	11,000	0	89,000	146,000	1,100	97,000	0	57,000	155,000	-9,000
2031 - 2032	1,000	600	2,100	500	800	12,700	2,300	3,700	21,500	700	11,000	0	88,000	145,000	1,100	97,000	0	56,000	154,000	-9,000
2032 - 2033	1,000	600	2,100	500	800	12,700	2,300	3,700	21,500	700	11,000	0	87,000	144,000	1,100	97,000	0	55,000	153,000	-9,000
2033 - 2034	1,000	600	2,100	500	800	12,700	2,300	3,700	21,500	700	11,000	0	87,000	144,000	1,100	97,000	0	55,000	153,000	-9,000
2034 - 2035	1,000	600	2,100	500	800	12,700	2,300	3,700	15,000	700	7,000	0	78,000	124,000	1,100	67,000	0	57,000	125,000	-1,000
2035 - 2036	1,000	600	2,100	500	800	12,700	2,300	3,700	15,000	700	6,000	0	77,000	122,000	1,100	67,000	0	56,000	124,000	-2,000
2036 - 2037	1,000	600	2,100	500	800	12,700	2,300	3,700	15,000	700	6,000	0	76,000	121,000	1,100	67,000	0	56,000	124,000	-3,000
2037 - 2038	1,000	600	2,100	500	800	12,700	2,300	3,700	15,000	700	6,000	0	75,000	120,000	1,100	67,000	0	55,000	123,000	-3,000
2038 - 2039	1,000	600	2,100	500	800	12,700	2,300	3,700	15,000	700	6,000	0	75,000	120,000	1,100	67,000	0	55,000	123,000	-3,000
2039 - 2040	1,000	600	2,100	500	800	12,700	2,300	3,700	10,000	700	3,000	0	70,000	107,000	1,100	45,000	0	57,000	103,000	4,000
2040 - 2041	1,000	600	2,100	500	800	12,700	2,300	3,700	10,000	700	3,000	0	68,000	105,000	1,100	45,000	0	56,000	102,000	3,000
2041 - 2042	1,000	600	2,100	500	800	12,700	2,300	3,700	10,000	700	3,000	0	67,000	104,000	1,100	45,000	0	56,000	102,000	2,000
2042 - 2043	1,000	600	2,100	500	800	12,700	2,300	3,700	10,000	700	3,000	0	67,000	104,000	1,100	45,000	0	56,000	102,000	2,000
2043 - 2044	1,000	600	2,100	500	800	12,700	2,300	3,700	10,000	700	3,000	0	66,000	103,000	1,100	45,000	0	56,000	102,000	1,000
2044 - 2045	1,000	600	2,100	500	800	12,700	2,300	3,700	10,000	700	3,000	0	66,000	103,000	1,100	45,000	0	56,000	102,000	1,000
2045 - 2046	1,000	600	2,100	500	800	12,700	2,300	3,700	10,000	700	3,000	0	65,000	102,000	1,100	45,000	0	55,000	101,000	1,000
2046 - 2047	1,000	600	2,100	500	800	12,700	2,300	3,700	10,000	700	2,000	0	65,000	101,000	1,100	45,000	0	55,000	101,000	0
2047 - 2048	1,000	600	2,100	500	800	12,700	2,300	3,700	10,000	700	2,000	0	65,000	101,000	1,100	45,000	0	55,000	101,000	0
2048 - 2049	1,000	600	2,100	500	800	12,700	2,300	3,700	10,000	700	2,000	0	65,000	101,000	1,100	45,000	0	55,000	101,000	0
2049 - 2050	1,000	600	2,100	500	800	12,700	2,300	3,700	10,000	700	2,000	0	65,000	101,000	1,100	45,000	0	55,000	101,000	0
2050 - 2051	1,000	500	2,100	500	800	12,700	2,300	3,700	10,000	700	2,000	0	65,000	101,000	1,100	45,000	0	55,000	101,000	0
2051 - 2052	1,000	500	2,100	500	800	12,700	2,300	3,700	10,000	700	2,000	0	65,000	101,000	1,100	45,000	0	55,000	101,000	0
2052 - 2053	1,000	500	2,100	500	800	12,700	2,300	3,700	10,000	700	2,000	0	65,000	101,000	1,100	45,000	0	55,000	101,000	0
2053 - 2054	1,000	500	2,100	500	800	12,700	2,300	3,700	10,000	700	2,000	0	65,000	101,000	1,100	45,000	0	55,000	101,000	0
2054 - 2055	1,000	500	2,100	500	800	12,700	2,300	3,700	10,000	700	2,000	0	64,000	100,000	1,100	45,000	0	54,000	100,000	0
2055 - 2056	1,000	500	2,100	500	800	12,700	2,300	3,700	10,000	700	2,000	0	65,000	101,000	1,100	45,000	0	55,000	101,000	0
2056 - 2057	1,000	500	2,100	500	800	12,700	2,300	3,700	10,000	700	2,000	0	64,000	100,000	1,100	45,000	0	54,000	100,000	0
2057 - 2058	1,000	500	2,100	500	800	12,700	2,300	3,700	10,000	700	2,000	0	64,000	100,000	1,100	45,000	0	54,000	100,000	0
2058 - 2059	1,000	500	2,100	500	800	12,700	2,300	3,700	10,000	700	2,000	0	64,000	100,000	1,100	45,000	0	54,000	100,000	0
2059 - 2060	1,000	500	2,100	500	800	12,700	2,300	3,700	10,000	700	2,000	0	64,000	100,000	1,100	45,000	0	54,000	100,000	0
2060 - 2061	1,000	500	2,100	500	800	12,700	2,300	3,700	10,000	700	2,000	0	64,000	100,000	1,100	45,000	0	54,000	100,000	0
2061 - 2062	1,000	500	2,100	500	800	12,700	2,300	3,700	10,000	700	2,000	0	64,000	100,000	1,100	45,000	0	54,000	100,000	0
2062 - 2063	1,000	500	2,100	500	800	12,700	2,300	3,700	10,000	700	2,000	0	64,000	100,000	1,100	45,000	0	54,000	100,000	0
2063 - 2064	1,000	500	2,100	500	800	12,700	2,300	3,700	10,000	700	2,000	0	64,000	100,000	1,100	45,000	0	54,000	100,000	0
2064 - 2065	1,000	500	2,100	500	800	12,700	2,300	3,700	10,000	700	2,000	0	64,000	100,000	1,100	45,000	0	54,000	100,000	0
2065 - 2066	1,000	500	2,100	500	800	12,700	2,300	3,700	10,000	700	2,000	0	64,000	100,000	1,100	45,000	0	54,000	100,000	0
2066 - 2067	1,000	500	2,100	500	800	12,700	2,300	3,700	10,000	700	2,000	0	64,000	100,000	1,100	45,000	0	54,000	100,000	0
2067 - 2068	1,000	500	2,100	500	800	12,700	2,300	3,700	10,000	700	2,000	0	64,000	100,000	1,100	45,000	0	54,000	100,000	0
2068 - 2069	1,000	500	2,100	500	800	12,700	2,300	3,700	10,000	700	2,000	0	64,000	100,000	1,100	45,000	0	54,000	100,000	0
2069 - 2070	1,000	500	2,100	500	800	12,700	2,300	3,700	10,000	700	2,000	0	64,000	100,000	1,100	45,000	0	54,000	100,000	0
17/18-69/70 Avg	1,000	600	2,100	500	800	12,700	2,300	3,700	15,100	700	6,000	0	78,000	124,000	1,100	68,000	0	58,000	127,000	-3,000

Pixley Irrigation District GSA
Representative Monitoring Site

Appendix **D**
Figure **1**

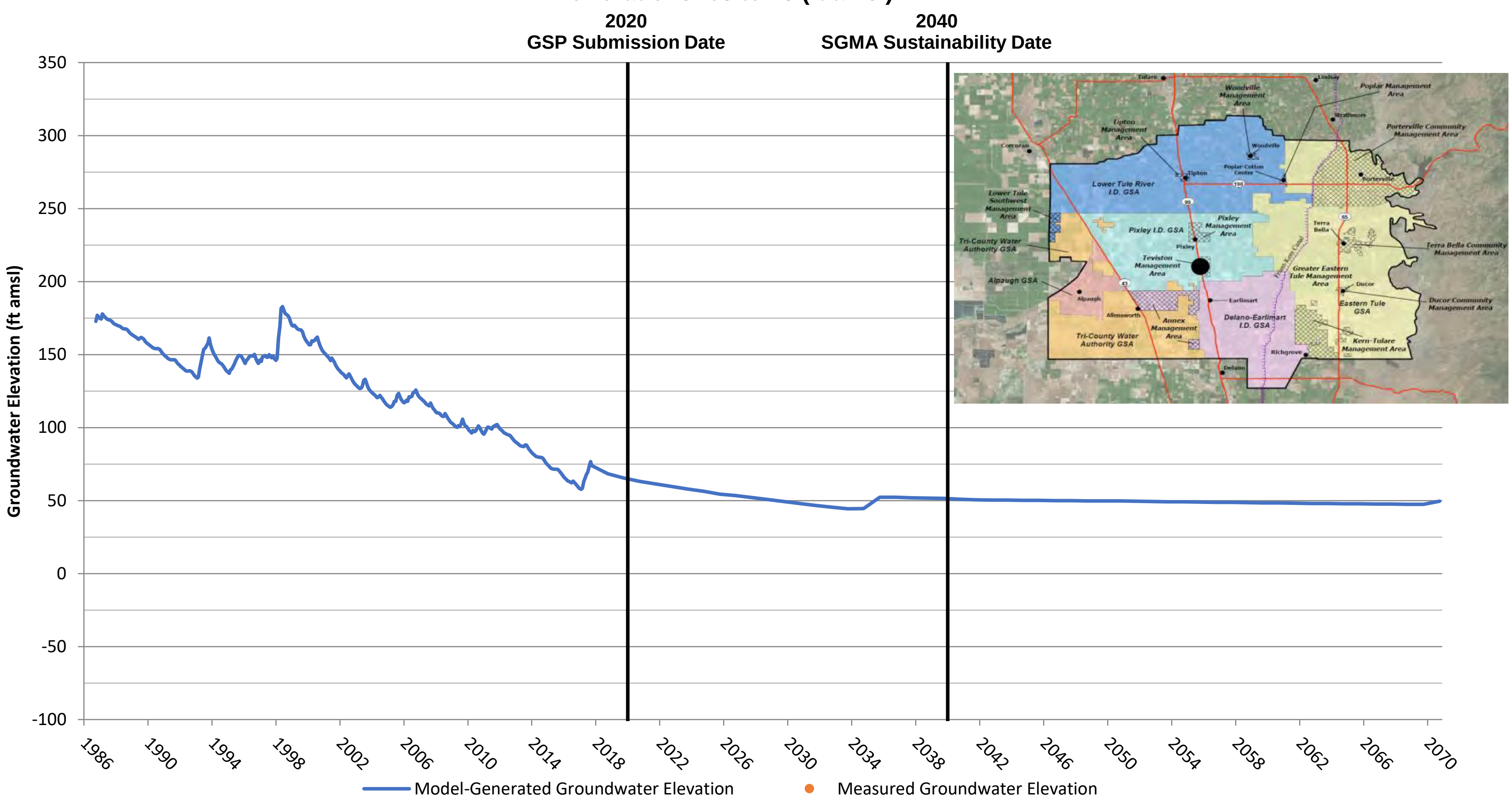
22S/24E-23J01
Upper Aquifer
Bore Depth: -145 (ft amsl)



Pixley Irrigation District GSA
Representative Monitoring Site

Appendix **D**
Figure 2

23S/25E-16N04
Upper Layer
Perforations: 63 to 23 (ft amsl)



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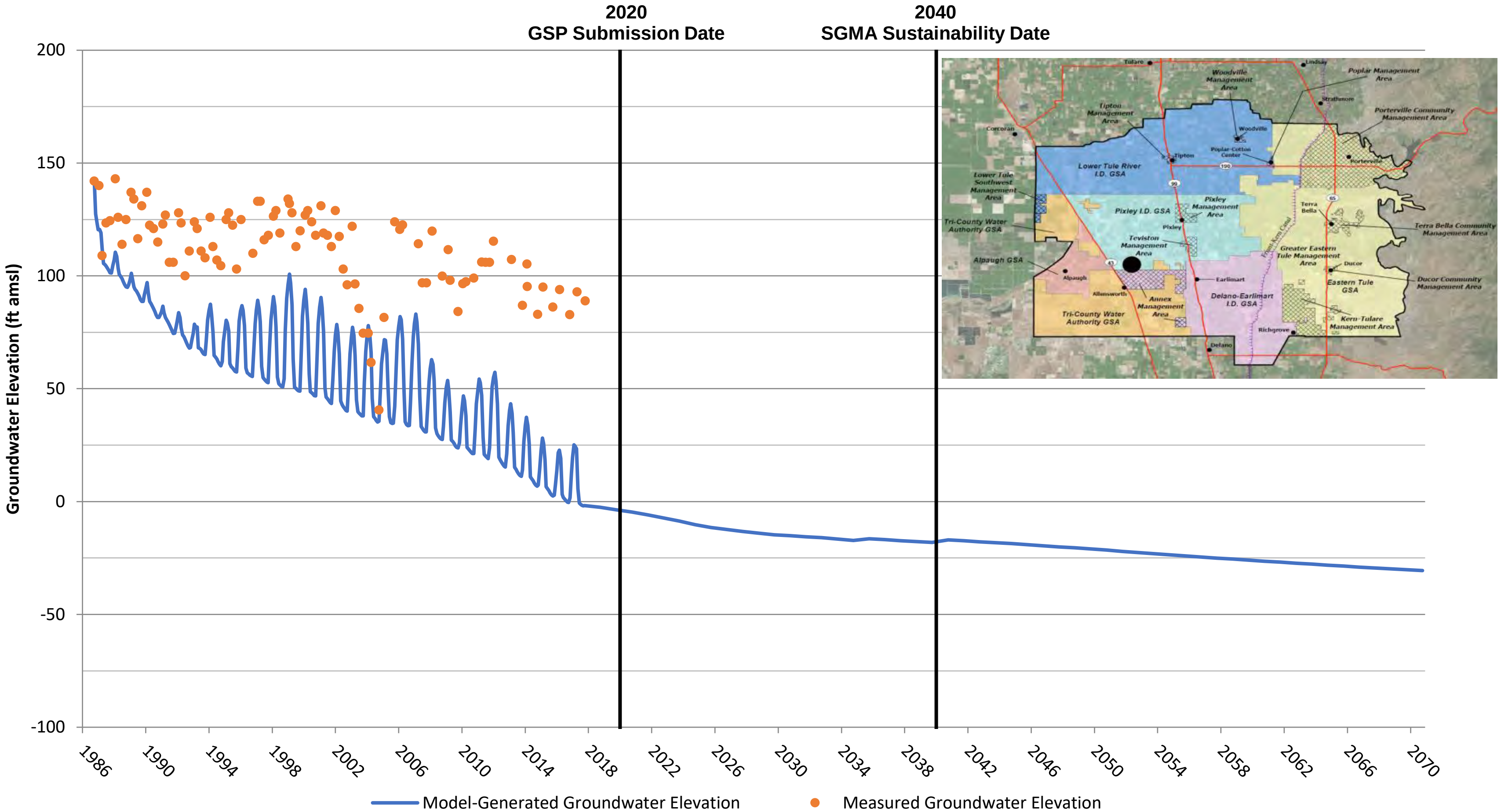
Pixley Irrigation District GSA
Representative Monitoring Site

23S/24E-28J02
Upper Aquifer

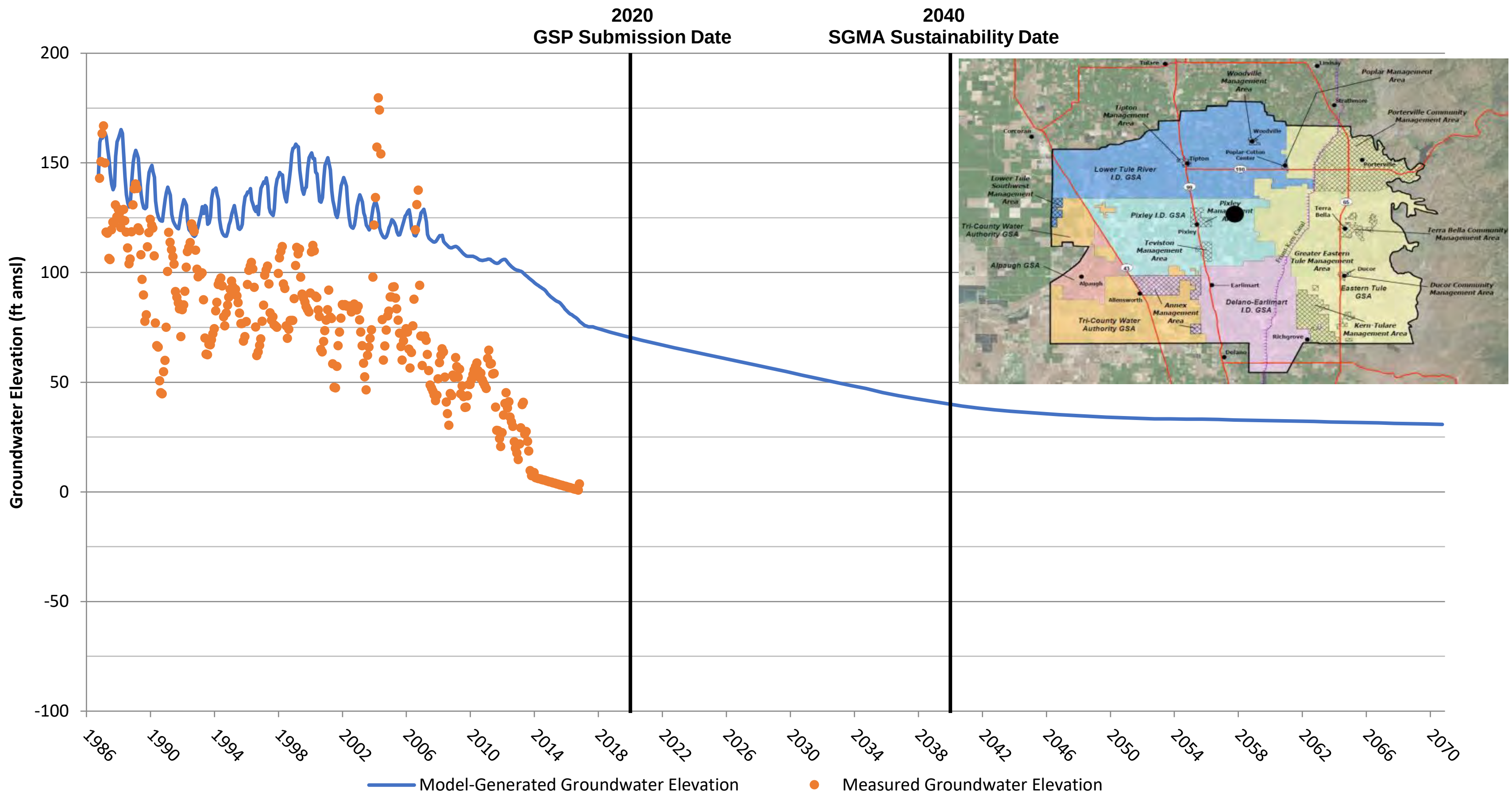


Tule Subbasin
Basin Setting

Pixley Irrigation District GSA
Representative Monitoring Site

Appendix **D**
Figure **4**

22S/25E-25N01
Upper Aquifer
Bore Depth: -128 (ft amsl)



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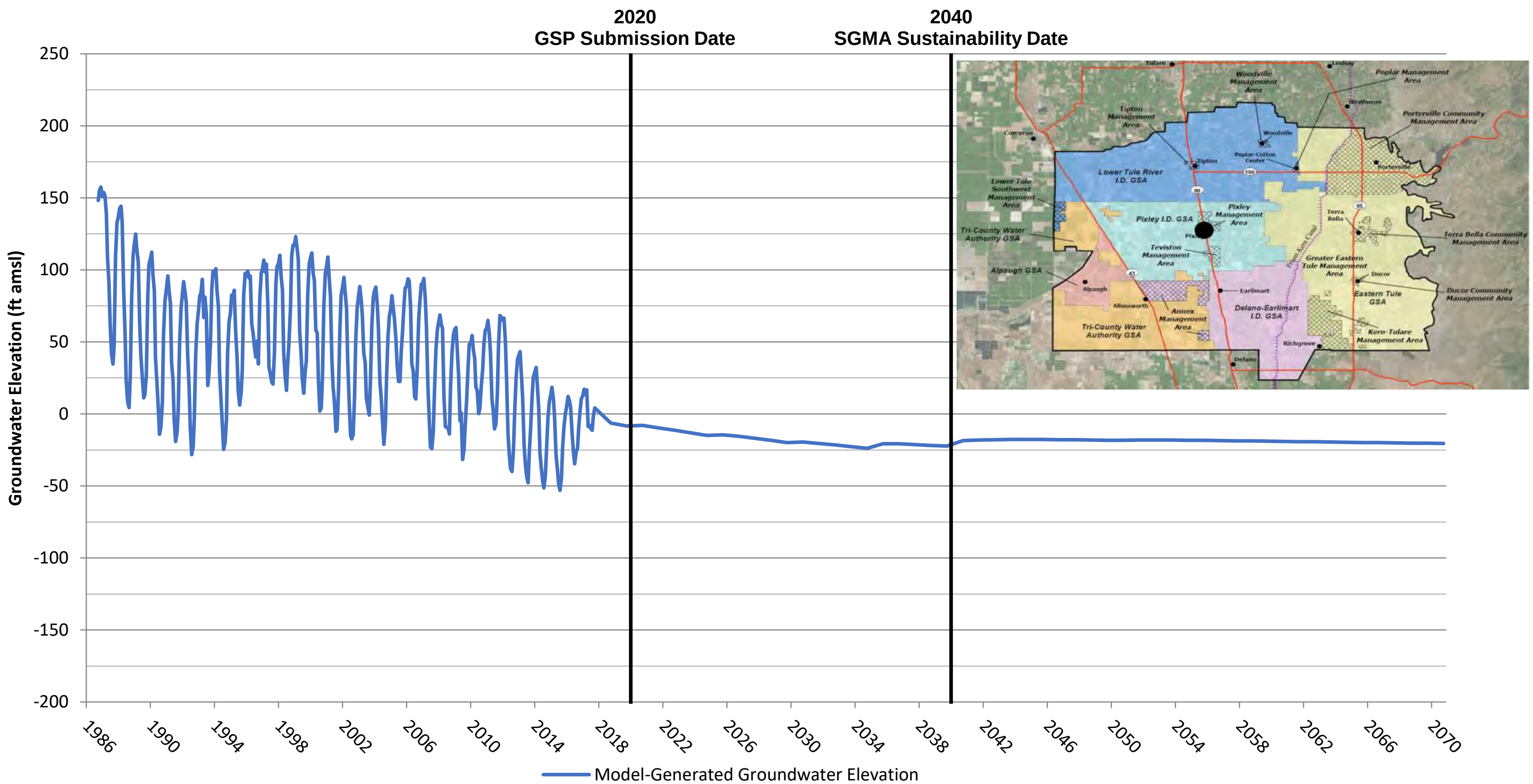
January 2020

Pixley Irrigation District GSA
Representative Monitoring Site

22S/25E-32K01
Lower Aquifer
Perforations: -231 to -431 (ft amsl)



Appendix E

Tri-County Water Authority GSA

Water Budgets and Hydrographs

Thomas Harder & Co.
Groundwater Consulting

Appendix E
Table 1a

Tri-County Water Authority GSA
Historical Surface Water Budget 1986/87 to 2016/17

Water Year	Surface Water Inflow (acre-ft)					Total In
	Precipitation	Imported Water			Discharge from Wells	
		Atwell Island WD	Alpaugh ID	Angiola WD	Agricultural	
1986 - 1987	21,000	711	45	7,278	49,000	78,000
1987 - 1988	30,000	0	0	3,530	53,000	87,000
1988 - 1989	24,000	0	0	6,026	51,000	81,000
1989 - 1990	23,000	0	0	3,847	53,000	80,000
1990 - 1991	31,000	0	0	925	56,000	88,000
1991 - 1992	27,000	0	0	1,611	55,000	84,000
1992 - 1993	44,000	4,121	700	3,420	49,000	101,000
1993 - 1994	28,000	1,283	206	3,640	51,000	84,000
1994 - 1995	57,000	3,462	473	8,918	44,000	114,000
1995 - 1996	30,000	3,379	637	12,551	57,000	104,000
1996 - 1997	42,000	0	0	12,383	63,000	117,000
1997 - 1998	69,000	0	0	7,460	68,000	144,000
1998 - 1999	35,000	0	0	9,778	66,000	111,000
1999 - 2000	33,000	162	0	8,118	67,000	108,000
2000 - 2001	25,000	0	0	3,824	72,000	101,000
2001 - 2002	24,000	0	0	2,932	73,000	100,000
2002 - 2003	23,000	0	6	4,728	67,000	95,000
2003 - 2004	19,000	0	0	3,434	58,000	80,000
2004 - 2005	37,000	0	830	11,741	48,000	98,000
2005 - 2006	38,000	0	923	10,909	49,000	99,000
2006 - 2007	16,000	0	0	6,641	55,000	78,000
2007 - 2008	18,000	0	0	2,165	59,000	79,000
2008 - 2009	19,000	0	122	191	60,000	79,000
2009 - 2010	31,000	0	153	3,243	57,000	91,000
2010 - 2011	45,000	0	627	6,476	63,000	115,000
2011 - 2012	28,000	0	54	3,156	67,000	98,000
2012 - 2013	13,000	0	0	1,492	70,000	84,000
2013 - 2014	9,000	0	0	1,048	70,000	80,000
2014 - 2015	13,000	0	0	575	70,000	84,000
2015 - 2016	20,000	0	0	587	70,000	91,000
2016 - 2017	21,000	0	136	12,146	58,000	91,000
86/87-16/17 Avg	29,000	400	200	5,300	60,000	95,000

Appendix E
Table 1b

Tri-County Water Authority GSA
Historical Surface Water Budget 1986/87 to 2016/17

Water Year	Surface Water Outflow (acre-ft)						Total Out
	Areal Recharge of Precipitation	Deep Percolation of Applied Water		Evapotranspiration			
		Imported Water	Agricultural Pumping	Precipitation Crops/Native	Imported Water Agricultural Cons. Use	Ag. Cons. Use from Pumping	
1986 - 1987	0	2,300	11,700	21,000	5,800	37,000	78,000
1987 - 1988	0	900	12,900	30,000	2,600	40,000	86,000
1988 - 1989	0	1,600	12,300	24,000	4,500	38,000	80,000
1989 - 1990	0	1,000	12,800	23,000	2,800	40,000	80,000
1990 - 1991	0	300	13,700	31,000	600	42,000	88,000
1991 - 1992	0	400	13,300	27,000	1,200	42,000	84,000
1992 - 1993	0	2,200	11,800	44,000	6,000	37,000	101,000
1993 - 1994	0	1,300	12,400	28,000	3,800	39,000	85,000
1994 - 1995	5,000	3,300	10,500	52,000	9,500	33,000	113,000
1995 - 1996	0	4,200	13,700	30,000	12,300	44,000	104,000
1996 - 1997	0	3,200	15,100	42,000	9,200	48,000	118,000
1997 - 1998	12,000	1,900	16,400	56,000	5,500	52,000	144,000
1998 - 1999	0	2,500	15,800	35,000	7,300	50,000	111,000
1999 - 2000	0	2,100	16,200	33,000	6,200	51,000	109,000
2000 - 2001	0	1,000	17,300	25,000	2,800	54,000	100,000
2001 - 2002	0	800	17,600	24,000	2,200	55,000	100,000
2002 - 2003	0	1,100	13,200	23,000	3,600	54,000	95,000
2003 - 2004	0	1,000	11,200	19,000	2,400	46,000	80,000
2004 - 2005	0	4,500	9,100	37,000	8,000	39,000	98,000
2005 - 2006	0	4,300	9,100	38,000	7,500	40,000	99,000
2006 - 2007	0	2,700	11,600	16,000	3,900	43,000	77,000
2007 - 2008	0	900	12,500	18,000	1,200	46,000	79,000
2008 - 2009	0	100	12,900	19,000	200	47,000	79,000
2009 - 2010	0	1,100	11,800	31,000	2,300	45,000	91,000
2010 - 2011	0	3,500	12,200	45,000	3,600	51,000	115,000
2011 - 2012	0	1,900	13,800	28,000	1,300	53,000	98,000
2012 - 2013	0	900	16,600	13,000	600	54,000	85,000
2013 - 2014	0	800	15,600	9,000	200	54,000	80,000
2014 - 2015	0	300	15,700	13,000	300	54,000	83,000
2015 - 2016	0	300	15,700	20,000	300	54,000	90,000
2016 - 2017	0	4,200	11,300	21,000	8,000	46,000	91,000
86/87-16/17 Avg	1,000	1,800	13,400	28,000	4,100	46,000	94,000

Groundwater Inflows to be Included in Sustainable Yield Estimates (light blue)
Groundwater Inflows to be Excluded from the Sustainable Yield Estimates (pink)
Surface Water or ET Outflows Not Included in Groundwater Recharge or Sustainable Yield Estimates (yellow)

Tri-County Water Authority GSA
Historical Groundwater Budget 1986/87 to 2016/17

Water Year	Groundwater Inflows (acre-ft)						Total In	Groundwater Outflows (acre-ft)				Total Out	Change in Storage (acre-ft)
	Areal Recharge from Precipitation	Imported Water Deliveries	Agricultural Pumping	Release of Water from Compression of Aquitards	Sub-surface Inflow			Groundwater Pumping		Sub-surface Outflow			
		Return Flow	Return Flow		From Outside Subbasin	From Other GSAs		Agricultural	Exports	To Outside Subbasin	To Other GSAs		
1986 - 1987	0	2,300	11,700	19,000	10,000	79,000	122,000	49,000	6,550	16,000	47,000	119,000	3,000
1987 - 1988	0	900	12,900	15,000	12,000	89,000	130,000	53,000	18,240	12,000	48,000	131,000	-1,000
1988 - 1989	0	1,600	12,300	13,000	12,000	85,000	124,000	51,000	12,130	11,000	51,000	125,000	-1,000
1989 - 1990	0	1,000	12,800	17,000	14,000	85,000	130,000	53,000	23,840	11,000	49,000	137,000	-7,000
1990 - 1991	0	300	13,700	18,000	15,000	90,000	137,000	56,000	18,120	16,000	50,000	140,000	-3,000
1991 - 1992	0	400	13,300	18,000	13,000	95,000	140,000	55,000	23,840	13,000	56,000	148,000	-8,000
1992 - 1993	0	2,200	11,800	10,000	9,000	100,000	133,000	49,000	6,610	16,000	58,000	130,000	3,000
1993 - 1994	0	1,300	12,400	12,000	14,000	91,000	131,000	51,000	11,220	12,000	58,000	132,000	-1,000
1994 - 1995	5,000	3,300	10,500	8,000	13,000	83,000	123,000	44,000	1,320	13,000	54,000	112,000	11,000
1995 - 1996	0	4,200	13,700	5,000	15,000	94,000	132,000	57,000	0	12,000	54,000	123,000	9,000
1996 - 1997	0	3,200	15,100	7,000	20,000	97,000	142,000	63,000	0	12,000	60,000	135,000	7,000
1997 - 1998	12,000	1,900	16,400	6,000	20,000	105,000	161,000	68,000	0	12,000	61,000	141,000	20,000
1998 - 1999	0	2,500	15,800	6,000	20,000	101,000	145,000	66,000	0	12,000	63,000	141,000	4,000
1999 - 2000	0	2,100	16,200	6,000	20,000	101,000	145,000	67,000	4,900	11,000	63,000	146,000	-1,000
2000 - 2001	0	1,000	17,300	11,000	17,000	105,000	151,000	72,000	13,310	11,000	63,000	159,000	-8,000
2001 - 2002	0	800	17,600	12,000	17,000	109,000	156,000	73,000	18,930	11,000	65,000	168,000	-12,000
2002 - 2003	0	1,100	13,200	8,000	19,000	100,000	141,000	67,000	13,050	10,000	64,000	154,000	-13,000
2003 - 2004	0	1,000	11,200	9,000	18,000	89,000	128,000	58,000	20,360	11,000	56,000	145,000	-17,000
2004 - 2005	0	4,500	9,100	4,000	13,000	86,000	117,000	48,000	4,000	15,000	51,000	118,000	-1,000
2005 - 2006	0	4,300	9,100	3,000	17,000	77,000	110,000	49,000	150	12,000	49,000	110,000	0
2006 - 2007	0	2,700	11,600	9,000	19,000	82,000	124,000	55,000	21,570	11,000	49,000	137,000	-13,000
2007 - 2008	0	900	12,500	14,000	13,000	100,000	140,000	59,000	23,950	16,000	59,000	158,000	-18,000
2008 - 2009	0	100	12,900	18,000	13,000	112,000	156,000	60,000	27,390	18,000	66,000	171,000	-15,000
2009 - 2010	0	1,100	11,800	15,000	13,000	119,000	160,000	57,000	17,760	24,000	71,000	170,000	-10,000
2010 - 2011	0	3,500	12,200	10,000	15,000	110,000	151,000	63,000	4,180	18,000	63,000	148,000	3,000
2011 - 2012	0	1,900	13,800	14,000	18,000	103,000	151,000	67,000	21,980	15,000	60,000	164,000	-13,000
2012 - 2013	0	900	16,600	17,000	19,000	93,000	147,000	70,000	23,730	9,000	59,000	162,000	-15,000
2013 - 2014	0	800	15,600	18,000	18,000	89,000	141,000	70,000	20,900	9,000	60,000	160,000	-19,000
2014 - 2015	0	300	15,700	20,000	18,000	88,000	142,000	70,000	20,100	9,000	60,000	159,000	-17,000
2015 - 2016	0	300	15,700	18,000	20,000	99,000	153,000	70,000	21,690	10,000	61,000	163,000	-10,000
2016 - 2017	0	4,200	11,300	12,000	17,000	107,000	152,000	58,000	4,520	17,000	69,000	149,000	3,000
36/87-16/17 Avg	1,000	1,800	13,400	12,000	16,000	96,000	140,000	60,000	13,000	13,000	58,000	144,000	-4,000
											Cumulative Change in Storage		-140,000

Legend colour	Meaning
Light blue	Groundwater Inflows or Outflows to be Included in Sustainable Yield Estimates
Pink	Groundwater Inflows to be Excluded from the Sustainable Yield Estimates
Yellow	Groundwater Outflows Not Included in Sustainable Yield Estimates

Projected Future Tri-County Water Authority GSA Surface Water Budget

Water Year	Surface Water Inflow (acre-ft)						Total In
	Precipitation	Imported Water				Discharge from Wells	
		Atwell Island WD	Alpaugh ID	Angiola WD	Private	Agricultural	
2017 - 2018	29,000	0	0	5,911	0	63,000	98,000
2018 - 2019	29,000	0	0	5,911	0	63,000	98,000
2019 - 2020	29,000	0	0	7,961	0	61,000	98,000
2020 - 2021	29,000	0	0	9,211	0	60,000	98,000
2021 - 2022	29,000	0	0	10,461	0	59,000	98,000
2022 - 2023	29,000	0	0	13,590	0	58,000	101,000
2023 - 2024	29,000	0	0	18,926	0	58,000	106,000
2024 - 2025	29,000	0	0	24,261	1,500	52,000	107,000
2025 - 2026	29,000	0	0	29,597	1,500	45,000	105,000
2026 - 2027	29,000	0	0	34,933	1,500	39,000	104,000
2027 - 2028	29,000	0	0	40,268	1,500	32,000	103,000
2028 - 2029	29,000	0	0	43,725	1,500	26,000	100,000
2029 - 2030	29,000	0	0	43,430	1,500	20,000	94,000
2030 - 2031	29,000	0	0	43,430	1,500	19,000	93,000
2031 - 2032	29,000	0	0	43,430	1,500	18,000	92,000
2032 - 2033	29,000	0	0	43,430	1,500	17,000	91,000
2033 - 2034	29,000	0	0	43,430	1,500	15,000	89,000
2034 - 2035	29,000	0	0	43,430	1,500	14,000	88,000
2035 - 2036	29,000	0	0	43,430	1,500	14,000	88,000
2036 - 2037	29,000	0	0	43,430	1,500	14,000	88,000
2037 - 2038	29,000	0	0	43,430	1,500	14,000	88,000
2038 - 2039	29,000	0	0	43,430	1,500	14,000	88,000
2039 - 2040	29,000	0	0	43,430	1,500	14,000	88,000
2040 - 2041	29,000	0	0	43,430	1,500	14,000	88,000
2041 - 2042	29,000	0	0	43,430	1,500	14,000	88,000
2042 - 2043	29,000	0	0	43,430	1,500	14,000	88,000
2043 - 2044	29,000	0	0	43,430	1,500	14,000	88,000
2044 - 2045	29,000	0	0	43,430	1,500	14,000	88,000
2045 - 2046	29,000	0	0	43,430	1,500	14,000	88,000
2046 - 2047	29,000	0	0	43,430	1,500	14,000	88,000
2047 - 2048	29,000	0	0	43,430	1,500	14,000	88,000
2048 - 2049	29,000	0	0	43,430	1,500	14,000	88,000
2049 - 2050	29,000	0	0	43,430	1,500	14,000	88,000
2050 - 2051	29,000	0	0	43,209	1,500	13,000	87,000
2051 - 2052	29,000	0	0	43,209	1,500	13,000	87,000
2052 - 2053	29,000	0	0	43,209	1,500	13,000	87,000
2053 - 2054	29,000	0	0	43,209	1,500	13,000	87,000
2054 - 2055	29,000	0	0	43,209	1,500	13,000	87,000
2055 - 2056	29,000	0	0	43,209	1,500	13,000	87,000
2056 - 2057	29,000	0	0	43,209	1,500	13,000	87,000
2057 - 2058	29,000	0	0	43,209	1,500	13,000	87,000
2058 - 2059	29,000	0	0	43,209	1,500	13,000	87,000
2059 - 2060	29,000	0	0	43,209	1,500	13,000	87,000
2060 - 2061	29,000	0	0	43,209	1,500	13,000	87,000
2061 - 2062	29,000	0	0	43,209	1,500	13,000	87,000
2062 - 2063	29,000	0	0	43,209	1,500	13,000	87,000
2063 - 2064	29,000	0	0	43,209	1,500	13,000	87,000
2064 - 2065	29,000	0	0	43,209	1,500	13,000	87,000
2065 - 2066	29,000	0	0	43,209	1,500	13,000	87,000
2066 - 2067	29,000	0	0	43,209	1,500	13,000	87,000
2067 - 2068	29,000	0	0	43,209	1,500	13,000	87,000
2068 - 2069	29,000	0	0	45,214	1,500	13,000	89,000
2069 - 2070	29,000	0	0	24,476	1,500	13,000	68,000
17/18-69/70 Avg	29,000	0	0	37,800	1,300	22,000	90,000

Projected Future Tri-County Water Authority GSA Surface Water Budget

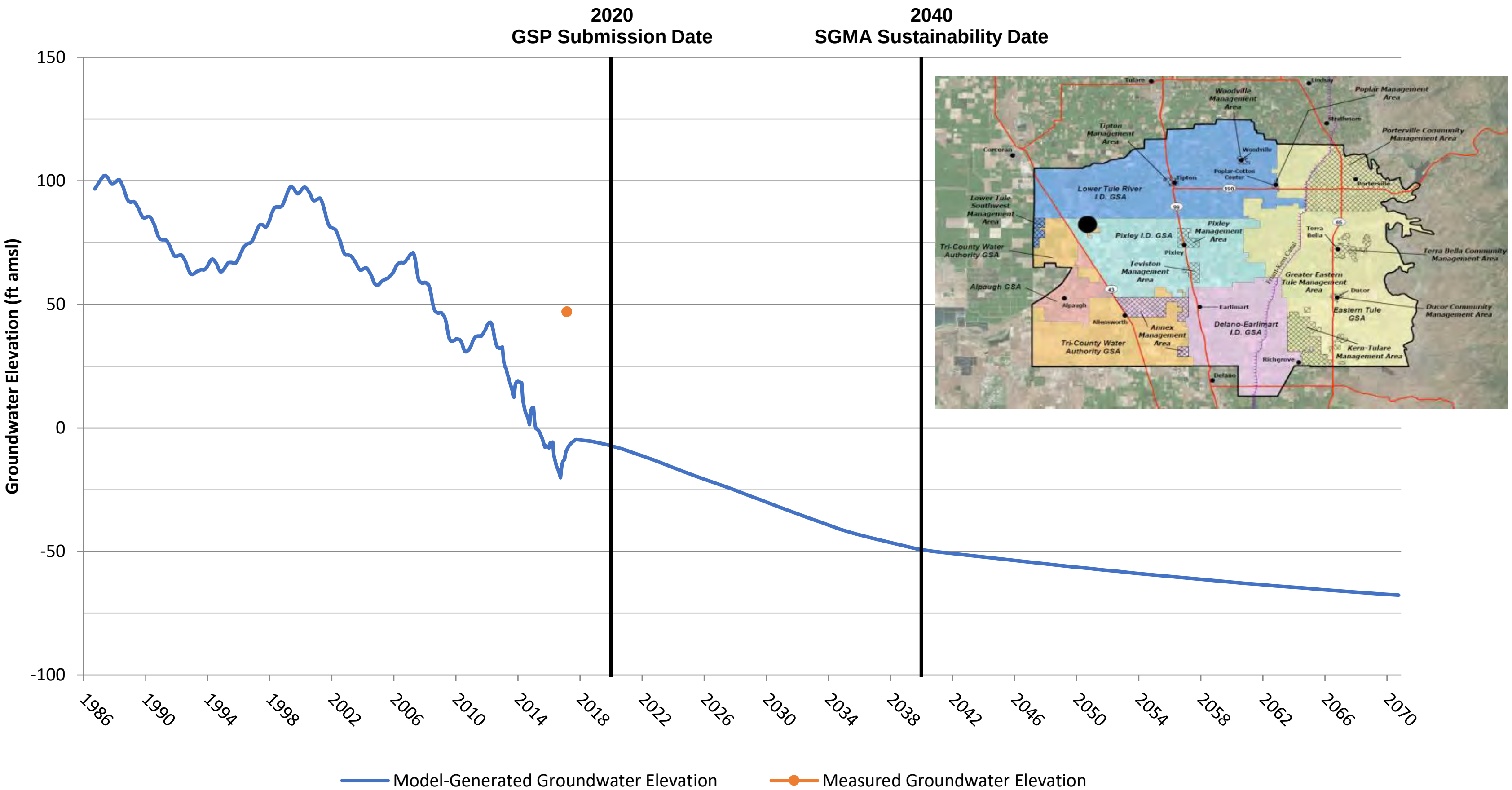
Water Year	Surface Water Outflow (acre-ft)							Total Out
	Areal Recharge of Precipitation	Recharge in Basins	Deep Percolation of Applied Water		Evapotranspiration			
		Imported Water	Imported Water	Agricultural Pumping	Precipitation Crops/Native	Imported Water Agricultural Cons. Use	Ag. Cons. Use from Pumping	
2017 - 2018	1,000	0	1,900	12,200	29,000	4,000	50,000	98,000
2018 - 2019	1,000	0	1,900	12,200	29,000	4,000	50,000	98,000
2019 - 2020	1,000	0	2,200	11,900	29,000	5,400	49,000	99,000
2020 - 2021	1,000	0	2,400	11,700	29,000	6,200	48,000	98,000
2021 - 2022	1,000	0	2,600	11,500	29,000	7,000	47,000	98,000
2022 - 2023	1,000	0	2,700	11,300	29,000	7,800	47,000	99,000
2023 - 2024	1,000	0	2,700	11,300	29,000	7,800	47,000	99,000
2024 - 2025	1,000	2,000	3,700	10,100	29,000	12,100	41,000	99,000
2025 - 2026	1,000	2,000	4,700	8,900	29,000	16,500	36,000	98,000
2026 - 2027	1,000	2,000	5,700	7,800	29,000	20,900	31,000	97,000
2027 - 2028	1,000	2,000	6,700	6,600	29,000	25,200	26,000	97,000
2028 - 2029	1,000	2,000	7,600	5,400	29,000	29,600	20,000	95,000
2029 - 2030	1,000	2,000	8,600	4,300	29,000	33,700	15,000	94,000
2030 - 2031	1,000	2,000	8,600	4,100	29,000	33,700	15,000	93,000
2031 - 2032	1,000	2,000	8,600	3,900	29,000	33,700	14,000	92,000
2032 - 2033	1,000	2,000	8,600	3,700	29,000	33,700	13,000	91,000
2033 - 2034	1,000	2,000	8,600	3,500	29,000	33,700	12,000	90,000
2034 - 2035	1,000	2,000	8,600	3,300	29,000	33,700	11,000	89,000
2035 - 2036	1,000	2,000	8,600	3,300	29,000	33,700	11,000	89,000
2036 - 2037	1,000	2,000	8,600	3,300	29,000	33,700	11,000	89,000
2037 - 2038	1,000	2,000	8,600	3,300	29,000	33,700	11,000	89,000
2038 - 2039	1,000	2,000	8,600	3,300	29,000	33,700	11,000	89,000
2039 - 2040	1,000	2,000	8,600	3,300	29,000	33,700	11,000	89,000
2040 - 2041	1,000	2,000	8,600	3,300	29,000	33,700	11,000	89,000
2041 - 2042	1,000	2,000	8,600	3,300	29,000	33,700	11,000	89,000
2042 - 2043	1,000	2,000	8,600	3,300	29,000	33,700	11,000	89,000
2043 - 2044	1,000	2,000	8,600	3,300	29,000	33,700	11,000	89,000
2044 - 2045	1,000	2,000	8,600	3,300	29,000	33,700	11,000	89,000
2045 - 2046	1,000	2,000	8,600	3,300	29,000	33,700	11,000	89,000
2046 - 2047	1,000	2,000	8,600	3,300	29,000	33,700	11,000	89,000
2047 - 2048	1,000	2,000	8,600	3,300	29,000	33,700	11,000	89,000
2048 - 2049	1,000	2,000	8,600	3,300	29,000	33,700	11,000	89,000
2049 - 2050	1,000	2,000	8,600	3,300	29,000	33,700	11,000	89,000
2050 - 2051	1,000	2,000	8,500	3,000	29,000	33,500	10,000	87,000
2051 - 2052	1,000	2,000	8,500	3,000	29,000	33,500	10,000	87,000
2052 - 2053	1,000	2,000	8,500	3,000	29,000	33,500	10,000	87,000
2053 - 2054	1,000	2,000	8,500	3,000	29,000	33,500	10,000	87,000
2054 - 2055	1,000	2,000	8,500	3,000	29,000	33,500	10,000	87,000
2055 - 2056	1,000	2,000	8,500	3,000	29,000	33,500	10,000	87,000
2056 - 2057	1,000	2,000	8,500	3,000	29,000	33,500	10,000	87,000
2057 - 2058	1,000	2,000	8,500	3,000	29,000	33,500	10,000	87,000
2058 - 2059	1,000	2,000	8,500	3,000	29,000	33,500	10,000	87,000
2059 - 2060	1,000	2,000	8,500	3,000	29,000	33,500	10,000	87,000
2060 - 2061	1,000	2,000	8,500	3,000	29,000	33,500	10,000	87,000
2061 - 2062	1,000	2,000	8,500	3,000	29,000	33,500	10,000	87,000
2062 - 2063	1,000	2,000	8,500	3,000	29,000	33,500	10,000	87,000
2063 - 2064	1,000	2,000	8,500	3,000	29,000	33,500	10,000	87,000
2064 - 2065	1,000	2,000	8,500	3,000	29,000	33,500	10,000	87,000
2065 - 2066	1,000	2,000	8,500	3,000	29,000	33,500	10,000	87,000
2066 - 2067	1,000	2,000	8,500	3,000	29,000	33,500	10,000	87,000
2067 - 2068	1,000	2,000	8,500	3,000	29,000	33,500	10,000	87,000
2068 - 2069	1,000	2,000	8,500	3,000	29,000	33,500	10,000	87,000
2069 - 2070	1,000	2,000	8,500	3,000	29,000	33,500	10,000	87,000
17/18-69/70 Avg	1,000	2,000	7,500	4,800	29,000	28,800	18,000	91,000

Projected Future Tri-County Water Authority GSA Groundwater Budget

Water Year	Groundwater Inflows (acre-ft): Areal Recharge from Precipitation	Imported Water Deliveries		Agricultural Pumping	Release of Water from Compression of Aquitards	Sub-surface Inflow		Total In	Groundwater Outflows (acre-ft): Groundwater Pumping		Sub-surface Outflow		Total Out	Change in Storage (acre-ft)
		Return Flow	Recharge in Basins	Return Flow		From Outside Subbasin	From Other GSAs		Agricultural	Exports	To Outside Subbasin	To Other GSAs		
2017 - 2018	1,000	1,900	0	12,200	13,000	14,000	99,000	141,000	63,000	11,280	13,000	61,000	148,000	-7,000
2018 - 2019	1,000	1,900	0	12,200	13,000	14,000	96,000	138,000	63,000	11,280	13,000	61,000	148,000	-10,000
2019 - 2020	1,000	2,200	0	11,900	13,000	13,000	96,000	137,000	61,000	11,280	13,000	62,000	147,000	-10,000
2020 - 2021	1,000	2,400	0	11,700	13,000	12,000	94,000	134,000	60,000	11,280	13,000	62,000	146,000	-12,000
2021 - 2022	1,000	2,600	0	11,500	13,000	10,000	93,000	131,000	59,000	11,280	13,000	61,000	144,000	-13,000
2022 - 2023	1,000	2,700	0	11,300	13,000	10,000	91,000	129,000	58,000	11,280	14,000	61,000	144,000	-15,000
2023 - 2024	1,000	2,700	0	11,300	13,000	10,000	92,000	130,000	58,000	11,280	14,000	61,000	144,000	-14,000
2024 - 2025	1,000	3,700	1,500	10,100	12,000	8,000	90,000	126,000	52,000	11,280	15,000	61,000	139,000	-13,000
2025 - 2026	1,000	4,700	1,500	8,900	11,000	8,000	86,000	121,000	45,000	11,280	18,000	60,000	134,000	-13,000
2026 - 2027	1,000	5,700	1,500	7,800	10,000	8,000	84,000	118,000	39,000	11,280	20,000	60,000	130,000	-12,000
2027 - 2028	1,000	6,700	1,500	6,600	10,000	8,000	82,000	116,000	32,000	11,280	22,000	61,000	126,000	-10,000
2028 - 2029	1,000	7,600	1,500	5,400	9,000	8,000	81,000	114,000	26,000	11,280	24,000	62,000	123,000	-9,000
2029 - 2030	1,000	8,600	1,500	4,300	8,000	9,000	82,000	114,000	20,000	11,280	25,000	64,000	120,000	-6,000
2030 - 2031	1,000	8,600	1,500	4,100	8,000	9,000	81,000	113,000	19,000	11,280	25,000	66,000	121,000	-8,000
2031 - 2032	1,000	8,600	1,500	3,900	8,000	9,000	82,000	114,000	18,000	11,280	25,000	67,000	121,000	-7,000
2032 - 2033	1,000	8,600	1,500	3,700	8,000	9,000	82,000	114,000	17,000	11,280	24,000	69,000	121,000	-7,000
2033 - 2034	1,000	8,600	1,500	3,500	7,000	9,000	83,000	114,000	15,000	11,280	23,000	71,000	120,000	-6,000
2034 - 2035	1,000	8,600	1,500	3,300	6,000	9,000	86,000	115,000	14,000	11,280	24,000	72,000	121,000	-6,000
2035 - 2036	1,000	8,600	1,500	3,300	6,000	9,000	85,000	114,000	14,000	11,280	23,000	73,000	121,000	-7,000
2036 - 2037	1,000	8,600	1,500	3,300	6,000	10,000	84,000	114,000	14,000	11,280	22,000	73,000	120,000	-6,000
2037 - 2038	1,000	8,600	1,500	3,300	6,000	10,000	84,000	114,000	14,000	11,280	21,000	74,000	120,000	-6,000
2038 - 2039	1,000	8,600	1,500	3,300	6,000	11,000	83,000	114,000	14,000	11,280	20,000	74,000	119,000	-5,000
2039 - 2040	1,000	8,600	1,500	3,300	5,000	11,000	85,000	115,000	14,000	11,280	21,000	75,000	121,000	-6,000
2040 - 2041	1,000	8,600	1,500	3,300	5,000	11,000	85,000	115,000	14,000	11,280	21,000	74,000	120,000	-5,000
2041 - 2042	1,000	8,600	1,500	3,300	5,000	11,000	85,000	115,000	14,000	11,280	21,000	74,000	120,000	-5,000
2042 - 2043	1,000	8,600	1,500	3,300	5,000	11,000	85,000	115,000	14,000	11,280	21,000	74,000	120,000	-5,000
2043 - 2044	1,000	8,600	1,500	3,300	5,000	11,000	85,000	115,000	14,000	11,280	21,000	74,000	120,000	-5,000
2044 - 2045	1,000	8,600	1,500	3,300	5,000	11,000	85,000	115,000	14,000	11,280	21,000	74,000	120,000	-5,000
2045 - 2046	1,000	8,600	1,500	3,300	5,000	11,000	85,000	115,000	14,000	11,280	21,000	74,000	120,000	-5,000
2046 - 2047	1,000	8,600	1,500	3,300	5,000	11,000	84,000	114,000	14,000	11,280	21,000	74,000	120,000	-6,000
2047 - 2048	1,000	8,600	1,500	3,300	5,000	11,000	85,000	115,000	14,000	11,280	21,000	74,000	120,000	-5,000
2048 - 2049	1,000	8,600	1,500	3,300	4,000	11,000	84,000	113,000	14,000	11,280	21,000	73,000	119,000	-6,000
2049 - 2050	1,000	8,600	1,500	3,300	4,000	11,000	84,000	113,000	14,000	11,280	21,000	73,000	119,000	-6,000
2050 - 2051	1,000	8,500	1,500	3,000	4,000	11,000	83,000	112,000	13,000	11,280	21,000	73,000	118,000	-6,000
2051 - 2052	1,000	8,500	1,500	3,000	4,000	11,000	83,000	112,000	13,000	11,280	21,000	73,000	118,000	-6,000
2052 - 2053	1,000	8,500	1,500	3,000	4,000	11,000	83,000	112,000	13,000	11,280	21,000	72,000	117,000	-5,000
2053 - 2054	1,000	8,500	1,500	3,000	4,000	11,000	82,000	111,000	13,000	11,280	21,000	72,000	117,000	-6,000
2054 - 2055	1,000	8,500	1,500	3,000	4,000	11,000	82,000	111,000	13,000	11,280	20,000	72,000	116,000	-5,000
2055 - 2056	1,000	8,500	1,500	3,000	4,000	11,000	82,000	111,000	13,000	11,280	21,000	72,000	117,000	-6,000
2056 - 2057	1,000	8,500	1,500	3,000	4,000	11,000	82,000	111,000	13,000	11,280	20,000	72,000	116,000	-5,000
2057 - 2058	1,000	8,500	1,500	3,000	4,000	11,000	82,000	111,000	13,000	11,280	20,000	72,000	116,000	-5,000
2058 - 2059	1,000	8,500	1,500	3,000	4,000	11,000	82,000	111,000	13,000	11,280	20,000	72,000	116,000	-5,000
2059 - 2060	1,000	8,500	1,500	3,000	4,000	12,000	82,000	112,000	13,000	11,280	20,000	72,000	116,000	-4,000
2060 - 2061	1,000	8,500	1,500	3,000	4,000	11,000	82,000	111,000	13,000	11,280	20,000	72,000	116,000	-5,000
2061 - 2062	1,000	8,500	1,500	3,000	4,000	12,000	82,000	112,000	13,000	11,280	20,000	71,000	115,000	-3,000
2062 - 2063	1,000	8,500	1,500	3,000	4,000	12,000	82,000	112,000	13,000	11,280	20,000	71,000	115,000	-3,000
2063 - 2064	1,000	8,500	1,500	3,000	4,000	12,000	82,000	112,000	13,000	11,280	20,000	72,000	116,000	-4,000
2064 - 2065	1,000	8,500	1,500	3,000	4,000	12,000	81,000	111,000	13,000	11,280	20,000	71,000	115,000	-4,000
2065 - 2066	1,000	8,500	1,500	3,000	4,000	12,000	81,000	111,000	13,000	11,280	20,000	71,000	115,000	-4,000
2066 - 2067	1,000	8,500	1,500	3,000	4,000	12,000	81,000	111,000	13,000	11,280	20,000	71,000	115,000	-4,000
2067 - 2068	1,000	8,500	1,500	3,000	4,000	12,000	81,000	111,000	13,000	11,280	20,000	71,000	115,000	-4,000
2068 - 2069	1,000	8,500	1,500	3,000	4,000	12,000	81,000	111,000	13,000	11,280	19,000	71,000	114,000	-3,000
2069 - 2070	1,000	8,500	1,500	3,000	4,000	12,000	81,000	111,000	13,000	11,280	19,000	71,000	114,000	-3,000
17/18-69/70 Avg	1,000	7,500	1,300	4,800	7,000	11,000	85,000	118,000	22,000	11,300	20,000	69,000	122,000	-4,000

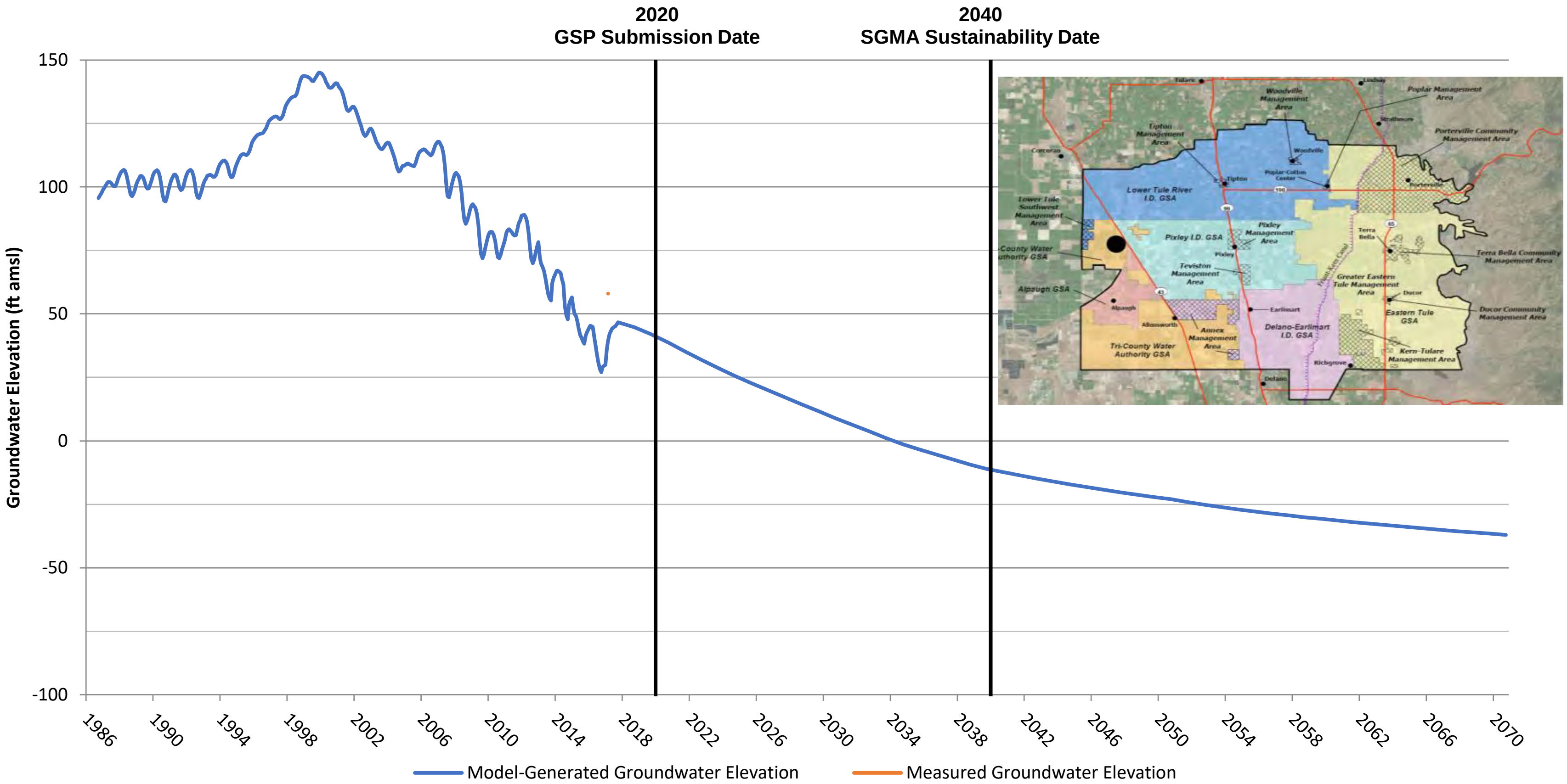
Tri-County Water Authority GSA
Representative Monitoring Site

Angiola E20
Upper Aquifer
Perforations: -26 to -266 (ft amsl)



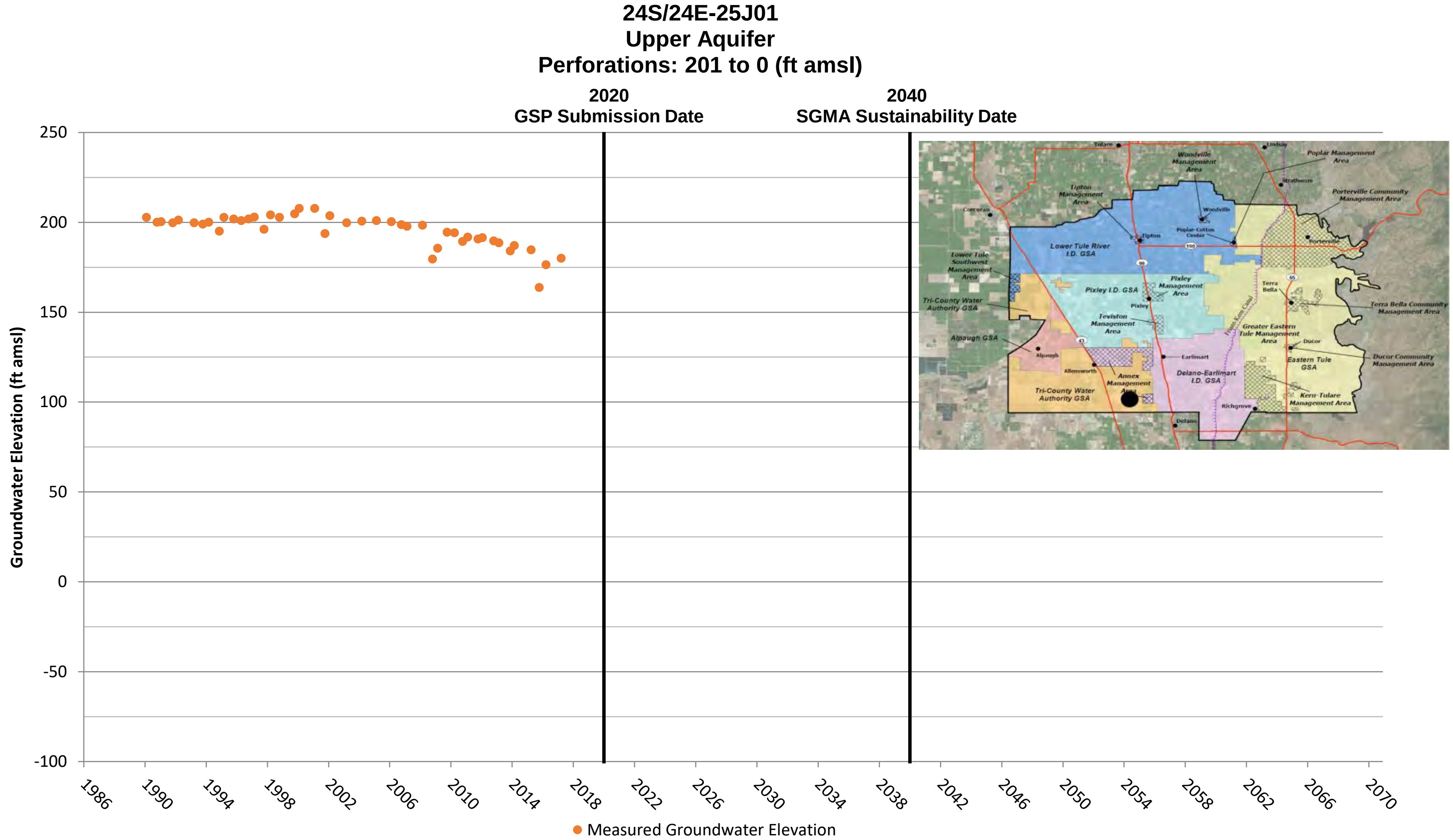
Tri-County Water Authority GSA
Representative Monitoring Site

Angiola W14
Upper Aquifer
Perforations: -43 to -283 (ft amsl)



Tri-County Water Authority GSA
Representative Monitoring Site

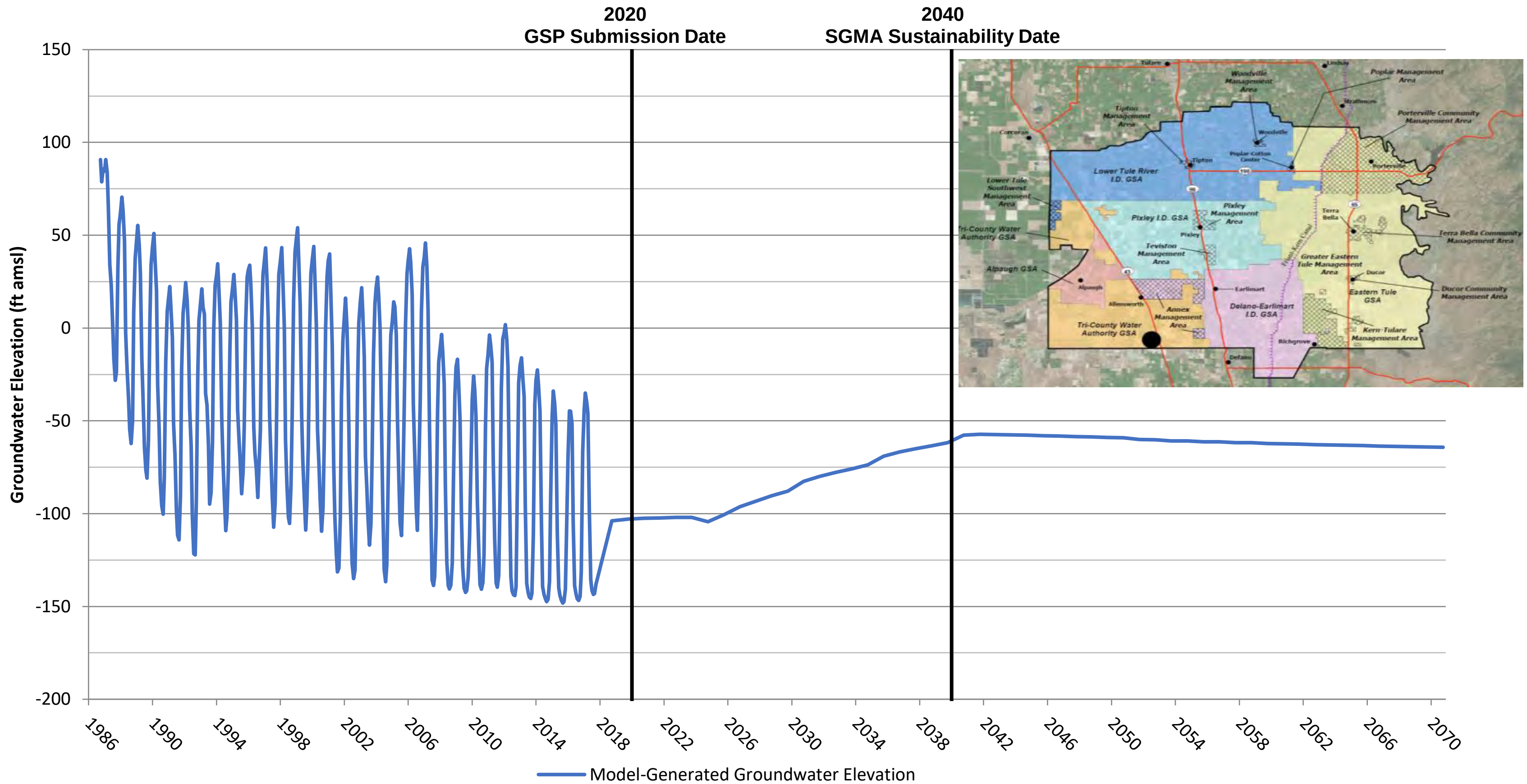
Appendix **E**
Figure **3**



Tri-County Water Authority GSA
Representative Monitoring Site

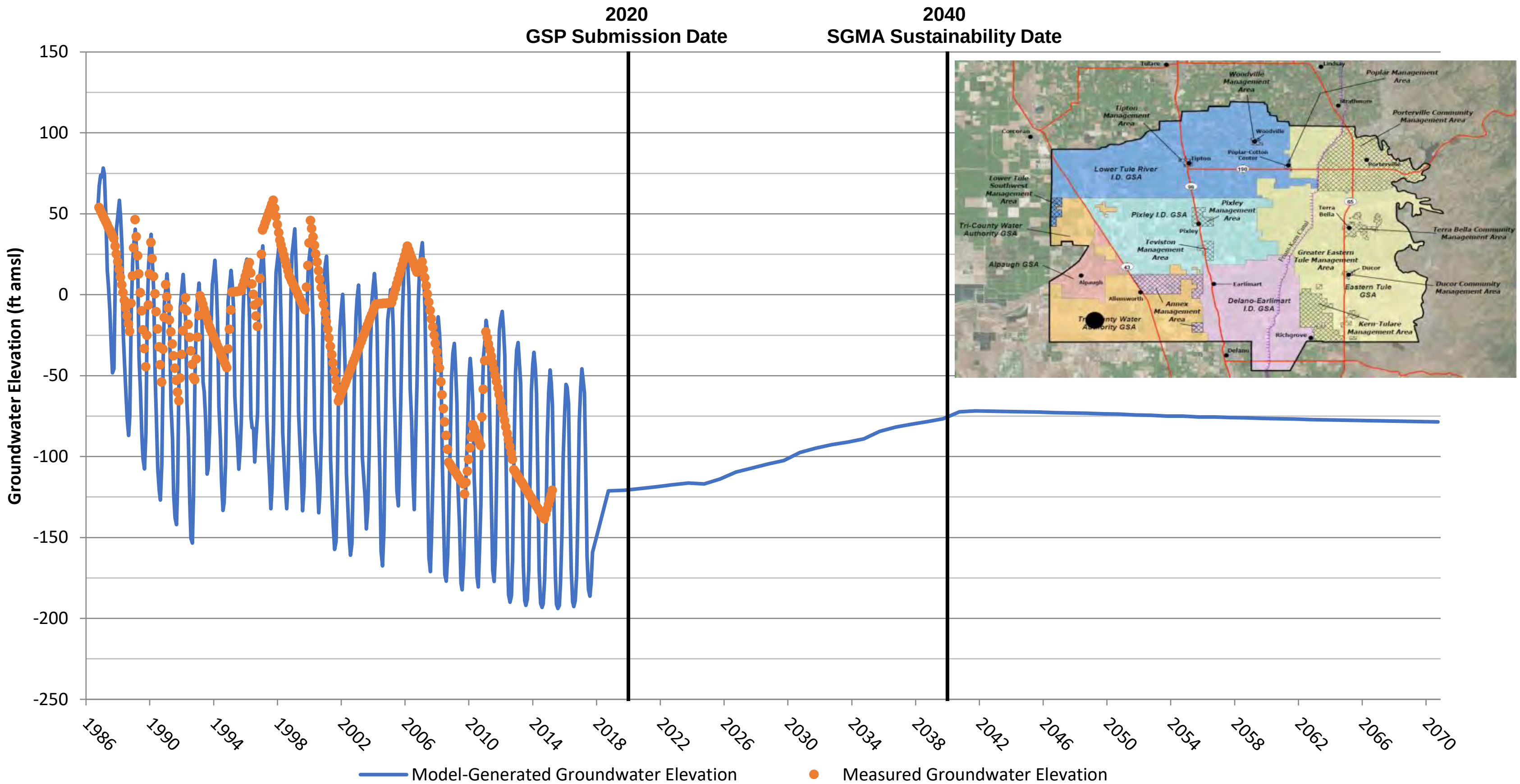
Appendix **E**
Figure **4**

E0346058
Lower Aquifer
Well Depth: -1,029 (ft amsl)



Tri-County Water Authority GSA
Representative Monitoring Site

24S/23E-22R02
Lower Aquifer
Perforations: -813 to -793 (ft amsl)

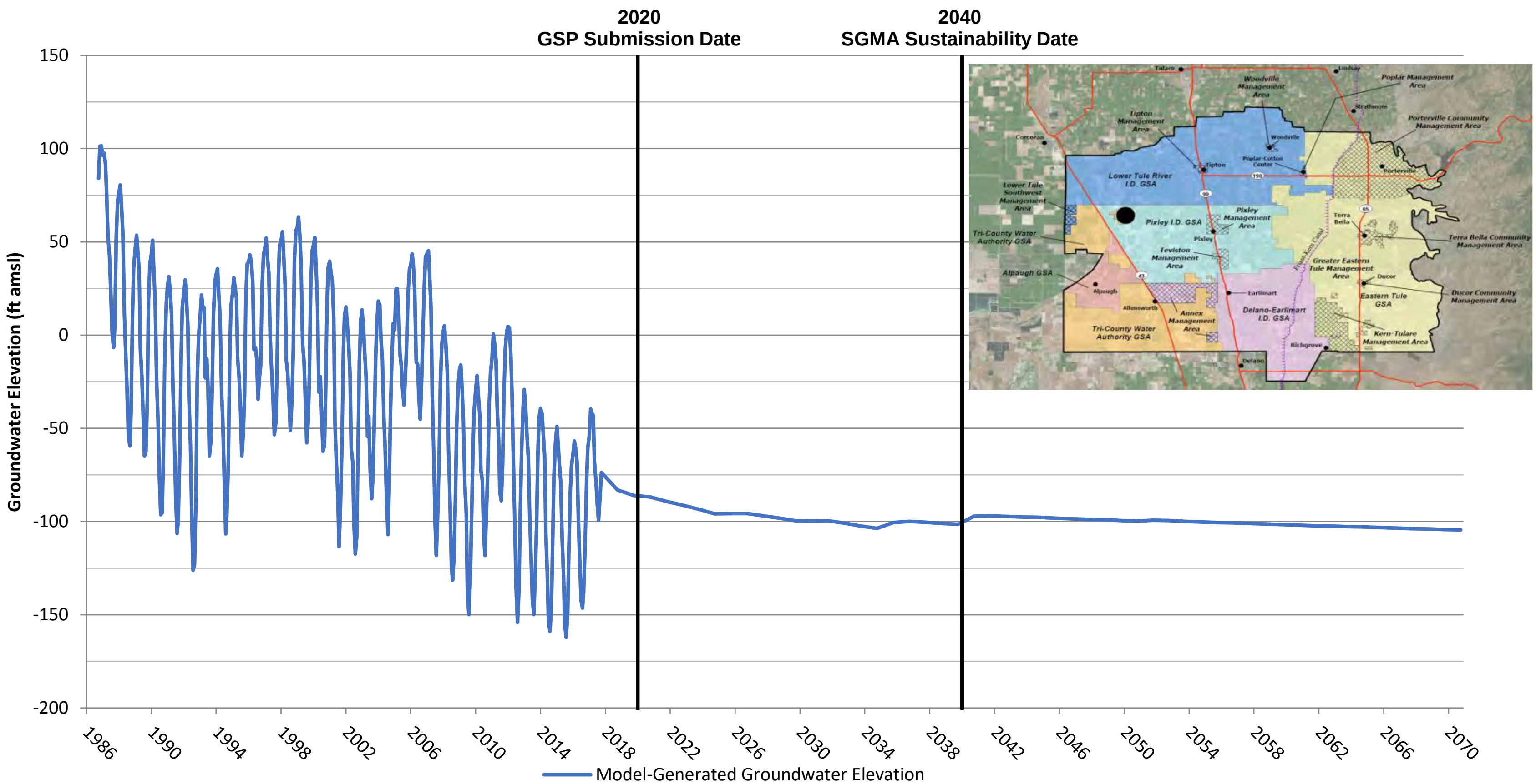


Tule Subbasin
Basin Setting

Tri-County Water Authority GSA
Representative Monitoring Site

Appendix **E**
Figure **6**

Angiola E22
Lower Aquifer
Perforations: -421 to -901 (ft amsl)



Thomas Harder & Co.
Groundwater Consulting

January 2020

Appendix F

Alpaugh Irrigation District GSA

Water Budgets and Hydrographs

Alpaugh GSA
Historical Surface Water Budget 1986/87 to 2016/17

Water Year	Surface Water Inflow (acre-ft)					Total In
	Precipitation	Imported Water		Discharge from Wells		
		Alpaugh ID	Atwell Island WD	Agricultural	Municipal	
1986 - 1987	5,000	748	397	35,000	200	41,000
1987 - 1988	7,000	0	0	36,000	200	43,000
1988 - 1989	6,000	0	0	36,000	200	42,000
1989 - 1990	6,000	0	0	36,000	200	42,000
1990 - 1991	7,000	0	0	36,000	200	43,000
1991 - 1992	6,000	0	0	36,000	200	42,000
1992 - 1993	10,000	11,519	2,302	22,000	200	46,000
1993 - 1994	7,000	3,398	717	32,000	200	43,000
1994 - 1995	14,000	7,790	1,934	26,000	200	50,000
1995 - 1996	7,000	10,493	1,888	21,000	200	41,000
1996 - 1997	10,000	0	0	33,000	200	43,000
1997 - 1998	16,000	0	0	33,000	200	49,000
1998 - 1999	8,000	0	0	33,000	200	41,000
1999 - 2000	8,000	0	91	33,000	200	41,000
2000 - 2001	6,000	0	0	33,000	200	39,000
2001 - 2002	6,000	0	0	33,000	200	39,000
2002 - 2003	6,000	98	0	33,000	200	39,000
2003 - 2004	5,000	0	0	30,000	200	35,000
2004 - 2005	9,000	13,660	0	17,000	300	40,000
2005 - 2006	9,000	15,189	0	16,000	300	40,000
2006 - 2007	4,000	0	0	30,000	300	34,000
2007 - 2008	4,000	0	0	30,000	300	34,000
2008 - 2009	5,000	2,009	0	28,000	300	35,000
2009 - 2010	7,000	2,518	0	27,000	300	37,000
2010 - 2011	11,000	10,324	0	10,000	300	32,000
2011 - 2012	7,000	889	0	18,000	300	26,000
2012 - 2013	3,000	0	0	19,000	300	22,000
2013 - 2014	2,000	0	0	19,000	300	21,000
2014 - 2015	3,000	0	0	19,000	300	22,000
2015 - 2016	5,000	0	0	19,000	300	24,000
2016 - 2017	5,000	2,232	0	16,000	300	24,000
86/87-16/17 Avg	7,000	2,600	200	27,000	200	37,000

Appendix F
Table 1b

Alpaugh GSA
Historical Surface Water Budget 1986/87 to 2016/17

Water Year	Surface Water Outflow (acre-ft)								Total Out
	Areal Recharge of Precip-itation	Deep Percolation of Applied			Evapotranspiration				
		Imported Water	Agri-cultural Pumping	Municipal Pumping	Precipitation Crops/Native	Imported Water Agricultural Cons. Use	Ag. Cons. Use from Pumping	Municipal (Landscape ET)	
1986 - 1987	0	300	8,600	100	5,000	900	26,000	100	41,000
1987 - 1988	0	0	8,900	100	7,000	0	27,000	100	43,000
1988 - 1989	0	0	8,900	100	6,000	0	27,000	100	42,000
1989 - 1990	0	0	8,900	100	6,000	0	27,000	100	42,000
1990 - 1991	0	0	8,900	100	7,000	0	27,000	100	43,000
1991 - 1992	0	0	8,900	100	6,000	0	27,000	100	42,000
1992 - 1993	0	3,500	5,500	100	10,000	10,400	16,000	100	46,000
1993 - 1994	0	1,000	7,900	100	7,000	3,100	24,000	100	43,000
1994 - 1995	1,000	2,400	6,500	100	12,000	7,300	20,000	100	49,000
1995 - 1996	0	3,100	5,300	100	7,000	9,300	16,000	100	41,000
1996 - 1997	0	0	8,400	100	10,000	0	25,000	100	44,000
1997 - 1998	3,000	0	8,400	100	13,000	0	25,000	100	50,000
1998 - 1999	0	0	8,400	100	8,000	0	25,000	100	42,000
1999 - 2000	0	0	8,300	100	8,000	100	25,000	100	42,000
2000 - 2001	0	0	8,400	100	6,000	0	25,000	100	40,000
2001 - 2002	0	0	8,400	100	6,000	0	25,000	100	40,000
2002 - 2003	0	0	7,500	200	6,000	100	25,000	100	39,000
2003 - 2004	0	0	6,900	200	5,000	0	23,000	100	35,000
2004 - 2005	0	3,700	3,900	200	9,000	10,000	13,000	100	40,000
2005 - 2006	0	4,700	3,700	200	9,000	10,500	13,000	100	41,000
2006 - 2007	0	0	6,800	200	4,000	0	23,000	100	34,000
2007 - 2008	0	0	6,800	200	4,000	0	23,000	100	34,000
2008 - 2009	0	500	6,400	200	5,000	1,500	21,000	100	35,000
2009 - 2010	0	600	6,200	200	7,000	1,900	21,000	100	37,000
2010 - 2011	0	3,100	2,400	200	11,000	7,200	8,000	100	32,000
2011 - 2012	0	400	4,100	200	7,000	500	14,000	100	26,000
2012 - 2013	0	0	4,200	200	3,000	0	14,000	100	22,000
2013 - 2014	0	0	4,200	200	2,000	0	14,000	100	21,000
2014 - 2015	0	0	4,200	200	3,000	0	14,000	100	22,000
2015 - 2016	0	0	4,200	200	5,000	0	14,000	100	24,000
2016 - 2017	0	500	3,700	200	5,000	1,700	13,000	100	24,000
86/87-16/17 Avg	0	800	6,600	100	7,000	2,100	21,000	100	38,000

Groundwater Inflows to be Included in Sustainable Yield Estimates
Groundwater Inflows to be Excluded from the Sustainable Yield Estimates
Surface Water or ET Outflows Not Included in Groundwater Recharge or Sustainable Yield Estimates

Alpaugh GSA
Historical Groundwater Budget 1986/87 to 2016/17

Water Year	Groundwater Inflows (acre-ft)							Total In	Groundwater Outflows (acre-ft)				Total Out	Change in Storage (acre-ft)
	Areal Recharge from Precipitation	Imported Water Deliveries	Agricultural Pumping	Municipal Pumping	Release of Water from Compression of Aquitards	Sub-surface Inflow			Groundwater Pumping		Sub-surface Outflow			
		Return Flow	Return Flow	Return Flow		From Outside Subbasin	From Other GSAs		Municipal	Agricultural	To Outside Subbasin	To Other GSAs		
1986 - 1987	0	300	8,600	100	3,000	10,000	32,000	54,000	200	35,000	2,000	12,000	49,000	5,000
1987 - 1988	0	0	8,900	100	3,000	9,000	35,000	56,000	200	36,000	2,000	14,000	52,000	4,000
1988 - 1989	0	0	8,900	100	3,000	9,000	38,000	59,000	200	36,000	2,000	15,000	53,000	6,000
1989 - 1990	0	0	8,900	100	3,000	9,000	35,000	56,000	200	36,000	2,000	15,000	53,000	3,000
1990 - 1991	0	0	8,900	100	4,000	10,000	36,000	59,000	200	36,000	2,000	17,000	55,000	4,000
1991 - 1992	0	0	8,900	100	4,000	8,000	40,000	61,000	200	36,000	3,000	18,000	57,000	4,000
1992 - 1993	0	3,500	5,500	100	2,000	5,000	36,000	52,000	200	22,000	5,000	22,000	49,000	3,000
1993 - 1994	0	1,000	7,900	100	3,000	8,000	37,000	57,000	200	32,000	3,000	20,000	55,000	2,000
1994 - 1995	1,000	2,400	6,500	100	2,000	8,000	32,000	52,000	200	26,000	3,000	20,000	49,000	3,000
1995 - 1996	0	3,100	5,300	100	1,000	10,000	29,000	49,000	200	21,000	2,000	23,000	46,000	3,000
1996 - 1997	0	0	8,400	100	1,000	14,000	36,000	60,000	200	33,000	2,000	24,000	59,000	1,000
1997 - 1998	3,000	0	8,400	100	1,000	15,000	38,000	66,000	200	33,000	2,000	26,000	61,000	5,000
1998 - 1999	0	0	8,400	100	1,000	13,000	38,000	61,000	200	33,000	2,000	24,000	59,000	2,000
1999 - 2000	0	0	8,300	100	1,000	13,000	38,000	60,000	200	33,000	2,000	24,000	59,000	1,000
2000 - 2001	0	0	8,400	100	2,000	11,000	40,000	62,000	200	33,000	3,000	24,000	60,000	2,000
2001 - 2002	0	0	8,400	100	2,000	9,000	41,000	61,000	200	33,000	3,000	25,000	61,000	0
2002 - 2003	0	0	7,500	200	2,000	9,000	40,000	59,000	200	33,000	3,000	24,000	60,000	-1,000
2003 - 2004	0	0	6,900	200	2,000	11,000	33,000	53,000	200	30,000	2,000	21,000	53,000	0
2004 - 2005	0	3,700	3,900	200	0	11,000	26,000	45,000	300	17,000	2,000	26,000	45,000	0
2005 - 2006	0	4,700	3,700	200	0	11,000	25,000	45,000	300	16,000	2,000	25,000	43,000	2,000
2006 - 2007	0	0	6,800	200	1,000	14,000	29,000	51,000	300	30,000	1,000	21,000	52,000	-1,000
2007 - 2008	0	0	6,800	200	3,000	7,000	38,000	55,000	300	30,000	3,000	24,000	57,000	-2,000
2008 - 2009	0	500	6,400	200	4,000	5,000	42,000	58,000	300	28,000	6,000	26,000	60,000	-2,000
2009 - 2010	0	600	6,200	200	3,000	6,000	45,000	61,000	300	27,000	6,000	28,000	61,000	0
2010 - 2011	0	3,100	2,400	200	2,000	8,000	33,000	49,000	300	10,000	6,000	31,000	47,000	2,000
2011 - 2012	0	400	4,100	200	3,000	8,000	32,000	48,000	300	18,000	6,000	26,000	50,000	-2,000
2012 - 2013	0	0	4,200	200	3,000	6,000	33,000	46,000	300	19,000	6,000	24,000	49,000	-3,000
2013 - 2014	0	0	4,200	200	4,000	5,000	32,000	45,000	300	19,000	6,000	23,000	48,000	-3,000
2014 - 2015	0	0	4,200	200	4,000	5,000	31,000	44,000	300	19,000	6,000	23,000	48,000	-4,000
2015 - 2016	0	0	4,200	200	3,000	6,000	33,000	46,000	300	19,000	5,000	25,000	49,000	-3,000
2016 - 2017	0	500	3,700	200	2,000	8,000	37,000	51,000	300	16,000	6,000	29,000	51,000	0
36/87-16/17 Avg	0	800	6,600	100	2,000	9,000	35,000	54,000	200	27,000	3,000	23,000	53,000	1,000
												Cumulative Change in Storage		31,000

Groundwater Inflows or Outflows to be Included in Sustainable Yield Estimates
Groundwater Inflows to be Excluded from the Sustainable Yield Estimates
Groundwater Outflows Not Included in Sustainable Yield Estimates

Appendix F
Table 3a

Projected Future Alpaugh GSA Surface Water Budget

Water Year	Surface Water Inflow (acre-ft)						Total In
	Precipitation	Stream Inflow	Imported Water		Discharge from Wells		
		Deer Creek	Alpaugh ID	Atwell Island WD	Agricultural	Municipal	
2017 - 2018	7,000	280	3,680	0	15,000	300	26,000
2018 - 2019	7,000	280	3,680	0	15,000	300	26,000
2019 - 2020	7,000	280	3,680	0	15,000	300	26,000
2020 - 2021	7,000	280	3,680	0	15,000	300	26,000
2021 - 2022	7,000	280	3,680	0	14,000	300	25,000
2022 - 2023	7,000	280	3,680	0	14,000	300	25,000
2023 - 2024	7,000	280	3,680	0	13,000	300	24,000
2024 - 2025	7,000	280	3,680	0	13,000	300	24,000
2025 - 2026	7,000	1,380	4,813	0	10,000	300	23,000
2026 - 2027	7,000	1,380	4,751	0	10,000	300	23,000
2027 - 2028	7,000	1,380	4,689	0	10,000	300	23,000
2028 - 2029	7,000	1,380	4,627	0	9,000	300	22,000
2029 - 2030	7,000	1,380	4,565	0	9,000	300	22,000
2030 - 2031	7,000	1,380	5,737	0	8,000	300	22,000
2031 - 2032	7,000	1,380	5,737	0	8,000	300	22,000
2032 - 2033	7,000	1,380	5,737	0	8,000	300	22,000
2033 - 2034	7,000	1,380	5,737	0	8,000	300	22,000
2034 - 2035	7,000	1,380	5,737	0	8,000	300	22,000
2035 - 2036	7,000	1,380	6,970	0	7,000	300	23,000
2036 - 2037	7,000	1,380	6,970	0	7,000	300	23,000
2037 - 2038	7,000	1,380	6,970	0	7,000	300	23,000
2038 - 2039	7,000	1,380	6,970	0	7,000	300	23,000
2039 - 2040	7,000	1,380	6,970	0	7,000	300	23,000
2040 - 2041	7,000	1,380	7,793	0	6,000	300	22,000
2041 - 2042	7,000	1,380	7,793	0	6,000	300	22,000
2042 - 2043	7,000	1,380	7,793	0	6,000	300	22,000
2043 - 2044	7,000	1,380	7,793	0	6,000	300	22,000
2044 - 2045	7,000	1,380	7,793	0	6,000	300	22,000
2045 - 2046	7,000	1,380	7,793	0	6,000	300	22,000
2046 - 2047	7,000	1,380	7,793	0	6,000	300	22,000
2047 - 2048	7,000	1,380	7,793	0	6,000	300	22,000
2048 - 2049	7,000	1,380	7,793	0	6,000	300	22,000
2049 - 2050	7,000	1,380	7,793	0	6,000	300	22,000
2050 - 2051	7,000	1,380	7,793	0	6,000	300	22,000
2051 - 2052	7,000	1,380	7,793	0	6,000	300	22,000
2052 - 2053	7,000	1,380	7,793	0	6,000	300	22,000
2053 - 2054	7,000	1,380	7,793	0	6,000	300	22,000
2054 - 2055	7,000	1,380	7,793	0	6,000	300	22,000
2055 - 2056	7,000	1,380	7,793	0	6,000	300	22,000
2056 - 2057	7,000	1,380	7,793	0	6,000	300	22,000
2057 - 2058	7,000	1,380	7,793	0	6,000	300	22,000
2058 - 2059	7,000	1,380	7,793	0	6,000	300	22,000
2059 - 2060	7,000	1,380	7,793	0	6,000	300	22,000
2060 - 2061	7,000	1,380	7,793	0	6,000	300	22,000
2061 - 2062	7,000	1,380	7,793	0	6,000	300	22,000
2062 - 2063	7,000	1,380	7,793	0	6,000	300	22,000
2063 - 2064	7,000	1,380	7,793	0	6,000	300	22,000
2064 - 2065	7,000	1,380	7,793	0	6,000	300	22,000
2065 - 2066	7,000	1,380	7,793	0	6,000	300	22,000
2066 - 2067	7,000	1,380	7,793	0	6,000	300	22,000
2067 - 2068	7,000	1,380	7,793	0	6,000	300	22,000
2068 - 2069	7,000	1,380	7,793	0	6,000	300	22,000
2069 - 2070	7,000	1,380	7,793	0	6,000	300	22,000
17/18-69/70 Avg	7,000	1,200	6,600	0	8,000	300	23,000

Projected Future Alpaugh GSA Surface Water Budget

Water Year	Surface Water Outflow (acre-ft)										Total Out
	Areal Recharge of Precip-itation	Deep Percolation of Applied Water				Evapotranspiration					
		Imported Water	Deer Creek	Agri-cultural Pumping	Municipal Pumping	Precipitation Crops/Native	Imported Water (Agricultural Cons. Use)	Deer Creek (Agricultural Cons. Use)	Ag. Cons. Use from Pumping	Municipal (Landscape ET)	
2017 - 2018	0	800	100	3,300	200	7,000	2,800	200	11,000	100	26,000
2018 - 2019	0	800	100	3,300	200	7,000	2,800	200	11,000	100	26,000
2019 - 2020	0	800	100	3,300	200	7,000	2,800	200	11,000	100	26,000
2020 - 2021	0	800	100	3,300	200	7,000	2,800	200	11,000	100	26,000
2021 - 2022	0	800	100	3,200	200	7,000	2,800	200	11,000	100	25,000
2022 - 2023	0	800	100	3,200	200	7,000	2,800	200	11,000	100	25,000
2023 - 2024	0	800	100	3,100	200	7,000	2,800	200	10,000	100	24,000
2024 - 2025	0	800	100	3,000	200	7,000	2,800	200	10,000	100	24,000
2025 - 2026	0	1,100	300	2,400	200	7,000	3,700	1,100	8,000	100	24,000
2026 - 2027	0	1,100	300	2,300	200	7,000	3,700	1,100	8,000	100	24,000
2027 - 2028	0	1,100	300	2,200	200	7,000	3,600	1,100	7,000	100	23,000
2028 - 2029	0	1,100	300	2,100	200	7,000	3,600	1,100	7,000	100	23,000
2029 - 2030	0	1,000	300	2,100	200	7,000	3,500	1,100	7,000	100	22,000
2030 - 2031	0	1,300	300	1,800	200	7,000	4,400	1,100	6,000	100	22,000
2031 - 2032	0	1,300	300	1,800	200	7,000	4,400	1,100	6,000	100	22,000
2032 - 2033	0	1,300	300	1,800	200	7,000	4,400	1,100	6,000	100	22,000
2033 - 2034	0	1,300	300	1,800	200	7,000	4,400	1,100	6,000	100	22,000
2034 - 2035	0	1,300	300	1,800	200	7,000	4,400	1,100	6,000	100	22,000
2035 - 2036	0	1,600	300	1,500	200	7,000	5,400	1,100	5,000	100	22,000
2036 - 2037	0	1,600	300	1,500	200	7,000	5,400	1,100	5,000	100	22,000
2037 - 2038	0	1,600	300	1,500	200	7,000	5,400	1,100	5,000	100	22,000
2038 - 2039	0	1,600	300	1,500	200	7,000	5,400	1,100	5,000	100	22,000
2039 - 2040	0	1,600	300	1,500	200	7,000	5,400	1,100	5,000	100	22,000
2040 - 2041	0	1,800	300	1,400	200	7,000	6,000	1,100	5,000	100	23,000
2041 - 2042	0	1,800	300	1,400	200	7,000	6,000	1,100	5,000	100	23,000
2042 - 2043	0	1,800	300	1,400	200	7,000	6,000	1,100	5,000	100	23,000
2043 - 2044	0	1,800	300	1,400	200	7,000	6,000	1,100	5,000	100	23,000
2044 - 2045	0	1,800	300	1,400	200	7,000	6,000	1,100	5,000	100	23,000
2045 - 2046	0	1,800	300	1,400	200	7,000	6,000	1,100	5,000	100	23,000
2046 - 2047	0	1,800	300	1,400	200	7,000	6,000	1,100	5,000	100	23,000
2047 - 2048	0	1,800	300	1,400	200	7,000	6,000	1,100	5,000	100	23,000
2048 - 2049	0	1,800	300	1,400	200	7,000	6,000	1,100	5,000	100	23,000
2049 - 2050	0	1,800	300	1,400	200	7,000	6,000	1,100	5,000	100	23,000
2050 - 2051	0	1,800	300	1,400	200	7,000	6,000	1,100	5,000	100	23,000
2051 - 2052	0	1,800	300	1,400	200	7,000	6,000	1,100	5,000	100	23,000
2052 - 2053	0	1,800	300	1,400	200	7,000	6,000	1,100	5,000	100	23,000
2053 - 2054	0	1,800	300	1,400	200	7,000	6,000	1,100	5,000	100	23,000
2054 - 2055	0	1,800	300	1,400	200	7,000	6,000	1,100	5,000	100	23,000
2055 - 2056	0	1,800	300	1,400	200	7,000	6,000	1,100	5,000	100	23,000
2056 - 2057	0	1,800	300	1,400	200	7,000	6,000	1,100	5,000	100	23,000
2057 - 2058	0	1,800	300	1,400	200	7,000	6,000	1,100	5,000	100	23,000
2058 - 2059	0	1,800	300	1,400	200	7,000	6,000	1,100	5,000	100	23,000
2059 - 2060	0	1,800	300	1,400	200	7,000	6,000	1,100	5,000	100	23,000
2060 - 2061	0	1,800	300	1,400	200	7,000	6,000	1,100	5,000	100	23,000
2061 - 2062	0	1,800	300	1,400	200	7,000	6,000	1,100	5,000	100	23,000
2062 - 2063	0	1,800	300	1,400	200	7,000	6,000	1,100	5,000	100	23,000
2063 - 2064	0	1,800	300	1,400	200	7,000	6,000	1,100	5,000	100	23,000
2064 - 2065	0	1,800	300	1,400	200	7,000	6,000	1,100	5,000	100	23,000
2065 - 2066	0	1,800	300	1,400	200	7,000	6,000	1,100	5,000	100	23,000
2066 - 2067	0	1,800	300	1,400	200	7,000	6,000	1,100	5,000	100	23,000
2067 - 2068	0	1,800	300	1,400	200	7,000	6,000	1,100	5,000	100	23,000
2068 - 2069	0	1,800	300	1,400	200	7,000	6,000	1,100	5,000	100	23,000
2069 - 2070	0	1,800	300	1,400	200	7,000	6,000	1,100	5,000	100	23,000
17/18-69/70 Avg	0	1,500	300	1,800	200	7,000	5,100	1,000	6,000	100	23,000

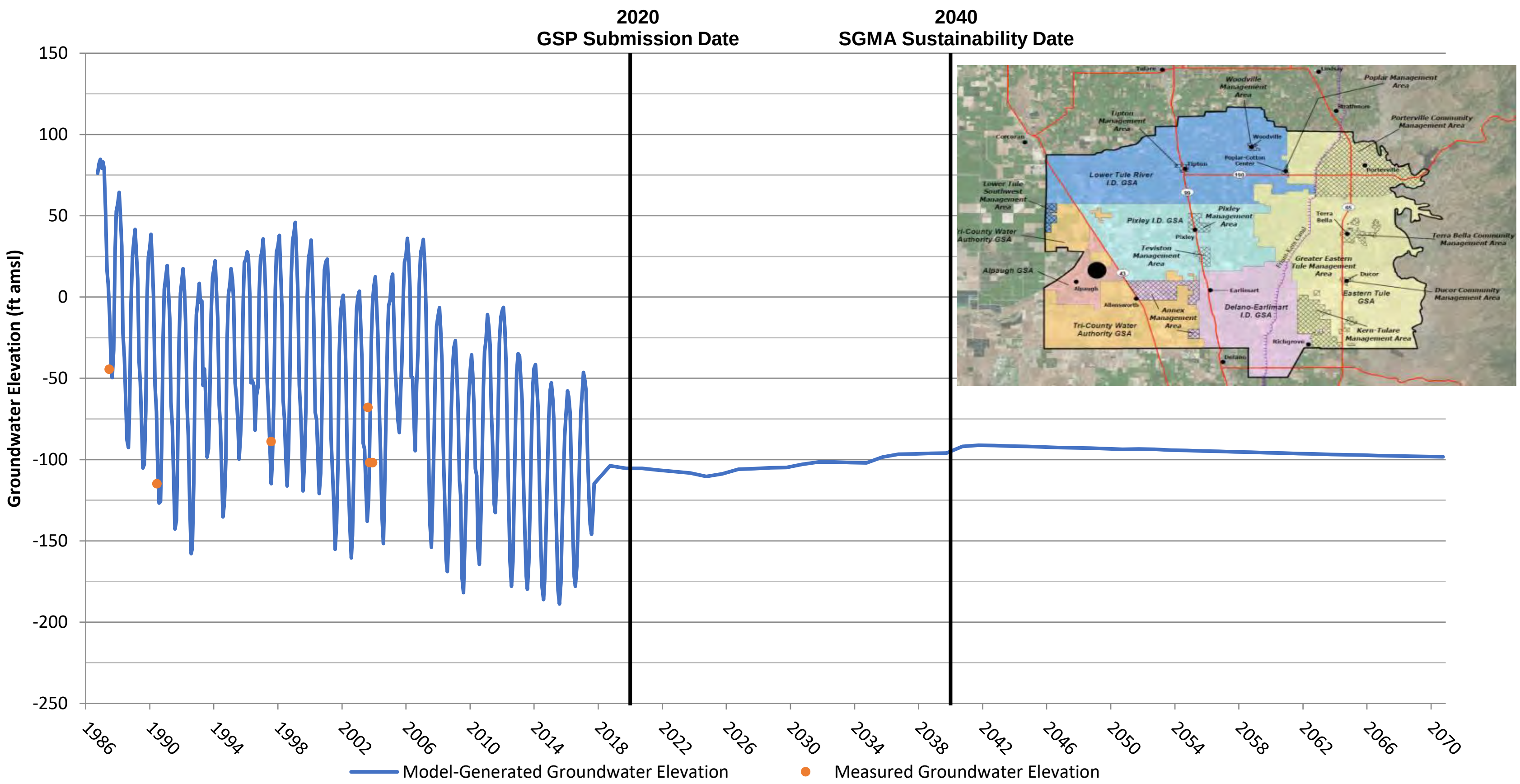
Projected Future Alpaugh GSA Groundwater Budget

Water Year	Groundwater Inflows (acre-ft)								Total In	Groundwater Outflows (acre-ft)				Total Out	Change in Storage (acre-ft)
	Areal Recharge from Precipitation	Imported Water Deliveries	Deer Creek	Agricultural Pumping	Municipal Pumping	Release of Water from Compression of Aquitards	Sub-surface Inflow			Groundwater Pumping		Sub-surface Outflow			
		Return Flow	Return Flow	Return Flow	Return Flow		From Outside Subbasin	From Other GSAs		Municipal	Agricultural	To Outside Subbasin	To Other GSAs		
2017 - 2018	0	800	100	3,300	200	3,000	5,000	29,000	41,000	300	15,000	3,000	25,000	43,000	-2,000
2018 - 2019	0	800	100	3,300	200	3,000	4,000	29,000	40,000	300	15,000	4,000	24,000	43,000	-3,000
2019 - 2020	0	800	100	3,300	200	3,000	4,000	28,000	39,000	300	15,000	4,000	23,000	42,000	-3,000
2020 - 2021	0	800	100	3,300	200	3,000	3,000	28,000	38,000	300	15,000	4,000	22,000	41,000	-3,000
2021 - 2022	0	800	100	3,200	200	3,000	3,000	27,000	37,000	300	14,000	4,000	21,000	39,000	-2,000
2022 - 2023	0	800	100	3,200	200	3,000	3,000	27,000	37,000	300	14,000	5,000	21,000	40,000	-3,000
2023 - 2024	0	800	100	3,100	200	3,000	2,000	27,000	36,000	300	13,000	5,000	20,000	38,000	-2,000
2024 - 2025	0	800	100	3,000	200	3,000	2,000	27,000	36,000	300	13,000	5,000	20,000	38,000	-2,000
2025 - 2026	0	1,100	300	2,400	200	3,000	2,000	25,000	34,000	300	10,000	6,000	19,000	35,000	-1,000
2026 - 2027	0	1,100	300	2,300	200	3,000	2,000	26,000	35,000	300	10,000	7,000	19,000	36,000	-1,000
2027 - 2028	0	1,100	300	2,200	200	3,000	2,000	26,000	35,000	300	10,000	8,000	19,000	37,000	-2,000
2028 - 2029	0	1,100	300	2,100	200	3,000	2,000	27,000	36,000	300	9,000	8,000	19,000	36,000	0
2029 - 2030	0	1,000	300	2,100	200	3,000	2,000	30,000	39,000	300	9,000	9,000	20,000	38,000	1,000
2030 - 2031	0	1,300	300	1,800	200	2,000	2,000	30,000	38,000	300	8,000	10,000	21,000	39,000	-1,000
2031 - 2032	0	1,300	300	1,800	200	2,000	2,000	32,000	40,000	300	8,000	10,000	22,000	40,000	0
2032 - 2033	0	1,300	300	1,800	200	2,000	2,000	33,000	41,000	300	8,000	11,000	23,000	42,000	-1,000
2033 - 2034	0	1,300	300	1,800	200	2,000	2,000	35,000	43,000	300	8,000	11,000	24,000	43,000	0
2034 - 2035	0	1,300	300	1,800	200	2,000	2,000	36,000	44,000	300	8,000	12,000	24,000	44,000	0
2035 - 2036	0	1,600	300	1,500	200	2,000	2,000	37,000	45,000	300	7,000	12,000	25,000	44,000	1,000
2036 - 2037	0	1,600	300	1,500	200	2,000	2,000	37,000	45,000	300	7,000	12,000	26,000	45,000	0
2037 - 2038	0	1,600	300	1,500	200	2,000	2,000	38,000	46,000	300	7,000	13,000	26,000	46,000	0
2038 - 2039	0	1,600	300	1,500	200	2,000	2,000	38,000	46,000	300	7,000	13,000	26,000	46,000	0
2039 - 2040	0	1,600	300	1,500	200	1,000	2,000	39,000	46,000	300	7,000	13,000	26,000	46,000	0
2040 - 2041	0	1,800	300	1,400	200	1,000	2,000	39,000	46,000	300	6,000	13,000	27,000	46,000	0
2041 - 2042	0	1,800	300	1,400	200	1,000	2,000	39,000	46,000	300	6,000	13,000	27,000	46,000	0
2042 - 2043	0	1,800	300	1,400	200	1,000	2,000	39,000	46,000	300	6,000	13,000	26,000	45,000	1,000
2043 - 2044	0	1,800	300	1,400	200	1,000	2,000	39,000	46,000	300	6,000	13,000	27,000	46,000	0
2044 - 2045	0	1,800	300	1,400	200	1,000	2,000	39,000	46,000	300	6,000	13,000	26,000	45,000	1,000
2045 - 2046	0	1,800	300	1,400	200	1,000	1,000	39,000	45,000	300	6,000	13,000	26,000	45,000	0
2046 - 2047	0	1,800	300	1,400	200	1,000	1,000	39,000	45,000	300	6,000	13,000	26,000	45,000	0
2047 - 2048	0	1,800	300	1,400	200	1,000	1,000	39,000	45,000	300	6,000	13,000	26,000	45,000	0
2048 - 2049	0	1,800	300	1,400	200	1,000	1,000	39,000	45,000	300	6,000	13,000	26,000	45,000	0
2049 - 2050	0	1,800	300	1,400	200	1,000	1,000	39,000	45,000	300	6,000	13,000	26,000	45,000	0
2050 - 2051	0	1,800	300	1,400	200	1,000	1,000	38,000	44,000	300	6,000	13,000	26,000	45,000	-1,000
2051 - 2052	0	1,800	300	1,400	200	1,000	1,000	38,000	44,000	300	6,000	13,000	26,000	45,000	-1,000
2052 - 2053	0	1,800	300	1,400	200	1,000	1,000	38,000	44,000	300	6,000	13,000	26,000	45,000	-1,000
2053 - 2054	0	1,800	300	1,400	200	1,000	1,000	38,000	44,000	300	6,000	13,000	26,000	45,000	-1,000
2054 - 2055	0	1,800	300	1,400	200	1,000	1,000	38,000	44,000	300	6,000	13,000	26,000	45,000	-1,000
2055 - 2056	0	1,800	300	1,400	200	1,000	1,000	38,000	44,000	300	6,000	13,000	26,000	45,000	-1,000
2056 - 2057	0	1,800	300	1,400	200	1,000	1,000	38,000	44,000	300	6,000	13,000	25,000	44,000	0
2057 - 2058	0	1,800	300	1,400	200	1,000	1,000	38,000	44,000	300	6,000	13,000	25,000	44,000	0
2058 - 2059	0	1,800	300	1,400	200	1,000	1,000	38,000	44,000	300	6,000	13,000	25,000	44,000	0
2059 - 2060	0	1,800	300	1,400	200	1,000	1,000	38,000	44,000	300	6,000	13,000	25,000	44,000	0
2060 - 2061	0	1,800	300	1,400	200	1,000	1,000	38,000	44,000	300	6,000	13,000	25,000	44,000	0
2061 - 2062	0	1,800	300	1,400	200	1,000	1,000	38,000	44,000	300	6,000	13,000	25,000	44,000	0
2062 - 2063	0	1,800	300	1,400	200	1,000	1,000	38,000	44,000	300	6,000	13,000	25,000	44,000	0
2063 - 2064	0	1,800	300	1,400	200	1,000	1,000	38,000	44,000	300	6,000	13,000	25,000	44,000	0
2064 - 2065	0	1,800	300	1,400	200	1,000	1,000	38,000	44,000	300	6,000	13,000	25,000	44,000	0
2065 - 2066	0	1,800	300	1,400	200	1,000	1,000	38,000	44,000	300	6,000	13,000	25,000	44,000	0
2066 - 2067	0	1,800	300	1,400	200	1,000	1,000	38,000	44,000	300	6,000	13,000	25,000	44,000	0
2067 - 2068	0	1,800	300	1,400	200	1,000	1,000	38,000	44,000	300	6,000	13,000	25,000	44,000	0
2068 - 2069	0	1,800	300	1,400	200	1,000	1,000	38,000	44,000	300	6,000	13,000	25,000	44,000	0
2069 - 2070	0	1,800	300	1,400	200	1,000	1,000	38,000	44,000	300	6,000	13,000	25,000	44,000	0
17/18-69/70 Avg	0	1,500	300	1,800	200	2,000	2,000	35,000	43,000	300	8,000	11,000	24,000	43,000	0

Alpaugh GSA
Representative Monitoring Site

Appendix **F**
Figure 1

Well 51
Lower Aquifer
Perforations: -563 to -1,193 (ft amsl)



Thomas Harder & Co.
Groundwater Consulting

January 20**20**

APPENDIX H

PUBLIC REVIEW COMMENTS & RESPONSES

Tri-County Water Authority – Groundwater Sustainability Plan (GSP)

The following table identifies the Comments/Comment Letters Received on the GSP. Each letter is designated a letter code, and each letter is divided into separate comments, where the *Issue Addressed* column captures the main topic(s) addressed by the comments. Note that similar comments are addressed by referring to the response where the comment was first addressed. A copy of each of the comment letters is provided after the responses. Note – the Letter Code in the table is linked to where the letter is addressed below, and the Full Name is linked to the comment letter itself.

Letter Code	Full Name	Comment Type	Comment Code	Issue Addressed
A	California Department of Fish and Wildlife (CDFW) , Julie A. Vance, Regional Manager, Central Region	Letter	A-1	Plan Area
			A-2	Interconnected Surface Waters (ISWs)
			A-3	Groundwater-Dependent Ecosystems (GDEs)
			A-4	Sustainable Management Criteria
			A-5	Monitoring Network
			A-6	Projects and Management Actions
B	Friant Water Authority (FWA), Jason Phillips, CEO	Letter	B-1	Outreach/Collaboration
			B-2	Friant-Kern Canal (FKC) Subsidence
			B-3	Impacts of subsidence on the FKC and Minimum Thresholds
			B-4	Undesirable Result Criteria
			B-5	Site Specific Monitoring
			B-6	Subsidence and Loss of Water Deliveries
			B-7	Management Actions to Mitigate Subsidence
C	U.S. Department of the Interior – Bureau of Reclamation (USDOI – BOR) – Mid-Pacific Region, South-Central California Area Office, Michael P. Jackson, P.E., Area Manager	Letter	C-1	Friant-Kern Canal – Water Deliveries/Land Subsidence
			C-2	Concurrence with Friant Water Authority Letter
D	Delano-Earlimart Irrigation District (DEID) GSA, Lower Tule River Irrigation District (LTRID) GSA, Pixley irrigation District (PID) GSA, Eric Quinley – Manager DEID GSA, Eric Limas – Manager LTRID GSA and PID GSA	Letter	D-1	Angiola Water District – Prescriptive Groundwater Right
			D-2	Groundwater Sustainable Yield
			D-3	Management Actions
E	Shafter-Wasco Irrigation District	Letter	E-1	Minimum Thresholds and Undesirable Results in Adjacent Basins

	(SWID), Craig Fulwyler – SWID President, Edwin Camp, Arvin-Edison Water Storage District (AEWSD) President		E-2	FKC, Subsidence and Water Supply Losses
			E-3	FKC – Subsidence and Increased O&M Costs
			E-4	Undesirable Results – Minimum Thresholds at Representative Monitoring Sites (RMS).
			E-5	Management Actions to Mitigate Continued Subsidence
F	Lindsay-Strathmore Irrigation District (LSID), Craig N. Wallace – General Manager	Letter	F-1	Concurrence with FWA Comment Letter
			F-2	Subsidence – FKC and Criteria for Establishing Undesirable Results
G	Tulare County	Letter	G-1	Disadvantaged Communities
			G-2	Executive Summary Correction
			G-3	Allensworth Municipal Wells
			G-4	Land Use Designations
			G-5	Allensworth Wells
			G-6	Water Supply Table
			G-7	Allensworth CSD – Growth
			G-8	Allensworth - Arsenic
			G-9	Future Project – Construction of New Well
			G-10	West of Earlimart – Proposed Study
			G-11	Prosperity Farms Project
H	Hancock Farmland Services (HFS), Molly Thurman – Water Resource Manager	Letter	H-1	Allocation of Groundwater
			H-2	Groundwater Credits
			H-3	Sustainability Target Date
I	The Nature Conservancy (TNC), Sandi Matsumoto, Associate Director, California Water Program	Letter	I-1	Notice & Communication: Identification of Groundwater Beneficial Uses/Stakeholders
			I-2	General Plans – Description of the Plan Area/Land Use Elements
			I-3	New/Replacement Wells Permitting Process / Well Construction Policies
			I-4	Hydrogeologic Conceptual Model (HCM) – Basin Boundaries
			I-5	HCM – Cross Sections
			I-6	HCM – Principal Aquifer and Aquitards
			I-7	HCM – Groundwater Elevation
			I-8	HCM – Groundwater Quality
			I-9	ISW – Groundwater Discharge Areas
			I-10	ISW Systems

			I-11	Identifying and Mapping GDEs
			I-12	Describing GDEs
			I-13	Water Budget - Evapotranspiration
			I-14	Monitoring and Analysis – Data Gaps
			I-15	Sustainability Goal – Sustainable Groundwater Management Criteria – Recognition of GDEs and ISWs
			I-16	Sustainability Goal – Inclusion of GDEs and ISWs
			I-17	Measurable Objectives – Consideration of GDEs and ISWs
			I-18	Minimum Thresholds – Recognition of All Potential Beneficial Users
			1-19	Undesirable Results – Recognition of GDEs and ISWs
			I-20	Undesirable Results (Degraded Groundwater Quality) – Address Potential Impacts to GDEs and ISWs
			I-21	Undesirable Results (Depletion of ISWs) – Assessment of GDEs and ISWs
			I-22	Undesirable Results
			I-23	Monitoring Network – Inclusion of GDEs and ISWs
			I-24	Projects and Management Actions – Inclusion of GDEs and ISWs
J	Local Government Commission (LGC), Danielle V. Dolan - Water Program Director; Clean Water Action (CWA)/ Clean Water Fund (CWF), Jennifer Clary – Water Program Manager; Audobon California, Samantha Arthur – Working Lands Program Director; The Nature Conservancy (TNC), Sandi Matsumoto – Associate Director – California Water Program	Letter	J-1	Identification of Beneficial Users
			J-2	Notice & Communication - Stakeholder Communication and Engagement Plan (SCEP)
			J-3	Maps Related to Key Beneficial Uses
			J-4	Water Budget
			J-5	Management Areas & Monitoring Network
			J-6	Measurable Objectives, Minimum Thresholds, and Undesirable Results
			J-7	Management Actions and Costs
K	Global Ag Properties USA, LLC.. Mark Coelho, Vice President	E-Mail	K-1	Groundwater Allocation Structure
			K-2	On-Farm Recharge Projects
			K-3	Sustainable Management Criteria
			K-4	Timeline to Address Overdraft

RESPONSE TO COMMENTS

LETTER A - CDFW

Comment A-1: Plan Area

The comment notes that the GSP recognizes that the Allensworth Ecological Reserve (ER) is owned by CDFW and adds that the ER has four wells, but that the ownership and related groundwater rights of those four wells were retained by the previous owner. Hence, CDFW does not own any wells on the ER.

Response:

Comment noted. The GSP has been amended to include the information provided regarding the four wells within the Allensworth ER.

Comment A-2: ISWs

The comment notes that the ISW analysis lacks sufficient evidence to justify an absence of interconnected streams in the Subbasin and recommends that the GSP clarify the approach used to analyze streams for interconnectivity and to define a clear and expeditious path to improved shallow groundwater and surface water monitoring for periodic re-analysis of surface water-groundwater interconnectivity.

Response:

As noted in the GSP, although shallow groundwater is common beneath the Tulare Lakebed, there is no indication that any of the streams in the GSA are in hydraulic connection with the shallow groundwater. It also noted that when there is water present in the Tulare Lakebed, water may temporarily be in hydraulic connection with the shallow groundwater in some locations. However, groundwater monitoring at agricultural drainage water evaporation ponds has not indicated that there is a hydraulic connection between water in the ponds and the underlying groundwater. Further, there are no records of pumping of this shallow groundwater in the lakebed area, due to its high salinity. Further, as noted in the Tule Subbasin Monitoring Plan (SMP), Surface water flow in the White River does not reach the Tulare Lake bed, and surface water flow in the Tule River and Deer Creek only flow into the historical Tulare Lake during periods of prolonged above-normal precipitation.

Regardless, the Final GSP notes that there currently is not sufficient data available to accurately determine areas of shallow groundwater within the North and Southeast Management Areas, hence this is recognized as a data gap. Additional evaluation is needed to determine connectivity between surface water and groundwater. Therefore, if data (obtained from the proposed monitoring network) shows that lands within the TCWA are underlain by shallow groundwater and it is likely that these areas could support GDEs, TCWA will consider installing an appropriate number of shallow monitor wells as funding becomes available. Data obtained from these monitor wells will determine if the water is shallow enough (less than 30 feet below ground surface) to support preliminary locations of potential GDEs.

Further, as provided in the Tule SMP, new lower aquifer wells will be drilled in areas where there currently are no monitor wells to fill data gaps.

Comment A-3: GDEs

The comment notes that the GSP recognizes the presence of GDEs within the GSA that may depend on groundwater and recommends including additional references for a more robust GDE evaluation. The comment includes information on several additional references.

Response:

The GSP has been amended to reflect preliminary review of the resources recommended by CDFW.

Comment A-4: Sustainable Management Criteria

The comment notes that sustainable management criteria do not reflect a ‘Critically Overdrafted’ basin status and demonstrate no consideration of undesirable results for environmental beneficial uses and users of groundwater. The comment notes that the groundwater trends and resulting adverse impacts identified in the GSP support the Subbasin characterization as ‘Critically Overdrafted’, meaning “continuation of present water management practices [in the basin] would probably result in significant adverse overdraft-related environmental, social, or economic impacts” (CDWR “Critically Overdrafted”). The comment further notes that the GSP is proposing minimum thresholds (MTs) that are significantly lower than current groundwater elevations and that the GSP’s MTs may therefore allow for 20 implementation years of groundwater table decline – mirroring the historical trends that led to the subbasin’s Critically Overdrafted status. The comment recommends reconsideration of MTs after collection of additional shallow groundwater data and to reanalyze the presence of ISWs.

Response:

Comment noted. Please refer to the response to Comment A-2. The Final GSP identifies GDEs as beneficial user/uses of groundwater. Therefore, potential impacts to GDEs and the wildlife species that may depend on these habitat areas will be considered. However, as additional data is needed in order to confirm parcels currently identified as potential GDEs, any impact evaluation of species that may depend on these areas for nesting/breeding or utilize these areas as foraging habitat is premature. TCWA will consider impacts to these potential plant and habitat communities pending acquisition of depth to groundwater data.

As noted in the GSP minimum thresholds in the Southeast Area will be different compared to those in the North Area.

Comment A-5: Monitoring

The comment states that shallow groundwater monitoring wells are lacking in number and distribution and that the GSP narrative conflicts on data collection frequency. The comment recommends installing additional shallow groundwater monitoring wells near GDE's and ISWs and to clarify groundwater elevation data collection frequency.

<u>Response:</u>

Comment noted. Refer to the response to Comment A-2 above.

Comment A-6: Projects and Management Actions

The comment notes that conversion of pumping from the Lower Aquifer to the Upper Aquifer to mitigate subsidence may incur other risks, including localized subsidence in shallower fine-grained material and degradation of the relatively 'stable' Upper Aquifer. The comment recommends that the GSP clarify have the GSA will identify and analyze potential adverse impacts of this proposed management action and to identify potential mitigation strategies for increased Upper Aquifer pumping to avoid undesirable results.

<u>Response:</u>

TCWA intends to monitor the effects of the conversion from lower aquifer pumping to upper aquifer pumping. TCWA understands that there is a limit to the amount of pumping that can be converted without creating undesirable results and will monitor the situation as conversions are accomplished.

LETTER B - FWA

Comment B-1: Outreach/Collaboration

The comment expresses appreciation for the outreach efforts undertaken by the GSAs to engage and work with the FWA. The FWA supports the adoption and implementation of the GSPs with the exceptions identified in the letter.

<u>Response:</u>

Comment noted. TCWA will continue to work with the FWA to ensure that all concerns are addressed.

Comment B-2: FKC Subsidence

The comment notes that allowing continued unmitigated subsidence to the FKC is unacceptable and that feasible solutions must be identified.

Response:

Tri-County Water Authority agrees that pumping in the vicinity of the Friant-Kern Canal is the cause of subsidence of the canal and that this pumping should be reduced. It also asserts that pumping that occurs miles away from the canal is not the cause of the subsidence of the canal. However, subsidence in other areas of the county also causes damaging effects to infrastructure in those areas – damage to well casings, roads and local canals. Therefore, TCWA has set as a goal to reduce pumping from beneath the Corcoran Clay by converting some lower aquifer pumping to upper aquifer pumping, by implementing supplemental surface water projects, and by reduction of groundwater demands through reduction of irrigate acreage.

Comment B-3: Impacts of subsidence on the FKC and Minimum Thresholds

The comment emphasizes the importance of the FKC with respect to conveyance of water for beneficial use. It notes that groundwater pumping in the vicinity of the FKC has resulted in upwards of 9 feet of land subsidence in recent decades – several feet occurring in recent years after the adoption of SGMA. The comment also notes that the FKC delivery system relies on a gravity design where subsidence has reduced the capacity of the Canal to 40% of its original capacity. This has precluded delivery of significant amounts of water to Friant Districts below the subsided areas and affects Friant Districts above the constricted area to engage in water transfers. The FWA notes that due to the overdraft conditions of the Tule Subbasin, plans are being developed at considerable expense to address the subsidence impacts by restoring capacity through the Friant-Kern Canal Middle Reach Capacity Project. Given this, FWA is dissatisfied with the proposed minimum thresholds for subsidence and the criteria used to define undesirable results. The GSPs allows for up to 3 feet of additional subsidence along the canal caused by transitional pumping before the minimum thresholds are exceeded.

Response:

Pumping in the vicinity of the Friant-Kern Canal should be immediately ceased. It has been shown that cessation of pumping in the vicinity of a subsidence area has an immediate effect on subsidence in that area. Pumping that is occurring miles away from the canal does not cause subsidence of the canal but does cause subsidence in the area where pumping is occurring. Therefore, steps are being taken by TCWA to reduce subsidence in its area.

Comment B-4: Undesirable Result Criteria

This comment refers to Representative Monitoring Sites (RMS) along the most severely subsided portion of the FKC as identified within the ETGSA GSP. The comment specially notes that the criteria for an undesirable result (greater than 50% of GSA Management Area RMS) is unacceptable unless there is compensation to FWA and the Friant Districts to pay for the damages resulting from transitional overdraft pumping. The comment notes that if the GSAs agree to adopt management actions to compensate for the continuation of subsidence until the proposed MTs are reached, the FWA would not object to the GSPs maintaining these objectives if used as a basis for additional management actions but not as MTs that must be exceeded before management actions are taken.

Response:

The initial mitigation steps should occur in the area next to the Friant-Kern Canal. It is agreed that pumping in the immediate vicinity of the canal is causing subsidence of the canal and pumping in the vicinity of the canal should be reduced as quickly as possible.

Comment B-5: Site Specific Monitoring

The comment notes the need for site specific monitoring of any continued undesirable results for land subsidence pertaining to the FKC, and that the criteria for undesirable result should be based on any additional subsidence detected at a single RMS location. The comment recommends that the Tule Subbasin GSPs incorporate additional RMS along the FKC (within the entire length of the Tule Subbasin) and that such RMS locations be spaced no more than 1 mile apart.

Response:

Comment Noted – TCWA does not have wells along the FKC.

Comment B-6: Subsidence and Loss of Water Deliveries

This comment notes the loss of the FKC's conveyance capacity due to 3 additional feet of subsidence predicted over the first 15 years of the GSPs. The FWA estimates that this level of subsidence will result in further reduced water deliveries to Friant Districts below the impacted area in the order of at least 30,000 to 40,000 acre-feet (AF) per year in addition to the inability to convey water during wet years. For 2017 and 2019 FWA estimates that 300,000 plus AF could have been delivered to Friant Districts if not for the capacity restrictions caused by subsidence dur to overdraft groundwater pumping in the Tule Subbasin.

Response:

Comment noted. See responses to previous comments.

Comment B-7: Management Actions to Mitigate Subsidence

This comment notes that the GSPs do not include any management actions or mitigation to address continued subsidence impacts to the Canal especially as the GSPs allow for continued overdraft condition (transitional pumping) through the implementation period of 2014. The comment notes that due the impacts highlighted in this letter, all further subsidence along the Canal should be considered significant and unreasonable and deemed to substantially interfere with surface land uses unless appropriate mitigation is provided. Hence, the comment notes the need for the GSPs to be revised to mandate adoption of management actions that provide for compensation as a condition of the transitional groundwater pumping permitted under each GSP in areas where such pumping can reasonably be demonstrated to cause continued subsidence impacts to the FKC. Hence, the FWA requests that the Board of each GSA direct staff to work with FWA and Friant Districts to develop and bring back for adoption management actions that would establish mechanisms to mitigate future subsidence impacts in the form of compensation to FWA and Friant Districts to pay for repairs to the FKC.

Response:

Comment noted.

LETTER C – U.S. DOI - BOR

Comment C-1: Friant-Kern Canal – Water Deliveries/Land Subsidence

The comment notes that the Friant-kern Canal is one of the most critical features of infrastructure to manage, develop, and protect water and related resources in the interest of the American Public. The purpose of the canal was to, among other things, combat issues such as subsidence by conveying surface water to incentivize farmers to pump less ground water. The comment notes that the system has performed as intended for decades. The comment notes that after the prolonged drought that ended in 2017, it was discovered that about 60% of the Friant-Kern canal delivery capacity had been lost due to severe land subsidence, and that this was caused largely by the over-pumping of groundwater on lands not currently served by surface water that lie within the Tule Subbasin GSAs. The FWA estimates that the Friant-Kern Canal will be operating at 30% capacity within three years.

Response:

Comment noted. Refer to the responses to Comment Letter B above.

Comment C-2: Concurrence with the Comment Letter submitted by the Friant Water Authority dated December 16, 2019.

Response:

The comment letter has been received and comments noted.

LETTER D – DEID, LTRID, PID

Comment D-1: Angiola Water District – Prescriptive Groundwater Right

The comment notes that TCWA asserts a prescriptive groundwater right for Angiola Water District. It notes that this has been disputed by many parties in the Tule Subbasin and should therefore not be relied upon by the TCWA GSP as the basis for continued groundwater overdraft by TCWA members.

Response:

Comment noted.

Comment D-2: Groundwater Sustainable Yield

The comment notes that the GSP does not appear to adopt the groundwater sustainable yield concepts that a majority of the Tule Subbasin GSAs have agreed to utilize in their GSPs. Failure to do so will result in de-facto non-coordination of the Tule Subbasin plans which exposes the entire Subbasin to a "probationary" determination by the Department of Water Resources (DWR).

Response:

Sustainable yield values developed by TCWA are within the range of values that have been developed by the Tule Subbasin.

Comment D-3: Management Action

The comment notes that the GSP does not appear to identify any meaningful management actions that would be reasonably expected to bring groundwater use in the TCWA service area to within sustainable levels within the planning time frame.

Response:

TCWA's GSP notes that the current levels of groundwater pumpage, particularly in the Southeast Area are not sustainable. The solution is to develop additional surface water supplies or to reduce pumpage. The Board of Directors of TCWA will take the appropriate actions once information is developed during the first five years of the program.

LETTER E – SWID, AEWSD

Comment E-1: Minimum Thresholds and Undesirable Results in Adjacent Basins

The comment notes that Friant Districts (AEWSD and SWID) are concerned that the minimum thresholds in the Tule Subbasin GSPs are not protective of the beneficial water users downstream of the Tule Subbasin which will negatively impact the Friant Districts by limiting their ability to receive significant quantities of their contracted surface water imports due to past and ongoing subsidence within the Tule Subbasin.

Response:

Subsidence along the Friant Kern Canal is ascribed to pumping in the vicinity of the canal. See TCWA's response to FWA Comment B-3. TCWA concurs that pumping in the vicinity of the canal is the cause of the subsidence of the canal. TCWA does not have wells in the vicinity of the canal.

Comment E-2: Friant-kern Canal, Subsidence and Water Supply Losses

The comment references the *Friant-Kern Canal Middle Reach Capacity Correction Project Draft Recommended Plan Report* (Report) which states that an average annual loss of up to 145,000 acre-feet per year of surface water supply caused by continued land subsidence and the corresponding reduction in the conveyance capacity of the Friant-Kern Canal. The comment notes that the Friant water Districts' imported surface water supplies through FKC will be restricted thereby compromising the District's ability to contribute to the sustainable management of the Kern Subbasin. The Friant Districts take exception to the Tule Subbasin GSPs that assume up to a maximum of 3 feet of additional subsidence along the KFC. As current conditions already restrict KFC deliveries, any further subsidence would be significant and unreasonable and substantially interfere with surface land uses. The Friant Districts recommend that the Tule Subbasin GSPs include immediate management actions that provide for no additional subsidence beyond the legacy subsidence.

Response:

See TCWA's response to FWA Comment B-3, above.

Comment E-3: Friant-Kern Canal – Subsidence and Increased O&M Costs

The comment notes that FKC contractors located upstream of the Tule Subbasin would also experience negative financial impacts as FWA's FKC O&M costs recovery is based on actual deliveries. Hence, with continued subsidence, the Friant Districts deliveries will be reduced resulting in an increase in northern FKC contractors prorate share of the O&M costs.

Response:

Comment noted.

Comment E-4: Undesirable Results – Minimum Thresholds (MT) at Representative Monitoring Sites (RMS)

The comment notes that the Tule Subbasin GSPs define an Undesirable Result for subsidence to occur when subsidence minimum thresholds are exceeded at greater than 50% of RMS on a Management Area basis. The comment notes that this would allow exceedances of MTs at multiple RMS without it being deemed an Undesirable Result. The comment further states that the GSPs do not clarify the projects or management actions that would be taken to avoid such Undesirable Results. The Friant Districts recommend an Undesirable Result at just 1 RMS.

Response:

Comment noted.

Comment E-5: Management Actions to Mitigate Continued Subsidence

The comment notes that the Tule Subbasin GSPs with the exception of DEID, do not propose any management actions to mitigate impacts from continued overdraft conditions through the implementation period of 2040 which has been modelled by the Tule Subbasin to cause subsidence. The comment notes that the Tule Subbasin Coordination Agreement recognizes that FKC subsidence may result in an interim loss of benefit to the users of such infrastructure and that exceedance of MTs could likely induce financial hardship on land and property interest.

Response:

Comment noted.

LETTER F – LSID

Comment F-1: Support of the FWA Comment Letter

The comment notes that it adopts each comment and objection in FWA's comment letter as its own.

Response:

Comment noted.

Comment F-2: Friant-Kern Canal Subsidence

The comment notes the importance of addressing and resolving the ongoing subsidence issues with FKC caused or exacerbated by groundwater pumping in the Tule Subbasin. It notes that allowing for 3 additional feet of subsidence along the FKC is unacceptable without adequate mitigation. It also states that it is unacceptable to further handicap this issue by requiring more than 50% of the RMS to show 3 feet of subsidence before considering this an undesirable result.

Response:

See TCWA response to FWA Comment B-4, above.

Letter G – Tulare County

Comment G-1: Disadvantaged Communities

The comment notes that growth is expected in the two rural disadvantaged communities (Allensworth and West of Earlimart).

Response:

Comment noted. The GSP has been revised to reflect municipal groundwater demands. Pumpage in Allensworth and West of Earlimart has been accounted for and allows for continued pumping in Allensworth and West of Earlimart. With the County's assistance, the pumpage West of Earlimart will be monitored and better estimates of water use in this community will be developed. Demands will be updated in 2025 as more information is gained.

Comment G-2: Executive Summary Correction

The comment notes that a correction is needed to identify that the project to convert lower aquifer pumping to upper aquifer pumping needs to be corrected to say that "This project involves drilling wells into the upper aquifer…" as the statement identified the lower aquifer.

Response:

Comment noted. The GSP has been corrected accordingly.

Comment G-3: Allensworth Municipal Wells

The comment notes that there may be impacts to the two municipal wells within Allensworth Community Services District. It adds that the South Management Area expanded significantly with pistachios which is highly reliant on groundwater, and although this will be transitioned during the implementation period, there is still a potential risk to these two wells in the meantime.

Response:

Comment noted. TCWA will monitor the semi-annual Allensworth well water levels.

Comment G-4: Land Use Designations

The comment recommends updating Figure 1.4.5 to show that the General Plan Land Use Designation for Allensworth is "Mixed Use".

Response:

Comment noted. Figure 1.4.5 has been revised accordingly.

Comment G-5: Allensworth Municipal Wells

The comment notes that there is a potential for the well to go dry due to continued groundwater level declines. It is assumed that this comment is referring to the two municipal wells within Allensworth.

Response:

Comment noted.

Comment G-6: Water Supply Table

The comment refers to Table 1.4.1 – Water Supply and Water Use for TCWA and notes that it should include rural domestic groundwater users.

Response:

Comment noted. As provided in the Tule SMP, it is recognized that there are some households in the rural portions of the Tule Subbasin that rely on private wells to meet their domestic water supply needs. However, based on the low population density of these areas, the volume of pumping from private domestic wells is considered negligible compared to the other pumping sources. Private domestic wells draw water from the upper aquifer. TCWA will develop upper aquifer water level maps to monitor the effects of upper aquifer pumping.

Comment G-7: Allensworth CSD – Growth

The comment provides information on the adopted Allensworth Hamlet Plan and the projected annual growth rate within this community.

Response:

Comment noted. Growth in municipal demand is accounted for in the water balance.

Comment G-8: Allensworth – Arsenic

This comment provides information on communities, including Allensworth, that face drinking water contamination from arsenic and nitrates. It includes a reference to the 2018 Annual Report for the Central Valley Disadvantaged Community Water Quality Grants Program, administered by the Rose Foundation. The comment specifically refers to the Supplemental Environmental Project (SEP) completed by Center on Race Poverty and the Environment for South San Joaquin Valley Watershed Improvement Programs: Promoting Community Participation.

Response:

Comment noted. As noted in the GSP, a future project includes construction of well to replace one of two domestic wells in Allensworth, and the addition of a 500,000-gallon storage tank in the community.

Comment G-9: Future Project – Construction of New Well

The comment refers to a future project to construct a new well to replace one of two existing wells within Allensworth CSD and to add a 500,000-gallon storage tank. The comment inquires if this future project is identified in anybody's budget.

Response:

Comment noted. Financing is being pursued by the CSD.

Comment G-10: West of Earlimart – Proposed Study

The comment expresses support for a study to determine the current water quality conditions within the small rural community identified in the GSP as "West of Earlimart" and if the community would benefit from a community water system.

Response:

Comment noted. Self-Help Enterprises has been contacted regarding a water system feasibility study for this community in cooperation with Tulare County.

Comment G-11: Prosperity Farms Project

The comment refers to a landowner sponsored groundwater recharge project identified as the Prosperity Farms Project. The comment notes that it is unclear how this project involves or affects the CSD's wells serving Allensworth. Figure 5.2.2 (Prosperity Farms) appears to show CSD wells but the description does not include a reference to the CSD.

Response:

Comment noted. A recharge project would likely benefit the Allensworth wells. However, the proximity of the project to the community wells will need to be considered when developing the recharge project.

Letter H – HFS

Comment H-1: Allocation of Groundwater

The comment outlines an allocation of groundwater methodology in the event it is contemplated by the GSA. The comment notes that the methodology should be consistent with various legal considerations drawn from applicable case law and attempt to be consistent with groundwater rights and recognizing that a GSA does not have statutory authority to make a final determination of water rights.

Response:

Comment noted.

Comment H-2: Groundwater Credits

The comment encourages the GSA to establish a policy for generating groundwater credits from project development and implementation by landowners.

Response:

Comment noted. The TCWA will take into consideration recommendations related to potential future projects and associated incentives to landowners. The projects currently identified in the GSP have been proposed by landowners. The initial evaluation conducted in the GSP represents a pre-feasibility review of the proposed projects subject to further evaluation to substantiate both the projected demand and availability/reliability of future surface water supplies.

Comment H-3: Sustainability Target Date

The comment refers to the GSP stating the plan is to address the 2040 deficit by 2030 and that this is a typographical error as SGMA requires sustainability by 2040 (not 2030).

Response:

Comment noted. The GSP identifies corrective measures to achieve balance by 2030 to allow ample time to monitor the effects of the corrections implemented and identify if additional revisions are needed in order to achieve sustainability by 2040.

Letter I – TNC

Comment I-1: Notice & Communication: Identification of Groundwater Beneficial Uses/Stakeholders

The comment asks that the GSP describe other beneficial users of groundwater in the Subbasin including GDE's managed wetlands, Protected Lands, including conservation areas and other protected lands, and Public Trust Uses. It also asks the GSP to identify environmental uses and users of groundwater.

Response:

Comment noted.

Comment I-2: General Plans – Description of the Plan Area/Land Use Elements

The comment asks that the GSP include a description of any current and planned instream flow requirements for Deer Creek. The comment also notes that General Plan objectives and policies for water resources management, and management and protection of aquatic, riparian and wetland resources should be discussed in the GSP, and how GSP implementation may affect and be coordinated with such policies and objectives. It also asks that all relevant HCPs and NCCPs within the Subbasin be identified, including any reaches with instream flow and critical habitat requirements. The comment adds that the GSP elaborate on the natural resources within the Subbasin and how the GSP implementation will coordinate with the goals of these plans. The comment also asks for a discussion regarding the management of protected species and their habitats for the aquatic ecosystems and its relationship to the GSP.

Response:

Comment noted.

Comment I-3: New/Replacement Wells Permitting Process/Well Construction Policies

The comment requests additional detail regarding the Tulare County well permitting program and how it will prevent potential adverse impacts to GDEs and ISWs. It also asks that the GSP acknowledge that future well permitting must be coordinated with the GSP to assure achievement of the GSP's sustainability goal. It also asks that the GSP state that well permitting programs will consider potential impacts of groundwater withdrawals on public trust resources when permitting new wells near streams with public trust uses.

Response:

Comment noted. Refer to the response to Comment A-2 above.

Comment I-4: Hydrogeologic Conceptual Model (HCM) – Basin Boundaries

The comment notes that groundwater extraction well depth data should be included in the determination of the basin bottom. It asks that groundwater well extractions from the deepest wells should be characterized in relation to defining the basin bottom.

Response:

Comment noted. The basin bottom is defined by the electrical conductivity/ total dissolved solids level of the groundwater. This is addressed in Chapter 2 of the GSP.

Comment I-5: HCM – Cross Sections

The comment asks that the GSP include near surface cross section details that depict the conceptual understanding of shallow groundwater and stream interactions at different locations, including the Shallow Zone, any perched aquifers, and the Upper Aquifer.

Response:

Comment noted. This is a data gap that will be addressed during the first five years of plan implementation.

Comment I-6: HCM – Principal Aquifer and Aquitards

The comment asks that the GSP explicitly enumerate the principal aquifer(s) and intervening aquitards, their relationship to each other, and their role in supplying groundwater to all beneficial users of groundwater. It also requests that the GSP clarify the connectivity of GDEs and ISWs to each aquifer.

Response:

Comment noted. Chapter 2 of the GSP contains a number of geologic cross sections of the Subbasin and contains detailed discussions of the geology of the area. Refer to the response to Comment A-2 above.

Comment I-7: HCM - Groundwater Elevation

The comment asks that the GSP provide groundwater level contour maps that are representative of the following: historical as well as current conditions; the uppermost aquifer on which GDEs and ISWs may be reliant. It also ask for dept to water contour maps that allow for interpretation of beneficial groundwater uses by environmental users.

Response:

Comment noted. This is a data gap that is planned to be addressed during the first five years of plan implementation. Refer to the response to Comment A-2 above.

Comment I-8: HCM – Groundwater Quality

The comment asks that the GSP modify Section 2.2.4 – Groundwater Quality – to include data about water quality in the zones where GDEs are present.

Response:

Comment noted.

Comment I-9: Interconnected Surface Waters (ISWs) – Groundwater Discharge Areas

The comment asks that the GSP include locations of phreatophytes and other GDEs to provide a complete representation of all groundwater discharge areas.

Response:

Comment noted. Refer to the response to Comment A-2.

Comment I-10: ISW Systems

The comment asks that data or analysis be provided to document that the streams in the GSA are not in hydraulic connection with shallow groundwater. It also asks that data gaps be identified.

Response:

Comment noted. This is a data gap that requires development of the occurrence of shallow groundwater within the GSA.

Comment I-11: Identifying and Mapping GDEs

The comment notes that the GSP acknowledges the potential for GDEs but that there's no documentation regarding depth to groundwater in areas near GDEs. It asks that depth to groundwater maps should be included in the GSP for the uppermost shallow groundwater system, unless determined to be perched. IT also asks that the GSP indicate what vegetation is present in the possible GDEs and if GDEs were eliminated or retained based solely on the 30-foot depth limit.

Response:

Comment noted. See response to Comment I-10 above.

Comment I-12: Describing GDEs

The comment asks that the GSP provide information on the historical and current groundwater conditions near the GDEs. I also asks for an ecological inventory for all potential GDEs and to identify if any endangered or threatened freshwater species of animal and plants, or areas with critical habitats have been identified in or near any of the GDEs.

Response:

Comment noted.

Comment I-13: Water Budget – Evapotranspiration

The comment asks that the GSP provide a breakdown of ET for all land-cover types, including environmental beneficial users, and to identify any data gaps.

Response:

Comment noted. This is a data gap that requires development of more information on the occurrence of GDEs.

Comment I-14: Monitoring and Analysis – Data Gaps

The comment asks that the GSP update the discussion on data gaps, where appropriate, to acknowledge the lack of detailed information on shallow groundwater in the upper aquifer, and its relationship to GDEs.

Response:

Comment noted.

Comment I-15: Sustainability Goal – Sustainable Groundwater Management Criteria – Recognition of GDEs and ISWs

The comment notes that as GDEs and ISWs may be present in and near the GSP area they should be explicitly recognized in the establishment of sustainable management criteria for the groundwater level decline and ISW sustainability indicators.

Response:

Comment noted. It is planned to address this data gap during the first five years of plan implementation. Refer to the response to Comment A-2 above.

Comment I-16: Sustainability Goal: Inclusion of GDEs and ISWs

The comment notes that the discussion of the sustainability goal should be expanded to include environmental uses/users of groundwater. It also not that as GDEs and ISWs may present – they should be recognized as beneficial users of groundwater and included in the sustainability goal. The comment also adds that as GDEs may be affected by water quality, they should be included in the sustainability goal and addressed in the sustainable management criteria established for the water quality sustainability indicator

Response:

Comment noted. It is planned to address this data gap during the first five years of plan implementation. Refer to the response to Comment A-2 above.

Comment I-17: Measurable Objectives – Consideration of GDEs and ISWs

The comment asks that the GSP include GDEs in Section 3.5 – Measurable Objectives – and whether the measurable objectives and interim milestones will help achieve the sustainability goal as it pertains to environmental beneficial users. The comment also asks that the GSP be modified to recognize the potential for ISWs, pending the characterization of the upper aquifer and analysis of monitoring data. The comment asks that Section 3.5 be modified to include impacts from degraded water quality on the plant and wildlife communities within GDEs. It also asks that the GSP acknowledge the potential for ISWs and GDEs and establish MOs for this indicator based on the discussion in Section 2.2.6 which states there may be a temporary connection between surface water in the upper aquifer system in the Tulare Lakebed.

Response:

Comment noted. It is planned to address this data gap during the first five years of plan implementation. Refer to the response to Comment A-2 above.

Comment I-18: Minimum Thresholds – Recognition of All Potential Beneficial Users

The comment notes that although there are many data gaps associated with GDEs and ISWs, it must be assumed that potential significant and unreasonable impacts to these beneficial users could occur and they should be addressed in the evaluation of MTs. It asks that Section 3.3.3. – Evaluation of Minimum Thresholds address how potential ISWs and GDEs would be affected by further lowering of groundwater levels. It also asks that the GSP include a discussion of GDEs and water quality and if the MTs and IMs will help achieve sustainability for environmental users.

Response:

Comment noted. Refer to the responses to the previous comments.

Comment I-19: Undesirable Results – Recognition of GDEs and ISWs

The comment asks that the GSP add “possible adverse impacts to potential GDEs and ISWs” to the list of potential undesirable results.

Response:

Comment noted. This will be developed after the plan is implemented. This is a data gap that must be addressed during the initial years of operation of the plan. Refer to the response to Comment A-2 above.

Comment I-20: Undesirable Results (Degraded Groundwater Quality) – Address Potential Impacts to GDEs and ISWs

The comment asks that Section 3.3 Undesirable Results (for degraded groundwater quality) be modified to address degraded water quality from TDS and B to the vegetative portion of GDEs and ISWs.

Response:

Comment noted.

Comment I-21: Undesirable Results (Depletion of ISWs) – Assessment of GDEs and ISWs

The comment asks that Section 3.3 Undesirable Results (for ISWs) be modified to include an assessment of the nature of potential undesirable results to ISWs and GDEs, a recognition of the existence of potential

GDEs and ISWs unless adequate data can be provided to dismiss them, a statement that aquifers will be managed such that there will be no depletion of ISWs that result in a significant and unreasonable impact to GDEs and any data gaps and specific steps to verify the presence or absence of ISWs and GDEs with monitoring wells screened at the appropriate depths.

Response:

Comment noted. Refer to the response to Comment A-2 above.

Comment I-22: Undesirable Results

The comment asks that biological data be compiled and synthesized for each GDE unit. It also asks that the GSP describe potential effects to GDEs, land uses and property interests. The comment also asks that any data gaps be identified including a plan on how to address the data gaps.

Response:

Comment noted. Refer to the response to Comment A-2 above.

Comment I-23: Monitoring Network – Inclusion of GDEs and ISWs

The comment asks that the monitoring network be revised to include methodologies, data and other information to support the monitoring of GDEs and ISWs to assess and prevent potential significant and unreasonable impacts. It notes that new wells should be located that are appropriately screened to detect connectivity of GDEs and ISWs with the upper aquifer and that additional stream gages should be identified or installed in areas where there is potential for ISWs and GDEs. This comment also asks that data gaps be reconciled along Deer Creek in this section of the GSP to improve ISW mapping in future GSPs.

Response:

Comment noted. Refer to the response to Comment A-2 above.

Comment I-24: Projects and Management Actions – Inclusion of GDEs and ISWs

The comment asks that the GSP with respect to the proposes projects consider stating how ISWs and GDEs will benefit or be protected, or what other environmental benefits will accrue. The comment also asks that if ISWs will not be adequately protected by the projects to include and describe additional management actions and projects that will protect ISWs. The comment also asks that for projects that construct recharge ponds, the GSP should consider identifying if there is habitat value incorporated into the design and how recharge ponds can be managed as multiple-benefit projects to benefit environmental users. The comment also notes that Chapter 5 (Projects and Management Actions) should identify the specific actions and schedules proposed to address data gaps in the hydrogeologic conceptual model, water budget and monitoring network.

Response:

Comment noted. Refer to the response to Comment J-7 below.

Letter J – LGC, CWA/CWF, Audubon California, TNC

Comment J-1: Identification of Beneficial Users

The comment notes that the GSP should identify whether tribes are present in the GSA or not. The comment also asks that the GSP identify the sources used to determine the presence of DACs. The Comment notes that the GSP should describe all beneficial users of groundwater in the Subbasin that may be affected by groundwater extraction. The comment also notes that MTs for water quality in areas where groundwater is use for drinking water should be tied to water quality standards and not just historic concentrations.

Response:

Comment noted.

Comment J-2: Notice & Communication - Stakeholder Communication and Engagement Plan (SCEP)

The comment notes that a SCEP should be attached to the GSP. It further notes that the GSP should identify how DAC beneficial users were engaged in the GSP planning process and that the GSP should provide a detailed description of stakeholder input and responses and how those are addressed by the decisions.

Response:

Comment noted. A list of public meetings addressing the GSP is included in Section 1.5.2 of the GSP. Section 1.5.3 of the GSP (Public Review Comments & Responses) provides a reference to Appendix H where the public review comments and responses have been compiled.

Comment J-3: Maps Related to Key Beneficial Uses

The comment notes that detailed information on domestic wells are lacking and that such information is essential for evaluating impacts of proposed MOs/MTs on domestic wells. The comment also notes that maps showing the representative monitoring network overlaid with DACs, GDEs, and other sensitive beneficial users should be included in the GSP. This comment also notes that depth to groundwater maps should be included for the uppermost shallow groundwater system, unless conclusively determined to be perched. The comment also requests a better evaluation of GDEs, and provide data do document the absence of interconnected surface water systems within the GSA.

Response: Comment Noted. Water quality at the town of Allensworth is monitored and reported to the State of California and will be included in TCWA's annual reports. Water quality monitoring results obtained from wells in the town of Alpaugh will be reported annually, or when the information is available. Owners of individual shallow domestic wells in the "white area" located West of Earlimart are not required to test or report water quality. The plan is to sample some of these wells if TCWA can obtain permission from the individual landowners to do so. There are a number of isolated domestic wells scattered throughout TCWA that are candidates for monitoring. It is planned to contact farm operators and land owners in an effort to obtain water quality samples from some of these wells. This is a data gap at this time – refer to the response to Comment A-2 above.

Comment J-4: Water Budget

The comment notes that no detailed description of the methodology used for calculating climate change impacts were included. The comment also notes that the GSP references Tables A-1a, A-1b, and A-1c being included in an appendix, but that the tables are not included in Appendix A. The comment also notes that it is unclear whether the GSP considered drinking water demands in the historic, current, and/or projected water budgets. It notes that water demands by domestic well users and those of the Allensworth CSD should be accounted for in all water budgets. It also requests a breakdown of ET for all land-cover types.

Response:

Comment noted. ET tables include the effects of climate change. See text – Chapter 2. Current and projected water demands by Allensworth and West of Earlimart have been included. ET values for Zone 15 are included in Appendix A-5. Tables A-1a, A-1b, and A-1c are provided is Appendix A-1a.

Comment J-5: Management Areas & Monitoring Network

The comment notes that management areas and the associated monitoring network should be designed to assess and protect against impacts to all beneficial users. The comment also requests a description of the methodologies, data and other information to support the monitoring of GDEs and ISWs to assess and prevent potential significant and unreasonable impacts. The comment also suggests that data gaps be reconciled along Deer Creek to improve ISW mapping.

Response:

Comment noted. Data gaps exist that will be addressed during the initial phases of GSP implementation. Refer to the response to Comment A-2 above.

Comment J-6: Measurable Objectives, Minimum Thresholds, and Undesirable Results

The comment expands on the issues related to the development of MOs/MTs and if they are protective of the diverse drinking water users within the GSA. It also requests a map displaying potentially impacted wells so that the public and DWR can assess well impacts specific to DACs and other sensitive users. It notes that the current threshold requiring an exceedance in at least 50% of the basin is not protective of DACs. The comment also notes that the GSP should explain how the additional water level declines at MTs will result in sustainable conditions for beneficial users. The comment also asks that the GSP quantify the potential dewatering of wells and the pumping costs associated with the increased lift at the projected lower water levels. The comment also notes that the GSP does not clearly present which Constituents of Concern (COC) will be monitored for at which wells. The comment also notes that the GSP does not mention sampling of domestic wells and that it's not clear how the proposed water quality sustainable management criteria will be protective of drinking water users, especially if irrigation wells located near domestic well users are not monitored for the constituents that affect drinking water usability. The comment also states that the proposed water quality sustainable management criteria allow for the increase in water quality constituent concentrations and are not tied to any kind of drinking water usability standards.

Response:

Comment noted.

Comment J-7: Management Actions and Costs

The comment states that likely benefits and impacts to DAC members by the proposed projects and management actions are not clearly identified in the GSP. The comment notes that management actions need to identify how proposed actions will impact water quality, and if that information is not available, the GSP should discuss how water quality impacts will be determined. The comment asks that the GSP with respect to the proposed projects consider stating how ISWs and GDEs will benefit or be protected, or what other environmental benefits will accrue. The comment also asks that if ISWs will not be adequately protected by the projects to include and describe additional management actions and projects that will protect ISWs. The comment also asks that for projects that construct recharge ponds, the GSP should consider identifying if there is habitat value incorporated into the design and how recharge ponds can be managed as multiple-benefit projects to benefit environmental users.

Response:

Comment noted. The projects identified in the GSP have been proposed by landowners and are in the early planning stages. As such the information provided in the GSP represents a pre-feasibility review of the projects subject to additional environmental review, agency consultations including necessary NEPA/CEQA compliance and other permits as determined by the results of biological, cultural, air quality studies and other technical studies that may be required for each individual project. Hence, the potential for impacts to various resource areas (including water quality) will be evaluated and considered during that environmental review process as directed by federal, state, and local agencies that may have jurisdiction over the proposed projects. Also, as noted in the GSP, the Liberty and Property Farms Projects incorporate design features to improve wildlife habitat. Specifically, these two projects include proposed recharge areas that will provide habitat for wildlife and shorebirds. Refer to the response to Comment A-2 above.

Letter K – Global Ag Properties USA

Comment K-1: Groundwater Allocation Structure

The comment notes that the GSP does not make a reference to a groundwater allocation structure. The comment expresses support for a stakeholder driven process to develop a valid and justifiable methodology for establishing landowner level allocations of native yields that are coordinated across the Subbasin. It also notes that groundwater markets and credits should be addressed in the GSP.

Response:

Comment noted. The Board of Directors will develop the groundwater allocation policy.

Comment K-2: On-Farm Recharge Projects

The comment notes that the GSP does not encourage or account for on-farm recharge projects. It notes that such projects align landowner and the basin goals.

Response:

Comment noted. The projects proposed in the GSP are all privately owned. The policy regarding recharge credits will be set by the Board of Directors.

Comment K-3: Sustainable Management Criteria

The comment notes that the GSP does not discuss in detail sustainable management criteria relative to subsidence and encourage the development of such criteria using best available data and technologies.

Response:

Comment noted. Refer to the response to Comment B-3 above.

Comment K-4: Timeline to Address Overdraft

The comment observes that the GSP outlines a plan to address overdraft by 2030 and recommend that the GSA utilize the full timeline allowable under SGMA (2040) for attaining groundwater sustainability. It notes that management actions are stated to reduce such deficit by 10% in both 2025 and 2030, which they calculate as offsetting overdraft by about 22,500 AF as compared to the total projected overdraft across the subbasin of 45,100 AF. It asks what other actions are being considered to bring the basin into sustainability, presumably after 2030.

Response:

Comment noted. Refer to the response to Comment H-3 above.

COMMENT REVIEW LETTERS

LETTER A

CDFW

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GAVIN NEWSOM, Governor
CHARLTON H. BONHAM, Director

LETTER A

November 7, 2019

Via Mail and Electronic Mail

Tri-County Water Authority GSP
Deanna Jackson, Executive Director
Tri-County Water Authority
944 Whitley Avenue, Suite E
Corcoran, California 93212
Email: djackson@tcwater.org

Subject: Comments on the Tri-County Water Authority Groundwater Sustainability Plan

Dear Ms. Jackson:

The California Department of Fish and Wildlife (CDFW) Central Region is providing comments on the Tri-County Water Authority Draft Groundwater Sustainability Plan (GSP) prepared by Tri-County Water Authority Groundwater Sustainability Agency (TCWAGSA) pursuant to the Sustainable Groundwater Management Act (SGMA). As trustee agency for the State's fish and wildlife resources, CDFW has jurisdiction over the conservation, protection, and management of fish, wildlife, native plants, and the habitat necessary for biologically sustainable populations of such species (Fish & Game Code §§ 711.7 and 1802).

Development and implementation of GSPs under SGMA represents a new era of California groundwater management. CDFW has an interest in the sustainable management of groundwater, as many sensitive ecosystems and species depend on groundwater and interconnected surface waters. SGMA and its implementing regulations afford ecosystems and species specific statutory and regulatory consideration, including the following as pertinent to Groundwater Sustainability Plans:

- Groundwater Sustainability Plans should identify and consider impacts to groundwater dependent ecosystems (GDEs) pursuant to 23 CCR § 354.16(g) and Water Code § 10727.4(l);

- Groundwater Sustainability Agencies should consider all beneficial uses and users of groundwater, including environmental users of groundwater pursuant to Water Code §10723.2 (e); and Groundwater Sustainability Plans should identify and consider potential effects on all beneficial uses and users of groundwater pursuant to 23 CCR §§ 354.10(a), 354.26(b)(3), 354.28(b)(4), 354.34(b)(2), and 354.34(f)(3);

- Groundwater Sustainability Plans should establish sustainable management criteria that avoid undesirable results within 20 years of the applicable statutory deadline, including depletions of interconnected surface water that have significant and unreasonable adverse impacts on beneficial uses of the surface water pursuant to 23 CCR § 354.22 *et seq.* and Water Code §§ 10721(x)(6) and 10727.2(b) and describe monitoring networks that can identify adverse impacts to beneficial uses of interconnected surface waters pursuant to 23 CCR § 354.34(c)(6)(D); and

- Groundwater Sustainability Plans should account for groundwater extraction for all Water Use Sectors including managed wetlands, managed recharge, and native vegetation pursuant to 23 CCR §§ 351(al) and 354.18(b)(3).

Accordingly, CDFW values SGMA groundwater planning that carefully considers and protects groundwater dependent ecosystems and fish and wildlife beneficial uses and users of groundwater and interconnected surface waters.

COMMENT OVERVIEW

CDFW supports ecosystem preservation in compliance with SGMA and its implementing regulations based on CDFW expertise and best available information and science.

CDFW recommends the GSP provide additional information and analysis that considers all environmental beneficial uses and users of groundwater in its sustainability management criteria and better characterize or consider surface water-groundwater connectivity. In addition, CDFW is providing additional comments and recommendations below.

COMMENTS AND RECOMMENDATIONS

CDFW's comments are as follows:

1. **Comment #1. Plan Area.** Chapter 1 Administrative Information. Section 1.4-3 Jurisdictional Boundaries (page 11) and Figure 1.4.4 (pages 12 and 13). The GSP recognizes the Allensworth Ecological Reserves (ER) that is owned by CDFW. Allensworth ER has 6,423 acres that are scattered in small parcels throughout the GSP in Tulare County, with additional parcels outside the GSP in Kern County. Approximately 5,208 acres are within the GSP. Allensworth ER has four wells, however the previous owner retained the ownership and groundwater rights to these wells, as such, CDFW does not own any wells on this ecological reserve. A-1

2. **Comment #2. Interconnected Surface Waters.** Chapter 2 Basin Setting. Section 2.2.6 Interconnected Surface Water Systems (page 116). The interconnected surface water analysis lacks sufficient evidence to justify an absence of interconnected streams in the subbasin.

    a. *Issue:* The analysis of surface water interconnectivity is based on limited data and poorly justifies the conclusion that there are no interconnected surface waters in the basin. The GSP claims, "there is no indication that any of the streams in the GSA are in hydraulic connection with the shallow groundwater" (page 116) but does not elaborate on how this conclusion was reached. The Upper Aquifer groundwater contours (that may have been considered for a 'depth-to-water' analysis) are based on limited data, and there is no identification of a baseline period of analysis.

       The GSP further states that when the Tulare Lakebed contains lake water, there may be a temporary hydraulic connection. A report completed by the California Department of Water Resources (1997) shows that a large area of the TCWAGSA area has 0 to 20 feet to depth to free water below the surface (see Figures 2, 3 and 5). CDFW lands flood when the White River receives flood waters from the upper watershed. Between these flood waters in conjunction with shallow ground water, CDFW recommends further evaluation of interconnected groundwater within the TCWAGSA. A-2

    b. *Recommendations:* CDFW recommends the GSP clarify what approach was used to analyze streams for interconnectivity and define a clear and expeditious path to improved shallow groundwater and surface water monitoring for periodic re-analysis of surface water-groundwater interconnectivity.

3. **Comment #3. Groundwater-Dependent Ecosystems**. Chapter 1 Administrative Information. Section 1, 1.4.7-12 Impacts of Water Supply and Management Practices on Groundwater Dependent Ecosystems (page 34) and Figure 1.4.9 (page 35), Chapter 2 Basin Setting, Section 2.2.7 Groundwater Dependent Ecosystems (page 117). The GDE identification section, pursuant to 23 CCR § 354.16 (g), recognizes approximately 3,516 acres of GDEs exist within the GSP that may depend on groundwater. A-3

    a. *Recommendation:* CDFW recommends including additional references for a more robust GDE evaluation. CDFW recognizes that the Natural Communities Commonly Associated with Groundwater (NCCAG) (Klausmeyer et al. 2018) provided by California Department of Water Resources (CDWR) is a good starting reference for GDEs. There are additional resources available for evaluating GDE locations and habitat types, as well as information for State and Federal listed species. These recommended references include, but are not limited to, the following tools and other resources: CDFW Vegetation Classification and Mapping Program (VegCAMP) (CDFW 2019A); the CDFW California Natural Diversity Database (CNDDB) (2019B); the California Native Plant Society (CNPS) Manual of California Vegetation (CNPS 2019A); the CNPS California Protected Areas Database (CNPS 2019B); the United States Fish and Wildlife Service (USFWS) National Wetlands Inventory (2018); the USFWS online mapping tool for listed species critical habitat (2019); the United States Forest Service (USFS) CALVEG ecological grouping classification and assessment system (2019); and other publications by Klausmeyer et al. (2019), Rohde et al. (2018), The Nature Conservancy (TNC) (2014, 2019), and Witham et al. (2014). A-3

4. **Comment #4. Sustainable Management Criteria.** Chapter 3 Sustainable Management Criteria, Section 3.3.3 Evaluation of Minimum Thresholds (starting on page 180). Sustainable management criteria do not reflect a 'Critically Overdrafted' basin status and demonstrate no consideration of undesirable results for environmental beneficial uses and users of groundwater. A-4

   a. *Issue:*

      i. The GSP identifies minimum thresholds that are well below the deepest groundwater readings on record (pages 182-193), even though the basin has experienced sustained chronic groundwater decline and significant subsidence. The GSP notes that several wells have already converted operations from the Lower Aquifer to the Upper Aquifer to mitigate long-term decline of the Lower Aquifer (page 208), which suggests that beneficial users of groundwater are experiencing the effects of undesirable results such as additional operational costs for groundwater extraction including drilling new wells (page 180). These groundwater trends and resulting adverse impacts support the subbasin characterization as 'Critically Overdrafted,' meaning "continuation of present water management practices [in the basin] would probably result in significant adverse overdraft-related environmental, social, or economic impacts" (CDWR "Critically Overdrafted"). The GSP identifies minimum groundwater elevation thresholds for representative monitoring wells, each of which serves as a threshold beyond which undesirable results are expected if the threshold is exceeded for two consecutive years (page 180). The proposed minimum thresholds suggest that groundwater elevations at representative wells can continue to decrease for the next 20 years, dropping further from historically low drought groundwater elevations, without witnessing undesirable results. The GSP is concurrently: 1) describing undesirable results that are currently present, 2) noting that minimum thresholds are designed to protect against undesirable results, and 3) proposing minimum thresholds that are significantly lower than current groundwater elevations. Therefore, the GSP's minimum thresholds may allow for 20 implementation years of groundwater table decline, mirroring the historical trends that led to the subbasin's Critically Overdrafted status. Conceptually, there is a disconnect between the subbasin's 'Critically Overdrafted' designation and sustainable management criteria that allow for continued groundwater level decline. A-4

ii. The GSP does not consider effects of minimum thresholds and associated undesirable results on environmental beneficial uses and users of groundwater. The GSP identifies potential GDEs (page 117) but does not elaborate on how these GDEs might rely on groundwater, nor does the GSP consider how these areas and the fish and wildlife species and the habitats that they depend on may be impacted by sustainability management criteria.

b. *Recommendations:* CDFW recommends reconsideration of minimum thresholds after the GSA collects additional shallow groundwater information and re-analyzes the presence of interconnected surface waters (see Comments 2 and 3 on Interconnected Surface Water and GDEs).

i. Revise sustainable management criteria to reflect a 'Critically Overdrafted' subbasin designation by establishing minimum thresholds that empower the groundwater basin to improve upon current groundwater conditions rather than allowing for continued aquifer depletions over the next two decades.

ii. Revise sustainable management criteria accounting for undesirable results for environmental beneficial users of groundwater and clarify how species and habitat groundwater needs were considered in the identification of sustainable management criteria.

5. **Comment #5. Monitoring.** Chapter 4: Monitoring Network (starting page 210). Shallow groundwater monitoring wells are lacking and the GSP narrative conflicts on data collection frequency. A-5

a. *Issue*:

i. The current monitoring network lacks a sufficient number and distribution of shallow groundwater monitoring wells to understand shallow groundwater trends and to monitor potential impacts to environmental beneficial uses and users of groundwater and interconnected surface waters [23 CCR § 354.34(2)]. Only three wells exist in the Upper Aquifer, meaning there are insufficient data points on shallow groundwater level trends to develop groundwater contours enough in resolution to confirm or reject the presence of shallow groundwater (e.g., 30 feet or shallower). Shallow groundwater data are critical to understanding groundwater management impacts on fish and wildlife beneficial uses and users of groundwater, including GDE's and potential interconnected surface water habitats, that are impacted disproportionately by shallow groundwater trends. A-5

ii. The GSP states that it will monitor groundwater annually in the spring at designated wells (page ES-6:ES-11), and later states that groundwater elevation data will be collected semi-annually (page 212).

b. *Recommendations*:

i. Install additional shallow groundwater monitoring wells near GDE's and interconnected surface waters, potentially pairing multiple-completion wells with streamflow gauges for improved understanding of surface water-groundwater interconnectivity.

ii. Clarify groundwater elevation data collection frequency. Collect groundwater elevation information semi-annually at a *minimum* to capture seasonal highs and lows and to comply with GSP regulations (23 CCR § 354.34 (c)(1)(B)). A greater frequency of data collection will better enable the GSA to achieve its objective of characterizing "seasonal, annual, and long-term trends in depth to water for each aquifer" (page ES-11).

6. **Comment #6. Project and Management Actions.** Chapter 5 Projects and Management Actions. Section 5.2 Projects and Management Actions. Subsection 1. Deep Aquifer Pumping Conversion to Upper Aquafer Pumping (page 273). Conversion of pumping from the Lower Aquifer to the Upper Aquifer to mitigate subsidence may incur other risks, including localized subsidence in A-6

shallower fine-grained material and degradation of the relatively 'stable' (page 180) Upper Aquifer.

a. *Issues:*

i. The GSP proposes shifting 24,000 acre-feet/year of Lower Aquifer pumping to the Upper Aquifer (page 273), but the plan does not identify potential adverse impacts of this pumping conversion on the Upper Aquifer nor does the GSP offer strategies to mitigate impacts. This proposed action, if fully implemented, could significantly increase the Upper Aquifer's net groundwater storage losses (ES-10).

ii. Within the GSP, land subsidence is attributed to the extraction of water in aquifers beneath the Corcoran Clay, resulting in land subsidence. It is important to understand that subsidence does and can occur at locations outside of the constraints of the Corcoran Clay and at shallower depths. Within the Basin Setting (Chapter 2), the GSP provides a description of the geologic materials encountered beneath ground surface and provides a number of geologic cross sections depicting the hydrogeologic framework. Within these cross sections, the GSP identifies a number of confining layers (A & C clay layers) above the Corcoran Clay which are described as being extensive in some areas. These clay layers act as confining beds and restrict the movement of groundwater. The generalized characterization of the unconfined aquifer within the GSP addresses SGMA requirements for a principal aquifer; however, as presented within Chapter 2 - Basin Setting, the unconfined aquifer realistically is comprised of many discrete aquifer assemblages that could be under semi-confined to confined conditions. A-6

Redirecting pumping from the Lower Aquifer to the Upper Aquifer presents risks with regard to subsidence. The lowering of groundwater levels within the Upper Aquifer provides the potential to create groundwater-level-induced stresses which can promote subsidence within the Upper and Lower Aquifers. In addition, the lowering of groundwater levels in the Upper Aquifer where confining clay layers exist could potentially generate localized subsidence issues. Historic records from an extensometer station (23S/25E-16N4, Pixley Shallow (250' depth)) indicates that from between the years of 1959 to 1983, up to 0.122 feet of compaction occurred. At the Oro Loma extensometer site (12S/12E-16H3, Oro

Loma Shallow (350' depth)) located northwest of the plan area, historic records indicate up to 0.34 feet of compaction within the Upper Aquifer system (Corcoran Clay is reported at a depth of between 350 feet to 400 feet). Although these sites are not within the constraints of the GSP plan area, these scenarios illustrate the potential for subsidence at depths shallower than the Corcoran Clay. The GSP describes groundwater levels within the unconfined aquifer currently as being stable; however, if the redirected pumping induces water level drop below critical head, preconsolidation stresses may be surpassed and compaction of fine-grained materials may occur, resulting in subsidence. A-6

b. *Recommendation:* Clarify how the GSA will identify and analyze potential adverse impacts of this proposed management action (e.g., modeling increased pumping impacts on Upper Aquifer). Identify potential mitigation strategies for increased Upper Aquifer pumping to avoid undesirable results.

CONCLUSION

In conclusion, the Tri-County Water Authority Draft GSP needs to address all SGMA statutes and regulations, and CDFW recommends the GSP seriously consider fish and wildlife beneficial uses and interconnected surface waters. CDFW recommends that the TCWAGSA consider the above comments before the GSP is submitted to CDWR. CDFW appreciates the opportunity to provide comments on the Tri-County Water Authority Draft GSP. If you have any further questions, please contact Dr. Andrew Gordus at Andy.Gordus@wildlife.ca.gov or (559) 243-4014 x 239.

Sincerely,

Julie A. Vance
Regional Manager, Central Region

Enclosures (Literature Cited)

ec: See Page 9

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LETTER B

FWA

Friant WATER AUTHORITY

LETTER B

854 N. Harvard Ave.
Lindsay, CA 93247

1121 L St., Ste. 610
Sacramento, CA 95814

(559) 562-6305

December 16, 2019

Alpaugh GSA
Delano Earlimart Irrigation District GSA
Eastern Tule GSA
Lower Tule River Irrigation District GSA
Pixley Irrigation District GSA
Tri-County Water Authority GSA

Re: **Comments on Tule Subbasin Groundwater Sustainability Plans**

To: The Directors and Staff of the Referenced Groundwater Sustainability Agencies

The Friant Water Authority (FWA), which operates the 152-mile long Friant-Kern Canal (FKC or Canal) on behalf of the United States Department of Interior's Bureau of Reclamation (Reclamation) and which Canal conveys contract water to 34 water agencies and municipalities that in turn serve tens of thousands of residential customers and over 1 million acres of farmland, respectfully submits this comment letter on the Groundwater Sustainability Plans (GSPs) that have been drafted by each of the Groundwater Sustainability Agencies (GSAs) addressed in this letter pursuant to the Sustainable Groundwater Management Act (SGMA).[1]

As a preliminary matter, we commend the various boards, staff members and technical consultants for the efforts that have gone into the preparation of the draft GSPs and for the transparent and collaborative manner in which the GSAs have engaged with stakeholders such as FWA. We are in this together, and your leadership to date, as evidenced by the outreach to our agency, has been exemplary. With the exception of the issues noted below, FWA fully supports the adoption and implementation of the GSPs. To that end, FWA looks forward to continuing our collaboration in order to achieve the "Sustainability Goal" of the Tule Subbasin, which, as defined in the Tule Subbasin Coordination Agreement (Coordination Agreement), is "the absence of significant and unreasonable undesirable results associated with groundwater pumping."[2] B-1

In our initial comment letter of May 28, 2019, we notified each GSA that FWA would be carefully reviewing the draft GSPs in terms of the description and definition of undesirable results with respect to subsidence impacts to the Canal, and noted that while SGMA established a 20-year planning period to bring the Tule Subbasin into sustainability, the continuation of unmitigated land subsidence impacts to the Canal would be unacceptable and that feasible solutions must be identified. With that B-2

[1] Water Code § 10720 and following.

[2] Coordination Agreement, § 4.2.

outcome in mind, we provide our specific comments on the draft GSPs, particularly the GSP of the Eastern Tule GSA (ETGSA). B-2

We support the stated intent in the Coordination Agreement as to the purpose of avoiding undesirable results in the context of land subsidence: "the avoidance of an undesirable result of land subsidence is to protect critical infrastructure for the beneficial uses within the Tule Subbasin, including excessive costs to fix, repair, or otherwise retrofit such infrastructure and may also result in an interim loss of benefits to the users of such infrastructure."[3] It cannot be disputed that the FKC is one of if not THE most critical infrastructure facility in the Tule Subbasin with respect to the conveyance of water for beneficial use. It also cannot be disputed, as documented in the GSPs, that groundwater pumping in the vicinity of the Canal has resulted in upwards of 9 feet of land subsidence in recent decades - several feet of which has occurred in recent years even after the adoption of SGMA.[4] Because the Canal's conveyance system relies on a "gravity" design, this subsidence has reduced the conveyance capacity of the Canal to 40% of its original capacity (from 4,000 to 1,650 cubic-feet per second (cfs)) in these subsided areas. The resulting constriction in the Canal is precluding the delivery of significant amounts of water to Friant Division Contractors (Friant Districts) below the subsided areas and also affects the ability to Friant Districts above the constricted area to engage in exchanges or transfers of water. B-3

As a result of the persistent overdraft conditions in the Tule Subbasin, FWA, at considerable expense, is developing plans, undertaking environmental review, and pursuing permitting to address these existing subsidence impacts by restoring capacity through a project referred to as the "Friant-Kern Canal Middle Reach Capacity Correction Project" (Project). The current engineering estimates place the cost of the Project in excess of $500 million.

With this well-documented and undisputed background in mind, including the extensive information, analysis and modeling in the GSPs and their supporting technical appendices, FWA must express its dissatisfaction with both the proposed "minimum thresholds" for subsidence and the criteria used to define "undesirable results" with respect to future subsidence as applied to the FKC. Specifically, the draft GSPs provide for **up to three feet of additional subsidence along the Canal** caused by transitional pumping/use **BEFORE** the identified ***minimum thresholds*** are exceeded. This impact will be compounded by the reliance of the GSPs on the definition of undesirable results in the Coordination Agreement, which provides as follows:

> <u>§ 4.3.4.2 Criteria to Define Undesirable Results</u>: "*the criteria for an undesirable result for land subsidence is defined as the unreasonable subsidence below minimum thresholds at **greater than 50% of GSA Management Area RMS** resulting in significant impacts to critical infrastructure*." (Emphasis added.)

Figure 5-1 of the GSP for the ETGSA identifies seven Representative Monitoring Sites (RMS) along the most severely subsided portion of the FKC covering a distance of approximately 12 miles measured from the Tule River at Avenue 152 to Avenue 80. Using the proposed criteria for defining an undesirable result, the "transitional" overdraft pumping will be permitted to potentially cause 3 additional feet of B-4

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[3] Coordination Agreement, § 4.3.4.3.
[4] ETGSA GSP, § 4.3.5; see also FWA's Friant-Kern Canal Fact Sheet (attached).

subsidence over at least a 4-6 mile area (the distance of 4 of 7 RMS (i.e., more than 50% of the Representative Monitoring Sites)) BEFORE being deemed an undesirable result.[5] This is not acceptable to FWA unless there is concurrent and corresponding mitigation in the form of compensation to FWA and the Friant Districts to pay for the damages resulting from such pumping as discussed further below.[6] If the GSAs agree to incorporate the prompt adoption of management actions that would provide reasonable compensation to address "interim" subsidence (i.e., the continuation of subsidence until the proposed "minimum thresholds" are reached), then FWA would not object to the GSPs maintaining these objectives, not as minimum thresholds that must be exceeded before management action is taken, but rather, as a basis for ***additional*** management actions, including greater compensation for damages to the Canal and Friant Districts and potential additional reductions in groundwater pumping to achieve sustainability sooner and avoid further impacts to the Canal if these so-called minimum thresholds are exceeded. B-4

In addition to establishing a uniform zero-tolerance for additional subsidence impacts to the Canal absent appropriate compensation/mitigation, the criteria for monitoring any continued undesirable results for land subsidence as pertaining to the Canal need to be site specific and should be based on <u>any additional subsidence detected at a</u> <u>single RMS location</u>. Furthermore, because the FKC is critical infrastructure, FWA recommends that the Tule Subbasin GSPs incorporate additional RMS along the FKC for the entire length of the Tule Subbasin and that such RMS locations be spaced not more than one mile apart. Some of the Friant Districts are adding such monitoring sites for their own water banking/recharge projects near the FKC, and we would encourage the GSAs to incorporate these facilities as part of their subsidence monitoring management actions with respect to the FKC. B-5

While the GSPs do not calculate the amount of capacity loss to the Canal from the contemplated 3 additional feet of subsidence that is predicted over the first 15 years of the GSPs, FWA estimates this capacity reduction to be on order of 460 cubic feet per second (cfs), which would result in a conveyance capacity of 1,140 cfs (based on current deficient conditions) and put the Canal capacity at 2,860 cfs below the original design capacity of 4,000 cfs. FWA further estimates that the 3 additional feet of subsidence contemplated under the GSPs will result in further reduced water deliveries to Friant Districts below the impacted area on the order of at least 30,000 to 40,000 acre feet (AF) per year, in addition to the already significant inability to convey water during wet years such as 2017 and 2019 where FWA estimates that upwards of 300,000 AF could have been delivered to Friant Districts <u>but for</u> the capacity restrictions caused by subsidence due to overdraft groundwater pumping in the Tule Subbasin. Under such conditions, Friant Districts' imported surface water supplies through the FKC will be even further restricted, which in turn will diminish their ability to contribute to the sustainable management of their own respective subbasins in the future. B-6

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[5] See ETGSA GSP, § 5.8.3.1.2 (Quantified Minimum Thresholds).

[6] See Civil Code section 3479: "**Anything which is injurious to** health, including, but not limited to … an obstruction to the free use of property, so as to interfere with the comfortable enjoyment of life or property, or unlawfully obstructs **the free passage or use**, in the customary manner, **of any …canal** … **is a nuisance**." (Emphasis added.) It is FWA's position that any pumping activity causing further subsidence to the Canal constitutes a nuisance unless appropriate compensation/mitigation is provided.

FWA is encouraged that the GSP for ETGSA establishes a "Friant-Kern Canal Subsidence Management Area." However, neither that Plan nor any of the other GSPs establish specific management actions or mitigation to address the continued subsidence impacts to the Canal despite the fact that the GSPs contemplate continued overdraft conditions (aka "transitional pumping/use") through the implementation period of 2040.[7]

For the above reasons, **all** further subsidence along the Canal as contemplated in the GSPs should be considered significant and unreasonable and deemed to substantially interfere with surface land uses unless appropriate mitigation is provided to fairly compensate FWA and the Friant Districts for such interference.[8] Accordingly, the GSPs should be revised to mandate the prompt adoption of management actions (following adoption of the GSP) that provide for such equitable compensation as a condition of the transitional groundwater pumping permitted under each GSP in areas where such pumping can reasonably be demonstrated to cause continued subsidence impacts to the Canal. B-7

Given the acknowledged effects of continued subsidence proximate to the FKC, these immediate management actions to mitigate such impacts are required. To this end, concurrent with the adoption of the final GSPs, as amended to address the comments provided herein, FWA respectfully request that the Board of each GSA direct staff to continue to work with FWA and Friant Districts to promptly develop and bring back for adoption management actions that would establish mechanisms to mitigate future subsidence impacts in the form of compensation to FWA and Friant Districts to pay for the costs of repairs to the FKC resulting from the transitional pumping/use permitted under the GSPs as well as the reduced water deliveries to Friant Districts until such repairs are completed. This mitigation could come in the form of fees or charges imposed on groundwater pumping and/or assessments or charges spread over the lands benefitting from groundwater pumping permitted under the GSPs that have caused, and can reasonably be demonstrated will continue to cause, undesirable results to the Friant-Kern Canal.

On behalf of FWA, I appreciate your consideration of these comments. FWA staff looks forward to continued collaboration on prompt and appropriate actions that will help us move forward with our mandate to restore critically needed capacity to the Friant-Kern Canal.

Sincerely,

Jason Phillips, CEO

Attachment: FWA Subsidence Fact Sheet

---

[7] We acknowledge that the Delano-Earlimart GSP does contain management actions that assert it will achieve sustainability, but because the plan still anticipates that future subsidence will occur, more attention to address FWA's concerns regarding compensation for continuing subsidence impacts to the FKC is still warranted.

[8] See Water Code § 10721(x)(5).

LETTER C

USDOI - BOR

LETTER C

United States Department of the Interior

BUREAU OF RECLAMATION
Mid-Pacific Region
South-Central California Area Office
1243 N Street
Fresno, CA 93721-1813

IN REPLY REFER TO:
SCC-100
2.2.4.23

DEC 16 2019

VIA ELECTRONIC AND U.S. MAIL

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Eastern Tule GSA
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Tri-County Water Authority GSA
944 Whitley Avenue, Suite E
Corcoran, CA 93212
djackson@tcwater.org

Subject: Comments on Tulare Subbasin Groundwater Sustainability Plans

Dear Tule Subbasin Groundwater Sustainability Agencies:

The United States Bureau of Reclamation (Reclamation) provides these comments on the draft groundwater sustainability plans submitted by the addressee Groundwater Sustainability Agencies (GSA) in the Tule Subbasin.

We commend and appreciate your efforts, time, and energy devoted to the very difficult task of developing groundwater sustainability plans (GSP) to comply with the Sustainable Groundwater Management Act of 2014.

The mission of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public. In the Friant Division, one of the most critical features of infrastructure that allows us to meet our mission is the Friant-Kern Canal, which, has been operated and maintained by the Friant Water Users Authority and subsequently the Friant Water Authority (FWA) since 1986. The Friant-Kern Canal delivers water to numerous water and irrigation districts, as well as cities, and about 15,000 family farms, and the very existence and inspiration of the canal was to, among other things, combat issues such as subsidence by conveying surface water to incentivize farmers to pump less ground C-1 water. For decades, the Friant Division system has performed as intended and the farms and towns on the eastside of the San Joaquin Valley have flourished. C-1

However, after the last prolonged drought that ended in 2017, it was discovered that about 60% of the Friant-Kern Canal delivery capacity had been lost due to severe land subsidence. The clearest explanation for this subsidence, is that it was caused largely by the over-pumping of groundwater on lands not currently served by surface water that lie within your respective GSAs. At the current detrimental rate of subsidence, FWA estimates that the Friant-Kern Canal will be operating at 30% capacity within three years. This is a trajectory that we ought naught allow to continue unchecked, and proactive measures need to be taken now to mitigate and prevent this cause and effect phenomenon. C-1

For these and other reasons, as title holder and owner of the Friant-Kern Canal, we substantially concur with the comment letter submitted to the GSAs of the Tule Subbasin by the FWA on December 16, 2019 (attached) and look forward to the coordination and collaboration necessary to adopt appropriate management actions and plans to properly deal with staving off subsidence and its detrimental effects to the Friant-Kern Canal. C-2

If you should have any questions on this matter, please contact me at (559) 262-0300 or by cellphone at (559) 260-8714, by electronic mail at mjackson@usbr.gov or for the hearing impaired at TTY (800) 877-8339.

Sincerely,

Michael P. Jackson

Michael P. Jackson, P.E.
Area Manager

Enclosure
Friant Water Authority Comment letter dated December 16, 2019

cc: Mr. Jason Phillips, CEO
Friant Water Authority
854 North Harvard Avenue
Lindsay, CA 93247
(w/enclosure)

Friant
WATER AUTHORITY

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December 16, 2019

Alpaugh GSA
Delano Earlimart Irrigation District GSA
Eastern Tule GSA
Lower Tule River Irrigation District GSA
Pixley Irrigation District GSA
Tri-County Water Authority GSA

Re: **Comments on Tule Subbasin Groundwater Sustainability Plans**

To: The Directors and Staff of the Referenced Groundwater Sustainability Agencies

The Friant Water Authority (FWA), which operates the 152-mile long Friant-Kern Canal (FKC or Canal) on behalf of the United States Department of Interior's Bureau of Reclamation (Reclamation) and which Canal conveys contract water to 34 water agencies and municipalities that in turn serve tens of thousands of residential customers and over 1 million acres of farmland, respectfully submits this comment letter on the Groundwater Sustainability Plans (GSPs) that have been drafted by each of the Groundwater Sustainability Agencies (GSAs) addressed in this letter pursuant to the Sustainable Groundwater Management Act (SGMA).[1]

As a preliminary matter, we commend the various boards, staff members and technical consultants for the efforts that have gone into the preparation of the draft GSPs and for the transparent and collaborative manner in which the GSAs have engaged with stakeholders such as FWA. We are in this together, and your leadership to date, as evidenced by the outreach to our agency, has been exemplary. With the exception of the issues noted below, FWA fully supports the adoption and implementation of the GSPs. To that end, FWA looks forward to continuing our collaboration in order to achieve the "Sustainability Goal" of the Tule Subbasin, which, as defined in the Tule Subbasin Coordination Agreement (Coordination Agreement), is "the absence of significant and unreasonable undesirable results associated with groundwater pumping."[2]

In our initial comment letter of May 28, 2019, we notified each GSA that FWA would be carefully reviewing the draft GSPs in terms of the description and definition of undesirable results with respect to subsidence impacts to the Canal, and noted that while SGMA established a 20-year planning period to bring the Tule Subbasin into sustainability, the continuation of unmitigated land subsidence impacts to the Canal would be unacceptable and that feasible solutions must be identified. With that

[1] Water Code § 10720 and following.

[2] Coordination Agreement, § 4.2.

outcome in mind, we provide our specific comments on the draft GSPs, particularly the GSP of the Eastern Tule GSA (ETGSA).

We support the stated intent in the Coordination Agreement as to the purpose of avoiding undesirable results in the context of land subsidence: "the avoidance of an undesirable result of land subsidence is to protect critical infrastructure for the beneficial uses within the Tule Subbasin, including excessive costs to fix, repair, or otherwise retrofit such infrastructure and may also result in an interim loss of benefits to the users of such infrastructure."[3] It cannot be disputed that the FKC is one of if not THE most critical infrastructure facility in the Tule Subbasin with respect to the conveyance of water for beneficial use. It also cannot be disputed, as documented in the GSPs, that groundwater pumping in the vicinity of the Canal has resulted in upwards of 9 feet of land subsidence in recent decades - several feet of which has occurred in recent years even after the adoption of SGMA.[4] Because the Canal's conveyance system relies on a "gravity" design, this subsidence has reduced the conveyance capacity of the Canal to 40% of its original capacity (from 4,000 to 1,650 cubic-feet per second (cfs)) in these subsided areas. The resulting constriction in the Canal is precluding the delivery of significant amounts of water to Friant Division Contractors (Friant Districts) below the subsided areas and also affects the ability to Friant Districts above the constricted area to engage in exchanges or transfers of water.

As a result of the persistent overdraft conditions in the Tule Subbasin, FWA, at considerable expense, is developing plans, undertaking environmental review, and pursuing permitting to address these existing subsidence impacts by restoring capacity through a project referred to as the "Friant-Kern Canal Middle Reach Capacity Correction Project" (Project). The current engineering estimates place the cost of the Project in excess of $500 million.

With this well-documented and undisputed background in mind, including the extensive information, analysis and modeling in the GSPs and their supporting technical appendices, FWA must express its dissatisfaction with both the proposed "minimum thresholds" for subsidence and the criteria used to define "undesirable results" with respect to future subsidence as applied to the FKC. Specifically, the draft GSPs provide for **up to three feet of additional subsidence along the Canal** caused by transitional pumping/use **BEFORE** the identified ***minimum thresholds*** are exceeded. This impact will be compounded by the reliance of the GSPs on the definition of undesirable results in the Coordination Agreement, which provides as follows:

> § 4.3.4.2 Criteria to Define Undesirable Results: *"the criteria for an undesirable result for land subsidence is defined as the unreasonable subsidence below minimum thresholds at **greater than 50% of GSA Management Area RMS** resulting in significant impacts to critical infrastructure."* (Emphasis added.)

Figure 5-1 of the GSP for the ETGSA identifies seven Representative Monitoring Sites (RMS) along the most severely subsided portion of the FKC covering a distance of approximately 12 miles measured from the Tule River at Avenue 152 to Avenue 80. Using the proposed criteria for defining an undesirable result, the "transitional" overdraft pumping will be permitted to potentially cause 3 additional feet of

[3] Coordination Agreement, § 4.3.4.3.

[4] ETGSA GSP, § 4.3.5; see also FWA's Friant-Kern Canal Fact Sheet (attached).

subsidence over at least a 4-6 mile area (the distance of 4 of 7 RMS (i.e., more than 50% of the Representative Monitoring Sites)) BEFORE being deemed an undesirable result.[5] This is not acceptable to FWA unless there is concurrent and corresponding mitigation in the form of compensation to FWA and the Friant Districts to pay for the damages resulting from such pumping as discussed further below.[6] If the GSAs agree to incorporate the prompt adoption of management actions that would provide reasonable compensation to address "interim" subsidence (i.e., the continuation of subsidence until the proposed "minimum thresholds" are reached), then FWA would not object to the GSPs maintaining these objectives, not as minimum thresholds that must be exceeded before management action is taken, but rather, as a basis for ***additional*** management actions, including greater compensation for damages to the Canal and Friant Districts and potential additional reductions in groundwater pumping to achieve sustainability sooner and avoid further impacts to the Canal if these so-called minimum thresholds are exceeded.

In addition to establishing a uniform zero-tolerance for additional subsidence impacts to the Canal absent appropriate compensation/mitigation, the criteria for monitoring any continued undesirable results for land subsidence as pertaining to the Canal need to be site specific and should be based on any additional subsidence detected at a single RMS location. Furthermore, because the FKC is critical infrastructure, FWA recommends that the Tule Subbasin GSPs incorporate additional RMS along the FKC for the entire length of the Tule Subbasin and that such RMS locations be spaced not more than one mile apart. Some of the Friant Districts are adding such monitoring sites for their own water banking/recharge projects near the FKC, and we would encourage the GSAs to incorporate these facilities as part of their subsidence monitoring management actions with respect to the FKC.

While the GSPs do not calculate the amount of capacity loss to the Canal from the contemplated 3 additional feet of subsidence that is predicted over the first 15 years of the GSPs, FWA estimates this capacity reduction to be on order of 460 cubic feet per second (cfs), which would result in a conveyance capacity of 1,140 cfs (based on current deficient conditions) and put the Canal capacity at 2,860 cfs below the original design capacity of 4,000 cfs. FWA further estimates that the 3 additional feet of subsidence contemplated under the GSPs will result in further reduced water deliveries to Friant Districts below the impacted area on the order of at least 30,000 to 40,000 acre feet (AF) per year, in addition to the already significant inability to convey water during wet years such as 2017 and 2019 where FWA estimates that upwards of 300,000 AF could have been delivered to Friant Districts but for the capacity restrictions caused by subsidence due to overdraft groundwater pumping in the Tule Subbasin. Under such conditions, Friant Districts' imported surface water supplies through the FKC will be even further restricted, which in turn will diminish their ability to contribute to the sustainable management of their own respective subbasins in the future.

[5] See ETGSA GSP, § 5.8.3.1.2 (Quantified Minimum Thresholds).

[6] See Civil Code section 3479: "**Anything which is injurious to** health, including, but not limited to ... an obstruction to the free use of property, so as to interfere with the comfortable enjoyment of life or property, or unlawfully obstructs **the free passage or use**, in the customary manner, **of any ...canal ... is a nuisance.**" (Emphasis added.) It is FWA's position that any pumping activity causing further subsidence to the Canal constitutes a nuisance unless appropriate compensation/mitigation is provided.

FWA is encouraged that the GSP for ETGSA establishes a "Friant-Kern Canal Subsidence Management Area." However, neither that Plan nor any of the other GSPs establish specific management actions or mitigation to address the continued subsidence impacts to the Canal despite the fact that the GSPs contemplate continued overdraft conditions (aka "transitional pumping/use") through the implementation period of 2040.[7]

For the above reasons, **all** further subsidence along the Canal as contemplated in the GSPs should be considered significant and unreasonable and deemed to substantially interfere with surface land uses unless appropriate mitigation is provided to fairly compensate FWA and the Friant Districts for such interference.[8] Accordingly, the GSPs should be revised to mandate the prompt adoption of management actions (following adoption of the GSP) that provide for such equitable compensation as a condition of the transitional groundwater pumping permitted under each GSP in areas where such pumping can reasonably be demonstrated to cause continued subsidence impacts to the Canal.

Given the acknowledged effects of continued subsidence proximate to the FKC, these immediate management actions to mitigate such impacts are required. To this end, concurrent with the adoption of the final GSPs, as amended to address the comments provided herein, FWA respectfully request that the Board of each GSA direct staff to continue to work with FWA and Friant Districts to promptly develop and bring back for adoption management actions that would establish mechanisms to mitigate future subsidence impacts in the form of compensation to FWA and Friant Districts to pay for the costs of repairs to the FKC resulting from the transitional pumping/use permitted under the GSPs as well as the reduced water deliveries to Friant Districts until such repairs are completed. This mitigation could come in the form of fees or charges imposed on groundwater pumping and/or assessments or charges spread over the lands benefitting from groundwater pumping permitted under the GSPs that have caused, and can reasonably be demonstrated will continue to cause, undesirable results to the Friant-Kern Canal.

On behalf of FWA, I appreciate your consideration of these comments. FWA staff looks forward to continued collaboration on prompt and appropriate actions that will help us move forward with our mandate to restore critically needed capacity to the Friant-Kern Canal.

Sincerely,

Jason Phillips, CEO

Attachment: FWA Subsidence Fact Sheet

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[7] We acknowledge that the Delano-Earlimart GSP does contain management actions that assert it will achieve sustainability, but because the plan still anticipates that future subsidence will occur, more attention to address FWA's concerns regarding compensation for continuing subsidence impacts to the FKC is still warranted.
[8] See Water Code § 10721(x)(5).

LETTER D

DEID, LTRID, PID

LETTER D

November 7, 2019

Sent Via U.S. Mail and E-Mail to: djackson@tcwater.org

Tri-County Water Authority
c/o Deanna Jackson
944 Whitley Avenue, Suite E
Corcoran, CA 93212

Re: Public Comments by Delano-Earlimart Irrigation GSA, Lower Tule River Irrigation District GSA, and Pixley Irrigation District GSA on Tri-County Water Authority Groundwater Sustainability Plan

To Tri-County Water Authority GSA,

Reference is made to the notice of Tri-County Water Authority ("TCWA") dated September 18, 2019, providing the Counties of Tulare and Kings with notice of TCWA's intent to adopt the TCWA Groundwater Sustainability Plan for the Tule Subbasin (the "GSP"). That notice indicates that TCWA will accept public comments until November 7, 2019.

Please be advised that the Delano-Earlimart Irrigation District Groundwater Sustainability Agency, the Lower Tule River Irrigation District Groundwater Sustainability Agency, and the Pixley Irrigation District Groundwater Sustainability Agency are currently completing an initial review of the TCWA GSP. That review has revealed significant concerns regarding the adequacy of the plan and its ability to be considered "coordinated" with the other GSPs that are being developed and are being considered for adoption. As you know, the DEID GSA, LTRID GSA, and PID GSA are three of the six GSA's developing plans for portions of the Tule Sub-Basin and are three of the GSAs with whom TCWA GSP is obligated to coordinate plans with. These three GSAs intend to provide detailed comments, criticisms and concerns about the draft TCWA GSP prior to adoption, but are not prepared to do so prior to the date that TCWA established for receiving "public" comments.

Among the major areas of concern that have been identified in our preliminary review are the following:

- The TCWA asserts, without detail and without apparent legal support, a prescriptive groundwater right for Angiola Water District. Such assertion has historically been disputed by many parties in the Tule Sub-Basin, and as such should not be relied upon by the TCWA GSP as the basis for continued groundwater overdraft by members of TCWA. D-1

- The TCWA GSP does not appear to adopt the groundwater sustainable yield or basin-wide safe-yield calculation concepts that a majority of the Tule Sub-Basin GSAs have agreed to utilize in their GSPs. Such failure will result in de-facto non-coordination of the Tule-Sub Basin plans, which exposes the entire sub-basin to a "probationary" D-2 determination by the State of California (Department of Water Resources and/or the State Water Resources Control Board). D-2

- The TCWA GSP does not appear to identify any meaningful management actions that are intended to be adopted that would be reasonably expected to bring groundwater use in the TCWA service area to within sustainable levels within the planning time frame. This is another fatal flaw of the plan that threatens the entire sub-basin. D-3

We discussed many of these concerns with TCWA through multiple meetings that were held as part of the Tule Sub-Basin Coordination Group, so we believe TCWA is well aware of these positions. We are disappointed that these concerns were not more fully or adequately addressed by the GSP, and we look forward to providing more detailed comments to the draft GSP either directly to you or through the continued efforts of the Tule Sub-Basin Coordination Group.

Sincerely,

for Eric Quinley,
Manager, DEID GSA

Eric Limas
Manager, LTRID GSA and PID GSA

LETTER E

SWID, AEWSD

SWID
Shafter-Wasco Irrigation District

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RE: Public Comments to Tule Basin Groundwater Sustainability Plans (GSP)

To Whom It May Concern,

The letter concerns the Groundwater Sustainability Plans (GSPs) that have been drafted by each of the agencies addressed in this letter pursuant to the Sustainable

Groundwater Management Act (Water Code § 10720 *et seq.*) ("SGMA"). The GSPs are referred to herein collectively as the "Tule Subbasin GSPs".

SGMA regulations are set forth in Title 23 of the California Code of Regulations. 23 CCR § 350.4(f) (General Principles) state a GSP "will be evaluated, and its implementation assessed, consistent with the objective that a basin be sustainably managed within 20 years of Plan implementation *without adversely affecting the ability of an adjacent basin to implement its Plan or achieve and maintain its sustainability goal over the planning and implementation horizon.*" (Emphasis added.) Furthermore, 23 CCR § 354.28 (Minimum Thresholds) states a GSP must describe "how minimum thresholds have been selected to avoid causing undesirable results in adjacent basins or affecting the ability of adjacent basins to achieve sustainability goals." There are other sections that speak to similar requirements regarding adjacent basins (e.g., §§ 354.34, 354.38, 355.4).

As you are well aware, there are at least two (2) Kern County water districts, Arvin-Edison Water Storage District and Shafter-Wasco Irrigation District (collectively referred to as "Friant Districts"), that have contracts for 441,275 acre-feet of water service with the United States Department of Interior's Bureau of Reclamation (Reclamation) from Millerton Lake located in Fresno/Madera County that is subsequently conveyed through the Friant-Kern Canal (FKC). E-1

The Friant Districts encompass over 170,000 acres within the Kern Subbasin, which is adjacent to and just south of the Tule Subbasin. **The Friant Districts are concerned that the minimum thresholds in the Tule Subbasin GSPs as currently drafted are not protective of the beneficial water users downstream of the Tule Subbasin and will negatively impact the Friant Districts by limiting their ability to receive significant quantities of their contracted surface water imports due to past and ongoing subsidence within the Tule Subbasin**. Historically, the surface water imports into Kern County from the FKC have enabled the Friant Districts to achieve sustainable groundwater conditions. Unlike declines in groundwater levels, subsidence is a largely irreversible process and therefore once they occur impacts to the FKC from subsidence cannot be reversed, only mitigated through costly infrastructure repairs.

While the Tule Subbasin GSPs did not report loss of water supply from continued subsidence, the Friant Water Authority (FWA) in coordination with others, has completed a draft feasibility study and performed engineering estimates that are detailed in the attached "Friant-Kern Canal Middle Reach Capacity Correction Project Draft Recommended Plan Report" (Report), with current FKC repairs being in excess of $500 million. The Report estimated a projected average annual loss of up to 145,000 acre-feet per year of surface supply caused by continued land subsidence and the corresponding reduction in the conveyance capacity of the FKC (**Report Table 5-4**). However, during wet years, similar to 2017 and 2019, FWA has estimated the water supply losses to be nearly 300,000 acre-feet in both wet years, which figure would be significantly higher with an additional 3 feet of subsidence. Under such E-2 conditions of continued subsidence, the Friant Districts' imported surface water supplies through the FKC will be restricted such that the Friant Districts' ability to contribute to the sustainable management of the Kern Subbasin will be greatly compromised. The continued subsidence negatively impacts the Friant Districts and does not comport with the SGMA regulations, which therefore violates the following, including without limitation: 23 CCR §§ 350.4(f), 354.28, and 355.4(b)(7).

Friant Districts take great exception to the Tule Subbasin GSPs that assume up to a **maximum of 3 feet** of additional subsidence along the FKC (as well as up to nearly 9 additional feet of subsidence in other areas in the Tule Subbasin). While the GSPs did not calculate the amount of FKC capacity loss from such 3 feet drop in elevation, the FWA estimated the capacity reduction to be 1,140 cfs (or 460 cfs drop from current conditions and 2,860 cfs from original design of 4,000 cfs) (Report Figure 5-2). Given current conditions that already restrict FKC deliveries, any further subsidence would be significant and unreasonable and substantially interfere with surface land uses. (See Water Code § 10721(x)(5)). **Consequently, the Friant Districts recommend the Tule Subbasin GSPs include immediate management actions that provide for no additional subsidence (0 feet) beyond that "legacy" subsidence[1] which would occur if pumping were to cease immediately.** No analysis was undertaken to demonstrate how minimum thresholds for subsidence would impact the FKC and affected interests of beneficial users of groundwater or land uses and property interests. Furthermore, the analysis conducted to establish minimum thresholds in the Tule Subbasin GSPs relies on modeling for which sufficient uncertainty and sensitivity analysis have not been completed, or at the very least are not presented. Given the inherent uncertainty in the subsidence model, use of a safety factor in establishing minimum thresholds is warranted. E-2

The Friant Districts' note that in addition to negative impacts to the Friant Districts' water supply, other FKC contractors that are located upstream of the Tule Subbasin will also experience negative financial impacts as a result of the FWA's FKC Operations & Maintenance (O&M) cost recovery methodology, which methodology is essentially based on *actual deliveries*. With continued subsidence in the Tule Subbasin, the Friant Districts' deliveries will be reduced and therefore northern FKC contractors' prorata share of the FKC O&M will increase. E-3

In addition to the continued 3-foot subsidence allowance, the Tule Subbasin GSPs define an Undesirable Result for subsidence to occur when subsidence minimum thresholds are exceeded at greater than 50% of Representative Monitoring Sites (RMS) on a Management Area basis. This definition would allow exceedances of minimum thresholds at multiple RMS (e.g., 3 out of 7 RMS along the FKC in the Eastern Tule GSA area) without it being deemed an Undesirable Result. Friant E-4

[1] "Legacy" subsidence here refers to subsidence resulting from ongoing depressurization and compaction of compressible subsurface units due to historical groundwater pumping and groundwater level declines. Based on the physical characteristics of the compressible subsurface units in the Tule Subbasin, such "legacy" subsidence would be expected to continue for a period of up to approximately two years if groundwater pumping were to cease immediately (see attached letter from Dr. Chin Man Mok, GSI Environmental Inc.).

Districts' recommend an Undesirable Result at just 1 RMS. In addition to changing the threshold, provided that the FKC is critical infrastructure, Friant Districts recommend that the Tule Subbasin GSPs incorporate additional RMS, located at one-mile intervals or less, along the FKC that spans the entire length of the Tule Subbasin. **However, the GSPs do not clarify the projects or management actions that would be taken to avoid such Undesirable Results.** E-4

The GSPs contemplate the continued overdraft conditions (aka "transitional pumping") through the implementation period of 2040, which has been modelled by the Tule Subbasin to cause subsidence. However, the Tule Subbasin GSPs (except one) do not propose any form of mitigation. (See CCR 23 § 354.44) In that regard, the Friant Districts' appreciate the Delano-Earlimart Irrigation District's (DEID) Policy Point #8 (Transitional Pumping), which states unmitigated transitional pumping within the Tule Subbasin would not be supported by DEID, and DEID's treatment of the Western Management Area covering non-districted or "white lands", which states transitional pumping would be subject to mitigation fees. E-5

It shall be noted that the Tule Subbasin Coordination Agreement states the following regarding FKC subsidence:

- "...may result in an interim loss of benefit to the users of such infrastructure..."
- "...exceedance of minimum thresholds...could likely induce financial hardship on land and property interest..."

Given the acknowledged effects of continued subsidence proximate to the FKC, management actions expressly required to avoid and mitigate such impacts are promptly required. (See CCR 23, § 355.4 and Water Code § 10720.1(e).)

Additional observations about the GSP, including review of subsidence information from local experts, is detailed in the attached is EKI Environment and Water and GSI Environmental Technical memorandums.

Sincerely,

Edwin Camp
AEWSD President

Craig Fulwyler
SWID President

cc. California Department of Water Resources
Friant Water Authority
Kern Groundwater Authority
AEWSD Board of Directors
SWID Board of Directors
Legal Counsel
Mike McKenzie, DWR (Charles.McKenzie@water.ca.gov)
Matthew Owens, DWR (Matthew.Owens@water.ca.gov)

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16 December 2019

To: Jeevan Muhar, Arvin-Edison Water Storage District (AEWSD)
Dana Munn, Shafter-Wasco Irrigation District (SWID)

From: Anona Dutton, P.G., C.Hg., EKI Environment & Water, Inc. (EKI)
Christopher Heppner, Ph.D., P.G., EKI

Subject: Review and Comment on Treatment of Subsidence in Draft Tule Subbasin Groundwater Sustainability Plans, Particularly in the Vicinity of the Friant-Kern Canal
(EKI B60064.03)

Dear Messrs. Muhar and Munn,

EKI Environment & Water, Inc. (EKI) has conducted a review of selected draft Tule Subbasin Groundwater Sustainability Plans (GSPs) with respect to their treatment of subsidence, particularly in the vicinity of the Friant-Kern Canal (FKC). This review was conducted on behalf of the Arvin-Edison Water Storage District (AEWSD) and the Shafter-Wasco Irrigation District (SWID), collectively referred to herein as "Friant Districts". Our review encompassed the following documents, collectively referred to herein as the "Tule Subbasin GSPs":

1. Eastern Tule Groundwater Sustainability Agency, Tule Subbasin, *Sustainable Groundwater Management Act Groundwater Sustainability Plan*, September 2019.[1]
2. Delano-Earlimart Irrigation District Groundwater Sustainability Agency, Tule Subbasin, *Sustainable Groundwater Management Act Groundwater Sustainability Plan*, November 15, 2019, 1st Revision.[2]
3. Alpaugh Groundwater Sustainability Agency, *Groundwater Sustainability Plan*, DRAFT, October 2019.[3]
4. Lower Tule River Irrigation District Groundwater Sustainability Agency, Tule Subbasin, *Sustainable Groundwater Management Act Groundwater Sustainability Plan*, September 2019.[4]

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[1] "ETGSA Draft GSP_19.10.2.pdf" obtained from https://easterntulegsa.com/gsp/ on 10/22/2019.
[2] "0.1-DEIDGSA Draft GSP (Full Document)_11.15.19_Rev1.pdf" obtained from https://deid.org/gsa/ on 12/11/2019.
[3] "Alpaugh_GSP_2019 DRAFT with appendices.pdf" obtained from https://alpaughgsa.com/ on 11/11/2019.
[4] "LTRID GSA Draft GSP_10.2.19.pdf" obtained from http://www.ltrid.org/sgma/#gsp on 11/7/2019.

5. Pixley Irrigation District Groundwater Sustainability Agency, Tule Subbasin, *Sustainable Groundwater Management Act Groundwater Sustainability Plan*, September 2019.[5]
6. Tri-County Water Authority, *Groundwater Sustainability Plan*, December 2019.[6]
    a. Addendum No. 1 to Tri-County Water Authority, *Groundwater Sustainability Plan*, dated September 25, 2019.[7]

This letter is structured as follows: First, relevant background information is presented regarding the Tule Subbasin Groundwater Sustainability Agencies (GSAs), the coordination amongst the GSAs, and the FKC. Next, we provide a set of specific comments on the reviewed documents related to the topic of subsidence. Comments are organized by topic and are prefaced by specific background information relevant to that topic. In some cases, comments are further refined to address issues identified in those three GSPs that cover lands that are "adjacent" to the FKC as well as issues identified in the other GSPs that cover lands that are "non-adjacent" to the FKC but still have the potential to impact the FKC (i.e., critical infrastructure).[8] The FKC should reasonably be considered as one of the "land uses and property interests that have been affected or are likely to be affected by land subsidence in the basin" per 23 CCR § 354.28(c)(5)(A).

GENERAL BACKGROUND INFORMATION

Tule Subbasin GSAs

There are seven GSAs within the Tule Subbasin:

- "Adjacent" GSAs
    - Delano-Earlimart GSA (DEIDGSA)
    - Eastern Tule GSA (ETGSA)
    - Lower Tule River Irrigation District GSA (LTRIDGSA)
- "Non-adjacent" GSAs
    - Alpaugh GSA (AGSA)
    - Pixley Irrigation District GSA (PIDGSA)

[5] "Draft PixID GSA GSP_10.27.19.pdf" obtained from http://www.ltrid.org/sgma/#gsp on 11/7/2019.
[6] "GSP PUBLIC DRAFT MASTER B-3 REVISIONS_FINAL_120419.pdf" obtained from https://tcwater.org/ on 12/11/2019.
[7] "TCWA-GSP-Addendum-No.-1.pdf" obtained from https://tcwater.org/ on 11/7/2019.
[8] The DWR DRAFT Sustainable Management Criteria Best Management Practices (BMP) document (https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Groundwater-Management/Sustainable-Groundwater-Management/Best-Management-Practices-and-Guidance-Documents/Files/BMP-6-Sustainable-Management-Criteria-DRAFT_ay_19.pdf) states that "A GSA may decide, for example, that localized inelastic land subsidence near critical infrastructure (e.g., a canal) and basinwide loss of domestic well pumping capacity due to lowering of groundwater levels are both significant and unreasonable conditions."

- Tri-County Water Authority GSA (TCWAGSA)
- Tulare County GSA

The map figure below shows the jurisdictional boundaries of the seven GSAs in the Tule Subbasin, as well as the location of the FKC. The DEIDGSA, the ETGSA, and the LTRIDGSA cover lands that underlie portions of the FKC, and for the purposes of this comment letter are classified as "adjacent" GSAs. The remaining four GSAs cover lands that do not underlie the FKC and are thus considered "non-adjacent", but still have the potential to impact the FKC indirectly through management actions related to groundwater supply, demand, and level management.

Figure 3-2 from the ETGSA GSP

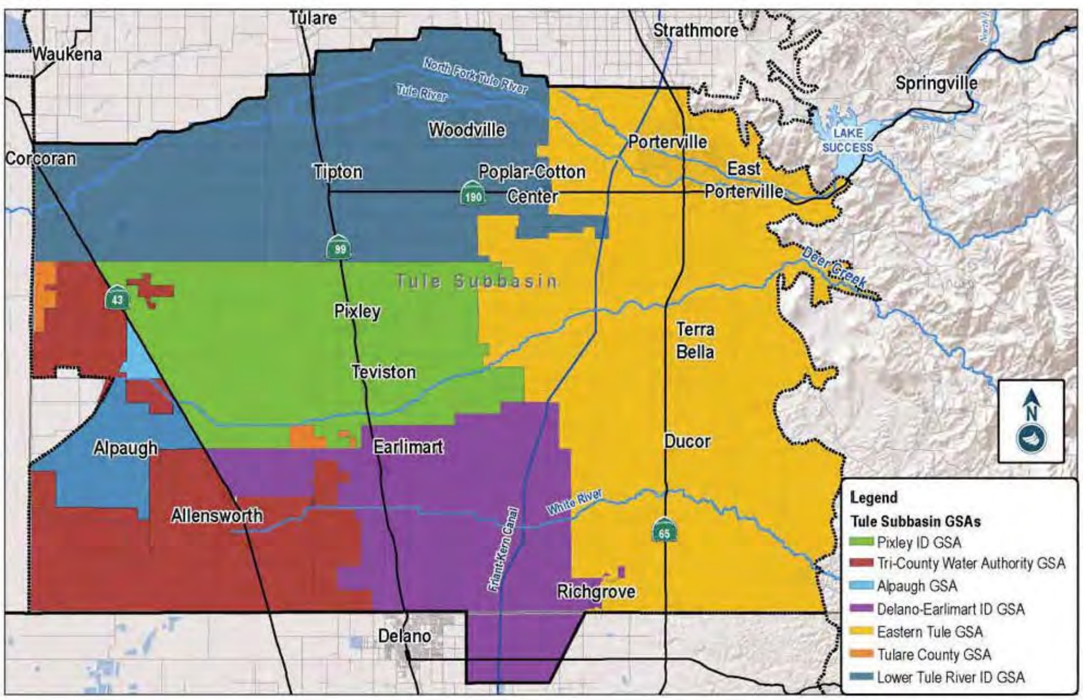

Figure 3-2: Tule Subbasin GSAs and GSP Plan Areas

Tule Subbasin Coordination Agreement

The seven Tule Subbasin GSAs have developed six coordinated GSPs[9], with certain key elements contained in a draft Tule Subbasin Coordination Agreement (TSCA). The version of the TSCA available at the time of this review is dated 9/16/2019. The key elements in the TSCA include:

[9] According to the Tule Subbasin Coordination Agreement (Section 1.2), the Tulare County GSA has entered into Memoranda of Understanding concerning coverage of territories under adjacent GSPs, and is therefore not preparing its own GSP.

- Coordinated Data and Methodologies for groundwater elevation and extraction, surface water supply, total water use, change in groundwater storage, and water budgets;
- Sustainable Management Criteria, including Undesirable Results (but not Minimum Thresholds, Measurable Objectives, and Interim Milestones);
- Monitoring Protocols, Networks, and Identification of Data Gaps; and,
- Implementation of GSPs.

The TSCA includes the following two attachments:

- Attachment 1: Tule Subbasin Monitoring Plan
- Attachment 2: Tule Subbasin Setting

Comments herein that pertain to topics covered in the TSCA are generally applicable to all Tule Subbasin GSAs, including the adjacent and non-adjacent GSAs, unless otherwise noted.

Friant-Kern Canal (FKC)

The FKC is a 152-mile long canal that forms the backbone of the United States Bureau of Reclamation (USBR) Central Valley Project's (CVP) Friant Division. The FKC conveys CVP Friant Division water from the Division's primary storage reservoir, Millerton Lake (formed by Friant Dam on the San Joaquin River), southwards to CVP Friant Division contractors within the Fresno, Kings, Kaweah, Tule and Kern County Subbasins, including to the Friant Districts. The Friant Districts collectively hold CVP contracts totaling 90,000 acre-feet (AF) of Class 1 Friant water (11.25% of the total Class 1) and 351,275 AF of Class 2 Friant water (25.0647% of the total Class 2 amount) (Friant Water Authority, 2019)[10]. As such, the Friant water supplies delivered through the FKC are critical to the ability of the Friant Districts to maintain and/or achieve sustainability within their service areas.

To date, subsidence along the FKC has impacted its conveyance capacity by 60 percent (Friant Water Authority, 2019).[11] As such, the Friant Districts have already lost access to a significant volume of their surface water supply, which has exacerbated groundwater issues in the Kern County Subbasin. Any further reduction in this critical surface water supply due to conveyance restrictions will impact the ability of the Friant Districts to support sustainable groundwater management locally and will impact the Kern County Subbasin's ability to implement its Plan and achieve and maintain its sustainability goal over the planning and implementation horizon.

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[10] Future Friant Division Supplies Tech Memo, https://friantwater.org/s/Future-Friant-Supplies-TM_20181228.pdf. Friant District contract amounts: Class 1 contracts: AEWSD: 40,000 AFY (5% of total Class 1), SWID: 50,000 AFY (6.25% of total Class 1). Class 2 contracts: AEWSD: 311,675 (22.2391% of total Class 2), SWID: 39,600 AFY (2.8256% of total Class 2).
[11] Friant Kern Canal Subsidence Fact Sheet, https://friantwater.org/s/Friant_Subsience_Impacts_Brochure.pdf

As shown in the figure above, the FKC passes through the eastern portion of the Tule Subbasin, primarily through the areas of the ETGSA and the DEIDGSA (with a small segment passing through the LTRIDGSA area). For this reason, some of the comments herein focus specifically on the treatment of subsidence in the DEIDGSA GSP, the ETGSA GSP and the LTRIDGSA GSP (i.e., the "adjacent" GSPs). However, given the critical importance of the FKC to the region's water supply, the comments pertain as well to the other GSPs prepared by the other Tule Subbasin GSAs (i.e., the "non-adjacent" GSPs) as they also have potential ability to impact the canal.

SELECTED COMMENTS

Based upon our review, we have the following comments, organized by topic.

1. **Regarding Tule Subbasin Sustainability Goal**

Background

Section 4.2 of the TSCA presents the Sustainability Goal for the Tule Subbasin, as follows:

> "Pursuant to 23 Cal. Code Regs. §357.24, the Sustainability Goal of the Tule Subbasin is defined as the absence of significant and unreasonable undesirable results associated with groundwater pumping, accomplished by 2040 and achieved through a collaborative, Subbasin-wide program of sustainable groundwater management by the various Tule Subbasin GSAs.
>
> Achievement of this goal will be accomplished through the coordinated effort of the Tule Subbasin GSAs in cooperation with their many stakeholders. It is further the goal of the Tule Subbasin GSAs that coordinated implementation of their respective Groundwater Sustainability Plans will achieve sustainability in a manner that facilitates the highest degree of collective economic, societal, environmental, cultural, and communal welfare and provides all beneficial uses and users the ability to manage the groundwater resource at least cost. Moreover, this coordinated implementation is anticipated to ensure that the sustainability goal, once achieved, is also maintained through the remainder of the 50-year planning and implementation horizon, and well thereafter.
>
> In achieving the Sustainability Goal, these Plans will inherently balance average annual inflows and outflows of water so that negative change in storage does not occur over time. The stabilization in change in storage should also drive stable groundwater elevations, which, in turn, works to inhibit water quality degradation and arrest land subsidence."

Comment: The Sustainability Goal in the TSCA and the Tule Subbasin GSPs is not fully consistent with the General Principles laid forth in the GSP Regulations.

This comment pertains to all of the Tule Subbasin GSPs (i.e., both the adjacent and the non-adjacent GSPs), as they all employ the same basin-wide definition of the Sustainability Goal found in the TSCA.

Under the GSP Emergency Regulations (Title 23 of the California Code of Regulations; 23 CCR) § 350.4(f), "a Plan will be evaluated, and its implementation assessed, consistent with the objective that a basin be sustainably managed within 20 years of Plan implementation without adversely affecting the ability of an adjacent basin to implement its Plan or achieve and maintain its sustainability goal over the planning and implementation horizon." The Sustainability Goal for the Tule Subbasin (Section 4.2 of the TSCA) does not mention ensuring that the GSPs prepared by GSAs within and for the Tule Subbasin will not adversely affect the ability of an adjacent basin to implement its Plan or achieve and maintain its sustainability goal over the planning and implementation horizon. Therefore, the Sustainability Goal does not reflect the General Principles of the GSP Emergency Regulations.

2. Regarding Undesirable Results Definitions

Background

This comment pertains to all of the Tule Subbasin GSPs (i.e., both the adjacent and the non-adjacent GSPs), as they all employ the same basin-wide definition of Undesirable Results found in the TSCA.

Section 4.3 of the TSCA asserts that four of the six Sustainability Indicators are relevant to the Tule Subbasin: (1) Chronic Lowering of Groundwater Levels, (2) Reduction of Groundwater Storage, (3) Degraded Water Quality, and (4) Land Subsidence. Section 4.3.4 of the TSCA provides the basin-wide definition of Undesirable Results for Land Subsidence.

Section 4.3.4.1 of the TSCA states:

> "Land subsidence shall be considered significant and unreasonable if there is a loss of a functionality of a structure or a facility to the point that, due to subsidence, the structure or facility cannot reasonably operate without either significant repair or replacement."

Section 4.3.4.2 of the TSCA further states:

> "the criteria for an undesirable result for land subsidence is defined as the unreasonable subsidence below minimum thresholds at greater than 50% of GSA Management Area [Representative Monitoring Sites] RMS resulting in significant impacts to critical infrastructure."

Section 4.3.4.3 of the TSCA further states:

> "the avoidance of an undesirable result of land subsidence is to protect critical infrastructure for the beneficial uses within the Tule Subbasin, including excessive costs to fix, repair, or otherwise retrofit such infrastructure and may also result in an interim loss of benefits to the users of such infrastructure."

Comment: The definition of Undesirable Results in the TSCA and the Tule Subbasin GSPs is not compliant with the GSP Regulations.

This comment pertains to all of the Tule Subbasin GSPs (i.e., both the adjacent and the non-adjacent GSPs), as they all employ the same basin-wide definition of Undesirable Results found in the TSCA.

Currently portions of the FKC have already experienced a 60 percent reduction of capacity due to subsidence (see Section 3.2 of the ETGSA Joint Powers Authority [JPA] Communication and Engagement Plan; Section III.B.3 of the DEIDGSA Communication & Engagement Plan). The Undesirable Results definition for Land Subsidence (Section 4.3.4.1 of the TSCA) does not provide a clear statement regarding whether the loss of FKC capacity to date is considered "significant and unreasonable". The TSCA also does not quantify how much additional capacity loss would be allowed by the GSAs before they would determine that the FKC "cannot reasonably operate without either significant repair or replacement". The Friant Districts maintain that the current 60 percent loss in FKC capacity is significant and unreasonable and that already the FKC is not able to reasonably operate without either significant repair or replacement. As such, the current condition meets the definition of an "Undesirable Result" and must be addressed.

As discussed further below under Comment #5, the Minimum Thresholds (MTs) for subsidence in the ETGSA GSP and DEIDGSA GSP allow for between 1.3 and 3.0 feet of additional subsidence at the eight Representative Monitoring Sites (RMS) along the FKC. The MT established in the LTRIDGSA GSP for the RMS closest to the FKC (RMS location W) would allow for up to 2.55 feet of additional subsidence. Any additional subsidence and subsequent loss of FKC capacity (and surface water supply) will adversely affect the ability of the Kern County Subbasin (which includes the Friant Districts) to implement its Plan or achieve and maintain its sustainability goal over the planning and implementation horizon. As such the MT definitions in the adjacent GSPs are inconsistent with GSP Regulations 23 CCR § 350.4(f) and § 354.28(b)(3). Furthermore, as discussed below, potential impacts to adjacent basins are required to be considered in the development of GSP monitoring networks, per GSP Regulations 23 CCR § 354.34(f)(3) and § 354.38(e)(4), and in the evaluation of Plans by the Department of Water Resources (DWR) per GSP Regulations 23 CCR § 355.4(b)(7).

The Undesirable Results definition for Land Subsidence (Section 4.3.4.2 of the TSCA) allows for up to 50 percent of the RMS to exceed their MTs. Given the sensitivity of the FKC capacity to changes in land surface elevation, and the documented loss of FKC capacity under historical subsidence conditions (mentioned in Sections 1.6 and 3.2 of the ETGSA JPA Communication and Engagement Plan; Sections III.A.1 and III.B.3 of the DEIDGSA Communication & Engagement Plan; Sections 5.2.1.2.1 and 5.2.2.2.2 of the DEIDGSA GSP; Section 2.5 of the Tule Subbasin Monitoring

Plan [Attachment 1 of the TSCA]; and Section 2.3.4 of the Tule Subbasin Setting [Attachment 2 to the TSCA]), allowing further subsidence to exceed MTs in up to 50% of RMS is not protective of this critical infrastructure. This Undesirable Results definition has the potential to significantly and unreasonably affect not only the Tule Subbasin but the Friant Districts and adversely affect the ability of the Kern County Subbasin (which includes the Friant Districts) to implement its Plan or achieve and maintain its sustainability goal over the planning and implementation horizon, which would be inconsistent with GSP Regulations 23 CCR § 350.4. and § 354.28(b)(3).

The Undesirable Results definition for Land Subsidence (Section 4.3.4.3 of the TSCA) only recognizes the beneficial uses within the Tule Subbasin, neglecting to recognize those downstream beneficial uses and users of critical infrastructure (i.e., the Friant Districts). This limited consideration of only in-basin beneficial uses and users in inconsistent with the GSP Emergency Regulations 23 CCR § 354.26(b)(3) which makes no such distinction between in-basin and out-of-basin beneficial uses and users, and § 350.4(f) which describes the evaluation of a Plan "consistent with the objective that a basin be sustainably managed within 20 years of Plan implementation without adversely affecting the ability of an adjacent basin to implement its Plan or achieve and maintain its sustainability goal over the planning and implementation horizon."

3. Regarding the Basin Setting

Background

A Tule Subbasin-wide summary of the Basin Setting element of GSPs is contained within the TSCA (Section II and Attachment 2) and includes a discussion of subsidence (Section 2.2.5 of Attachment 2 of the TSCA). With respect to subsidence along the FKC, the subsidence section in the TSCA Tule Subbasin Setting includes a single sentence providing a range of cumulative subsidence values for the 58-year period from 1959 – 2017 from benchmarks monitored by the Friant Water Authority:

> "Based on benchmarks located along the Friant-Kern Canal and monitored by the Friant Water Authority, cumulative land subsidence along the canal between 1959 and 2017 has ranged from approximately 1.7 ft in the Porterville area to 9 feet in the vicinity of Deer Creek (see Figure 2-24)".

A number of other subsidence rates for different time periods and different parts of the Tule Subbasin are mentioned and two subsidence map figures (one for the period 2015-2018 and the other for 2007-2011 which does not cover the FKC area) are included in the TSCA. However, despite the statement that "land surface subsidence in the Tule Subbasin as a result of lowering the groundwater level from groundwater production has been well documented" (TSCA, Attachment 2, Section 2.2.5), no supporting information is provided on groundwater level changes or groundwater production as it relates to observed subsidence rates. Additional and readily available information available through the SGMA Data Viewer is not used. As such, the Basin Setting portion of the TSCA and the GSPs is inconsistent with the standard that the "best available information" be used (23 CCR § 354.16).

The water budget section of the Tule Subbasin Setting (TSCA Attachment 2, Section 2.3.5) mentions impacts to the FKC due to subsidence:

> "The primary surface water supply issue affecting the ability of agencies to operate within the Sustainable Yield of the subbasin is reduced delivery capacity in the Friant-Kern Canal due to land subsidence. Land subsidence has lowered the canal elevation in certain areas resulting in a reduction in downstream canal delivery capacity".

The above statement does not include any quantitative descriptions of impacts to the FKC from subsidence, although such description is mentioned elsewhere in the document (i.e., in the Communication and Engagement Plans of the ETGSA and DEIDGSA).

Each individual GSP also contains a brief discussion of the Basin Setting elements, including subsidence, but the discussion refers to the TSCA Tule Subbasin Setting and does not provide any additional information.

Comment: The Basin Setting information lacks sufficient discussion of the serious issue of subsidence.

Adjacent GSPs: The Basin Setting sections of the adjacent GSPs do not provide detailed information about subsidence, particularly as it pertains to the impacts on the FKC. For example, the cumulative subsidence data provided at several points along the FKC are values over a very long time period (58 years), with no attempt made to correlate such values either in time or in space with changes in groundwater elevation. The InSAR data shown on one map figure (Figure 2-25 of the Tule Subbasin Setting) only cover four years. These exhibits are therefore of limited value in understanding the scale of the subsidence issue in the Tule Subbasin and its relation to declining groundwater levels which are the key factor over which GSAs are likely to have direct control (i.e., through management of water supplies and demands). By providing such a limited presentation of data and discussion, the GSPs are not in compliance with 23 CCR § 354.16(e), which states that a GSP must include information on "the extent, cumulative total, and annual rate of land subsidence, including maps depicting total subsidence, utilizing data available from the Department… or the best available information". Additional datasets available through the SGMA Data Viewer (i.e., data from USGS and DWR extensometers and InSAR data from the TRE Altamira and NASA JPL) should be examined and presented in the GSPs to the greatest extent possible and applicable, along with data on changes in groundwater levels.

While the 60 percent reduction in FKC delivery capacity as a result of subsidence in the Tule Subbasin is mentioned in the ETGSA JPA Communication and Engagement Plan and in the DEIDGSA Communication & Engagement Plan, it is not discussed elsewhere in either of these two GSP documents, nor in the LTRIDGSA GSP. This important fact should be mentioned in the "Potential Effects on Beneficial Uses and Users" sections of the GSPs and/or the Land Subsidence section (Section 2.2.5) of the Tule Subbasin Setting document (Attachment 2 to the TSCA). Additional information related to impacts to the FKC conveyance capacity should be included and appropriately cited.

Non-Adjacent GSPs: The non-adjacent GSPs similarly contain only limited information and discussions about subsidence in their Basin Setting sections. No correlations between subsidence, groundwater level declines and/or groundwater production area provided. Given the significance of the subsidence issue in the Tule Subbasin, and the relatively large subsidence rates observed over time and recently, more detailed information should be provided (for example, the additional datasets that have been made readily available through the DWR SGMA Data Viewer website; see list above). By providing such a limited presentation of data and discussion, the GSPs are not in compliance with 23 CCR § 354.16(e), which states that a GSP must include information on “the extent, cumulative total, and annual rate of land subsidence, including maps depicting total subsidence, utilizing data available from the Department… or the best available information”.

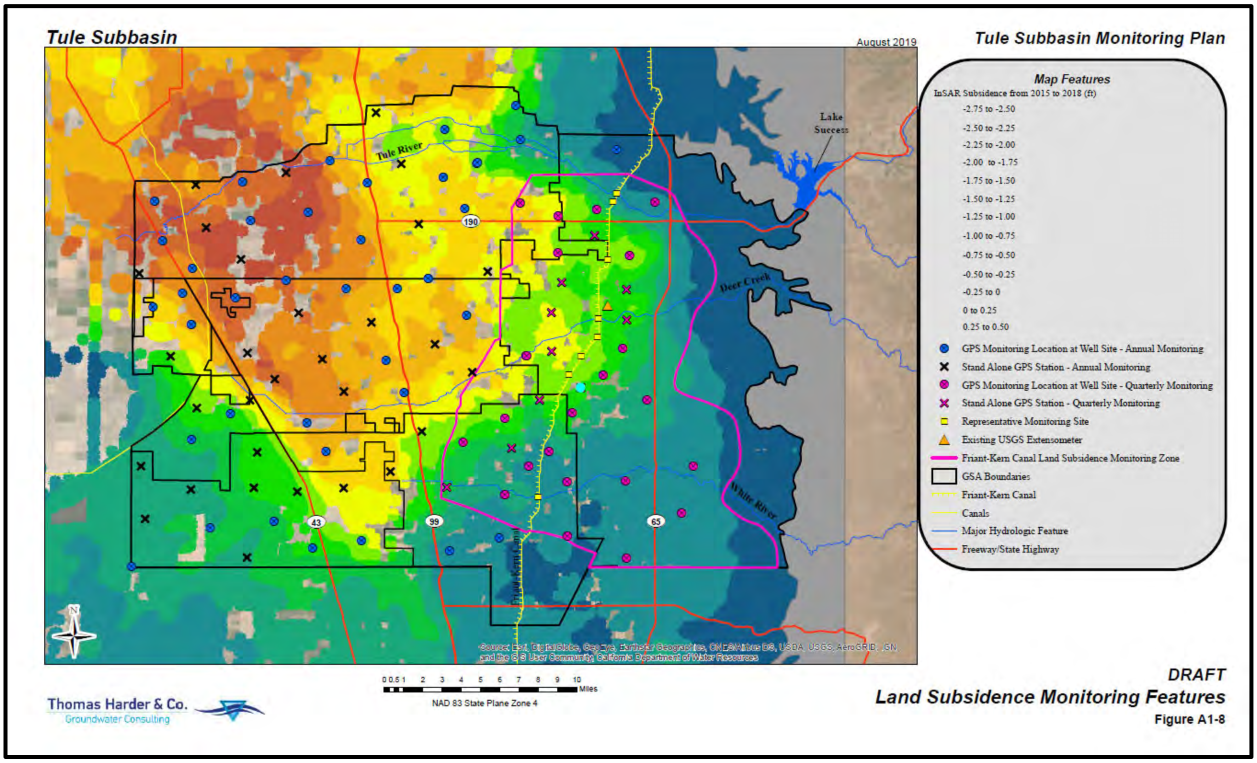
4. Regarding Monitoring Networks and Management Areas for Subsidence

Background

The Tule Subbasin contains a “land subsidence monitoring area” that is approximately centered around the FKC and extends west four miles and eastward to the 1-ft cumulative subsidence 1986-2017 contour. This area is shown by the solid pink line in Figure A1-8 of Attachment 1 of the TSCA (see figure below). This map figure also shows the cumulative subsidence between 2015 and 2018 based on InSAR data. Based on this data, the subsidence along the FKC during this period was up to 1.25 ft.

The ETGSA contains a “Friant-Kern Canal Subsidence Management Area” which appears to be the same as the “land subsidence monitoring area” mentioned in the TSCA Monitoring Plan.

Figure A1-8 from the Tule Subbasin Monitoring Plan (Attachment 1 of the TSCA)



The Tule Subbasin Monitoring Plan (Attachment 1 to the TSCA) describes the network and protocols for land subsidence (and other indicators). It consists of:

- GPS stations (existing ones operated by USBR along the FKC, and new ones including 63 at monitoring well locations and 39 standalone GPS stations); annual frequency for all sites, except quarterly for sites within the "FKC Monitoring Zone" (which is presumably the same as the "land subsidence monitoring area" mentioned in the TSCA);
- Extensometers (one operated by USGS along the FKC one mile north of Deer Creek crossing); continuous data collection with periodic uploads by USGS; and
- Satellite data (InSAR), obtained from JPL, USGS, or ESA and analyzed/interpreted by 3rd party to develop maps, for six periods over the first year of monitoring and then less frequent after that.

The Tule Subbasin Monitoring Plan also recommends the installation of a new extensometer in the northwestern portion of basin (not near the FKC).

There are a total of eight GPS monitoring locations along the FKC that are used as RMS in the three adjacent GSPs (seven RMS in the ETGSA GSP and one RMS in the DEIDGSA GSP). These locations are labeled B through I and shown in the two figures below.

Figure 6-3 from the ETGSA GSP

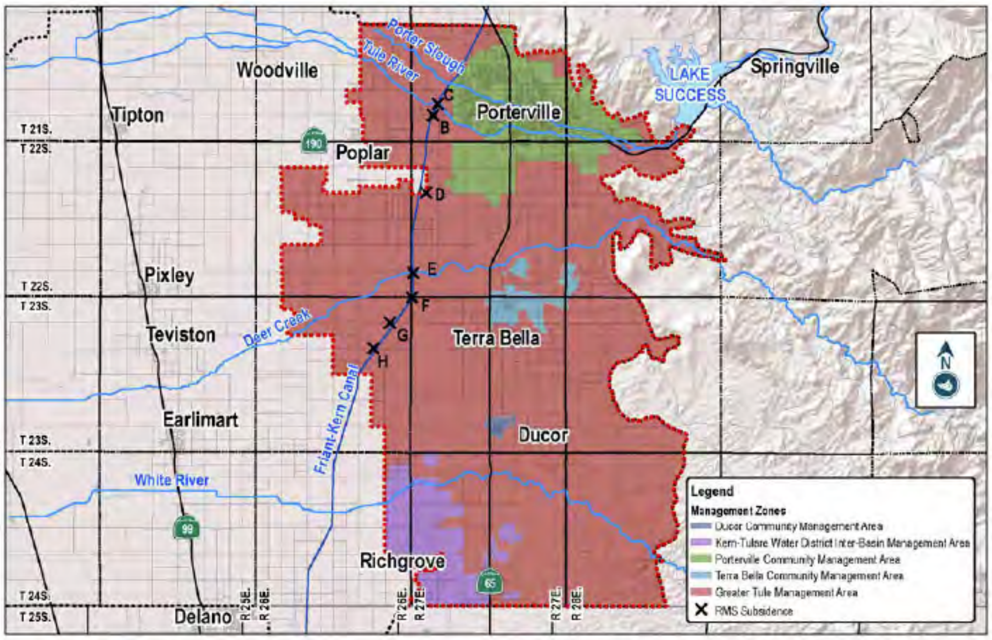


Figure 6-3: RMS for Monitoring Land Subsidence

Figure 4-3 from the DEIDGSA GSP

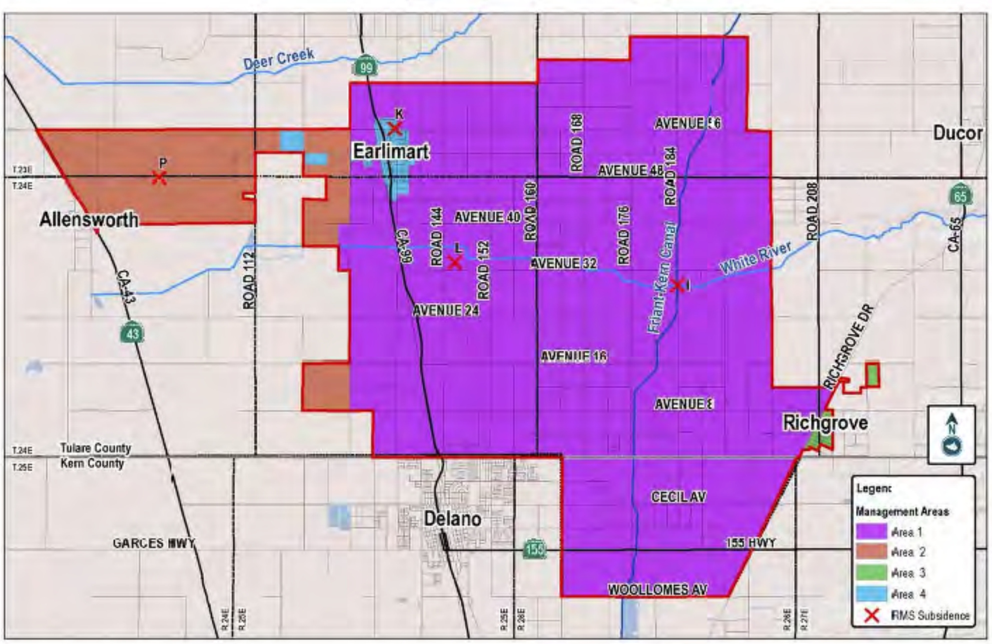


Figure 4-3: RMS for Monitoring Land Subsidence

Comment: The Monitoring Network for subsidence in the vicinity of the FKC is inadequate.

Adjacent GSPs: The DEIDGSA GSP monitoring network (Section 4.2.3.5) only contains a single RMS along the FKC, which provides inadequate spatial resolution to capture the details of subsidence in the DEIDGSA area. The GSP Regulations 23 CCR § 354.34(f) requires that the Agency "determine the density of monitoring sites and frequency of measurements required to demonstrate short-term, seasonal, and long-term trends based upon the following factors … (3) Impacts to beneficial uses and users of groundwater and land uses and property interests affected by groundwater production, and adjacent basins that could affect the ability of that basin to meet the sustainability goal." Given that the DEIDGSA GSP monitoring network only contains a single subsidence RMS along the FKC, the network will not allow for sufficient characterization of impacts to overlying land uses (i.e., including critical infrastructure such as the FKC) and impacts to adjacent basins. As such, the subsidence monitoring network does not appear to satisfy the requirements of GSP Regulations 23 CCR § 354.34(f).

5. Regarding Sustainable Management Criteria for Subsidence in Adjacent GSPs

Background

Sustainable Management Criteria (SMCs) include Measurable Objectives (MOs), Interim Milestones (IMs), and Minimum Thresholds (MTs). The IMs and MOs for subsidence are defined based on the projected depth of subsidence calculated by the Groundwater Flow Model[12] based on a model run that incorporates planned Projects & Management Actions (P/MAs).

The MTs for subsidence, in terms of change from baseline (2020) elevations, are defined in the ETGSA GSP (Section 5.8.3.1.1) as the lesser of 3 ft -OR- the amount of elevation change observed over the 2007-2016 period (a "recent drought") subtracted from the lowest interim milestone from 2020-2030). This value is then subtracted from the baseline elevation to determine the MT in terms of elevation at each RMS. In the DEIDGSA GSP, there is no 3-ft maximum included in the subsidence MT definition (Section 3.5.2.4.1). Similarly, in the LTRIDGSA GSP, there is no 3-ft maximum included in the subsidence MT definition (Section 3.5.2.4.1), meaning that the MT is not limited to 3 feet.

The SMCs for the eight subsidence monitoring locations along the FKC are shown in Table 1, below, compiled by EKI from information included separately in the ETGSA and DEIDGSA GSPs. As shown in Table 1, five of the eight RMS locations along the FKC have MTs for subsidence that are 3.0 feet below the Baseline elevation (i.e., they would allow an additional 3.0 feet of land subsidence directly adjacent to the FKC). SMCs for subsidence RMS locations that are not along the FKC are also shown in Table 1. These MTs allow for subsidence of up to approximately 9.0 feet at some RMS locations.

[12] The numerical Groundwater Flow Model is based on the hydrogeologic conceptual model (see TSCA Section 2.2). Thomas Harder & Co., 2019. Groundwater Flow Model of the Tule Subbasin (DRAFT in Progress).

Table 1
SMCs for Land Subsidence in the Tule Subbasin GSPs

GSA	RMS ID	Baseline 2020 ft msl	Interim Milestones 2025 ft msl	Interim Milestones 2030 ft msl	Interim Milestones 2035 ft msl	Measurable Objective 2040 ft msl	Minimum Threshold ft msl	Difference between Baseline and MT ft
RMS Locations Along the Friant-Kern Canal								
ETGSA	B	406.46	406.12	405.90	405.84	405.85	404.80	1.66
ETGSA	C	404.30	404.03	403.83	403.78	403.77	403.00	1.30
ETGSA	D	403.99	403.50	403.25	403.25	403.25	400.99	3.00
ETGSA	E	396.86	396.54	396.38	396.39	396.39	393.86	3.00
ETGSA	F (1)	406.46	406.12	405.90	405.84	405.85	403.46	3.00
ETGSA	G	391.70	390.59	389.98	389.92	389.85	388.70	3.00
ETGSA	H	394.13	392.57	391.62	391.49	391.36	391.13	3.00
DEID GSA	I	396.24	396.00	395.77	395.65	395.62	394.77	1.47
RMS Locations Not Along the Friant-Kern Canal								
PIDGSA	A	201.95	201.2	200.39	199.83	199.66	194.6	7.35
PIDGSA	J	261.59	260.77	259.96	259.23	258.80	256.51	5.08
PIDGSA	Q	258.93	258.90	257.31	256.74	256.43	252.84	6.09
PIDGSA	R	232.34	231.07	230.22	229.70	229.37	225.94	6.40
PIDGSA	T	193.10	190.99	188.95	187.04	185.44	184.38	8.72
LTRIDGSA	U	202.19	200.80	199.35	197.94	194.91	194.91	7.28
LTRIDGSA	W	350.25	349.71	349.10	348.60	348.28	347.70	2.55
LTRIDGSA	X	259.71	257.98	256.14	254.48	253.24	250.73	8.98
LTRIDGSA	Y	255.53	254.39	253.25	252.10	251.18	249.64	5.89
LTRIDGSA	Z	228.86	227.34	225.84	224.51	223.60	220.25	8.61
TCWAGSA	No subsidence SMCs established	-	-	-	-	-	-	-
AGSA		-	-	-	-	-	-	-

Abbreviations

AGSA = Alpaugh Groundwater Sustainability Agency
DEID = Delano-Earlimart Irrigation District
ET = Eastern Tule
ft = feet
ft msl = feet above mean sea level
GSA = Groundwater Sustainability Agency
GSP = Groundwater Sustainability Plan
LTR = Lower Tule River
MT = Minimum Threshold
PID = Pixly Irrigation District
RMS = Representative Monitoring Site
SMC = Sustainable Management Criteria
TCWA = Tri-County Water Authority

Note:

(1) The Baseline, Interim Milestones, and Measurable Objective for RMS location F appears to be duplicative of RMS location B, and therefore may be incorrect.

The ETGSA GSP contains a subsidence discussion of "Minimum Thresholds in Relation to Adjacent Basins" (Section 5.8.3.3), as follows:

> "Per criteria described for define minimum thresholds for groundwater levels in Section 5.8.3.1 Criteria to Define Minimum Thresholds, the GFM projects groundwater elevations based the Tule Subbasin reaching sustainability by 2040, with built in operational flexibility of a 10-year drought occurring during the 20-year implementation horizon of this plan. Adjacent basins have been tasked with the same objective to reach sustainability 2040, therefore, based on the criteria previously described, if minimum thresholds were experienced at groundwater level RMS, adjacent basins would experience similar groundwater conditions not as a direct result of minimum thresholds set by the Agency."

The DEIDGSA GSP contains a section called "Effects on Adjacent Basins" that simply concludes that:

> "as groundwater elevations are stabilized to natural conditions during the Plan Implementation period, adjacent basins should not be affected by the GSA".

The DEIDGSA GSP also includes a section called "Effects on Beneficial Uses" that has a bullet on subsidence that mentions impacts to existing critical infrastructure "including the District canal system" but does not mention the FKC.

Comment: The proposed Sustainable Management Criteria for subsidence are insufficient in their consideration of impacts on adjacent basins.

Adjacent GSPs: The definitions of MTs for subsidence in the ETGSA GSP and the DEIDGSA GSP allows for large amounts of additional subsidence at the eight RMS locations along the FKC relative to present "Baseline" elevations. The MTs for subsidence at these eight RMS locations range from 1.3 feet to 3.0 feet, with five RMS locations with MTs of 3.0 feet. The MT established in the LTRIDGSA GSP for the RMS closest to the FKC (RMS location W) would allow for up to 2.55 feet of additional subsidence. These amounts of additional subsidence in close proximity to the FKC could have significant and unreasonable impacts on the FKC's ability to convey water to all downstream users and adversely affect the ability of the Kern County Subbasin (and Friant Districts) to implement its Plan or achieve and maintain its sustainability goal over the planning and implementation horizon. The MTs are therefore not protective of those beneficial users of the FKC both within the Tule Subbasin and in the adjacent Kern County Subbasin.

No analysis is provided in the ETGSA, DEIDGSA, and LTRIDGSA GSPs or in the TSCA as to specifically how the MTs for subsidence would impact the FKC, a "land use" of critical regional importance. Therefore, the discussion does not satisfy the requirements of GSP Regulations 23 CCR § 354.28(b)(4) which states that the description of MTs shall include "How minimum thresholds affect the interests of beneficial uses and users of groundwater or land uses and property interests" and GSP Regulations 23 CCR § 354.28(c)(5), which states "The minimum thresholds for land subsidence shall be the rate and extent of subsidence that substantially interferes with surface land uses and may lead to undesirable results."

The reference to Section 4.3.4.3 of the TSCA is insufficient in this regard, as that section (which pertains to Undesirable Results for Land Subsidence) only mentions "financial hardship on land and property interests, such as the redesign of previously planned construction projects and the fixing and retrofitting of existing infrastructure"; it does not contemplate the reduction in FKC capacity and subsequent reduced availability of FKC supplies to downstream users which will directly impact those users' and basin's ability to achieve and maintain sustainability throughout the planning and implementation horizon. Nor does it contemplate the significant financial impacts related to addressing the subsidence impacts to the FKC.

The ETGSA GSP discussion of "Minimum Thresholds in Relation to Adjacent Basins" (Section 5.8.3.3) is not specific to or relevant to the subsidence sustainability indicator (i.e., the same text is used for subsidence as for the chronic lowering of groundwater levels sustainability indicator). The discussion furthermore dismisses the possibility that actions or inactions within the Tule Subbasin could negatively affect adjacent basins, rather stating that "adjacent basins would experience similar groundwater conditions not as a direct result of minimum thresholds set by the Agency". This assertion is not supported by facts or consistent with the reality that the MTs for subsidence set by the Agency (i.e., the ETGSA) will affect FKC conveyance capacity and therefore adversely affect the Friant Districts and impact the Kern County Subbasin's ability to achieve groundwater sustainability.

The DEIDGSA GSP contains a section "Effects on Adjacent Basins" (Section 3.5.2.5.2) that simply concludes that "as groundwater elevations are stabilized to natural conditions during the Plan Implementation period, adjacent basins should not be affected by the GSA." This assertion is not supported by facts or consistent with the reality that the MTS for subsidence set by the Agency (i.e., the DIEDGSA) will very likely impact FKC conveyance capacity and therefore adversely affect the Friant Districts and impact the Kern County Subbasin's ability to achieve groundwater sustainability.

None of the adjacent GSA GSPs contains a discussion of how the out-of-basin interests were considered during the Minimum Threshold development process. The definitions of MTs in the ETGSA GSP and the DEIDGSA GSP, therefore, do not satisfy the requirements of GSP Regulations 23 CCR § 354.28(b)(3), which states that the description of MTs shall include "how minimum thresholds have been selected to avoid causing undesirable results in adjacent basins or affecting the ability of adjacent basins to achieve sustainability goals".

<u>Non-Adjacent GSPs</u>: The establishment of SMCs for subsidence in the non-adjacent Tule Subbasin GSPs is also problematic, even though subsidence in those areas may not have a direct impact on the FKC. For the two non-adjacent GSPs that do establish SMCs for subsidence, the MTs are set so as to allow for significant further subsidence beyond baseline conditions (see Table 1). Specifically, the MTs for subsidence in the LTRGSA GSP for RMS locations other than location W (discussed above) allow for between 5.89 and 8.98 feet of subsidence relative to baseline

conditions, and the MTs for subsidence in the PIDGSA GSP allow for between 5.08 and 8.72 feet of subsidence relative to baseline conditions.

The other two non-adjacent GSPs do not even set SMCs for subsidence. The TCWAGSA GSP does not set SMCs for subsidence, citing a lack of ground-based measurements, even though the available satellite-based subsidence data suggest subsidence rates of approximately 0.7 to 2.0 feet over the 16-month period from May 7, 2015 to September 10, 2016. Likewise, the AGSA GSP does not define SMCs for subsidence, but rather states that five years of monitoring (i.e., from 2020 – 2024) will be used to establish baseline rates of subsidence and then to set site-specific SMCs.

6. Regarding Projects and Management Actions

Background

The DEIDGSA GSP mentions subsidence-related FKC capacity constraints in one P/MA (Action 2 – Increase Importation of Imported Waters; Section 5.2.1.2), but only as a reason to pursue the action, not as a problem to be addressed. Under another P/MA (Action 1 – Transitional Pumping [for White Areas]), the DEIDGSA GSP includes additional discussion of impacts to the FKC, and states that additional study and analysis will:

> "look at finding the relative cause of future predicted subsidence along the FKC … likely to lead to an assessment of costs of FKC subsidence mitigation to those lands employing transitional pumping … collection of mitigation fees would then be used to correct subsidence impacts on the FKC … would restore the carrying capacity of the FKC … would restore the ability of Friant contractors in the Tule Subbasin and those further south to receive their contractual imported water without capacity limitations."

The ETGSA mentions subsidence as being one of the sustainability indicators that will be "generally" affected by various P/MAs.

The planned P/MAs that are aimed at achieving sustainability through a balancing of the groundwater budget are described in Section 2.3.5 of the Tule Subbasin Setting (Attachment 2 of the TSCA). Details of "transitional pumping" schedules for each of the GSAs under the planned P/MAs are provided in Table 2-7 of the Tule Subbasin Setting (below). As shown in Table 2-7, the projected year for achieving sustainability ranges from 2035 to 2040 for all areas except for the DEIDGSA District Area which is described as already being sustainable (i.e., "No Change / Sustainable"). Until sustainable conditions are achieved (i.e., for at least 15 more years in all areas except the DEIDGSA District Area), the planned P/MAs will allow for continued over-pumping which will result in continued water level declines. For the DEID White Lands (i.e., the "Western Management Area" consisting of undistricted lands), the transitional pumping schedule calls for no reduction in pumping relative to existing crop consumptive use.

Table 2-7 of the Tule Subbasin Setting (Attachment 2 of the TSCA)

Tule Subbasin
Chapter 2 - Basin Setting

DRAFT
Table 2-7

Planned Transitional Pumping by GSA

	Eastern Tule GSA	LTRID GSA	Pixley ID GSA	DEID-District Area	DEID White Lands Area	Tri-Co GSA	Alpaugh GSA
	2	A	A		-	-	-
2020-2025	90% of over-pumping[1]	2.0 af/ac Over Cons. Use Target	Fallow 5,000 acres; Remaining no change	No Change/ Sustainable	100% of over-pumping	100% of over-pumping	Reduce cropped area by 880 acres; 80% of overpumping
2025-2030	80% of over-pumping	1.5 af/ac Over Cons. Use Target	Fallow 5,000 acres; Remaining 1.5 af/ac Over Cons. Use Target[2]		Linear Transitional Pumping	Reduce pumping 10,000 af/yr	
2030-2035	30% of over-pumping	1.0 af/ac Over Cons. Use Target	Fallow 5,000 acres; Remaining 1.0 af/ac Over Cons. Use Target				50% of overpumping
2035-2040	Sustainable	0.5 af/ac Over Cons. Use Target	Fallow 5,000 acres; Remaining 0.5 af/ac Over Cons. Use Target		Sustainable	Sustainable	20% of overpumping
2040+		Sustainable	Sustainable				Sustainable

Notes:
[1] Over-pumping means pumping in excess of the consumptive use target
[2] Over consumptive use target means over pumping

Comment: The proposed Projects and Management Actions do not adequately address and mitigate impacts from subsidence.

<u>Adjacent GSPs</u>: None of the adjacent GSA GSPs include projects whose specific anticipated benefits will be mitigation of subsidence related impacts. The DEIDGSA GSP, under Action 1 for the Western Management Area "White Lands" (Section 5.2.2.2), discusses impacts to the FKC, and says that a future study is "anticipated", but it is not specifically called for. The P/MAs section of the ETGSA GSP (Section 7) only mentions subsidence as being one of the sustainability indicators that will be "generally" affected by various P/MAs.

GSP Regulations 23 CCR § 354.44(b)(1) require that a GSP include a description of P/MAs that includes "A list of projects and management actions … that may be utilized to meet interim milestones, the exceedance of minimum thresholds, or where undesirable results have occurred or are imminent." Given that significant and unreasonable impacts for land subsidence may have already occurred or are imminent, and that the list of P/MAs in the ETGSA GSP and DEIDGSA GSP does not include actions to address these undesirable results (only mentioning an "anticipated" future study), the list of P/MAs does not meet the requirements of GSP Regulations 23 CCR § 354.44(b)(1).

Further, the transitional pumping schedule for the DEIDGSA Western Management Area "White Lands" calls for no reduction from existing crop consumptive use demands for the first five years. This five-year delay in commencement of transitional pumping will perpetuate the water budget deficits in the DEIDGSA Area which are estimated through groundwater modeling to be in excess of -30,000 acre-feet per year (AFY) initially in 2020, eventually ramping down to -15,000 AFY in 2030 and -4,000 AFY in 2040 (Appendix C of the Tule Subbasin Setting). This five-year delay in commencement of transitional pumping will also perpetuate the subsidence issues and impacts to the FKC. As such evaluation of this P/MA has not considered "the interests of the beneficial uses and users of groundwater in the basin, and the land uses and property interests potentially affected…" as is required per CCR 23 § 354.4(b)(4).

Non-Adjacent GSPs: The TCWAGSA GSP similarly delays commencement of transitional pumping for the first five years (i.e., until 2025) which is projected to results in continued groundwater deficits of -12,000 AFY in 2020, -8,000 AFY in 2030, -6,000 AFY in 2040, and -3,000 AFY in 2070. These continued water budget imbalances will likely result in continued groundwater declines, as is corroborated by the projected hydrographs from the groundwater model (included in Appendices A through F of the Tule Subbasin Setting [Attachment 2 to the TSCA]). Consequently, the declining groundwater levels will likely lead to further land subsidence, effects of which could negatively impact beneficial uses and users within the Tule Subbasin and the adjacent Kern County Subbasin. As such evaluation of potential P/MAs has not considered "the interests of the beneficial uses and users of groundwater in the basin, and the land uses and property interests potentially affected…" as is required per CCR 23 § 354.4(b)(4).

Please let us know if you have any questions regarding this matter.

Sincerely,

EKI Environment & Water, Inc.

Anona Dutton, P.G., C.Hg.	Christopher Heppner, Ph.D., P.G.
Vice President	Supervising Hydrogeologist

December 16, 2019
GSI Proposal No. 9000-910
GSI EKI MSA 20180103

Anona Dutton, PG, CHg
EKI Environment and Water, Inc.
577 Airport Boulevard, Suite 500
Burlingame, California 94010

Re: Subsidence-Focused Review of Tule Subbasin Groundwater Sustainability Plans For Friant Districts in Kern County

Dear Ms. Dutton:

Per the request by EKI Environment and Water, Inc. (EKI) on behalf of the Friant Districts (Arvin Edison Water Storage District and Shafter-Wasco Irrigation District), GSI Environmental Inc. (GSI) has performed a subsidence-focused review of the following six draft Groundwater Sustainability Plans (GSPs) individual released by six respective Groundwater Sustainability Agencies (GSAs) in the Tule Subbasin:

- Alpaugh (A) GSA GSP,
- Delano-Earlimart Irrigation District (DEID) GSA GSP,
- Lower Tule River Irrigation District (LTRID) GSA GSP,
- Pixley Irrigation District (PID) GSA GSP,
- Eastern Tule (ET) GSA GSP, and
- Tri-County Water Authority (TCWA) GSA GSP.

The review focused on assessing whether subsidence has been adequately addressed in the GSPs to avoid negative future impacts on the Friant-Kern Canal (FKC) to an extent that will adversely affect the Friant Districts plan to achieve the groundwater sustainability goals in compliance with the State of California's Sustainable Groundwater Management Act (SGMA). The version of each document reviewed was downloaded through the website (https://tulesgma.com/) on December 2, 2019.

BACKGROUND

The Friant Districts are developing a GSP. To achieve the groundwater sustainability goals, the Friant Districts relies on contracts with the United States Bureau of Reclamation (USBR) for 90,000 acre-feet per year (AFY) of Class 1 water and 351,275 AFY of Class 2 water from the Friant Division of the Central Valley Project (CVP), delivered through the FKC, as a component of the available water resources to meet the predicted agricultural water demands. The FKC transmit water from the north, through the DEID and ET GSP Management Area in the Tule Subbasin and then through the Kern-Tulare GSP Management Area, into Kern County Subbasin.

Groundwater extraction has caused ground subsidence along the FKC in the Tule Subbasin since its construction was completed. The rate of subsidence was accelerated between 2008 and 2016 due to extreme drought condition. The water flow through the FKC was primarily driven by gravity. It has been reported that the FKC has lost approximately 60 percent of its design delivery capacity because historical land subsidence has reduced the topographic slope along the FKC alignment. In addition to ground subsidence and topographic slope changes, groundwater extraction also induces horizontal and vertical curvatures along a line on the ground surface in the vicinity of the extraction well. Differential subsidence also causes stresses and strains in the subsurface soils. Excessive strains can generate fissures and compaction faults. If the induced curvatures and slopes along the FKC are excessive, or if fissures and compaction faults developed in the subsurface underlying the FKC, FKC structural damage and water leak might occur. Reduction of water conveyance capacity and water leak along the FKC in the Tule Subbasin would potentially jeopardize Friant District's ability to achieve the groundwater sustainability goal set in their GSP. According to the GSP Regulations under the SGMA, the Tule Subbasin GSPs should "avoid causing undesirable results in adjacent basins or affecting the ability of adjacent basins to achieve sustainability goals".

OVERVIEW OF THE GSP REVIEW

The six GSPs were developed primarily based on a similar document structure. The GSPs include sections that describe the plan area, basin setting, sustainable management criteria, monitoring network, and projects and management actions. The following two attachments to the Tule Subbasin Coordination Agreement (TSCA):

- Attachment 1 (A1) – Tule Subbasin Monitoring Plan
- Attachment 2 (A2) – Tule Subbasin Basin Setting

were presented as appendices attached to the GSPs and are the basis for developing the GSPs. The TSCA provides a platform for coordinating data sharing and GSP approach. In addition, the GSPs were developed using the results of a Tule Subbasin Groundwater Flow Model (TSGFM) which has not been released for this review. Therefore, our review focused on how the TSGFM results were utilized to establish sustainability metrics. The quantitative metrics should be reviewed when the TSGFM is finalized.

The FKC passes through the ET and DEID GSA Management Areas (MA). The TSCA defined an area centered around the FKC and extends west four miles and eastward to the 1986-2017 one-foot subsidence contour as "land subsidence monitoring area". The ETGSA GSP refers to this area as "Friant-Kern Canal Subsidence Management Area" (FKCSMA). The A GSA and TCWA GSA GSP Management Areas (MA) are over ten miles from the FKC. The subsidence in these two GSP MAs is not expected to induce significant topographic slope changes, curvatures, or strain along the FKC. Our review focused on the sections related to subsidence along the FKC in the ET and DEID GSA GSPs. The sections in the LTRID and PID GSA GSP related to subsidence within the FKCSMA were also reviewed.

REVIEW COMMENTS

The following comments are related to defining the performance metric in relation to the potential subsidence impacts on FKC:

- The "Undesirable Results for Land Subsidence" were not adequately defined regarding subsidence related impacts on the FKC

  The GSPs only consider conveyance capacity reduction as an undesirable result of the FKC. Other undesirable results, such as structural damage resulting from curvatures and ground strains induced by groundwater extraction from nearby wells, were not considered. Based on our past experience, a major groundwater production well in the Corcoran area can potentially induce a vertical curvature on the order of 5e-6 ft^{-1}. In addition, such well can induce a horizontal movement of up to approximately 1/4 of the vertical subsidence within 2000 ft from the well. The FKC was constructed almost seventy years ago. The GSPs do not address the current condition and the vulnerability of the FKC. A major groundwater production well in close proximity to the FKC can potentially affect the structural integrity of the FKC. Based on the historical subsidence data from the United States Geologic Survey (USGS) and Jet Propulsion Laboratory (JPL), subsidence in the Tule Subbasin has been shifting eastward in the past decades due to additional groundwater extraction. The GSPs do not preclude the possibility of groundwater production wells in close proximity to the FKC.

- Allowing less than 50% of the Representative Monitoring Sites (RMSs) to exceed the Minimum Thresholds (MT) criterion might not be protective of adequate conveyance capacity of the FKC.

  Conveyance capacity is governed by topographic slope, which is dictated by the differential subsidence at two locations. Although only up to 50% of the Representative Monitoring Sites

(RMSs) are allowed to exceed their MTs, it does not prohibit the differential subsidence between two neighboring RMSs to be large (e.g., no subsidence at one RMS while the next upgradient RMS has reached the maximum subsidence limit). Based on our past experience, a major groundwater production well in the Corcoran area can potentially induce a vertical slope on the order of 0.002. A major groundwater production well in close proximity to the FKC can potentially affect the conveyance capacity of the FKC. In addition, the 50% criterion is not location specific. In an extreme case, if 50% of the upgradient RMSs has reached the MT limits and the subsidence at the downgradient RMSs are minimal, it is unclear whether the FKC conveyance capacity can meet the target flow rate needed.

- The FKC Conveyance Capacity needed was not defined

  Although FKC conveyance capacity is a major groundwater sustainability consideration, the GSPs did not present the FKC conveyance capacity needed. It has been reported that the FKC has already lost 60% of its conveyance capacity due to historical subsidence. The GSPs did not discuss the current conveyance capacity can adequately meet the flow rate needed and how much additional conveyance capacity loss is acceptable. The subsidence related Sustainable Management Criteria should address the acceptable FKC conveyance capacity loss.

- The relationship between the FKC Conveyance Capacity and Measurable Objectives (MOs)

  The GSP subsidence metric was defined in terms of subsidence, but the FKC conveyance capacity is a major groundwater sustainability consideration. The relationship between the subsidence metric and the FKC conveyance capacity was not addressed. The subsidence related Sustainable Management Criteria should be established to represent the acceptable FKC conveyance capacity loss.

- The ET and DEID GSA GSPs did not consider the amount of FKC flow needed by the Kern-Tulare GSA and Friant Districts (among others downstream that have historically taken delivery of FKC water) to achieve their GSP.

  According to the GSP Regulations under the SGMA, the GSP should “avoid causing undesirable results in adjacent basins or affecting the ability of adjacent basins to achieve sustainability goals”. The Friant Districts and many water agencies south of the Tule Subbasin rely on the water delivered through the FKC to meet their groundwater sustainability goals. The GSPs should ensure that subsidence would not cause the FKC conveyance capacity to be lower than the flow rate needed for the impacted GSAs to meet their groundwater sustainability goals.

- The Interim Milestones (IMs) and MTs were defined based on a TSGFC that has not been completed at the time this review is performed. When TSGFC is completed, its accuracy and uncertainty shall be evaluated, especially regarding the simulation of elastic and inelastic subsidence as well as the delayed responses. Matching ground level change does not guarantee accurate representation of individual deformation components. It appears that the current versions of the GSPs do not consider model errors and uncertainty. If model errors/uncertainty are large, uncertainty/error margin should be considered in deciding the IMs and MTs.

The following comments are related to monitoring:

- Insufficient RMSs along the FKC in the DEID GSA MA

  Only one RMS is located in the DEID GSP MA. Although historical subsidence along the FKC in the DEID GSA MA has been small, future subsidence will increase if groundwater extraction increases in the vicinity of the FKC. The GSPs do not preclude the possibility of groundwater production wells in close proximity to the FKC. Without additional RMSs along the FKC in the DEID GSP MA, the FKC conveyance loss and structural impacts might not be noticeable.

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- RMSs at river crossing might not be approximate

  A few RMSs are located at river crossing. The actual siting should be appropriately evaluated to avoid potential subsurface influence by the river flow condition.

- The is no RMSs to address the concern of FKC structural damages

  Groundwater extraction close to the FKC might induce curvatures and strain. Monitoring and/or precaution against this situation was not addressed in the GSPs.

- The FKCSMA does not include the portions of FKC in the ET and DEID GSA MA. Although historical subsidence along the FKC in the DEID GSA MA has been small, future subsidence will increase if groundwater extraction increases in the vicinity of the FKC.

Other Comments:

- Overdraft in the subbasin was defined based on averaged hydrology from the years 1990/91 through 2009/10. The average condition between 1990/91 and 2009/10 might not be representative of the long-term average condition.

- Subsidence and associated ground deformation are mostly irreversible

  When the subsurface is stressed by groundwater extraction from a well, the associated elastic deformation is relatively small in comparison to inelastic deformation. Due to the presence of compressible materials in the aquifer unit, compression and subsidence has a delayed response component. After pumping stops, or even if groundwater level rises, ground surface elevation rebound is typically on the order of 10% of the subsided amount. If subsidence MTs are reached, they are not recoverable.

- Under the current project and management actions, if there is no curtailment of groundwater extraction, especially in the area close to the FKC, subsidence will continue and MTs would likely be reached in the future.

If you have any questions regarding the review comments, please let us know.

Best regards,
GSI ENVIRONMENTAL INC.

Chin Man Mok

Chin Man W. Mok, PhD, PE, GE, D.WRE, D.GE
Vice President and Principal Engineer

Chin Man W. Mok
PhD, PE, GE, PG, D.WRE, D.GE, F.ASCE, F.EWRI

Biographical Summary

Dr. Mok is a water resources and geo- professional with 34 years of consulting experience. He has directed many projects supporting the analysis and design of infrastructures, such as buildings, bridges, highways, tunnels, railroads, locks, dams and levees, pipelines, and underground structures; water resources management, such as watershed/groundwater basin evaluation, sustainability planning and optimization, system reliability assessment, flood and drainage evaluation, recharge study, and environmental remediation. His has substantial technical experience in evaluating subsurface stability and deformation due to infrastructure loading, groundwater extraction, and natural hazards. He has recently completed a subsidence study for the California High-Speed Rail System from San Francisco to Los Angeles through the rapidly subsiding Corcoran, El Nido, and Antelope Valley areas. He has been appointed to serve as a hydro- and geo- specialist on review panels for several high-profile projects. In addition, he has experience providing technical support to litigation projects.

In addition to consulting, Dr. Mok has been active in teaching and research. He is an adjunct professor at the University of Waterloo and Rice University. He has been teaching undergraduate and graduate courses on groundwater, geotechnics, engineering risk, data sciences, ground improvement, and environmental remediation at several universities, including the University of California at Berkeley. He has been a Principal Instructor of short courses in California and overseas, including workshops sponsored by the California State Water Resources Control Board and internal training classes for the Thailand Department of Groundwater Resources on issues related to water resources management, land subsidence, and environmental remediation. He has been the Principal Investigator of many research projects funded by federal agencies on high-resolution subsurface characterization, groundwater optimization, and subsurface system reliability analysis. He has been a Chair of the Groundwater Management Committee and is currently a panel member of the KSTAT standard committee of the American Society of Civil Engineers developing guidance documents.

Professional Background

Consulting:

Vice President / Principal Engineer and Hydrogeologist, GSI Environmental Inc., Oakland, CA. 2013 to present

Principal Engineer and Hydrogeologist, AMEC Environment and Infrastructure (currently Wood PLC), Oakland, California. 2008 to 2013

Principal Engineer and Hydrogeologist, Geomatrix Consultants, Inc., (acquired by AMEC), Oakland, California. 1987 to 2008

Structural and Geotechnical Engineer, Maunsell Consultants Asia, (currently AECOM), Hong Kong. 1985 to 1986

Academic:

Adjunct Professor, Earth, Environmental and Planetary Sciences, Rice University, Houston. 2017 to present

Adjunct Professor, Earth and Environmental Sciences, University of Waterloo, Canada. 2008 to present

Lecturer, Civil and Environmental Engineering, University of California at Berkeley, California. 2014, 2016

Rudolf Diesel Industry Fellow and Affiliated Professor, Engineering Risk Analysis, Institute for Advanced Study, Technical University of Munich, Germany. 2011 to 2014

Visiting Associate Professor, Civil and Environmental Engineering, University of Hong Kong, 2010

Education

Ph.D., Department of Civil and Environmental Engineering, University of California at Berkeley, 1999.

M.S., Department of Civil and Environmental Engineering, University of California at Berkeley, 1987.

B.Sc. (Eng.), Department of Civil and Structural Engineering, University of Hong Kong, 1985.

Professional Registrations, Qualifications and Affiliations

Professional Civil Engineer, California 46755, Arizona 39042, Florida 75351, Texas 119446

Professional Geologist, Arizona 40746

Registered Geotechnical Engineer, California 2365

Founding Diplomate, Water Resources Engineer, American Academy of Water Resources Engineers

Diplomate, Geotechnical Engineer, Academy of Geo-professionals

Honors and Awards

Rudolf Diesel Industry Fellow, Institute for Advanced Study, Technical University of Munich

Fellow, American Society of Civil Engineers

Fellow, Environmental and Water Resources Institute

Jane Lewis Fellowship, University of California, Berkeley

Parker Trask Fellowship, University of California, Berkeley

Hui Yin Hing Fellowship, University of Hong Kong

S.L. Pao Education Foundation Scholarship, University of Hong Kong

Representative Projects

Ground Subsidence Study, California High-Speed Rail Authority (CAHSR). Principal-in-charge. Task Leader of the AMEC Foster Wheeler team. Directed three-dimensional coupled groundwater and geomechanical modeling to estimate the potential impacts of groundwater extraction on subsurface deformation and induced vertical/horizontal topographic curvatures for infrastructure analysis. Evaluated the accuracy and reliability of an USGS' Central Valley Hydrologic Model in regard to refinement and specific calibration for HSR use. Applied data fusion to integrate available LiDAR, InSAR, GPS/RTK, survey data collected in the different areas and periods to develop data-driven subsidence prediction model. Developed simulation models to predict future subsidence in the HSR alignment areas in the San Joaquin Valley and Antelope Valley. Performed flood modeling to delineate runoff pathways and evaluated the subsidence induced flood plain changes in the historical Tulare Lake area. Flood plain change will impact surface water recharge to groundwater.

Tai Hang Road Subsidence Investigation, Government Geotechnical Engineering Office, Hong Kong. Principal-in-charge. Tasked by the Geotechnical Engineering Office, Dr. Mok was engaged by Fugro (Hong Kong) Limited as a subject expert in a detailed study of the subsurface conditions below Tai Hang Road where land subsidence occurred. Notable signs of subsurface deformation, slope failure, and road damages were observed. He conducted field-testing at several locations to investigate the hydrogeologic condition in the area for evaluating the likelihood of groundwater being the major cause of failure.

Northern California Toll Bridges, San Francisco Bay Area, California. Project Manager. Provided geotechnical engineering support for the seismic retrofit and vulnerability studies of the San Mateo–Hayward Bridge, Benicia-Martinez Bridge, Carquinez Bridge, Richmond–San Rafael Bridge, and the cable-suspension section of the San Francisco–Oakland Bay Bridge. Static and dynamic stability analyses were performed for natural terrain and slopes during and after construction. Analysis also included settlement and subsurface deformation estimation. The foundation types of these bridges include spread footings, driven piles, cast-in-drilled-hole piles, cast-in-steel-shell piles, and large caissons. Some of these piles terminate in soil and some are anchored in rock. Difficult geotechnical conditions were encountered at many bridge locations, including liquefiable zones, soft surficial soils, and weak rocks.

Optimized Regional Water Supply Operation Management and Water Resources Planning, Tampa Bay Water, Florida. Principal-in-charge. The project team developed an optimization framework to identify the best plan for operating the Agency's interconnected water supply system and managing the integrated water resources. The goal is to reliably and sustainably meet the municipal and industrial water demands while minimizing the hydro-ecological impacts on wetlands and the potential of seawater intrusion in multiple counties. The optimization considers physical system capacity, water use regulations and other operational constraints, as well as the uncertainties associated with the forecasting of water demands, surface water availability, climatic condition, and groundwater-surface water interaction.

Effects of Climate Variations and Water Management Strategies on Eco-Hydrologic Condition, Tampa Bay Water, Florida. Principal-in-charge. The project team evaluated the eco-hydrologic effects of various water management and operational strategies while accounting for the uncertainty of future climate condition, including severe droughts. A Monte Carlo approach was used to generate time series realizations of future climatic events. These realizations were utilized to generate time histories of the resulting water supply operation under various water management strategies. The effects of these water supply operations on the environmental and hydrologic condition in the region were estimated using a calibrated Integrated Hydrologic Model. The results were used to evaluate the reliability associated with each water management strategy to address the issues associated with large groundwater production during droughts.

Cost-effective Characterization of Large Plume Arrival Front at Edwards AFB, Air Force Civil Engineering Center, United States Department of Defence. Principal Investigator. This project demonstrated and validated that integrating data from hydraulic tomography (HT); groundwater and mass flux measurements; geophysical tomography (GT); chemical and hydraulic monitoring data; and geologic data cost-effectively improves the prediction of groundwater flow regime and reduces the associated uncertainty at the EAFB. Downhole, cross-hole, and hole-to-surface electrical resistivity tomography was performed. Tracer-enhanced time-lapsed tomography was conducted. Flux measurements using single-hole tracer dilution test, point velocity probes, and passive mass fluxmeters were performed and compared.

Erodibility Assessment of Lyons Dam, Tiger Creek Dam, Spaulding Lake Dams, Balch Diversion and Afterbay Dams, Lake Tabeaud Dam, and Lower Bear River Dam (Multiple Projects), Pacific Gas and Electric Company, California. Directed analyses to address the erosion potential of the foundation and abutment materials due to the hydrodynamic impact forces caused by water overflowing over dam crests during the maximum flood event. Both the Erodibility Index Method as well as the Comprehensive Fracture Mechanics and Dynamic Impulsion Models are used. Rock quality were evaluated based on field investigation and inspection.

Groundwater Training Courses, Thailand Department of Groundwater Resources. Principal Instructor. Retained to provide a series of three five-day short courses to train the Agency's professional staff on groundwater modeling, focusing on applications to water resources management, environmental remediation, and land subsidence control.

Groundwater and Seepage, University of California at Berkeley. Taught a one-semester course on flow through porous media, numerical analysis, hydrogeology, aquifer testing, and contaminant transport, focusing on the practical applications to geotechnical, water resources, and environmental problems, such as dams, levees, slope stability, land subsidence, water supplies, landfills, waste disposal, and contamination control and remediation.

Groundwater, University of Hong Kong. Taught a one-semester graduate-level course on groundwater and geotechnics. The course covered saturated and unsaturated flow, seepage, infiltration, slope stability, land subsidence, and contaminant transport. The focuses were on applications to water infrastructures and geo-environmental issues.

RECLAMATION

Managing Water in the West

SAN JOAQUIN RIVER RESTORATION PROGRAM

Friant WATER AUTHORITY

Friant-Kern Canal Middle Reach Capacity Correction Project

Draft Recommended Plan Report

October 2019

Mission Statements

The mission of the Department of the Interior is to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to Indian Tribes and our commitments to island communities.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

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Abbreviations and Acronyms

AF	acre-feet
APE	Area of Potential Effect
B-C	benefit cost
CalSim II	California Water Resources Simulation Model
CDFW	California Department of Fish and Wildlife
CEC	California Energy Commission
CEQA	California Environmental Quality Act
CER	Canal Enlargement and Realignment
cfs	cubic feet per second
CVP	Central Valley Project
CWC	California Water Commission
DEC	Design Engineering and Cost
D&S	Directives and Standards
DWR	California Department of Water Resources
EA	Environmental Assessment
EIS/R	Environmental Impact Statement/Environmental Impact Report
ESA	Endangered Species Act
FAA	Financial Assistance Agreement
FKC	Friant-Kern Canal
FWA	Friant Water Authority
GSA	groundwater sustainability agency
GSP	groundwater sustainability plan
Guidelines	Guidelines for the Application of Criteria for Financial Assistance for Local Projects under Part III of Public Law 111-11
HGL	Hydraulic Grade Line
ID	Irrigation District
IDC	Interest During Construction
InSAR	interferometric synthetic aperture radar
IS	Initial Study
JPA	Joint Powers Authority
MP	Mile Post
MUD	Municipal Utility District
NED	National Economic Development
NEPA	National Environmental Policy Act
NOD	Notice of Determination
NOI	Notice of Intent
NOP	Notice of Preparation
NMFS	National Marine Fisheries Service
NRDC	Natural Resources Defense Council

O&M	operations and maintenance
OM&R	operations, maintenance, and replacement
OPCC	opinion of probable construction cost
PCA	Project Cooperation Agreement
P.L	Public Law
PR&G	Principles, Requirements, and Guidelines for Federal Investment in Water Resources
Project	Friant-Kern Canal Middle Reach Capacity Correction Project
Reclamation	U.S. Department of the Interior, Bureau of Reclamation
Report	Draft Recommended Plan Report
ROD	Record of Decision
ROW	Right of way
RWA	Recovered Water Account
Settlement	Stipulation of Settlement of Natural Resource Defense Council (NRDC) et al. v. Kirk Rodgers et al.
Settlement Act	San Joaquin River Restoration Settlement (Title X, Subtitle A) Provisions of Public Law 111-11
SGMA	Sustainable Groundwater Management Act
SJRRP	San Joaquin River Restoration Program
State	State of California
Study	FKC Middle Reach Capacity Correction Project Feasibility Study
SWAP	State-Wide Agricultural Production
TAF	thousand acre-feet
TM	technical memorandum
URFs	Unreleased Restoration Flows
USDA	U.S. Department of Agriculture
USFWS	U.S. Fish and Wildlife Service
VERA	Voluntary Emission Reduction Agreement
WD	Water District
WEAT	worker environmental awareness training
WIIN Act	Water Infrastructure Improvements for the Nation Act (P.L. 114-322) of 2016.
WSD	Water Storage District

Chapter 1
Introduction

The Friant-Kern Canal (FKC) is a principal feature of the Central Valley Project (CVP) that extends approximately 152 miles from Millerton Lake to the Kern River in the eastern portion of the San Joaquin Valley in central California. The FKC delivers CVP water supplies to Friant Division long-term contractors. The Middle Reach of the FKC, an approximately 33-mile section located within Tulare and Kern Counties, has experienced significant capacity loss. The capacity loss is a result of both regional land subsidence that has occurred over the past decade and an original design deficiency that prevents the intended flow capacity to be actualized. The FKC Middle Reach Capacity Correction Project (Project) is being developed to provide improvements to restore its originally designed and constructed capacity through the Middle Reach of the FKC.

The FKC Middle Reach Capacity Correction Project Feasibility Study (Study) is being developed by the Friant Water Authority (FWA) in coordination with the U.S. Department of the Interior, Bureau of Reclamation (Reclamation). Progress and results of the Study are being documented in a series of interim reports that will culminate in a Final Feasibility Report and associated compliance documentation consistent with the National Environmental Policy Act (NEPA) and the California Environmental Quality Act (CEQA), the *Principles, Requirements, and Guidelines for Federal Investment in Water Resources* (PR&G) (CEQ 2013), Reclamation Directives and Standards (D&S) CMP 09-02 for Water and Related Resources Feasibility Studies (2015), and applicable environmental laws.

In recognition of the urgent need to address the capacity problems in the FKC, the Study is being prepared on an expedited schedule. This Draft Recommended Plan Report (Report) is the second progressive document in the development of the Final Feasibility Report. This Report presents the formulation and evaluation of Initial Alternatives, selection and evaluation of Feasibility Alternatives, and identification of a Recommended Plan.

Reclamation is the lead Federal agency for reviewing and approving this Study. FWA is the non-Federal partner and will implement the Selected Plan that will be identified in the Final Feasibility Report. The following subsections describe Federal, State of California (State), and local authorization and legislation relevant to this Project.

Purpose

The reduced capacity of FKC Middle Reach has resulted in water delivery impacts on Friant Division long-term contractors, reduced ability of the FKC to convey flood waters during wet periods, and reduced ability to implement provisions of the Water Management Goal as described in Paragraph 16 of the San Joaquin River Restoration Settlement (Settlement). The reduced delivery of water via the Friant-Kern Canal under long-term Friant Division contracts, the Recovered Water Account (RWA), and Unreleased Restoration Flows (URFs) also reduces funding necessary to implement the Restoration Goal provisions of the Settlement as described in Paragraph 11.

The purpose of the Project is to restore the conveyance capacity of the FKC Middle Reach to such capacity as previously designed and constructed by Reclamation, as provided for in the San Joaquin River Restoration Settlement Act (Public Law 111-11, Title X, Part III(a)(1)). The purpose of this Study is to describe the formulation, evaluation, and comparison of alternatives that address Project planning objectives and identify a Recommended Plan consistent with Federal authorizations and requirements. Information developed through the Study will be used in preparation of required environmental compliance documentation.

Planning Objective

The planning objective is to restore the capacity of the FKC in the Middle Reach from Mile Post (MP) 88.2 to MP 121.5 to address the subsidence-induced and original design deficiency capacity reductions. The FKC was designed to convey water at a normal capacity for the delivery of water under CVP contracts, and maximum capacity for the short-term conveyance of flood flows.

Organization of this Report

This report is organized as follows:

- **Chapter 1** provides background information about the study and related studies, projects, and programs.
- **Chapter 2** provides an overview of the water and related resources, problems, opportunities, and constraints.
- **Chapter 3** describes the initial alternative formulation process.
- **Chapter 4** presents the No Action Alternative and the two Feasibility Alternatives in terms of major features, costs, and other defining characteristics.
- **Chapter 5** presents benefit cost analyses of the Feasibility Alternatives and identifies a Recommended Plan.
- **Chapter 6** describes the Recommended Plan.
- **Chapter 7** presents findings.

- **Chapter 8** presents recommendations.
- **Chapter 9** provides a list of sources consulted in preparation of this report.

This report is supported by several appendices, attachments, and exhibits that provide greater technical detail used in the evaluation of project feasibility. The organization hierarchy of the Draft Recommended Plan Report is shown in Figure 1-1.

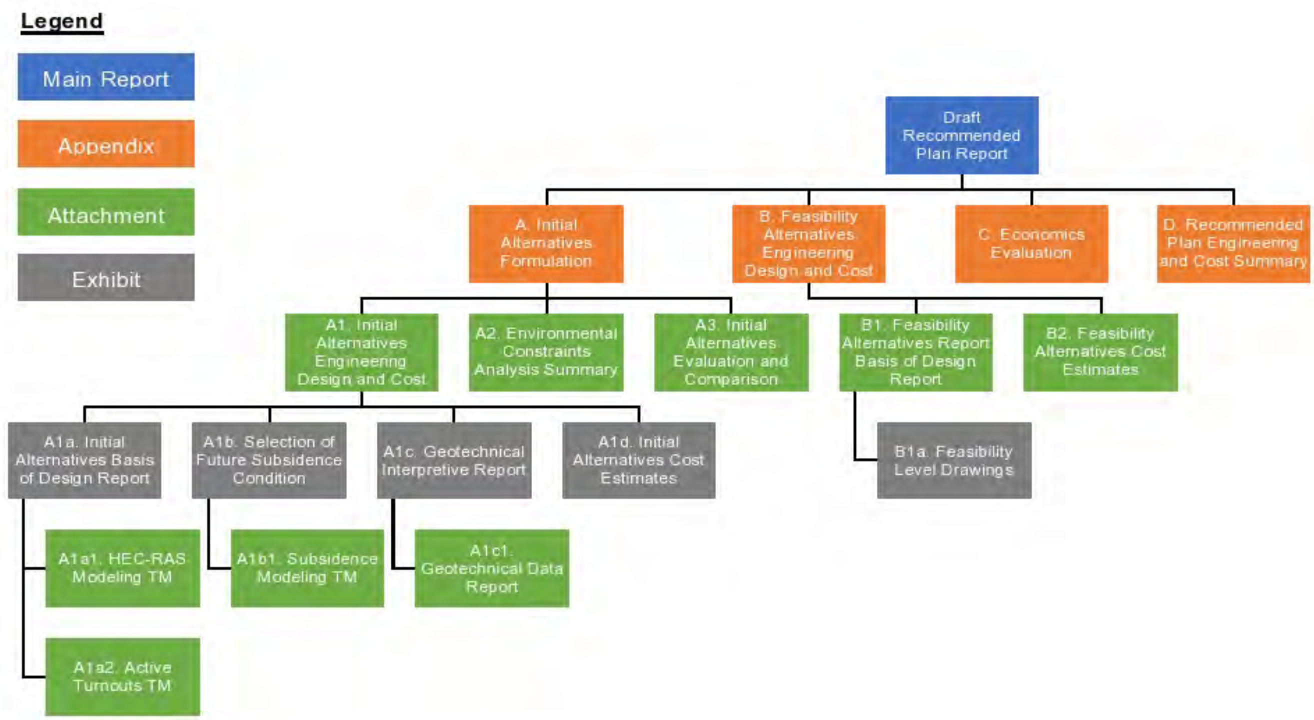

Figure 1-1. Draft Recommended Plan Report Document Hierarchy

Federal Authorities

The Study is being prepared to support feasibility determinations in accordance with the following Federal authorities:

- San Joaquin River Restoration Settlement (Title X, Subtitle A) provisions of Public Law [P.L.] 111-11 (Settlement Act), the Omnibus Public Land Management Act of 2009;
- Section 9603, Extraordinary Operation and Maintenance Work Performed by the Secretary, of P.L. 111-11; and
- The Water Infrastructure Improvements for the Nation Act (WIIN Act) (P.L. 114-322) of 2016.

P.L. 111-11

The Project and Study is authorized and funded in part by Sections 10201 and 10203(a) of the Settlement Act.

> *Section 10201:*
>
> *"(a) The Secretary of the Interior (hereafter referred to as the 'Secretary') is authorized and directed to conduct feasibility studies in coordination with appropriate Federal, State, regional, and local authorities on the following improvements and facilities in the Friant Division, Central Valley Project, California:*
>
> > *(1) Restoration of the capacity of the Friant-Kern and Madera Canal to such capacity as previously designed and constructed by the Bureau of Reclamation...*
>
> *(b) Upon completion of and consistent with the applicable feasibility studies, the Secretary is authorized to construct the improvements and facilities identified in subsection (a) in accordance with applicable Federal and State laws.*
>
> *(c) The costs of implementing this section shall be in accordance with Section 10203 and shall be a nonreimbursable Federal expenditure."*
>
> *Section 10203(a):*
>
> *"(a) The Secretary is authorized and directed to use monies from the fund established under section 10009 to carry out the provisions of section 10201(a)(1), in an amount not to exceed $35,000,000."*

Shortly following enactment of P.L. 111-11, Reclamation began evaluating the restoration of the capacity of the FKC and Madera Canal jointly. However, due to unique differences in the design and construction of these canals, Reclamation, in agreement with FWA and Madera-Chowchilla Water and Power Authority, separated the authorized funding as follows: $25 million for the FKC; and $10 million for the Madera Canal (Reclamation 2011). Of the $25 million for the FKC, approximately $6.1 million has been obligated and about $18.9 million remains available to study and implement projects that address FKC restored capacity, including the Project.

Project construction is also authorized under Section 9603, which addresses Extraordinary Operation and Maintenance Work Performed by the Secretary.

> *9603 (a) IN GENERAL.—The Secretary or the transferred works operating entity may carry out, in accordance with subsection (b) and consistent with existing transfer contracts, any extraordinary operation and maintenance work on a project facility that the Secretary determines to be reasonably required to preserve the structural safety of the project facility.*
>
> *(b) REIMBURSEMENT OF COSTS ARISING FROM EXTRAORDINARY OPERATION AND MAINTENANCE WORK.—*
>
> *(1) TREATMENT OF COSTS.—For reserved works, costs incurred by the Secretary in conducting extraordinary operation and maintenance work will be allocated to the authorized reimbursable purposes of the project and shall be repaid within 50 years, with interest, from the year in which work undertaken pursuant to this subtitle is substantially complete.*
>
> *(2) AUTHORITY OF SECRETARY.—For transferred works, the Secretary is authorized to advance the costs incurred by the transferred works operating entity in conducting extraordinary operation and maintenance work and negotiate appropriate 50-year repayment contracts with project beneficiaries providing for the return of reimbursable costs, with interest, under this subsection: Provided, however, That no contract entered into pursuant to this subtitle shall be deemed to be a new or amended contract for the purposes of section 203(a) of the Reclamation Reform Act of 1982 (43 U.S.C. 390cc(a)).*

WIIN Act

Authorization and funding for planning has been provided under authority of the WIIN Act. The WIIN Act addresses the needs of the nation's harbors, locks, dams, flood protection, and other water resources infrastructure critical to the economic growth, health, and competitiveness. The WIIN Act authorizes appropriations for Federal funding for the final design and construction of water storage projects and extends the authorization for Federal feasibility studies.

Unless directed otherwise by Congress, all costs for studies, report preparation, and review that falls under the WIIN Act authorization must be shared with a non-Federal cost-sharing partner. Costs will be accounted for and in-kind services valued in accordance with *Uniform Administrative Requirements, Cost Principles, and Audit Requirements for Federal Awards* (2 CFR 200). Cost-sharing must be in the form of in-kind services, cash payments, or a combination of the two. Unless authorizing legislation specifies a cost-share formula, the minimum non-Federal cost-share will be 50 percent of the total study costs.

The WIIN Act is applicable to non-reimbursable federal expenditures for authorized purposes. The Settlement Act authorizes non-reimbursable federal expenditures to restore the designed and constructed capacity of the FKC, thus, the WIIN Act is applicable for up to 50 percent federal non-reimbursable funding for the Project.

Local Authorities

The FWA is a Joint Powers Authority (JPA) public agency formed through its members under California law to operate and maintain the FKC and to represent its members in policy, political, and operational decisions that could affect the Friant Division of the CVP. FWA was formed in 2004 as the successor agency to the Friant Water Users Authority, which began FKC operations and maintenance (O&M) under agreement with Reclamation in 1986.

FWA maintains a professional staff with expertise in project operations, finance, and technical services that perform all on-going services related to the FKC O&M and represent their member entities. During the past 25 years, FWA has conducted several O&M actions along the FKC, including panel replacements, canal embankment seepage control, gate maintenance and repairs, automated monitoring, and control systems implementation.

As the responsible O&M entity for the FKC, FWA is leading the planning, permitting and design of the Project in coordination with Reclamation. FWA is the lead agency for environmental compliance pursuant to CEQA and will be responsible for the construction and O&M of the Project, if implemented.

Study Area

The study area, shown in Figure 1-2, encompasses the FKC from MP 88.2 (Fifth Avenue check) to MP 121.5 (Lake Woollomes check), the service areas of six[1] Friant Division long-term contractors that can experience water supply reductions as a result of capacity restrictions in this reach, and the areas that would be directly affected by construction-related activities.

[1] The six affected Friant Division long-term contractors include: Arvin-Edison Water Storage District, Delano-Earlimart Irrigation District, Kern-Tulare Water District, Saucelito Irrigation District, Shafter-Wasco Irrigation District, and Southern San Joaquin Municipal Utility District.

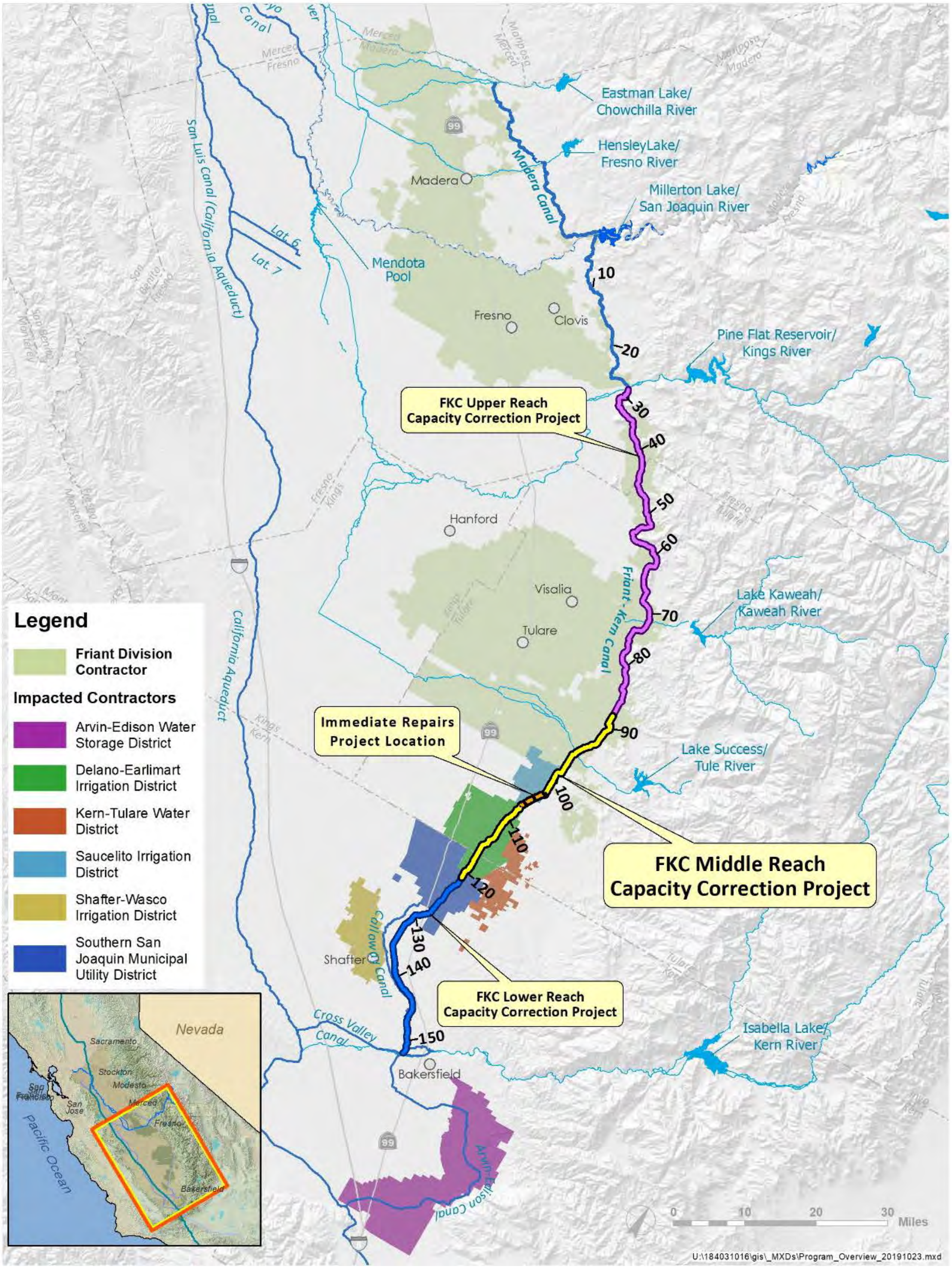

Figure 1-2. Study Area

Background

The FKC has a maximum design capacity of 5,300 cubic feet per second (cfs), gradually decreasing to 2,500 cfs to accommodate conveyance for downstream water demand. However, the maximum conveyance capacity has not been actualized due to several factors. Original design assumptions regarding the roughness or Manning's "n" value were found inaccurate shortly following construction completion. As a result, the FKC operating capacity is less than designed. Capacity has been further reduced by additional canal surface roughness with age, vegetation within canal sections, changes in water delivery patterns, localized seepage through embankments, and regional land subsidence.

In conjunction with the adjacent land, the canal has subsided. The FKC was designed with a relatively flat gradient, approximately 6 inches per mile, which makes it vulnerable to capacity reductions from subsidence. In particular, the section from MP 99 to MP 116 has subsided the most, with a significant localized depression between MP 103 and MP 107 that experienced subsidence greater than 10 feet since the FKC was constructed.

Over the decades, several efforts have been made to restore the canal capacity. In the late 1970s, Reclamation addressed subsidence-associated capacity reduction between MP 99 and MP 116 by raising the concrete lining on the canal. In the 1980s, Reclamation performed a subsequent lining raise between MP 0.0 and MP 28.5 that increased the canal capacity from 5,000 cfs to the design capacity of 5,300 cfs. While these efforts were successful, capacity restrictions continue to limit water deliveries throughout most of the canal.

The Settlement Act authorized the Secretary of the Interior to study, construct, and fund FKC capacity restoration to the original designed and constructed capacity. Under this authorization, Reclamation, identified four alternatives to restore the capacity of the entire FKC. However, the cost of all alternatives exceeded the available funding, which led to a focus on first restoring the Upper Reach from MP 29.14 to MP 88.2. Alternatives to restore capacity in the Upper Reach also exceeded the available funding. Reclamation presented the estimated costs to restore capacity of the Upper Reach to a group of Friant Division long-term contractors and FWA staff in September 2015. From that meeting, the contractors determined they would take the lead in identifying a path forward and report back to Reclamation.

In February 2017, FWA observed that a flow of 1,900 cfs was encroaching on the top of the liner and the lower chords of some bridges in the portions of the FKC Middle Reach (MP 88.2 to MP 121.5). In December 2017, FWA, on behalf of the Friant Division long-term contractors, provided their recommendations to Reclamation to complete appropriate feasibility, design, and compliance documents for the FKC Middle Reach and apply any remaining funds toward construction. To temporarily reduce capacity constraints in the Middle Reach of the FKC before the Project is constructed, FWA also implemented an Immediate Repairs Project which installed a temporarily liner between 103.85 to MP 106.32 in the winter of 2018-2019.

The Project is part of the FWA's approach to restore the design capacity of the entire FKC. The approach, with Reclamation's guidance and approval, will be implemented through projects located in three reaches of the FKC, based on the operational characteristics of the canal as well as the nature of the corrective actions to be accomplished. Reaches with the greatest capacity reduction will be prioritized, and all reaches will be designed to restore the original design capacity of the FKC:

- Upper Reach Capacity Correction Project – this project will address design capacity reduction in the FKC from approximately MP 29 (Downstream Kings River Siphon) to MP 88 (Fifth Avenue Check). As noted above, this project was previously evaluated by Reclamation and has an estimated cost of $140 million in 2014 dollars;

- Middle Reach Capacity Correction Project – this project, which is the subject of this Report, will address design and subsidence capacity reduction in the FKC from approximately MP 88 (Fifth Avenue Check) to MP 121 (Woollomes Check). The Project includes the Immediate Repairs Project (MP 103.6 to MP 107.3). If the Project includes modifications at the same location, the Immediate Repair improvements will be removed and replaced with Project actions. The Project will be coordinated with the FKC Pump-back Project, also authorized by the SJRRS Act, to the extent possible to identify infrastructure affected by both projects in the Middle Reach; and

- Lower Reach Capacity Correction Project – this project will address capacity reduction in the FKC from approximately MP 121 to the canal terminus at MP 152. The project will also coordinate with FKC Pump-back Project for affected infrastructure in the Lower Reach. The extent of work required in the Lower Reach has not been evaluated at this time and does not impact the Project.

As of December 2018, Reclamation and the FWA finalized a Financial Assistance Agreement (FAA) for the FKC Capacity Correction Project (R19AC00013). The FAA describes authorized federal funding sources including the Settlement Act and the WIIN Act.

Related Studies, Projects, and Programs

The following is a summary of pertinent previous studies and current activities that affect the Study.

1960s – Reclamation Technical Memorandum No. 661

In the 1940s and 1950s, Reclamation constructed several large concrete canals and subsequently found they were incapable of conveying the flows specified in the original designs. In response, Reclamation conducted a technical investigation of several canals, including the FKC, to determine the cause of conveyance limitations in canals and published its findings in Technical Memorandum No. 661 – Analyses and Descriptions of Capacity Tests in Large Concrete-Lined Canals (Reclamation 1964). A major conclusion from the Technical Memorandum No. 661 was that the basic hydraulic loss formulas used during the design of the large concrete canals required adjustment. Specifically, the original designs for the FKC used a Manning's "n-value" (or friction coefficient) of 0.014 for concrete-lined sections. Results from the Technical Memorandum No. 661 demonstrated that the friction coefficient for concrete-lined sections ranges from 0.015 to 0.019.

1970s – Reclamation Friant-Kern Canal Liner Raise

In the late 1970s, Reclamation addressed subsidence problems along the FKC between MP 99 to MP 116. In the 16.5-mile stretch, the concrete lining was raised between 1 foot and 4.5 feet above the top-of-canal lining. To accommodate the canal lining raise, Reclamation raised four concrete bridges approximately 3 feet (Ave. 112, Ave. 88, Ave. 80, and Road 192) and reconstructed and raised a farm bridge by 4.5 feet. When raising the bridges, Reclamation also modified attached utility pipe crossings. In conjunction with the liner raise and bridge work, Reclamation adjusted several turnouts, drain inlets, check structures, and culverts.

1980 – Reclamation Upper Reach Work

Between 1977 and 1980, Reclamation authorized, designed, and constructed a lining raise between the FKC headworks at MP 0.00 and the Kings River Check at MP 28.50. This work was necessitated by an increase in water demand and operational control. Thus, the initial maximum capacity of the FKC was increased from 5,000 cfs to 5,300 cfs and the design deficiency in this reach was corrected. The details for this construction can be found in Reclamation specification DC-7295.

2002 – FWA Liner Raise

In 2002, FWA installed an 18-inch concrete liner raise, from MP 75.77 (Spruce Bridge) to just downstream of MP 76.37 (Marinette Bridge). The purpose of this project was to both address subsidence and increase the flow capacity from 3,950 cfs to 4,300 cfs.

2018-2019 – Immediate Repairs

During the winter of 2018 to 2019, FWA undertook a series of repairs to increase the capacity of the Middle Reach to the extent possible while the Project is implemented. FWA installed a 0.045-inch-thick reinforced polypropylene liner between MP 103.85 and MP 106.32, coated five bridges with a protective sealant, repaired or reinforced utility supports spanning bridges, and mud-jacked as necessary to control seepage.

San Joaquin River Restoration Program

The Settlement Act, included in Public Law 111-11 and signed into law on March 30, 2009, authorizes and directs the Secretary of the Interior to implement the Stipulation of Settlement of Natural Resource Defense Council (NRDC) et al. v. Kirk Rodgers et al. (Settlement), which ended an 18-year legal dispute over the operation of Friant Dam and resolved longstanding legal claims brought by a coalition of conservation and fishing groups led by the NRDC. Reclamation is the Federal lead agency for the San Joaquin River Restoration Program (SJRRP). Along with Reclamation, the National Marine Fisheries Service (NMFS), U.S. Fish and Wildlife Service (USFWS), California Department of Water Resources (DWR), and California Department of Fish and Wildlife (CDFW) are implementing agencies.

The Settlement establishes two goals: (1) the Restoration Goal is to restore and maintain fish populations in good condition in the main stem of the San Joaquin River below Friant Dam to the confluence of the Merced River, including naturally reproducing and self-sustaining populations of salmon and other fish, and (2) the Water Management Goal is to reduce or avoid adverse water supply impacts to all of the Friant Division long-term contractors that may result from the Interim Flows and Restoration Flows provided for in the Settlement.

To achieve the Water Management Goal, Paragraph 16 of the Settlement and Part III of the Settlement Act provide for actions to recapture Restoration Flows and increase access to water supply during wet hydrologic conditions, including restoration of the capacity of the FKC and Madera Canal. The reduced capacity of the FKC constrains Reclamation's ability to implement actions to achieve the Water Management Goal.

Interim Flows for experimental purposes began in 2009, and Restoration Flows began January 1, 2014. Current channel capacity constraints limit the ability to release full Restoration Flows. The flows will increase gradually over the next several years as channel capacity is increased through the implementation of SJRRP actions.

Friant-Kern Canal Capacity Restoration Feasibility Study

Part III of the Settlement Act authorizes Reclamation to conduct feasibility studies on restoration of the designed and constructed capacity of the FKC and Madera Canal. In 2011, Reclamation completed a Draft Feasibility Report for the FKC with the planning objective to improve the water deliveries and reliability within a funding constraint of $25,000,000. Estimated costs to restore the original designed and constructed capacity of the entire FKC exceeded the available funding. Therefore, the feasibility study alternative focused on raising the canal lining in the Upper Reach from the Kings River Siphon outlet (MP 29.14) to the 5th Avenue Check (MP 88.2). Based on the Draft Feasibility Report recommendations, Reclamation prepared a 60 percent design and cost estimate for the Upper Reach of the FKC, which found the project formulation was not feasible within the funding authorized in the Settlement Act.

Part III Financial Assistance for Local Projects

Part III of the Settlement Act authorizes Reclamation to provide financial assistance to local agencies within the Friant Division of the CVP for the planning, design, environmental compliance, and construction of local facilities to bank water underground or recharge groundwater. A project will be eligible if all or a portion of the project is designed to reduce, avoid, or offset the quantity of expected water supply impacts to Friant Division long-term contractors caused by Restoration Flows in the San Joaquin River released pursuant to the Settlement.

Reclamation completed Guidelines for the Application of Criteria for Financial Assistance for Local Projects under Part III of Public Law 111-11 (Guidelines) in consultation with Friant Division long-term contractors. The Guidelines provide a framework for obtaining Federal financial assistance for Friant Division groundwater recharge and/or banking projects as authorized by Part III. Consistent with statutory requirements of Part III of the Settlement Act, Office of Management and Budget cost principles and Reclamation policy, the Guidelines address the contents of a complete Planning Report and cost-share agreement.

Several Part III Projects have been constructed and are in operation in the Study Area and result in an increased ability to recharge groundwater. This increase in recharge capability can increase demand during wet hydrologic periods when FKC flows are typically highest. The reduced capacity of the FKC constrains the ability to deliver water to Part III projects.

Friant-Kern Canal Reverse Flow Pump-back Project

In September 2016, Reclamation and FWA entered into FAA Number R16AC00106 for the Friant-Kern Canal Reverse Flow Pump-back Project whereby FWA will perform the planning, environmental compliance documentation, and design and construction of Reverse Flow Pump-back Facilities. Reclamation initially studied permanent pump-back facilities along the southern portion of the FKC as part of the SJRRP. Reclamation evaluated permanently increasing pumping capacities to 200 cfs at the Shafter Check Structure and 75 cfs at the Lake Woollomes and Deer Creek Check structures. Building on the appraisal study, FWA is considering sizing the Reverse Flow Pump-back to improve water management during drought conditions. The MRCCP involves coordination with the Pump-Back Facilities Project.

Sustainable Groundwater Management Act

A three-bill package, known as the Sustainable Groundwater Management Act (SGMA), was passed by the California legislature and signed into law by Governor Edmund G. Brown in 2014. This legislation, amended in 2015, allows local agencies to customize groundwater sustainability plans to their regional economic and environmental needs, and creates a framework for sustainable, local groundwater management. The act defines sustainable groundwater management as the “management and use of groundwater in a manner that can be maintained during the planning and implementation horizon without causing undesirable results” such as land subsidence and water quality degradation.

The Study Area includes several high-priority basins under SGMA due to the severity of groundwater overdraft. As a result of this designation, the managing agencies or groundwater sustainability agencies (GSA) in the area are required to adopt groundwater sustainability plans (GSP) by January 31, 2020. The GSAs have twenty years to implement their GSPs and achieve their sustainability goal in the basin by 2040.

Chapter 2 Water Resources and Related Conditions

One of the most important elements of any water resources evaluation is defining existing conditions in the study area, the associated problems and opportunities, and how these conditions may change in the future. This chapter describes these critical topics which will provide guidance for the solutions presented in subsequent chapters.

Existing Conditions in Study Area

The existing and likely future conditions are used to establish the basis of comparing potential alternative plans, a process consistent with PR&G, NEPA, CEQA, and Reclamation D&S Standards. This section briefly discusses existing conditions in the study area.

Surface Water

The major surface water resources in the study area are the San Joaquin River and its tributaries. The San Joaquin River is the second longest river in California. It originates in the Sierra Nevada mountain range at an elevation of approximately 12,000 feet above mean sea level and carries snowmelt from mountain meadows to the valley floor before turning north and becoming the backbone of tributaries draining into the San Joaquin Valley. The San Joaquin River discharges to the Sacramento-San Joaquin Delta from the south and, ultimately, to the Pacific Ocean through San Francisco Bay.

Groundwater

The San Joaquin Valley Groundwater Basin, Figure 2-1, makes up the southern two-thirds of the 400-mile-long, northwest-trending, asymmetric trough of the Central Valley regional aquifer system (Page 1986). The study area overlies two main hydrologic regions within the San Joaquin Valley Groundwater Basin: The San Joaquin River Hydrologic Region and the Tulare Lake Hydrologic Region.

The San Joaquin River Hydrologic Region consists of surface-water basins that drain into the San Joaquin River system, from the Cosumnes River basin in the north through the southern boundary of the San Joaquin River watershed (DWR 1999). Aquifers in the San Joaquin Valley Groundwater Basin typically extend to depths of 800 feet. The San Joaquin River Hydrologic Region relies heavily on groundwater, accounting for approximately 30 percent of the region’s annual water supply for agricultural and urban uses (DWR 2003).

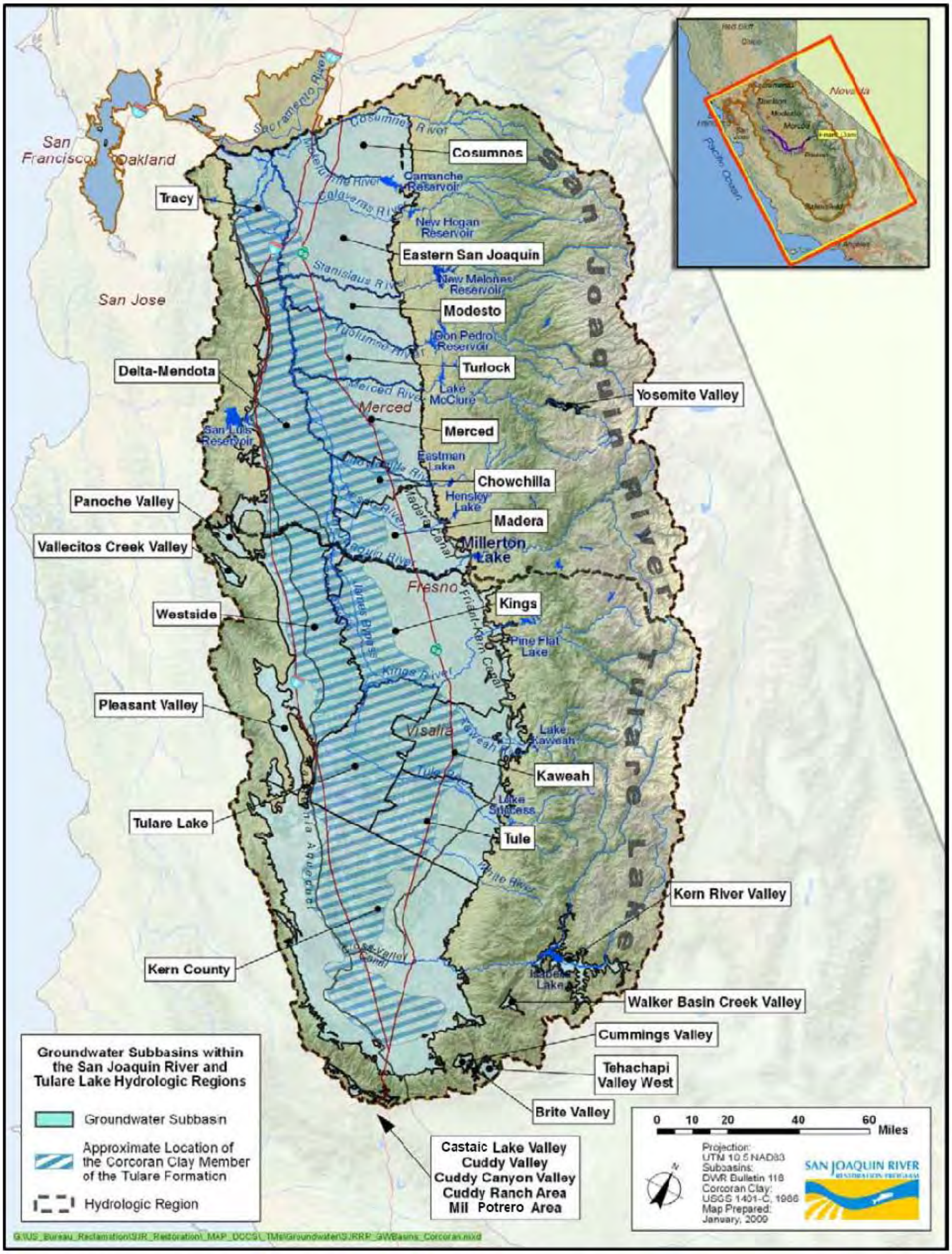

Figure 2-1. San Joaquin Valley Groundwater Basin and Sub-basins

The Tulare Lake Hydrologic Region is a closed drainage basin at the south end of the San Joaquin Valley, and encompasses the Kings, Westside, Pleasant Valley, Kaweah, Tulare Lake, Tule, and Kern County groundwater sub-basins. In the hydrologic region, the primary aquifer extends 1,000 feet below the surface (DWR 2003). The Tulare Lake Hydrologic Region also relies heavily on groundwater supplies; groundwater use has historically accounted for 41 percent of the total annual water supply within the region and for 35 percent of all groundwater use in California. Groundwater use in this hydrologic region represents approximately 10 percent of the state's total agricultural and urban water use (DWR 1998).

Friant Division of the Central Valley Project

The Friant Division of the CVP provides water to over one million acres of irrigated land on the east side of the southern San Joaquin Valley. Principal features of the Friant Division include Friant Dam and Millerton Lake, and the Madera and Friant-Kern canals.

Friant Dam and Millerton Lake

Friant Dam is a concrete gravity dam that impounds Millerton Lake on the San Joaquin River, located about 16 miles northeast of Fresno near the community of Friant. The dam, owned and operated by Reclamation, began releasing water from Millerton Lake in 1942. The lake has a capacity of 524 thousand acre-feet (TAF) which is typically filled during late spring and early summer from snowmelt. Prior to SJRRP implementation, annual water allocations draw down the reservoir storage to minimum levels by the end of September. Post-SJRRP implementation, the reservoir will reach minimum storage levels during late fall to early winter.

Friant Dam releases water deliveries to the Friant-Kern and Madera canal through outlet works. Outlets to the Madera Canal are located on the right side of the dam and outlets to the Friant-Kern Canal are located on the left. There is also a river outlet works located to the left of the spillway within the lower portion of the dam. The Friant Power Authority owns and operates powerhouses located on the FKC and Friant Dam river outlets that have a combined capacity of about 30 megawatts.

Madera Canal

The Madera Canal, operated and maintained by the Madera and Chowchilla Water and Power Authority, is a 36-mile-long canal that begins at Millerton Lake and terminates at the Chowchilla River. The canal was designed with an initial capacity of 1,000 cfs at the headworks, decreasing to 625 cfs at the Chowchilla River. In 1965, the canal lining was raised from the headworks to MP 2.09, increasing the capacity in that reach to 1,250 cfs.

Friant-Kern Canal

The FKC, operated and maintained by FWA, is a 152-mile, gravity canal that spans from Friant Dam south to the Kern River. The FKC has a maximum design capacity of 5,300 cfs, gradually decreasing to 2,500 cfs to accommodate conveyance for downstream water demand. However, maximum design capacity has not been actualized. Original design assumptions regarding the roughness or Manning's "n" value were found inaccurate shortly following completion of the canal, resulting in capacity reductions. The capacity has been further reduced because of increased canal surface roughness with age, vegetation within canal sections, changes in water delivery patterns, localized seepage through canal embankments, and land subsidence. As described in Chapter 1, the Project focuses on the Middle Reach of the FKC, from MP 88.2 to MP 121.5, which comprises four segments, as described below. The features and structures of the Middle Reach FKC are depicted in Figure 2-2A and 2-2B and summarized in Table 2-1. For more detail, refer to Appendix B Feasibility Alternatives Engineering Design and Cost.

Segment 1: 5th Ave. to Tule River The first (most upstream) segment of the Project is about 13 miles long and extends from the 5th Ave. Check (MP 88.2) to the Tule River (MP 95.6). It was designed for a normal flow of 3,500 cfs and a design maximum flow of 4,500 cfs. Sixteen state/county bridges cross the FKC in this segment and one bridge runs parallel to a siphon. In addition, this segment includes seven turnouts, three siphons, one wasteway, and one weir.

Segment 2: Tule River to Deer Creek The second segment is about seven miles long and extends from Tule River (MP 95.6) to Deer Creek (MP 102.7). It was designed for a normal flow of 3,000 cfs and a maximum flow of 4,000 cfs. Six state/county bridges one farm bridge, and one bridge parallel to a siphon cross the FKC in this segment. In addition, this segment includes ten turnouts and one siphon.

Segment 3: Deer Creek to White River The third segment is about 10 miles long and extends from Deer Creek (MP 102.7) to White River (MP 112.9). It was designed for a normal flow of 3,000 cfs and a maximum flow of 4,000 cfs.. Ten state/county bridges and two farm bridges cross the FKC in this segment. In addition, this segment includes, nine turnouts, one siphon, and one wasteway in this segment.

Segment 4: White River to Woollomes The fourth segment is about eight miles long and extends from White River (MP 112.9) to Lake Woollomes (MP 121.5). It was designed for a normal flow of 2,500 cfs and a design maximum flow of 3,000 cfs. Eight state or county bridges, two farm bridges, and one abandoned railroad bridge cross the FKC in this segment. In addition, this segment includes 12 turnouts, one siphon, and one reservoir structure (Lake Woollomes). The downstream limit of the Project is MP 121.5.

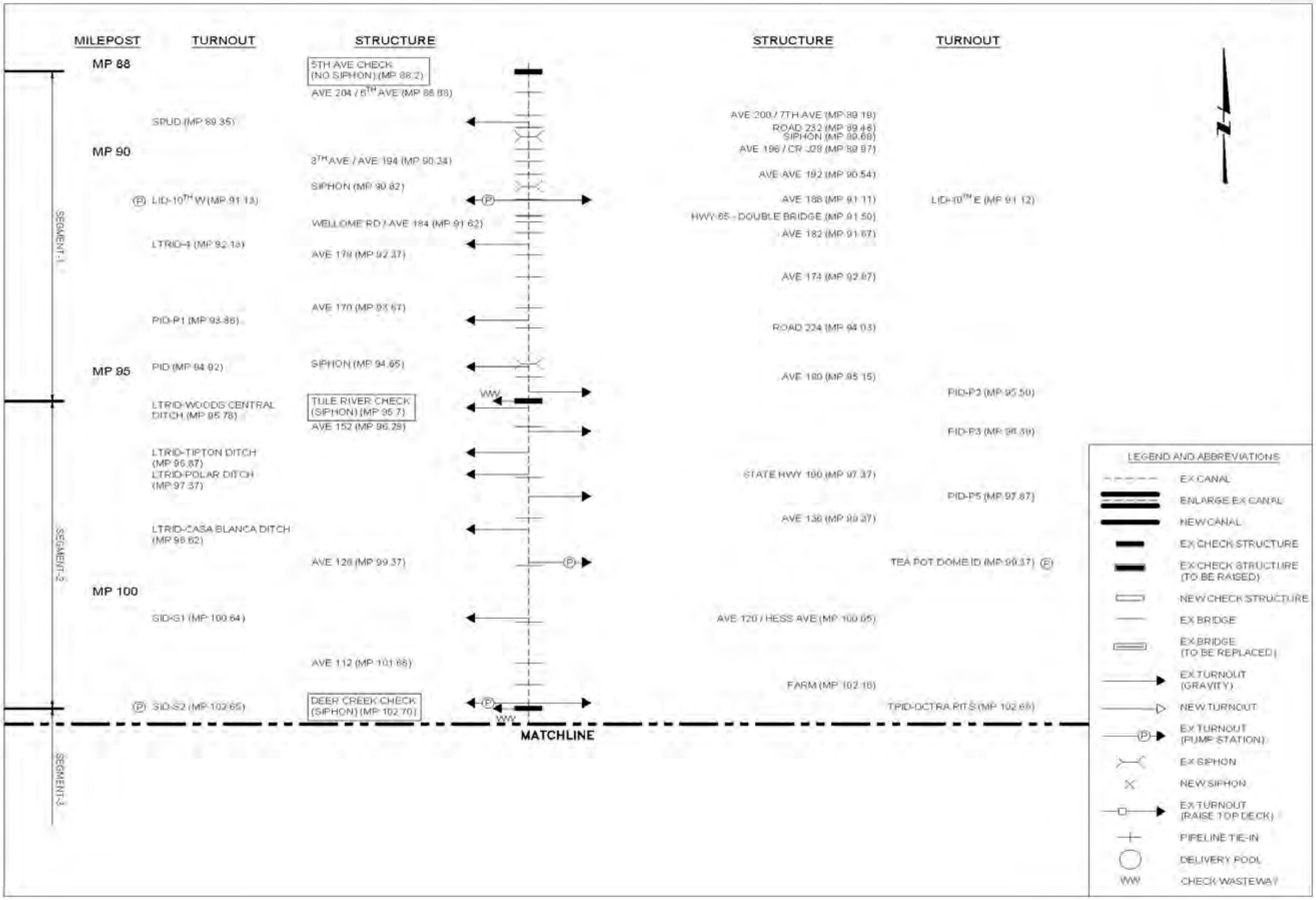

Figure 2-2A. Existing Canal Diagram Segments 1 and 2

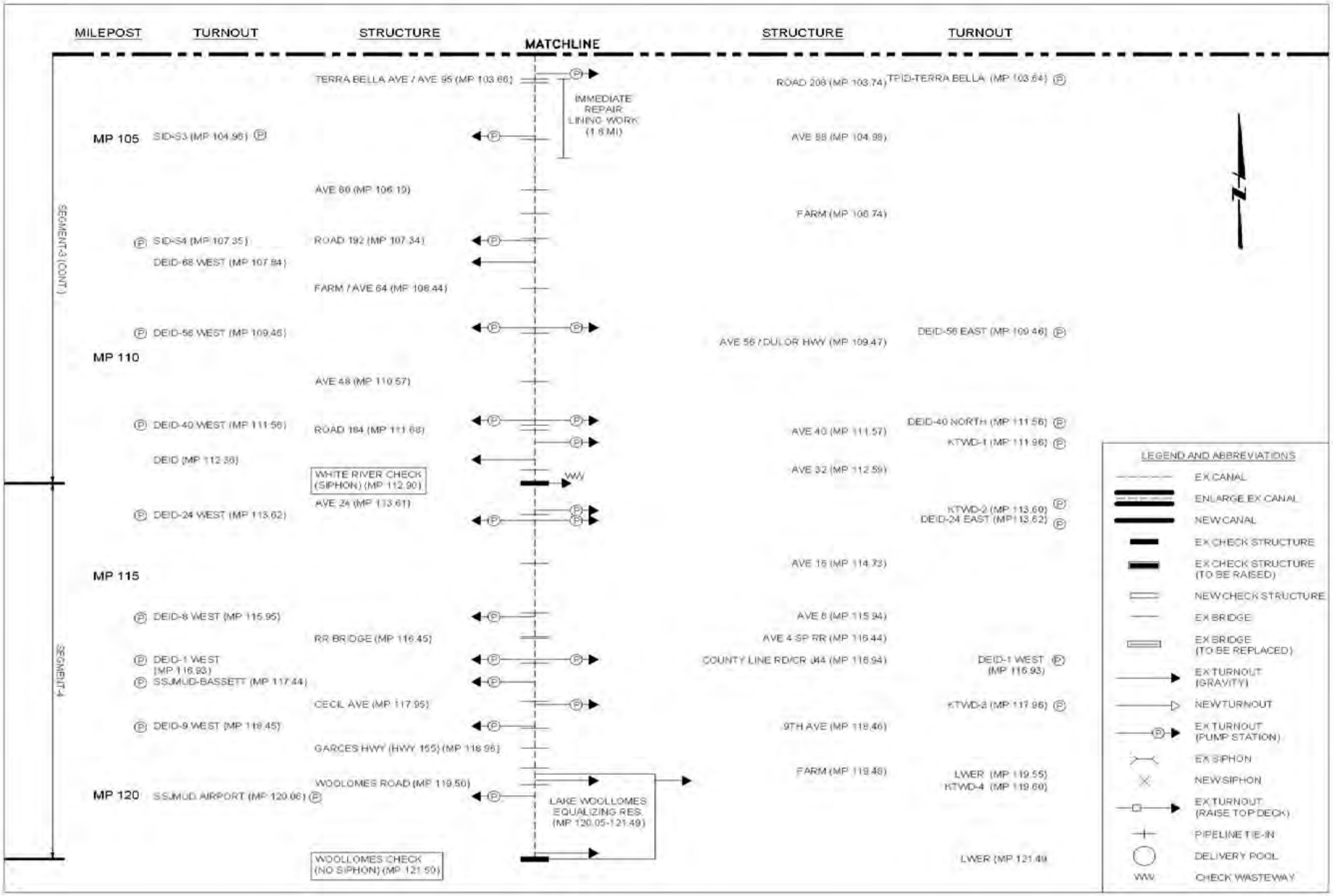

Figure 2-2B. Existing Canal Diagram Segments 3 and 4

Table 2-1. Friant-Kern Canal Structures by Segment

Structures	Segment 1 5th Ave. to Tule River (MP 88.2 – 95.6)	Segment 2 Tule River. to Deer Creek (MP 95.6 – 102.7)	Segment 3 Deer Creek to White River (MP 102.7 – 112.9)	Segment 4 White River. to Woollomes (MP 112.9 – 121.5)
Bridges, State/County	16	6	10	8
Bridges, Farm	0	1	2	2
Bridges, Other	1	1	0	1
Turnouts	7	10	9	12
Siphons	3	1	1	1
Other Structures	1 Wasteway, 1 Weir	0	1 Wasteway	1 Reservoir Structure

Note: Bridges, Other refers to the bridges parallel to siphons or the abandoned railroad bridge.

Friant Division Water Contracts

Reclamation holds most of the water rights on the San Joaquin River, allowing diversions at Friant Dam through purchase and exchange agreements with entities, or long-term contractors. Thirty-two Friant Division long-term contractors in Madera, Fresno, Kings, Tulare and Kern counties supply water to over 1.2 million acres of irrigated land, several small rural communities, and large urban areas.

Reclamation employs a two-class system of water contracts in the Friant Division. Class 1 contracts total 800 TAF and are dependable water supply and are generally assigned to agricultural and urban water users who have limited access to good quality groundwater. Class 2 contracts total approximately 1,401 TAF and, because of its uncertainty as to availability and timing, Class 2 contracts are considered undependable in nature and are applicable only when Reclamation makes available. Class 2 contracts support regional conjunctive use and are the basis to provide water supplies for groundwater replenishment during wetter years. Contract amounts for all Friant Division long-term contractors are listed in Table 2-2 and locations are shown in Figure 2-3.

Table 2-2. Friant Division Long-Term Contractors and Friant Water Authority Membership

Friant Division Long-Term Contractor[1]	FWA Membership		Class 1 Contract		Class 2 Contract		Total Contract	
	FKC O&M Membership	Representation Membership	(AF)	(% of Total)	(AF)	(% of Total)	(AF)	(% of Total)
Chowchilla WD		X	55,000	6.9	160,000	11.4	215,000	9.8
Madera ID		X	85,000	10.6	186,000	13.3	271,000	12.3
Gravelly Ford WD			-	0.0	14,000	1.0	14,000	0.6
Madera County			200	0.0	-	0.0	200	0.0
Fresno County			150	0.0	-	0.0	150	0.0
Garfield WD	X		3,500	0.4	-	0.0	3,500	0.2
International WD	X		1,200	0.2	-	0.0	1,200	0.1
City of Fresno	X	X	60,000	7.5	-	0.0	60,000	2.7
Fresno ID	X	X	-	0.0	75,000	5.4	75,000	3.4
Tri-Valley WD	X		400	0.1	-	0.0	400	0.0
Hills Valley ID	X	X	1,250	0.2	-	0.0	1,250	0.1
City of Orange Cove	X		1,400	0.2	-	0.0	1,400	0.1
Orange Cove ID	X	X	39,200	4.9	-	0.0	39,200	1.8
Stone Corral ID	X		10,000	1.3	-	0.0	10,000	0.5
Ivanhoe ID	X		6,500	0.8	500	0.0	7,000	0.3
Kaweah Delta Water Conservation District	X	X	1,200	0.2	7,400	0.5	8,600	0.4
Tulare ID	X	X	30,000	3.8	141,000	10.1	171,000	7.8
Exeter ID	X		11,100	1.4	19,000	1.4	30,100	1.4
Lewis Creek WD	X		1,200	0.2	-	0.0	1,200	0.1
City of Lindsay	X		2,500	0.3	-	0.0	2,500	0.1
Lindsay-Strathmore ID	X	X	27,500	3.4	-	0.0	27,500	1.2
Lindmore ID	X	X	33,000	4.1	22,000	1.6	55,000	2.5
Lower Tule River ID	X		61,200	7.7	238,000	17.0	299,200	13.6
Porterville ID	X	X	15,000	1.9	30,000	2.1	45,000	2.0
Saucelito ID	X	X	21,500	2.7	32,800	2.3	54,300	2.5
Terra Bella ID	X	X	29,000	3.6	-	0.0	29,000	1.3
Tea Pot Dome WD	X		7,200	0.9	-	0.0	7,200	0.3
Delano-Earlimart ID	X		108,800	13.6	74,500	5.3	183,300	8.3
Kern-Tulare WD	X	X	-	0.0	5,000	0.4	5,000	0.2
Southern San Joaquin MUD	X		97,000	12.1	45,000	3.2	142,000	6.5
Shafter-Wasco ID	X		50,000	6.3	39,600	2.8	89,600	4.1
Arvin-Edison Water Storage District	X	X	40,000	5.0	311,675	22.2	351,675	16.0
Total Contract (AF)	**800,000**			**1,401,475**		**2,201,475**		

Note: [1]Contractors listed in a north to south orientation
Key:
AF = acre-feet
FKC = Friant-Kern Canal
FWA = Friant Water Authority
ID = irrigation district
MUD = municipal utility district
O&M = operations and maintenance
WD = water district

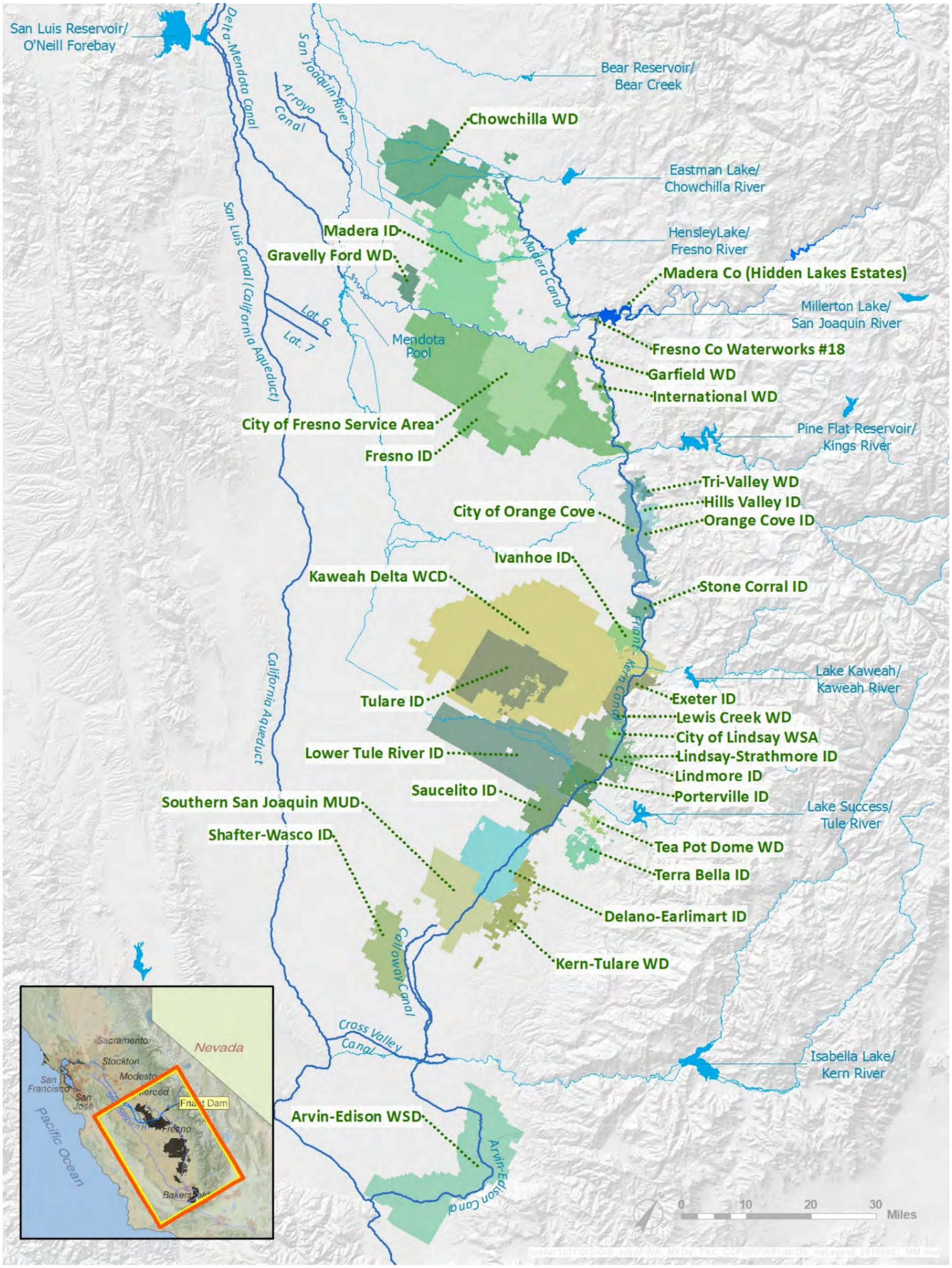

Figure 2-3. Friant Division Long-Term Contractors

In addition, Friant Division long-term contractors can obtain surface water in accordance with Section 215 of the Reclamation Reform Act of 1982 and under the provisions of Paragraph 16(b) of the Settlement. Section 215 authorizes Reclamation to deliver water that cannot be stored and otherwise would be released in accordance with flood management criteria or unmanaged flood flows. Delivery of Section 215 water has enabled the replenishment of San Joaquin Valley groundwater at higher levels than otherwise could be supported with Class 1 and Class 2 contract deliveries. Paragraph 16(b) provides for the delivery of water during wet hydrologic conditions at a cost of $10 per acre-foot, when water is not needed for Restoration Flows.

Friant Division long-term contractors schedule deliveries through daily water orders to Reclamation at Friant Dam. Due to long-standing irrigation practices, water delivery amounts vary by day of the week; water delivery demands are generally higher mid-week and lower on weekends. A review of historical releases at the FKC headworks from 2000 to 2017 demonstrates that daily demand can vary by week, month, and water year type. During a week, daily demand can vary by as much as 30 percent during July, at the peak of the irrigation season (Figure 2-4). The magnitude and timing of the variations fluctuate in accordance with the water year type; the largest variations occur during the peak irrigation months of dryer years and late irrigation months of wet years, as shown in Figure 2-5.

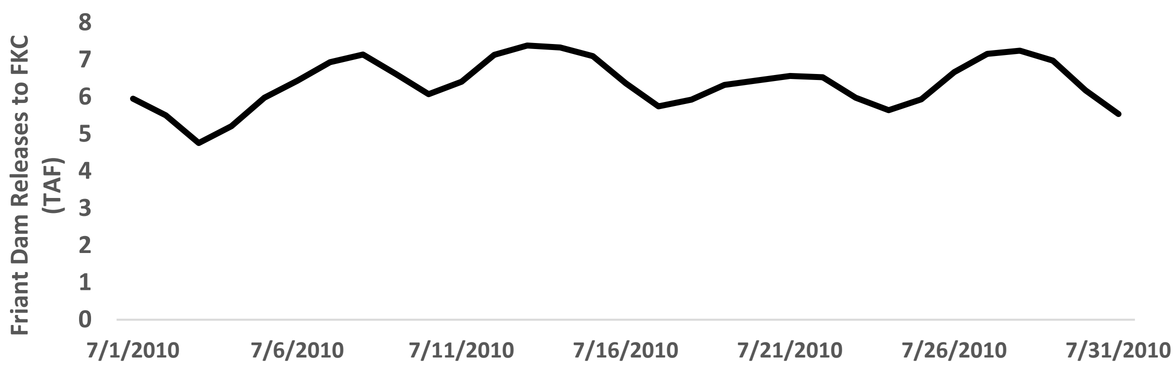

Figure 2-4. Variation of Daily Friant Dam Releases to Friant-Kern Canal During July 2010

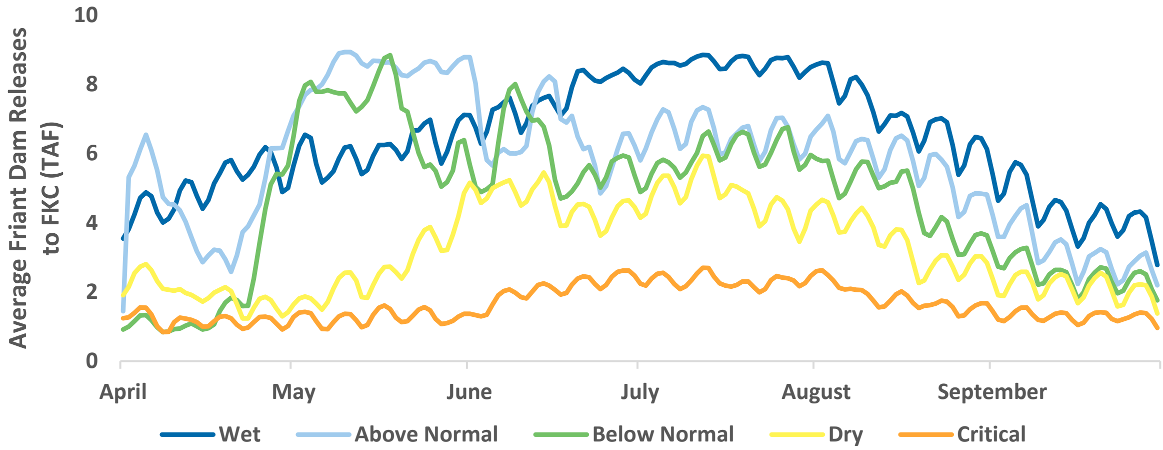

Figure 2-5. Average Daily Distribution Pattern by Water Year Type from 1921-2003

Land Use and Agricultural Resources

The Friant Division of the CVP contains some of the most productive lands in California, with the study area containing the top three agricultural producing counties in the nation (USDA 2007). The primary land uses in the study area are agriculture, urban, and open space; agriculture accounts for the majority of land use, with urban and open space accounting for only a small percentage. Table 2-3 shows the acreages of land use by the Friant Division long-term contractors that receive water deliveries from the FKC.

Table 2-3. Existing Land Uses in Friant Division Long-Term Contractors

Friant Division Long-Term Contractor	Land Use (acres)			
	Agricultural	Open Space	Urban	Total
Chowchilla ID	85,869	0	2,250	88,119
Madera ID	123,830	1	6,882	130,713
Gravelly Ford WD	8,431	0	0	8,431
*Madera County**	0	0	154	154
Fresno County WW No. 18	251	2	0	253
Garfield WD	1,813	0	0	1,813
International WD	724	0	0	724
City of Fresno	0	1,210	88,790	90,000
Fresno ID	187,489	64	60,336	247,889
*Tri Valley WD**	1,800	2,700	0	4,500
*Hills Valley ID**	3,500	800	0	4,300
City of Orange Cove	286	0	674	960
Orange Cove ID	29,163	0	116	29,279
Stone Corral ID	6,882	0	0	6,882
Ivanhoe ID	10,983	0	0	10,983
*Kaweah Delta Water Conservation District**	299,000	11,000	30,000	340,000
Tulare ID	69,293	0	4,220	73,513
Exeter ID	14,078	0	1,136	15,214
Lewis Creek WD	1,297	0	0	1,297
City of Lindsay	415	0	1,113	1,528
Lindsay-Strathmore ID	15,628	0	492	16,120
Lindmore ID	27,483	0	214	27,697
Lower Tule River ID	102,159	932	185	103,276
Porterville ID	15,842	0	1,194	17,036
Saucelito ID	19,826	0	0	19,826
Terra Bella ID	13,642	0	272	13,914
Tea Pot Dome WD	3,581	0	0	3,581
Delano-Earlimart ID	56,264	0	353	56,617
Kern-Tulare WD	17,433	2,639	0	20,082
Southern San Joaquin MUD	56,233	79	5,308	61,620
Shafter-Wasco ID	36,042	0	2,952	38,994
Arvin-Edison WSD	128,941	220	3,691	132,852
Total	**1,338,178**	**19,647**	**210,332**	**1,568,157**

Source: Draft SJRRP PEIS/R.
* *Friant Division Atlas*
Key:
ID = Irrigation District
MUD = Municipal Utility District
WD = Water District
WSD = Water Storage District

Problems, Needs, and Opportunities

Four predominant problems in the study area impact Friant Division water supply delivery and reliability: FKC design deficiency, groundwater overdraft, subsidence, and reduced canal capacity. These problems can be addressed through the Settlement Act, other provisions of P.L. 111-11, the WIIN Act, and the local implementation of SGMA.

Friant-Kern Canal Design Deficiency

The FKC was built prior to the development of Reclamation's current Design Standards No. 3, Release No. DS-3-5, dated 1967, and revised in 1994. As such, assumptions used in the original design led to an inability to achieve design conveyance capacity.

The design deficiency was recognized in the 1940s and 1950s when Reclamation observed that many large concrete canals were incapable of conveying flows specified in the original designs. This problem prompted a study on several canals in the 1950s, including the FKC. Reclamation documented the conclusions and results of this study in their early 1960s Technical Memorandum No. 661 – Analyses and Descriptions of Capacity Tests in Large Concrete-Lined Canals. Through Part III of the Settlement Act, Reclamation is authorized to restore the original design capacity.

Groundwater Overdraft

Groundwater overdraft is a regional problem that directly impacts FKC water deliveries. Overdraft occurs when use exceeds the recharge rate of an aquifer. Through an extensive evaluation process, the State classified which groundwater basins are subject to critical conditions of overdraft.[1] According to Bulletin 118 (DWR 2016), five subbasins in the Tulare Lake Hydrologic Region (Kings, Tulare Lake, Kern County, Kaweah, and Tule) and three subbasins in the San Joaquin River Hydrologic Region (Chowchilla, Eastern San Joaquin, and Madera) are subject to critical conditions of overdraft.

These eight subbasins are subject to critical conditions of overdraft as a result of limited access to surface water during dry hydrologic periods and widespread agricultural land use. The reduced FKC capacity, as a result of subsidence, affects Friant Division water deliveries to lands in some of these subbasins. As FKC capacity decreases, Friant Division contractors will likely meet their water needs with additional groundwater, causing groundwater levels to further decline. As groundwater levels decrease, the risk grows for impaired water quality, reduced water storage, and increased subsidence. To mitigate these risks, GSAs are developing GSPs under SGMA requirements. As the plans go into effect, it is likely that water users will adopt water management practices that include greater conservation of groundwater and surface water, yet their ability to implement these actions will be limited due to reduced capacity in the FKC.

Subsidence

Subsidence is a consequence associated with groundwater overdraft. When groundwater is extracted faster than the natural rate of replenishment, the water suspending fine-grained sediments are removed and the sediments compact, resulting in subsidence.

Subsidence is an ongoing regional issue, which was exacerbated during the 2012 to 2016 drought. Data from an interferometric synthetic aperture radar (InSAR) shows regional land

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[1] Bulletin 118, Update 1980 defines a groundwater basin subject to critical conditions of overdraft "when continuation of present water management practices would probably result in significant adverse overdraft related environmental, social, or economic impacts."

subsidence from May 2015 to September 2016 lowered the land surface elevation by as much as 25 inches; within the FKC Middle Reach, the land subsided between 5 and 20 inches during this 16-month period (Figure 2-6).

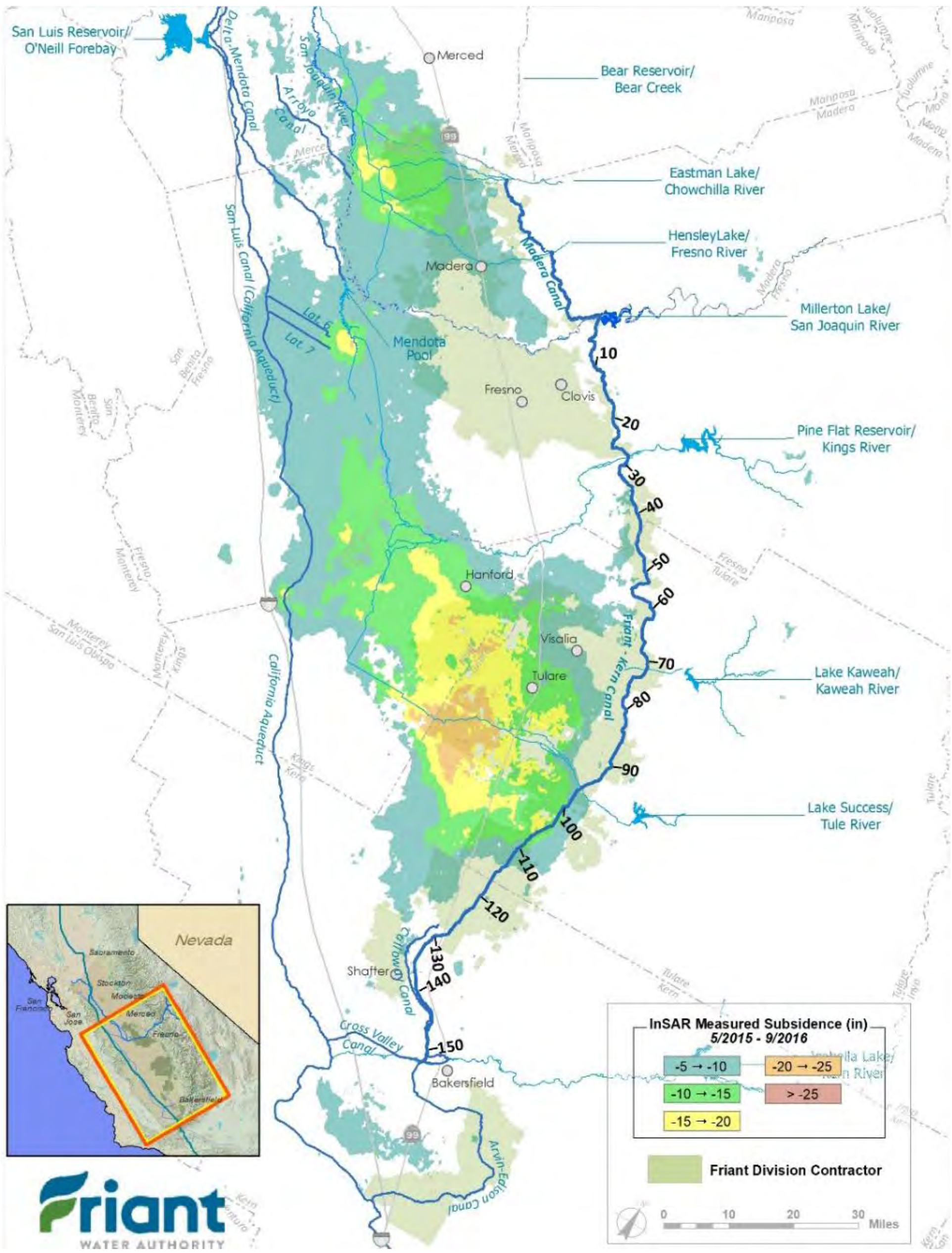

Figure 2-6. Recent Subsidence in the Friant Division

The FKC is located over the eastern portion of the regionally subsided area. As of July 2018, it is estimated that the FKC is approximately 12 feet below the original constructed elevation, creating a significant low point in the Middle Reach between MP 103 and MP 107 (Figure 2-7). Subsidence, and its consequences for the FKC, can be minimized through implementation of both SGMA and the Settlement Act. With the implementation of GSPs, it is expected that subsidence will lessen over time. While the GSPs address the root cause of subsidence, the Settlement Act provides the authority to restore the original design capacity of the FKC. To minimize the potential recurrence of this problem, design improvements should include features to accommodate future subsidence.

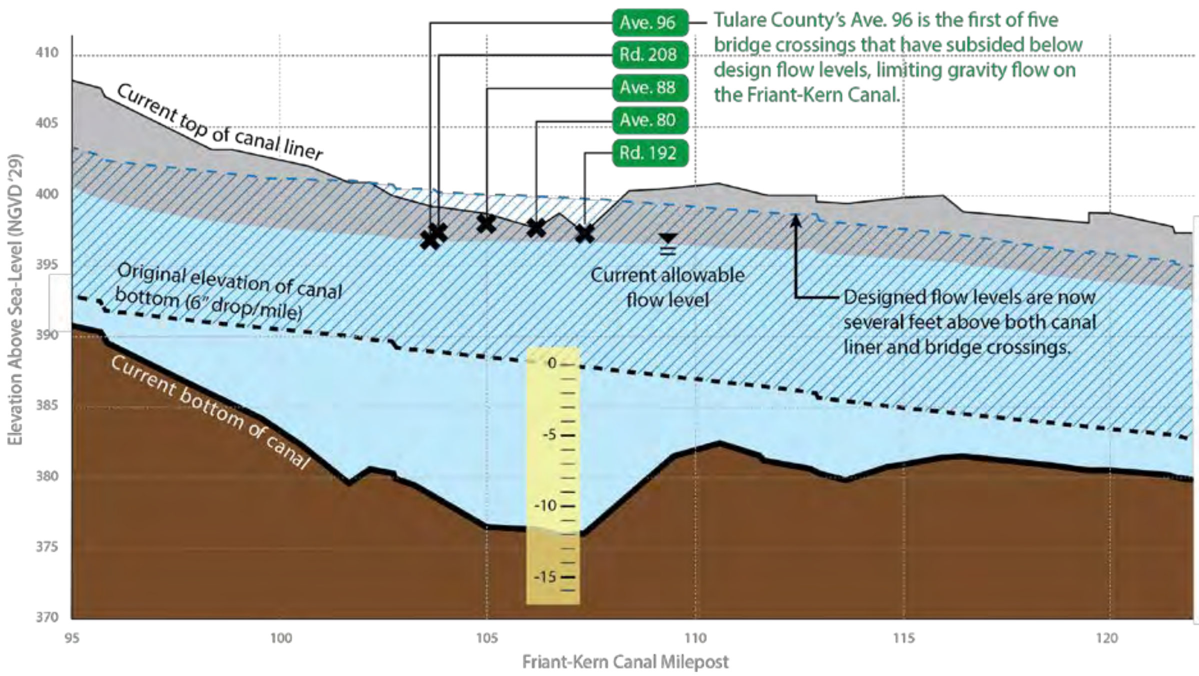

Figure 2-7. Schematic Illustration Along Friant-Kern Canal

Reduced Canal Capacity

As shown in Figure 2-8, the canal capacity is well below its designed maximum flow. The capacity reduction causes the water surface to encroach upon the operating freeboard and, at times, approach the top of the existing concrete liner. Operating canals at reduced freeboard increases seepage, which can damage the liner and increase risk of embankment failure. Higher water surface elevations can also adversely affect bridges, utilities, and other infrastructure.

During wet years, the reduced canal capacity limits the delivery of surface water supplies that would be used for groundwater replenishment, thereby creating an even greater reliance on groundwater supply. During dry years, contractors in the Friant Division conjunctive use area rely more on groundwater than surface water. The increased groundwater pumping reduces groundwater levels, which can further exacerbate subsidence and reduce the FKC capability to deliver surface water.

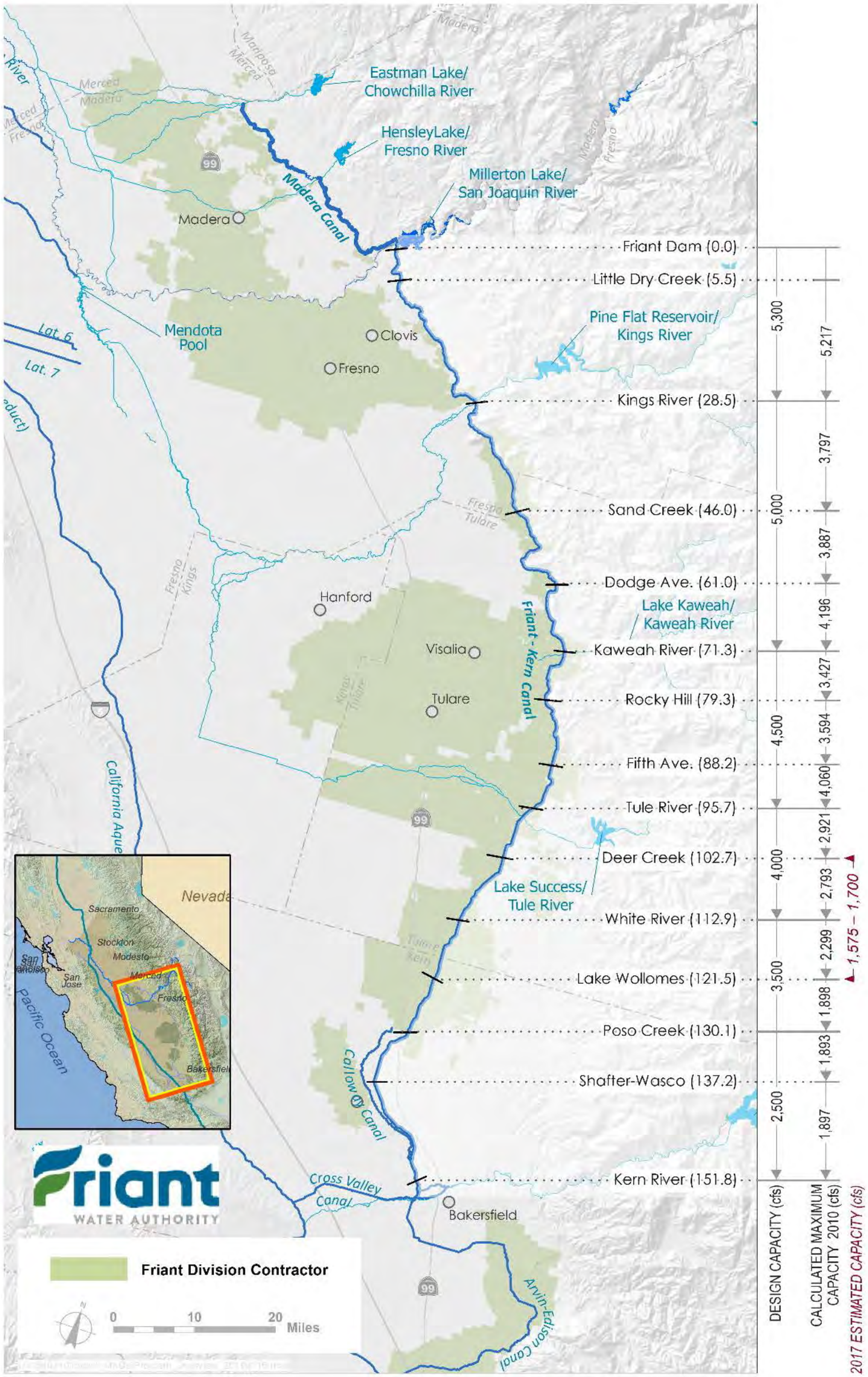

Figure 2-8. Friant-Kern Canal 2017 Capacity

Likely Future Without-Project Conditions Summary

The magnitude of potential water resources and related problems, needs, and opportunities is based not only on the existing conditions described above, but also on how these conditions may change in the future. Predicting future conditions is complicated by a variety of factors, including uncertainty regarding future regulatory requirements, ongoing programs and projects in the study area, future land subsidence, SGMA implementation, and future hydrologic conditions. The likely future without-project conditions represent the No Action Alternative, as discussed further in Chapter 4.

San Joaquin River Restoration Program Implementation

Physical changes to the San Joaquin River from Friant Dam to the Merced River are being implemented by the SJRRP and are assumed to be in place in the future without-project condition. These changes include levee modifications associated with incorporating new floodplain and related riparian habitat in the San Joaquin River, structure modifications to ensure fish passage, and channel capacity changes to accommodate Restoration Flows. The release of Restoration Flows will result in reductions to Friant Division water supplies.

Implementation of the SJRRP is progressing more slowly than planned due to unforeseen conditions and funding limitations. Currently, the release of full Restoration Flows is not possible due to downstream channel capacity constraints. As a result, URFs have been made available to Friant Contractors. The availability of URFs will decrease as channel improvements enable greater releases of Restoration Flows. Stage 1 SJRRP Implementation is scheduled to be completed by 2024 (SJRRP, 2018). The SJRRP anticipates project implementation would enable the release of full Restoration Flows no later than 2030. If that occurs, water deliveries to Friant Division contractors will decrease to levels anticipated by the SJRRP no later than the year 2030.

SGMA Implementation

Over the coming decades, SGMA will be implemented by GSAs. The eight high priority basins will have from 2020 until 2040 to come into compliance. Since the GSPs are still under development, the specific projects, programs, and anticipated timelines could not be included in this Study. Despite these unknowns, it is likely that SGMA implementation will include changes in agricultural practices and cropping patterns, reduction in irrigated acreage, and implementation of local and regional water management programs.

Future Subsidence

The performance of alternative designs should be evaluated relative to potential future conditions, particularly as it relates to subsidence. Subsidence projection studies relevant to the Middle Reach of the FKC are being developed in support of the Eastern Tule Basin GSA using the Tule Subbasins Groundwater Model.

To support evaluations presented in this Study, four potential groundwater pumping and hydrologic scenarios were evaluated to identify potential future subsidence along the alignment of the FKC. Results for each scenario are provided by decade (2030 – 2070), cumulating in a total of 20 potential subsidence profiles in the project area. Because it is not feasible to evaluate each design alternative over all subsidence projections, it is necessary to define a small number of potential conditions that represent a reasonable range of future outcomes. To achieve this, results were grouped into the following potential future subsidence conditions:

- Group 1. Minimal Mid-Term Subsidence Condition;
- Group 2. Moderate Mid-Term Subsidence Condition;
- Group 3. Severe Mid-Term Subsidence Condition; and
- Group 4. Severe Long-Term Subsidence Condition.

Each of the potential future subsidence conditions are based on achieving SGMA compliance by the year 2040, and residual subsidence continuing to the year 2070 and no subsidence thereafter. The subsidence conditions vary based on hydrologic assumptions and the timing of groundwater pumping reductions from current pumping levels to anticipated pumping levels that would achieve SGMA compliance.

Both Groups 1 and 2 represent conditions that are similar to today's groundwater pumping and may come to fruition by the time the Project is constructed with little addition subsidence thereafter. Group 4 represents a worst-case scenario in terms of both hydrology and timeframe to achieve SGMA compliance and is thus unlikely. Therefore, the future subsidence condition described by Group 3, Severe Mid-Term Subsidence Condition, was selected as most representative for use in the evaluation of Project alternatives.

The results of Group 3 indicate that about 8.5 feet of additional subsidence could occur on the FKC by the year 2070 (see Figure 2-9). For a detailed explanation, please refer to Appendix B Engineering Design and Cost, Attachment 3 Selection of Future Subsidence Condition.

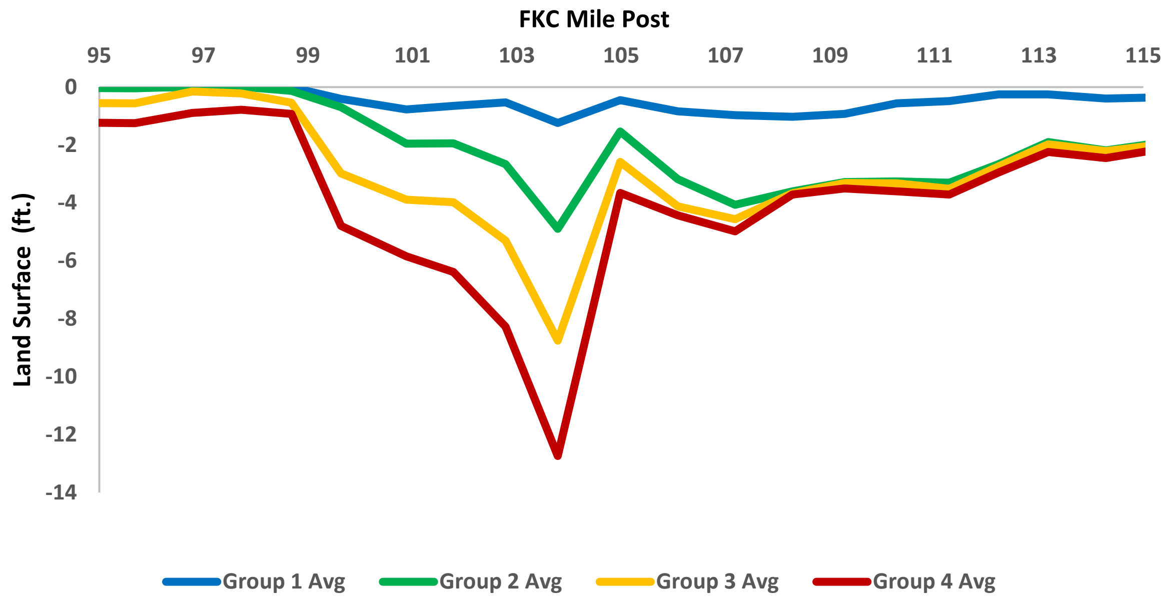

Figure 2-9. FKC Profiles Under Future Subsidence Scenarios

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Chapter 3 Initial Alternatives

The plan formulation process to the Study is based on the PR&G (CEQ 2013) and consists of the following deliberate and iterative steps:

1. Specify the water and related land resources problems and opportunities associated with the Federal objective and specific State and local concerns.
2. Inventory, forecast, and analyze existing and projected future resources conditions in the study area.
3. Formulate alternative plans.
4. Evaluate the potential effects of alternative plans.
5. Compare alternative plans.
6. Select a recommended plan to decision makers based on the comparison of alternatives.

Alternatives formulation was accomplished through a two-step approach: the Initial Alternative evaluation and Feasibility Alternative evaluation. This chapter describes the first step of the formulation, evaluation and comparison of Initial Alternatives and the selection of alternatives to be carried forward for evaluation as Feasibility Alternatives. Information in this chapter is supported with additional detail provided in Appendix A Initial Alternatives Formulation.

Project Planning Horizon

The Project is intended to be integrated into a long-term solution to restore capacity of the entire FKC, as part of the FWA's approach to restore the design capacity of the entire FKC. The planning horizon is 100 years, which is consistent with the expected service life of large civil engineering projects.

Planning and Resource Constraints

The primary constraints that affect the Project are funding availability and physical boundary conditions.

Funding Constraints

As described in Chapter 1, two Federal funding sources are currently available for the Project. These include SJRRP non-reimbursable funds of about $19 million and 2019 WIIN Act appropriations of about $2.2 million. WIIN Act appropriations are subject to a 50 percent cost share.

Boundary Conditions

When designing either a new canal or modifications to an existing canal, the first step is to identify the boundary conditions, or the required (design) water levels at each end of the system. Boundary conditions may be difficult to define, especially since they can change significantly with relatively minor changes to the Project. Although the upstream and downstream limits for this Project are the 5th Avenue Check and the Lake Woollomes Check, hydraulics were analyzed from the 5th Avenue Check through the canal terminus at the Kern River Check. The boundary condition was considered the Kern River Check because the Project needs to be compatible with any future modifications in the Lower Reach. From the analysis, it was determined that the hydraulic head varies about 25 feet between 5th Avenue Check and the Kern River. Of this, approximately 20 feet is required for the canal gradient and the remaining 5 feet is required to accommodate for losses at canal structures, including bridges, turnouts, checks, and siphons.

The boundary conditions, along with the Project objectives, were used to establish a proposed hydraulic grade line (HGL). The proposed HGL was set as low as possible to minimize embankment raise requirements and the need to modify bridges. All management measures considered, and subsequent Project alternatives, are based on the proposed HGL. The proposed HGL is shown in Figure 3-1.

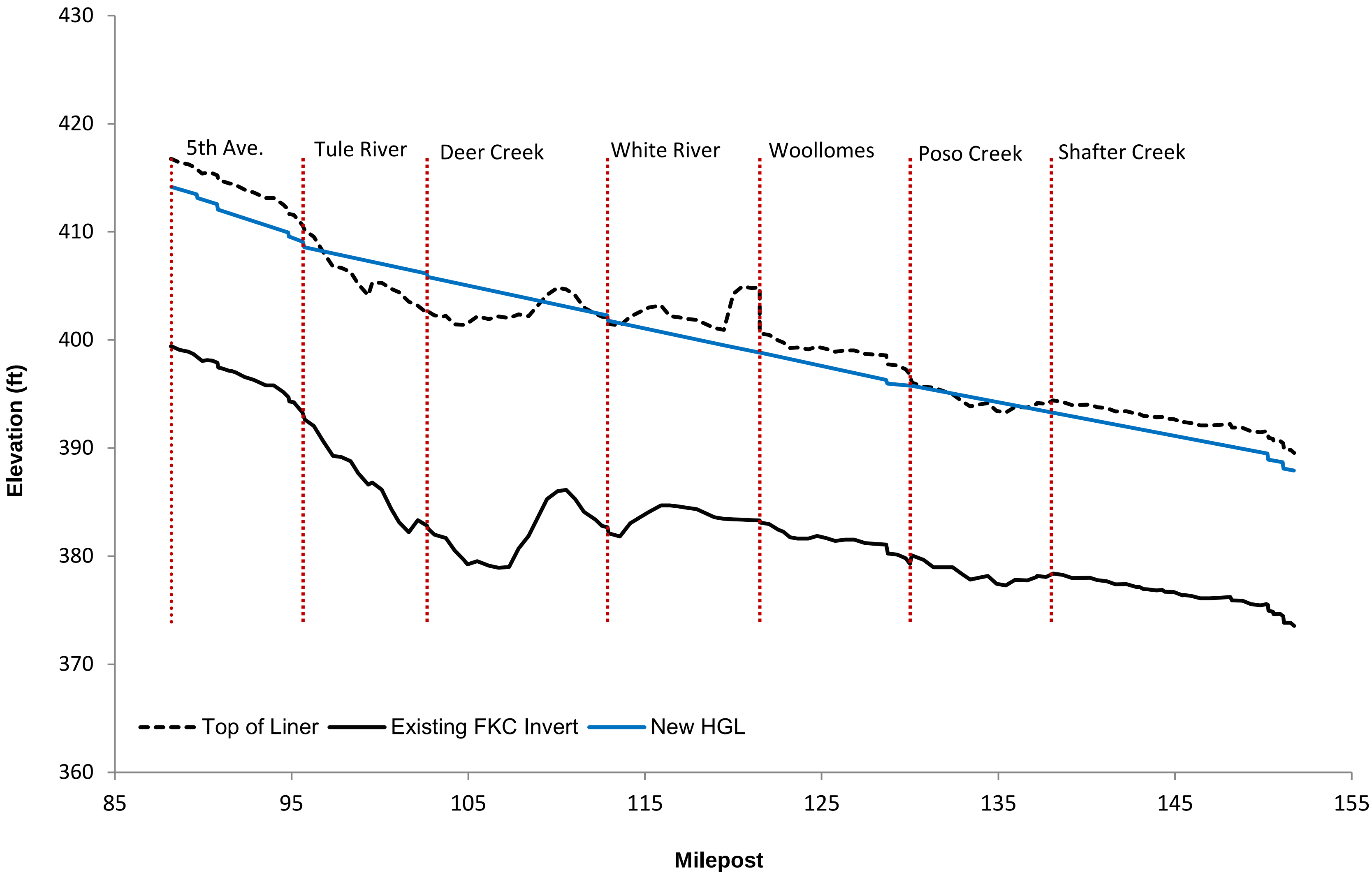

Figure 3-1. Canal Profile with Proposed Hydraulic Grade Line

Initial Alternatives Formulation

The Initial Alternatives Formulation describes the development, evaluation, and comparison of a set of seven Initial Alternatives. From the evaluation, two Initial Alternatives were selected for further development in this Study. For more detail, refer to Appendix A Initial Alternatives Formulation.

Measures Considered

In the formulation of Initial Alternatives, several structural measures were identified that could contribute to the Project objective of restoring the design FKC flow capacity. Nonstructural measures were not considered because the SJRRS Act requires the restoration of the originally designed and constructed capacity, which cannot be achieved through the implementation of nonstructural actions. Structural measures were organized into the following categories: canal enlargement, pumping plant, new canal, bridge modification, and other. Of the measures identified, several were selected for development into Initial Alternatives investigated in this Study (Table 3-1).

Table 3-1. Measures to Restore Friant-Kern Canal Capacity

Resource Management Measure	Status	Rationale
Canal Enlargement		
Raise Canal	Retained	Raising the canal would contribute to the Project objectives.
Raise and Widen Entire Cross Section	**Removed**	This measure is cost prohibitive and raises constructability concerns. Dropped from further consideration,
Raise and Widen Upper Portion of Cross Section	Retained	Enlarging the canal would contribute to Project objectives.
Pumping Plant		
Pumping Plant	Retained	The addition of a pumping plant would help restore capacity, thus contributing to Project objectives.
New Canal		
Bypass Canal	Retained	A bypass canal would restore capacity, though not in the original FKC.
Parallel Canal	Retained	A parallel canal would restore capacity, though not in the original FKC.
Bridge Modification		
Bridge Raise	Retained	A bridge raise does not sufficiently meet Project objectives but is an operational requirement.
Bridge Replacement	Retained	A bridge replacement does not sufficiently meet Project objectives but is an operational requirement to be included.
Other		
Pipeline	**Removed**	Initial hydraulic analysis revealed that headlosses would be greater than the available head, and project would require a pump station(s) to move water. This would be more costly than other available options.

Capacity Restoration Objectives for Initial Alternatives

As stated in Chapter 1, the objective of the Project is to restore the capacity of the FKC as previously design and constructed, consistent with SJRRS Act authority. This involves restoring the original design capacity of the FKC consistent with current Reclamation design standards for Normal and Design Maximum flow rates. The design of all Initial Alternatives was based on a canal capacity equal to the Design Maximum Flow Rate (Table 3-2). Canal lining depths were based on the normal depths at the Design Maximum Flow Rates plus the lined freeboard criteria for normal operations. The design flow rates were used to develop the HGL profiles for the Initial Alternatives. This approach is considered conservative and is inclusive of all potential flow and freeboard design requirements that may be considered in future evaluations.

Table 3-2. Design Flow Rates for Initial Alternatives

Canal Section No.	Canal Segment (MP to MP)	Description (Check to Check)	Normal Flow Rate (cfs)	Design Maximum Flow Rate (cfs)
4	88 to 95.67	5th Avenue to Tule	3,500	4,500
5	95.67 to 112.90	Tule to White River	3,000	4,000
6.1	112.90 to 128.69	White River to HWY 99	2,500	3,500
6.2	128.69 to 130.03	HWY 99 to Poso	2,500	3,000

Key:
cfs = cubic feet per second
HWY = highway
MP = mile post

Initial Alternatives

Seven Initial Alternatives were developed to meet the Project objective using the management measures. A brief overview of each alternative is provided below. A summary of features of each Initial Alternative is provided in Table 3-3.

Initial Alternative 1: Canal Enlargement

Initial Alternative 1 would increase the capacity of the FKC by either raising the embankments and the concrete liner or raising and widening the embankments and liner. To raise and widen the canal, a portion of the existing liner would be removed, a bench would be cut into the existing grade, the embankment would be widened, and liner would be extended on the bench and the raised embankment. This approach would minimize land acquisition requirements; however, 67 miles of embankment would be modified.

Initial Alternative 2: Pump Station at MP 109

Initial Alternative 2 would change the FKC from a gravity canal to a pumped canal. When flows are high and cannot be conveyed by gravity, water would be diverted from the original canal at MP 109, into a forebay, then pumped back into the original canal. The initial pump station design includes eight 250-cfs pumps. In the event of a power failure, water would be directed into a 400-acre emergency reservoir to prevent a surge.

Initial Alternative 3: Pump to Woollomes

In Initial Alternative 3, capacity restoration would be achieved by moving water from the original canal into an approximately 10-mile-long bypass canal and pumping it into Lake Woollomes. The existing canal would be used to maintain deliveries within the bypassed section.

Initial Alternative 4A: Bypass Canal-Tule River to White River

Alternative 4A is an offset bypass canal that would move water into a new canal at the Tule River and connect back into the existing canal at White River. The existing canal would be used solely to maintain deliveries between the two checks.

Initial Alternative 4B: Bypass Canal-Tule River to Woollomes

Initial Alternative 4B is the same as Initial Alternative 4A but extends to Lake Woollomes.

Initial Alternative 5A: Parallel Canal-Tule River to White River

Initial Alternative 5A is a combination of the canal enlargement and parallel canal measures. The parallel canal would run from Tule River to White River.

Initial Alternative 5B: Parallel Canal-Tule River to Woollomes

Initial Alternative 5B is the same as Initial Alternative 5A but extends to Lake Woollomes.

Table 3-3. Initial Alternative Features Summary

Alternative	Capital Cost (M)	Present Worth Additional OM&R (M)	Material Balance[1] (1,000 yd^3)	ROW Required (acres)[2]	Bridge Modification[3]	Stream Crossing	Embankment Modification (mi)
1: Canal Enlargement	$290	$0.3	-1,550	170	17	0	66
2: Pump Station at MP 109	$270	$3.1	+542	522	14	0	52
3: Pump to Woollomes	$380	$3.5	+945	622	23	1	27
4A: Bypass Canal—Tule River to White River	$300	$1	+1,750	508	18	1	32
4B: Bypass Canal—Tule River to Woollomes	$320	$1.4	+2,418	650	24	2	20
5A: Parallel Canal—Tule River to White River	$300	$0.9	Balanced	321	18	0	49
5B: Parallel Canal—Tule River to Woollomes	$300	$1.3	Balanced	390	24	0	43

Notes:
1 Negative values indicate borrow and positive values indicate surplus.
2 ROW required is the additional ROW needed outside the existing Reclamation ROW.
3 Modifications can be a raise, replace, or new bridge. Farm bridge modifications are not included in this count.
Key:
M = million dollars
mi =miles
MP = mile post
OM&R = operations, maintenance, and replacement
yd^3 = cubic yard

Evaluation and Comparison of Initial Alternatives

The seven Initial Alternatives were evaluated and scored based on five criteria and several related sub-criteria, as listed in Table 3-4. The criteria addressed: (1) constructability, (2) operational requirements and flexibility, (3) cost, (4) schedule, and (5) environmental compliance and permitting. The evaluation and scoring considered both current (2018 survey) and projected future land surface elevations. Scoring results were evaluated as unweighted and weighted based on Project priorities of cost and schedule. A summary of the ranking results based on existing land surface is shown in Figure 3-2. The results from this analysis, as well as an analysis that considered potential future subsidence, revealed that Alternatives 1 and 5 consistently ranked highest. On the basis of these findings, Alternatives 1 and 5 were selected for further evaluation. Additional information on the Initial Alternatives evaluation can be found in Appendix A Initial Alternatives Formulation.

Table 3-4. Initial Alternatives Evaluation Criteria and Sub-Criteria

I. Constructability	II. Operational Requirements and Flexibility	III. Cost	IV. Schedule	V. Environmental Compliance and Permitting
CON-1. Complexity to Maintain Water Deliveries during Construction	OPS-1. Additional O&M Requirements and Expertise of FWA Staff	COST-1. Construction Cost*	SCH-1. Time to Start Construction	ENV-1. Complexity of Required Environmental Compliance
CON-2. Ability to O&M during Construction	OPS-2. Operations of District Turnouts	COST-2. Non-contract Cost*	SCH-2. Construction Duration	ENV-2. Number of Stream Crossings*
CON-3. Temporary Bypasses and Tie-Ins Needed to Construct the Project*	OPS-3. Ability to Accommodate Power Outages	COST-3. Present Worth Additional OM&R Costs*	SCH-3. Time Until Benefits Realized	ENV-3. Number of Bridges*
CON-4. Extent of Dewatering			SCH-4. Potential to Phase Construction	ENV- 4. Length of Modified Existing Embankment*
CON-5. Material Balance*			SCH-5. Land Acquisition*	
			SCH-6. Schedule Risk	

Note:
*Qualitative sub-criterion
Key:
O&M = operations and maintenance
OM&R = operations, maintenance, and replacement

UNWEIGHTED

ID	Alternative Name	Alternative Type	Constructability (20%)	Operational Requirments and Flexibility (20%)	Cost (20%)	Schedule (20%)	Environmental Compliance and Permitting (20%)	UNWEIGHTED Composite Score	UNWEIGHTED Alternative Ranking
1	Canal Enlargement	G	1.8	5.0	4.7	4.8	2.6	3.8	1
2	Pump Station at MP 109	PS	2.7	2.3	3.4	2.8	2.9	2.8	5
3	Woollomes Pump Station	PS	2.8	2.0	1.0	1.9	1.7	1.9	7
4A	Bypass Canal: Tule River to White River	G	4.1	3.7	3.8	2.0	2.3	3.2	4
4B	Bypass Canal: Tule River to Woollomes	G	4.2	3.0	2.1	1.2	1.6	2.4	6
5A	Parallel Canal: Tule River to White River	G	4.2	4.3	3.9	3.0	2.4	3.6	2
5B	Parallel Canal: Tule River to Woollomes	G	4.5	3.7	3.4	2.4	2.0	3.2	3

COST

ID	Alternative Name	Alternative Type	Constructability (10%)	Operational Requirments and Flexibility (15%)	Cost (50%)	Schedule (10%)	Environmental Compliance and Permitting (15%)	COST Composite Score	COST Alternative Ranking
1	Canal Enlargement	G	1.8	5.0	4.7	4.8	2.6	4.1	1
2	Pump Station at MP 109	PS	2.7	2.3	3.4	2.8	2.9	3.0	5
3	Woollomes Pump Station	PS	2.8	2.0	1.0	1.9	1.7	1.5	7
4A	Bypass Canal: Tule River to White River	G	4.1	3.7	3.8	2.0	2.3	3.4	3
4B	Bypass Canal: Tule River to Woollomes	G	4.2	3.0	2.1	1.2	1.6	2.3	6
5A	Parallel Canal: Tule River to White River	G	4.2	4.3	3.9	3.0	2.4	3.7	2
5B	Parallel Canal: Tule River to Woollomes	G	4.5	3.7	3.4	2.4	2.0	3.2	4

SCHEDULE

ID	Alternative Name	Alternative Type	Constructability (10%)	Operational Requirments and Flexibility (15%)	Cost (10%)	Schedule (50%)	Environmental Compliance and Permitting (15%)	SCHEDULE Composite Score	SCHEDULE Alternative Ranking
1	Canal Enlargement	G	1.8	5.0	4.7	4.8	2.6	4.2	1
2	Pump Station at MP 109	PS	2.7	2.3	3.4	2.8	2.9	2.8	4
3	Woollomes Pump Station	PS	2.8	2.0	1.0	1.9	1.7	1.9	7
4A	Bypass Canal: Tule River to White River	G	4.1	3.7	3.8	2.0	2.3	2.7	5
4B	Bypass Canal: Tule River to Woollomes	G	4.2	3.0	2.1	1.2	1.6	1.9	6
5A	Parallel Canal: Tule River to White River	G	4.2	4.3	3.9	3.0	2.4	3.3	2
5B	Parallel Canal: Tule River to Woollomes	G	4.5	3.7	3.4	2.4	2.0	2.8	3

Figure 3-2. Evaluation and Comparison of Initial Alternatives

Selection of Alternatives for Feasibility-Level Evaluation

Alternatives 1 and 5 were further evaluated following the failure of California Proposition 3 in November 2018, a potential non-Federal funding source for the Project. The additional evaluation considered various design capacity and freeboard requirements for Initial Alternatives 1 and 5 with the objective of identifying challenges that may be associated with Project phasing.

Estimates of material quantities and costs were prepared for Initial Alternatives 1 and 5 under the following capacity and freeboard options:

- **Option 1 - Maximum Historical Flow with Flood Freeboard**. This option was defined based on a review of historical peak flows in each segment of the FKC. The existing flood freeboard was applied based on the assumption that historical peak flows were associated with the conveyance of flood flows. This condition occurs during the delivery of 215 water supplies and, in some instances, the delivery of Class 2 water supplies.
- **Option 2 - Design Normal Flow with Standard Freeboard**. This option was defined based on the original normal design flow using the current standard freeboard requirements.
- **Option 3 - Design Maximum Flow with Flood Freeboard**. This option was defined based on the original maximum design flow using the current flood freeboard requirements.
- **Option 4 - Design Maximum Flow with Standard Freeboard**. This option was defined based on the original maximum design flow using the current standard freeboard requirements. This assumption was applied in the assessment of all Initial Alternatives.

A summary of results of the additional analysis of Initial Alternatives is presented in Table 3-5. Based on this analysis, the following alternatives were selected for evaluation as Feasibility Alternatives:

- Initial Alternative 1 Option 1, hereafter referred to as Canal Enlargement, was selected for feasibility evaluation because it identifies modifications necessary to maintain continued operations of the FKC consistent with historical operations. While this capacity the original designed capacity, this information may be beneficial in evaluating cost allocation requirements.
- Initial Alternative 5 Option 3, hereafter referred to as Parallel Canal, was selected for feasibility evaluation. Option 3 would restore the canal to the original design capacity.

Table 3-5. Additional Analysis of Initial Alternatives for Selection of Feasibility Alternatives

Quantity	Alternative 1				Alternative 5			
	Option 1	**Option 2**	**Option 3**	**Option 4**	**Option 1**	**Option 2**	**Option 3**	**Option 4**
Length of Modified Canal (miles)	**17.10**	24	31	31	17.08	24	**31**	31
Length of Modified FKC Embankment (miles)	**34.20**	47.20	62.00	62.00	17.08	23.60	**38.40**	38.43
Permanent ROW required (acres)	**0**	0	154	170	218	299	**371**	386
Number of Parcels for Permanent ROW	**0**	16	131	165	70	87	**189**	182
Excavation of Existing Canal (1,000 cubic yards)	**190**	577	4,015	3,709	1,533	3,014	4,871	4,875
Embankment Material Required (1,000 cubic yards)	**1,883,537**	2,690,072	4,359,154	5,259,535	3,110,475	3,968,826	**3,552,038**	4,459,080
Material Balance (Borrow) or Waste (1,000 cubic yards)	**(1,694)**	(2,113)	(344)	(1,551)	(1,578)	(955)	**1,319**	416
Borrow / Waste Disposal ROW (acres)	**210**	326	469	488	195	403	**396**	448
Lining Required (thousand square yards)	**405**	488	1,612	1,686	968	1,327	**1,845**	1,946
Bridge Raise	**2**	2	3	3	0	0	**1**	1
Bridge Replacement/New Bridge	**16**	17	17	17	19	27	**27**	27
Total Project Cost ($M)	**$150**	$191	$298	$316	$192	$270	**$309**	$330
Low Cost Range (-25% on Field Costs; $M)	**$113**	$144	$228	$240	$147	$208	**$236**	$252
High Cost Range (+25% on Field Costs; $M)	**$185**	$235	$369	$391	$236	$334	**$381**	$405

Note: The ROW information presented in this table was calculated using two map layers. One layer called record ROW shows the right-of-way for the Friant-Kern Canal as described in the deed maps on record with the Bureau of Reclamation. Any misclosures or overlaps that occur reflect the problems contained within the legal description. The other layer called adjusted ROW shows the approximation of the right-of-way boundaries corrected and adjusted based upon minimal survey control. This information is not to be considered official or final and is only intended to show discrepancies and or problems between the deed and preliminary survey evidence recovered in the field.

Key:
$M = Million Dollars
FKC = Friant-Kern Canal
ROW = Right of Way

Chapter 4 Feasibility Alternatives

This chapter provides a description of the No Action Alternative and the two Feasibility Alternatives. The physical features of the Feasibility Alternatives, as well as the costs and anticipated permitting requirements, are summarized below and evaluated further in Chapter 5.

No Action Alternative

The No Action Alternative represents a projection of reasonably foreseeable future conditions that could occur if no action is taken to address current and projected future capacity reductions to the FKC (i.e., the future without the proposed Project). Reclamation recommends several criteria for including proposed future actions within the No Action Alternative: proposed actions should be (1) authorized; (2) approved through completion of NEPA, CEQA, Endangered Species Act (ESA), and other compliance processes; (3) funded; and (4) permitted. The No Action Alternative is considered the basis for comparison with the Recommended Plan, consistent with NEPA and the PR&G (CEQ 2013) guidelines. Therefore, if no proposed action is determined feasible, the No Action Alternative is the default option.

Under the No Action Alternative, Reclamation and FWA would not take additional actions towards restoring the capacity of the Middle Reach of the FKC. However, four foreseeable actions have been identified that affect future conditions: SJRRP implementation, continued subsidence, SGMA implementation, and CVP water delivery rescheduling in Millerton Lake.

SJRRP Implementation

Under the No Action Alternative, water supply availability to Friant Division long-term contractors will decrease as San Joaquin River channel improvements are implemented that allow for increased and ultimately full release of Restoration Flows. As shown in Figure 4-1, simulated long-term average annual Friant Division deliveries under the current level of SJRRP implementation is estimated at 1,119 TAF per year. As of October 2019, release of full Restoration Flows is not possible due to downstream channel capacity constraints. With full release of Restoration Flows to the San Joaquin River, anticipated by 2030, long-term annual average deliveries to the Friant Division would be reduced to about 1,052 TAF.

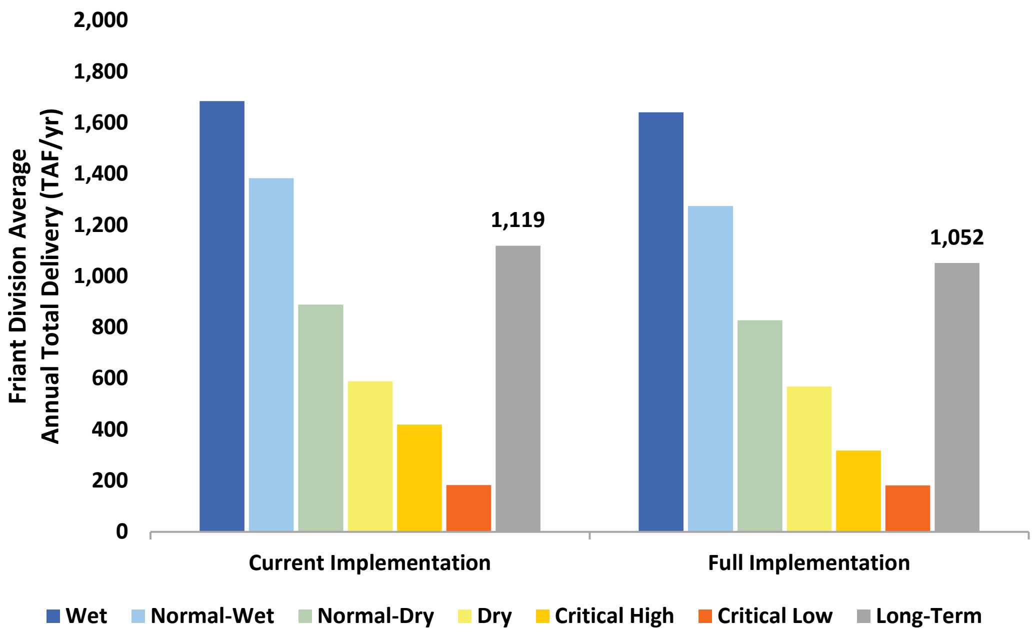

Figure 4-1. Simulated Friant Division Delivery Capability with SJRRP Implementation

Under the No Action Alternative, the current capacity-restricted condition of the FKC would continue to limit affected Friant Division long-term contractors' ability to receive water during periods of peak demand or peak flow. This could impact the ability of the contractors to take delivery of water under Paragraph 16 (b) of the Settlement "for the purpose of reducing or avoiding impacts to water deliveries to all of the Friant Division long-term contractors caused by the Interim and Restoration Flows," thus limiting the Secretary of the Interior's ability to achieve the Water Management Goal in the Settlement. As subsidence continues, water delivery impacts associated with decreased canal capacity would increase.

Future Subsidence

Under the No Action Alternative subsidence is expected to continue throughout the project area. As described in Chapter 2, a groundwater model of the Tule Subbasin was developed to simulate potential future groundwater and land subsidence conditions in support of planning for SGMA compliance. As described in Chapter 2 a condition of Severe Mid-Term Subsidence conditions was selected for use in Project evaluations, resulting in the maximum total subsidence displacement from the current condition of each year described in Table 4-1.

Table 4-1. Maximum Simulated Additional Subsidence in the Middle Reach of the FKC

Year	Displacement from Current Condition (ft)
2025	3.9
2030	6.7
2040	8.5
2070	9.5

Key:
ft = feet

SGMA Implementation

In response to reduced deliveries from Friant Dam as a result of SJRRP implementation and FKC capacity reduction, affected Friant Division long-term contractors would likely increase groundwater pumping. However, the duration of this response will be limited. SGMA implementation is expected to limit allowable groundwater pumping to amounts less than historical and current amounts. SGMA requires that actions to achieve sustainable groundwater management be in place no later than 2040. Therefore, it is assumed that any increased groundwater pumping in response to surface water reductions due to SJRRP Restoration Flow increases and FKC capacity limitations would be gradually reduced to zero by 2030.

Water Delivery Rescheduling

It is reasonable to expect the Friant Division long-term contractors would take some action to minimize water delivery shortages by rescheduling affected water deliveries in Millerton Lake. The potential for rescheduling affected water supplies is based on the following factors:

- Water demands for affected Friant Division contractors that would be served by non-Friant Division water supplies (local surface water, groundwater, or other supplies).
- Available storage capacity in Millerton Lake.
- Available capacity in the FKC to convey rescheduled water supplies.

The potential to reschedule affected Friant Division water deliveries in Millerton Lake was simulated by creating an account to track the storage of affected water supplies. Water in the rescheduled water account would be the first water subject to spill to assure that all existing obligations for the operation of Friant Dam would continue under existing priorities. Water would be diverted from the rescheduled water storage account to the FKC in months when demand that would be served by other supplies is available, as constrained by available conveyance capacity in the FKC.

Water would remain in the rescheduled storage account, including into successive years, until the account is evacuated, or flood releases are made from Friant Dam to the San Joaquin River. It is assumed that the rescheduled supplies would result in a shifting the timing of groundwater pumping and local surface water supply use to continue to meet demands in districts that would have a reduction in allocated CVP water supplies due to FKC capacity limitations. When capacity in the FKC is available to deliver rescheduled supplies, this would come at a time that would offset typical use of groundwater pumping or local surface water supplies.

Feasibility Alternative Plans

Based on the evaluation of Initial Alternatives, two alternatives were carried forward for an evaluation at a feasibility level. The Parallel Canal Alternative was developed based on refinements to Initial Alternative 5 Option 3, which includes construction of a new canal parallel to the FKC and modifying the FKC where possible to convey maximum design flow of the original authorized project. The Canal Enlargement Alternative was developed based on refinements to Initial Alternative 1 Option 1, which includes modifying the FKC to convey maximum capacity based on maximum historic flow. A summary of design capacity and freeboard requirements for the Feasibility Alternative Plans is provided in Table 4-2.

Table 4-2. Design Capacity and Freeboard Requirements in Feasibility Alternatives

	Canal Enlargement		**Parallel Canal**	
	Capacity (cfs)	**Freeboard (ft)**	**Capacity (cfs)**	**Freeboard (ft)**
Segment 1	4,008	1.12	4,500	1.12
Segment 2	3,497	1.08	4,000	1.08
Segment 3	2,888	1.08	4,000	1.08
Segment 4	2,490	1.03	3,500	1.03

Key:
cfs = cubic feet per second
ft = feet

In refining the retained Initial Alternatives, additional detail was developed regarding turnouts and canal crossings, consideration was given to minimizing ROW requirements, and modifications were made to minimize material hauling requirements. Descriptions of Feasibility Alternatives are provided below.

Parallel Canal Alternative

The Parallel Canal Alternative was refined after the Initial Alternatives Formulation in terms of alignment, water delivery strategy (turnouts), canal cross-section design, road crossings, check structures, utilities, and costs. A single-line schematic showing features included in the Parallel Canal Alternative is provided in Figure 4-2A and Figure 4-2B. As shown, the Parallel Canal Alternative includes a combination of modifications to the existing FKC and the construction of a new parallel canal immediately to the east of the FKC. The selection of canal modification or parallel canal was made based on the extent of modifications that would be required to the FKC. The parallel canal would be constructed in reaches where land subsidence has occurred to an extent that raising and widening the FKC to achieve the design capacity is considered less practical. Features of the Parallel Canal Alternative are described in the following sections.

Canal Alignment and Cross Sections

In comparison to Initial Alternative 5, significant refinements were incorporated in the Parallel Canal Alternative regarding the canal alignment and the cross sections. Initial Alternative 5 was based on a parallel canal from the 5th Avenue Check to either White River or Lake Woollomes, and the continued operation of the existing FKC for deliveries in the bypassed reaches.

Through the refinement process, the length of the parallel canal portion of this alternative was reduced. In some locations, it was found that modifying the FKC to achieve the objective conveyance capacity would be more practical than constructing a parallel canal. It was also found that retaining long segments of the existing FKC to provide deliveries in the bypassed segments would require modifications to several turnouts. In light of these refinements, the Parallel Canal Alternative was revised to a configuration that includes modifications to the FKC and the construction of a replacement parallel canal.

Where constructed, the parallel canal would be the exclusive water conveyance and delivery mechanism and most of the existing FKC would be demolished, filled in, and taken out of service. This approach was selected due to the numerous benefits it provides; it would reduce ROW acquisition requirements, reduce material hauling during canal earthwork, provide access to existing material, improve constructability, and would provide greater long-term durability.

The Parallel Canal Alternative would include modifications to the current FKC alignment from 5th Ave. Check (MP 88) to Ave. 152 (MP 96.3). Through this reach, the cross section of the existing FKC would be enlarged with a 24-foot bench on either side to increase canal capacity to meet the Design Maximum flow rate of 4,500 cfs in this segment, as shown in Figure 4-3. From 5th Ave. Check (MP 88) to Ave. 152 (MP 96.3) the existing bridges are estimated to be high enough to accommodate the new canal water surface level and the existing turnouts could continue to function without modification. To reduce cost, the enlarged canal would transition into the existing canal prism upstream and downstream from existing bridges and turnouts so that these structures may remain in place without modification.

At MP 96.3, the Parallel Canal Alternative alignment would head east, away from the existing canal centerline, and run on a parallel alignment until it reaches Garces Highway (MP 118.96). In this reach, the Parallel Canal would have a regular trapezoidal shape based on the configuration shown in Figure 4-4. At MP 118.96, the Parallel Canal Alternative would head west and reconnect with the existing alignment of the FKC, which would be enlarged between MP 118.96 to MP 121.5 as described above and shown in Figure 4-3.

The Parallel Canal Alternative, as described in this Report is based on canal embankments and liner that would achieve objective capacities if constructed at the current ground level. The alternative also includes design features to accommodate anticipated future subsidence. For example, the siphon-type road crossings are sized to accommodate future increases in HGL. In addition, canal embankments were configured such that they could be raised without interfering with the operation of the restored FKC and necessary right of way to accommodate the future raise is included, as identified as future concrete liner raise with embankment on Figure 4-4.

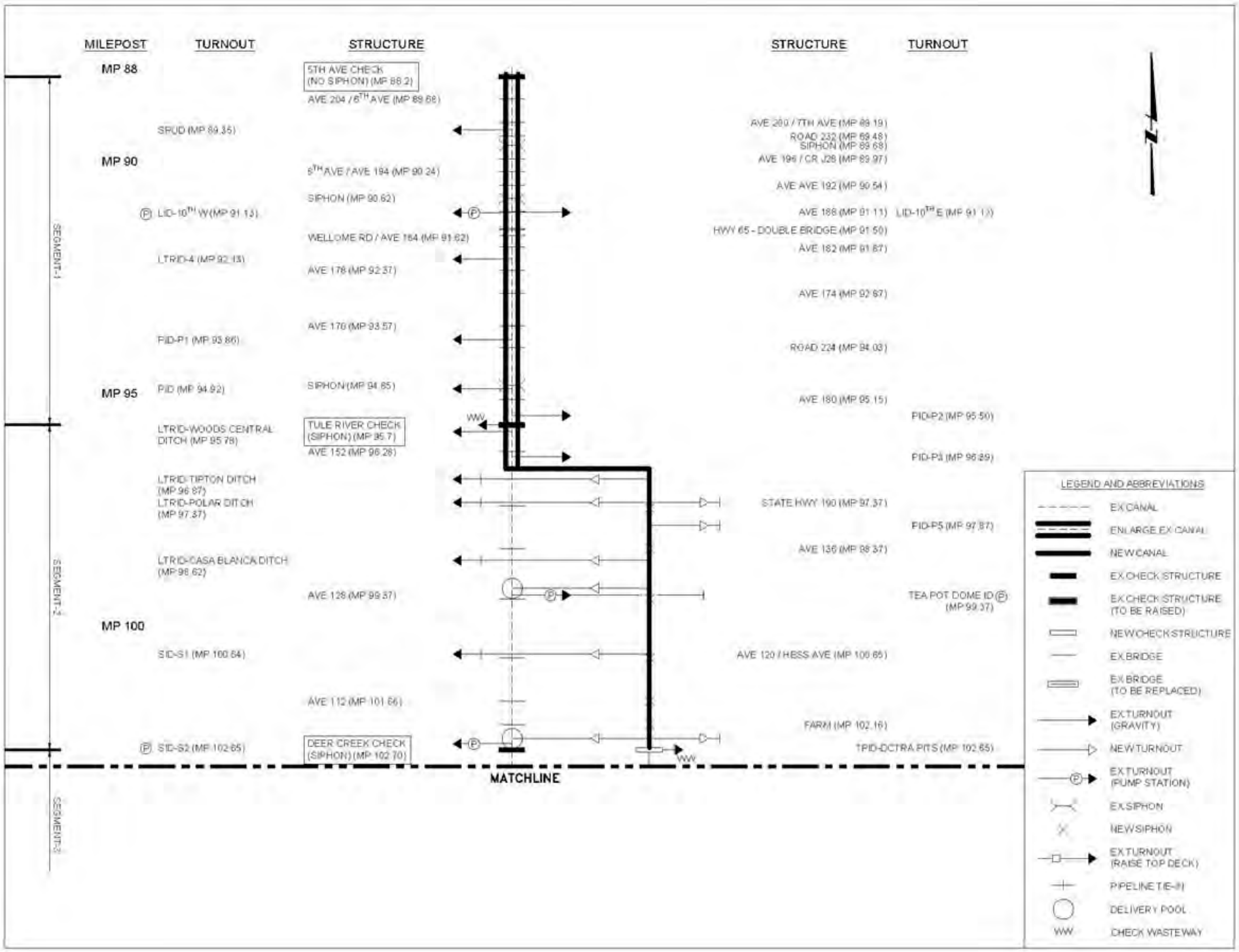

Figure 4-2A. Parallel Canal Alternative Single-Line Diagram of Canal Segments 1 and 2

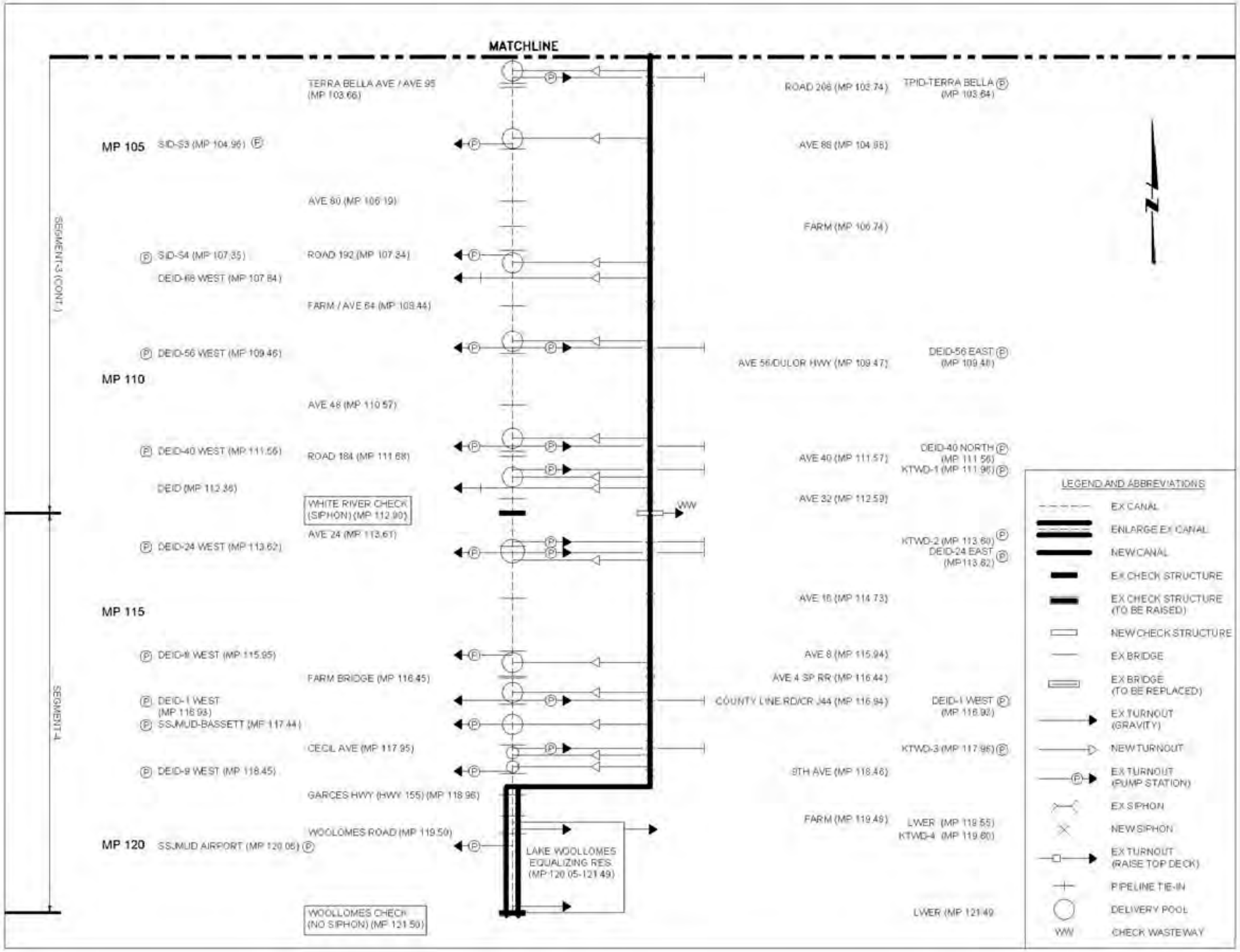

Figure 4-2B. Parallel Canal Alternative Single Line Diagram of Segments 3 and 4

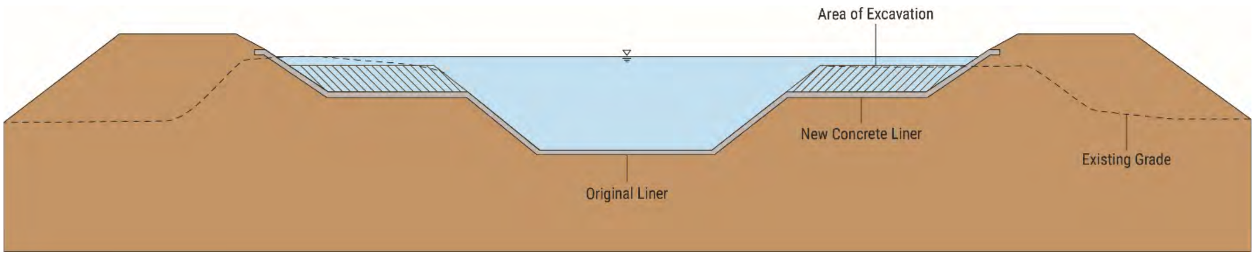

Figure 4-3. Compound Trapezoidal Cross Section in the Parallel Canal Alternative

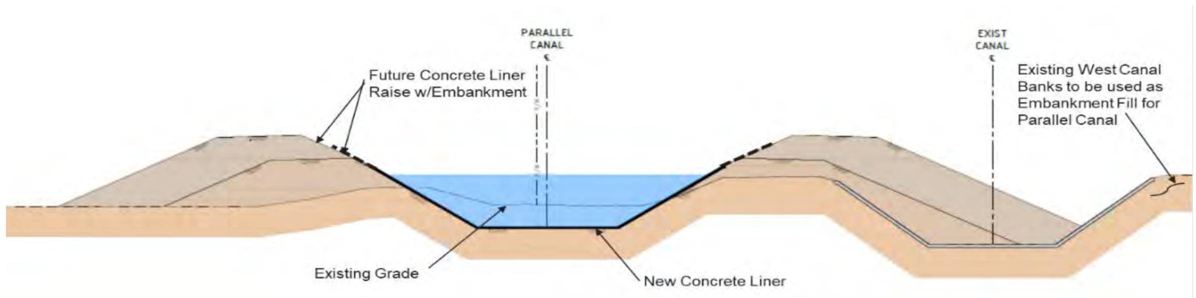

Figure 4-4. Trapezoidal Cross Section in the Parallel Canal Alternative

Construction Sequencing

The parallel canal portion of the Parallel Canal Alternative would be constructed as follows:

1. Partially build the right bank, from existing canal left bank material, while maintaining water deliveries in the existing canal.

2. Excavate the new cross section and use the excavated material to build the left bank. This work could be accomplished while the existing canal is in operation.

3. Put the Parallel Canal into operation and decommission the bypassed portion of the existing FKC.

4. Complete building the Parallel Canal right bank by using the decommissioned FKC right bank material.

For a detailed discussion on construction sequencing, refer to Appendix B Engineering Design and Cost.

Turnouts

The Parallel Canal Alternative includes features to address water delivery at existing turnouts, based, in part, on input provided by Friant Division long-term contractors. The Parallel Canal Alternative incorporates design concepts for pressurized and gravity systems to ensure compatibility between the canal and the contractors' distribution systems, maintain water delivery capability during construction, control overflow, and enhance operational flexibility.