Pressurized Turnout Modifications In the Middle Reach, many of the 20 pressurized distribution systems have subsided at different rates than the land under the canal, causing varying differential head conditions from those used in the original system designs. All alternatives have been developed to achieve the proposed HGL, which is higher than the current water surface in the FKC. Increasing the HGL would increase head on the suction side of the pumping plants, which would increase the delivery head on district distribution systems. The removal and replacement of current pump stations at a location compatible with the current design was considered and dropped because of significant costs.

The water elevation in the parallel canal would often be above the elevation of the top decks of existing pump stations. If a pump station were to unexpectedly shutdown, the incoming flow from the adjacent canal could overflow the pump station and flood the facility and surrounding land, resulting in equipment and property damage. To avoid the potential risk associated with unexpected shutdowns, the Parallel Canal Alternative includes small delivery pools at each pump station turnout. As shown in Figure 4-5, the delivery pool would be created by preserving small portions of the existing FKC. Water would flow from the parallel canal through a new pipe to the delivery pool which would serve as a forebay for the existing turnout pump station. The parallel canal alignment would be modified at the location of each pump station turnout and be customized to meet the specific needs of each pressurized delivery system. A list of the modifications proposed to the pump station turnouts is provided in Table 4-3.

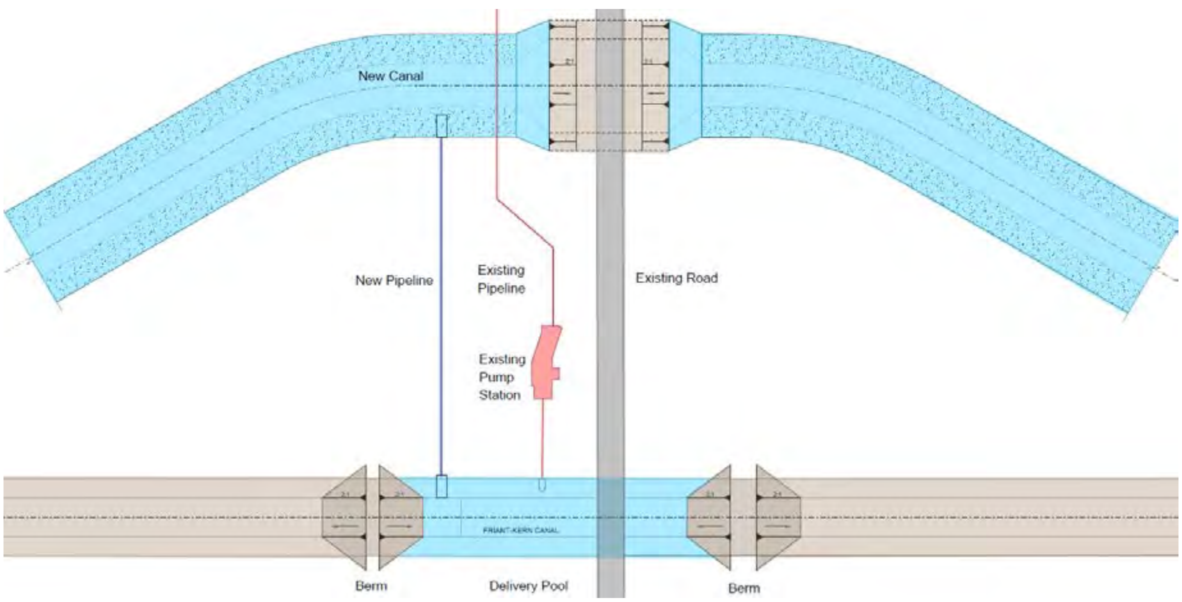

Figure 4-5. Example Pressurized System Turnout Design in the Parallel Canal Alternative

Table 4-3. Modifications at Pump Station Turnouts in the Parallel Canal Alternative

Pump Station Turnout	Canal Side	MP	Modification
LID-10th W	West	91.12	Unmodified
TPDWD-Teapot Dome	East	99.35	Remain Plus Delivery Pool
SID-S2	West	102.65	Remain Plus Delivery Pool
TBID-Terra Bella	East	103.64	Remain Plus Delivery Pool
SID-S3	West	104.96	Remain Plus Delivery Pool
SID-S4	West	107.35	Remain Plus Delivery Pool
DEID-56 EAST	East	109.46	Remain Plus Delivery Pool
DEID-56 West	West	109.46	Remain Plus Delivery Pool
DEID-40 North	East	111.56	Remain Plus Delivery Pool
DEID-40 West	West	111.56	Remain Plus Delivery Pool
KTWD-1	East	111.96	Remain Plus Delivery Pool
KTWD-2	East	113.6	Remain Plus Delivery Pool
DEID-24 East	East	113.62	Remain Plus Delivery Pool
DEID-24 West	West	113.62	Remain Plus Delivery Pool
DEID-8th West	West	115.95	Remain Plus Delivery Pool
DEID-#1 West	East	116.93	Remain Plus Delivery Pool
SSJMUD-Bassett	West	117.44	Remain Plus Delivery Pool
KTWD-3	East	117.96	Remain Plus Delivery Pool
DEID-9th West	West	118.45	Remain Plus Delivery Pool
SSJMUD-Airport	West	120.06	Unmodified

Gravity Turnout Modifications There are 18 gravity systems located in the Middle Reach, each of which were individually analyzed to determine an appropriate design approach. The analysis revealed that all existing gravity turnouts can either be preserved and reused or connected to new turnouts and pipelines on the parallel canal. A summary of actions for gravity turnouts under the Parallel Canal Alternative is provided in Table 4-4.

Table 4-4. Modifications at Gravity Turnouts Under the Parallel Canal Alternative

Gravity Turnout	Canal Side	MP	Modification
SPUD-STRATHMORE	West	89.35	Unmodified
LID-10th E	East	91.12	Unmodified
LTRID-4	West	92.13	Unmodified
PID-P1	West	93.86	Unmodified
PID-Porter Slough	West	94.92	Unmodified
PID-P2	East	95.50	Unmodified
LTRID-Tule River WW Gates	West	95.64	Unmodified
LTRID-Woods Central Ditch	West	95.78	Unmodified
PID-P3	East	96.39	Build Turnout on Parallel Canal
LTRID-Tipton Ditch	West	96.87	Build Turnout on Parallel Canal
LTRID-Poplar Ditch N&S	West & East	97.34	Build Turnout on Parallel Canal
PID-P5	East	97.86	Build Turnout on Parallel Canal
LTRID-Casa Blanca Ditch	West	98.62	Build Turnout on Parallel Canal
SID-S1	West	100.63	Build Turnout on Parallel Canal
TBID-DCTRA Pits	East	102.65	Build Turnout on Parallel Canal
DEID-68 West	West	107.84	Build Turnout on Parallel Canal
DEID	West	112.36	Build Turnout on Parallel Canal
LWER	East	119.55	Unmodified
LWER	East	121.49	Unmodified

Checks and Siphons

In the analysis of Initial Alternative 5, it was assumed that the parallel canal would tie-in to the FKC at the existing check and siphon structures at Deer Creek and White River, and that existing structures and gates would be raised to meet the new canal design objectives. It was expected that continued use of existing structures would reduce cost and environmental consequences. Upon further refinement, it was discovered that this approach would require significant structural modifications to the existing structures, would add two new road crossings (bridges) at the White River check, and ultimately increase the amount of bridge work and overall project cost. Thus, the Parallel Canal Alternative includes new checks and siphons at Deer Creek and White River.

Road Crossings

In the formulation of Initial Alternative 5, bridge modification options included either a raise of the existing bridge or replacement with a new bridge. However, after further analysis it has become apparent that raising or replacing bridges as part of the Parallel Canal Alternative would add complexity and cost.

Designs for raising or replacing existing bridges would require that each bridge design be assessed for current highway and seismic design standards. It is anticipated that significant bridge retrofits would be required should the existing bridge infrastructure remain. In addition, raising or replacing bridges would require approach roadway improvements. It is estimated that up to 1,800 feet of additional road work would be required per bridge, including significant amounts of earthwork to build up the approaches consistent with vertical curve requirements.

Through the refinement process, raised bridges and replacement bridges have been removed from further consideration in the Parallel Canal Alternative in favor of siphon- type crossings that divert canal flow below the existing roadway and allow the road to stay at existing grade. Two typical siphon-type road crossing designs were developed, based on the relative elevation of the existing roadway in comparison to the elevation of the parallel canal. Siphon A would be applied in conditions where the parallel canal water surface elevation would be higher than the existing road elevation at the crossing, as illustrated in Figure 4-6. Siphon B would be applied in conditions where the parallel canal water surface elevation would be lower than the existing road elevation at the crossing, as illustrated in Figure 4-7.

For either application, the existing bridge over the current FKC would be demolished and the abandoned portion of the FKC would be filled to road grade, with the new siphon placed under the new parallel canal. For bridges that fall outside of the parallel canal, no action would be taken. A list of anticipated modifications to bridges in the Parallel Canal Alternative is provided in Table 4-5.

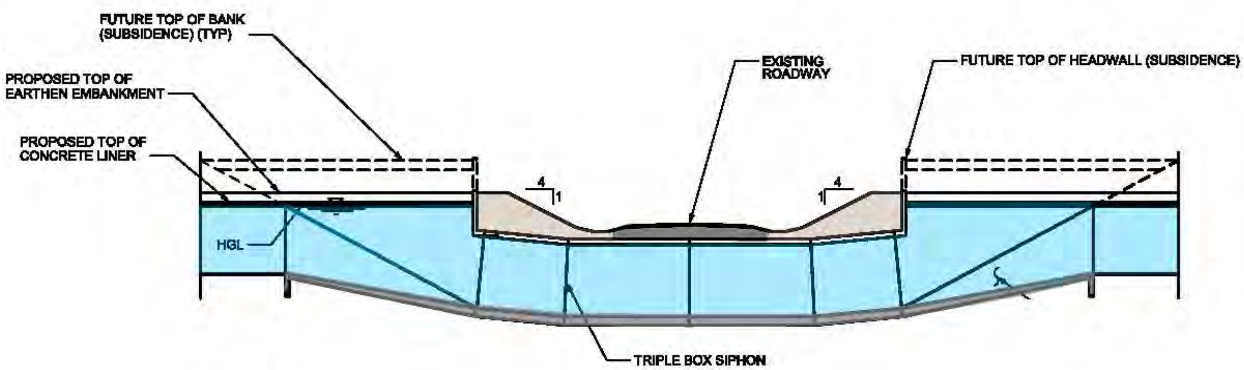

Figure 4-6. Typical Siphon A Road Crossing

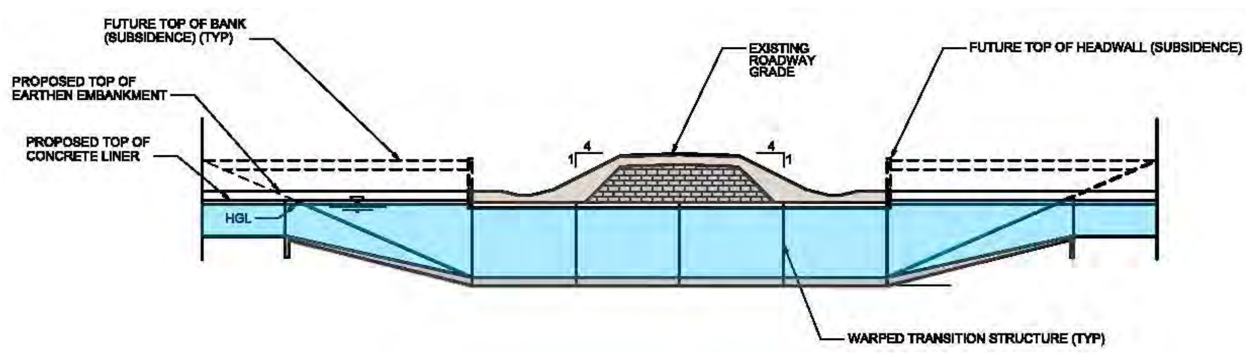

Figure 4-7. Typical Siphon B Road Crossing

Table 4-5. Road Crossing Actions in the Parallel Canal Alternative

Name	MP	Modification
6th Avenue Bridge	88.67	Unmodified
7th Avenue Bridge	89.17	Unmodified
Road 232 Bridge	89.45	Unmodified
Frazier Highway 196 Bridge	89.95	Unmodified
8th Avenue Bridge	89.95	Unmodified
Avenue 192 Bridge	90.23`	Unmodified
Avenue 188 Bridge	91.10	Unmodified
State Highway 65 Northbound Bridge (Double Bridge)	91.51	Unmodified
Welcome Avenue Bridge (Avenue 184)	91.60	Unmodified
Avenue 182 Bridge	91.85	Unmodified
Avenue 178 Bridge	92.35	Unmodified
W Linda Vista Avenue	92.85	Unmodified
W North Grand Avenue Bridge	93.55	Unmodified
N Westwood Street Bridge	94.01	Unmodified
W Henderson Avenue Bridge	95.12	Unmodified
Avenue 152 Bridge	96.26	Unmodified
Avenue 144 Bridge (Highway 190)	97.35	Demo- New Road Crossing/Siphon A
Avenue 136 Bridge	98.35	Demo- New Road Crossing/Siphon A
Avenue 128 Bridge	99.37	Demo- New Road Crossing/Siphon A
Hesse Avenue Bridge	100.64	Demo- New Road Crossing/Siphon A
Avenue 112 Bridge	101.64	Demo- New Road Crossing/Siphon A
Timber Farm Bridge	102.14	Demo- New Road Crossing/Siphon A
Road Terra Bella Avenue (J24)	103.65	Demo- New Road Crossing/Siphon A
Road 208 Bridge	103.72	Demo- New Road Crossing/Siphon A
Avenue 88 Bridge	104.95	Demo- New Road Crossing/Siphon A
Avenue 80 Bridge	106.72	Demo- New Road Crossing/Siphon A
Farm Bridge	106.75	Demo- New Road Crossing/Siphon A
Road 192 Bridge	107.32	Demo- New Road Crossing/Siphon A
Avenue 64 Bridge	108.42	Demo- New Road Crossing/Siphon A
Avenue 56 Bridge	109.45	Demo- New Road Crossing/Siphon A
Avenue 48 Bridge	110.55	Demo- New Road Crossing/Siphon A
Avenue 40 Bridge	111.55	Demo- New Road Crossing/Siphon A
Road 184 Bridge	111.66	Demo and Fill
Avenue 32 Bridge	112.57	Demo- New Road Crossing/Siphon A
Avenue 24 Bridge	113.59	Demo- New Road Crossing/Siphon A
Avenue 16 Bridge	114.71	Demo- New Road Crossing/Siphon B
Avenue 8 Bridge	115.91	Demo- New Road Crossing/Siphon B
Timber Farm (Avenue 4) Bridge (2 Bridges)	116.41	Demo- New Road Crossing/Siphon B
County Road Avenue 0 Bridge	116.91	Demo- New Road Crossing/Siphon B

Table 4-5. Road Crossing Actions in the Parallel Canal Alternative (contd.)

Name	MP	Modification
Timber Farm (Avenue 4) Bridge (2 Bridges)	116.41	Demo- New Road Crossing/Siphon B
County Road Avenue 0 Bridge	116.91	Demo- New Road Crossing/Siphon B
Cecil Avenue Bridge	117.92	Demo- New Road Crossing/Siphon B
9th Avenue Bridge	118.44	Demo- New Road Crossing/Siphon B
Garces Highway Bridge	118.94	Unmodified
Timber Farm Bridge	119.46	Unmodified
Woollomes Avenue Bridge	120.02	Unmodified

Utilities

Numerous utilities located in, along, and across the FKC would be affected by implementation of the Parallel Canal Alternative. The utilities include parallel irrigation canals, fly overs, overhead power lines, adjacent wells, drainage siphons and irrigation crossings under the existing canal, and utilities connected to bridges. Depending on the location and extent of canal modifications, the utilities will either be relocated or entirely replaced, as determined in the final design. A current estimate of potentially affected utilities, based on observations made during a site visit during February 2019, is provided in Table 4-6. It is expected that additional utilities that would be affected by the Parallel Canal Alternative will be identified as design progresses. More detailed information on utilities is provided in Appendix B Engineering Design and Cost.

Table 4-6. Preliminary Estimate of Modifications to Utilities for the Parallel Canal Alternative

Utility Modification	Quantity
Parallel Overhead Powerline Relocations	14 miles
Adjacent Groundwater Well Abandonments	23 wells
Culvert Extensions	13 extensions
Pipeline Overcrossing Replacements	7 replacements
Utility Crossing Replacements	14 crossings

Estimated Quantities and Cost

A list of items that will be included in the summary of quantities and costs is included in Table 4-7. A cost estimate is provided in Table 4-8.

Table 4-7. Parallel Canal Alternative Summary of Estimated Quantities

	-	Seg 1: 5th Ave. to Tule	Seg 2: Tule to Deer Creek	Seg 3: Deer Creek to White River	Seg 4: White River to Garces Highway	Seg 4: Garces Highway to Woollomes	-
Design Flow (Design Maximum) (cfs)	-	4,500	4,000	4,000	3,500	3,500	-
From MP to MP	-	88.2-96.67	95.67-102.7	102.7-112.9	112.9-118.96	118.96-121.5	-
Total Canal Miles	-	7.47	7.0	10.2	6.06	2.54	-
Description	**Unit**	**Quantity**	**Quantity**	**Quantity**	**Quantity**	**Quantity**	**Total**
NEW CANAL							
Clearing and grubbing	Acres	-	102	149	95	-	**346**
Pre-wetting	LS	-	-	-	-	-	-
Dewatering	LS	-	-	-	-	-	-
Excavation	CY	1,050,639	1,896,999	2,710,319	1,761,749	175,558	**7,595,264**
Compacted Canal Embankment construction	CY	530,741	1,939,674	2,748,399	401,363	43,436	**5,663,613**
Spoil Embankment		519,898	0	0	1,319,983	132,437	**1,972,318**
Trimming	SY	384,213	396,505	632,657	366,827	0	**1,780,202**
3-1/2" thick concrete lining	SY	384,213	396,505	632,657	366,827	0	**1,780,202**
Furnish and Place Transverse Canal Joints	LF	230,528	237,903	379,594	220,096	0	**1,068,121**
Furnish and Place Longitudinal Canal Joints	LF	313,720	265,534	423,682	263,499	0	**1,266,435**
Ladders	EA	105	99	144	92	0	**440**
Aggregate base O&M road surfacing	SY	105,011	98,653	149	92,245	28,701	**468,565**
CHECK STRUCTURES	**Unit**	**Quantity**	**Quantity**	**Quantity**	**Quantity**	**Quantity**	**Total**
New Check/Siphon Structure	-	0	1	1	0	0	**2**
Existing Check Structures Demolition and Disposal	-	0	1	1	0	0	**2**

Table 4-7. Parallel Canal Alternative Summary of Estimated Quantities (contd.)

		Seg 1: 5th Ave. to Tule River	Seg 2: Tule to Deer Creek	Seg 3: Deer Creek to White River	Seg 4: White River to Garces Highway	Seg 4: Garces Highway to Woollomes	
ROAD CROSSINGS – BRIDGES	**Unit**	**Quantity**	**Quantity**	**Quantity**	**Quantity**	**Quantity**	**Total**
Canal Transitions to Existing Bridges	EA	18	1	0	0	0	19
Bridge Replacement on Existing Canal – County or State Bridges	EA	0	0	0	0	0	0
Bridge Replacement on Existing Canal – Farm Bridges	EA	0	0	0	0	0	0
Existing Bridge Demolition	EA	0	6	12	8	0	26
ROAD CROSSINGS – SIPHONS	**Unit**	**Quantity**	**Quantity**	**Quantity**	**Quantity**	**Quantity**	**Total**
Siphon Construction on New Canal	EA	0	6	11	8	0	25
TURNOUTS	**Unit**	**Quantity**	**Quantity**	**Quantity**	**Quantity**	**Quantity**	**Total**
Canal Transitions on Existing Canal to Existing Turnouts	EA	7	2	0	0	3	12
Raise/Modify Existing Turnout Top Deck and Actuators	EA	0	0	0	0	0	0
Turnouts on New Canal	EA	0	9	8	6	0	23
Delivery Pools	EA	0	2	6	6	0	14
UTILITIES	**Unit**	**Quantity**	**Quantity**	**Quantity**	**Quantity**	**Quantity**	**Total**
Parallel Overhead Powerline Relocations	MI	4.5	3.5	3.0	2.5	0.5	14
Adjacent Groundwater Well Abandonments	EA	6	4	8	4	1	23
Culvert Extensions (Each End)	EA	4	5	4	0	0	13
Pipeline Overcrossing Replacements (8" to 12")	EA	0	1	2	4	0	7
Impacted Utility Crossings (Attached to Existing Bridge sizes range from 4" to 24")	EA	0	4	7	3	0	14
LAND ACQUISITION	**Unit**	**Quantity**	**Quantity**	**Quantity**	**Quantity**	**Quantity**	**Total**
Impacted Parcels	EA	69	17	25	20	8	139
Permanent Land Acquisition (ROW)	Acres	20	110	260	80	40	510

Key:
- = Not Applicable or zero
cfs = cubic feet per second
CY = cubic yard
EA = each
LF = linear feet
LS = lump sum
MI = mile
MP = milepost
O&M = operations and maintenance
ROW = Right of Way
SY = square yard

Table 4-8. Parallel Canal Alternative Cost Estimate

Item	Reference	Cost	Notes/ Inclusions
Segment 1 - 5th Ave to Tule	from estimate	$28,799,642	
Segment 2 - Tule to Deer Creek (New Bypass Canal)	from estimate	$56,507,656	
Segment 3 - Deer Creek to White River (New Bypass Canal)	from estimate	$91,356,060	
Segment 4 - White River to Garces Hwy (New Bypass Canal)	from estimate	$58,590,113	
Segment 5 - Garces Hwy to Woollomes (Widen Existing Canal)	from estimate	$1,943,335	
Construction Allowances, Mobilization, Startup, Commission, and Owner Training	from estimate	$4,001,997	
Subtotal		*$241,198,803*	
Contract Cost Allowance - Design Contingency	17%	$41,003,796	
Contract Cost		**$280,000,000**	Rounded
Construction Contingencies	20%	$56,000,000	
FIELD COST		**$340,000,000**	Rounded
Land Purchase - Construction Phase and ROW		$15,300,000	510 acres at $30,000/acre
Environmental Mitigation	5%	$17,000,000	Calculated as % of Field Cost
Engineering, Permitting, and Construction Management	10%	$34,000,000	Calculated as % of Field Cost
Legal and Administrative	2%	$6,800,000	Calculated as % of Field Cost
Non-Contract Costs		**$73,000,000**	Rounded
TOTAL CONSTRUCTION COST		**$410,000,000**	Rounded
Interest During Construction	3% Discount Rate	$22,091,214	2.5 year construction period
TOTAL CAPITAL COST		**$430,000,000**	Rounded
Annualized Capital Costs		$16,446,466	2.875% (FY19) over 50 years
Additional Annualized O&M Costs		$967,676	Excludes current O&M costs; 2.875% (FY19) over 50 years
TOTAL ANNUALIZED COST		**$17,500,000**	Rounded

Canal Enlargement Alternative

The Canal Enlargement Alternative closely follows the design evaluated as Initial Alternative 1. The design capacity was modified based on historical maximum flows. A single-line schematic showing features included in the Parallel Canal Alternative is provided in Figure 4-8A and Figure 4-8B.

In comparison to the Initial Alternative configuration, the concrete liner freeboard height in the Canal Enlargement Alternative was revised from the standard freeboard requirements applied to maximum design to the flood flow freeboard lining requirements applied to historical maximum flows. The application of revised freeboard criteria resulted in a concrete canal liner that is 1.03 to 1.18 feet lower than originally presented in the Initial Alternative 1. Other project refinements have been made to the canal cross section, turnouts, and road crossings.

Canal Alignment and Cross Section

The Canal Enlargement Alternative design was modified in comparison to the version included in Initial Alternative 1. The design of the canal cross section in Initial Alternative 1 used a 24-foot wide benched section to accommodate the maximum design flow and flood freeboard at the proposed HGL. The section was applied to the entire length of the Middle Reach.

The use of historical delivery capacity for the Canal Enlargement Alternative limited the need for a large bench and the extent of modifications. The Canal Enlargement Alternative design includes enlarging the FKC from the Tule River Check (MP 95.7) to Ave. 6 (MP 115.94). A 10-foot wide bench is included in the most subsided sections for the purpose of maintaining slope stability, as shown in Figure 4-9, not to provide additional cross section for conveyance capacity. Enlarging other portions of the canal would be accomplished by raising the lining at the current slope with no bench because the relatively small lining raise would not be expected to adversely affect slope stability.

The Canal Enlargement 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 indicated as the Stage 2 Raise in Figure 4-9.

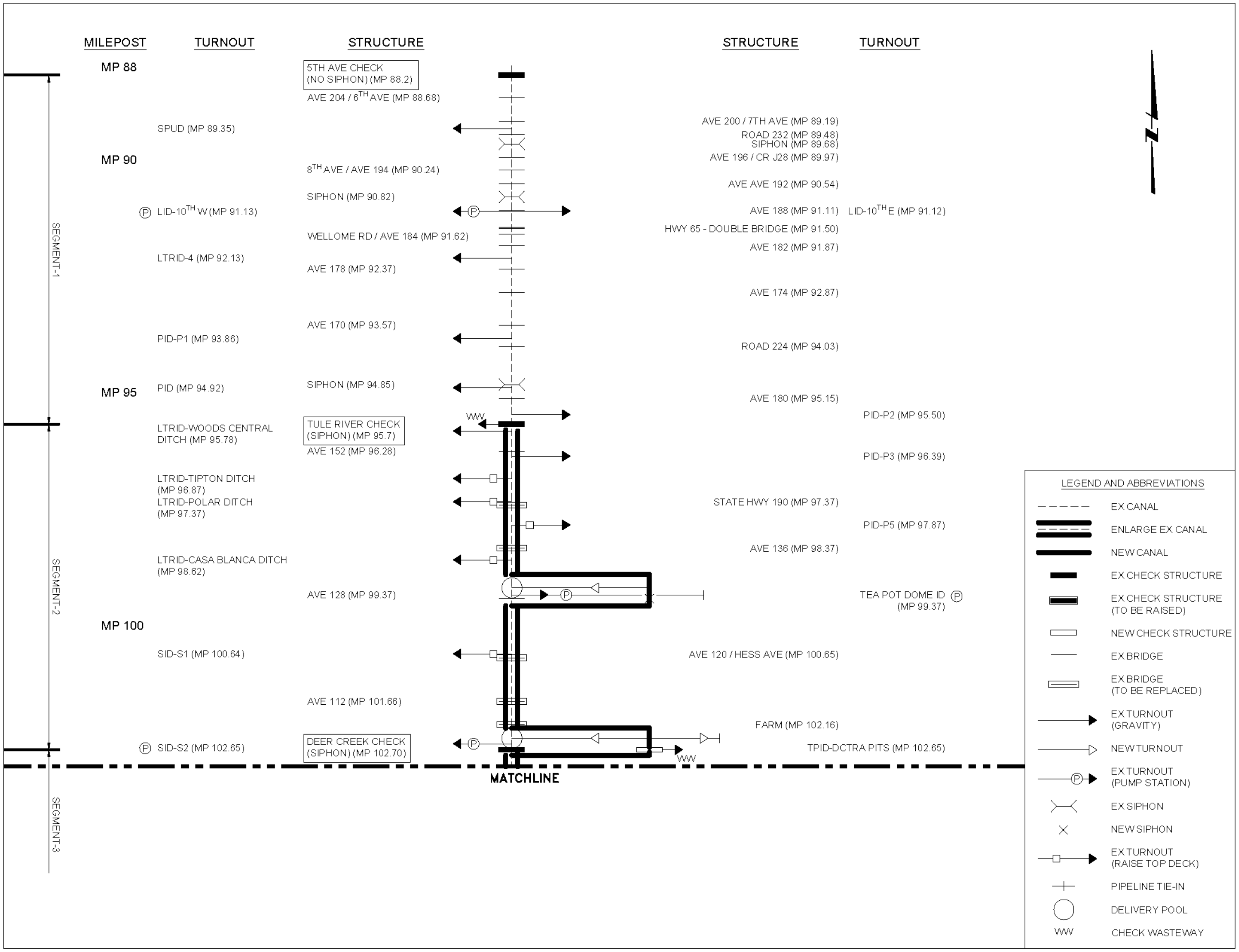

Figure 4-8A Canal Enlargement Alternative Single Line Diagram for Segments 1 and 2

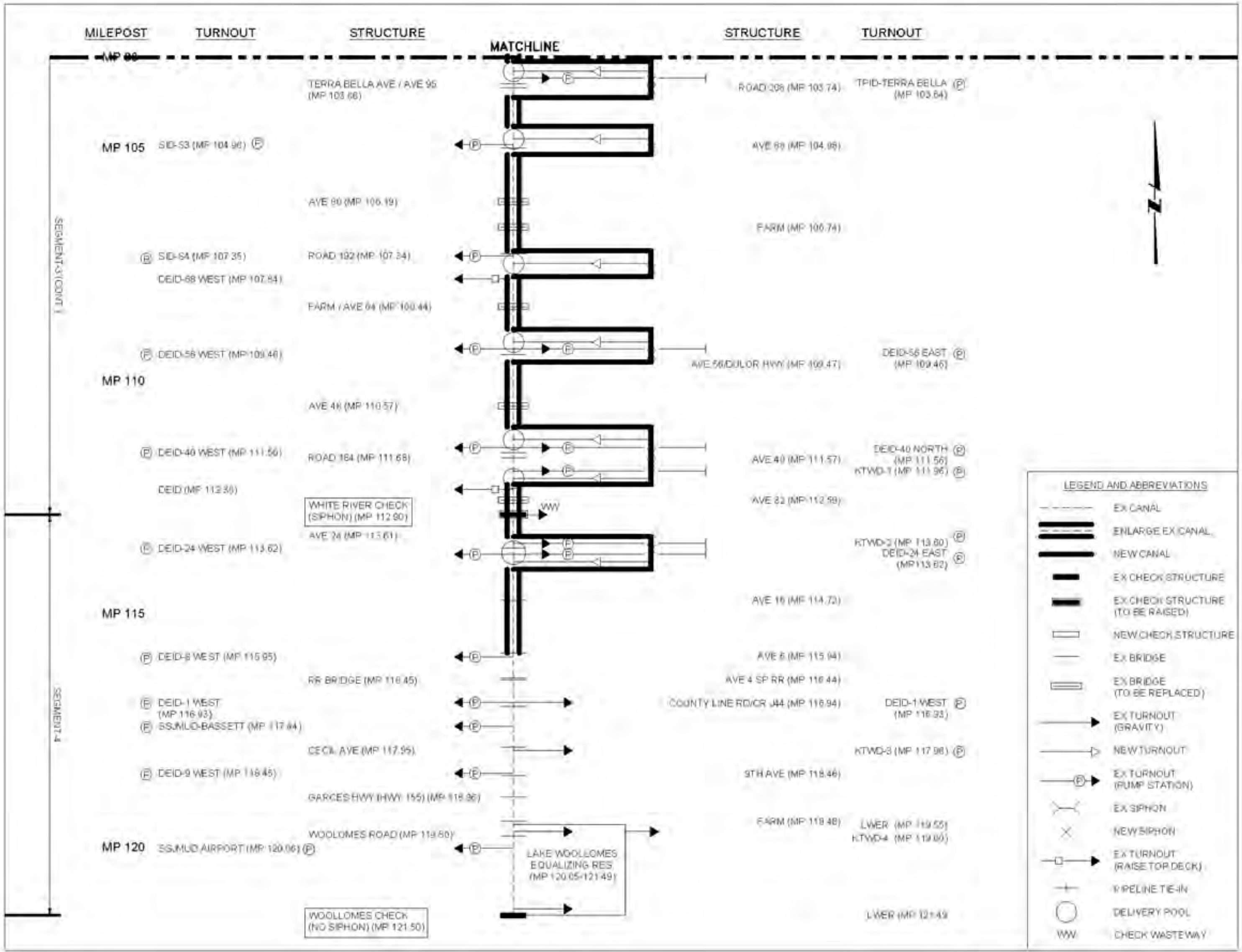

Figure 4-8B. Canal Enlargement Alternative Single Line Diagram for Segments 3 and 4

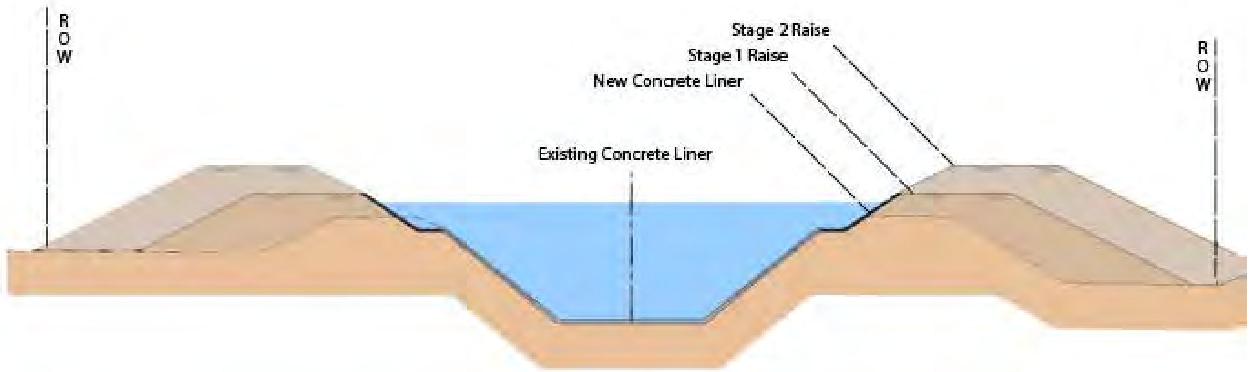

Figure 4-9. Typical Canal Enlargement Cross Section with 10-ft Slope Stability Bench

As shown in Figures 4-8A and 4-8B, the alignment of the Canal Enlargement Alternative would jog out to the east, away from the existing canal alignment, in the vicinity of each pumping plant turnout. Each jog out would include construction of a new trapezoidal canal similar to the trapezoidal cross section described for the Parallel Canal Alternative and shown in Figure 4-4.

Construction Sequencing

The enlargement of the existing canal would be constructed as follows:

1. During an annual two-month maximum canal shutdown period, the existing canal would be taken out of service and drained down to a level below the original grade at the toe of the existing canal banks. Existing bank material would be removed, processed, and recompacted with added material sourced offsite to construct the new, taller banks. During this step, the existing canal lining and supporting bank would be left in place for use during the following operational period.

2. The existing canal would be put back into service for use during the operational season. The existing canal would continue to operate at typical water surface elevations. "In-canal" work would cease until the next two-month canal shutdown period. Work outside of the existing canal prism, such as parallel canal sections and siphons, could continue during this period.

3. During the next shutdown period, the existing canal would be taken out of service and drained down to a level below the original grade at the toe of the existing canal banks. The portion of canal that had the bank earthwork completed in Step 1 above would have part of the existing lining removed, the slope stability bench constructed, and the new lining installed to the final elevations. This portion of canal would then be ready to operate at the new water surface elevations; however, this could not be done until an entire canal segment (check to check) had been completed and lined.

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

Turnouts

Similar to the Parallel Canal Alternative, the Canal Enlargement Alternative includes more detail for modifications at pressurized and gravity turnouts. Each turnout in the Middle Reach of the FKC was reviewed to determine modifications that would be required to maintain compatibility between the enlarged canal and district distribution systems, maintain water delivery capability during construction, control overflow, and enhance operational flexibility.

Pressurized Turnout Modifications The Canal Enlargement Alternative uses the same design for pressurized turnouts that is described under the Parallel Canal Alternative. The Canal Enlargement Alternative would modify a shorter portion of the Middle Reach and therefore fewer pressurized turnout modifications are required. It is estimated that this delivery pool concept would be applied at nine locations for the Canal Enlargement Alternative using the design approach shown in Figure 4-5. A summary of modifications to pressurized turnouts under the Canal Enlargement Alterative is provided in Table 4-9.

Table 4-9. Modifications to Actions for Pressurized Turnouts Systems Under the Canal Enlargement Alternative

Name	Side	MP	Modification
LID-10th West	West	91.12	Unmodified
TPDWD-Teapot Dome	East	99.35	Remain Plus Delivery Pool
SID-S2	West	102.65	Remain Plus Delivery Pool
TBID-Terra Bella	East	103.64	Remain Plus Delivery Pool
SID-S3	West	104.96	Remain Plus Delivery Pool
SID-S4	West	107.35	Remain Plus Delivery Pool
DEID-56 EAST	East	109.46	Remain Plus Delivery Pool
DEID-56 West	West	109.46	Remain Plus Delivery Pool
DEID-40 North	East	111.56	Remain Plus Delivery Pool
DEID-40 West	West	111.56	Remain Plus Delivery Pool
KTWD-1	East	111.96	Remain Plus Delivery Pool
KTWD-2	East	113.6	Remain Plus Delivery Pool
DEID-24 East	East	113.62	Remain Plus Delivery Pool
DEID-24 West	West	113.62	Remain Plus Delivery Pool
DEID-8th West	West	115.95	Unmodified
DEID-#1 West	East	116.93	Unmodified
SSJMUD-Bassett	West	117.44	Unmodified
KTWD-3	East	117.96	Unmodified
DEID-9th West	West	118.45	Unmodified
SSJMUD-Airport	West	120.06	Unmodified

Gravity Turnout Modifications In the portions of the Middle Reach where no modifications would be necessary to convey historical peak flows, existing gravity turnouts would not be modified. In the reach from MP 95.7 to MP 115.94, nearly all existing gravity turnouts would require raising the top deck by two to five feet. The extent of the raise at each turnout is dependent upon the lining raise at that location.

Raising the top deck of a gravity turnout generally consists of removing the existing top concrete deck, extending the turnout wall height to the new lining height, modifying the existing turnout gates to the new structure height, and rebuilding the top deck and site appurtenances such as retaining walls, railing, and fencing. A list of modifications to gravity turnouts in the Canal Enlargement Alternative is provided in Table 4-10 and shown in Figure 4-10. Additional detail is provided in Appendix B Engineering Design and Cost.

Table 4-10. Modifications to Gravity Turnouts Under the Canal Enlargement Alternative

Name	Side	MP	Modification
SPUD-STRATHMORE	West	89.35	Unmodified
LID-10th East	East	91.12	Unmodified
LTRID-4	West	92.13	Unmodified
PID-P1	West	93.86	Unmodified
PID-Porter Slough	West	94.92	Unmodified
PID-P2	East	95.5	Unmodified
LTRID-Tule River WW Gates	West	95.64	Unmodified
LTRID-Woods Central Ditch	West	95.78	Unmodified
PID-P3	East	96.39	Unmodified
LTRID-Tipton Ditch	West	96.87	1' Top Deck Raise
LTRID-Poplar Ditch N&S	West & East	97.34	2' Top Deck Raise
PID-P5	East	97.86	2' Top Deck Raise
LTRID-Casa Blanca Ditch	West	98.62	3' Top Deck Raise
SID-S1	West	100.63	4' Top Deck Raise
TBID-DCTRA Pits	East	102.65	Build New Turnout on New Canal
DEID-68 West	West	107.84	3' Top Deck Raise
DEID	West	112.36	2' Top Deck Raise
LWER	East	119.55	Unmodified
LWER	East	121.49	Unmodified

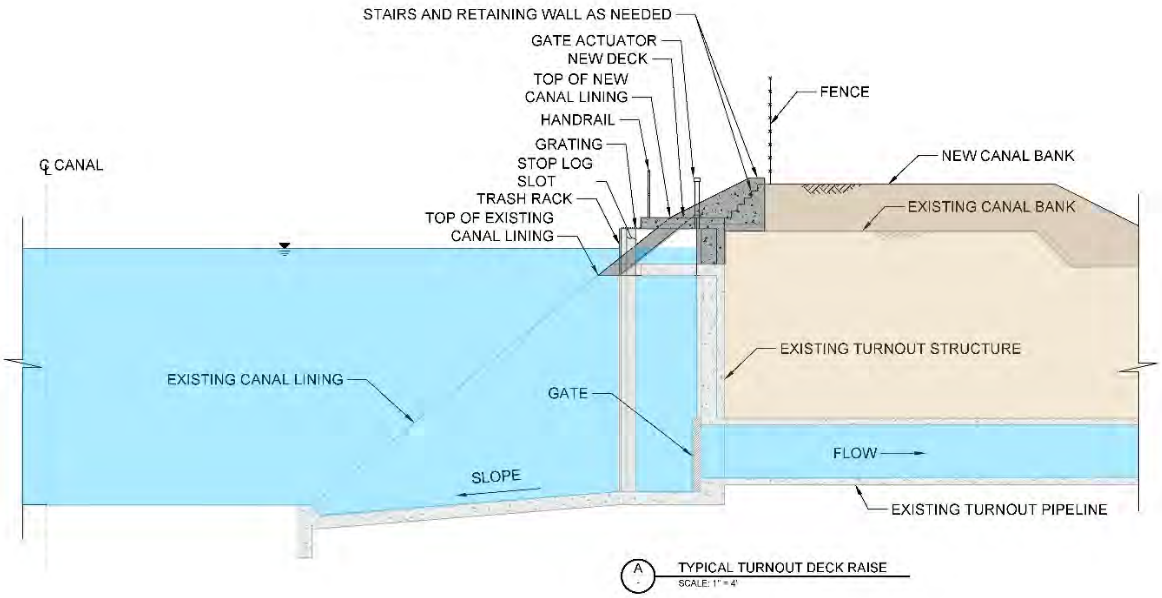

Figure 4-10. Typical Gravity Turnout Deck Raise

Checks and Siphons

The Canal Enlargement Alternative involves a new check and siphon at Deer Creek and modification of the existing check and siphon at White River. Modification of the White River check would generally consist of extending the height of the concrete canal warped transitions and the headwalls at upstream and downstream end of the existing siphon, plus raising the two existing radial gates and invert sill on the upstream end of the structure.

Road Crossings

Modifications at each road crossing would depend on the alignment and cross section modification at that location. In the segment from MP 88 to MP 95.7, where no modifications would be required, the road crossings would remain unchanged. In the modified portion, from MP 95.7 to MP 115.94, road crossings would either be replaced with a trapezoidal bridge along the existing FKC alignment or filled in and replaced with a siphon where the alignment jogs to the east to accommodate an existing pump station turnout. The Canal Enlargement Alternative includes installation of a trapezoidal bridge at 10 locations along the existing FKC alignment. A typical section for a trapezoidal bridge is shown in Figure 4-11. Siphons would be installed at nine road crossings affected by canal jogs to accommodate pump station turnouts, based on the design. Siphon A design is shown in Figure 4-6. A summary of road crossing modifications in the Canal Enlargement Alternative is provided in Table 4-11.

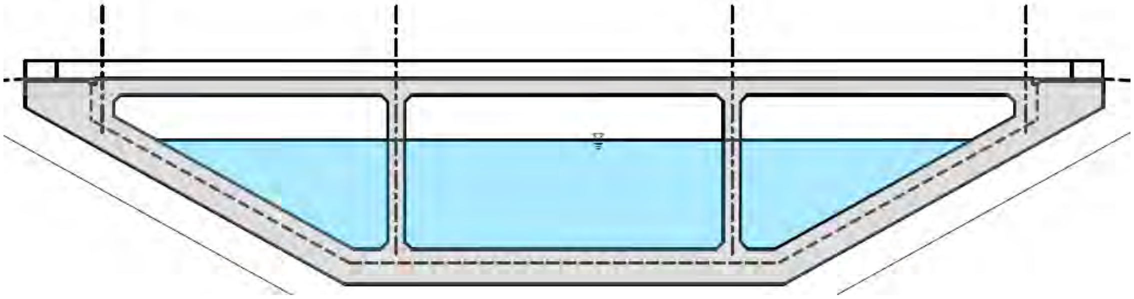

Figure 4-11. Trapezoidal Bridge Concept

Table 4-11. Road Crossing Modifications in the Canal Enlargement Alternative

Name	MP	Modification
6th Avenue Bridge	88.67	Unmodified
7th Avenue Bridge	89.17	Unmodified
Road 232 Bridge	89.45	Unmodified
Frazier Highway 196 Bridge	89.95	Unmodified
8th Avenue Bridge	89.95	Unmodified
Avenue 192 Bridge	90.23	Unmodified
Avenue 188 Bridge	91.10	Unmodified
State Highway 65 Northbound Bridge (Double Bridge)	91.51	Unmodified
Welcome Avenue Bridge (Avenue 184)	91.60	Unmodified
Avenue 182 Bridge	91.85	Unmodified
Avenue 178 Bridge	92.35	Unmodified
W Linda Vista Avenue	92.85	Unmodified
W North Grand Avenue Bridge	93.55	Unmodified
N Westwood Street Bridge	94.01	Unmodified
W Henderson Avenue Bridge	95.12	Unmodified
Avenue 152 Bridge	96.26	Unmodified
Avenue 144 Bridge (Highway 190)	97.35	New Trapezoidal Bridge
Avenue 136 Bridge	98.35	New Trapezoidal Bridge
Avenue 128 Bridge	99.37	Demo- New Road Crossing/Siphon A
Hesse Avenue Bridge	100.64	New Trapezoidal Bridge
Avenue 112 Bridge	101.64	New Trapezoidal Bridge
Timber Farm Bridge	102.14	New Trapezoidal Bridge
Road Terra Bella Avenue (J24)	103.65	Demo- New Road Crossing/Siphon A
Road 208 Bridge	103.72	Demo- New Road Crossing/Siphon A
Avenue 88 Bridge	104.95	Demo- New Road Crossing/Siphon A
Avenue 80 Bridge	106.72	New Trapezoidal Bridge
Farm Bridge	106.75	New Trapezoidal Bridge
Road 192 Bridge	107.32	Demo- New Road Crossing/Siphon A
Avenue 64 Bridge	108.42	New Trapezoidal Bridge

Table 4-11. Road Crossing Modifications in the Canal Enlargement Alternative (contd.)

Name	MP	Modification
Avenue 56 Bridge	109.45	Demo- New Road Crossing/Siphon A
Avenue 48 Bridge	110.55	New Trapezoidal Bridge
Avenue 40 Bridge	111.55	Demo- New Road Crossing/Siphon A
Road 184 Bridge	111.66	Demo- New Road Crossing/Siphon A
Avenue 32 Bridge	112.57	New Trapezoidal Bridge
Avenue 24 Bridge	113.59	Demo- New Road Crossing/Siphon A
Avenue 16 Bridge	114.71	Unmodified
Avenue 8 Bridge	115.91	Unmodified
Timber Farm (Avenue 4) Bridge (2 Bridges)	116.41	Unmodified
County Road Avenue 0 Bridge	116.91	Unmodified
Cecil Avenue Bridge	117.92	Unmodified
9th Avenue Bridge	118.44	Unmodified
Garces Highway Bridge	118.94	Unmodified
Timber Farm Bridge	119.46	Unmodified
Woollomes Avenue Bridge	120.02	Unmodified

Utilities

Numerous utilities located in, along, and across the FKC would be affected by implementation of the Canal Enlargement Alternative. The utilities include parallel irrigation canals, fly overs, overhead power lines, adjacent wells, drainage siphons and irrigation crossings under the existing canal, and utilities connected to bridges. Depending on the location and extent of canal modifications, the utilities will either be relocated or entirely replaced, as determined in the final design. A current estimate of potentially affected utilities, based on observations made during a February 2019 site visit, is provided in Table 4-12. It is expected that additional utilities that would be affected by the Parallel Canal Alternative will be identified as design progresses. More detailed information on utilities is provided in Appendix B Engineering Design and Cost.

Table 4-12. Preliminary Estimate of Modifications to Utilities for the Canal Enlargement Alternative

Utility Action	Quantity
Parallel Overhead Powerline Relocations	8 miles
Adjacent Groundwater Well Abandonments	12 wells
Culvert Extensions	9 extensions
Pipeline Overcrossing Replacements	5 replacements
Utility Crossing Replacements	12 crossings

Estimated Quantities and Cost A list of items that will be included in the summary of quantities is included in Table 4-13. The cost for the Canal Enlargement Alternative is presented in Table 4-14.

Table 4-13. Canal Enlargement Alternative Summary of Estimated Quantities

		Seg 1: 5th Ave. to Tule River	Seg 2: Tule to Deer Creek	Seg 3: Deer Creek to White River	Seg 4: White River to Ave. 8 Bridge	Total
Design Flow (Historical Maximum) (cfs)	-	4,008	3,497	2,888	2,490	-
From MP to MP	-	88.2-95.67	95.67-102.7	102.7-112.9	112.9-115.94	-
Total Canal Miles	-	7.47	7.0	10.2	3.04	-
Description	**Unit**	**Quantity**	**Quantity**	**Quantity**	**Quantity**	**Total**
NEW CANAL						
Clearing and grubbing	Acres	-	34	50	14	**99**
Pre-wetting	LS	-	-	-	-	**-**
Dewatering	LS	-	-	-	-	**-**
Excavation	CY	-	152,649	430,113	122,032	**704,794**
Compacted Canal Embankment construction	CY	-	695,487	1,679,261	96,709	**2,471,457**
Spoil Embankment		-	146,123	307,553	69,142	**522,818**
Trimming	SY	-	146,123	307,553	69,142	**522,818**
3-1/2" thick concrete lining	SY	-	87,674	184,532	41,485	**313,691**
Furnish and Place Transverse Canal Joints	LF	-	121,681	230,482	64,923	**417,086**
Furnish and Place Longitudinal Canal Joints	LF	-	100	146	42	**287**
Ladders	EA	-	99,515	145,860	41,938	**287,313**
Aggregate base O&M road surfacing	SY	-	4,000	14,500	2,500	**21,000**
CHECK STRUCTURES	**Unit**	**Quantity**	**Quantity**	**Quantity**	**Quantity**	**Total**
New Check/Siphon Structure		-	1	0	0	1
Existing Check Structures Demolition and Disposal		-	0	1	0	1

Table 4-13. Canal Enlargement Alternative Summary of Estimated Quantities (contd.)

		Seg 1: 5th Ave. to Tule	Seg 2: Tule to Deer Creek	Seg 3: Deer Creek to White River	Seg 4: White River to Ave. 8 Bridge	
ROAD CROSSINGS – BRIDGES	**Unit**	**Quantity**	**Quantity**	**Quantity**	**Quantity**	**Total**
Canal Transitions to Existing Bridges	EA	-	1	0	2	**3**
Bridge Replacement on Existing Canal - County or State Bridges	EA	-	4	3	0	**7**
Bridge Replacement on Existing Canal - Farm Bridges	EA	-	1	2	0	**3**
Existing Bridge Demolition	EA	-	1	7	1	**9**
ROAD CROSSINGS - SIPHONS	**Unit**	**Quantity**	**Quantity**	**Quantity**	**Quantity**	**Total**
Siphon Construction on New Canal	EA	-	1	7	7	**9**
TURNOUTS	**Unit**	**Quantity**	**Quantity**	**Quantity**	**Quantity**	**Total**
Canal Transitions on Existing Canal to Existing Turnouts	EA	-	10	10	11	**31**
Raise/Modify Existing Turnout Top Deck and Actuators	EA	-	5	2	0	**7**
Turnouts on New Canal	EA	-	3	6	1	**10**
Delivery Pools	EA	-	2	6	1	**9**
UTILITIES	**Unit**	**Quantity**	**Quantity**	**Quantity**	**Quantity**	**Total**
Parallel Overhead Powerline Relocations	MI	-	3.5	3.0	1	**8**
Adjacent Groundwater Well Abandonments	EA	-	4	8	0	**12**
Culvert Extensions (Each End)	EA	-	5	4	0	**9**
Pipeline Overcrossing Replacements (8" to 12")	EA	-	1	2	2	**5**
Impacted Utility Crossings (Attached to Existing Bridge sizes range from 4" to 24")	EA	-	4	7	1	**12**
LAND ACQUISITION	**Unit**	**Quantity**	**Quantity**	**Quantity**	**Quantity**	**Total**
Impacted Parcels	EA	-	TBD	TBD	TBD	**TBD**
Permanent Land Acquisition (ROW)	Acres	-	20	70	10	**100**

Key:
- = Not Applicable or zero
cfs = cubic feet per second
CY = cubic yard
EA = each
LF = linear feet
LS = lump sum
MI = mile
MP = milepost
O&M = operations and maintenance
ROW = Right of Way
SY = square yard

Table 4-14. Parallel Canal Alternative Cost Estimate

Item	Reference	Cost	Notes/ Inclusions
Segment 1 - 5th Ave to Tule	from estimate	$0	
Segment 2 - Tule to Deer Creek (Enlarge Canal)	from estimate	$42,956,860	
Segment 3 - Deer Creek to White River (Enlarge Canal)	from estimate	$87,815,210	
Segment 4 - White River to Ave 8 Bridge (Enlarge Canal)	from estimate	$12,425,645	
Construction Allowances, Mobilization, Startup, Commission, and Owner Training	from estimate	$6,369,115	
Subtotal		*$149,566,830*	
Contract Cost Allowance - Design Contingency	17%	$25,426,361	
Contract Cost		**$175,000,000**	Rounded
Construction Contingencies	20%	$35,000,000	
FIELD COST		**$210,000,000**	Rounded
Land Purchase - Construction Phase and ROW		$3,000,000	100 acres at $30,000/acre
Environmental Mitigation	5%	$10,500,000	Calculated as % of Field Cost
Engineering, Permitting, and Construction Management	10%	$21,000,000	Calculated as % of Field Cost
Legal and Administrative	2%	$4,200,000	Calculated as % of Field Cost
Non-Contract Costs		**$39,000,000**	Rounded
TOTAL CONSTRUCTION COST		**$250,000,000**	Rounded
Interest During Construction	3% Discount Rate	$40,895,938	10-year construction period
TOTAL CAPITAL COST		**$290,000,000**	Rounded
Annualized Capital Costs		$10,989,353	2.875% (FY19) over 50 years
Additional Annualized O&M Costs		$284,611	Excludes current O&M costs; 2.875% (FY19) over 50 years
TOTAL ANNUALIZED COST		**$11,300,000**	Rounded

Chapter 5 Evaluation of Feasibility Alternatives

This chapter presents an evaluation and comparison of the No Action Alternative and the Feasibility Alternatives described in Chapter 4 based on an assessment of economic effects associated with changes in the delivery of water to Friant Division long-term contractors. Other potential benefit categories have not been evaluated for this Study. This chapter also presents a comparison of Feasibility Alternatives with respect to effectiveness, efficiency, completeness, and acceptability, the selection of a Recommended Plan, and the summary of refinements to the Recommended Plan.

Evaluation Approach to Quantify Water Supply Effects

Evaluating the benefits of the Feasibility Alternatives involves consideration of conditions that are expected to change over the 100-year planning horizon. Identified conditions that are expected to change and affect the Project include water supply availability at Friant Dam, the delivery capability of the FKC under the no action and all action alternatives in response to future subsidence, and changes in the value of water. The quantification of physical effects and calculation of monetary benefits of Feasibility Alternatives was accomplished through a multiple-step process, that included the following:

- Estimate water supply available at Friant Dam
- Determine the capacity of the existing FKC and the capacity of Feasibility Alternatives in response to future subsidence over the planning horizon
- Quantify water deliveries affected by reduced canal capacity
- Reschedule affected supplies in Millerton Lake to the extent possible
- Pump additional groundwater to offset reduced deliveries during the SGMA implementation period
- Quantify and value lost water supply based on current and future water values

A schematic of the evaluation approach is shown in Figure 5-1 and described in the following sections; additional detail is provided in the Appendix C Economics Evaluation.

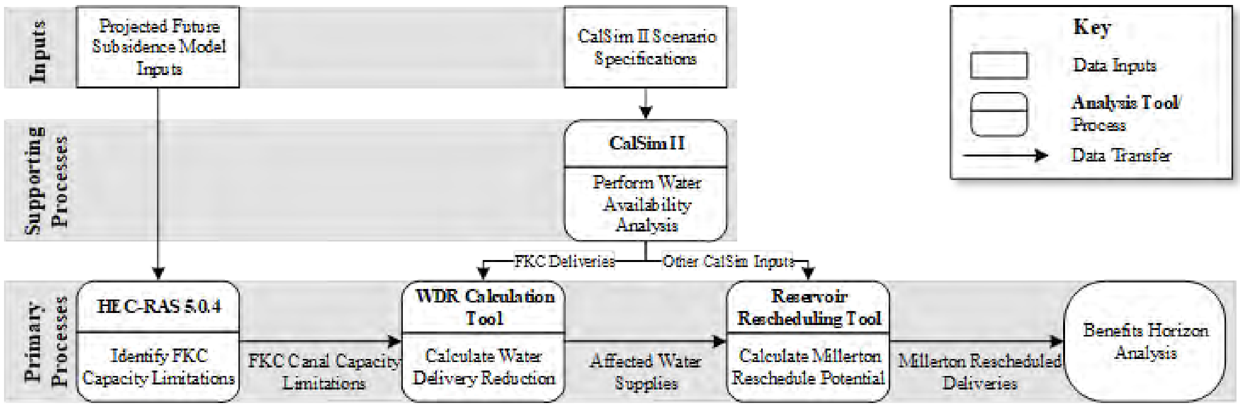

Figure 5-1. Modeling Process for Economics Evaluations

Water Supply Availability at Friant Dam

The California Water Resources Simulation Model (CalSim II) was used to estimate water deliveries from Friant Dam to Friant Division long-term contractors over an 82-year simulation period based on historical hydrologic data for water years 1922 through 2003. The CalSim II model simulates the operation of Millerton Lake to meet a variety of objectives, including the release of flows to the San Joaquin River for water rights and SJRRP Restoration Flows, diversion to the San Joaquin River and Friant-Kern and Madera canals for delivery of water under Friant Division Class 1 and Class 2 contracts and Section 215/other contracts and obligations, and flood operations. Simulated diversions to the Friant-Kern and Madera canals are based on CalSim-estimated water supply allocations under the various contract types, as applied to typical diversion patterns into the canals based on historical data. Only the capacity at the headworks of the canal is considered in the operation of the CalSim II model, meaning the diversions assume no conveyance capacity restrictions due to design deficiencies or subsidence.

For the benefits evaluation, the current implementation of the SJRRP Flow is used for the current water supply availability in the year 2019. This amount is projected to linearly decrease to delivery amounts under the full implementation of the SJRRP Flow in the year 2030. It is assumed that annual average Friant Division water supply availability would remain constant after 2030.

FKC Capacity

The capacity of the FKC will continue to decrease as land subsides in the future and the decreased capacity will reduce water delivery capability. The rate of land subsidence is assumed to be the same in the No Action Alternative and all action alternatives. Estimates of subsidence along the FKC for Group 3 conditions, as described in Chapter 2, for years 2030, 2040, and 2070 were used in a HEC-RAS model of the FKC, described in Appendix A1a1 HEC-RAS Modeling Technical Memorandum ™, to determine canal capacity at these dates. The groundwater model results indicate that the greatest amount of future land subsidence is projected occur between 2017 (first year of groundwater model simulation) and 2030, with additional subsidence occurring to 2040 when actions to achieve SGMA requirements would be fully implemented, and additional subsidence occurring to 2070 as a result of 'residual' subsidence of subsurface formations. As shown in Figure 5-2, additional land subsidence will reduce the capacity of the FKC. Similar computations were conducted to estimate the effect of land subsidence on the restored canal capacity at future points in time under the two Feasibility Alternatives.

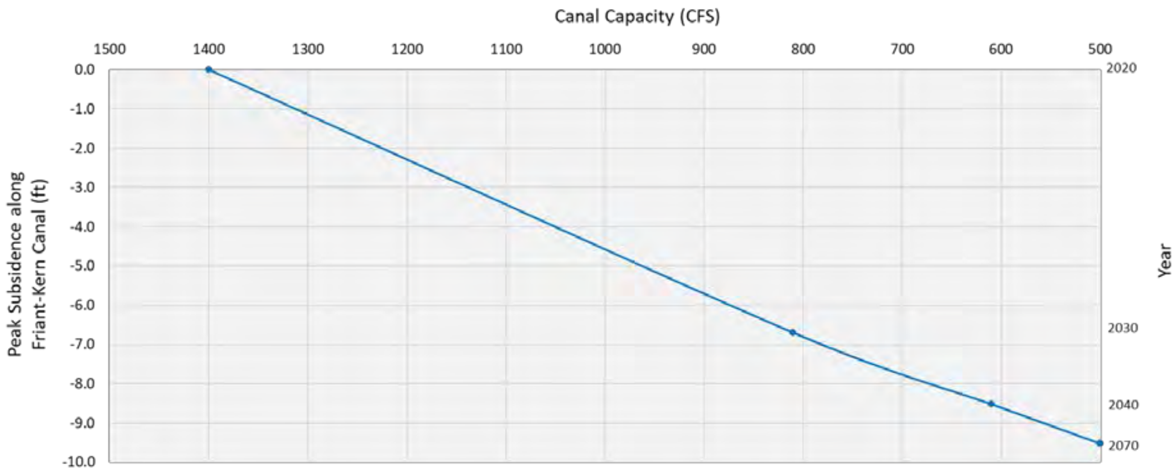

Figure 5-2. Friant-Kern Canal Capacity Under Future Peak Subsidence

Affected Water Deliveries

The modeled canal capacities from HEC-RAS simulations, combined with the variations of water availability, were used in the Water Delivery Reduction Tool to calculate the affected Class 1 and Class 2/other water supply for the Friant Division long-term contractors on the FKC downstream of the subsidence chokepoint. As described in the Economics Evaluation Appendix, the Water Delivery Reduction Tool applies historical patterns of daily diversions to the FKC to estimate water deliveries that would be affected as a result of reduced canal capacity. Evaluations were made for years corresponding to results for simulated ground subsidence during the project planning horizon and interpolated for intervening years. Table 5-1 presents the results of modeled flow capacity, from the HEC-RAS model and the total expected annual affected water deliveries, based on the Water Delivery Reduction Tool described in Appendix C.

Table 5-1. Modeled FKC Capacity and Average Annual Affected Water Supplies

Year	Estimated Minimum Capacity (cfs)	Average Annual Affected Water Supply (AF/yr)
2018	1,400	27,083
2030	810	102,651
2040	610	149,346
2070	500	179,746

Source: Information is from the Water Delivery Reduction Tool Calculation described in Appendix C-Economics Evaluation
Key:
cfs = cubic feet per second

The average annual affected water supply quantities listed in Table 5-1 apply to Class 1 and Class 2/Other water deliveries, based on information provided in the CalSim II model, which includes 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."

In the benefits evaluation over the planning horizon, the values of annual estimated capacity of the FKC and corresponding average annual affected water deliveries were linearly interpolated between the evaluation results listed in Table 5-1. It is assumed canal capacity and average annual affected water deliveries would remain constant after 2070.

Rescheduled Water Deliveries

As described in Chapter 4, the No Action Alternative and the Feasibility Alternatives assume that affected water supplies due to FKC capacity constraints would be rescheduled through Millerton Lake operations to the extent possible. While Millerton Lake is typically operated as an annual reservoir with no long-term carry-over storage objectives, the operation of Millerton Lake provides some opportunities to store water for use in successive periods. The approach used to evaluate rescheduled water deliveries for the Project assumes that all affected deliveries would be rescheduled using available conservation storage capacity in Millerton Lake. This approach is considered conservative because it represents the maximum opportunity for rescheduling and therefore results in a minimum estimate of additional groundwater pumping or lost water supplies. Actual opportunities for rescheduling are expected to be less than evaluated due to several factors, including supply and demand forecasting uncertainty, Millerton Lake operations, the ability of Friant Division long-term contractors to adjust local water uses, and CVP Friant Division contract term requirements. The economic analysis assumes that rescheduling of affected water deliveries could be accomplished at no additional cost.

Additional Groundwater Pumping

Under the No Action and Feasibility Alternatives, affected water supplies that could not be delivered through rescheduling in Millerton Lake would result in water supply reductions to Friant Division long-term contractors. In the near future, it is assumed that reduced deliveries would be replaced with additional groundwater pumping in the affected districts. However, this additional groundwater pumping to replace undeliverable supplies would exceed groundwater pumping conditions being used to develop long-term SGMA implementation plans. As a result, groundwater pumping to replace undeliverable water supplies was assumed to reduce from full replacement in 2020 to no groundwater pumping after 2030.

Reduced Deliveries to Friant Division Long-Term Contractors

Affected water supplies that could not be rescheduled in Millerton Lake or replaced with additional groundwater pumping would be lost as flood releases from Friant Dam to the San Joaquin River and represents a loss of water supply to affected Friant Division long-term contractors.

Water Valuation

The cost for pumping additional groundwater and value of water are both expected to change over the life of the project. Groundwater pumping cost is based on the cost of energy and the depth to groundwater, and capital costs associated with the construction or replacement of groundwater infrastructure. Costs for additional groundwater pumping in this analysis are limited to those associated with energy.

As reported by the California Energy Commission (CEC), electricity costs are projected to increase by about 1.7 percent annually between 2015 and 2024 (CEC 2014). The CEC does not provide estimated electricity costs after 2024.

The depth to groundwater in each affected Friant Division long-term contractor service area was estimated using 2018 available groundwater depth information. The weighted cost of groundwater pumping was calculated for years 2015, 2020, and 2024 using the groundwater depth, projected electricity prices, and the share of total subsidence water affected delivery for each affected contractor. Values were linearly interpolated between calculated years and assumed to remain constant after 2024. The calculated weighted average value of groundwater pumping is listed on Table 5-2.

Table 5-2. Weighted Average Value of Groundwater Pumping

Year	Groundwater Pumping Cost ($/AF)[1,2]
2015	$203
2020	$219
2024	$229

Notes:
1 Based on CEC electricity costs projections
2 2018 Price Level

In 2015, the California Water Commission (CWC) prepared estimates of water value in California under current operational requirements. The CWC classified current unit values of water as those for 2030 conditions. The values provided by the CWC in 2015, escalated to 2018 price levels using the U.S. Bureau of Economic Analysis GDP Deflator, are shown in Table 5-3.

Table 5-3. Estimated Water Values in the Eastern San Joaquin Valley

Water Year Type	2030 Condition Friant Service Area 2015 Price Value ($/AF of Consumptive Use)	2030 Condition Friant Service Area 2018 Price Value ($/AF of Consumptive Use)
Wet	$200	$211
Above Normal	$251	$265
Below-Normal	$261	$276
Dry	$278	$294
Critical	$324	$342
Weighted Average	$256	$271

Source: CWC WSIP Technical Reference Document

Monetary Benefits of Feasibility Alternatives

This Study anticipates that regional subsidence will continue and cause a decrease in the capacity of the FKC over the planning horizon, under the No Action Alternative and with the implementation of Feasibility Alternatives. To estimate the benefits of Feasibility Alternatives, the value of water delivery reductions was estimated for the No Action Alternative and Feasibility Alternatives. Benefits of the Feasibility Alternatives are based on differences in delivery reduction value in comparison to the No Action Alternative.

Table 5-4 through Table 5-6 show the planning horizon analysis for the No-Action and Feasibility Alternatives. Computations are made each year in the planning horizon. For ease of presentation, the tables report annual results for years 1 through 10 and then every decade following until year 100, the end of the planning horizon. The tables provide the net present value of reduced water deliveries over the planning horizon.

Feasibility Alternatives cost estimates are reported as an opinion of probable construction cost (OPCC) and cost ranges were provided based on plus or minus 25 percent variation in field costs. Feasibility Alternatives costs include Interest During Construction (IDC) over the construction duration, and life cycle costs over the planning horizon.

A summary of benefits associated with water deliveries and costs of Feasibility Alternatives is provided in Table 5-7.

Table 5-4. No-Action Horizon Analysis

Year	Average Annual Deliveries (TAF)	Average Annual No Action Affected Water Supply (TAF)	Reschedule in Millerton (TAF)	Percent Groundwater Pumping (%)	Assumed Groundwater Pumping (TAF)	Average Annual Reduction in Supply (TAF)	Value of Water Lost ($M)	Groundwater Pumping Cost ($M)	Annual Value of Water ($M)
1	410.2	41.3	15.6	90%	23.2	2.6	$271	$221	$5.8
2	408.2	46.1	17.3	80%	23.0	5.8	$271	$224	$6.7
3	406.2	50.9	19.0	70%	22.3	9.5	$271	$226	$7.6
4	404.2	55.6	20.8	60%	20.9	13.9	$271	$229	$8.6
5	402.2	60.4	22.5	50%	18.9	18.9	$271	$229	$9.5
6	400.2	68.8	24.7	40%	17.7	26.5	$271	$229	$11.2
7	398.2	77.3	26.8	30%	15.1	35.3	$271	$229	$13.0
8	396.2	85.7	29.0	20%	11.3	45.4	$271	$229	$14.9
9	394.2	94.2	31.2	10%	6.3	56.7	$271	$229	$16.8
10	392.2	102.7	33.3	0%	0.0	69.3	$271	$229	$18.8
20	392.2	149.3	36.4	0%	0.0	112.9	$271	$229	$30.6
30	392.2	159.5	35.7	0%	0.0	123.8	$271	$229	$33.5
40	392.2	169.6	34.9	0%	0.0	134.7	$271	$229	$36.5
50	392.2	179.7	34.1	0%	0.0	145.6	$271	$229	$39.4
60	392.2	179.7	34.1	0%	0.0	145.6	$271	$229	$39.4
70	392.2	179.7	34.1	0%	0.0	145.6	$271	$229	$39.4
80	392.2	179.7	34.1	0%	0.0	145.6	$271	$229	$39.4
90	392.2	179.7	34.1	0%	0.0	145.6	$271	$229	$39.4
100	392.2	179.7	34.1	0%	0.0	145.6	$271	$229	$39.4
								Net Present Value	$923

Table 5-5. Canal Enlargement Horizon Analysis

Year	Average Annual Deliveries (TAF)	Average Annual No Action Affected Water Supply (TAF)	Reschedule in Millerton (TAF)	Percent Groundwater Pumping (%)	Assumed Groundwater Pumping (TAF)	Average Annual Reduction in Supply (TAF)	Value of Water Lost ($M)	Groundwater Pumping Cost ($M)	Annual Value of Water ($M)
1	410.2	41.3	15.6	90%	23.2	2.6	$271	$221	$5.8
2	408.2	46.1	17.3	80%	23.0	5.8	$271	$224	$6.7
3	406.2	50.9	19.0	70%	22.3	9.5	$271	$226	$7.6
4	404.2	55.6	20.8	60%	20.9	13.9	$271	$229	$8.6
5	402.2	60.4	22.5	50%	18.9	18.9	$271	$229	$9.5
6	400.2	68.8	24.7	40%	17.7	26.5	$271	$229	$11.2
7	398.2	77.3	26.8	30%	15.1	35.3	$271	$229	$13.0
8	396.2	85.7	29.0	20%	11.3	45.4	$271	$229	$14.9
9	394.2	94.2	31.2	10%	6.3	46.7	$271	$229	$16.8
10	392.2	102.7	33.3	0%	0.0	69.3	$271	$229	$18.8
20	392.2	0.3	0.1	0%	0.0	0.2	$271	$229	$0.1
30	392.2	0.7	0.2	0%	0.0	0.4	$271	$229	$0.1
40	392.2	1.0	0.3	0%	0.0	0.7	$271	$229	$0.2
50	392.2	1.3	0.4	0%	0.0	0.9	$271	$229	$0.2
60	392.2	1.3	0.4	0%	0.0	0.9	$271	$229	$0.2
70	392.2	1.3	0.4	0%	0.0	0.9	$271	$229	$0.2
80	392.2	1.3	0.4	0%	0.0	0.9	$271	$229	$0.2
90	392.2	1.3	0.4	0%	0.0	0.9	$271	$229	$0.2
100	392.2	1.3	0.4	0%	0.0	0.9	$271	$229	$0.2
								Net Present Value	$100

Table 5-6. Parallel Canal Horizon Analysis

Year	Average Annual Deliveries (TAF)	Average Annual No Action Affected Water Supply (TAF)	Reschedule in Millerton (TAF)	Percent Groundwater Pumping (%)	Assumed Groundwater Pumping (TAF)	Average Annual Reduction in Supply (TAF)	Value of Water Lost ($M)	Groundwater Pumping Cost ($M)	Annual Value of Water ($M)
1	410.2	41.3	15.6	90%	23.2	2.6	$271	$221	$5.8
2	408.2	46.1	17.3	80%	23.0	5.8	$271	$224	$6.7
3	406.2	50.9	19.0	70%	22.3	9.5	$271	$226	$7.6
4	404.2	0.0	0.0	60%	0.0	0.0	$271	$229	$0.0
5	402.2	0.0	0.0	50%	0.0	0.0	$271	$229	$0.0
6	400.2	0.0	0.0	40%	0.0	0.0	$271	$229	$0.0
7	398.2	0.0	0.0	30%	0.0	0.0	$271	$229	$0.0
8	396.2	0.0	0.0	20%	0.0	0.0	$271	$229	$0.0
9	394.2	0.0	0.0	10%	0.0	0.0	$271	$229	$0.0
10	392.2	0.0	0.0	0%	0.0	0.0	$271	$229	$0.0
20	392.2	0.0	0.0	0%	0.0	0.0	$271	$229	$0.0
30	392.2	0.0	0.0	0%	0.0	0.0	$271	$229	$0.0
40	392.2	0.0	0.0	0%	0.0	0.0	$271	$229	$0.0
50	392.2	0.0	0.0	0%	0.0	0.0	$271	$229	$0.0
60	392.2	0.0	0.0	0%	0.0	0.0	$271	$229	$0.0
70	392.2	0.0	0.0	0%	0.0	0.0	$271	$229	$0.0
80	392.2	0.0	0.0	0%	0.0	0.0	$271	$229	$0.0
90	392.2	0.0	0.0	0%	0.0	0.0	$271	$229	$0.0
100	392.2	0.0	0.0	0%	0.0	0.0	$271	$229	$0.0
								Net Present Value	$20

Table 5-7. Benefit Cost Analysis of Feasibility Alternatives

Item	Canal Enlargement Alternative	Parallel Canal Alternative
Value of reduced water delivery in the No Action Alternative[1,2]	$923	$923
Value of reduce water delivery in the Project Alternative[1,2]	$100	$20
Net Benefit[1,2]	$823	$904
Net Present Value of Total Capital and Life Cycle Costs [1,3]	$267	$452
Cost Range of Net Present Value of Total Capital[1,4]	($220 - $360)	($320 - $540)

Notes:
[1] All costs are in millions of dollars
[2] Net Present Value based on 100-year project life
[3] Construction Cost of Initial Alternatives
[4] +/- 25% applied to field cost

Evaluation of Feasibility Alternatives using Federal Planning Criteria

The Federal planning process described in the PR&G includes four criteria for consideration in formulating and evaluating alternative plans: completeness, effectiveness, efficiency, and acceptability (CEQ 2013). A summary of the evaluation is provided in Table 5-8 and described in the following sections.

Table 5-8. Summary of Federal Planning Criteria Evaluation

	Canal Enlargement Alternative	Parallel Canal Alternative
Effectiveness	Medium-High	High
Efficiency	High	Medium-High
Completeness	Medium	High
Acceptability	Not yet determined	Not yet determined

Effectiveness

Effectiveness is the extent to which an alternative plan would alleviate problems and achieve the planning objectives for a project. Both Feasibility Alternatives would restore the capability to convey water supplies based on historical operations. However, the performance of the Feasibility Alternatives would not be the same if future operational objectives include deliveries that exceed historical peak flows.

Evaluations presented in this report are based on historical deliveries and do not include operational objectives in response to changing water supply conditions, particularly the implementation of SGMA. For example, many Friant Division long-term contractors have considered development of local water projects such as groundwater banking, canal enlargement or interties, and other actions that would improve water management in response to reduced water supply availability. If the implementation of such projects results in delivery of water from Friant Dam under existing CVP contracts at flows that exceed historical FKC flow rates, the performance of the Feasibility Alternatives would change.

Efficiency

This evaluation criterion is a measure of how an alternative plan alleviates the specified problems and realizes the specified opportunities at the least cost, or in a cost-effective manner. As noted in the discussion on Effectiveness, all analyses presented in this report are based on historical deliveries and do not include potential changes in future operations. Economic benefits for water supply based on this approach were compared to costs estimated for the Initial Alternatives (Alternative 1 Option 1 and Alternative 5 Option 3) as described in Chapter 3. Using this information, the benefit cost (B-C) ratios are 2.0 for the Parallel Canal Alternative and 3.0 for the Canal Enlargement Alternative. Both alternatives are efficient in achieving project objectives as evaluated. If future operational objectives include deliveries that exceed historical peak flows, the efficiency of the Feasibility Alternatives would change.

Completeness

Completeness is a determination of whether an alternative plan includes all elements necessary to realize planned effects, and the degree that intended benefits of the plan depend on the actions of others. Sub-criteria that are important in measuring completeness include (1) authorization, (2) planning objective(s), (3) reliability or durability, (4) physical implementability or constructability, and (5) effects on environmental resources. Each of these sub-criteria are described below.

Authorization

Authorization for Reclamation participation in this Project is provided by the Settlement Act (Public Law 111-11) and the WIIN Act.

Part III of the Settlement Act authorizes the restoration of the FKC to such capacity as previously designed and constructed by the Bureau of Reclamation. The Canal Enlargement Alternative, as evaluated in this Study, would restore the capacity of the FKC to less than the original capacity. The Parallel Canal Alternative, as evaluated in this Study, would restore the capacity of the FKC to the original maximum capacity with current freeboard Reclamation freeboard criteria. Both Feasibility Alternatives are consistent with the Settlement Act.

Reclamation is reviewing requirements of the WIIN Act as applicable to the FKC Middle Reach Subsidence and Capacity Correction Project. Additional benefit evaluations to support WIIN Act funding may be included in subsequent versions of this report.

Planning Objectives

The two Feasibility Alternatives evaluated in this Study would meet the planning objectives of increasing canal capacity and improving water supply reliability to Friant Division long-term contractors south of the FKC low point.

Reliability or Durability

The two Feasibility Alternatives would have different degrees of reliability in response to future land subsidence. The Canal Enlargement Alternative, which would be constructed to meet maximum historical deliveries, would be subject to reduced capacity in response to additional land subsidence early in the project life. As evaluated in this Study, the Parallel Canal Alternative, which would be constructed to the maximum design capacity, would not experience water delivery reductions during the planning horizon in response to additional land subsidence.

Physical Implementability or Constructability

Similar features have been included in both Feasibility Alternatives to address requirements for turnouts, road crossings, checks, siphons, and utilities. Both Feasibility Alternatives are constructible using accepted construction methods, however constraints associated with construction of canal modifications differ between the Feasibility Alternatives. Although detailed construction constraints and sequencing plans have not been developed, several challenges associated with their construction, particularly within the prism of an operating canal, have been identified.

- Borrow Material – The Parallel Canal Alternative could be constructed with either balanced material requirements for earthwork or a surplus that could be spoiled on project features. The Canal Enlargement Alternative would require significant borrow material, with borrow sources ideally located on each side of the FKC to limit hauling over the existing bridges, many of which have load restrictions. Depending on the location of borrow sources (which have not yet been identified), constraints on the larger equipment ideally suited to hauling large loads may be imposed.

- Potential Reduction in Water Deliveries During Construction – The water surface elevation in the FKC will need to be lowered in order to remove existing concrete lining to construct a new bench (setback) below the existing top of lining. This is required to reduce additional loading on the existing 1.25:1 canal side slopes. During this portion of the construction, the conveyance capacity of the canal will be reduced. Detailed analyses will need to be performed to define the actual bench elevation, with full consideration of geotechnical slope stability, and then estimate this impact to water supply deliveries. It is envisioned that scheduling of this construction will need to be coordinated with low delivery periods, which would extend the construction schedule so that water supply deliveries can be maintained as much as possible. Reduced water levels to accommodate in-prism construction would be more significant in the Canal Enlargement Alternative because the bench features would be constructed in the most subsided portion of the FKC, whereas bench features in the Parallel Canal Alternative would be located in the upper-most and lower-most portions of the Middle Reach.

- Safety Risk During Construction – The Canal Enlargement Alternative would have a greater safety risk to staff during construction than the Parallel Canal Alternative because more of the work would be completed within an active water delivery system.

- Tie-ins – Both Feasibility Alternatives include structures, such as check structures, wasteways, and siphons, that will require upstream and downstream tie-ins to the existing FKC. While achievable, tie-ins require appropriate advance planning, reliable concepts, and carry some risk that water deliveries could be interrupted during construction.

Environmental Resources

An analysis of potential environmental constraints was prepared and applied to the evaluation of Initial Alternatives. This evaluation contributed to the selection of the Feasibility Alternatives. Further environmental evaluations are being performed through the development of environmental compliance documents.

Acceptability

Acceptability is the viability and appropriateness of an alternative plan from the perspective of the Nation's general public and consistency with existing Federal laws, authorities, and public policies. It does not include local or regional preference for particular solutions or political expediency. Acceptability among Friant Division long-term contractors will consider several factors that have not yet been evaluated, including the availability of Federal and State funding, the allocation of costs among Friant Division contractors, and the need for conveyance capacity to accommodate potential future operational requirements.

Identification of the Recommended Plan

The identification of the Recommended Plan is based on evaluation and comparisons of the net benefits and additional criteria to limit the impacts to Friant Division long-term contractors. As described below, the Parallel Canal Feasibility Alternative is identified as the Recommended Plan. The selection of the Parallel Canal Feasibility Alternative was also supported by the findings of a Value Planning Study performed by Reclamation which ranked the alternative highest compared to alternatives considered during the value planning process.

National Economic Development Plan

The objective of the National Economic Development (NED) analysis estimates the economic benefits of potential effects is necessary to establish the feasibility and identify a corresponding alternative plan that maximizes net benefits. As described above, the maximum net benefit is achieved by the Parallel Canal Feasibility Alternative, which supports the selection of this alternative as the Recommended Plan.

Constructability and Operational Considerations

Additional criteria considered in the selection of the Recommended Plan included potential to impact water deliveries during construction. The Parallel Canal Feasibility Alternative has a construction duration of two and half years compared to the Canal Enlargement Alternative could last up to ten years due to limitations time available for canal construction during lowered water levels. Water delivery impacts during construction of the Parallel Canal Feasibility Alternative would be minimal because most construction activities will be in the dry, using new materials and does not rely on the existing embankments for stability. The shorter construction duration, limited impact to contract deliveries during construction, and the more reliable construction methods are reasons support the selection of Parallel Canal Feasibility Alternative as the Recommended Plan.

Value Planning Study

In October of 2019 Reclamation performed a value planning study of the Friant-Kern Canal Capacity Correction Project. The goal of the value planning study is to achieve the most appropriate and highest value solution for an identified problem. The value planning study included an examination of the component features of the Project, or activity to define the critical functions, governing criteria, and associated costs. Alternative ideas and solutions were suggested to perform the functions, consistent with the identified criteria, at a lower cost or with an increase in long-term value.

The Value Planning review of the Initial and Feasibility Alternatives confirmed the Parallel Canal Feasibility Alternative as the superior alternative considered in this Study. The value planning study considers the Parallel Canal Feasibility Alternative as the Baseline Design in which alternative ideas are compared to, and additional design considerations are added to. The ideas were evaluated, analyzed, and prioritized, and a few of these were evaluated to a level suitable for comparison, decision-making, and adoption.

Reclamation produced the Draft Value Planning Report that summarizes the activities and ideas developed the value planning team. Table 5-9 shows the analysis matrix developed by the value planning team that ranked the developed ideas compared to the Baseline Design (Parallel Canal Feasibility Alternative). From the proposed ideas the Parallel Canal Feasibility Alternative was evaluated as the highest value project and confirms that selection of the Parallel Canal Alternative as the Recommended Plan.

Table 5-9. Analysis Matrix from Value Planning Study

Analysis Matrix

Criteria	A		B		C		D		E		F		Raw Score	Weighted Score	Ranking	Disposition
Weight	0.07		0.04		0.19		0.04		0.33		0.33					
Idea	Score	Weighted	Score	Weighted	Score	Weighted	Score	Weighted	Score	Weighted	Score	Weighted				
Baseline Design	4	0.27	5	0.22	5	0.93	5	0.22	4	1.31	5	1.64	28	4.6	**1**	
RCC Embakment	2	0.14	2	0.09	4	0.75	5	0.22	4	1.31	2	0.66	19	3.2	**4**	
MSE Wall	3	0.20	5	0.22	4	0.75	4	0.18	4	1.31	4	1.31	24	4	**3**	
Unlined Parallel Canal	4	0.27	5	0.22	5	0.93	3	0.13	3	0.99	5	1.64	25	4.2	**2**	
Recharge w/ Existing	5	0.34	5	0.22	5	0.93	5	0.22	2	0.66	5	1.64	27	4.01		

Score: Excellent = 5, Very Good = 4, Good = 3, Fair = 2, Poor = 1

Score 4-5
Score 3-4
Score 2-3

Summary of Refinements to the Parallel Canal Feasibility Alternative

As described above, the Parallel Canal Feasibility Alternative was selected as the Recommended Plan. Following that selection, several refinements were made to reduce material requirements and improve constructability and project resilience. Design refinements included reduction of the required length of canal realignment portion, refinement of the location of the center-line of the realigned segment, selection of canal cross-sections that provide greater resiliency under future subsidence conditions, identification of potential borrow sites, and other considerations. The results of these additional refinements reduced the cost of the Recommended Plan without reducing the estimated benefits in comparison to the Parallel Canal Feasibility Alternative described above. The refinements to the Parallel Canal Feasibility Alternative described below are reflected in the description of the Recommended Plan presented in Chapter 6. The Recommended Plan is also referred to as the Canal Enlargement and Realignment (CER) Alternative in environmental compliance documents.

Refinement of Length of Canal Realignment

The Parallel Canal Feasibility Alternative included a realigned canal segment from south of Ave. 152 near MP 96 to Garces Highway near MP 119. Through additional modeling and refinement, it was determined that the length of canal realignment segment could be shortened and achieve the maximum design capacity and HGL. The canal realignment in the Recommended Plan extends from MP 96 to Avenue 8 near MP 116. This refinement resulted in reducing the canal realignment by approximately 3 miles, reducing the among of required embankment material and reducing project costs.

Refinement of Canal Realignment Offset from Existing FKC

The realigned canal portion of Parallel Canal Feasibility Alternative, which was developed based on minimizing ROW requirements, required the placement of material within the existing FKC.

Upon consideration of material requirements, the centerline of the realigned canal was moved further east such that the west embankment of the realigned canal tied into the existing the eastern canal embankment. This refinement reduced the required embankment material by about 1 million cubic yards and enables a construction sequencing that provides for potential use of material in the existing canal embankments to construct parts of the realigned canal embankments.

Refinement of Raised and Widened Canal Segment Cross-Sections

The Parallel Canal Feasibility Alternative included canal enlargement in Segment 1 and a portion of Segment 4 through raising and widening the FKC. In these segments, the raised and widened section would include a 24-foot bench on either side of the canal. Through additional hydraulic modeling, it was determined that required capacity could be achieved by extending the existing prism by raising the embankment and extending the lining, thereby eliminating the need to widen the canal. Depending on location, the required lining raise varies from 15 inches to 24 inches. The elimination of the bench reduced the amount of embankment material and liner on the bench portion, and lowered cost. Table 5-10 shows the approximate lining raise required in Segment 1, a portion of Segment 2, and Segment 4B to achieve the maximum design flow.

Table 5-10. Lining Raise Requirements for the Recommend Plan

Segment	Maximum Design Flow (cfs)	Required Lined Freeboard	Canal Milepost (MP)	Canal Milepost (MP)	Approx. Canal Length	Lining Raise "H"
1	4,500 cfs	1.15' (13.80")	88.2 (5th Ave Check Outlet)	95.1 (Ave 180 Bridge)	6.9-miles	15"
			95.1 (Ave 180 Bridge)	95.7 (Tule Check Inlet)	0.6-miles	24"
2	4,000 cfs	1.11' (13.32")	95.7 (Tule Check Outlet)	96.3 (Ave 152 Bridge)	0.6-miles	24"
2/3/4A	*4,000 cfs 3,500 cfs*	*1.11' 1.08'*	*96.3 (Ave 152 Bridge)*	*115.9 (Ave 8 Bridge)*	*19.6-miles Parallel Canal*	
4B	3,500 cfs	1.08' (12.96")	115.9 (Ave 8 Bridge)	119.5 (Woollomes Rd Bridge)	3.6-miles	13"
4C	3,500 cfs	1.08' (12.96")	*119.5 (Woollomes Rd Bridge)*	*121.5 (Woollomes Check Inlet)*	*2.0-miles Existing Earth Canal (No Mods Necessary)*	

Key:
ave – avenue
cfs – cubic feet per second
mp – milepost
rd - road

Refinement of Realigned Canal Segment Cross-Sections

The cross-section geometry of the Parallel Canal Feasibility Alternative was based a 40-foot bottom width of the canal in all realigned segments. Further evaluation revealed that material balance could be improved and resiliency under future subsidence could be increased if the bottom width were narrowed. An analysis was performed to identify effect on canal capacity under future subsidence for a variety of bottom-width canal designs at the same design capacity Table 5-11 shows the reduction in capacity resulting from capacity on a variety of canal sections designed to convey 4,000 cfs. Under a future subsidence of 4 feet, the capacity of a 16-foot bottom width would be reduced by about 12 percent whereas the same subsidence would cause a 25 percent reduction of the capacity for a 40-foot bottom with canal.

On the basis of this analysis, the design for the Recommended Plan was revised to include varying widths from 16 to 24 feet. This change was made to minimize the canal capacity loss that would be experienced in the future from subsidence. This reduction in bottom width has the added advantage of reducing the amount of concrete lining required as part of the construction.

Table 5-11. Effect of Subsidence on Canal Capacity of Various 4,000 cfs Canal Designs

Future Subsidence	Canal Capacity Reduction Resulting from Subsidence			
	16-ft Bottom Width	24-ft Bottom Width	32-ft Bottom Width	40-ft Bottom Width
2-feet	5% (200 cfs)	7% (280 cfs)	10% (400 cfs)	12% (480 cfs)
4-feet	12% (480 cfs)	16% (640 cfs)	20% (800 cfs)	25% (1,000 cfs)
8.5-feet	32% (1,280 cfs)	41% (1,640 cfs)	49% (1,960 cfs)	56% (2,240 cfs)

Key:
cfs – cubic feet per second

Refinement to Identification of Borrow Sources

During the refinement of the Recommended Plan, as described above, additional potential borrow sites were identified through coordination with Friant Division long-term contractors. In response to SGMA requirements, some Friant Division long-term contractors are advancing plans to develop permanent groundwater recharge basins. To date, Friant Division long-term contractors have expressed interest in developing three sites in the general vicinity of the Project Area and have indicated their interest in making material from these sites available as borrow. In addition, at least one site, which is immediately adjacent to the FKC, is a candidate construction staging location. Preliminary designs, environmental compliance and permitting has been completed for some sites, whereas others have been evaluated at a conceptual or appraisal level. Geotechnical information is available at all sites and further evaluations will be included in the design development of the Recommended Plan.

Based the current design of the Recommended Plan and consideration of potential borrow from nearby and adjacent identified sites, the identified available borrow to construct exceeds the requirements for the Recommended Plan. Table 5-12 shows the borrow source and the amount of material identified as available from that source. As noted in Table 5-12 over 9 million cubic yards of potential borrow material has been identified, which significantly exceeds the estimated material requirements of approximately 5.7 million cubic yards.

Table 5-12. Borrow Sources and Estimated Volume Available

Borrow Source	General Location	Estimated Volume Available (CY)
Excavation of Realigned Canal	MP 96 to MP 116	2.1M
Existing FKC Bank Material[1]	Along 20 miles of existing canal (MP 96 to MP 116)	3.0M
SITE B - Terra Bella Irrigation District Site	East of canal at Milepost 102.2	1.5M
SITE A – Private Landowner Site	East of canal at Milepost 97.4	0.5M
SITE C - Delano-Earlimart Irrigation District Site	1 mile West of Canal near Milepost 114.0	2.0M
Total Potential Available Borrow		9.1M

Notes:
1 Material is not available until segments of old canal are out of operation.

Chapter 6 Recommended Plan

This chapter describes the Recommended Plan and project implementation requirements. It includes the demonstration of the feasibility of the Recommended Plan, identification of areas of potential risk and uncertainty, project implementation requirements, Federal and non-Federal responsibilities, and a project timeline.

Description of Recommended Plan Features

A single-line schematic showing features included in the Recommended Plan is provided in Figure 6-1A and Figure 6-1B. The Recommended Plan includes modification to enlarge the FKC where practical, and construction of a new canal realignment in locations where the land subsidence has occurred or is expected to occur to an extent that modifying the existing FKC to achieve the design capacity and HGL is considered less practical. Features of the Recommended Plan are described in the following sections.

Canal Alignment and Cross Sections

The Recommended Plan 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 canal embankment and lining raise to increase canal capacity to meet the Design Maximum flow rate and HGL in this segment, as shown in Figure 6-2. From 5th MP 88 to MP 96.3 existing bridge soffits are anticipated to be above the new maximum water surface elevation in the canal. Many of the existing turnouts in this segment of the canal will require raising the top deck by 0.5 to 2 feet. The extent of the raise at each turnout is dependent upon the lining raise at that location.

At MP 96.3, the new canal alignment would head east, away from the existing canal centerline, and run on a generally parallel alignment to the existing FKC until it reaches Ave. 8 (MP 115.94). In this reach, the new canal alignment would have a regular trapezoidal shape based on the configuration shown in Figure 6-3. At MP 115.94, the canal realignment would reconnect with the existing alignment of the FKC, which would be enlarged between MP 115.94 to Woollomes Ave. (MP 120) as described above and shown in Figure 6-2. From MP 120 to Reservoir Check Structure (MP 121.5) will remain as is with no modifications necessary to convey the Design Maximum flow.

The Recommended Plan is based on canal embankments and liner that would achieve objective capacities if constructed at the current (2018 survey) ground level and 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. The necessary ROW to accommodate such a future raise, as identified as future concrete liner raise with embankment on Figure 6-3.

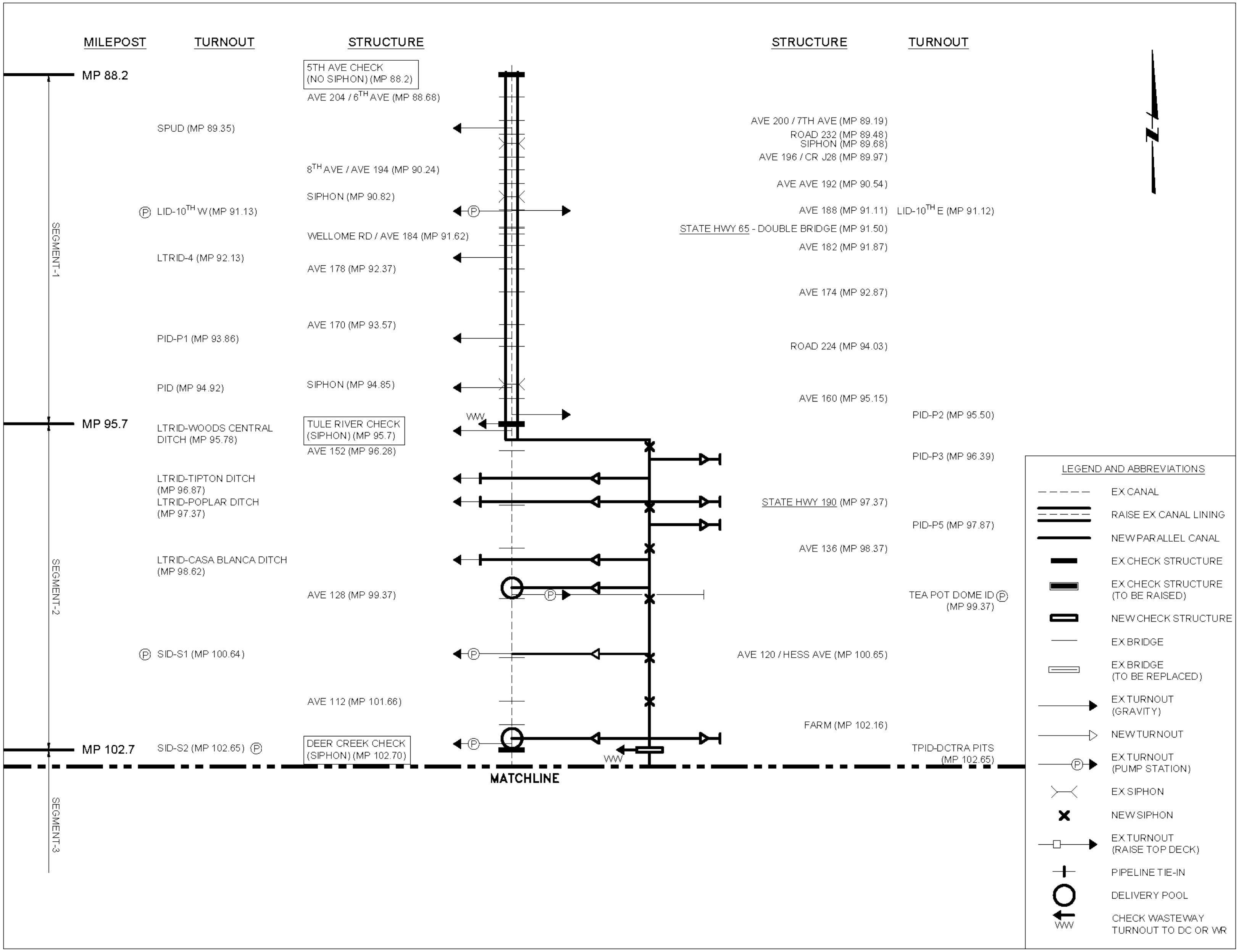

Figure 6-1A. Recommended Plan Single-Line Diagram of Canal Segments 1 and 2

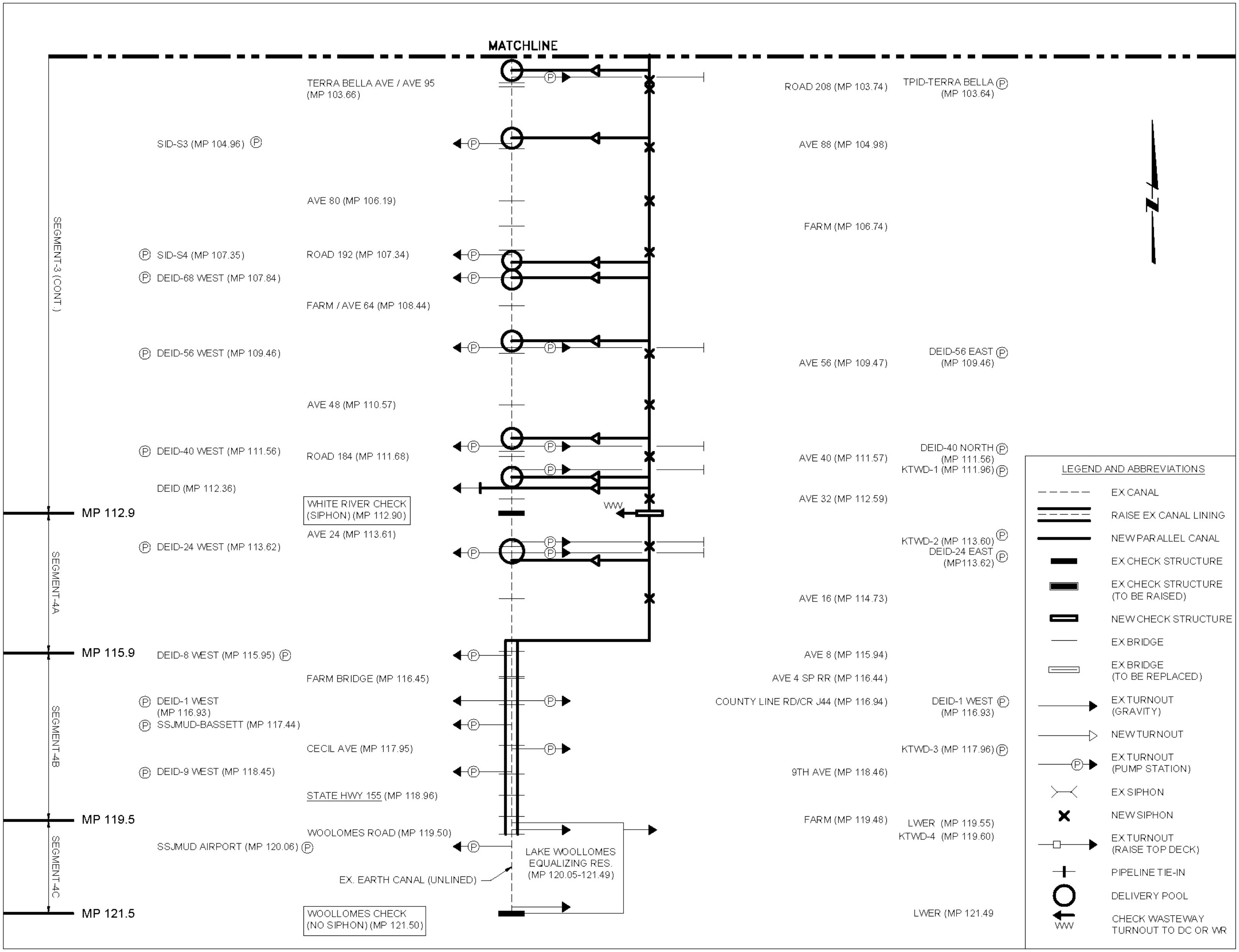

Figure 6-1B. Recommended Plan Single Line Diagram of Segments 3 and 4

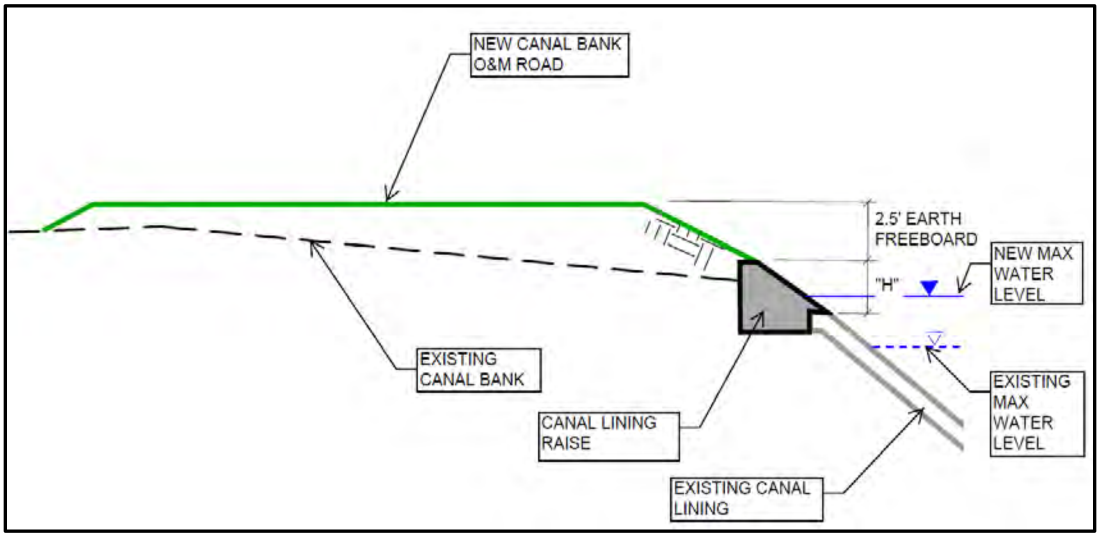

Figure 6-2. Canal Lining Raise in Segment 1 and Segment 4b of the Recommended Plan

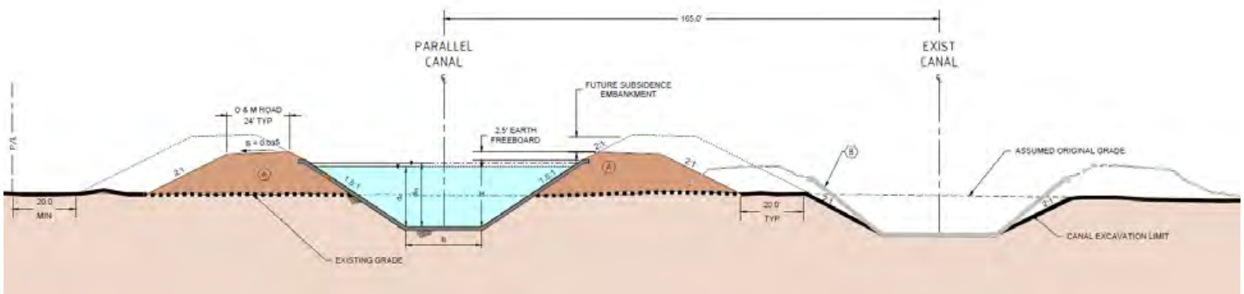

Figure 6-3. Trapezoidal Cross Section of Realigned Canal Segments in the Recommended Plan

Construction Sequencing

The canal realignment portion of the Recommended Plan would be constructed as follows:

1. Construct the new canal section from Ave. 56 (MP 109.47) to MP 115.94 with excavated prism material, construct the new White River Check Structure, and line the newly constructed canal.

2. The newly constructed canal from MP 109.47 to MP 115.94 put into operations with temporary tie in on the northern end.

3. Excavate material from the old FKC banks and haul material from MP 109.47 to White River Check (MP 112.9) north to construct canal realignment prism from Ave. 96 (MP 103.66) to MP 109.47.

4. Construct the new canal section from MP 103.66 to MP 109.47 with excavated prism material, and the hauled material from Step 3 or other potential borrow area near the Deer Creek Check. Line the canal section from MP 103.66 to MP 109.47.

5. The newly constructed canal from MP 103.66 to MP 109.47 put into operations with temporary tie on the northern end and connected to the canal section from MP 109.47 to MP 115.94.

6. Construct the canal section from MP 96.3 to Ave. 128 (MP 99.37) with excavated prism material, and line the newly constructed section.

7. The newly constructed canal from MP 96.3 to MP 99.37 put into operations with temporary tie in at the southern end.

8. Excavate material from the old FKC banks and haul material from MP 96.3 to MP 99.37 south to construct canal realignment prism from MP 99.37 to MP 103.66.

9. Construct the new canal section from MP 99.37 to MP 103.66 with excavated prism material, and the hauled material from Step 8. Line the canal section from MP 99.37 to MP 103.66. Construct the new Deer Creek Check Structure.

10. New Canal Realignment completed and in operation.

For a detailed discussion on construction sequencing, refer to Appendix D Recommended Plan Design and Cost Summary.

Turnouts

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

Pressurized Turnout Modifications

In the Middle Reach, many of the 21 pressurized distribution systems have subsided at different rates than the land under the canal, causing varying differential head conditions from those used in the original system designs. All alternatives have been developed to achieve the proposed HGL, which is higher than the current water surface in the FKC. Increasing the HGL would increase head on the suction side of the pumping plants, which would increase the delivery head on district distribution systems. The removal and replacement of current pump stations at a location compatible with the current design was considered and dropped because of significant costs.

The water elevation in the new realigned canal would often be above the elevation of the top decks of existing pump stations. If a pump station were to unexpectedly shutdown, the incoming flow from the adjacent canal could overflow the pump station and flood the facility and surrounding land, resulting in equipment and property damage. To avoid the potential risk associated with unexpected shutdowns, the Recommended Plan includes small delivery pools at each pump station turnout in the canal realignment section. As shown in Figure 6-4, the delivery pool would be created by preserving small portions of the existing FKC to serve as a forebay for the existing turnout pump station. Water would flow from the new realigned canal through a new pipe to the delivery pool. The new canal realignment would be modified at the location of each pump station turnout and be customized to meet the specific needs of each pressurized delivery system. A list of the modifications proposed to the pump station turnouts is provided in Table 6-1.

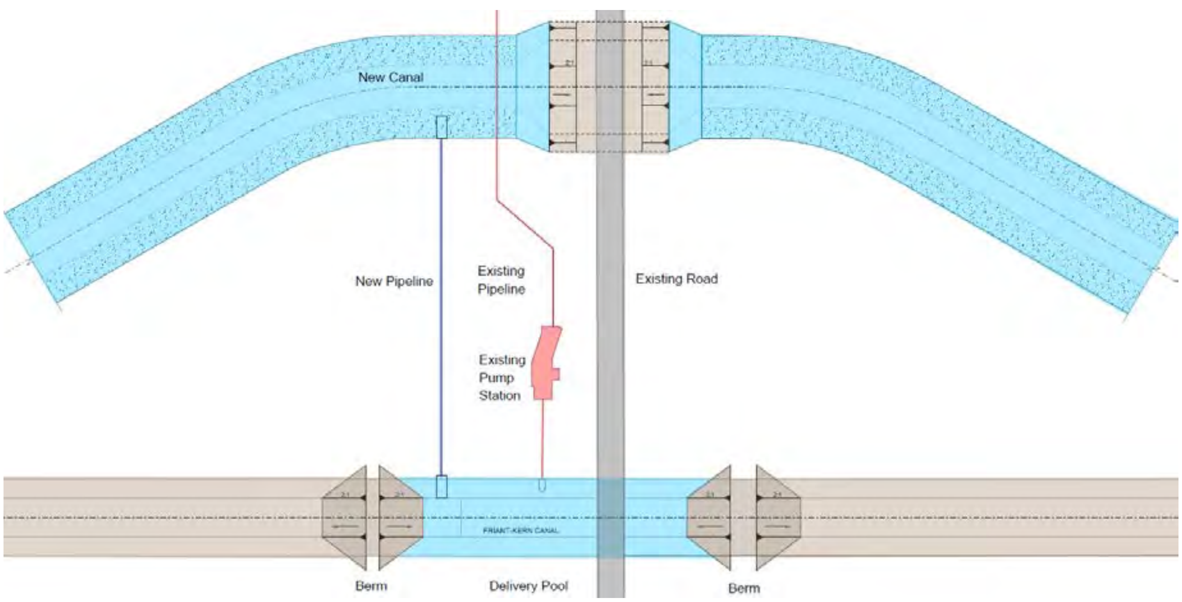

Figure 6-4. Example Pressurized System Turnout Design in the Recommended Plan

Table 6-1. Modifications at Pump Station Turnouts in the Recommended Plan

Pump Station Turnout	Canal Side	MP	Modification
LID-10th W	West	91.12	Raise Top Deck
TPDWD-Teapot Dome	East	99.35	New Delivery Pool Turnout
SID-S2	West	102.65	New Delivery Pool Turnout
TBID-Terra Bella	East	103.64	New Delivery Pool Turnout
SID-S3	West	104.96	New Delivery Pool Turnout
SID-S4	West	107.35	New Delivery Pool Turnout
DEID – 68 West	West	107.84	New Delivery Pool Turnout
DEID-56 EAST	East	109.46	New Delivery Pool Turnout (Shared)
DEID-56 West	West	109.46	New Delivery Pool Turnout (Shared)
DEID-40 North	East	111.56	New Delivery Pool Turnout (Shared)
DEID-40 West	West	111.56	New Delivery Pool Turnout (Shared)
KTWD-1	East	111.96	New Delivery Pool Turnout
KTWD-2	East	113.6	New Delivery Pool Turnout (Shared)
DEID-24 East	East	113.62	New Delivery Pool Turnout (Shared)
DEID-24 West	West	113.62	New Delivery Pool Turnout (Shared)
DEID-8th West	West	115.95	Raise Top Deck
DEID-#1 West	East	116.93	Raise Top Deck
SSJMUD-Bassett	West	117.44	Raise Top Deck
KTWD-3	East	117.96	Raise Top Deck
DEID-9th West	West	118.45	Raise Top Deck
SSJMUD-Airport	West	120.06	Unmodified

Gravity Turnout Modifications

There are 17 gravity systems located in the Middle Reach, each of which were individually analyzed to determine an appropriate design approach. The analysis revealed that all existing gravity turnouts can either be preserved and reused or connected to new turnouts and pipelines on the new canal realignment. A summary of actions for gravity turnouts under the Recommended Plan is provided in Table 6-2.

Table 6-2. Modifications at Gravity Turnouts Under the Recommended Plan

Gravity Turnout	Canal Side	MP	Modification
SPUD-STRATHMORE	West	89.35	Raise Top Deck
LID-10th E	East	91.12	Raise Top Deck
LTRID-4	West	92.13	Raise Top Deck
PID-P1	West	93.85	Raise Top Deck
PID-Porter Slough	West	94.92	Raise Top Deck
PID-P2	East	95.50	Raise Top Deck
LTRID-Woods Central Ditch	West	95.78	Raise Top Deck
PID-P3	East	96.39	New Gravity Turnout on Canal Realignment
LTRID-Tipton Ditch	West	96.87	New Gravity Turnout on Canal Realignment
LTRID-Poplar Ditch N&S	West & East	97.37	New Gravity Turnout on Canal Realignment
PID-P5	East	97.86	New Gravity Turnout on Canal Realignment
LTRID-Casa Blanca Ditch	West	98.62	New Gravity Turnout on Canal Realignment
SID-S1	West	100.64	New Gravity Turnout on Canal Realignment
TBID-DCTRA Pits	East	102.65	New Gravity Turnout on Canal Realignment
DEID	West	112.36	New Gravity Turnout on Canal Realignment
LWER	East	119.55	Unmodified
LWER	East	121.49	Unmodified

Checks and Siphons

The Recommended Plan project area includes five existing check structures located at 5th Avenue (MP 88.2), Tule River (MP 95.7), Deer Creek (MP 102.7), White River (MP 112.9), and Lake Woollomes (MP 121.5). Check Structures are essential to the operation of the FKC. These structures house radial gates that maintain the water level in the upstream canal segments to provide enough head to maintain submergence of turnouts. Table 6-3 provides a description of the existing check structures, and appurtenance facility, as well as the proposed modifications for each. The Recommended Plan would include new check structures at Deer Creek and White River. Additionally, there are 5 existing siphons, 3 in Segment 1 that will not require modification, and siphons at Deer Creek and White River that will require replacement.

Table 6-3. Modifications at Existing Check Structures Recommended Plan

Description	Gate Type	MP	Modification
Fifth Avenue Check	Radial Gates	88.22	No Modification
Tule River Wasteway	Radial Gates	95.64	No Modification
Tule River Check and Siphon	Radial Gates	95.66	No Modification
Deer Creek Wasteway	Radial Gates	102.69	Abandon Existing – Replace on New Realigned Canal
Deer Creek Check and Siphon	Radial Gates	102.69	Abandon Existing – Replace on New Realigned Canal
White River Wasteway	Radial Gates	112.9	Abandon Existing – Replace on New Realigned Canal
White River Check and Siphon	Radial Gates	112.9	Abandon Existing – Replace on New Realigned Canal
Lake Woollomes Check	Radial Gates	121.5	No Modification

Road Crossings

The Middle Reach of the FKC has approximately 45 existing bridge crossings, some of which will require replacement to accommodate the project. The majority of existing bridges are cast-in-place concrete type with a system of reinforced concrete “T” beams, or girders supporting a concrete roadway deck, and supported by a concrete pier wall in the center of the FKC and concrete abutments with monolithic wingwalls on either side of the canal. There are 2 proposed measures to accommodate all roadway crossings in the Middle Reach either leave in place or replace bridge with concrete box siphon.

The leave in place measure would generally consist of minimal to no modifications to the existing bridges. This is typically the case with existing bridges in the enlarged sections of the existing canal in Segments 1 and 4.

The concrete box siphon measure would be applied in the new realigned canal roadway crossings in Segments 2, 3, and part of 4. Along these segments County and State bridges would be removed and the crossings would be replaced with concrete box siphons. The concrete box siphons would generally consist of a buried cast-in-place concrete triple box siphon with each of the three boxes estimated to be 19 feet tall by 19 feet wide.

Canal lining transitions approximately 50 feet long would be provided at the siphon entrance and exit to transition from the trapezoidal open canal geometry to the square box geometry. The length of the siphons would vary by location but would range from 100 to 200 feet The concrete box siphons are designed to accommodate potential subsidence by considering future soil loading and extension of the concrete headwalls at the entrance and outlets. Figure 6-5 shows the concrete box siphon concept.

At each new siphon the adjacent existing bridge over the current FKC would be demolished and the abandoned portion of the FKC would be filled to road grade and the paved road surface reconstructed on earth fill. Table 6-4 provides a summary of the existing bridges and measures proposed for the roadway crossings in the Middle Reach.

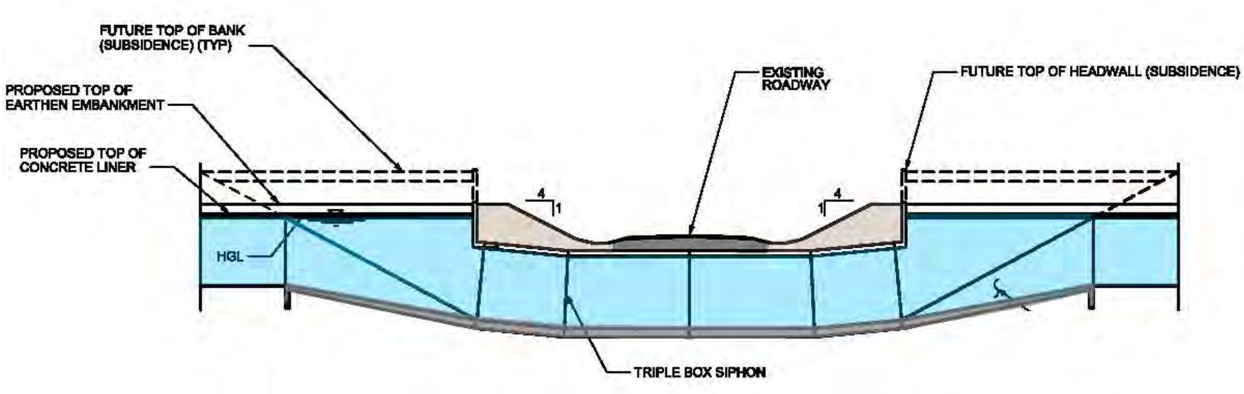

Figure 6-5. Typical Siphon Road Crossing

Table 6-4. Road Crossing Actions in the Recommended Plan

Name	MP	Modification
6th Avenue Bridge	88.67	No Modifications
7th Avenue Bridge	89.17	No Modifications
Road 232 Bridge	89.45	No Modifications
Frazier Highway/ Ave 196 Bridge	89.95	No Modifications
8th Avenue Bridge	89.95	No Modifications
Avenue 192 Bridge	90.23`	No Modifications
Avenue 188 Bridge	91.10	No Modifications
State Highway 65 Northbound Bridge (Double Bridge)	91.51	No Modifications
Welcome Avenue Bridge (Avenue 184)	91.60	No Modifications
Avenue 182 Bridge	91.85	No Modifications
Avenue 178 Bridge	92.35	No Modifications
W Linda Vista Avenue	92.85	No Modifications
W North Grand Avenue Bridge	93.55	No Modifications
N Westwood Street Bridge	94.01	No Modifications
W Henderson Avenue Bridge	95.12	No Modifications
Avenue 152 Bridge	96.26	Concrete Box Siphon

Table 6-4. Road Crossing Actions in the Recommended Plan (contd.)

Name	MP	Modification
Avenue 144 Bridge (Highway 190)	97.35	Concrete Box Siphon
Avenue 136 Bridge	98.35	Concrete Box Siphon
Avenue 128 Bridge	99.37	Concrete Box Siphon
Hesse Avenue Bridge	100.64	Concrete Box Siphon
Avenue 112 Bridge	101.64	Concrete Box Siphon
Timber Farm Bridge	102.14	None
Road Terra Bella Avenue (J24)	103.65	Concrete Box Siphon
Road 208 Bridge	103.72	Concrete Box Siphon
Avenue 88 Bridge	104.95	Concrete Box Siphon
Avenue 80 Bridge	106.72	Concrete Box Siphon
Farm Bridge	106.75	None
Road 192 Bridge	107.32	Concrete Box Siphon
Avenue 64 Bridge	108.42	None
Avenue 56 Bridge	109.45	Concrete Box Siphon
Avenue 48 Bridge	110.55	Concrete Box Siphon
Avenue 40 Bridge	111.55	Concrete Box Siphon (Shared)
Road 184 Bridge	111.66	Concrete Box Siphon (Shared)
Avenue 32 Bridge	112.57	Concrete Box Siphon
Avenue 24 Bridge	113.59	Concrete Box Siphon
Avenue 16 Bridge	114.71	Concrete Box Siphon
Avenue 8 Bridge	115.91	No Modifications
Timber Farm (Avenue 4) Bridge (2 Bridges)	116.41	No Modifications
County Road Avenue 0 Bridge	116.91	No Modifications
Cecil Avenue Bridge	117.92	No Modifications
9th Avenue Bridge	118.44	No Modifications
Garces Highway Bridge	118.94	No Modifications
Timber Farm Bridge	119.46	No Modifications
Woollomes Avenue Bridge	120.02	No Modifications

Utilities

Numerous utilities located in, along, and across the FKC would be affected by implementation of the Recommended Plan. The utilities include pipeline overcrossings, overhead power lines, adjacent wells, irrigation crossings under the existing canal, and utilities connected to bridges. Depending on the location and extent of canal modifications, the utilities will either be relocated or entirely replaced, as determined in the final design. Table 6-5 summarizes utility quantities that would require modification for the Recommended Plan. These quantities should be considered approximate until field locating confirms actual locations. Additional detailed information on utilities is provided in Appendix D.

Table 6-5. Preliminary Estimate of Modifications to Utilities for the Recommended Plan

Utility Modification	Quantity
Parallel Overhead Powerline Relocations	~1 mile
Overhead Electrical Crossing Modifications	20 crossings
Adjacent Groundwater Well Abandonments	10 wells
Drainage Culvert Conflicts	4 Conflicts
Pipeline Overcrossing Replacements	5 replacements
Pipeline Undercrossing Replacements	5 replacements
Utility Crossings at Bridges	20 crossings

Estimated Quantities and Cost

A list of items that will be included in the summary of quantities and costs is included in Table 6-6. A cost estimate is provided in Table 6-7.

Table 6-6. Recommended Plan Alternative Summary of Estimated Quantities

	-	Seg 1: 5th Ave. to Tule	Seg 2: Tule to Deer Creek	Seg 3: Deer Creek to White River	Seg 4: White River to Ave. 8	Seg 4: Ave. 8 to Woollomes	-
Design Flow (Design Maximum) (cfs)	-	4,500	4,000	4,000	3,500	3,500	-
From MP to MP	-	88.2-96.67	95.67-102.7	102.7-112.9	112.9-115.94	115.94-121.5	-
Total Canal Miles	-	7.47	7.0	10.2	3.04	5.56	-
Description ***NEW CANAL***	***Unit***	***Quantity***	***Quantity***	***Quantity***	***Quantity***	***Quantity***	***Total***
Excavation	CY	125,000	1,813,350	2,558,850	330,750	75,000	**4,902,950**
Compacted Canal Embankment construction	CY	100,000	1,727,000	2,437,000	315,000	60,000	**4,639,000**
Concrete Lining	SY	4,200	396,905	632,657	184,000	2,800	**1,220,562**
Concrete for Structures	SY	-	19,976	30,682	6,501	-	**57,159**
Reinforcing Steel	lbs	-	3,822,812	5,945,669	117,035	-	**9,885,516**
Ladders	EA	105	99	144	46	-	**394**
Aggregate base O&M road surfacing	SY	104,221	98,653	105,011	47,000	77,067	**431,952**
CHECK STRUCTURES	**Unit**	**Quantity**	**Quantity**	**Quantity**	**Quantity**	**Quantity**	**Total**
New Check/Siphon Structure	-	-	1	1	-	-	**2**
Existing Check Structures Demolition and Disposal	-	-	1	1	-	-	**2**

Table 6-6. Recommended Plan Alternative Summary of Estimated Quantities (contd.)

		Seg 1: 5th Ave. to Tule	Seg 2: Tule to Deer Creek	Seg 3: Deer Creek to White River	Seg 4: White River to Ave. 8	Seg 4: Ave 8 to Woollomes	
ROAD CROSSINGS – BRIDGES	**Unit**	**Quantity**	**Quantity**	**Quantity**	**Quantity**	**Quantity**	**Total**
Bridge Replacement on Existing Canal – County or State Bridges	EA	-	-	-	-	-	-
Bridge Replacement on Existing Canal – Farm Bridges	EA	-	-	-	-	-	-
Existing Bridge Demolition	EA	-	7	12	2	-	21
ROAD CROSSINGS – SIPHONS	**Unit**	**Quantity**	**Quantity**	**Quantity**	**Quantity**	**Quantity**	**Total**
Siphon Construction on New Canal	EA	-	6	11	-	-	17
TURNOUTS	**Unit**	**Quantity**	**Quantity**	**Quantity**	**Quantity**	**Quantity**	**Total**
Raise/Modify Existing Turnout Top Deck and Actuators	EA	7	1	-	-	5	13
Turnouts on New Canal	EA	-	9	8	1	-	18
Delivery Pools	EA	-	2	7	1	-	10
UTILITIES	**Unit**	**Quantity**	**Quantity**	**Quantity**	**Quantity**	**Quantity**	**Total**
Parallel Overhead Powerline Relocations	Feet	-	800	4,400	-	-	5,200
Overhead Electrical Lines	EA	-	7	11	1	-	20
Adjacent Groundwater Well Abandonments	EA	-	4	6	-	-	10
Culvert Extensions (Each End)	EA	-	2	2	0	-	4
Pipeline Overcrossing Replacements (8" to 12")	EA	-	1	2	2	-	5
Impacted Utility Crossings (Attached to Existing Bridge sizes range from 4" to 24")	EA	-	5	11	4	-	20
LAND ACQUISITION	**Unit**	**Quantity**	**Quantity**	**Quantity**	**Quantity**	**Quantity**	**Total**
Impacted Parcels	EA	69	17	25	20	8	139
Permanent Land Acquisition (ROW)	Acre	-	138	230	62	-	430

Key:
- = Not Applicable or zero
cfs = cubic feet per second
CY = cubic yard
EA = each
Lbs = pounds
LF = linear feet
LS = lump sum
MI = mile
MP = milepost
O&M = operations and maintenance
ROW = Right of Way
SY = square yard

Table 6-7. Recommended Plan Alternative Cost Estimate

Item	Reference	Cost	Notes/ Inclusions
Segment 1 - 5th Ave to Tule	from estimate	$7,434,215	
Segment 2 - Tule to Deer Creek (New Bypass Canal)	from estimate	$71,146,020	
Segment 3 - Deer Creek to White River (New Bypass Canal)	from estimate	$106,108,628	
Segment 4a - White River to Garces Hwy (New Bypass Canal)	from estimate	$18,320,084	
Segment 4b - Garces Hwy to Woollomes (Widen Existing Canal)	from estimate	$4,027,327	
Construction Allowances, Mobilization, Startup, Commission, and Owner Training	from estimate	$6,315,222	
Subtotal		$213,351,496	
Contract Cost Allowance - Design Contingency	17%	$36,239,754	
Contract Cost		**$250,000,000**	Rounded
Construction Contingencies	20%	$50,000,000	
FIELD COST		**$300,000,000**	Rounded
Land Purchase - Construction Phase and ROW		$20,000,000	Based on market research
Environmental Mitigation	5%	$29,000,000	From separate estimate
Engineering, Permitting, and Construction Management	20%	$60,000,000	Calculated as % of Field Cost
Legal and Administrative	2%	$6,800,000	Calculated as % of Field Cost
Non-Contract Costs		**$115,000,000**	Rounded
TOTAL CONSTRUCTION COST		**$415,000,000**	Rounded
Interest During Construction	3% Discount Rate	$25,562,071	4 year construction period
TOTAL CAPITAL COST		**$440,000,000**	Rounded
Annualized Capital Costs		$16,697,158	2.875% (FY19) over 50 years
Additional Annualized O&M Costs		$967,676	Excludes current O&M costs; 2.875% (FY19) over 50 years
TOTAL ANNUALIZED COST		**$17,500,000**	Rounded

Feasibility Determination for the Recommended Plan

A determination of feasibility is based on a review of four tests of feasibility: technical, environmental, economic and financial.

Technical Feasibility

Technical feasibility consists of engineering, operations, and constructability analyses verifying that it would be physically and technically possible to construct, operate, and maintain the Recommended Plan. The Recommended Plan is technically feasible, and includes features to address constructability and long-term operations, as demonstrated above. A Design, Engineering, and Cost (DEC) review will be performed on the Recommended Plan described in this chapter and Appendix D to identify additional information that is required to determine technical feasibility.

Environmental Feasibility

Environmental feasibility consists of analyses verifying that constructing or operating the project would not result in unacceptable environmental consequences or require costs that would adversely affect economic feasibility. Generally, environmental feasibility is based on the completion of NEPA compliance and environmental permitting processes. These processes are underway and are expected to be completed during 2020.

To date, several evaluations have been completed to inform environmental feasibility of the Project. An environmental constraints analysis was performed and applied to the evaluation of Initial Alternatives and selection of Feasibility Alternatives. An Environmental Assessment (EA)/Initial Study (IS) was prepared to evaluate potential environmental effects associated with the Canal Enlargement and Parallel Canal Feasibility Alternatives. The EA/IS identified the following resource areas may that have potentially significant impacts resulting from construction of the Feasibility Alternatives: agriculture/land use, air quality/Green House Gases, biological, cultural and tribal, hydrology, and water quality. Reclamation has determined that a joint Environmental Impact Statement/Environmental Impact Report (EIS/R) will be prepared because the Project could result in significant impacts, is a major undertaking and private land acquisition will be required.

Three cultural resources reports have been completed to support Section 106 compliance for geotechnical investigations of the Project. To date, the findings of two of these reports have been concurred on and the third is currently under review by the California Office of Historic Preservation. Additionally, a Section 106 technical memorandum was prepared in support of immediate repair activities from MP 103 to MP 107 and those findings have also been concurred on by the California Office of Historic Preservation.

Work is progressing on preparation of Section 106 reporting for the complete Project. Reclamation has established an Area of Potential Effect (APE) that accounts for potential direct and indirect effects of the Recommended Plan. Pedestrian surveys have been completed for all property within the Reclamation ROW, publicly accessible direct and direct APE have been completed, and a records search with a 1-mile search area of the entire project area from Mile Post 88 to 121 has been completed. The effects analysis is underway, the Section 106 report is in preparation, and a historic property treatment plan is in the early stages of development.

For biological resources, two Section 7 consultations have been completed for geotechnical investigations of the Project. The schedule for the Section 7 compliance consultation with the US Fish and Wildlife Services for the complete Project has been set. An aquatic resources delineation report for the Project is in preparation, and habitat characterization and assessment of potential biological in the Project area is in progress.

Environmental Mitigation Cost Estimates

The Feasibility Alternatives cost estimates presented in Chapter 5 included an allowance for environmental mitigation (which includes cultural resources mitigation) at 5 percent of the field cost. More detailed environmental mitigation cost estimates have been developed and incorporated into the cost estimate for the Recommended Plan.

The design and environmental analyses conducted to date for the project indicate that cost elements associated with environmental mitigation can be grouped into three main categories: 1) biological mitigation, 2) cultural mitigation, and 3) air quality mitigation. It is recognized that potential impacts of other project elements not yet defined, such as borrow pits, construction staging areas, and installation of construction access roads, could result in additional mitigation requirements. Details for each of these three main categories are summarized below.

- Biological Mitigation; general preconstruction surveys, San Joaquin Kit Fox pre-construction surveys, worker environmental awareness training (WEAT), environmental compliance monitoring during construction, fish salvage during canal tie-ins, and compensatory mitigation for San Joaquin Kit Fox.

- Cultural Mitigation; data recordation and mitigation for above-ground bridges and the FKC, WEAT, Construction monitoring for archeological and paleontological resources, and tribal monitoring in the vicinity of Deer Creek and White River.

- Air Quality Mitigation; preparation of a fugitive dust plan, and Voluntary Emission Reduction Agreement (VERA) with the San Joaquin Valley Air Pollution Control District.

Table 6-8 provides a budget estimate for each of the cost elements listed above, grouped into the three main categories. The following assumptions were used in developing these cost estimates:

- Construction monitoring for cultural resources, tribal resources, San Joaquin Kit Fox, and other biological resources for 3 years

- San Joaquin Kit Fox compensatory mitigation approach similar to the California High Speed Rail Project. Mitigation ratios of 2.0 to 1 for natural habitat; .and 0.1 to 1 for developed habitat.
- San Joaquin Kit Fox compensatory mitigation cost $15,000 per acre
- VERA approach similar to Reclamation's 2017 Reach 2B Mendota Pool Bypass Project

Table 6-8 Estimated Environmental Mitigation Cost

Item	Cost Estimate
Biological Mitigation	
General Pre-construction surveys	$133,000
San Joaquin Kit Fox pre-construction surveys	$1,464,000
WEAT	$20,000
During-construction compliance monitoring	$3,337,000
Fish Salvage	$279,000
Compensatory San Joaquin Kit Fox mitigation	$13,895,000
Subtotal, Biological Mitigation	**$19,128,000**
Cultural Mitigation	
Data recordation and mitigation for above-ground bridges and the FKC,	$150,000
WEAT	$20,000
Construction monitoring for archeological and paleontological resources	$2,246,000
Tribal monitoring in the vicinity of Deer Creek and White River	$1,123,000
Subtotal, Cultural Mitigation	**$3,539,000**
Air Quality Mitigation	
Fugitive dust plan	$100,000
VERA	$6,000,000
Subtotal, Air Quality Mitigation	**$6,100,000**
Total Estimated Mitigation Cost	**$28,767,000**

Economic Feasibility

As discussed in Chapter 5 the monetary benefits of the Feasibility Alternatives were determined using a 100-year planning horizon, that anticipates the regional subsidence will continue to cause a decrease in capacity of the FKC. The benefits of the Feasibility Alternatives presented in Chapter 5 are based on the differences in the delivery reduction in comparison to the No Action Alternative. The Recommended Plan is a design refinement of the Parallel Canal Feasibility Alternative that resulted in lower costs without reducing the estimated benefits. Table 6-9 shows the planning horizon analysis for the Recommended Plan. Computations are made for each year in the planning horizon. For ease of presentation, the tables report annual results for years 1 through 10 and then every decade following until year 100, the end of the planning horizon. The table provides the net present value of reduced water supply over the planning horizon.

A summary of benefits associated with water deliveries and costs of the Recommended Plan is provided in Table 6-10. As shown in Table 6-9, the calculated B-C ratio for the Recommended Plan is 2.0.

Table 6-9. Recommended Plan Horizon Analysis

Year	Average Annual Deliveries (TAF)	Average Annual No Action Affected Water Supply (TAF)	Reschedule in Millerton (TAF)	Percent Groundwater Pumping (%)	Assumed Groundwater Pumping (TAF)	Average Annual Reduction in Supply (TAF)	Value of Water Lost ($M)	Groundwater Pumping Cost ($M)	Annual Value of Water ($M)
1	410.2	41.3	15.6	90%	23.2	2.6	$271	$221	$5.8
2	408.2	46.1	17.3	80%	23.0	5.8	$271	$224	$6.7
3	406.2	50.9	19.0	70%	22.3	9.5	$271	$226	$7.6
4	404.2	55.6	20.8	60%	20.9	13.9	$271	$229	$8.6
5	402.2	0.0	0.0	50%	0.0	0.0	$271	$229	$0.0
6	400.2	0.0	0.0	40%	0.0	0.0	$271	$229	$0.0
7	398.2	0.0	0.0	30%	0.0	0.0	$271	$229	$0.0
8	396.2	0.0	0.0	20%	0.0	0.0	$271	$229	$0.0
9	394.2	0.0	0.0	10%	0.0	0.0	$271	$229	$0.0
10	392.2	0.0	0.0	0%	0.0	0.0	$271	$229	$0.0
20	392.2	0.0	0.0	0%	0.0	0.0	$271	$229	$0.0
30	392.2	0.0	0.0	0%	0.0	0.0	$271	$229	$0.0
40	392.2	0.0	0.0	0%	0.0	0.0	$271	$229	$0.0
50	392.2	0.0	0.0	0%	0.0	0.0	$271	$229	$0.0
60	392.2	0.0	0.0	0%	0.0	0.0	$271	$229	$0.0
70	392.2	0.0	0.0	0%	0.0	0.0	$271	$229	$0.0
80	392.2	0.0	0.0	0%	0.0	0.0	$271	$229	$0.0
90	392.2	0.0	0.0	0%	0.0	0.0	$271	$229	$0.0
100	392.2	0.0	0.0	0%	0.0	0.0	$271	$229	$0.0
								Net Present Value	$28

Table 6-10. Benefit Cost Analysis of Recommended Plan

Item	Recommended Plan
Value of reduced water delivery in the No Action Alternative[1,2]	$923
Value of reduce water delivery in the Project Alternative[1,2]	$28
Net Benefit[1,2]	$895
Net Present Value of Total Capital and Life Cycle Costs [1,3]	$451
Cost Range of Net Present Value of Total Capital [1,4]	($375 - $527)
B-C Ratio[5]	2.0

Notes:
[1] All costs are in millions of dollars
[2] Net Present Value based on 100-year project life
[3] Construction Cost of Initial Alternatives
[4] +/- 25% applied to field cost
[5] B-C Ratio based on Net Present Value of Total Capital and Life Cycle Costs (Total Construction Cost + IDC + OM&R)

Financial Feasibility

Financial feasibility consists of examining and evaluating project beneficiaries' ability to pay their allocated portion of the Recommended Plan, consistent with applicable law. Funding for the Project is expected to be derived from Federal and non-Federal sources. On the basis of WIIN Act authorizations, the Project is eligible for Federal funding of up to 50 percent of Project costs. FWA has been pursuing and evaluating multiple sources of funding to provide the non-Federal cost share, including potential funding from the State of California and financing through the FWA or member agencies. A summary of Federal and non-Federal funding under the SJRRS Act and the WIIN Act is shown in Table 6-11.

Table 6-11. Eligible Project Funding

Authorization	Federal Funds	Non-Federal Funds	Total
SJRSS Act	$18,900,000	$0	$18,900,000
WIIN Act	$198,050,000	$198,050000	$396,100,000
Total	$216,950,000	$198,050000	$415,000,000

Risk and Uncertainty

As described above, the Recommended Plan is economically feasible. However, as also described above and in Chapter 5, several assumptions have been made that can affect estimated project benefits and the resulting B-C ratio. In the economic analysis of the Recommended Plan, most assumptions regarding uncertainty were made that would result in conservative (i.e. lower benefit) estimates. This section describes how uncertainty regarding assumptions could affect estimated project benefits and the B-C ratios of the Recommended Plan. The evaluations presented below provide a reasonable range of expected outcomes under uncertainty.

Future Water Value

The economic analysis of the Recommended Plan is based on the estimated current value of agricultural water in the eastern San Joaquin Valley (representative of the Friant Division of the CVP). These values were developed by the CWC in 2015 through application of the State-Wide Agricultural Production (SWAP) model based on CALSIM II simulations of CVP and SWP operations that reflect water rights, contracts, and regulatory requirements, and the continued unrestricted availability of groundwater. The CWC classified the values of water estimated under projected 2030 land-use conditions as current values. The economic analyses of the Recommend Plan applied the 2030 (current) water values on a constant basis throughout the 100-year planning horizon. This analysis assumes that water values would not increase in response to reduced water supply availability due to SJRRS and SGMA implementation, changes in commodity values, changes in irrigation technology, or other factors.

The value of surface water in the eastern San Joaquin Valley has increased over the past several years as the percentage of land planted to permanent crops has increased, irrigation technology improvements have been implemented, more land has been brought into production, surface water supply reliability in the San Joaquin Valley have decreased, the reliance on groundwater has grown, and groundwater depth has increased. As described in Chapter 1, the State of California enacted SGMA in 2014, which requires the development and implementation of sustainable groundwater management practices. SGMA mandates that GSPs be developed by 2020 and groundwater sustainability be achieved by 2040 for "high priority basins". The entire Friant Division of the CVP overlies groundwater basins that are designated as "high priority basins", therefore it is expected that full SGMA compliance in the eastern San Joaquin Valley will be achieved by 2040. It is expected that water values in the eastern San Joaquin Valley will change over time in response to changes in water supply availability, particularly in response to SGMA implementation, because groundwater use will be limited to amounts that do not cause undesirable effects such as additional subsidence.

In 2015, the CWC also prepared estimates of future agricultural water value in California based on the same land uses, water rights, contracts and regulatory requirements as those included in the 2030 analysis, plus assumed groundwater availability limitations due to SGMA implementation. The resulting values are significantly greater than those based on 2030 conditions. While it is not certain that actual water values will result as projected, these estimates provide an indication of the potential future value of agricultural water supply in the eastern San Joaquin Valley once SGMA compliance is achieved. A comparison of 2030 (non-SGMA) and 2040 (with SGMA) values is provided in Table 6-12. For the economic analysis of the Recommend Plan, the 2030 values provided by the CWC in 2015 were escalated to a 2018 price level using once the U.S. Bureau of Economic Analysis GDP Deflator. The same escalation was applied to the 2040 values for use in this uncertainty analysis.

Table 6-12. Estimated Water Values in the Eastern San Joaquin Valley

Year	Estimated Consumptive Use Water Value ($/AF)	
	2015 Price Level	2018 Price Level
2030	$256	$271
2040	$511	$540

Source: CWC WSIP Technical Reference Document

If the value of agricultural water in the eastern San Joaquin Valley increases from the current value of $271/af to $540/af by the year 2040 in the planning horizon analysis and then remained constant at that value for the remaining of the planning horizon with all other variables unchanged, the net benefits of the Recommended Plan would increase by $808M and the B-C ratio would increase to 3.8.

Date Future Subsidence Stops

The economic analysis of the No Action Alternative and Recommended Plan is based on a projection of continued subsidence in response to gradually reduced groundwater pumping between 2018 and 2040 to levels that achieve SGMA requirements. The groundwater model simulations, which were based on a range of pumping reductions to achieve SGMA compliance by 2040, show that subsidence would continue at a generally consistent rate through 2030, then slow between 2030 and 2040 when actions to achieve SGMA requirements would be fully implemented. Groundwater model results also reveal that additional land subsidence would continue through 2070 as a result of residual consolidation of subsurface formations. As noted previously, GSAs in the region are in the process of developing their SGMA compliance plans and therefore is not precisely known how regional subsidence would occur.

If land subsidence occurs as projected from 2018 to 2040 and no additional subsidence occurs after 2040 and all other variables remain unchanged, the net benefits of the Recommended Plan would decrease by $104M and the B-C ratio would decrease to 1.8.

Design for Projected Future Subsidence

All analysis of the Recommended Plan is based on a 2018 topography and assumes the project will be built to the design capacity based on that ground surface. The analysis also included an evaluation of costs and required land acquisition of the Recommended Plan based on providing the design capacity at projected land conditions in the year 2040, based on land subsidence estimates developed using the groundwater analysis described above. The total increase in costs to accommodate future subsidence in the Recommended Plan is estimated at an additional $48M.

If the Recommended Plan includes features to provide the design capacity at the projected future land surface in 2040 and all other variables remain unchanged, the net benefits of the Recommended Plan would remain unchanged and, due to the increase in total construction cost, the B-C ratio would decrease to 1.8.

Millerton Reoperation

The economic analysis of the Recommended Plan assumes that affected water supplies could be rescheduled in Millerton Lake to subsequent months when the Friant Division contractor has sufficient water demand and capacity is available in the FKC. The only constraint applied to this operational assumption in the Recommended Plan was that the reoperation of affected water supply in Millerton Lake could not affect existing flood control requirements and operations. The analysis did not consider potential limitations to storing Class 2 water in Millerton Lake longer than the contractual maximum of 30 days. The analysis also assumes that water users could increase the use of non-CVP water supplies when canal capacity limits deliveries and would have perfect foresight of hydrologic conditions to predict when such changes would be required. Due to these assumptions, the analysis likely overestimates the amount of affected water supply that could be rescheduled, and therefore likely underestimates the water supply impact of the No Action Alternative. While it is not possible to precisely estimate the extent to which water users and Reclamation could optimize the use of Millerton Lake and the FKC to reschedule allocated water supplies, it is expected that no more than 70 percent of the affected water supply could be available for rescheduling in Millerton Lake and delivery in any given month.

If the amount of affected water supply that available be rescheduled in Millerton Lake is limited to 70 percent and all other variables remain unchanged, the net benefits of the Recommended Plan would increase by $121M and the B-C ratio would increase to 2.3.

Construction Duration Due to Funding Availability

The economic analysis of the Recommended Plan assumes a construction duration of four years, and the availability of funding to enable uninterrupted construction of all plan features. In the economic analysis, this assumption is reflected in the planning horizon analysis in the benefits provided by the project in the first three years and costs associated with construction and IDC. If the availability of funds is delayed, the rate of construction would be reduced, and the duration of construction would increase.

If availability of funding to implement the Recommended Plan required that the construction duration increase from three years to six years all other variables remain unchanged, the net benefits of the Recommended Plan would decrease by $19M and the B-C ratio would decrease to 1.95.

Reduced Deliveries in the Subsidence Section of the Canal

As described in Chapter 2, the reduced capacity of the FKC caused by subsidence limits flows can be conveyed for downstream deliveries, resulting in reduced water supplies to downstream Friant Division long-term contractors. The benefits of the Recommended Plan are based on avoiding reduced downstream deliveries that would occur in the No Action Alternative. In addition, subsidence in the Middle Reach of the FKC has decreased, and will further decrease, available head (water level) at water turnouts in the subsided reach and in some upstream portions of the FKC. The water diversion capacity of up to 6 gravity turnouts downstream from

Tule River Check Structure and the upstream from Deer Creek Check Structure is reduced and will further decline in the No Action Alternative as subsidence continues. It is likely that modifications would be required to some or all of these gravity turnouts to maintain continued delivery of allocated CVP contract supplies. While specific improvements have not been evaluated, or valued, it is expected that temporary permanent, pumps would be installed to assure access to contract water supplies. The timing of pump installation and use in the No Action Alternative would depend on site specific conditions for each contractor and CVP water supply availability. The Recommended Plan will return the HGL to restore the ability of these turnouts to deliver water at their designed capacity. If the reduced deliveries immediately upstream of the subsided section of the canal were valued, the quantified benefits of the Recommended Plan would be greater than those presented in this Report.

Summary of Risk and Uncertainty Findings

A summary of risk and uncertainty factors on project costs and benefits is provided in Table 6.13. Although the identified risk and uncertainty factors have the potential to increase or decrease project costs and benefits, none have been identified that could be expected to reduce the benefit cost ratio to less than one.

Table 6.13. Summary of Risk and Uncertainty Effect on Economic Feasibility of the Recommended Plan

Risk and Uncertainty Factor	Change in Net Benefits from Recommended Plan ($M)	Benefit-Cost Ratio Based on Risk and Uncertainty Factor
Recommended Plan	No change	2.0
Potentially Greater Future Water Value	808	3.8
Potential Less Future Subsidence	-104	1.8
Project Design for Projected Future Subsidence	No change	1.8
Ability to Operate Affected Water Supply in Millerton Lake	121	2.3
Potential Extended Construction Duration Due to Funding Availability	-19	2.0
Reduced Water Deliveries in the Subsided Portion of the FKC	Increase – not quantified	Increase – not quantified

Implementation Requirements

Implementation of the Recommended Plan would include major activities for design, environmental compliance and permitting, land acquisition, financing, and construction and O&M. It is anticipated that FWA would to lead all of these activities in close coordination with Reclamation. A schedule for implementation is shown in Figure 6-6, and brief descriptions of major activities is provided in the following sections.

Design Activities

FWA, in coordination with Reclamation, has begun to advance design of the Recommended Plan. This will include several the following key steps:

- DEC Review of the Recommended Plan
- Preparation of a 30 percent design report
- Geotechnical investigations to support final design
- Preparation of 60 percent, 90 percent, and 100 percent designs
- Establishing agreements with key project partners and stakeholders (e.g. Tulare County, SCE, So Cal Gas, Kern County) related to planning design, and construction activities.
- Preparing detailed plans, specifications, and bid packages.

Environmental Compliance and Permitting

Reclamation is initiating environmental compliance and permitting activities, in coordination with the FWA, to conduct and complete required NEPA and CEQA environmental compliance and all necessary permitting before implementation of the Project. Several key activities include the following:

- Required environmental compliance under NEPA and CEQA will involve preparation of a joint EIS/EIR document and issuance of a Record of Decision (ROD) and Notice of Determination (NOD), on the following schedule:
  - Notice of Intent/Notice of Preparation (NOI/NOP) - November, 2019
  - The Draft EIS/EIR release for public review - late January/early February, 2020
  - The Final EIS/EIR released to public - May, 2020
  - The Record of Decision (ROD) - October 2020

- Permitting requirements of Federal, state, and local laws, policies and environmental regulations.
- Implementation of mitigation measures may proceed before, or consistent with construction of project physical features.

Land Acquisition

Following completion of NEPA and CEQA compliance requirements, FWA would initiate activities in coordination with Reclamation to complete the acquisition of required lands, easements, and ROW.

Financing

Funding for the project would be obtained through Federal appropriations and non-Federal sources prior to the initiation of construction. If all project funds are not available at the time of construction initiation, the Project would be segmented into construction packages that could be accomplished with available funding to address the most urgent capacity correction portions of the Project.

Project Construction and Transfer to O&M Status

After the completion of environmental compliance and permitting, design, land acquisition, and financing, project implementation efforts would transition to the preparing and executing construction contracts, starting implementation of mitigation measures and/or construction activities, completing construction activities, commissioning new facilities, and finally, operating and maintenance responsibilities. FWA, in coordination with Reclamation, would solicit and award one or more construction contracts based that can be accomplished with available funds and right of way. As shown in Figure 6-6, construction is estimated to occur over a 3-year period, assuming all necessary funding and right of way is available.

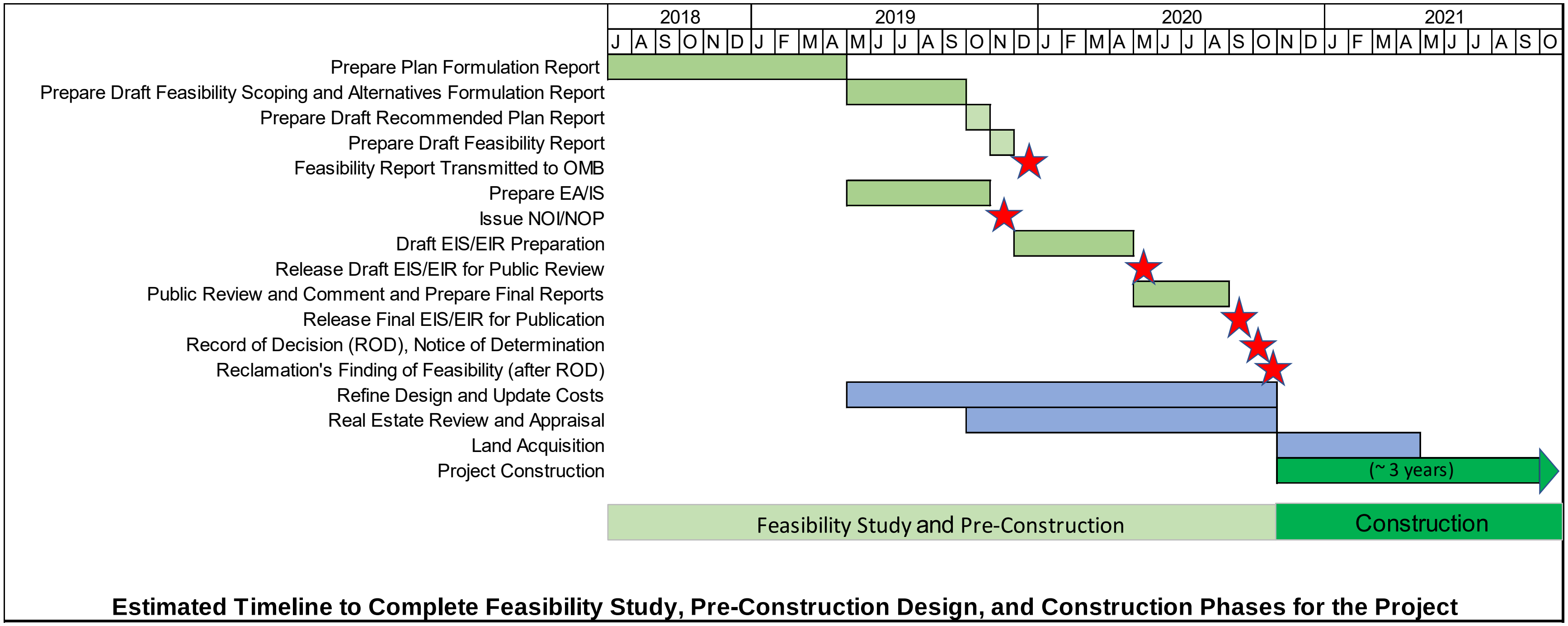

Figure 6-6. Friant-Kern Canal Middle Reach Capacity Correction Project Feasibility Study

Federal and Non-Federal Responsibilities

If a project is recommended for implementation, Federal and non-Federal obligations and requirements would be contained in a Project Cooperation Agreement (PCA).

Federal Responsibilities

If recommended for implementation, Reclamation would complete the required environmental analyses and documentation for NEPA. This includes other Federal laws, policies, and plans that may affect the implementation of any plan authorized for construction (e.g. Federal Endangered Species Act, National Historic Preservation Act Section 106). Reclamation would review and approve project designs, approve bid packages, approve the plan for Real Estate Acquisition, Administer Federal Funding, and monitor construction progress and closeout.

Non-Federal Responsibilities

Before implementation the FWA would perform items of local and state cooperation specific to the project. This would include the completion of environmental documentation for CEQA and acquiring relevant local and state permits. The FWA would also lead the completion of design of the project, acquire ROW, and obtain necessary non-Federal funding. In additional FWA would award construction contract(s), manage the construction of the project. Once completed FWA will continue with long-term O&M requirements as agreed upon with Reclamation.

Chapter 7 Findings

This Study includes development, evaluation, and comparison of alternatives consistent with the Federal PR&G (CEQ 2013). In coordination with this report, a Final EIS/R will be prepared consistent with NEPA and CEQA. This chapter summarizes major findings and conclusions of this Study.

Need for Project

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.

Recommended Plan

As required by the PR&G, the plan that produces the greatest net public benefit is identified as the Recommended Plan and is typically selected for recommendation to the Secretary of the Interior for consideration and approval (CEQ 2013). The identification of the Recommended Plan based upon the evaluation and comparisons described in Chapter 5. The Recommended Plan is described in detail in Chapter 6 and summarized below.

Recommended Plan Major Components

Major components of the Recommended Plan include:

- **Canal Enlargement** — The existing canal would be enlarged by raising the lining one to four feet from MP 88.2 to MP 95.7 and MP 119.0 to MP 121.5.
- **Canal Realignment** — A new realigned 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. The realignment would stretch from MP 96.3 to MP 115.94.
- **Turnouts** — The approach to the turnouts varies by location and configuration. Turnouts in the canal enlargement portion would not be modified. In the canal realignment portion gravity turnouts would be replaced and new delivery pool turnouts would be constructed for pressurized turnouts along the canal realignment potion.
- **Checks and Siphons** — New or replacement check structures, wasteways and siphons would be required at the Deer Creek and White River crossings
- **Road Crossings** — Road crossings would either be left in place or replaced with a concrete box siphon, depending on the location.
- **Utilities** — Depending on the location and extent of canal modifications, the utilities like overhead power lines, adjacent wells, and elevated pipeline canal crossings would either be relocated or entirely replaced.

Costs and benefits

A summary of the B-C analysis is presented in Table 7-1 below.

Table 7-1. Benefit Cost Analysis of Recommended Plan

Item	Recommended Plan
Value of reduced water delivery in the No Action Alternative[1,2]	$923
Value of reduce water delivery in the Project Alternative[1,2]	$28
Net Benefit[1,2]	$895
Net Present Value of Total Capital and Life Cycle Costs [1,3]	$451
Cost Range of Net Present Value of Total Capital [1,4]	($375 - $527)
B-C Ratio[5]	2.0

Notes:
[1] All costs are in millions of dollars
[2] Net Present Value based on 100-year project life
[3] Construction Cost of Initial Alternatives
[4] +/- 25% applied to field cost
[5] B-C Ratio based on Net Present Value of Total Capital and Life Cycle Costs (Total Construction Cost + IDC + OM&R)

Feasibility of the Recommended Plan

Feasibility of the Recommended Plan is summarized below.

- The Recommended Plan was found to be technically feasible and constructible. The Recommended Plan could be implemented with a balance or surplus of material. Designs and cost estimates for the Recommended Plan have been developed to a feasibility-level and will be verified through the DEC Review process.

- The Recommended Plan was found to be economically feasible on the basis that monetized benefits for avoided water supply shortages exceed project costs. As evaluated in this report, Recommended Plan produces a B-C ratio of 2.0.

    - The B-C ratio was calculated using a planning horizon benefits analysis over the project service life of 100 years, and feasibility-level construction costs, IDC, and, life cycle costs.

    - Regional subsidence is expected to continue and cause a decrease in the capacity of the FKC in the No Action Alternative and the performance of the Recommended Plan. Benefits of the Recommended Plan are based on differences in delivery reduction value, or avoided water shortages, in comparison to the No Action Alternative.

- Environmental compliance and permitting processes are under way. An environmental constraints analysis and EA/IS were prepared and an EIS/R is in development. Cultural and biological resources analysis are ongoing and will be incorporated into the EIS/R. The Record of Decision for the EIS/R is anticipated for October 2020.

- More detailed environmental mitigation cost estimates for biological mitigation, cultural mitigation, and air quality mitigation have been developed and incorporated into the cost estimate for the Recommended Plan.

- Funding for the Project is expected to be derived from Federal and non-Federal sources, potentially including the WIIN Act and financing through FWA member agencies.

Risks and Uncertainty

- The design of features in the Recommended Plan is based on the surveyed land surface in 2018. Because additional subsidence is expected to occur in the region over the next several years while compliance with SGMA is achieved, the design for Recommended Plan was evaluated based on a projected land surface in 2040. The resulting design based on 2040 land surface would increase the cost of the Recommended Plan by approximately $48 million and reduce the B-C ratio to 1.8.

- The effect of uncertainty on net benefits and the B-C ratio resulting from several factors, such as future water value, the date subsidence would stop, reoperation of affected water deliveries in Millerton Lake, and lengthened construction duration was evaluated. The resulting B-C ratios would range from 1.95 to 3.8.

- The performance of the Recommended Plan was evaluated using historical operations and does not consider potential future water deliver requirements that could exceed historical peak flows in the FKC. The net benefits and B-C ratio of the Recommend Plan would increase if future operational objectives include deliveries that exceed historical peak flows.

Federal Interest

This Report demonstrates Federal interest in the Recommended Plan. The Recommended Plan was identified as the NED Plan among two Feasibility Alternatives and produces a B-C ratio of 2.0. Federal participation for design and construction is authorized in Part III of the Settlement Act, and the Project is eligible for Federal funding pursuant to the WIIN Act.

Environmental Compliance and Regulatory Requirements for Project Implementation

The Final EIS/R will satisfy NEPA and CEQA requirements by providing a meaningful analysis of all issues relevant to the physical, biological, cultural and human environments. Implementation of the Recommended Plan will also be subject to additional Federal, State, and local laws, policies, and environmental regulations. All Federal, State, and local agencies with permitting or approval authority over any aspect of project implementation will be expected to use the information that will be included in the Final EIS to meet most, if not all, of their information needs, to make decisions, and/or issue permits with respect to the authorized project.

Findings

The following findings are made based on the evaluation of Feasibility Alternatives:

- The Recommended Plan has been found to be technically and economically feasible, and appears to be environmental feasible based on evaluations completed to date in support of NEPA compliance and permitting. Financial feasibility will be determined as Federal and non-Federal financing is identified.

- Uncertainty evaluations have demonstrated that the B-C ratio would remain greater than one under a variety of potential conditions that could affect costs and benefits of the Recommended Plan.

- Implementation of the Recommended Plan would restore the ability of the FKC to convey flood waters during wet periods and implement provisions of the Water

Management Goal as described in Paragraph 16 of the San Joaquin River Restoration Settlement. The restored capacity of the FKC would avoid water shortages, and resulting reduced revenue, associated with delivery of water under long-term Friant Division contracts, the Recovered Water Account (RWA), Unreleased Restoration Flows (URFs) and other available water supplies.

- Restoring the capacity of the FKC would support greater conjunctive management of Friant Division resulting in increasing groundwater storage and improved management of Friant Division water supplies in Millerton Lake.

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Chapter 8 Recommendations

This section presents describes recommendations for action by the Secretary or through Congressional action in support of implementing the Recommended Plan and identifies Federal and Non-Federal roles for implementing the Recommended Plan.

Recommendations

As the Recommended Plan is being reviewed for Congressional recommendation and appropriations, the following items should be considered:

- Approve the Recommended Plan, as described in this Report.
- Allow Reclamation to increase the construction cost to allow for escalation from stated price levels (2018) to the notice to proceed for each contract or work package, based upon Reclamation's Construction Cost Trends publication, or similar source.
- Appropriate funds such that pre-construction activities are completed within 2 years and construction is completed within 3 years following construction initiation to avoid cost overruns and ensure timely completion.
- Allow the Federal Government to accept title to any non-Federal property within the Project boundaries.

Federal Role

Under the Recommended Plan, the Federal Government would have the following roles and responsibilities:

- Complete a Final EIS, all federal permitting, and prepare a ROD.
- Identify Federal funding requirements
- Review and approve Project designs, environmental compliance and permitting documentation, and land acquisition services proved by FWA
- Perform DEC review of the Recommended Plan
- Perform value engineering and constructability review of Project design documents

- Review and approval of construction bid packages and selection of a construction contractor.
- Provide administrative and technical support during planning, design, and construction.
- Accept transferred title of acquired lands and constructed Project.

Non-Federal Role

Under the Recommended Plan, the following roles apply to non-Federal entities:

- Complete investigation and design of all project facilities, including mitigation requirements.
- As the CEQA lead, FWA would complete a final EIS/R and all state permitting.
- Acquire lands necessary for implementation of the Recommended Plan.
- Construct all project facilities.
- Transfer acquired lands and constructed facilities to Reclamation.

Chapter 9 References

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LETTER F

LSID

LETTER F

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

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

To: Directors and Staff of the Referenced Groundwater Sustainability Agencies

Lindsay Strathmore Irrigation District supports the comment letter dated December 16, 2019, submitted on behalf of Friant Water Authority concerning your Groundwater Sustainability Plans (GSP) for the Tule Subbasin. By and through this letter, the District adopts each comment and objection in that letter as its own, along with any exhibits or attachments to that letter, and incorporates herein by this reference all such comments, objections, and documents. F-1

The District specifically wants to emphasize the importance of addressing and resolving the ongoing subsidence issues with the Friant-Kern Canal that are caused or exacerbated by groundwater pumping in the Tule Subbasin. Allowing for three (3) additional feet of subsidence along the Friant-Kern Canal is unacceptable without adequate mitigation. Nor is it acceptable to further handicap this issue by requiring more than 50% of the seven (7) monitoring sites to show three (3) feet of subsidence before considering this matter an undesirable result. To prevent further water supply loss and economic injury to the Friant Contractors, the District urges you to meaningfully address and resolve the issue of subsidence in your GSPs, including undertaking the actions suggested by Friant Water Authority. F-2

Sincerely,

Craig N. Wallace
General Manager
Lindsay-Strathmore Irrigation District

cc. LSID Board of Directors
Friant Water Authority
District Legal Counsel

LETTER G

TULARE COUNTY

LETTER G

Tri-County Water Authority Draft GSP - summary of GY notes

Draft Copy	County Notes	
Pg ES-2. TCWA is predominantly irrigated and dryland agriculture. However, there are two small rural disadvantaged communities that depend on groundwater. • Allensworth State Park – population of about 600 persons. • "West of Earlimart" is a small community of 1 to 2.5 – acre parcels with an estimated population of less than 500 persons. • Additionally, there are a number of farmsteads scattered throughout the GSA that are dependent on groundwater.	The County anticipate growth in both of these 'communities'. The comments in this GSP are focused on the potential to impact domestic users, especially if the GSP anticipates continued lowering of gw while it attempts to become sustainable.	G-1
Pg ES-13. First paragraph. Convert lower aquifer pumping to upper aquifer pumping. This project involves drilling wells into the lower aquifer to replace the capacity of existing wells that are pumping from the lower aquifer. This will reduce land subsidence.	This should say 'upper aquifer' as the plan is to stop pumping from the lower aquifer.	G-2
Pg 7. Groundwater Basins - Areas Managed by TCWA. ... The largest community in TCWA is Allensworth, located in the Colonel Allensworth State Park, with a population of less than 500. Allensworth Community Services District serves domestic water to the community via two municipal wells.	There may be impacts caused to these wells. As noted, the south management area expanded significantly with pistachios and is highly reliant on gw. This will be transitioned during the implementation period, but there is potential risk to these wells in the meantime.	G-3
Pg. 11 1.4-4 LAND USE DESIGNATIONS [354.8(a) (4)] "The community of Allensworth in Tulare County is designated Hamlet Development and is within the Allensworth State Park."	The General Plan Land Use designation in Allensworth is "Mixed Use" as designated in the adopted Allensworth Hamlet Plan. Recommend modifying Figure 1.4.5 (Existing Land Use Designations) in the GSP to show Allensworth as "Mixed Use." The adopted Allensworth Hamlet Plan Hamlet Development Boundary (HDB) contains 1,051 acres and is larger than the Allensworth State Park. If you choose to reference General Plan Figure 4-1 and reference the Regional Planning Framework, Land Use Designations and Boundaries Legend, the terms, "Hamlet	G-4

	Development Boundaries" and "Urban Development Boundaries" should be utilized.	G-4
Pg 11. 1.4-5 WELLS AND WELL DENSITY [354.8(a) (5)] Figure 1.4.6 shows the density of wells per square mile and the general distribution of agricultural, industrial and public water supply wells. The community of Allensworth is the sole community dependent on groundwater in the TCWA. Groundwater use is minimal in Allensworth, averaging about 100 acre-feet annually.	This is minimal, but there is potential for the well to go dry due to continued groundwater level declines.	G-5
Pg 21. Table 1.4.1 **Water Supply and Water Use for TCWA**	This table should include rural domestic groundwater users. While there are very few and with nominal use, there are some (e.g. the 1+ ac parcels west of the town of Earlimart in the northeast part of the South Management Area).	G-6
Pg 27. 1.4.6-1 GENERAL PLANS SUMMARY [§354.8(f)(1)] The general plan designation for the majority of the lands within TCWA is Agriculture. The only urban lands in the TCWA are those of the Colonel Allensworth SHP - which houses about 500 residents. The State Park is served by wells that are operated by the Allensworth Community Services District.	Does the County foresee any growth in this area in its GP? The adopted Allensworth Hamlet Plan Hamlet Development Boundary (HDB) contains 1,051 acres and is larger than the Allensworth State Park. The Year 2015 baseline population and was determined by projecting the 2015 American Community Survey (Survey) data population by an annual growth rate of 1.3% annually. The Survey indicated that in year 2013 the community had 132 dwelling units (including vacant dwellings) with a population of 565. At an annual growth rate of 1.3%, the projected housing units are 141 and 160 in years 2020 and 2030, respectively, and projected population is 603 and 683 in Years 2020 and 2030, respectively. (Page 63 Adopted Allensworth Hamlet Plan.)	G-7
Pg 36. Allensworth. In 1912, Allensworth had a population of 300 persons. Today Allensworth has an estimated population of nearly 600 persons. In the 1960's the state of California discovered high levels of arsenic in the drinking water, which caused most of the residents to leave, with only 34 remaining.	Was the arsenic issue addressed through the CSD? Please see the following report: https://www.waterboards.ca.gov/	G-8

In 1976 the California State Parks and Recreation Commission approved plans to develop the Colonel Allensworth State Park. Today the Allensworth Community Services District provides water to the community. The District's service area is approximately 800 acres and comprises 146 households, one school, and the State Park. The District was formed in 1981 with assistance from Self Help Enterprises.	centralvalley/water_issues/ enforcement/rf_annual_sep_rpt_2018.pdf Page 5 **Center for Race Poverty & the Environment** ***South San Joaquin Valley Watershed Improvement Programs: Promoting Community Participation*** **$215,000 | 24 months** *Region: Fresno* ACL Order R5-2016-0535 Many communities in the South San Joaquin Valley (Allensworth, Alpaugh, Arvin, Delano and Lamont) face significant drinking water contamination from arsenic and nitrates, suffer from poor water quality and are faced with expensive treatment options. Lower water tables resulting from the CA drought pull in higher levels of nutrients like arsenic and nitrate from ground water, affecting well water and other sources of potable water. Through this project CRPE provided fact sheets and information to community residents on common contaminants found in Valley water supplies such as nitrates and arsenic. CRPE also trained community residents on possible solutions and treatment options to prevent future contamination and clean-up existing contamination. They worked with three predominately low-income communities of color in the San Joaquin Valley: Arvin, Lamont, and Allensworth, and secured several water benefits: • Engaged in 5 monthly meetings on water projects, water issues and capacity building. • Helped communities increase access to funding technology, and technical experts to help improve water quality in three San Joaquin Valley Communities. • Helped communities oversee the construction and testing of five new wells to ensure they achieve community goals for safe, clean, affordable drinking water. Page 80. Allensworth: The water is good from most of the wells at this point. There are still old wells that have arsenic contamination.	G-8

	The Water District is looking at a site to do a test well there, but the problem is that this is the site is protected under the Endangered Species Act. We worked with the State to get necessary permission to do a test well and Self-Help Enterprises found the water was potable. The Water District will need the State's permission to dig a permanent well. We will continue to work with the community to secure the necessary permits to drill permanent drinking water wells. CRPE held meetings at the end of 2018 to educate residents about the Endangered Species Act, as well as drinking water standards and requirements. We have been working with the Agricultural Sustainability Institute (ASI) at UC Davis to examine a pilot project to test technology that removes arsenic from the water. This technology has been used in India and is being replicated for testing in the US. They demonstrated the technology is successful by removing arsenic from a private well in Allensworth. There is the possibility of the community receiving a $10,000 for new projects as part of this demonstration. We are working with the Allensworth Progressive Association to conduct three trainings on arsenic contamination impacts and possible treatment options as part of this pilot project. We also provided one training to the community on Prop 218 to help the community prepare to participate in discussions around proposed water rate increases.	G-8
Pg 37. First paragraph. gpm. The well has an arsenic concentration of 11 – 14 ppb, and as such, is just above the newly-adopted arsenic mcl of 10 ppb. Well Number 2 was constructed in 1998-1999 to a depth of 315 feet, perforated from 100-150 feet, 170-240 feet, and 270-305 feet in depth. It is sealed from 90 feet in depth to the surface, produces 130 gpm, with an arsenic concentration of 7-14 ppb. However, with a bottom cement seal installed in 2015, from 260 feet to the bottom,	Is this future project identified in anybody's budget? Seems like the potential for the GSA's approach to transition to less gw use over time, while causing some continued lowering of gw levels, would be a good time to get this project done (deeper well, maybe with well-head treatment?).	G-9

arsenic concentrations have remained below 10 ppb. A future project includes construction of a new well to replace Well Number 1 and addition of a 500,000-gallon storage tank in the community. See discussion on water quality in KDSA HCM, page 38.		G-9
Pg 37. West of Earlimart. There were only two wells for which some water quality information was available, the owners of which had taken advantage of the County's offer to run water quality tests for new wells at no charge. Most of the wells in the community are around 200 feet in depth, which puts them above the Corcoran clay (refer to Figure 2.1.2 "Depth to the Top of the Corcoran Clay" – KDSA HCM). From a site visit in early August 2019, this rural community appears to be a severely disadvantaged community and would benefit from a study to determine the current water quality conditions and a feasibility study to determine if the community would benefit from a community water system. Discussions with Self Help Enterprises of Visalia and the Tulare County Environmental Health Department indicated that such a study would be given consideration for grant funding. This will be explored during the first five years of the implementation period.	The County supports a study by the GSA to look into such a system, as it could mitigate potential impacts to individual wells and improve water quality. As per Self Help Enterprises, Allensworth's course of action is to drill a new well and construct additional water storage. They've got a well site and are working on finalizing a tank location. A test well has been drilled and the recommendation is to go ahead with a production well at that location. This has all been funded by a planning grant from SWRCB. When the design phase wraps up, Self-help will help the CSD to pursue construction as per the CSD's Preliminary Engineering Report. The CSD has recently completed a Prop 218 process to adjust their water rates, They have applied for a wastewater planning grant from SWRCB, but haven't yet been funded.	G-10
Pg 279. Item 5. Landowner-sponsored Groundwater Recharge Project: The Prosperity Farms Project This project has been initiated by a landowner located within TCWA's Southeast Area. It involves developing a recharge area in the northeast portion of the Southeast Area (see Figure 5.2.2). The plan is to capture excess runoff and floodwaters for recharge. The area has been identified as one of the areas that have potential for recharge, as it is in the vicinity of White River, and permeabilities are indicated to be acceptable.	It is not clear how this project involves or affects the CSD's wells serving Allensworth. The description provides no referense to the CSD, yet the Figure seems to show CSD wells.	G-11

LETTER H

HFS

Hancock
Farmland
Services

A Manulife Investment Management Company

LETTER H

Ms. Deanna Jackson

October 7, 2019

Tri County Water Authority
944 Whitley Avenue, Suite E
Corcoran, CA 93212

Dear Ms. Jackson,

Hancock Farmland Services (HFS) would like to thank you for your efforts in producing the Tri-County Water Authority Public Draft Groundwater Sustainability Plan (GSP). In an effort to bolster the Draft GSP we provide the following comments:

1) In the event an allocation of groundwater is contemplated, HFS encourages the GSA to initiate a stakeholder-driven process to develop a methodology for establishing landowner-level allocations of native yield that are coordinated across the basin. The allocation methodology should be consistent with various legal considerations drawn from applicable case law and attempt to be consistent with groundwater rights, recognizing that GSAs do not have statutory authority to make a final determination of water rights. An equal-per-gross acre approach to allocations is not likely to be consistent with established water rights doctrine, which must recognize many equitable considerations, in addition to acreage owned, to determine a legally defensible allocation. Further information regarding allocation methodology can be found in Groundwater Pumping Allocations Under California's Sustainable Groundwater Management Act – EDF and NCWL, dated July, 2018. H-1

2) HFS encourages the GSA to establish and implement a policy for generating groundwater credits from project development and implementation by landowners. We believe such a policy would provide the necessary business assurances for individuals and entities to fund research and development and projects, as well as equity and clarity amongst all landowners in the GSA. H-2

3) On Draft GSP page 285 states, "The plan is to address the 2040 deficit by 2030..." We believe this is a typographic error given that this is the only mention of 2030 targets and SGMA requires sustainability by 2040 (not 2030). The GSP should use the entire period (2020-2040) available to achieve sustainability in order to allow landowners to effectively plan and mitigate impacts that are expected to occur through implementation of the GSP. H-3

Sincerely,

Molly Thurman

Molly Thurman
Water Resource Manager
661 204 0568
mthurman@hnrg.com

LETTER I

TNC

The Nature Conservancy
Protecting nature. Preserving life.

CALIFORNIA WATER | GROUNDWATER

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nature.org
GroundwaterResourceHub.org

November 7, 2019

LETTER I

Ms. Deanna Jackson
Tri-County Water Authority
944 Whitley Avenue, Suite E
Corcoran, CA 93212

Submitted online via: email to djackson@tcwater.org

Re: Public Draft of the Tri-County Water Authority Groundwater Sustainability Plan for the Tule Subbasin

Dear Ms. Jackson,

The Nature Conservancy (TNC) appreciates the opportunity to comment on the Public Draft of the Groundwater Sustainability Plan (GSP) for the Tri-County Water Authority (TCWA) that is being prepared under the Sustainable Groundwater Management Act (SGMA). We understand that TCWA is a Groundwater Sustainability Agency (GSA) with jurisdictional areas within both the Tule and Tulare Lake Groundwater Subbasins of the San Joaquin Valley Groundwater Basin, and that this GSP addresses its jurisdictional areas within the Tule Subbasin.

TNC as a Stakeholder Representative for the Environment

TNC is a global, nonprofit organization dedicated to conserving the lands and waters on which all life depends. We seek to achieve our mission through science-based planning and implementation of conservation strategies. For decades, we have dedicated resources to establishing diverse partnerships and developing foundational science products for achieving positive outcomes for people and nature in California. TNC was part of a stakeholder group formed by the Water Foundation in early 2014 to develop recommendations for groundwater reform and actively worked to shape and pass SGMA.

Our reason for engaging is simple: California's freshwater biodiversity is highly imperiled. We have lost more than 90 percent of our native wetland and river habitats, leading to precipitous declines in native plants and the populations of animals that call these places home. These natural resources are intricately connected to California's economy providing direct benefits through industries such as fisheries, timber and hunting, as well as indirect benefits such as clean water supplies. SGMA must be successful for us to achieve a sustainable future, in which people and nature can thrive within the Tri-County Water Authority and California.

We believe that the success of SGMA depends on bringing the best available science to the table, engaging all stakeholders in robust dialog, providing strong incentives for beneficial outcomes and rigorous enforcement by the State of California.

Given our mission, we are particularly concerned about the inclusion of nature, as required, in GSPs. TNC has developed a suite of tools based on best available science to help Groundwater Sustainability Agencies (GSAs), consultants, and stakeholders efficiently incorporate nature into GSPs. These tools and resources are available online at GroundwaterResourceHub.org. TNC's tools and resources are intended to reduce costs, shorten timelines, and increase benefits for both people and nature.

Addressing Nature's Water Needs *in GSPs*

SGMA requires that all beneficial uses and users, including environmental users of groundwater, be considered in the development and implementation of GSPs (Water Code § 10723.2).

The GSP Regulations include specific requirements to identify and consider groundwater-dependent ecosystems (GDEs) [23 CCR §354.16(g)] when determining whether groundwater conditions are having potential effects on beneficial uses and users. GSAs must also assess whether sustainable management criteria may cause adverse impacts to beneficial uses and users, which include environmental uses, such as plants and animals. TNC has identified each part of GSPs where consideration of beneficial uses and users are required. That list is available here: https://groundwaterresourcehub.org/importance-of-gdes/provisions-related-to-groundwater-dependent-ecosystems-in-the-groundwater-s. Please ensure that environmental beneficial users are addressed accordingly throughout the GSP. Adaptive management is embedded within SGMA and provides a process to work toward sustainability over time by beginning with the best available information to make initial decisions, monitoring the results of those decision, and using data collected through monitoring to revise decisions in the future. Over time, GSPs should improve as data gaps are reduced and uncertainties addressed.

To help ensure that GSPs adequately address nature as required under SGMA, TNC has prepared a checklist (Attachment A) for GSAs and their consultants to use. TNC believes the following elements are foundational for 2020 GSP submittals. For detailed guidance on how to address the checklist items, please also see our publication, *GDEs under SGMA: Guidance for Preparing GSPs*[1].

1. Environmental Representation

SGMA requires that GSAs consider the interests of all beneficial uses and users of groundwater. To meet this requirement, we recommend actively engaging environmental stakeholders by including environmental representation on the GSA board, technical advisory group, and/or working groups. This could include local staff from state and federal resource agencies, nonprofit organizations and other environmental interests. By engaging these stakeholders, GSAs will benefit from access to additional data and resources, as well as a more robust and inclusive GSP.

2. Basin GDE and ISW Maps

SGMA requires that GDEs and interconnected surface waters (ISWs) be identified in the GSP. We recommend using the Natural Communities Commonly Associated with Groundwater Dataset (NC Dataset) provided online[2] by the Department of Water Resources (DWR) as a starting point for the GDE map. The NC Dataset was developed through a collaboration

[1]GDEs under SGMA: Guidance for Preparing GSPs is available at: https://groundwaterresourcehub.org/public/uploads/pdfs/GWR_Hub_GDE_Guidance_Doc_2-1-18.pdf

[2] The Department of Water Resources' Natural Communities Commonly Associated with Groundwater dataset is available at: https://gis.water.ca.gov/app/NCDatasetViewer/

between DWR, the California Department of Fish and Wildlife (CDFW) and TNC. We also recommend using GDE Pulse, which is also available on the internet at https://gde.codefornature.org/#/home. We also recommend using the California Natural Diversity Database (CNDDB) provided by CDFW to look up species occurrences within your area.

3. Potential Effects on Environmental Beneficial Users

SGMA requires that potential effects on GDEs and environmental surface water users be described when defining undesirable results. In addition to identifying GDEs in the basin, TNC recommends identifying beneficial users of surface water, which include environmental users. This is a critical step, as it is impossible to define "significant and unreasonable adverse impacts" without knowing *what* is being impacted. For your convenience, we've provided a list of freshwater species within the boundary of the Tule Groundwater Subbasin (Subbasin) in Attachment C. Our hope is that this information will help your GSA better evaluate the impacts of groundwater management on environmental beneficial users of surface water. We recommend that after identifying which freshwater species exist in your basin, especially federal- and state-listed species, that you contact staff at CDFW, United States Fish and Wildlife Service (USFWS) and/or National Marine Fisheries Services (NMFS) to obtain their input on the groundwater and surface water needs of the organisms on the GSA's freshwater species list. We also refer you to the Critical Species Lookbook[3] prepared by TNC and partner organizations for additional background information on the water needs and groundwater reliance of critical species. Since effects to plants and animals are difficult and sometimes impossible to reverse, we recommend erring on the side of caution to preserve sufficient groundwater conditions to sustain GDEs and ISWs.

4. Biological and Hydrological Monitoring

If sufficient hydrological and biological data in and around GDEs is not available in time for the 2020/2022 plan, data gaps should be identified along with actions to reconcile the gaps in the monitoring network.

TNC has reviewed the Tri-County Water Authority's public review draft GSP and appreciates the use of some our relevant resources in addressing GDE-related topics. However, we consider it to be inadequate under SGMA since key environmental beneficial uses and users are not adequately identified and considered. In particular, 1) ISWs and GDEs are not adequately identified and evaluated for ecological importance or adequately considered in the basin's sustainable management criteria, and 2) connectivity of ISWs and GDEs with the Shallow Zone and Upper Aquifer was not characterized. Please present a more thorough analysis of the 1) connectivity of the Shallow Zone and Upper Aquifer, and 2) identification and evaluation of ISWs and GDEs in subsequent drafts of the GSP. Once potential GDEs and ISWs are identified, they must be considered when defining undesirable results and evaluated for further monitoring needs until data gaps are filled in the future.

Our specific comments related to the Tri-County Water Authority's GSP are provided in detail in Attachment B and are in reference to the numbered items in Attachment A. Attachment C provides a list of the freshwater species located in the Subbasin. Attachment D describes six best practices that GSAs and their consultants can apply when using local groundwater data to confirm a connection to groundwater for DWR's NC Dataset. Attachment E provides an overview of a new, free online tool (i.e., GDE Pulse) that allows GSAs to assess changes in GDE health using satellite, rainfall, and groundwater data.

[3] Available online at: https://groundwaterresourcehub.org/sgma-tools/the-critical-species-lookbook/

Thank you for fully considering our comments as you develop your GSP.

Best Regards,

Sandi Matsumoto
Associate Director, California Water Program
The Nature Conservancy

Attachment A

Environmental User Checklist

The Nature Conservancy is neither dispensing legal advice nor warranting any outcome that could result from the use of this checklist. Following this checklist does not guarantee approval of a GSP or compliance with SGMA, both of which will be determined by DWR and the State Water Resources Control Board.

GSP Plan Element*		GDE Inclusion in GSPs: Identification and Consideration Elements	Check Box
Admin Info	2.1.5 Notice & Communication *23 CCR §354.10*	Description of the types of environmental beneficial uses of groundwater that exist within GDEs and a description of how environmental stakeholders were engaged throughout the development of the GSP.	1
Planning Framework	2.1.2 to 2.1.4 Description of Plan Area *23 CCR §354.8*	Description of jurisdictional boundaries, existing land use designations, water use management and monitoring programs; general plans and other land use plans relevant to GDEs and their relationship to the GSP.	2
		Description of instream flow requirements, threatened and endangered species habitat, critical habitat, and protected areas.	3
		Summary of process for permitting new or replacement wells for the basin, and how the process incorporates any protection of GDEs	4
Basin Setting	2.2.1 Hydrogeologic Conceptual Model *23 CCR §354.14*	Basin Bottom Boundary: Is the bottom of the basin defined as at least as deep as the deepest groundwater extractions?	5
		Principal aquifers and aquitards: Are shallow aquifers adequately described, so that interconnections with surface water and vertical groundwater gradients with other aquifers can be characterized?	6
		Basin cross sections: Do cross-sections illustrate the relationships between GDEs, surface waters and principal aquifers?	7
	2.2.2 Current & Historical Groundwater Conditions *23 CCR §354.16*	Interconnected surface waters:	8
		Interconnected surface water maps for the basin with gaining and losing reaches defined (included as a figure in GSP & submitted as a shapefile on SGMA portal).	9
		Estimates of current and historical surface water depletions for interconnected surface waters quantified and described by reach, season, and water year type.	10
		Basin GDE map included (as figure in text & submitted as a shapefile on SGMA Portal).	11

		If NC Dataset *was* used:	Basin GDE map denotes which polygons were kept, removed, and added from NC Dataset (Worksheet 1, can be attached in GSP section 6.0).	12
			The basin's GDE shapefile, which is submitted via the SGMA Portal, includes two new fields in its attribute table denoting: 1) which polygons were kept/removed/added, and 2) the change reason (e.g., why polygons were removed).	13
			GDEs polygons are consolidated into larger units and named for easier identification throughout GSP.	14
		If NC Dataset *was not* used:	Description of why NC dataset was not used, and how an alternative dataset and/or mapping approach used is best available information.	15
		Description of GDEs included:		16
		Historical and current groundwater conditions and variability are described in each GDE unit.		17
		Historical and current ecological conditions and variability are described in each GDE unit.		18
		Each GDE unit has been characterized as having high, moderate, or low ecological value.		19
		Inventory of species, habitats, and protected lands for each GDE unit with ecological importance (Worksheet 2, can be attached in GSP section 6.0).		20
	2.2.3 Water Budget *23 CCR §354.18*	Groundwater inputs and outputs (e.g., evapotranspiration) of native vegetation and managed wetlands are included in the basin's historical and current water budget.		21
		Potential impacts to groundwater conditions due to land use changes, climate change, and population growth to GDEs and aquatic ecosystems are considered in the projected water budget.		22
Sustainable Management Criteria	3.1 Sustainability Goal *23 CCR §354.24*	Environmental stakeholders/representatives were consulted.		23
		Sustainability goal mentions GDEs or species and habitats that are of particular concern or interest.		24
		Sustainability goal mentions whether the intention is to address pre-SGMA impacts, maintain or improve conditions within GDEs or species and habitats that are of particular concern or interest.		25
	3.2 Measurable Objectives *23 CCR §354.30*	Description of how GDEs were considered and whether the measurable objectives and interim milestones will help achieve the sustainability goal as it pertains to the environment.		26
	3.3 Minimum Thresholds *23 CCR §354.28*	Description of how GDEs and environmental uses of surface water were considered when setting minimum thresholds for relevant sustainability indicators:		27
		Will adverse impacts to GDEs and/or aquatic ecosystems dependent on interconnected surface waters (beneficial user of surface water) be avoided with the selected minimum thresholds?		28
		Are there any differences between the selected minimum threshold and state, federal, or local standards relevant to the species or habitats residing in GDEs or aquatic ecosystems dependent on interconnected surface waters?		29
	3.4 Undesirable Results *23 CCR §354.26*	For GDEs, hydrological data are compiled and synthesized for each GDE unit:		30
		If hydrological data *are available* within/nearby the GDE	Hydrological datasets are plotted and provided for each GDE unit (Worksheet 3, can be attached in GSP Section 6.0).	31
			Baseline period in the hydrologic data is defined.	32

			GDE unit is classified as having high, moderate, or low susceptibility to changes in groundwater.	33
			Cause-and-effect relationships between groundwater changes and GDEs are explored.	34
		If hydrological data *are not available* within/nearby the GDE	Data gaps/insufficiencies are described.	35
			Plans to reconcile data gaps in the monitoring network are stated.	36
		For GDEs, biological data are compiled and synthesized for each GDE unit:		37
		Biological datasets are plotted and provided for each GDE unit, and when possible provide baseline conditions for assessment of trends and variability.		38
		Data gaps/insufficiencies are described.		39
		Plans to reconcile data gaps in the monitoring network are stated.		40
		Description of potential effects on GDEs, land uses and property interests:		41
		Cause-and-effect relationships between GDE and groundwater conditions are described.		42
		Impacts to GDEs that are considered to be "significant and unreasonable" are described.		43
		Known hydrological thresholds or triggers (e.g., instream flow criteria, groundwater depths, water quality parameters) for significant impacts to relevant species or ecological communities are reported.		44
		Land uses include and consider recreational uses (e.g., fishing/hunting, hiking, boating).		45
		Property interests include and consider privately and publicly protected conservation lands and opens spaces, including wildlife refuges, parks, and natural preserves.		46
Sustainable Management Criteria	3.5 Monitoring Network *23 CCR §354.34*	Description of whether hydrological data are spatially and temporally sufficient to monitor groundwater conditions for each GDE unit.		47
		Description of how hydrological data gaps and insufficiencies will be reconciled in the monitoring network.		48
		Description of how impacts to GDEs and environmental surface water users, as detected by biological responses, will be monitored and which GDE monitoring methods will be used in conjunction with hydrologic data to evaluate cause-and-effect relationships with groundwater conditions.		49
Projects & Mgmt Actions	4.0. Projects & Mgmt Actions to Achieve Sustainability Goal *23 CCR §354.44*	Description of how GDEs will benefit from relevant project or management actions.		50
		Description of how projects and management actions will be evaluated to assess whether adverse impacts to the GDE will be mitigated or prevented.		51

* In reference to DWR's GSP annotated outline guidance document, available at: https://water.ca.gov/LegacyFiles/groundwater/sgm/pdfs/GD_GSP_Outline_Final_2016-12-23.pdf

Attachment B

TNC Evaluation of the
Tri-County Water Authority Public Review Draft Groundwater Sustainability Plan

A public draft of the Tri-County Water Authority's GSP is available at https://tcwater.org for public review and comment. The GSP was published September 2019. This attachment summarizes our comments on the complete public draft GSP. Comments are provided in the order of the checklist items included as Attachment A.

Checklist Item 1 - Notice & Communication (23 CCR §354.10)

[Section 1.5.1 Identification of Groundwater Beneficial Uses/Stakeholders (p. 45)]

- California Water Code §1305(f) defines that beneficial uses of waters of the State include "preservation and enhancement of fish, wildlife, and other aquatic resources and preserves". Section 1.5.1 states the major use of groundwater is for agricultural irrigation. Please describe the other beneficial uses and users of groundwater in the Subbasin, including: GDEs, managed wetlands, Protected Lands, including conservation areas and other protected lands, and Public Trust Uses including wildlife, aquatic habitat, fisheries and recreation. I-1
- The types and locations of environmental uses, species and habitats supported, and the designated beneficial environmental uses and users of surface waters that may be affected by groundwater extraction in the Subbasin should be specified. Please explicitly identify any environmental uses and users of groundwater in the plan area, and take particular note of the species with protected status. The following are resources that can be used:
  - Natural Communities Commonly Associated with Groundwater dataset (NC Dataset) - https://gis.water.ca.gov/app/NCDatasetViewer/
  - The list of freshwater species located in the Tule Subbasin in Attachment C of this letter.
  - The California Department of Fish and Wildlife's California Natural Diversity Database (CNDDB).

Checklist Items 2 to 4 - Description of general plans and other land use plans relevant to GDEs and their relationship to the GSP (23 CCR §354.8)

[Section 1.4.1 Description of the Plan Area (pp. 3-42)]

- The GSP provides a description of the Central Valley Project and groundwater well density, however there is no discussion of any instream flow requirements, if any, or how the water infrastructure is in compliance with regulatory requirements set to protect species of concern. Please provide a description of any current and planned instream flow requirements for Deer Creek. If there are not instream flow requirements in place or planned, then please state that in the document. I-2

[Section 1.4.6 Land Use Elements or Topic Categories of Applicable General Plans (pp. 27-31)]

- This section is focused on agriculture and irrigation needs, demands, and types of irrigation. It briefly mentions the existence of a local gas field. It provides no description of the contents of the applicable county general plans and other land use and environmental plans that may contain information relevant to the GSP. We have the following specific comments.
  - The sections of the County General Plans describing objectives and policies for water resources management, and management and protection of aquatic, riparian and wetland resources should be discussed in the GSP. Please include a discussion of how implementation of the GSP may affect and be coordinated with General Plan policies and procedures regarding the protection of wetlands, aquatic resources and other GDEs and ISWs. I-2
  - This section should identify Habitat Conservation Plans (HCPs), Natural Community Conservation Plans (NCCPs) and management plans associated with wildlife refuges within and near the Plan area, and if they are associated with areas with instream flow requirements; or critical, GDE or ISW habitats. Please identify all relevant HCPs and NCCPs within the Subbasin, and any reaches with instream flow and critical habitat requirements. Please elaborate on the natural resources within the Subbasin and address how GSP implementation will coordinate with the goals of these plans and requirements.
  - The Critical Species Lookbook[4] includes the potential groundwater reliance of critical species in the basin. Please include a discussion regarding the management of protected species and their habitats for these aquatic ecosystems and its relationship to the GSP.
  - There are no figures that show the portions of the GSP area covered by city, community, and county general plans and other land management plans. Please include a figure that shows the areas covered by the general plans and other land use plans with which the GSP must be coordinated.

[Section 1.4.6-4 New/Replacement Wells Permitting Process (p. 28) and Section 1.4.7-10 Well Construction Policies (p. 33)]

Section 1.4.5-4 references the Tulare County well permitting program. Section 1.4.7.10 states that TCWA is developing well construction regulations that will restrict the construction of new lower aquifer wells in some areas and encourage the construction of upper aquifer wells instead, because it is considered more in balance; however, no details of this program are provided, and its potential impacts on the upper aquifer system, and of potential effects on GDEs and ISWs, are not discussed. Please include a discussion of the following in this section: I-3

[4] Available online at: https://groundwaterresourcehub.org/sgma-tools/the-critical-species-lookbook/

- Additional details of the program, and how it will prevent potential adverse impacts to GDEs and ISWs, should be presented. If such details are not yet available, the plans and objectives for development of the program should be discussed under the chapter regarding projects and management actions in sufficient detail to demonstrate that GDEs and ISWs is being considered. I-3
- Please acknowledge that future well permitting must be coordinated with the GSP to assure achievement of the Plan's sustainability goals.
- The State Third Appellate District recently found that Counties have a responsibility to consider the potential impacts of groundwater withdrawals on public trust resources when permitting new wells near streams with public trust uses (ELF v. SWRCB and Siskiyou County, No. C083239). The need for well permitting programs to comply with this requirement should be stated in the text.

<u>Checklist Items 5 to 7 – Hydrogeologic Conceptual Model (23 CCR §354.14)</u>

[Section 2.1.3 Basin Boundaries (p. 49)]

- Defining the bottom of the Subbasin based on geochemical properties is a suitable approach for defining the base of freshwater, however, as noted on page 9 of DWR's Hydrogeologic Conceptual Model BMP (https://water.ca.gov/LegacyFiles/groundwater/sgm/pdfs/BMP_HCM_Final_2016-12-23.pdf) "the definable bottom of the basin should be at least as deep as the deepest groundwater extractions". Thus, groundwater extraction well depth data should also be included in the determination of the basin bottom. This will prevent the possibility of extractors with wells deeper than the basin boundary (defined by the base of freshwater) from claiming exemption of SGMA due to their well residing outside the vertical extent of the basin boundary. Please characterize groundwater well extractions from the deepest wells in relation to defining the basin bottom. I-4

[Section 2.1.6 Cross Sections (p. 60-70)]

- Regional geologic cross sections are provided in Figures 2.1.4 through 2.1.10 (pp. 62-69). These cross-sections do not include a graphical representation of the shallow groundwater-bearing zones that may be connected to GDEs and ISWs in the GSP area, and how they are connected to the upper aquifer system. Please include example 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. I-5

[Section 2.1.4 Principal Aquifer and Aquitards (pp. 53 to 58)]

- Although there is robust description of the aquifers there is no explicit description or supporting data and information of whether and how pumping in the lower aquifer influences the upper aquifer. On page 53 it is stated that groundwater above the A-clay, (upper aquifer) is generally not used for water supply; however, Section 2.1.4- I-6

5 (p 59) it states that there are two aquifers in the GSA and both are used for irrigation. DWR's definition of a principal aquifers are "aquifers or aquifer systems that store, transmit, and yield significant or economic quantities of groundwater to wells, springs, or surface water systems" [*23 CCR §351(aa)*]. Groundwater above the A-Clay in the upper aquifer may provide water supply to GDEs and ISWs.

- Please explicitly enumerate the principal aquifer(s) and intervening aquitards, their relationship to each other, and their role in supplying groundwater to all beneficial uses and users of groundwater (including environmental). I-6
- In addition, we request that the connectivity of GDEs and ISWs to each aquifer (including very shallow groundwater, where present) be made clear. If connectivity to a very shallow surficial aquifer exists, please establish its current and/or future management to determine if it is a principal aquifer. If it is a principal aquifer, it should be included in the sustainability goal and sustainability criteria. If it **isn't a principal aquifer, please** include text that states the future protection of GDEs would be incorporated into the 5-year update as future management plans are developed.

[Section 2.2.1 Groundwater Elevation (pp. 87-93)]

- Groundwater elevation contours are shown for 2007 and 2010 on Figures 2.2.1, 2.2.2 (upper aquifer) and 2.2.3 and 2.2.4 (lower aquifer) with respect to mean sea level. Based on completion information, the wells used to contour groundwater levels in the upper aquifer do not necessarily monitor shallow groundwater that may be in communication with GDEs and ISWs. Depth to groundwater cannot be readily assessed from the maps. The latest groundwater levels provided are nearly 10 years old and predate the recent drought. Please provide the following: 1) Groundwater level contour maps that are representative of historical as well as current conditions; 2) Groundwater level contour maps representative of the uppermost aquifer on which GDEs and ISWs may be reliant; and 3) Depth to water contour maps that allow interpretation of beneficial groundwater uses by environmental users. I-7

[Section 2.2.4 Groundwater Quality (pp. 111-115)]

- There is water quality information for the upper aquifer and a statement that there is pumping from the upper aquifer for dairy use, but there is no information regarding water quality in the upper aquifer to understand how water quality may effect GDEs. Please modify this section of the GSP to include data about water quality in the zones where GDEs are present. If there is no data then please recognize this as a data gap and that additional data will need to be collected and analyzed. I-8

<u>Checklist Items 8 to 10 – Interconnected Surface Waters (ISW) (23 CCR §354.16)</u> I-9

[Figure 2.1.14 Groundwater Discharge Areas (p. 84)]

- Figure 2.1.14 shows only the locations of pumping wells, and does not include areas where groundwater discharge may be occurring through phreatophytes or other GDEs. Please include the locations of phreatophytes and other GDEs to provide a complete representation of all groundwater discharge areas. If the regional groundwater connection of phreatophytes and other GDEs is not known, please identify this data gap, provide an approach to address it, and include the GDEs as potential GDEs on the figure until they can be more conclusively evaluated. I-9

[Section 2.2.6 Interconnected Surface Water Systems (p. 116)]

- The regulations [23 CCR §351(o)] define ISWs as "surface water that is hydraulically connected at any point by a continuous saturated zone to the underlying aquifer and the overlying surface water is not completely depleted". "At any point" has both a spatial and temporal component. Even short durations of interconnections of groundwater and surface water can be crucial for surface water flow and supporting environmental users of groundwater and surface water. ISWs can be either gaining or losing. The defining feature of disconnected surface waters is that groundwater is consistently below surface water features such that an unsaturated zone always separates surface water from groundwater, not whether the reach is gaining or losing. The text states (p. 116) that "There is no indication that any of the streams in the GSA are in hydraulic connection with the shallow groundwater. However, when the Tulare Lakebed contains lake water, this water may temporarily be in hydraulic connection with the underlying shallow groundwater at some locations". No monitoring data, analysis, or other information is provided to support this important conclusion, as such, the statement that "there is no indication" could in fact mean that the conclusion is based on the existence of a data gap. Please provide data or analysis to document the statement. Please identify data gaps (e.g., lack of shallow or nested/clustered monitoring wells or stream gauges) and either reconcile them or provide a plan to address them as needed to improve identification of ISWs prior to disregarding them in the GSP. I-10

<u>Checklist Items 11 to 15 – Identifying and Mapping GDEs (23 CCR §354.16)</u>

[Section 2.2.7 Groundwater Dependent Ecosystems (p. 117)]

- The text acknowledges the potential for GDEs in both management areas; however, there is no documentation regarding the depth to groundwater in the areas near the GDEs. I-11
  - While depth to groundwater levels within 30 feet are generally accepted as being a proxy for deciding if polygons in the NC dataset are connected to groundwater, seasonal and interannual groundwater fluctuations in the

groundwater regime must be taken into consideration. Utilizing groundwater data from one point in time (e.g., Winter 2014 to 2015, during the height of the recent drought) can misrepresent groundwater levels near GDEs and whether groundwater is available to meet their water requirements, and result in adverse impacts to the GDEs. Based on a study we recently submitted to *Frontiers in Environmental Science*, we've observed riparian forests along the Cosumnes River to experience a range in groundwater levels between 1.5 and 75 feet over seasonal and interannual timescales. Seasonal fluctuations in the regional water table can support perched groundwater near an intermittent river that seasonally runs dry due to such fluctuations. While truly perched groundwater itself cannot directly be managed due to its isolation in the vadose zone, the water table position within a continuous saturated zone connected to the upper regional aquifer can and should be monitored and managed. Depth to groundwater maps should be included in the GSP for the uppermost shallow groundwater system, unless conclusively determined to be perched. We highly recommend using depth to groundwater data from multiple seasons and water year types (e.g., wet, dry, average, drought) to determine the range of depth to groundwater around NC dataset polygons to support determination whether or not they are groundwater-dependent. Please refer to Attachment D of this letter for best practices for using local groundwater data to verify whether polygons in the NC Dataset are supported by groundwater in an aquifer. If insufficient data are available to describe groundwater conditions within or near polygons from the NC dataset seasonally and interannually, or to determine conclusively whether shallow groundwater is hydraulically connected to underlying aquifers, include those polygons in the GSP until data gaps are reconciled in the monitoring network, and include specific measures and time tables to address the data gaps. I-11

- If there are insufficient groundwater level data in the upper aquifer and overlying shallow groundwater zones, then the NCCAGs in these areas should be included as GDEs in the GSP until data gaps are reconciled in the monitoring network. Confirmation of GDEs should be based on depth to groundwater in the Shallow Zone. Please revise the GDE analysis in the GSP to include a complete analysis and identification of data gaps.
- Please provide depth to groundwater contour maps and note the following best practices for doing so.
  - Are the wells used for interpolating depth to groundwater sufficiently close (<5km) to NC Dataset polygons to reflect local conditions relevant to ecosystems?
  - Are the wells used for interpolating depth to groundwater screened within the surficial unconfined aquifer and capable of measuring the true water table?
  - Is depth to groundwater contoured using groundwater elevations at monitoring wells to get groundwater elevation contours across the landscape? This layer can then be subtracted from land surface

elevations from a Digital Elevation Model (DEM) to estimate depth-to-groundwater contours across the landscape. This will provide much more accurate contours of depth to groundwater along streams and other land surface depressions where GDEs are commonly found. Depth to groundwater contours developed from depth to groundwater measurements at wells assumes that the land surface is constant, which is a poor assumption to make. It is better to assume that water surface elevations are constant in between wells, and then calculate depth to groundwater using a DEM of the land surface to contour depth to groundwater.

  - Groundwater requirements of GDEs vary with vegetation types and rooting depths. In identifying GDEs, care should be taken to consider rooting depths of vegetation. Please indicate what vegetation is present in the possible GDEs, and whether the GDE was eliminated or retained based solely on the 30-foot depth limit. While Valley Oak (*Quercus lobata*) have been observed to have a maximum rooting depth of ~24 feet (https://groundwaterresourcehub.org/gde-tools/gde-rooting-depths-database-for-gdes/), rooting depths are likely to spatially vary based on the local hydrologic conditions available to the plant. Also, maximum rooting depths do not take capillary action into consideration, which will vary with soil type and is an important consideration since woody phreatophytes generally do not prefer to have their roots submerged in groundwater for extended periods of time, and hence effectively redistribute their root systems to straddle the water table as it fluctuates. Hence, this species is highly capable of accessing groundwater at much deeper depths when needed. I-11

- In the scientific literature, it is generally acknowledged that GDEs can rely on groundwater for <u>some or all</u> of their requirements. GDEs can rely on multiple water sources simultaneously and at different temporal and / or spatial scales (e.g., precipitation, river water, reservoir water, soil moisture in the vadose zone, groundwater, applied water, treated wastewater effluent, urban stormwater, irrigated return flow), and yet still require groundwater in order to remain viable and healthy. SGMA defines GDEs as "ecological communities and species that depend on groundwater <u>emerging from aquifers</u> or on groundwater <u>occurring near</u> the ground surface". The operative consideration in this definition is dependence, not exclusive dependence or continuous connection. Hence, we recommend using depth to groundwater contour maps derived from subtracting groundwater levels from a DEM, as described above, to identify whether a connection to groundwater exists for the GDEs presented in Figure 1.4.9 in the Subbasin. Please refer to Attachments D and E of this letter for best practices for using local groundwater data to 1) verify whether polygons in the NC Dataset are supported by groundwater in an aquifer, and 2) verify ecosystem decline or recovery is correlated with groundwater levels.

<u>Checklist Items 16 to 20, Describing GDEs (23 CCR §354.16)</u>

[Section 2.2.4.4.5 Groundwater Dependent Ecosystems (p. 44)] I-12

- Please provide information on the historical and current groundwater conditions near the GDEs or the ecological conditions present during these times. Refer to GDE Pulse (https://gde.codefornature.org; See Attachment E of this letter for more details) or any other locally available data (e.g., leaf area index, evapotranspiration or other data) to describe depth to groundwater trends in and around GDE areas, and how they relate to trends in plant growth (e.g., NDVI) and plant moisture (e.g., NDMI). Below is a screenshot example of data available in GDE Pulse for NC dataset polygons found in the Tri-County Water Authority.

I-12

- Please provide an ecological inventory for all potential GDEs (see Appendix III, Worksheet 2 of the GDE Guidance) that includes vegetation or habitat types and ranks the GDEs as having a high, moderate or low value. Explain how each rank was characterized.
- Please identify whether any endangered or threatened freshwater species of animals and plants, or areas with critical habitat have been identified in or near any of the GDEs. Note that some organisms rely on uplands and wetlands during different stages of their lifecycle. Resources for this include the list of freshwater species located in the Subbasin that can be found in Attachment C of this letter, the Critical Species Lookbook, and CDFW's CNDDB database.

<u>Checklist Items 21 and 22 – Water Budget (23 CCR §354.18)</u>

[Section 2.3 Water Budget (pp. 118-161)]

- Evapotranspiration is included as category in the groundwater balances (Table 2.3.8); however, it is only included as it pertains to crop water requirements. Groundwater outflow to ET should be identified as a groundwater budget component. If the outflow is not known, it should be identified as a data gap and provisional information should be provided until an analysis can be performed to address the data gap. Please provide a breakdown of ET for all land-cover types, I-13 including environmental beneficial users like native and riparian vegetation (wetlands, phreatophytes and other communities). Identify any data gaps and outline the actions needed to address them and the schedule for their implementation. I-13

[Section 2.4.3 Monitoring and Analysis (p. 169)]

- Data Gaps (p. 170). This section includes a statement that recognizes data gaps particularly in the upper aquifer; however, the explanation of this data gap does not include a lack of temporal and spatial information for the monitoring, assessment and management of potential impacts to GDEs and ISWs, which are beneficial users of groundwater. Please update the data gaps section, where appropriate, for both management areas to acknowledge the lack of detailed information on shallow groundwater in the upper aquifer, and its relationship to GDEs. I-14

<u>Checklist Item 23-26 Sustainability Goal (23 CCR §354.24</u>)

[Section 3.1 Sustainable Groundwater Management Criteria (p. 173)]

- Since GDEs and ISWs may be present in and near the GSP area (please see comments under Checklist Items 16-20) they should be explicitly recognized in the establishment of sustainable management criteria for the groundwater level decline and ISW sustainability indicators. Please also update this section to recognize environmental beneficial groundwater uses as a component of the sustainable management goals. I-15

[Section 3.2 Sustainability Goal (p. 174)]

- The Sustainability Goal states that "The goal of the TCWA is the absence of significant and unreasonable undesirable results associated with groundwater pumping in TCWA, accomplished by 2040". Although this is followed by additional text on beneficial uses the overall theme is to protect groundwater resources for developed water users. The narrative discussion of the sustainability goal should be expanded to include the environmental uses and users of groundwater. I-16
- Since GDEs and ISWs may be present in the Subbasin (please see comments under Checklist Items 16-20) they should be recognized as beneficial users of groundwater and should be included in the Sustainability Goal. In addition, a statement about any intention to address pre-SGMA impacts should be included.
- The GSP states that there is no ISW connectivity for Deer Creek; however, there isn't any quantitative analysis, monitoring data, or other information provided to support this conclusion. Please include ISWs in the Sustainability Goal until sufficient data is available to conclude the status of ISWs.
- GDEs are dependent, in part, on suitable water quality; however, the GSP only considers water quality for irrigation and domestic use. Given that there are potential GDEs in the Subbasin, and they 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. I-16

Checklist Item 26 – Measurable Objectives (23 CCR §354.30)

[Section 3.5 Measurable Objectives (pp. 203-204)]

- This Measurable Objective for chronic decline in groundwater levels does not consider GDEs. Please include GDEs (see comments under checklist items 16-20) in this section and whether the measurable objectives and interim milestones will help achieve the sustainability goal as it pertains to environmental beneficial users.
- This GSP states that there are no ISWs in Deer Creek; however, the GSP provides no data or analysis to support this conclusion. In addition, Tule Lake is identified as potentially being groundwater connected during some periods. Please modify this section of the GSP to include a statement that recognizes the potential for ISWs, pending the characterization of the upper aquifer and analysis of monitoring data or monitoring from additional wells to be installed in the future to address data gaps. I-17
- This water quality Measurable Objective does not consider the water quality needs of GDEs. Please modify this section to include impacts from degraded water quality on the plant and wildlife communities within GDEs.
- Section 2.2.6 states (p 116) that there may be a temporary connection between surface water the upper aquifer system in the Tulare Lakebed. Many of the wells are screened deeper and nested wells have not been installed to inform how shallow groundwater interacts with potential ISWs and GDEs, and there are no data or analyses presented that would allow the potential for ISWs and GDEs to be dismissed. Based on this information, the GSP should acknowledge the potential for ISWs and GDEs and establish Measurable Objectives for this indicator. Please include all potential ISWs and GDEs in the analysis and develop measurable objectives and minimum thresholds, to be managed until data gaps prove they are not interconnected. Please identify any data gaps for future resolution.

Checklist Item 27-29 – Minimum Thresholds (23 CCR §354.26c)

[Section 3.3.3 Evaluation of Minimum Thresholds (pp. 180-200) and Section 3.4 Minimum Thresholds (pp. 201-202)]

- The evaluation of minimum thresholds disregards consideration of environmental beneficial users, such as ISWs or GDEs. Although there are many data gaps associated with ISWs and GDEs, it must be assumed that potential significant and unreasonable impacts to these beneficial users could occur. As such, they should be addressed in the evaluation of minimum thresholds. Section 3.3.3 should be modified to address how potential ISWs and GDEs would be affected by further lowering of groundwater levels. I-18

- Section 3.3.3 states that development of minimum thresholds for interconnected surface water is not applicable, but fails to provide any monitoring data, analysis or other information to substantiate this position. The GSP identifies groundwater levels in the upper aquifer as a data gap and indicates that Tule Lake may sometimes be hydraulically connected to the regional aquifer system. Minimum thresholds must be established for ISWs and GDEs unless and until sufficient data are provided to eliminate them from consideration. Please modify this section of the GSP to 1) develop minimum thresholds for possible ISWs, including GDEs, and 2) include a statement that a data gap exists related to the interconnectedness of the of the Lakebed and shallow groundwater as well as Deer Creek. I-18
- Section 3.3.3 and 3.4 does not include the required analysis of how the selected minimum thresholds for decline in groundwater levels could affect ISWs and GDEs within and near the GSP area. Please include an analysis of the potential effect of the established minimum thresholds on ISWs and GDES within and near the GSP area.
- Although agricultural and domestic water quality concerns were articulated, similar concerns were not identified for environmental users. Degradation of water quality can impact terrestrial and aquatic wildlife that live in or near these ecosystems during at least part of the year even if the water is not a concern from an agricultural or municipal standpoint. Please include a discussion about GDEs and water quality and whether the minimum thresholds and interim milestones will help achieve sustainability for environmental users.

<u>Checklist Item 30-36 – Undesirable Results (23 CCR §354.26</u>)

[Section 3.2.2 Undesirable Results (for chronic lowering of groundwater levels) (p. 176-177)]

- This section only describes undesirable results relating to human beneficial uses of groundwater and neglects environmental beneficial uses / users that could be adversely affected by chronic groundwater level decline or depletion of interconnected surface waters. **Please add "po**ssible adverse impacts to potential GDEs and ISWs**" to the list of potential undesirable results.** I-19
- The GDE Pulse web application developed by TNC provides easy access to 35 years of satellite data to view trends of vegetation metrics, groundwater depth (where available), and precipitation data. This satellite imagery can be used to observe trends for NC dataset polygons within and near the GSA. Over the past 10 years (2009-2018), some NC dataset vegetation polygons have experienced adverse impacts to vegetation growth and moisture. An example screen shot of GDEs near Huron, California from the GDE Pulse tool is presented under Checklist items 11-15 above.
    - For each potential GDE unit with supporting hydrological datasets please include the following:
        - Plot and provide hydrological datasets for each GDE.

        - Define the baseline period in the hydrologic data.
        - Classify GDE units as having high, moderate, or low susceptibility to changes in groundwater.
        - Explore cause-and-effect relationships between groundwater changes and GDEs.

    - For each identifiable GDE unit without supporting hydrological datasets please describe data gaps and / or insufficiencies.

    - Compile and synthesize biological data for each GDE unit by: I-19
        - Characterizing biological resources for each GDE unit, and when possible provide baseline conditions for assessment of trends and variability.
        - Describing data gaps / insufficiencies.

    - Describe possible effects on potential ISWs, GDEs, land uses, and property interests, including:
        - Cause-and-effect relationships between potential ISWs and GDEs with groundwater conditions.
        - Impacts to potential ISWs and GDEs that are considered to be "significant and unreasonable".
        - Report known hydrological thresholds or triggers (e.g., instream flow criteria, groundwater depths, water quality parameters) for significant impacts to relevant species or ecological communities.
        - Land uses should include recreational uses (e.g., fishing/hunting, hiking, boating).
        - Property interests should include and consider privately and publicly protected conservation lands and opens spaces, including wildlife refuges, parks, and natural preserves.

[Section 3.3 Undesirable Results (for degraded groundwater quality) (p. 195-196)]

- This section discusses water quality with respect to agricultural and municipal use but does not include discussion of potential undesirable results for GDEs and ISWs. Please modify this section to specifically address degraded water quality from TDS and B to the vegetative portion of GDEs and ISWs. Although As is mentioned in this GSP please consider adding a statement that over-pumping and dewatering of aquitards has been identified as a potential source of elevated As concentrations above drinking water standards in San Joaquin Valley aquifers. The following is a link to a paper by Smith, Knight and Fendorf (2018) titled "Overpumping leads to California groundwater arsenic threat": https://www.nature.com/articles/s41467-018-04475-3 I-20

[Sections 3.3 Undesirable Results (for depletion of interconnected surface water) (not discussed)]

- The GSP states that there are no ISWs; however, there is no monitoring data, analyses or other information to support this conclusion. In addition, Section 2.2.6 I-21 indicates a connection may sometimes exist between shallow groundwater and Tulare Lake. Furthermore, GDEs may exist within and near the GSP area. A data gap needs to be identified and a monitoring network employed to verify the status of ISWs prior to complete dismissal of ISWs from the GSP. Please modify this section of the GSP to include 1) an assessment of the nature of potential undesirable results to ISWs and GDEs; 2) recognition of the existence of potential ISWs and GDEs, unless adequate data can be provided to dismiss them, 3) a statement that the aquifers will be managed such there will be no depletion of ISWs that results in a significant and unreasonable impact to GDEs; and 4) recognition of any data gaps and specific steps to verify the presence or absence of ISWs and GDEs with monitoring wells screened at the appropriate depths. I-21

Checklist Item 37-46 – Undesirable Results (23 CCR §354.26)

- Biological data should be compiled and synthesized for each GDE unit. Based on the potential for GDEs in the Subbasin please include:
  - Characterization of biological resources for each GDE unit, and when possible provide baseline conditions for assessment of trends and variability.
  - A description of data gaps / insufficiencies.
  - Stated plans to reconcile data gaps in the monitoring network.
- Describe the following potential effects on GDEs, land uses and property interests: I-22
  - Cause-and-effect relationships between GDE and groundwater conditions.
  - Impacts to GDEs that are considered to be "significant and unreasonable".
  - Known hydrological thresholds or triggers (e.g., instream flow criteria, groundwater depths, water quality parameters) for significant impacts to relevant species or ecological communities.
  - Land uses include and consider recreational uses (e.g., fishing/hunting, hiking, boating).
  - Property interests include and consider privately and publicly protected conservation lands and opens spaces, including wildlife refuges, parks, and natural preserves.
- Define any data gaps in the above requests and develop a plan to address them.

Checklist Items 47-49 – Monitoring Network (23 CCR §354.34)

[Chapter 4 Monitoring Network (p. 210)]

- The GSP proposes to use groundwater level monitoring to assess potential groundwater level declines. A set of representative wells has been selected to monitor the upper and lower aquifer (Tables 3.4.1 and 3.5.1). However, there are no plans to monitor groundwater level declines to assess the potential for significant and unreasonable impacts to GDEs or ISWs. In addition, the monitoring wells are not screened in the upper portion of the upper aquifer, where environmental beneficial users would obtain the groundwater on which they rely. Finally, there are I-23 no plans to monitor potential depletions in surface water flows or to assess potential GDE responses to groundwater level declines Please modify the description of the new well network to provide methodologies, data and other information to support the monitoring of GDEs and ISWs so as to assess and prevent potential significant and unreasonable impacts. This modification should include 1) locating new wells that are appropriately screened to detect connectivity of GDEs and ISWs with the upper aquifer and 2) identifying or installing additional stream gages in areas where there is potential for ISWs and GDEs. In addition, monitoring or GDE responses to groundwater level declines should be included. GDE Pulse represents an example of how remote sensing can be used to achieve this objective. Please expand on the discussion of how the new well, stream and other data will be used to improve ISW mapping and inform an adequate analysis, and how the data will be used to verify possible GDEs and their sensitivity to groundwater level declines. I-23

- As stated above in the comments for Checklist Items 8-10, please reconcile data gaps (shallow monitoring wells, stream gauges, and nested/clustered wells, GDE responses to groundwater levels) along Deer Creek in this section of the GSP to improve ISW mapping in future GSPs.

<u>Checklist Items 50 and 51 – Projects and Management Actions to Achieve Sustainability Goal (23 CCR §354.44)</u>

[Chapter 5 Projects and Management Actions (pp. 260-286]

- This chapter identifies many important projects; however, the descriptions of Measurable Objectives for these projects only identifies benefits to water level and storage through changes in allocation, imports, surface water diversions, and pumping allowances, and adding percolation basin. Since maintenance or recovery of groundwater levels, or construction of recharge facilities, may have potential environmental benefits it would be advantageous to demonstrate multiple benefits from a funding and prioritization perspective. I-24
  - For the projects already identified, please consider stating how ISWs and GDEs will benefit or be protected, or what other environmental benefits will accrue.
  - If ISWs will not be adequately protected by those listed, please include and describe additional management actions and projects targeted for protecting ISWs.
  - The storage projects, such as identified as White Ranch/ Deer Creek Project (p 274) and Liberty Ranch (p 275) can be designed as multiple-benefit projects to include elements that act functionally as wetlands and provide a benefit for wildlife and aquatic species. In some cases, such facilities have been incorporated into local HCPs and NCCPs, more fully recognizing the value of the habitat that they provide and the species they support. For projects that construct recharge ponds, please consider identifying if there is habitat value incorporated into the design and how the recharge ponds can be managed as multiple-benefit projects to benefit environmental users. Grant and funding opportunities for

SGMA-related work may be available for multi-benefit projects that can address water quantity as well as provide environmental benefits. Please include environmental benefits and multiple benefits as criteria for assessing project priorities. I-24

- For examples of case studies on how to incorporate environmental benefits into groundwater projects, please visit our website: https://groundwaterresourcehub.org/case-studies/recharge-case-studies/

- This chapter should identify the specific actions and schedules proposed to address data gaps in the hydrogeologic conceptual model, water budget and monitoring network.

Attachment C

Freshwater Species Located in the Tule Lake Subbasin

To assist in identifying the beneficial users of surface water necessary to assess the undesirable result "depletion of interconnected surface waters", Attachment C provides a list of freshwater species located within the Tule Lake Subbasin. To produce the freshwater species list, we used ArcGIS to select features within the California Freshwater Species Database version 2.0.9 within the GSA's boundary. This database contains information on ~4,000 vertebrates, macroinvertebrates and vascular plants that depend on fresh water for at least one stage of their life cycle. The methods used to compile the California Freshwater Species Database can be found in Howard et al. 2015[5]. The spatial database contains locality observations and/or distribution information from ~400 data sources. The database is housed in the California Department of Fish and Wildlife's BIOS[6] as well as on TNC's science website[7].

Scientific Name	Common Name	Legally Protected Status		
		Federal	State	Other
BIRDS				
Actitis macularius	Spotted Sandpiper			
Aechmophorus clarkii	Clark's Grebe			
Aechmophorus occidentalis	Western Grebe			
Agelaius tricolor	Tricolored Blackbird	BCC	SSC	BSSC - First priority, BLM
Aix sponsa	Wood Duck			
Anas acuta	Northern Pintail			
Anas americana	American Wigeon			
Anas clypeata	Northern Shoveler			
Anas crecca	Green-winged Teal			
Anas cyanoptera	Cinnamon Teal			
Anas discors	Blue-winged Teal			
Anas platyrhynchos	Mallard			
Anas strepera	Gadwall			
Anser albifrons	Greater White-fronted Goose			
Ardea alba	Great Egret			
Ardea herodias	Great Blue Heron			
Aythya affinis	Lesser Scaup			
Aythya americana	Redhead		SSC	BSSC - Third priority
Aythya collaris	Ring-necked Duck			
Aythya valisineria	Canvasback		SSC	
Botaurus lentiginosus	American Bittern			
Bucephala albeola	Bufflehead			

[5] Howard, J.K. et al. 2015. Patterns of Freshwater Species Richness, Endemism, and Vulnerability in California. PLoSONE, 11(7). Available at: https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0130710
[6] California Department of Fish and Wildlife BIOS: https://www.wildlife.ca.gov/data/BIOS
[7] Science for Conservation: https://www.scienceforconservation.org/products/california-freshwater-species-database

Scientific Name	Common Name	Legally Protected Status		
		Federal	State	Other
Bucephala clangula	Common Goldeneye			
Butorides virescens	Green Heron			
Calidris alpina	Dunlin			
Calidris mauri	Western Sandpiper			
Calidris minutilla	Least Sandpiper			
Chen caerulescens	Snow Goose			
Chen rossii	Ross's Goose			
Chlidonias niger	Black Tern		SSC	BSSC - Second priority
Chroicocephalus philadelphia	Bonaparte's Gull			
Cistothorus palustris palustris	Marsh Wren			
Cygnus buccinator	Trumpeter Swan			
Cygnus columbianus	Tundra Swan			
Cypseloides niger	Black Swift	BCC	SSC	BSSC - Third priority
Dendrocygna bicolor	Fulvous Whistling-Duck		SSC	BSSC - First priority
Egretta thula	Snowy Egret			
Empidonax traillii	Willow Flycatcher	BCC	Endangered	USFS
Fulica americana	American Coot			
Gallinago delicata	Wilson's Snipe			
Grus canadensis	Sandhill Crane			
Haliaeetus leucocephalus	Bald Eagle	BCC	Endangered	USFS, BLM
Himantopus mexicanus	Black-necked Stilt			
Icteria virens	Yellow-breasted Chat		SSC	BSSC - Third priority
Ixobrychus exilis hesperis	Western Least Bittern		SSC	BSSC - Second priority
Limnodromus scolopaceus	Long-billed Dowitcher			
Lophodytes cucullatus	Hooded Merganser			
Megaceryle alcyon	Belted Kingfisher			
Mergus merganser	Common Merganser			
Numenius americanus	Long-billed Curlew			
Numenius phaeopus	Whimbrel			
Nycticorax nycticorax	Black-crowned Night-Heron			
Oxyura jamaicensis	Ruddy Duck			
Pelecanus erythrorhynchos	American White Pelican		SSC	BSSC - First priority

Scientific Name	Common Name	Legally Protected Status		
		Federal	State	Other
Phalacrocorax auritus	Double-crested Cormorant			
Phalaropus tricolor	Wilson's Phalarope			
Plegadis chihi	White-faced Ibis		Watch list	
Pluvialis squatarola	Black-bellied Plover			
Podiceps nigricollis	Eared Grebe			
Podilymbus podiceps	Pied-billed Grebe			
Porzana carolina	Sora			
Rallus limicola	Virginia Rail			
Recurvirostra americana	American Avocet			
Riparia riparia	Bank Swallow		Threatened	
Setophaga petechia	Yellow Warbler			BSSC - Second priority
Tachycineta bicolor	Tree Swallow			
Tringa melanoleuca	Greater Yellowlegs			
Tringa semipalmata	Willet			
Vireo bellii	Bell's Vireo			
Xanthocephalus xanthocephalus	Yellow-headed Blackbird		SSC	BSSC - Third priority
CRUSTACEANS				
Branchinecta lindahli	Versatile Fairy Shrimp			
Branchinecta lynchi	Vernal Pool Fairy Shrimp	Threatened	SSC	IUCN - Vulnerable
Branchinecta mackini	Alkali Fairy Shrimp			
Hyalella azteca	An Amphipod			
Hyalella spp.	Hyalella spp.			
HERPS				
Actinemys marmorata marmorata	Western Pond Turtle		SSC	ARSSC, BLM, USFS
Ambystoma californiense californiense	California Tiger Salamander	Threatened	Threatened	ARSSC
Anaxyrus boreas boreas	Boreal Toad			
Spea hammondii	Western Spadefoot	Under Review in the Candidate or Petition Process	SSC	ARSSC, BLM
Taricha torosa	Coast Range Newt		SSC	ARSSC
Thamnophis couchii	Sierra Gartersnake			
Thamnophis sirtalis sirtalis	Common Gartersnake			

Scientific Name	Common Name	Legally Protected Status		
		Federal	State	Other
INSECTS AND OTHER INVERTS				
Ambrysus amargosus	Ash Meadows Naucorid			
Ambrysus spp.	Ambrysus spp.			
Anax junius	Common Green Darner			
Argia agrioides	California Dancer			
Argia spp.	Argia spp.			
Baetis tricaudatus	A Mayfly			
Brechmorhoga mendax	Pale-faced Clubskimmer			
Caenis bajaensis	A Mayfly			
Chironomidae fam.	Chironomidae fam.			
Coenagrionidae fam.	Coenagrionidae fam.			
Corixidae fam.	Corixidae fam.			
Cricotopus annulator				Not on any status lists
Cricotopus spp.	Cricotopus spp.			
Dicrotendipes adnilus				Not on any status lists
Dicrotendipes spp.	Dicrotendipes spp.			
Enallagma civile	Familiar Bluet			
Eukiefferiella claripennis				Not on any status lists
Eukiefferiella spp.	Eukiefferiella spp.			
Fallceon quilleri	A Mayfly			
Hydropsyche alternans				Not on any status lists
Hydropsyche spp.	Hydropsyche spp.			
Hydroptila ajax	A Caddisfly			
Hydroptila spp.	Hydroptila spp.			
Ischnura barberi	Desert Forktail			
Ischnura denticollis	Black-fronted Forktail			
Leucorrhinia glacialis	Crimson-ringed Whiteface			
Leucorrhinia spp.	Leucorrhinia spp.			
Micropsectra nigripila				Not on any status lists
Micropsectra spp.	Micropsectra spp.			
Nectopsyche dorsalis	A Caddisfly			
Nectopsyche spp.	Nectopsyche spp.			
Orthocladius appersoni				Not on any status lists
Orthocladius spp.	Orthocladius spp.			
Pantala flavescens	Wandering Glider			
Pantala hymenaea	Spot-winged Glider			
Pentaneura inconspicua				Not on any status lists

Scientific Name	Common Name	Legally Protected Status		
		Federal	State	Other
Pentaneura spp.	Pentaneura spp.			
Phaenopsectra dyari				Not on any status lists
Phaenopsectra spp.	Phaenopsectra spp.			
Plathemis lydia	Common Whitetail			
Polypedilum albicorne				Not on any status lists
Polypedilum spp.	Polypedilum spp.			
Rheotanytarsus hamatus				Not on any status lists
Rheotanytarsus spp.	Rheotanytarsus spp.			
Sigara alternata				Not on any status lists
Sigara spp.	Sigara spp.			
Sperchon spp.	Sperchon spp.			
Sperchon stellata				Not on any status lists
Sympetrum corruptum	Variegated Meadowhawk			
Tanytarsus angulatus				Not on any status lists
Tanytarsus spp.	Tanytarsus spp.			
Telebasis salva	Desert Firetail			
Tramea lacerata	Black Saddlebags			
Tricorythodes explicatus	A Mayfly			
Tricorythodes spp.	Tricorythodes spp.			
MAMMALS				
Castor canadensis	American Beaver			Not on any status lists
Ondatra zibethicus	Common Muskrat			Not on any status lists
MOLLUSKS				
Helisoma spp.	Helisoma spp.			
Menetus opercularis	Button Sprite			CS
Menetus spp.	Menetus spp.			
Physa acuta	Pewter Physa			Not on any status lists
Physa spp.	Physa spp.			
Planorbella binneyi	Coarse Rams-horn			CS
Planorbella spp.	Planorbella spp.			
PLANTS				
Alisma triviale	Northern Water-plantain			
Allium validum	Tall Swamp Onion			
Alnus rhombifolia	White Alder			
Alopecurus aequalis aequalis	Short-awn Foxtail			
Alopecurus saccatus	Pacific Foxtail			

Scientific Name	Common Name	Legally Protected Status		
		Federal	State	Other
Ammannia coccinea	Scarlet Ammannia			
Ammannia robusta	Grand Redstem			
Anemopsis californica	Yerba Mansa			
Arundo donax	NA			
Azolla filiculoides	NA			
Baccharis glutinosa	NA			Not on any status lists
Baccharis salicina				Not on any status lists
Bergia texana	Texas Bergia			
Bidens laevis	Smooth Bur-marigold			
Bistorta bistortoides				Not on any status lists
Callitriche longipedunculata	Longstock Water-starwort			
Callitriche marginata	Winged Water-starwort			
Callitriche palustris	Vernal Water-starwort			
Carex alma	Sturdy Sedge			
Carex amplifolia	Bigleaf Sedge			
Carex densa	Dense Sedge			
Carex fissuricola	Cleft Sedge			
Carex integra	Smooth-beak Sedge			
Carex jonesii	Jones' Sedge			
Carex lasiocarpa	Slender Sedge		SSC	CRPR - 2B.3
Carex nebrascensis	Nebraska Sedge			
Carex nervina	Sierra Sedge			
Carex sartwelliana	Yosemite Sedge			
Carex senta	Western Rough Sedge			
Carex spectabilis	Northwestern Showy Sedge			
Carex utriculata	Beaked Sedge			
Carex vesicaria vesicaria	Inflated Sedge			
Castilleja miniata miniata	Greater Red Indian-paintbrush			
Castilleja minor minor	Alkali Indian-paintbrush			
Cephalanthus occidentalis	Common Buttonbush			
Cyperus acuminatus	Short-point Flatsedge			
Cyperus erythrorhizos	Red-root Flatsedge			
Datisca glomerata	Durango Root			
Downingia bella	Hoover's Downingia			
Eleocharis bella	Delicate Spikerush			

Scientific Name	Common Name	Legally Protected Status		
		Federal	State	Other
Eleocharis macrostachya	Creeping Spikerush			
Eleocharis quinqueflora	Few-flower Spikerush			
Epilobium campestre	NA			Not on any status lists
Epilobium cleistogamum	Cleistogamous Spike-primrose			
Epilobium oregonense	Oregon Willow-herb			
Erigeron coulteri	Coulter's Fleabane			
Eriophorum crinigerum	Fringed Cotton-grass			
Eryngium vaseyi vaseyi	Vasey's Coyote-thistle			Not on any status lists
Euphorbia hooveri	NA			Not on any status lists
Galium trifidum	Small Bedstraw			
Gentiana calycosa	Explorer's Gentian			
Gentianella amarella acuta	Autumn Dwarf Gentian			
Gentianopsis holopetala	Sierra Gentian			
Gentianopsis simplex	One-flower Gentian			
Glyceria elata	Tall Mannagrass			
Helenium bigelovii	Bigelow's Sneezeweed			
Helenium puberulum	Rosilla			
Hosackia oblongifolia	NA			1.B.3
Hydrocotyle verticillata verticillata	Whorled Marsh-pennywort			
Isoetes bolanderi	NA			
Juncus dubius	Mariposa Rush			
Juncus effusus effusus	NA			
Juncus effusus pacificus				
Juncus macrandrus	Long-anther Rush			
Juncus macrophyllus	Longleaf Rush			
Juncus mertensianus	Mertens' Rush			
Juncus xiphioides	Iris-leaf Rush			
Kyhosia bolanderi				Not on any status lists
Lasthenia ferrisiae	Ferris' Goldfields		SSC	CRPR - 4.2
Lasthenia fremontii	Fremont's Goldfields			
Leersia oryzoides	Rice Cutgrass			
Lepidium oxycarpum	Sharp-pod Pepper-grass			
Lilium kelleyanum	Kelley's Lily			

Scientific Name	Common Name	Legally Protected Status		
		Federal	State	Other
Limnanthes montana	Mountain Meadowfoam			
Ludwigia peploides peploides	NA			Not on any status lists
Lythrum californicum	California Loosestrife			
Marsilea vestita vestita	NA			Not on any status lists
Micranthes aprica				Not on any status lists
Micranthes odontoloma				Not on any status lists
Micranthes oregana	NA			Not on any status lists
Mimulus guttatus	Common Large Monkeyflower			
Myosurus minimus	NA			
Narthecium californicum	California Bog Asphodel			
Navarretia intertexta	Needleleaf Navarretia			
Oenanthe sarmentosa	Water-parsley			
Orcuttia inaequalis	San Joaquin Valley Orcutt Grass	Threatened	Endangered	CRPR - 1B.1
Oreostemma alpigenum andersonii	Anderson's Tundra Aster			
Orthilia secunda	One-side Wintergreen			
Oxypolis occidentalis	Western Cowbane			
Panicum acuminatum acuminatum				Not on any status lists
Panicum acuminatum lindheimeri				Not on any status lists
Paspalum distichum	Joint Paspalum			
Pedicularis attollens	NA			
Pedicularis groenlandica	NA			
Perideridia gairdneri gairdneri	Gairdner's Yampah		SSC	CRPR - 4.2
Perideridia parishii latifolia	Parish's Yampah			
Perideridia parishii parishii	Parish's Yampah		SSC	CRPR - 2B.2
Perideridia pringlei	Pringle's Yampah		SSC	CRPR - 4.3
Persicaria lapathifolia				Not on any status lists
Persicaria maculosa	NA			Not on any status lists
Persicaria punctata	NA			Not on any status lists
Phacelia distans	NA			

Scientific Name	Common Name	Legally Protected Status		
		Federal	State	Other
Phalaris arundinacea	Reed Canarygrass			
Phyla nodiflora	Common Frog-fruit			
Pilularia americana	NA			
Plagiobothrys acanthocarpus	Adobe Popcorn-flower			
Plagiobothrys humistratus	Dwarf Popcorn-flower			
Plagiobothrys leptocladus	Alkali Popcorn-flower			
Plantago elongata elongata	Slender Plantain			
Platanthera sparsiflora sparsiflora	Canyon Bog Orchid			
Platanus racemosa	California Sycamore			
Pluchea odorata odorata	Scented Conyza			
Pogogyne douglasii	NA			
Porterella carnosula	Western Porterella			
Potamogeton foliosus foliosus	Leafy Pondweed			
Potamogeton nodosus	Longleaf Pondweed			
Primula jeffreyi				Not on any status lists
Primula tetrandra	NA			Not on any status lists
Psilocarphus brevissimus brevissimus	Dwarf Woolly-heads			
Puccinellia simplex	Little Alkali Grass			
Ranunculus alismifolius alismifolius	Water-plantain Buttercup			
Ranunculus hystriculus				Not on any status lists
Rhododendron columbianum				Not on any status lists
Rhododendron occidentale occidentale	Western Azalea			
Rorippa curvisiliqua curvisiliqua	Curve-pod Yellowcress			
Rumex conglomeratus	NA			
Rumex salicifolius salicifolius	Willow Dock			
Rumex violascens	Violet Dock			
Sagina saginoides	Arctic Pearlwort			
Sagittaria longiloba	Longbarb Arrowhead			

Scientific Name	Common Name	Legally Protected Status		
		Federal	State	Other
Sagittaria montevidensis calycina				Not on any status lists
Salix drummondiana	Satiny Salix			
Salix eastwoodiae	Eastwood's Willow			
Salix exigua exigua	Narrowleaf Willow			
Salix exigua hindsiana				Not on any status lists
Salix gooddingii	Goodding's Willow			
Salix laevigata	Polished Willow			
Salix lasiandra lasiandra				Not on any status lists
Salix lasiolepis lasiolepis	Arroyo Willow			
Salix lemmonii	Lemmon's Willow			
Salix melanopsis	Dusky Willow			
Scirpus microcarpus	Small-fruit Bulrush			
Senecio triangularis	Arrow-leaf Groundsel			
Sidalcea calycosa calycosa	Annual Checker-mallow			
Sidalcea hirsuta	Hairy Checker-mallow			
Sidalcea ranunculacea	Marsh Checker-mallow			
Sisyrinchium elmeri	Elmer's Blue-eyed-grass			
Solidago elongata				Not on any status lists
Sparganium angustifolium	Narrowleaf Bur-reed			
Sphenosciadium capitellatum	Swamp Whiteheads			
Spiranthes romanzoffiana	Hooded Ladies'-tresses			
Stachys albens	White-stem Hedge-nettle			
Triglochin palustris	Slender Bog Arrow-grass		SSC	CRPR - 2B.3
Tuctoria greenei	Green's Awnless Orcutt Grass	Endangered	Rare	CRPR - 1B.1
Typha domingensis	Southern Cattail			
Typha latifolia	Broadleaf Cattail			
Vaccinium uliginosum occidentale				Not on any status lists
Veronica americana	American Speedwell			
Viola macloskeyi	NA			
FISHES				
Catostomus occidentalis occidentalis	Sacramento sucker			Least Concern - Moyle 2013

Scientific Name	Common Name	Legally Protected Status		
		Federal	State	Other
Lampetra hubbsi	Kern brook lamprey		SSC	Vulnerable - Moyle 2013, USFS
Lavinia exilicauda exilicauda	Sacramento hitch		SSC	Near-Threatened - Moyle 2013
Lavinia symmetricus symmetricus	Central California roach		SSC	Near-Threatened - Moyle 2013
Mylopharodon conocephalus	Hardhead		SSC	Near-Threatened - Moyle 2013, USFS
Oncorhynchus mykiss irideus	Coastal rainbow trout			Least Concern - Moyle 2013
Orthodon microlepidotus	Sacramento blackfish			Least Concern - Moyle 2013
Notes: ARSSC = At-Risk Species of Special Concern BCC = Bird of Conservation Concern BSSC = Bird Species of Special Concern CRPR = California Rare Plant Rank CS = Currently Stable IUCN = International Union for Conservation of Nature SSC = Species of Special Concern				

Attachment D

July 2019

IDENTIFYING GDEs UNDER SGMA
Best Practices for using the NC Dataset

The Sustainable Groundwater Management Act (SGMA) requires that groundwater dependent ecosystems (GDEs) be identified in Groundwater Sustainability Plans (GSPs). As a starting point, the Department of Water Resources (DWR) is providing the Natural Communities Commonly Associated with Groundwater Dataset (NC Dataset) online[8] to help Groundwater Sustainability Agencies (GSAs), consultants, and stakeholders identify GDEs within individual groundwater basins. To apply information from the NC Dataset to local areas, GSAs should combine it with the best available science on local hydrology, geology, and groundwater levels to verify whether polygons in the NC dataset are likely supported by groundwater in an aquifer (Figure 1)[9]. This document highlights six best practices for using local groundwater data to confirm whether mapped features in the NC dataset are supported by groundwater.

[8] *NC Dataset Online Viewer: https://gis.water.ca.gov/app/NCDatasetViewer/*

[9] California Department of Water Resources (DWR). 2018. Summary of the "Natural Communities Commonly Associated with Groundwater" Dataset and Online Web Viewer. Available at: https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Groundwater-Management/Data-and-Tools/Files/Statewide-Reports/Natural-Communities-Dataset-Summary-Document.pdf

The NC Dataset identifies vegetation and wetland features that are good indicators of a GDE. The dataset is comprised of 48 publicly available state and federal datasets that map vegetation, wetlands, springs, and seeps commonly associated with groundwater in California[10]. It was developed through a collaboration between DWR, the Department of Fish and Wildlife, and The Nature Conservancy (TNC). TNC has also provided detailed guidance on identifying GDEs from the NC dataset[11] on the Groundwater Resource Hub[12], a website dedicated to GDEs.

BEST PRACTICE #1. Establishing a Connection to Groundwater

Groundwater basins can be comprised of one continuous aquifer (Figure 2a) or multiple aquifers stacked on top of each other (Figure 2b). In unconfined aquifers (Figure 2a), using the depth-to-groundwater and the rooting depth of the vegetation is a reasonable method to infer groundwater dependence for GDEs. If groundwater is well below the rooting (and capillary) zone of the plants and any wetland features, the ecosystem is considered disconnected and groundwater management is not likely to affect the ecosystem (Figure 2d). However, it is important to consider local conditions (e.g., soil type, groundwater flow gradients, and aquifer parameters) and to review groundwater depth data from multiple seasons and water year types (wet and dry) because intermittent periods of high groundwater levels can replenish perched clay lenses that serve as the water source for GDEs (Figure 2c). Maintaining these natural groundwater fluctuations are important to sustaining GDE health.

Basins with a stacked series of aquifers (Figure 2b) may have varying levels of pumping across aquifers in the basin, depending on the production capacity or water quality associated with each aquifer. If pumping is concentrated in deeper aquifers, SGMA still requires GSAs to sustainably manage groundwater resources in shallow aquifers, such as perched aquifers, that support springs, surface water, domestic wells, and GDEs (Figure 2). This is because vertical groundwater gradients across aquifers may result in pumping from deeper aquifers to cause adverse impacts onto beneficial users reliant on shallow aquifers or interconnected surface water. The goal of SGMA is to sustainably manage groundwater resources for current and future social, economic, and environmental benefits. While groundwater pumping may not be currently occurring in a shallower aquifer, use of this water may become more appealing and economically viable in future years as pumping restrictions are placed on the deeper production aquifers in the basin to meet the sustainable yield and criteria. Thus, identifying GDEs in the basin should done irrespective to the amount of current pumping occurring in a particular aquifer, so that future impacts on GDEs due to new production can be avoided. A good rule of thumb to follow is: *if groundwater can be pumped from a well - it's an aquifer*.

[10] *For more details on the mapping methods, refer to: Klausmeyer, K., J. Howard, T. Keeler-Wolf, K. Davis-Fadtke, R. Hull, A. Lyons. 2018. Mapping Indicators of Groundwater Dependent Ecosystems in California: Methods Report. San Francisco, California. Available at: https://groundwaterresourcehub.org/public/uploads/pdfs/iGDE_data_paper_20180423.pdf*

[11] "Groundwater Dependent Ecosystems under the Sustainable Groundwater Management Act: Guidance for Preparing Groundwater Sustainability Plans" is available at: https://groundwaterresourcehub.org/gde-tools/gsp-guidance-document/

[12] *The Groundwater Resource Hub: www.GroundwaterResourceHub.org*

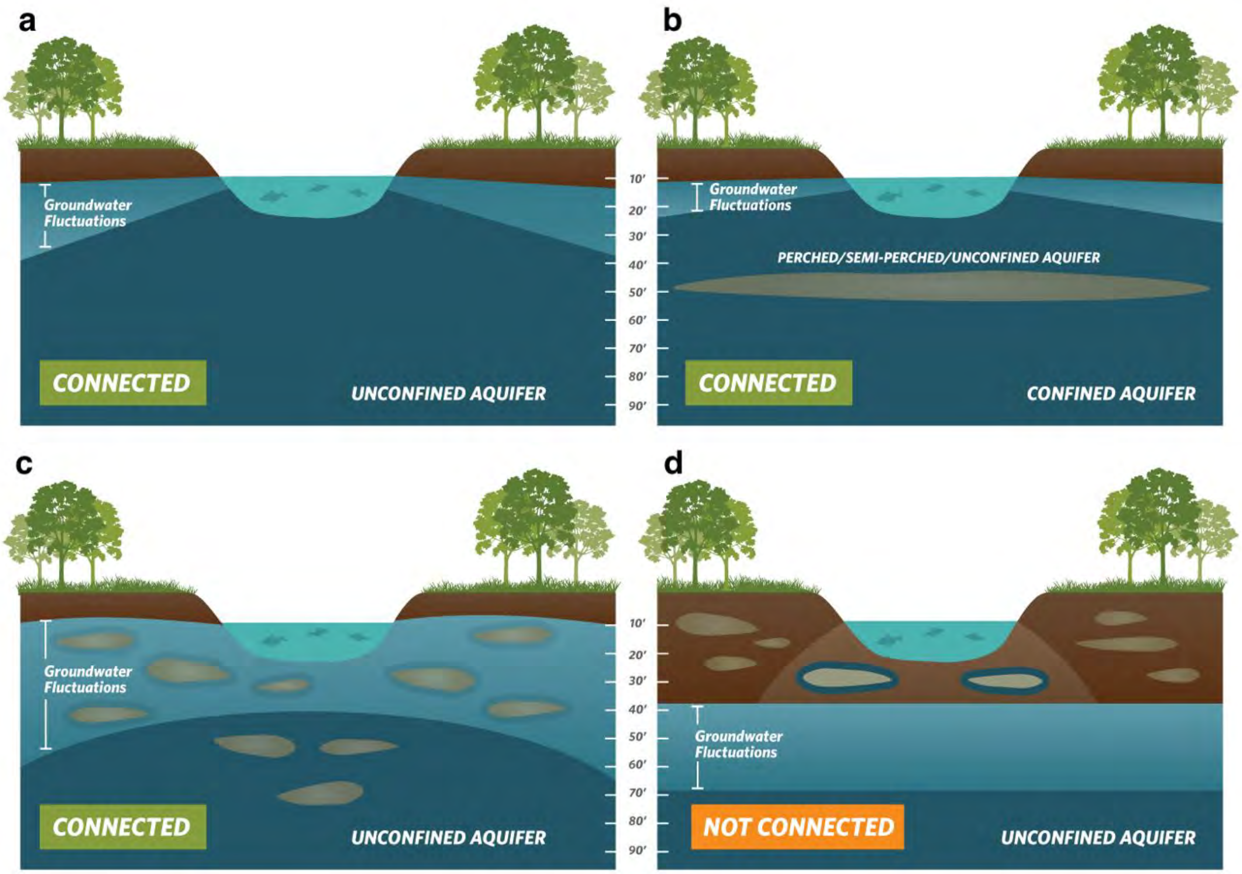

Figure 2. Confirming whether an ecosystem is connected to groundwater. Top: (a) Under the ecosystem is an unconfined aquifer with depth-to-groundwater fluctuating seasonally and interannually within 30 feet from land surface. (b) Depth-to-groundwater in the shallow aquifer is connected to overlying ecosystem. Pumping predominately occurs in the confined aquifer, but pumping is possible in the shallow aquifer. Bottom: (c) Depth-to-groundwater fluctuations are seasonally and interannually large, however, clay layers in the near surface prolong the ecosystem's connection to groundwater. (d) Groundwater is disconnected from surface water, and any water in the vadose (unsaturated) zone is due to direct recharge from precipitation and indirect recharge under the surface water feature. These areas are not connected to groundwater and typically support species that do not require access to groundwater to survive.

BEST PRACTICE #2. Characterize Seasonal and Interannual Groundwater Conditions

SGMA requires GSAs to describe current and historical groundwater conditions when identifying GDEs [23 CCR §354.16(g)]. Relying solely on the SGMA benchmark date (January 1, 2015) or any other single point in time to characterize groundwater conditions (e.g., depth-to-groundwater) is inadequate because managing groundwater conditions with data from one time point fails to capture the seasonal and interannual variability typical of California's climate. DWR's Best Management Practices document on water budgets[13] recommends using 10 years of water supply and water budget information to describe how historical conditions have impacted the operation of the basin within sustainable yield, implying that a baseline[14] could be determined based on data between 2005 and 2015. Using this or a similar time period, depending on data availability, is recommended for determining the depth-to-groundwater.

GDEs depend on groundwater levels being close enough to the land surface to interconnect with surface water systems or plant rooting networks. The most practical approach[15] for a GSA to assess whether polygons in the NC dataset are connected to groundwater is to rely on groundwater elevation data. As detailed in TNC's GDE guidance document[4], one of the key factors to consider when mapping GDEs is to contour depth-to-groundwater in the aquifer that is supporting the ecosystem (see Best Practice #5).

Groundwater levels fluctuate over time and space due to California's Mediterranean climate (dry summers and wet winters), climate change (flood and drought years), and subsurface heterogeneity in the subsurface (Figure 3). Many of California's GDEs have adapted to dealing with intermittent periods of water stress, however if these groundwater conditions are prolonged, adverse impacts to GDEs can result. While depth-to-groundwater levels within 30 feet[4] of the land surface are generally accepted as being a proxy for confirming that polygons in the NC dataset are supported by groundwater, it is highly advised that fluctuations in the groundwater regime be characterized to understand the seasonal and interannual groundwater variability in GDEs. Utilizing groundwater data from one point in time can misrepresent groundwater levels required by GDEs, and inadvertently result in adverse impacts to the GDEs. Time series data on groundwater elevations and depths are available on the SGMA Data Viewer[16]. However, if insufficient data are available to describe groundwater conditions within or near polygons from the NC dataset, include those polygons in the GSP until data gaps are reconciled in the monitoring network (see Best Practice #6).

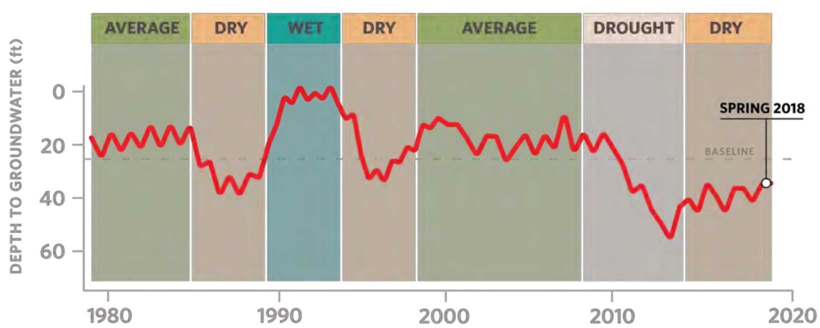

Figure 3. Example seasonality and interannual variability in depth-to-groundwater over time. Selecting one point in time, such as Spring 2018, to characterize groundwater conditions in GDEs fails to capture what groundwater conditions are necessary to maintain the ecosystem status into the future so adverse impacts are avoided.

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[13] DWR. 2016. Water Budget Best Management Practice. Available at: https://water.ca.gov/LegacyFiles/groundwater/sgm/pdfs/BMP_Water_Budget_Final_2016-12-23.pdf

[14] *Baseline is defined under the GSP regulations as "historic information used to project future conditions for hydrology, water demand, and availability of surface water and to evaluate potential sustainable management practices of a basin." [23 CCR §351(e)]*

[15] Groundwater reliance can also be confirmed via stable isotope analysis and geophysical surveys. For more information see The GDE Assessment Toolbox (Appendix IV, GDE Guidance Document for GSPs[4]).

[16] *SGMA Data Viewer: https://sgma.water.ca.gov/webgis/?appid=SGMADataViewer*

BEST PRACTICE #3. Ecosystems Often Rely on Both Groundwater and Surface Water

GDEs are plants and animals that rely on groundwater for all or some of its water needs, and thus can be supported by multiple water sources. The presence of non-groundwater sources (e.g., surface water, soil moisture in the vadose zone, applied water, treated wastewater effluent, urban stormwater, irrigated return flow) within and around a GDE does not preclude the possibility that it is supported by groundwater, too. SGMA defines GDEs as "ecological communities and species that depend on groundwater emerging from aquifers or on groundwater occurring near the ground surface" [23 CCR §351(m)]. Hence, depth-to-groundwater data should be used to identify whether NC polygons are supported by groundwater and should be considered GDEs. In addition, SGMA requires that significant and undesirable adverse impacts to beneficial users of surface water be avoided. Beneficial users of surface water include environmental users such as plants or animals[17], which therefore must be considered when developing minimum thresholds for depletions of interconnected surface water.

GSAs are only responsible for impacts to GDEs resulting from groundwater conditions in the basin, so if adverse impacts to GDEs result from the diversion of applied water, treated wastewater, or irrigation return flow away from the GDE, then those impacts will be evaluated by other permitting requirements (e.g., CEQA) and may not be the responsibility of the GSA. However, if adverse impacts occur to the GDE due to changing groundwater conditions resulting from pumping or groundwater management activities, then the GSA would be responsible (Figure 4).

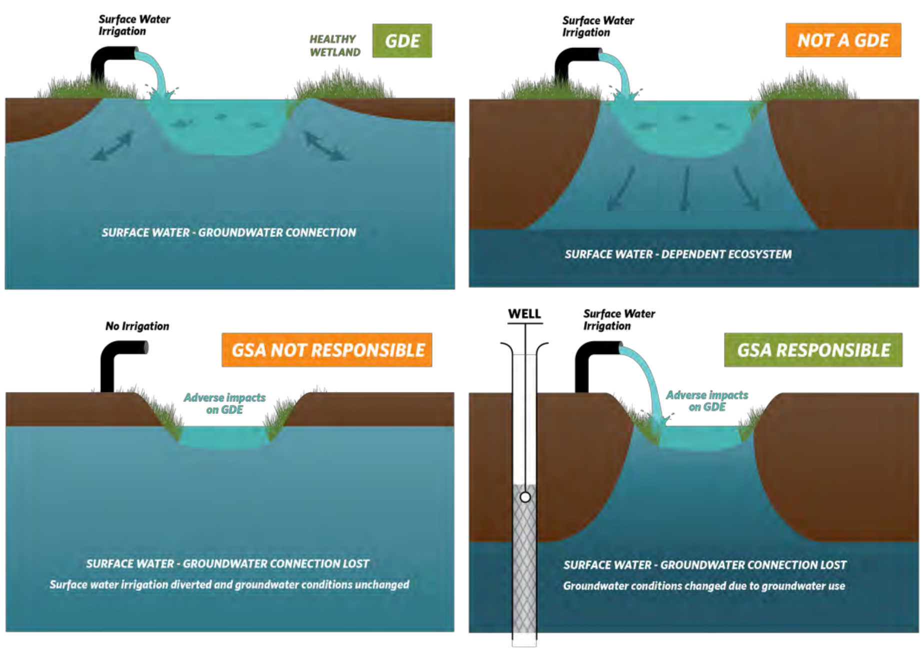

Figure 4. Ecosystems often depend on multiple sources of water. Top: (Left) Surface water and groundwater are interconnected, meaning that the GDE is supported by both groundwater and surface water. (Right) Ecosystems that are only reliant on non-groundwater sources are not groundwater-dependent. Bottom: (Left) An ecosystem that was once dependent on an interconnected surface water, but loses access to groundwater solely due to surface water diversions may not be the GSA’s responsibility. (Right) Groundwater dependent ecosystems once dependent on an interconnected surface water system, but loses that access due to groundwater pumping is the GSA’s responsibility.

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[17] *For a list of environmental beneficial users of surface water by basin, visit: https://groundwaterresourcehub.org/gde-tools/environmental-surface-water-beneficiaries/*

BEST PRACTICE #4. Select Representative Groundwater Wells

Identifying GDEs in a basin requires that groundwater conditions are characterized to confirm whether polygons in the NC dataset are supported by the underlying aquifer. To do this, proximate groundwater wells should be identified to characterize groundwater conditions (Figure 5). When selecting representative wells, it is particularly important to consider the subsurface heterogeneity around NC polygons, especially near surface water features where groundwater and surface water interactions occur around heterogeneous stratigraphic units or aquitards formed by fluvial deposits. The following selection criteria can help ensure groundwater levels are representative of conditions within the GDE area:

- Choose wells that are within 5 kilometers (3.1 miles) of each NC Dataset polygons because they are more likely to reflect the local conditions relevant to the ecosystem. If there are no wells within 5km of the center of a NC dataset polygon, then there is insufficient information to remove the polygon based on groundwater depth. Instead, it should be retained as a potential GDE until there are sufficient data to determine whether or not the NC Dataset polygon is supported by groundwater.

- Choose wells that are screened within the surficial unconfined aquifer and capable of measuring the true water table.

- Avoid relying on wells that have insufficient information on the screened well depth interval for excluding GDEs because they could be providing data on the wrong aquifer. This type of well data should not be used to remove any NC polygons.

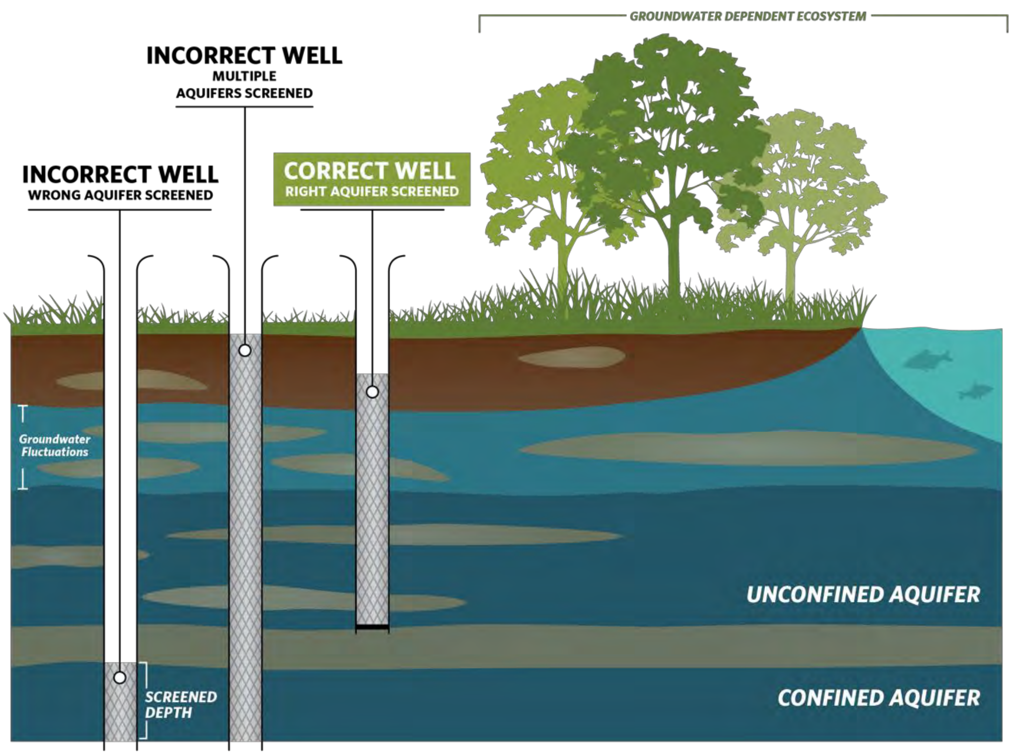


Figure 5. Selecting representative wells to characterize groundwater conditions near GDEs.

BEST PRACTICE #5. Contouring Groundwater Elevations

The common practice to contour depth-to-groundwater over a large area by interpolating measurements at monitoring wells is unsuitable for assessing whether an ecosystem is supported by groundwater. This practice causes errors when the land surface contains features like stream and wetland depressions because it assumes the land surface is constant across the landscape and depth-to-groundwater is constant below these low-lying areas (Figure 6a). A more accurate approach is to interpolate groundwater elevations at monitoring wells to get groundwater elevation contours across the landscape. This layer can then be subtracted from land surface elevations from a Digital Elevation Model (DEM)[18] to estimate depth-to-groundwater contours across the landscape (Figure b; Figure 7). This will provide a much more accurate contours of depth-to-groundwater along streams and other land surface depressions where GDEs are commonly found.

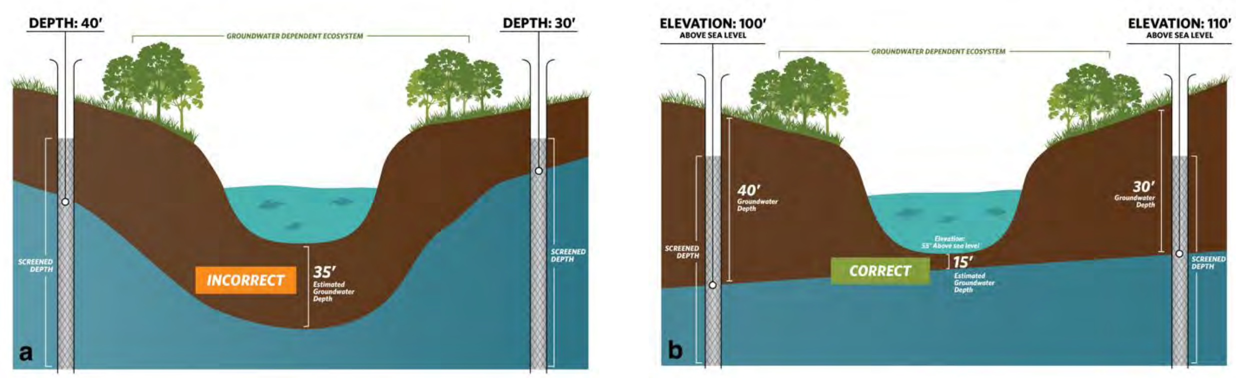


Figure 6. Contouring depth-to-groundwater around surface water features and GDEs. (a) Groundwater level interpolation using depth-to-groundwater data from monitoring wells. (b) Groundwater level interpolation using groundwater elevation data from monitoring wells and DEM data.

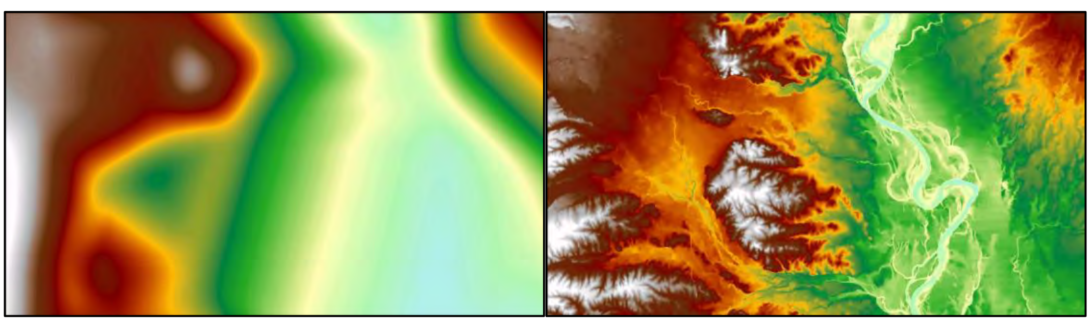


Figure 7. Depth-to-groundwater contours in Northern California. (Left) Contours were interpolated using depth-to-groundwater measurements determined at each well. (Right) Contours were determined by interpolating groundwater elevation measurements at each well and superimposing ground surface elevation from DEM spatial data to generate depth-to-groundwater contours. The image on the right shows a more accurate depth-to-groundwater estimate because it takes the local topography and elevation changes into account.

[18] USGS Digital Elevation Model data products are described at: https://www.usgs.gov/core-science-systems/ngp/3dep/about-3dep-products-services and can be downloaded at: https://iewer.nationalmap.gov/basic/

BEST PRACTICE #6. Best Available Science

Adaptive management is embedded within SGMA and provides a process to work toward sustainability over time by beginning with the best available information to make initial decisions, monitoring the results of those decisions, and using the data collected through monitoring programs to revise decisions in the future. In many situations, the hydrologic connection of NC dataset polygons will not initially be clearly understood if site-specific groundwater monitoring data are not available. If sufficient data are not available in time for the 2020/2022 plan, The Nature Conservancy strongly advises that questionable polygons from the NC dataset be included in the GSP until data gaps are reconciled in the monitoring network. Erring on the side of caution will help minimize inadvertent impacts to GDEs as a result of groundwater use and management actions during SGMA implementation.

KEY DEFINITIONS

Groundwater basin is an aquifer or stacked series of aquifers with reasonably well-defined boundaries in a lateral direction, based on features that significantly impede groundwater flow, and a definable bottom. *23 CCR §341(g)(1)*

Groundwater dependent ecosystem (GDE) are ecological communities or species that depend on groundwater emerging from aquifers or on groundwater occurring near the ground surface. *23 CCR §351(m)*

Interconnected surface water (ISW) surface water that is hydraulically connected at any point by a continuous saturated zone to the underlying aquifer and the overlying surface water is not completely depleted. *23 CCR §351(o)*

Principal aquifers are aquifers or aquifer systems that store, transmit, and yield significant or economic quantities of groundwater to wells, springs, or surface water systems. *23 CCR §351(aa)*

ABOUT US

The Nature Conservancy is a science-based nonprofit organization whose mission is *to conserve the lands and waters on which all life depends*. To support successful SGMA implementation that meets the future needs of people, the economy, and the environment, TNC has developed tools and resources (www.groundwaterresourcehub.org) intended to reduce costs, shorten timelines, and increase benefits for both people and nature.

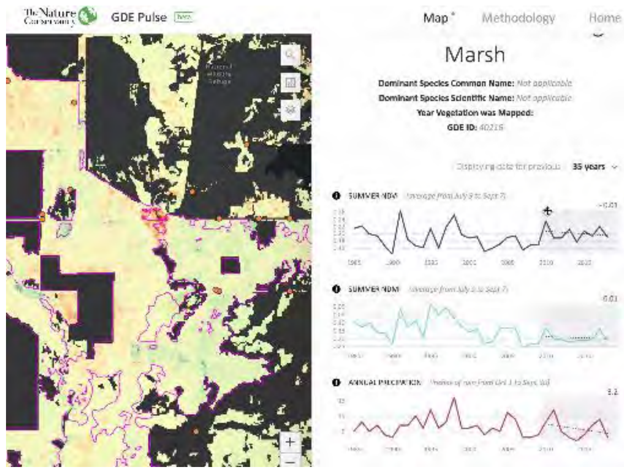
Attachment E

GDE Pulse

A new, free online tool that allows Groundwater Sustainability Agencies to assess changes in groundwater dependent ecosystem (GDE) health using satellite, rainfall, and groundwater data.

The Nature Conservancy
Protecting nature. Preserving life.

Visit
https://gde.codefornature.org/



Remote sensing data from satellites has been used to monitor the health of vegetation all over the planet. GDE pulse has compiled 35 years of satellite imagery from NASA's Landsat mission for every polygon in the Natural Communities Commonly Associated with Groundwater Dataset[19]. The following datasets are included:

Normalized Difference Vegetation Index (NDVI) is a satellite-derived index that represents the greenness of vegetation. Healthy green vegetation tends to have a higher NDVI, while dead leaves have a lower NDVI. We calculated the average NDVI during the driest part of the year (July - Sept) to estimate vegetation health when the plants are most likely dependent on groundwater.

Normalized Difference Moisture Index (NDMI) is a satellite-derived index that represents water content in vegetation. NDMI is derived from the Near-Infrared (NIR) and Short-Wave Infrared (SWIR) channels. Vegetation with adequate access to water tends to have higher NDMI, while vegetation that is water stressed tends to have lower NDMI. We calculated the average NDVI during the driest part of the year (July–September) to estimate vegetation health when the plants are most likely dependent on groundwater.

Annual Precipitation is the total precipitation for the water year (October 1^{st} – September 30^{th}) from the PRISM dataset[20]. The amount of local precipitation can affect vegetation with more precipitation generally leading to higher NDVI and NDMI.

Depth to Groundwater measurements provide an indication of the groundwater levels and changes over time for the surrounding area. We used groundwater well measurements from nearby (<1km) wells to estimate the depth to groundwater below the GDE based on the average elevation of the GDE (using a digital elevation model) minus the measured groundwater surface elevation.

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[19] The Natural Communities Commonly Associated with Groundwater Dataset is hosted on the California Department of Water Resources' website: https://gis.water.ca.gov/app/NCDatasetViewer/#

[20] The PRISM dataset is hosted on Oregon State University's website: http://www.prism.oregonstate.edu/

LETTER J

LGC, CWA/CWF, AUDUBON CALIFORNIA, TNC

November 7, 2019

Sent via email to djackson@tcwater.org

Re: Comments on Draft Groundwater Sustainability Plan for Tri County Groundwater Basin

To Whom It May Concern,

On behalf of the above-listed organizations, we would like to offer the attached comments on the draft Groundwater Sustainability Plan for the Santa Cruz Mid County Groundwater Basin. Our organizations are deeply engaged in and committed to the successful implementation of the Sustainable Groundwater Management Act (SGMA) because we understand that groundwater is a critical piece of a resilient California water portfolio, particularly in light of our changing climate. Because California's water and economy are interconnected, the sustainable management of each basin is of interest to both local communities and the state as a whole.

Our organizations have significant expertise in the environmental needs of groundwater and the needs of disadvantaged communities.

- The Nature Conservancy, in collaboration with state agencies, has developed several tools[1] for identifying groundwater dependent ecosystems in every SGMA groundwater basin and has made that tool available to each Groundwater Sustainability Agency.
- Local Government Commission supports leadership development, performs community engagement, and provides technical assistance dealing with groundwater management and other resilience-related topics at the local and regional scales; we provide guidance and resources for statewide applicability to the communities and GSAs we are working with directly in multiple groundwater basins.
- Audubon California is an expert in understanding wetlands and their role in groundwater recharge and applying conservation science to develop multiple-benefit solutions for sustainable groundwater management.
- Clean Water Action and Clean Water Fund are sister organizations that have deep expertise in the provision of safe drinking water, particularly in California's small disadvantaged communities, and co-authored a report on public and stakeholder engagement in SGMA[2].

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[1] https://groundwaterresourcehub.org/

[2] https://www.cleanwater.org/publications/collaborating-success-stakeholder-engagement-sustainable-groundwater-management-act

Because of the number of draft plans being released and our interest in reviewing every plan, we have identified key plan elements that are necessary to ensure that each plan adequately addresses essential requirements of SGMA. A summary review of your plan using our evaluation framework is attached to this letter as Appendix A. Our hope is that you can use our feedback to improve your plan before it is submitted in January 2020.

This review does not look at data quality but instead looks at how data was presented and used to identify and address the needs of disadvantaged communities (DACs), drinking water and the environment. In addition to informing individual groundwater sustainability agencies of our analysis, we plan to aggregate the results of our reviews to identify trends in GSP development, compare plans and determine which basins may require greater attention from our organizations.

Key Indicators

Appendix A provides a list of the questions we posed, how the draft plan responds to those questions and an evaluation by element of major issues with the plan. Below is a summary by element of the questions used to evaluate the plan.

1. Identification of Beneficial Users. This element is meant to ascertain whether and how DACs and groundwater-dependent ecosystems (GDEs) were identified, what standards and guidance were used to determine groundwater quality conditions and establish minimum thresholds for groundwater quality, and how environmental beneficial users and stakeholders were engaged through the development of the draft plan.
2. Communications plan. This element looks at the sufficiency of the communications plan in identifying ongoing stakeholder engagement during plan implementation, explicit information about how DACs were engaged in the planning process and how stakeholder input was incorporated into the GSP process and decision-making.
3. Maps related to Key Beneficial Uses. This element looks for maps related to drinking water users, including the density, location and depths of public supply and domestic wells; maps of GDE and interconnected surface waters with gaining and losing reaches; and monitoring networks.
4. Water Budgets. This element looks at how climate change is explicitly incorporated into current and future water budgets; how demands from urban and domestic water users were incorporated; and whether the historic, current and future water demands of native vegetation and wetlands are included in the budget.
5. Management areas and Monitoring Network. This element looks at where, why and how management areas are established, as well what data gaps have been identified and how the plan addresses those gaps.
6. Measurable Objectives and Undesirable Results. This element evaluates whether the plan explicitly considers the impacts on DACs, GDEs and environmental beneficial users in the development of Undesirable Results and Measurable Objectives. In addition, it examines whether stakeholder input was solicited from these beneficial users during the development of those metrics.
7. Management Actions and Costs. This element looks at how identified management actions impact DACs, GDEs and interconnected surface water bodies; whether mitigation for impacts to DACs is discussed or funded; and what efforts will be made to fill identified data gaps in the first five years of the plan. Additionally, this element asks whether any changes to local ordinances or land use plans are included as management actions.

Conclusion

We know that SGMA plan development and implementation is a major undertaking, and we want every basin to be successful. We would be happy to meet with you to discuss our evaluation as you finalize your Plan for submittal to DWR. Feel free to contact Suzannah Sosman at suzannah@aginnovations.org for more information or to schedule a conversation.

Sincerely,

Jennifer Clary
Water Program Manager
Clean Water Action/Clean Water Fund

Danielle V. Dolan
Water Program Director
Local Government Commission

Samantha Arthur
Working Lands Program Director
Audubon California

Sandi Matsumoto
Associate Director, California Water Program
The Nature Conservancy

Appendix A
Review of Public Draft GSP

Groundwater Basin/Subbasin: Tule Subbasin (DWR 5-22.13)
GSA: Tri-County Water Authority
GSP Date: September 2019 Public Review Draft

1. Identification of Beneficial Users

Were key beneficial users identified and engaged?

Selected relevant requirements and guidance:
GSP Element 2.1.5, "Notice & Communication" (§354.10):
(a) A description of the beneficial uses and users of groundwater in the basin, including the land uses and property interests potentially affected by the use of groundwater in the basin, the types of parties representing those interests, and the nature of consultation with those parties.
GSP Element 2.2.2, "Groundwater Conditions" (§354.16):
(d) Groundwater quality issues that may affect the supply and beneficial uses of groundwater, including a description and map of the location of known groundwater contamination sites and plumes.
(f) Identification of interconnected surface water systems within the basin and an estimate of the quantity and timing of depletions of those systems, utilizing data available from the Department, as specified in Section 353.2, or the best available information.
(g) Identification of groundwater dependent ecosystems within the basin, utilizing data available from the Department, as specified in Section 353.2, or the best available information.
GSP Element 3.3, "Minimum Thresholds" (§354.28):
(4) How minimum thresholds may affect the interests of beneficial uses and users of groundwater or land uses and property interests.

Review Criteria		Yes	No	N/A	Relevant Info per GSP	Location (Section, Page[1])
1. Do beneficial users (BUs) identified within the GSP area include:	a. Disadvantaged Communities (DACs)	X			"County area located about ½ mile west of the town of Earlimart and designated herein "West of Earlimart". A brief discussion of each of these communities follows. Allensworth was founded at the beginning of the last century (1908) and was initially named "Solito". It was re-named Allensworth in 1910. Earlimart was established in 1880 by the San Joaquin Valley Railroad and was originally named "ALILA" but became "Earlimart" in 1910. Subdivision of "West of Earlimart" into 1.25-acre parcels began in 1939." A detailed description of the two communities is provided, including a description of the Allenworth Community Services District and available information on domestic wells.	1.4.7-16, page 75
	b. Tribes		X		The draft GSP do not include any description about tribes. It is not clear if any tribes exist within the GSP area.	
	c. Small community public water systems (<3,300 connections)	X			"The majority of the water consumed in TCWA is used for agriculture irrigation. The two public supply wells of Allensworth Community Services District (CSD) are the only such wells in the GSA. There is a small number of domestic wells that serve farmsteads and private homes and dairies." "Today the Allensworth Community Services District provides water to the community. The District's service area is approximately 800 acres and	1.5, page 83; 1.4.7-16, page 75

[1] Page numbers refer to the page of the PDF.

					comprises 146 households, one school, and the State Park. The District was formed in 1981 with assistance from Self Help Enterprises. The District operates two water supply wells located about 3 miles east of the community in Section 13, T24S, R24E, M.D.B.&M. Water is piped to the community from this site via a 6-inch pipeline to a 42,000-gallon storage tank with a booster pumping plant to pressurize the community's water system. Well Number 1 was constructed in 1984, has a depth of 245 feet, with a perforated interval of 185-240 feet, sealed from 170 feet in depth to the surface, producing 140 gpm. The well has an arsenic concentration of 11 – 14 ppb, and as such, is just above the newly-adopted arsenic mcl of 10 ppb. Well Number 2 was constructed in 1998-1999 to a depth of 315 feet, perforated from 100-150 feet, 170-240 feet, and 270- 305 feet in depth. It is sealed from 90 feet in depth to the surface, produces 130 gpm, with an arsenic concentration of 7-14 ppb. However, with a bottom cement seal installed in 2015, from 260 feet to the bottom, arsenic concentrations have remained below 10 ppb. A future project includes construction of a new well to replace Well Number 1 and addition of a 500,000-gallon storage tank in the community. See discussion on water quality in KDSA HCM, page 38."	
2. What data were used to identify presence or absence of DACs?	a. DWR DAC Mapping Tool[2]		X		The draft GSP includes detailed information about the two rural DACs: Allensworth and West of Earlimart, but the draft GSP does not specify what data source was used for identifying these two DACs.	
	i. Census Places			X		
	ii. Census Block Groups			X		
	iii. Census Tracts			X		
	b. Other data source		X			
3. Groundwater Conditions section includes discussion of:	a. Drinking Water Quality	X			"In terms of public supply and domestic use, there are a number of problems in parts of the GSA. These include nitrate, DBCP, and 1,2,3-TCP in shallow groundwater in the east part of the GSA, and arsenic, color, manganese, methane gas, and hydrogen sulfide in deeper groundwater in the Alpaugh-Allensworth area."	2.1.4-4, page 98
	b. California Maximum Contaminant Levels (CA MCLs)[3] (or Public Health Goals where MCL does not exist, e.g. Chromium VI)	X			"Nitrate concentrations in all of the samples were non-detectable, indicative of reduced or anaerobic conditions in the groundwater. Iron and fluoride concentrations in water from these wells were below the respective MCLs. The manganese concentration in the sample from the Sweetwater Dairy was 0.09 mg/l, exceeding the recommended MCL of 0.05 mg/l. Manganese concentrations in water from the other wells were well below the MCL. Arsenic concentrations in water from the two AWD wells ranged from 2 to 3 ppb, well below the MCL of 10 ppb. The arsenic concentration in water from the Sweetwater Dairy well was 42 ppb, exceeding the MCL. Color values ranged from 4 to 6 units in water from the AWD wells, less than the recommended MCL of 15 units. Alpha activities in the samples were less than 2 picocuries per liter, well below the MCL of 15 picocuries per liter. Table 2.2.2 shows the results of analyses of water from the two Allensworth CSD wells that were sampled during 2011-13. Both wells tap the upper aquifer.	2.2.4, page 152

[2] DWR DAC Mapping Tool: https://gis.water.ca.gov/app/dacs/
[3] CA MCLs: https://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/MCLsandPHGs.html

					Total dissolved solids (TDS) concentrations ranged from 170 to 510 mg/l. Water from Well No. 1 was of the calcium-sodium bicarbonate type, the respective MCLs. Arsenic concentrations ranged from 10 to 11 ppb, compared to the MCL of 10 ppb. Hexavalent chromium concentrations ranged from 9.5 to 10 ppb, compared to the proposed MCL of 10 ppb. Alpha activities ranged from 1.3 to 1.7 picocuries per liter well below the MCL of 15 picocuries per liter. . . . Manganese concentrations in the samples were non-detectable, except for Well G-20 (0.05 mg/l, equal to the recommended MCL). Arsenic concentrations in water from five of the wells ranged from 12 to 89 ppb, exceeding the MCL of 10 ppb. Water from Well 14E, on the other hand, had an arsenic concentration of only 3 ppb. Alpha activities in water from five of the AWD lower aquifer wells ranged from about 1 to 13 picocuries per liter, below the MCL of 15 picocuries per liter. Water from Well 16E had an alpha activity of 16 picocuries per liter, exceeding the MCL. Color values in samples from the wells ranged from 13 to 19 units. Color values in water from four wells (13E, 14E, G-13, and 7W) exceeded the recommended MCL of 15 units."	
4. What local, state, and federal standards or plans were used to assess drinking water BUs in the development of Minimum Thresholds (MTs)?	a. Office of Environmental Health Hazard Assessment Public Health Goal (OEHHA PHGs)[4]		**X**		"Utilizing the Tule Subbasin Criteria, TCWA will establish the concentration of Constituents of Concern ("COC") for each representative monitoring site ("RMS"). These COCs will be determined based on the land use represented by the RMS. For domestic wells the COCs will be different from those for irrigation wells in some respects. Data utilized will be that collected by others such as the Irrigated Lands Regulatory Program or Drinking Water Standards for public water systems (for TCWA this is the community of Allensworth). The Minimum Thresholds shall be that there be no long term (10 year running average) increase above 15% in COC concentration above the initial baseline (2020 ten-year average) condition, caused by groundwater pumping and/or recharge efforts. First, the relationship between groundwater pumping, groundwater recharge efforts, and groundwater quality, as measured by the COCs, should be established. This will be done during the first five years of the program, as data are gathered on groundwater pumpage, water levels, and groundwater quality. It is anticipated that minimum thresholds and measurable objectives adopted in 2020 will be adjusted in 2025."	3.3.3, page 234
	b. CA MCLs[3]		**X**			
	c. Water Quality Objectives (WQOs) in Regional Water Quality Control Plans		**X**			
	d. Sustainable Communities Strategies/ Regional Transportation Plans[5]		**X**			
	e. County and/or City General Plans, Zoning Codes and Ordinances[6]		**X**			
5. Does the GSP identify how environmental BUs and environmental stakeholders were engaged throughout the development of the GSP?			**X**		California Water Code §1305(f) defines that beneficial uses of waters of the State include "preservation and enhancement of fish, wildlife, and other aquatic resources and preserves". The draft GSP states the major use of groundwater is for agricultural irrigation. The GSP should describe the other beneficial uses and users of groundwater in the Subbasin, including: GDEs, managed wetlands, Protected Lands, including conservation areas and other protected lands, and Public Trust Uses including wildlife, aquatic habitat,	1.5.1, page 84

[4] OEHHA PHGs: https://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/MCLsandPHGs.html
[5] CARB: https://ww2.arb.ca.gov/resources/documents/scs-evaluation-resources
[6] OPR General Plan Guidelines: http://www.opr.ca.gov/planning/general-plan/

				fisheries and recreation.	

Summary/ Comments

The draft GSP does not indicate whether tribes are present in the GSA or not. If no tribal lands are present, the GSP should clearly state this and provide the information reviewed to support this conclusion.

The GSP should specify what data sources were used to determine the presence of the two identified DACs.

Minimum thresholds for water quality in areas where groundwater is used for drinking water purposes should be tied to water quality standards, and not just historic concentrations. J-1

The GSP should describe the other beneficial uses and users of groundwater in the Subbasin, including: GDEs, managed wetlands, Protected Lands, including conservation areas and other protected lands, and Public Trust Uses including wildlife, aquatic habitat, fisheries and recreation.

The types and locations of environmental uses, species and habitats supported, and the designated beneficial environmental uses and users of surface waters that may be affected by groundwater extraction in the Subbasin should be specified. The GSP should explicitly identify any environmental uses and users of groundwater in the plan area, and take particular note of the species with protected status. The following are resources that can be used:

- Natural Communities Commonly Associated with Groundwater dataset (NC Dataset): https://gis.water.ca.gov/app/NCDatasetViewer/.
- The list of freshwater species located in the Tule Subbasin can be found here: https://groundwaterresourcehub.org/sgma-tools/environmental-surface-water-beneficiaries/ .
- The California Department of Fish and Wildlife's California Natural Diversity Database (CNDDB): https://www.wildlife.ca.gov/Data/CNDDB.

2. Communications Plan

How were key beneficial users engaged and how was their input incorporated into the GSP process and decisions?

Selected relevant requirements and guidance:
GSP Element 2.1.5, "Notice & Communication" (§354.10):
Each Plan shall include a summary of information relating to notification and communication by the Agency with other agencies and interested parties including the following:
(c) Comments regarding the Plan received by the Agency and a summary of any responses by the Agency.
(d) A communication section of the Plan that includes the following:
(1) An explanation of the Agency's decision-making process.
(2) Identification of opportunities for public engagement and a discussion of how public input and response will be used.
(3) A description of how the Agency encourages the active involvement of diverse social, cultural, and economic elements of the population within the basin.
(4) The method the Agency shall follow to inform the public about progress implementing the Plan, including the status of projects and actions.

DWR Guidance Document for GSP Stakeholder Communication and Engagement[7]

Review Criteria	Yes	No	N/A	Relevant Info per GSP	Location (Section, Page)
1. Is a Stakeholder Communication and Engagement Plan (SCEP) included?		X		The draft GSP does not include a SCEP or reference to a SCEP as a separate document.	
2. Does the SCEP or GSP identify that ongoing engagement will be conducted during GSP implementation?	X			"Public outreach will continue throughout the 20-year implementation period, focusing on the first five years of the implementation period. Results will be published on an annual basis and annual meetings held to discuss the program's achievements and areas needing modification. Public and stakeholder input will be requested and discussed, and program modifications implemented in order to achieve sustainability in 20 years."	1.5.4-2, page 86
3. Does the SCEP or GSP specifically identify how DAC beneficial users were engaged in the planning process?	X			"Notices and a listing of the public meetings of the TCWA is appended. Meetings are noticed and conducted in accordance with Section §54954.2 of the State of California Government Code. All meetings are open to the public, and public meetings specific to Allensworth, the only community in the GSA, have been held. Representatives of irrigation and water districts, landowners, the BLM, Tulare County, Alpaugh, Kings, County, the Tulare Basin Watershed Partnership, the Community of Allensworth, among others, attend the meetings." "The majority of the water consumed in TCWA is used for agriculture irrigation. The two public supply wells of Allensworth Community Services District (CSD) are the only such wells in the GSA. There is a small number of domestic wells that serve farmsteads and private homes and dairies. All landowners in the GSA have been notified that a GSP is being prepared for the GSA. The TCWA Board of Directors is comprised of four signatories and five	1.5.2, page 85 1.5, page 84

[7] DWR Guidance Document for GSP Stakeholder Communication and Engagement
https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Groundwater-Management/Sustainable-Groundwater-Management/Best-Management-Practices-and-Guidance-Documents/Files/Guidance-Document-for-Groundwater-Sustainability-Plan---Stakeholder-Communication-and-Engagement.pdf

				board seats: AWD (general manager and representative), Deer Creek Storm Water District (general manager and representative), Wilbur Reclamation District #825 (one representative), and County of Kings (non-voting representative). The regular Board of Directors meetings are held on the second Thursday of every other month at 1:00 p.m. at the TCWA Boardroom, located at 944 Whitley Avenue in Corcoran, unless otherwise noted on the GSA's website: http://tcwater.org/events/. Board of Directors meetings are noticed by email to the Board of Directors and the stakeholders / interested party email list, and posted at the District office location. Monthly Technical / Stakeholder Advisory Committee meetings are held where the findings and the progress of the preparation of the GSP are discussed. The Technical/Stakeholder Advisory Committee meets on the fourth Wednesday of every month at 10:00 am at the TCWA Boardroom. The Technical/Stakeholder and Board meetings often have representatives in attendance from Allensworth, the Bureau of Land Management, Tulare County Wildlife Partners, Tulare County LAFCo, the dairy industry, nut growers, farmers, and large agricultural representatives. Board and Technical/Stakeholder Committee meetings are open to all who desire to attend and comment. Allensworth representatives participate in monthly meetings and had a member on the Board from July 2015 to December 2018. This representative was recently replaced by a new representative of Deer Creek Storm Water District. A community meeting was held in Allensworth to discuss the status of the GSP and to receive input from the community. In addition to TCWA meetings, the Tule Subbasin holds regular Tule Subbasin Stakeholder meetings and maintains an Interested Parties email list."	
4. Does the SCEP or GSP explicitly describe how stakeholder input was incorporated into the GSP process and decisions?		X		The draft GSP provides limited information on how stakeholder input was incorporated into the GSP process and decisions. "The decisions regarding the adoption of sustainable management criteria are made by the TCWA's five-member board of directors. These decisions are made after thoughtful consideration of the results of the studies prepared by the TCWA's consultants, input from the stakeholders, the public, comments by neighboring GSAs, the Department of Water Resources ("DWR"), and recognition of the existing and surface water supplies and groundwater conditions within the GSA. TCWA will implement initial management actions and projects, review the results of these planned management actions and projects, fill in data gaps, and develop a better understanding of the groundwater basin over the next five years. TCWA will then determine what further adjustments are needed to achieve sustainability. TCWA will continue its participation and collaboration with the Tule Subbasin Technical Advisory Committee in an effort to achieve sustainability in the Tule Subbasin."	1.5.4-1, page 85

Summary/ Comments

The GSP does not include a copy of the SCEP. An SCEP should be included in the GSP as an appendix or attachment.

The GSP should clearly identify how DAC beneficial users were engaged in the GSP planning process, by providing detailed information on the number of meetings held, general levels of attendance, what feedback was provided by community members, etc. The draft GSP states that "Notices and a listing of the public meetings of the TCWA is appended.," but we could not locate these in the appended materials. J-2

The draft GSP states that stakeholders' input was considered during decision making process, however, it does not describe how the input was incorporated. The GSP should provide detailed description about stakeholder input and responses and how are those addressed by the decisions.

3. Maps Related to Key Beneficial Uses

Were best available data sources used for information related to key beneficial users?

<u>Selected relevant requirements and guidance:</u>
GSP Element 2.1.4 "Additional GSP Elements" (§354.8):
Each Plan shall include a description of the geographic areas covered, including the following information:
(a) One or more maps of the basin that depict the following, as applicable:
(5) The density of wells per square mile, by dasymetric or similar mapping techniques, showing the general distribution of agricultural, industrial, and domestic water supply wells in the basin, including de minimis extractors, and the location and extent of communities dependent upon groundwater, utilizing data provided by the Department, as specified in Section 353.2, or the best available information.

<u>GSP Element 3.5 Monitoring Network (§354.34)</u>
(b) Each Plan shall include a description of the monitoring network objectives for the basin, including an explanation of how the network will be developed and implemented to monitor groundwater and related surface conditions, and the interconnection of surface water and groundwater, with sufficient temporal frequency and spatial density to evaluate the affects and effectiveness of Plan implementation. The monitoring network objectives shall be implemented to accomplish the following:
(c) Each monitoring network shall be designed to accomplish the following for each sustainability indicator:
(1) Chronic Lowering of Groundwater Levels. Demonstrate groundwater occurrence, flow directions, and hydraulic gradients between principal aquifers and surface water features by the following methods:
(A) A sufficient density of monitoring wells to collect representative measurements through depth-discrete perforated intervals to characterize the groundwater table or potentiometric surface for each principal aquifer.
(4) Degraded Water Quality. Collect sufficient spatial and temporal data from each applicable principal aquifer to determine groundwater quality trends for water quality indicators, as determined by the Agency, to address known water quality issues.
(6) Depletions of Interconnected Surface Water. Monitor surface water and groundwater, where interconnected surface water conditions exist, to characterize the spatial and temporal exchanges between surface water and groundwater, and to calibrate and apply the tools and methods necessary to calculate depletions of surface water caused by groundwater extractions. The monitoring network shall be able to characterize the following:
(A) Flow conditions including surface water discharge, surface water head, and baseflow contribution.
(B) Identifying the approximate date and location where ephemeral or intermittent flowing streams and rivers cease to flow, if applicable.
(C) Temporal change in conditions due to variations in stream discharge and regional groundwater extraction.
(D) Other factors that may be necessary to identify adverse impacts on beneficial uses of the surface water.
(f) The Agency shall 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.

Review Criteria		Yes	No	N/A	Relevant Info per GSP	Location (Section, Page)
1. Does the GSP Include Maps Related to Drinking Water Users?	a. Well Density	X			"Figure 1.4.6 shows the density of wells per square mile and the general distribution of agricultural, industrial and public water supply wells. The community of Allensworth is the sole community dependent on groundwater in the TCWA. Groundwater use is minimal in Allensworth, averaging about 100 acre-feet annually. … Figure 1.4.6-C shows the relative density of the placement of wells in TCWA. There are a few sections with no wells, but the majority of sections have well densities of 1-4 wells per section."	1.4-5, page 50; Figure 1.4.6-C, page 57
	b. Domestic and Public Supply Well Locations & Depths		X		"Figure 1.4.6 is the well index map for TCWA. All known large capacity supply wells (not small domestic wells - such as at farmsteads) are plotted on Figures 1.4.6-A and 1.4.6-B. TCWA has been divided into three management areas based on groundwater conditions of which the North and Southeast Management Areas comprise the focus area of	

					this GSP. These areas are shown on this map bounded by red borders." However, the legend in Figure 1.4.6 only includes irrigation wells, and it is not clear if Figure 1.4.6-C includes all wells, or just irrigation wells. The draft GSP does not clearly present the domestic and public wells in maps. The draft GSP does specify that there are only 2 public supply wells within the GSA and references the presence of domestic wells in the area.	
	i. Based on DWR Well Completion Report Map Application[8]?			X		
	ii. Based on Other Source(s)?			X		
2. Does the GSP include maps related to Groundwater Dependent Ecosystem (GDE) locations?	a. Map of GDE Locations	X			The draft GSP acknowledges the potential for GDEs in both management areas; however, there is no documentation regarding the depth to groundwater in the areas near the GDEs. o While depth to groundwater levels within 30 feet are generally accepted as being a proxy for deciding if polygons in the NC dataset are connected to groundwater, seasonal and interannual groundwater fluctuations in the groundwater regime must be taken into consideration. Utilizing groundwater data from one point in time (e.g., Winter 2014 to 2015, during the height of the recent drought) can misrepresent groundwater levels near GDEs and whether groundwater is available to meet their water requirements, and result in adverse impacts to the GDEs. Based on a study we recently submitted to Frontiers in Environmental Science, we've observed riparian forests along the Cosumnes River to experience a range in groundwater levels between 1.5 and 75 feet over seasonal and interannual timescales. Seasonal fluctuations in the regional water table can support perched groundwater near an intermittent river that seasonally runs dry due to such fluctuations. While truly perched groundwater itself cannot directly be managed due to its isolation in the vadose zone, the water table position within a continuous saturated zone connected to the upper regional aquifer can and should be monitored and managed. Depth to groundwater maps should be included in the GSP for the uppermost shallow groundwater system, unless conclusively determined to be perched. It is highly recommend using depth to groundwater data from multiple seasons and water year types (e.g., wet, dry, average, drought) to determine the range of depth to groundwater around NC dataset polygons to support determination whether or not they are groundwater-dependent. Refer to TNC's guidance on Identifying GDEs Under SGMA (https://groundwaterresourcehub.org/public/uploads/pdfs/TNC_NCdataset_BestPracticesGuide_2019.pdf) for best practices for using local groundwater data to verify whether polygons in the NC Dataset are supported by groundwater in an aquifer. If insufficient data are available to describe groundwater conditions within or near polygons from the NC dataset seasonally and interannually, or to determine conclusively whether shallow groundwater is hydraulically connected to underlying aquifers, include those polygons in the GSP until data gaps are reconciled in the monitoring network, and include specific measures and time tables to address the data gaps. o If there are insufficient groundwater level data in the upper aquifer and overlying shallow groundwater zones, then the NCCAGs in these areas should be included as GDEs in the GSP until data gaps are reconciled in the monitoring network. Confirmation of GDEs should be based on depth to groundwater in the Shallow	Figure 1.4.9, page 74

[8] DWR Well Completion Report Map Application: https://www.arcgis.com/apps/webappviewer/index.html?id=181078580a214c0986e2da28f8623b37

					Zone. Please revise the GDE analysis in the GSP to include a complete analysis and identification of data gaps. o Groundwater requirements of GDEs vary with vegetation types and rooting depths. In identifying GDEs, care should be taken to consider rooting depths of vegetation. The GSP should indicate what vegetation is present in the possible GDEs, and whether the GDE was eliminated or retained based solely on the 30-foot depth limit. While Valley Oak (Quercus lobata) have been observed to have a maximum rooting depth of ~24 feet (https://groundwaterresourcehub.org/gde-tools/gde-rooting-depths-database-for-gdes/), rooting depths are likely to spatially vary based on the local hydrologic conditions available to the plant. Also, maximum rooting depths do not take capillary action into consideration, which will vary with soil type and is an important consideration since woody phreatophytes generally do not prefer to have their roots submerged in groundwater for extended periods of time, and hence effectively redistribute their root systems to straddle the water table as it fluctuates. Hence, this species is highly capable of accessing groundwater at much deeper depths when needed. o In the scientific literature, it is generally acknowledged that GDEs can rely on groundwater for some or all of their requirements. GDEs can rely on multiple water sources simultaneously and at different temporal and / or spatial scales (e.g., precipitation, river water, reservoir water, soil moisture in the vadose zone, groundwater, applied water, treated wastewater effluent, urban stormwater, irrigated return flow), and yet still require groundwater in order to remain viable and healthy. SGMA defines GDEs as "ecological communities and species that depend on groundwater emerging from aquifers or on groundwater occurring near the ground surface". The operative consideration in this definition is dependence, not exclusive dependence or continuous connection. Hence, we recommend using depth to groundwater contour maps derived from subtracting groundwater levels from a DEM, as described above, to identify whether a connection to groundwater exists for the GDEs presented in Figure 1.4.9 in the Subbasin. Refer to TNC's Best Practices guidance (https://groundwaterresourcehub.org/public/uploads/pdfs/TNC_NCdataset_BestPracticesGuide_2019.pdf) and the GDE Pulse tool (https://gde.codefornature.org/) to 1) verify whether polygons in the NC Dataset are supported by groundwater in an aquifer, and 2) verify ecosystem decline or recovery is correlated with groundwater levels. o Figure 2.1.14 shows only the locations of pumping wells, and does not include areas where groundwater discharge may be occurring to phreatophytes or other GDEs. The GSP should include the locations of phreatophytes and other GDEs to provide a complete representation of all groundwater discharge areas. If the regional groundwater connection of phreatophytes and other GDEs is not known, the GSP should identify this data gap, provide an approach to address it, and include the GDEs as potential GDEs on the figure until they can be more conclusively evaluated.	
	b. Map of Interconnected Surface Waters (ISWs)		X		The regulations [23 CCR §351(o)] define ISWs as "surface water that is hydraulically connected at any point by a continuous saturated zone to the underlying aquifer and the overlying surface water is not completely depleted". "At any point" has both a spatial and temporal component. Even short durations of interconnections of groundwater and surface water can be crucial for surface water flow and supporting environmental users of groundwater and surface water. ISWs can be either gaining or losing. The draft GSP states that "There is no indication that any of the streams in the GSA are in hydraulic connection with the shallow groundwater. However, when the Tulare Lakebed contains lake water, this water may temporarily be in hydraulic connection with the underlying shallow groundwater at some locations". No monitoring data, analysis, or other information is provided to support this important conclusion, as such, the statement that "there is no indication" could in fact mean that the conclusion is based on the existence of a data gap. The GSP should provide data or analysis to document the statement and identify data gaps	2.2.6, page 155
	i. Does it identify which reaches are gaining and which are losing?		X			
	ii. Depletions to ISWs are quantified by stream segments.		X			

	iii. Depletions to ISWs are quantified seasonally.		X		(e.g., lack of shallow or nested/clustered monitoring wells or stream gauges) and either reconcile them or provide a plan to address them as needed to improve identification of ISWs prior to disregarding them in the GSP.	
3. Does the GSP include maps of monitoring networks?	a. Existing Monitoring Wells	X			"Refer to Figure 2.2.4 herein, and Figures A1-2 and A1-5 of the Tule Subbasin Monitoring Plan (Appendix A-2), for prospective locations of existing wells to be monitored for water levels." Figure A1-2: Existing and Proposed Upper Aquifer Groundwater Level Monitoring Well Locations Figure A1-5: Existing and Proposed Lower Aquifer Groundwater Level Monitoring Well Locations	4.4, page 262; Appendix A-2, page 335
	b. Existing Monitoring Well Data sources: i. California Statewide Groundwater Elevation Monitoring (CASGEM)		X		The draft GSP does not clearly indicate the data source used for identifying existing monitoring wells.	
	ii. Water Board Regulated monitoring sites		X			
	iii. Department of Pesticide Regulation (DPR) monitoring wells		X			
	c. SGMA-Compliance Monitoring Network	X			"Figure 2.4.1 shows the location of the wells that will be measured for water level thresholds in the GSA. There are eight wells shown. Spring and Fall water levels will be measured. In addition, Figures 4.1.1 – 4.1.4 show additional wells to be measured annually, in the spring, in order to prepare water level elevation maps. These figures are included in the following pages."	4.4, page 262
	i. SGMA Monitoring Network map includes identified DACs?		X			
	ii. SGMA Monitoring Network map includes identified GDEs?		X			

Summary/ Comments

Detailed information regarding the location and depths of domestic wells is currently lacking in the GSP. Domestic well location and construction information are essential for evaluating impacts of proposed MOs/MTs on domestic wells. The GSP should provide the locations and depths of all domestic and public supply wells in the GSA area using the best available information, and present this information on maps along with the proposed SGMA-compliance monitoring network so that the public can evaluate how well the monitoring network addresses these key beneficial users. If no better source is available, DWR has made well construction records available through its Well Completion Report Map application website: https://www.arcgis.com/apps/webappviewer/index.html?id=181078580a214c0986e2da28f8623b37 J3

The GSP should also provide maps of the representative monitoring network overlaid with location of DACs, GDEs, the Allentown Community Services District and its wells, and any other sensitive beneficial users. Such maps will allow the reader to evaluate the adequacy of the network to monitor conditions near these beneficial users, and whether or not the GSP is compliant with 23 CCR § 354.34.(b)(2).

The GSP should also clarify what data sources were used for identifying existing monitoring wells.

Depth to groundwater maps should be included in the GSP for the uppermost shallow groundwater system, unless conclusively determined to be perched.

The GSP should provide a better assessment of GDEs, per the discussion provided in Question 2a above.

The GSP should provide depth to groundwater contour maps and note the following best practices for doing so:

- Are the wells used for interpolating depth to groundwater sufficiently close (<5km) to NC Dataset polygons to reflect local conditions relevant to ecosystems?
- Are the wells used for interpolating depth to groundwater screened within the surficial unconfined aquifer and capable of measuring the true water table?
- Is depth to groundwater contoured using groundwater elevations at monitoring wells to get groundwater elevation contours across the landscape? This layer can then be subtracted from land surface elevations from a Digital Elevation Model (DEM) to estimate depth-to-groundwater contours across the landscape. This will provide much more accurate contours of depth to groundwater along streams and other land surface depressions where GDEs are commonly found. Depth to groundwater contours developed from depth to groundwater measurements at wells assumes that the land surface is constant, which is a poor assumption to make. It is better to assume that water surface elevations are constant in between wells, and then calculate depth to groundwater using a DEM of the land surface to contour depth to groundwater.

The GSP should provide information on the historical and current groundwater conditions near the GDEs or the ecological conditions present during these times. Refer to GDE Pulse (https://gde.codefornature.org) or any other locally available data (e.g., leaf area index, evapotranspiration or other data) to describe depth to groundwater trends in and around GDE areas, and how they relate to trends in plant growth (e.g., NDVI) and plant moisture (e.g., NDMI).

The GSP should provide an ecological inventory for all potential GDEs (see Appendix III, Worksheet 2 of the GDE Guidance) that includes vegetation or habitat types and ranks the GDEs as having a high, moderate or low value. Explain how each rank was characterized.

The GSP should identify whether any endangered or threatened freshwater species of animals and plants, or areas with critical habitat have been identified in or near any of the GDEs. Note that some organisms rely on uplands and wetlands during different stages of their lifecycle. Resources for this include the list of freshwater species located in the Subbasin that can be found at https://groundwaterresourcehub.org/sgma-tools/environmental-surface-water-beneficiaries/, the Critical Species Lookbook, and CDFW's CNDDB database.

The GSP should provide data or analysis to document the statement of the absence of interconnected surface water systems within the GSA area. The GSP should also identify data gaps (e.g., lack of shallow or nested/clustered monitoring wells or stream gauges) and either reconcile them or provide a plan to address them as needed to improve identification of ISWs prior to disregarding them in the GSP.

J-3

4. Water Budgets

How were climate change projections incorporated into projected/future water budget and how were key beneficial users addressed?

<u>Selected relevant requirements and guidance:</u>
GSP Element 2.2.3 "Water Budget Information" (Reg. § 354.18)
Each Plan shall include a water budget for the basin that provides an accounting and assessment of the total annual volume of groundwater and surface water entering and leaving the basin, including historical, current and projected water budget conditions, and the change in the volume of water stored. Water budget information shall be reported in tabular and graphical form.

*Projected water budgets shall be used to estimate future baseline conditions of supply, **demand**, and aquifer response to Plan implementation, and to identify the uncertainties of these projected water budget components. The projected water budget shall utilize the following methodologies and assumptions to estimate future baseline conditions concerning hydrology, water demand and surface water supply availability or reliability over the planning and implementation horizon:*
(b) The water budget shall quantify the following, either through direct measurements or estimates based on data:
(5) If overdraft conditions occur, as defined in Bulletin 118, the water budget shall include a quantification of overdraft over a period of years during which water year and water supply conditions approximate average conditions.
(6) The water year type associated with the annual supply, demand, and change in groundwater stored.
(c) Each Plan shall quantify the current, historical, and projected water budget for the basin as follows:
*(1) Current water budget information shall quantify current inflows and outflows for the basin using the most recent hydrology, water supply, **water demand**, and land use information.*

DWR Water Budget BMP[9]
DWR Guidance for Climate Change Data Use During GSP Development and Resource Guide[10]

Review Criteria		Yes	No	N/A	Relevant Info per GSP	Location (Section, Page)
1. Are climate change projections explicitly incorporated in future/ projected water budget scenario(s)?		X			"Therefore, future crop demands can be estimated based on the historical weather patterns, assuming that future weather patterns will resemble past patterns, with adjustments in water supply and crop water requirements to reflect the forecast effects of climate change…. The Tables in Appendix A develop the crop water and applied water requirements for three climate conditions, based on the 2017/18 cropping patterns in the	2.3.1, page 161
2. Is there a description of the methodology used to include climate change?			X			
3. What is used as the basis	a. [DWR-Provided Climate Change Data and Guidance](https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Groundwater-Management/Sustainable-Groundwater-Management/Best-Management-Practices-and-Guidance-Documents/Files/Climate-Change-Guidance_Final.pdf)[11]			X		

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[9] DWR BMP for the Sustainable <management of Groundwater Water Budget: https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Groundwater-Management/Sustainable-Groundwater-Management/Best-Management-Practices-and-Guidance-Documents/Files/BMP-4-Water-Budget.pdf
[10] DWR Guidance Document for the Sustainable Management of Groundwater Guidance for Climate Change Data Use During GSP Development: https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Groundwater-Management/Sustainable-Groundwater-Management/Best-Management-Practices-and-Guidance-Documents/Files/Climate-Change-Guidance_Final.pdf
[11] DWR Guidance Document for the Sustainable Management of Groundwater Guidance for Climate Change Data Use During GSP Development: https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Groundwater-Management/Sustainable-Groundwater-Management/Best-Management-Practices-and-Guidance-Documents/Files/Climate-Change-Guidance_Final.pdf

for climate change assumptions?	b. Other				X	GSA. Table A-1a represents the current (2020) climate condition; Table A-1b represents the predicted conditions for Year 2040 due to climate change - which are increased ET and reduced precipitation and streamflow, and Table A-1c represents the effects of climate change in Year 2070. ET is predicted to increase 3% by Year 2030 and 6% by Year 2070. Precipitation and streamflow are predicted to decrease 2% by Year 2030 and 4% by Year 2070. Tables A-1 deal with the ET increase. Climate change effects on precipitation and surface water are considered in Tables 2.3.1)." Limited information on the method or data used to incorporate climate change into the water budget are provided in the draft GSP. Table A-1a, b, and c are not actually provided in the appendix.	
4. Does the GSP use multiple climate scenarios?			X				
5. Does the GSP quantitatively incorporate climate change projections?			X			"Chart 2.3.10-A depicts the 2040 conditions with planned projects included, reduction of net subsurface inflow to 20,000 afy, reduction of the recoverable volume of water from aquitard compression to 2,000 afy, and with a 20% reduction in crop water consumption achieved by a reduction in groundwater pumpage and permanently idling cropland. Unit crop water demands have been increased due to the effects of climate change"	2.3.10, page 203
6. Does the GSP explicitly account for climate change in the following elements of the future/projected water budget?	a. Inflows:	i. Precipitation	X			"Table A-1a represents the current (2020) climate condition; Table A-1b represents the predicted conditions for Year 2040 due to climate change - which are increased ET and reduced precipitation and streamflow, and Table A-1c represents the effects of climate change in Year 2070. ET is predicted to increase 3% by Year 2030 and 6% by Year 2070. Precipitation and streamflow are predicted to decrease 2% by Year 2030 and 4% by Year 2070. Tables A-1 deal with the ET increase. Climate change effects on precipitation and surface water are considered in Tables 2.3.1)."	2.3.1, page 161
		ii. Surface Water	X				
		iii. Imported Water		X			
		iv. Subsurface Inflow		X			
	b. Outflows:	i. Evapotranspiration	X				
		ii. Surface Water Outflows (incl. Exports)	X				
		iii. Groundwater Outflows (incl. Exports)		X			
7. Are demands by these sectors (drinking water users) explicitly included in the future/projected water budget?	a. Domestic Well users (<5 connections)			X		It is not clear that drinking water demands were considered in the historic, current, and/or projected water budgets, including demands by domestic well users and those of the Allensworth CSD.	
	b. State Small Water systems (5-14 connections)			X			
	c. Small community water systems (<3,300 connections)			X			
	d. Medium and Large community water systems (> 3,300 connections)			X			
	e. Non-community water systems			X			
8. Are water uses for native vegetation and/or wetlands explicitly included in the current and historical water budgets?				X		Evapotranspiration is included as a category in the groundwater balances (Table 2.3.8); however, it is only included as it pertains to crop water requirements. Groundwater outflow to ET should be identified as a	2.3, page 158-204

DWR Resource Guide DWR-Provided Climate Change Data and Guidance for Use During GSP Development: https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Groundwater-Management/Sustainable-Groundwater-Management/Best-Management-Practices-and-Guidance-Documents/Files/Resource-Guide-Climate-Change-Guidance_v8.pdf

9. Are water uses for native vegetation and/or wetlands explicitly included in the projected/future water budget?		X		groundwater budget component. If the outflow is not known, it should be identified as a data gap and provisional information should be provided until an analysis can be performed to address the data gap. The GSP should provide a breakdown of ET for all land-cover types, including native and riparian vegetation (such as wetlands, riparian vegetation, phreatophytes and other communities). Identify any data gaps and outline the actions needed to address them and the schedule for their implementation.	

Summary/ Comments

The draft GSP states that climate change impacts were considered for developing future water budget, but it does not provide a detailed description of the methodology used for calculating climate change impacts, or indicate whether the method used is consistent with DWR guidelines.

The draft GSP references Tables A-1a, A-1b, and A-1c as being in an appendix, but does not actually provide these tables in Appendix A.

The discussion about how climate change effects were incorporated into the future water budget is limited and does not describe whether the methodology used was consistent with DWR guidance. J-4

It is not clear from the description of the water budgets in the draft GSP whether drinking water demands were considered in the historic, current, and/or projected water budgets. Water demands by domestic well users and those of the Allensworth Community Services District should be explicitly discussed and accounted for in all water budgets.

The GSP should provide a breakdown of ET for all land-cover types, including native and riparian vegetation (such as wetlands, riparian vegetation, phreatophytes and other communities). Identify any data gaps and outline the actions needed to address them and the schedule for their implementation.

5. Management Areas and Monitoring Network

How were key beneficial users considered in the selection and monitoring of Management Areas and was the monitoring network designed appropriately to identify impacts on DACs and GDEs?

Selected relevant requirements and guidance:
GSP Element 3.3, "Management Areas" (§354.20):

(b) A basin that includes one or more management areas shall describe the following in the Plan:
(2) The minimum thresholds and measurable objectives established for each management area, and an explanation of the rationale for selecting those values, if different from the basin at large.
(3) The level of monitoring and analysis appropriate for each management area.
(4) An explanation of how the management area can operate under different minimum thresholds and measurable objectives without causing undesirable results outside the management area, if applicable.
(c) If a Plan includes one or more management areas, the Plan shall include descriptions, maps, and other information required by this Subarticle sufficient to describe conditions in those areas.

CWC Guide to Protecting Drinking Water Quality under the SGMA[12]
TNC's Groundwater Dependent Ecosystems under the SGMA, Guidance for Preparing GSPs[13]

Review Criteria	Yes	No	N/A	Relevant Info per GSP	Location (Section, Page)
1. Does the GSP define one or more Management Area?	X			"Figure 1.4.0 depicts the Management Areas (North Management Area and Southeast Management Area), which comprise the focus area of this GSP." "The GSA has been divided into three Management Areas, two of which are the focus of this GSA. These are shown in Figures 1.4.6-A - the North Area; and 1.4.6-B - the Southeast Area. Areas 1.4.6-A and 1.4.6-B are in the Tule Subbasin." The third management area is in the Tulare Lake subbasin. "TCWA has divided its GSA into two distinct management areas, the North Management Area (North Area) and the Southeast Management Area (Southeast Area). The North Management Area The North Area, which is nearly all within Angiola Water District, has a groundwater supply that is supplemented by a surface water supply. The wells extract water from the lower and upper aquifers. Crops grown in the North Area are field crops that can be fallowed to satisfy water supply reductions in times or drought. The surface water supply comes from various sources, including the State Water Project (Article 21 water), the Central Valley Project via the Fresno Slough Water District and Mercy Springs Water District Transfers, the Tule River (via the Bayou Vista Ditch Company), the Kings River,	1.4, page 42; 1.4-5, page 50; 5.1, page 296

[12] CWC Guide to Protecting Drinking Water Quality under the SGMA: https://d3n8a8pro7vhmx.cloudfront.net/communitywatercenter/pages/293/attachments/original/1559328858/Guide_to_Protecting_Drinking_Water_Quality_Under_the_Sustainable_Groundwater_Management_Act.pdf?1559328858
[13] TNC's Groundwater Dependent Ecosystems under the SGMA, Guidance for Preparing GSPs: https://www.scienceforconservation.org/assets/downloads/GDEsUnderSGMA.pdf

				Deer Creek, and flood waters when available. AWD owns two well fields that together contain about 35 wells. The gross area contained within the North Area is approximately 12,000 acres. The Southeast Management Area The Southeast Area is an Un-Districted ("White Area") that has no surface water supply. It relies on groundwater to supply its crop water needs. The east two-thirds of the area has access to both the upper and the lower aquifer. The west one-third has access only to the lower aquifer. Crops grown in the Southeast Area are predominantly permanent crops – mainly Pistachios. These crops cannot be fallowed in times of restricted water supplies, they must be idled, trees removed and land set aside. The gross area of the Southeast Area is about 50,000 acres."	
2. Were the management areas defined specifically to manage GDEs?		**X**		"The Management Areas are separated because of differences in location, water supplies and groundwater conditions. These Areas are discussed in greater detail in Chapter 2 of this report."	1.4-5, page 50
3. Were the management areas defined specifically to manage DACs?		**X**			
a. If yes, are the Measurable Objectives (MOs) and MTs for GDE/DAC management areas more restrictive than for the basin as a whole?			**X**		
b. If yes, are the proposed management actions for GDE/DAC management areas more restrictive/ aggressive than for the basin as a whole?			**X**		
4. Does the GSP include maps or descriptions indicating what DACs are located in each Management Area(s)?		**X**			
5. Does the GSP include maps or descriptions indicating what GDEs are located in each Management Area(s)?	**X**			"Approximately 125 acres of GDEs are present within the North Management Area, the majority of which are classified as shrubby seepweed (Suaeda moquinii). A total of 3,391 acres of GDEs were identified within the Southeast Management Area, of which the majority is also shrubby seepweed (approximately 2,483 acres). The two other main plant species present within the Southeast Management Area are alkali goldenbush (Isocoma acradenia) (approximately 607 acres), and iodine bush (Allenrolfea occidentalis) (approximately 214 acres). Refer to Figure 1.4.9 – Natural Communities Map, provided in Chapter 1."	2.2.7, page 156
6. Does the plan identify gaps in the monitoring network for DACs and/or GDEs?		**X**		The draft GSP proposes to use groundwater level monitoring for to assess potential groundwater level declines. A set of representative wells has been selected to monitor the upper and lower aquifer (Tables 3.4.1 and 3.5.1). However, there are no plans to monitor groundwater level declines to assess the potential for significant and unreasonable impacts to GDEs or ISWs. In addition, the monitoring wells are not screened in the upper portion of the upper aquifer, where environmental beneficial users would obtain the groundwater on which they rely. Finally, there are no plans to monitor potential depletions in surface water flows or to assess potential GDE responses to groundwater level declines.	4.1, page 249
a. If yes, are plans included to address the identified deficiencies?			**X**		
Summary/ Comments					

Care should be taken so that the management areas and the associated monitoring network are designed to adequately assess and protect against impacts to all beneficial users, including DACs. It is recommended that the GSP discuss what, if any, differential impacts would be anticipated as a result of the separate management of these areas.

The GSP should modify the description of the new well network to provide methodologies, data and other information to support the monitoring of GDEs and ISWs so as to assess and prevent potential significant and unreasonable impacts. This modification should include: 1) locating new wells that are appropriately screened to detect connectivity of GDEs and ISWs with the upper aquifer and 2) identifying or installing additional stream gages in areas where there is potential for ISWs and GDEs. In addition, monitoring or GDE responses to groundwater level declines should be included. GDE Pulse represents an example of how remote sensing can be used to achieve this objective. The GSP should expand on the discussion of how the new well, stream and other data will be used to improve ISW mapping and inform an adequate analysis, and how the data will be used to verify possible GDEs and their sensitivity to groundwater level declines. J-5

The GSP is suggested to reconcile data gaps (shallow monitoring wells, stream gauges, and nested/clustered wells, GDE responses to groundwater levels) along Deer Creek in this section of the GSP to improve ISW mapping.

6. Measurable Objectives, Minimum Thresholds, and Undesirable Results

How were DAC and GDE beneficial uses and users considered in the establishment of Sustainable Management Criteria?

Selected relevant requirements and guidance:
GSP Element 3.4 "Undesirable Results" (§ 354.26):
(b) The description of undesirable results shall include the following:
(3) Potential effects on the beneficial uses and users of groundwater, on land uses and property interests, and other potential effects that may occur or are occurring from undesirable results

GSP Element 3.2 "Measurable Objectives" (§ 354.30)
(a) Each Agency shall establish measurable objectives, including interim milestones in increments of five years, to achieve the sustainability goal for the basin within 20 years of Plan implementation and to continue to sustainably manage the groundwater basin over the planning and implementation horizon.

Review Criteria	Yes	No	N/A	Relevant Info per GSP	Location (Section, Page)
1. Are DAC impacts considered in the development of Undesirable Results (URs), MOs, and MTs for groundwater levels and groundwater quality?		X		"An undesirable result for TCWA would be the sustained lowering of spring groundwater levels in two consecutive reporting years, exceeding the minimum thresholds at Representative Monitoring Sites that collectively represent monitoring areas that comprise at least 50% of the TCWA GSA. … In accordance with the Tule Subbasin Sustainable Management Criteria, the projected trends for the upper aquifer wells from 2020 through 2030 are shown on the Figures for the upper aquifer. Not all wells have information through the drought, but the average drops in Spring water levels through the recent drought, using 2010 – 2016 for two shallow wells that have records in that time period, show declines of 20 to 30 feet. Projecting the lowest water levels to 2030 and subtracting 20-30 feet from that level, results in numbers in the range of the minimum thresholds shown on the figures. … Drops in Spring pressure levels in the lower aquifer wells varied with declines of 30 to 100 feet. The minimum thresholds that have been selected for these wells will have to be readjusted lower to fit the Tule criteria. … Interim Milestones have been set to reflect a steady improvement in groundwater levels from the minimum thresholds to the Measurable Objective of recovering to water levels near the 2015 water levels."	3.3.3, page 219-220
				"Utilizing the Tule Subbasin Criteria, TCWA will establish the concentration of Constituents of Concern ("COC") for each representative monitoring site ("RMS"). These COCs will be determined based on the land use represented by the RMS. For domestic wells the COCs will be different from those for irrigation wells in some respects. Data utilized will be that collected by others such as the Irrigated Lands Regulatory Program or Drinking Water Standards for public water systems (for TCWA this is the community of Allensworth). The Minimum Thresholds shall be that there be no long term (10 year running	3.3.3, page 234

				average) increase above 15% in COC concentration above the initial baseline (2020 ten-year average) condition, caused by groundwater pumping and/or recharge efforts. First, the relationship between groundwater pumping, groundwater recharge efforts, and groundwater quality, as measured by the COCs, should be established. This will be done during the first five years of the program, as data are gathered on groundwater pumpage, water levels, and groundwater quality. It is anticipated that minimum thresholds and measurable objectives adopted in 2020 will be adjusted in 2025."	
2. Does the GSP explicitly discuss how stakeholder input from DAC community members was considered in the development of URs, MOs, and MTs?		**X**			
3. Does the GSP explicitly consider impacts to GDEs and environmental BUs of surface water in the development of MOs and MTs for groundwater levels and depletions of ISWs?		**X**		<u>MOs:</u> The Measurable Objective for chronic decline in groundwater levels does not consider GDEs. The GSP should include GDEs in this section and whether the measurable objectives and interim milestones will help achieve the sustainability goal as it pertains to environmental beneficial users. The draft GSP states that there are no ISWs in Deer Creek; however, the GSP provides no data or analysis to support this conclusion. In addition, Tule Lake is identified as potentially being groundwater connected during some periods. Include a statement that recognizes the potential for ISWs, pending the characterization of the upper aquifer and analysis of monitoring data or monitoring from additional wells to be installed in the future to address data gaps. The water quality Measurable Objective does not consider the water quality needs of GDEs. The GSP should include impacts from degraded water quality on the plant and wildlife communities within GDEs. Section 2.2.6 states (p 116) that there may be a temporary connection between surface water the upper aquifer system in the Tulare Lakebed. Many of the wells are screened deeper and nested wells have not been installed to inform how shallow groundwater interacts with potential ISWs and GDEs, and there are no data or analyses presented that would allow the potential for ISWs and GDEs to be dismissed. Based on this information, the Plan should acknowledge the potential for interconnected surface waters and GDEs and establish Measurable Objectives for this indicator. Include all potential ISWs and GDEs in the analysis and develop measurable objectives and minimum thresholds, to be managed until data gaps prove they are not interconnected. Identify any data gaps for future resolution. <u>MTs:</u> The evaluation of minimum thresholds disregards consideration of environmental beneficial users, such as ISWs or GDEs. Although there are many data gaps associated with ISWs and GDEs, it must be assumed that potential significant and unreasonable impacts to these beneficial users could	3.5, page 242; 3.3.3, page 219;

				occur. As such, they should be addressed in the evaluation of minimum thresholds. Section 3.3.3 should be modified to address how potential ISWs and GDEs would be affected by further lowering of groundwater levels. Section 3.3.3 states that development of minimum thresholds for interconnected surface water is not applicable, but fails to provide any monitoring data, analysis or other information to substantiate this position. The GSP identifies groundwater levels in the upper aquifer as a data gap and indicates that Tule Lake may sometimes be hydraulically connected to the regional aquifer system. Minimum thresholds must be established for ISWs and GDEs unless and until sufficient data are provided to eliminate them from consideration. The GSP should 1) develop minimum thresholds for possible ISWs, including GDEs, and 2) include a statement that a data gap exists related to the interconnectedness of the of the Lakebed and shallow groundwater as well as Deer Creek. Section 3.3.3 and 3.4 does not include the required analysis of how the selected minimum thresholds for decline in groundwater levels could affect ISWs and GDEs within and near the GSP area. Include an analysis of the potential effect of the established minimum thresholds on ISWs and GDES within and near the GSP area. Although agricultural and domestic water quality concerns were articulated, similar concerns were not identified for environmental users. Degradation of water quality can impact terrestrial and aquatic wildlife that live in or near these ecosystems during at least part of the year even if the water is not a concern from an agricultural or municipal standpoint. Include a discussion about GDEs and water quality and whether the minimum thresholds and interim milestones will help achieve sustainability for environmental users.	 3.4, page 240
4. Does the GSP explicitly consider impacts GDEs and environmental BUs of surface water and recreational lands in the discussion and development of Undesirable Results?		X		The draft GSP only describes undesirable results relating to human beneficial uses of groundwater and neglects environmental beneficial uses / users that could be adversely affected by chronic groundwater level decline or depletion of interconnected surface waters. The GSP should add "possible adverse impacts to potential GDEs and ISWs" to the list of potential undesirable results. The draft GSP discusses water quality with respect to agricultural and municipal use but does not include discussion of potential undesirable results for GDEs and ISWs. The GSP should specifically address degraded water quality from TDS and B to the vegetative portion of GDEs and ISWs. Although As is mentioned in this GSP please consider adding a statement that over-pumping and dewatering of aquitards has been identified as a potential source of elevated As concentrations above drinking water standards in San Joaquin Valley aquifers. The following is a link to a paper by Smith, Knight and Fendorf (2018) titled "Overpumping leads to California groundwater arsenic threat": https://www.nature.com/articles/s41467-018-04475-3 The draft GSP states that there are no ISWs; however, there is no monitoring	3.2.2, page 215; 3.3, page 234

				data, analyses or other information to support this statement. In addition, Section 2.2.6 indicates a connection may exist between shallow groundwater and Tulare Like during some times. Furthermore, GDEs may exist within and near the GSP area. A data gap needs to be identified and a monitoring network employed to verify the status of ISWs prior to complete dismissal of ISWs from the GSP. The GSP should include 1) an assessment of the nature of potential undesirable results to ISWs and GDEs; 2) recognition of the existence of potential ISWs and GDEs, unless adequate data can be provided to dismiss them, 3) a statement that the aquifers will be managed such there will be no depletion of ISWs that results in a significant and unreasonable impact to GDEs; and 4) recognition of any data gaps and specific steps to verify the presence or absence of ISWs and GDEs with monitoring wells screened at the appropriate depths.	
5. Does the GSP clearly identify and detail the anticipated degree of water level decline from current elevations to the water level MOs and MTs?		X			
6. If yes, does it include: b. Is this information presented in table(s)?			X		
c. Is this information presented on map(s)?			X		
d. Is this information presented relative to the locations of DACs and domestic well users?			X		
e. Is this information presented relative to the locations of ISW and GDEs?			X		
2. Does the GSP include an analysis of the anticipated impacts of water level MOs and MTs on drinking water users?		X			
3. If yes: a. On domestic well users?			X		
b. On small water system production wells?			X		
c. Was an analysis conducted and clearly illustrated (with maps) to identify what wells would be expected to be partially and fully dewatered at the MOs?			X		
d. Was an analysis conducted and clearly illustrated (with maps) to identify what wells would be expected to be partially and fully dewatered at the MTs?			X		
e. Was an economic analysis performed to assess the increased operation costs associated with increased lift as a result of water level decline?			X		

Summary/ Comments

Based on the presented information, drinking water users, including domestic well users and DACs are not explicitly and thoroughly considered as part of the development of water level URs, MOs, and MTs. More detail and specifics regarding these drinking water users (both those that rely on smaller community drinking water systems and those that rely on domestic wells) is necessary to demonstrate that these beneficial users were adequately considered. J-6

The GSP should describe how the approach to developing water level MOs/MTs is protective of the diverse drinking water users within the GSP area. An impact analysis should be performed to evaluate the potential impacts to wells associated with the water level MOs/MTs and presented in the GSP. The locations of potentially impacted wells should be identified and presented in maps in the GSP so that the public and DWR may assess the well impacts specific to DACs and other sensitive users within the GSP area. As written a minimum threshold that requires exceedances in at least 50% of the basin is NOT protective of the DACs identified in this plan.

The GSP should clearly identify and detail the anticipated degree of water level decline from current elevations to the water level MOs and MTs. Given that the subbasin is in critical overdraft, the GSP should explain how the projected additional water level declines at MTs will result in sustainable conditions for beneficial users. The GSP should also consider and quantify both the potential dewatering of wells and the pumping costs associated with the increased lift at the projected lower water levels, in order to more fully and transparently consider the impacts to beneficial users.

The GSP includes a mention of domestic well users under the discussion of water quality criteria, i.e., that "For domestic wells the COCs [Constituents of Concern] will be different from those for irrigation wells in some respects," however, the GSP does not clearly present which COCs will be monitored for at which wells. Further, the discussion of the groundwater quality monitoring well network is vague, and does not mention the sampling of domestic wells at all. It is not clear from the information presented in the GSP how the proposed water quality sustainable management criteria will be protective of drinking water users, particularly if irrigation wells located near domestic well users are not even monitored for the constituents that affect drinking water usability.

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 (or even irrigation) usability standards. Given this, it is not at all clear in the GSP if this approach will result in constituent concentrations consistent with continued drinking water use. The GSP must clearly articulate the anticipated numeric MOs and MTs for each water quality constituent, and provide a map of the locations of the proposed water quality monitoring wells. J-6

The GSP should also present a clear and detailed plan for evaluating and establishing "the relationship between groundwater pumping, groundwater recharge efforts, and groundwater quality, as measured by the COCs [Constituents of Concern], and lay out in the GSP the specific planned analyses and framework for establishing this relationship that will be carried out over the next 5 years.

The GSP should include GDEs when developing MOs and MTs and whether the MOs and interim milestones will help achieve the sustainability goal as it pertains to environmental beneficial users. The water quality MOs does not consider the water quality needs of GDEs. The GSP should include impacts from degraded water quality on the plant and wildlife communities within GDEs. The GSP should include all potential MOs and MTs impacts on ISWs and GDEs in the analysis.

The GSP should add "possible adverse impacts to potential GDEs and ISWs" to the list of potential undesirable results.

The GDE Pulse web application developed by TNC provides easy access to 35 years of satellite data to view trends of vegetation metrics, groundwater depth (where available), and precipitation data. This satellite imagery can be used to observe trends for NC dataset polygons within and near the GSA. Over the past 10 years (2009-2018), some NC dataset vegetation polygons have experienced adverse impacts to vegetation growth and moisture.

For each potential GDE unit with supporting hydrological datasets, the GSP should include:

- Plot and provide hydrological datasets for each GDE.
- Define the baseline period in the hydrologic data.
- Classify GDE units as having high, moderate, or low susceptibility to changes in groundwater.
- Explore cause-and-effect relationships between groundwater changes and GDEs.

For each identifiable GDE unit without supporting hydrological datasets, describe data gaps and / or insufficiencies.

Describe possible effects on potential ISWs, GDEs, land uses, and property interests, including:

- Cause-and-effect relationships between potential ISWs and GDEs with groundwater conditions.
- Impacts to potential ISWs and GDEs that are considered to be "significant and unreasonable".
- Report known hydrological thresholds or triggers (e.g., instream flow criteria, groundwater depths, water quality parameters) for significant impacts to relevant species or ecological communities.
- Land uses should include recreational uses (e.g., fishing/hunting, hiking, boating).
- Property interests should include and consider privately and publicly protected conservation lands and opens spaces, including wildlife refuges, parks, and natural preserves.
- Define any data gaps in the above requests and develop a plan to address them.

J-6

The GSP should include 1) an assessment of the nature of potential undesirable results to ISWs and GDEs; 2) recognition of the existence of potential ISWs and GDEs, unless adequate data can be provided to dismiss them, 3) a statement that the aquifers will be managed such that there will be no depletion of ISWs that results in a significant and unreasonable impact to GDEs; and 4) recognition of any data gaps and specific steps to verify the presence or absence of ISWs and GDEs with monitoring wells screened at the appropriate depths.

Biological data should be compiled and synthesized for each GDE unit. Based on the potential for GDEs in the Subbasin, the GSP should include:

- Characterization of biological resources for each GDE unit, and when possible provide baseline conditions for assessment of trends and variability.
- A description of data gaps / insufficiencies.
- Stated plans to reconcile data gaps in the monitoring network.

7. Management Actions and Costs

What does the GSP identify as specific actions to achieve the MOs, particularly those that affect the key BUs, including actions triggered by failure to meet MOs? What funding mechanisms and processes are identified that will ensure that the proposed projects and management actions are achievable and implementable?

<u>Selected relevant requirements and guidance</u>
GSP Element 4.0 Projects and Management Actions to Achieve Sustainability Goal (§ 354.44)
(a) Each Plan shall include a description of the projects and management actions the Agency has determined will achieve the sustainability goal for the basin, including projects and management actions to respond to changing conditions in the basin.
(b) Each Plan shall include a description of the projects and management actions that include the following:
(1) A list of projects and management actions proposed in the Plan with a description of the measurable objective that is expected to benefit from the project or management action.

Review Criteria			Yes	No	N/A	Relevant Info per GSP	Location (Section, Page)
1.	Does the GSP identify benefits or impacts to DACs as a result of identified management actions?			X			
2.	If yes:	f. Is a plan to mitigate impacts on DAC drinking water users included in the proposed Projects and Management Actions?			X		
		g. Does the GSP identify costs to fund a mitigation program?			X		
		h. Does the GSP include a funding mechanism to support the mitigation program?			X		
4.	Does the GSP identify any demand management measures in its projects and management actions?		X			"Taking lands out of production is an alternative that is available and likely will be employed to some extent, but the goal of this GSP and the projects that are listed herein, and others that will be developed over the implementation period, is to preserve as much productive agriculture as possible. Management actions that are being considered are to reduce the deficit by 10% in 2025 and another 10% in 2030. This would reduce the deficit by about 7,500 afy in 2025 and 15,000 afy in 2030. This management action will not be employed for the first five years while a better understanding of groundwater conditions is developed."	5.2, page 323
5.	If yes, does it include:	a. Irrigation efficiency program		X			
		b. Ag land fallowing (voluntary or mandatory)	X			"<u>Reduction of Groundwater Extractions by Idling</u> → This is a TCWA management project whereby certain lands are fallowed in order to reduce groundwater extractions. → This project would place a fee on groundwater extractions beyond safe yield and designate the funds to be used for purchasing/leasing lands for idling purposes. <u>Reduction of Groundwater Extractions by Voluntarily Idling Lands</u> → This program would be accomplished by private landowners in order to reduce groundwater extractions. It is hoped that implementation of	5.2, page 309;

					projects will be sufficient to avoid idling lands." Reduction in Crop Water Demand by Taking Land Out of Production: "Proposed management action: Mandatory reduction in crop water use by taking land out of production, thereby reducing groundwater pumpage. Enforced by implementation of tolls on water use."	 4.2, page 318
	c. Pumping allocation/restriction		X			
	d. Pumping fees/fines	X			Deep Aquifer Pumping Conversion to Upper Aquifer Pumping: "Proposed management action: 1. Fees on pumpage from the lower aquifer. 2. Restrictions on drilling new wells into the lower aquifer. Description of the proposed management action: To the extent possible, wells pumping from the lower aquifer will be idled. These wells will be replaced by wells pumping from the upper aquifer. Hydrographs of wells in the upper aquifer show that it is in balance (ref. hydrographs Figs. 3.1.1 – 3.1.8). Wells in the west part of the Southeast Area will remain on the lower aquifer while surface water supplies are being developed for that area because of the absence of an upper aquifer in that area. It is proposed to transfer about 24,000 acre-feet/year of lower aquifer pumpage to the upper aquifer." The goal of this is to shift pumping to the upper aquifer, rather than reducing pumping overall.	5.2, page 312
	e. Development of a water market/credit system		X			
	f. Prohibition on new well construction	X			See above under 4.d. This restriction is limited to deep aquifer only.	5.2, page 312
	g. Limits on municipal pumping		X			
	h. Limits on domestic well pumping		X			
	i. Other	X			"Deep Aquifer Pumping Reduction → This project is to reduce pumping from the lower aquifer and thereby reduce land subsidence. → Pumping will be reduced or stopped for a number of wells tapping the lower ("deep") aquifer by replacing some of the wells pumping from the lower aquifer with wells pumping from the upper ("shallow") aquifer. → It is estimated that at least 80% of the groundwater pumping in TCWA is from the deep aquifer. Groundwater pumping is estimated to be about 60,000 afy, including groundwater exports out of the Subbasin. Therefore, an estimated 48,000 afy is being pumped out of the deep aquifer. → It is proposed to install 24 shallow wells and thereby reduce pumpage from the deep aquifer by an approximate 24,000 afy, or about half of the current deep aquifer pumpage." The goal of this is to shift pumping to the upper aquifer, rather than reducing pumping overall.	5.2, page 309
6. Does the GSP identify water supply augmentation projects in its projects and management actions?		X				
7. If yes, does it include:	a. Increasing existing water supplies		X			
	b. Obtaining new water supplies	X			"White Ranch → This project includes utilization of waters from the Liberty Project and capture of water from Deer Creek in flood years to reduce lower aquifer	5.2, page 301;

					groundwater pumping in the Tule Subbasin. → It is anticipated that one year out of seven, Deer creek produces 5,400 acre-feet of streamflow that can be captured by AWD. This amounts to an average 800 acre-feet per year." "Proposed management action: Replace groundwater pumpage with a surface water supply on AWD lands in the North Area. Description of the proposed project: Construction of a 1,280-acre storage facility on Liberty lands together with the necessary pumping plant(s) and transfer facilities to move water from the Wilbur Ditch / Lateral A to storage and transfer the water to the Deer Creek/White Ranch lands for recharge or to the AWD canal system for direct application in lieu of groundwater."	 5.2, page 314
	c. Increasing surface water storage	X			"→ The Liberty Project is a water storage project on about 20-sections of land on private lands within AWD in Kings County (see Figure 5.2.1). It will be built in phases. → This project will enable the capture and temporary storage of winter/spring flows from the Fresno Slough- Fresno Irrigation District, the CVP, the Kings, Tule and Kaweah Rivers, SWP Article 21 and CVP 215 waters. → The waters will be conveyed into, what ultimately, will be a 20-section storage reservoir constructed in Sections 14-23 and 26-35 of T.23S., R.21E., MDB&M, located south of Utica Avenue in Kings County. This water will be used in-lieu of groundwater for the irrigation of crops. The project will supply 5,000 af of water to the White Ranch area in Tulare County (Tule Subbasin)." "The Liberty Project is a large (20 sections – 12,800 acre) storage/transmission project that will store available water from multiple sources during periods of excess water supplies and distribute this water for in-lieu irrigation use and to remove some lands permanently from groundwater supplies. The project involves construction of an above-ground storage facility with pumping plants installed in the Wilbur Ditch or Blakeley Canal to pump water into the facility which will also incorporate facilities to return the water to Laterals A and B for distribution to lands in the North and Southeast Areas via existing canals. Agreements will be required with Alpaugh Irrigation District for use of the Alpaugh Canal to convey water to the Southeast Area for direct application to irrigation."	5.2, page 301; 5.2, page 315
	d. Groundwater recharge projects – District or Regional level	X			"TCWA GSA Recharge Project → This project is contemplated to be located in the northeast quadrant of the Southeast Area. The project will capture flood waters in years of seasonal flooding. Floodwaters would be directed to reservoirs constructed to capture and recharge these waters. → The project is in the feasibility study phase. → The goal is to capture about 1,200 – 1,800 afy of floodwaters for aquifer recharge."	5.2, page 309
	e. On-farm recharge		X			
	f. Conjunctive use of surface water		X			
	g. Developing/utilizing recycled water		X			
	h. Stormwater capture and reuse	X			"TCWA GSA Recharge Project	5.2, page 309

				→ This project is contemplated to be located in the northeast quadrant of the Southeast Area. The project will capture flood waters in years of seasonal flooding. Floodwaters would be directed to reservoirs constructed to capture and recharge these waters. → The project is in the feasibility study phase. → The goal is to capture about 1,200 – 1,800 afy of floodwaters for aquifer recharge."	
i. Increasing operational flexibility (e.g., new interties and conveyance)		X			
j. Other		X			
8. Does the GSP identify specific management actions and funding mechanisms to meet the identified MOs for groundwater quality and groundwater levels?	X			General descriptions of funding are given for most projects. **Deep Aquifer Pumping Conversion to Upper Aquifer Pumping** "1.6 Implementation Methodology: The TCWA will need to adopt a policy restricting new wells to the upper aquifer and placing fees on pumpage from the lower aquifer." **White Ranch/ Deer Creek Project** "2.6 Implementation Methodology: 1. The project will be financed by private funding. Planning and construction will be approved by AWD. 2. The project will rely on water supplies that are outside of the jurisdiction of AWD. The following is an explanation of the sources and reliability of the source water. *(description to be provided by AWD)"* **Liberty Project** "3.6 Implementation Methodology: 1. The project will be financed by private funding. Planning and construction will be approved by AWD. 2. The project will rely on water supplies that are outside of the jurisdiction of AWD. The following is an explanation of the sources and reliability of the source water. *(description to be provided by AWD)"* **Reduction in Crop Water Demand by Taking Land Out of Production** "4.6 Implementation methodology: Reductions will be required by TCWA and tolls initiated on excessive use of groundwater beyond that which is permitted by the TCWA. The TCWA's Board of Directors will implement policy at a public meeting after written and oral testimony is received and considered."	5, page 314

				Landowner-sponsored Groundwater Recharge Project: The Prosperity Farms Project "5.6 Implementation Methodology: 1. The project will be financed by private funding. Planning and construction will be approved by the County of Tulare. 2. The project will rely on floodwaters in White River."	
9. Does the GSP include plans to fill identified data gaps by the first five-year report?	X			"Monitoring Monitoring for the GSP will also begin in 2020 and it is planned to fill the data gaps that exist in the information that is required to effectively manage the GSA. The first five years of the implementation period for the GSP will be focused on gathering adequate information through monitoring, to develop an enhanced understanding of the water levels and land subsidence in the GSA. Data Gaps There are data gaps in measurements of groundwater pumpage and water levels, water quality testing, and the measurements of land subsidence. The following measures/actions will be implemented to address the data gaps. … Water Level Measurements Water level measurements will begin in 2020 for the Representative Monitoring Wells to establish progress towards the goal of sustainability. It is also planned to develop enough information on water levels that accurate water level elevation contour maps can be prepared for both aquifers in the GSA. These can then be used to better estimate lateral groundwater flows for both aquifers. Water Quality Testing Water samples will be collected in the GSA and other wells as required to develop changes in electrical conductivity in compliance with the Water Quality Control Plan for the Tulare Lake Basin. Base electrical conductivity will be established during the first five years of the plan, from which the maximum average annual conductivity increase will be determined and reported."	3.5.3, page 244
10. Do proposed management actions include any changes to local ordinances or land use planning?	X			Includes prohibition of new well construction in the deep aquifer.	
11. Does the GSP identify additional/contingent actions and funding mechanisms in the event that MOs are not met by the identified actions?		X			
12. Does the GSP provide a plan to study the interconnectedness of surface water bodies?		X		"Shallow groundwater (less than about 20 feet deep) is common beneath the Tulare Lakebed. In most cases, this shallow groundwater is located above the A-Clay. There is no indication that any of the streams in the GSA are in hydraulic connection with the shallow groundwater. However, when the Tulare Lakebed contains lake water, this water may temporarily be in hydraulic connection with the underlying shallow groundwater at some locations. There are a number of shallow observation wells and monitor wells in parts of the lakebed. Groundwater monitoring at agricultural drainage water evaporation ponds has not indicated a hydraulic connection between water in the ponds and the underlying groundwater. That is, water levels were below the bottom	2.2.6, page 155

				of the ponds. Also, there has been no known pumping of this shallow groundwater in the lakebed area, due to its high salinity."	
13. If yes: a. Does the GSP identify costs to study the interconnectedness of surface water bodies?			X		
b. Does the GSP include a funding mechanism to support the study of interconnectedness surface water bodies?			X		
14. Does the GSP explicitly evaluate potential impacts of projects and management actions on groundwater levels near surface water bodies?		X		Several important projects are identified in the GSP; however, the descriptions of Measurable Objectives for these projects only identifies benefits to water level and storage through changes in allocation, imports, surface water diversions, and pumping allowances, and adding percolation basin. Since maintenance or recovery of groundwater levels, or construction of recharge facilities, may have potential environmental benefits it would be advantageous to demonstrate multiple benefits from a funding and prioritization perspective. For the projects already identified, describe and assess how ISWs and GDEs will benefit or be protected, or what other environmental benefits will accrue. This should be done for all projects, in particular for the effort to shift deep aquifer pumping to the upper aquifer. If ISWs will not be adequately protected by those listed, include and describe additional management actions and projects targeted for protecting ISWs. The storage projects, such as identified as White Ranch/ Deer Creek Project (p 274) and Liberty Ranch (p 275) can be designed as multiple-benefit projects to include elements that act functionally as wetlands and provide a benefit for wildlife and aquatic species. In some cases, such facilities have been incorporated into local HCPs and NCCPs, more fully recognizing the value of the habitat that they provide and the species they support. For projects that construct recharge ponds, the GSP should consider identifying if there is habitat value incorporated into the design and how the recharge ponds can be managed as multiple-benefit projects to benefit environmental users. Grant and funding opportunities for SGMA-related work may be prioritized for multi-benefit projects that can address water quantity as well as provide environmental benefits. Include environmental benefits and multiple benefits as criteria for assessing project priorities. For examples of case studies on how to incorporate environmental benefits into groundwater projects, visit our website: https://groundwaterresourcehub.org/case-studies/recharge-case-studies/.	5, page 296

Summary/ Comments

The likely benefits and impacts to DAC members by the proposed projects and management actions are not clearly identified in the GSP. J-7

Projects and management actions include several designed to shift overall pumping from the deep aquifer to the upper aquifer. While this should improve subsidence conditions, the GSP must consider the effects of these projects and management actions on all beneficial users, including domestic well users that typically rely on the upper aquifer. The GSP should thoroughly consider and present what affects this shift will have on the conditions in the upper aquifer, including water levels and potential changes in water quality.

First, the relationship between groundwater pumping, groundwater recharge efforts, and groundwater quality, as measured by the COCs, should be established. This will be done during the first five years of the program, as data are gathered on groundwater pumpage, water levels, and groundwater quality. It is anticipated that minimum thresholds and measurable objectives adopted in 2020 will be adjusted in 2025." The GSP states that the conversion of deep aquifer pumping to upper aquifer pumping has begun and that "AWD has transferred several wells from the lower to the upper aquifer in the past several years and plans to remove several more between 2020 and 2025. Table ______ [sic] lists the proposed schedule." Given that this shift is already occurring, it is imperative that the GSA evaluate the relationship between these changes and groundwater quality quickly and thoroughly.

J-7

Groundwater recharge with surface water can affect groundwater quality for either better or worse; better if recharge can contribute to dilution of contaminants such as nitrate near a drinking source; harmful if the chemistry of the recharge water causes a spike in the concentration of heavy metals such as arsenic. The discussion of management actions needs to identify how proposed actions will impact water quality. If that information is not available, the plan should discuss how water quality impacts will be determined.

For the projects already identified, describe and assess how ISWs and GDEs will benefit or be protected, or what other environmental benefits will accrue. This should be done for all projects, but is of particular importance for the effort to shift deep aquifer pumping to the upper aquifer. If ISWs will not be adequately protected by those listed, include and describe additional management actions and projects targeted for protecting ISWs.

For projects that construct recharge ponds, the GSP should consider identifying if there is habitat value incorporated into the design and how the recharge ponds can be managed as multiple-benefit projects to benefit environmental users.

The GSP should include environmental benefits and multiple benefits as criteria for assessing project priorities. For examples of case studies on how to incorporate environmental benefits into groundwater projects, visit our website: https://groundwaterresourcehub.org/case-studies/recharge-case-studies/.

LETTER K

Global Ag Properties USA LLC

EMAIL K

From: Mark Coelho
To: djackson@tcwater.org
Cc: Brian Hauss
Subject: TCWA GSP Comments
Date: Tuesday, November 5, 2019 11:26:12 AM
Attachments: image001.jpg

Dear Ms. Jackson,

On behalf of Global Ag Properties USA LLC, please see the comments listed below regarding the TCWA draft GSP.

- The GSP makes no reference to a groundwater allocation structure.
  - We support the implementation of 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. Furthermore, the development of groundwater markets and credits should be addressed within the GSP. K-1

- The GSP makes no reference to encouraging or accounting for on-farm recharge projects.
  - We believe these types of projects properly align landowner and the basin goals and should be encouraged and promoted by the GSA. K-2

- The GSP does not discuss in detail sustainable management criteria relative to subsidence, a recognized issue within the GSA boundaries.
  - We encourage the development of such criteria using best available data and technologies. K-3

- The GSP outlines plans to address excessive overdraft by 2030 through implementation of a number of projects and actions.
  - We strongly recommend that the GSA utilize the full timeline allowable under SGMA (2040) for attaining groundwater sustainability.
  - Management actions are stated to reduce such deficit by 10% in both 2025 and 2030, which we calculate as offsetting overdraft by roughly 22,500 AF as compared to total projected overdraft across the subbasin of 45,100 AF. What other actions are being considered to bring the basin into sustainability, presumably after 2030? K-4

We appreciate the opportunity to contribute to this process.

Regards,

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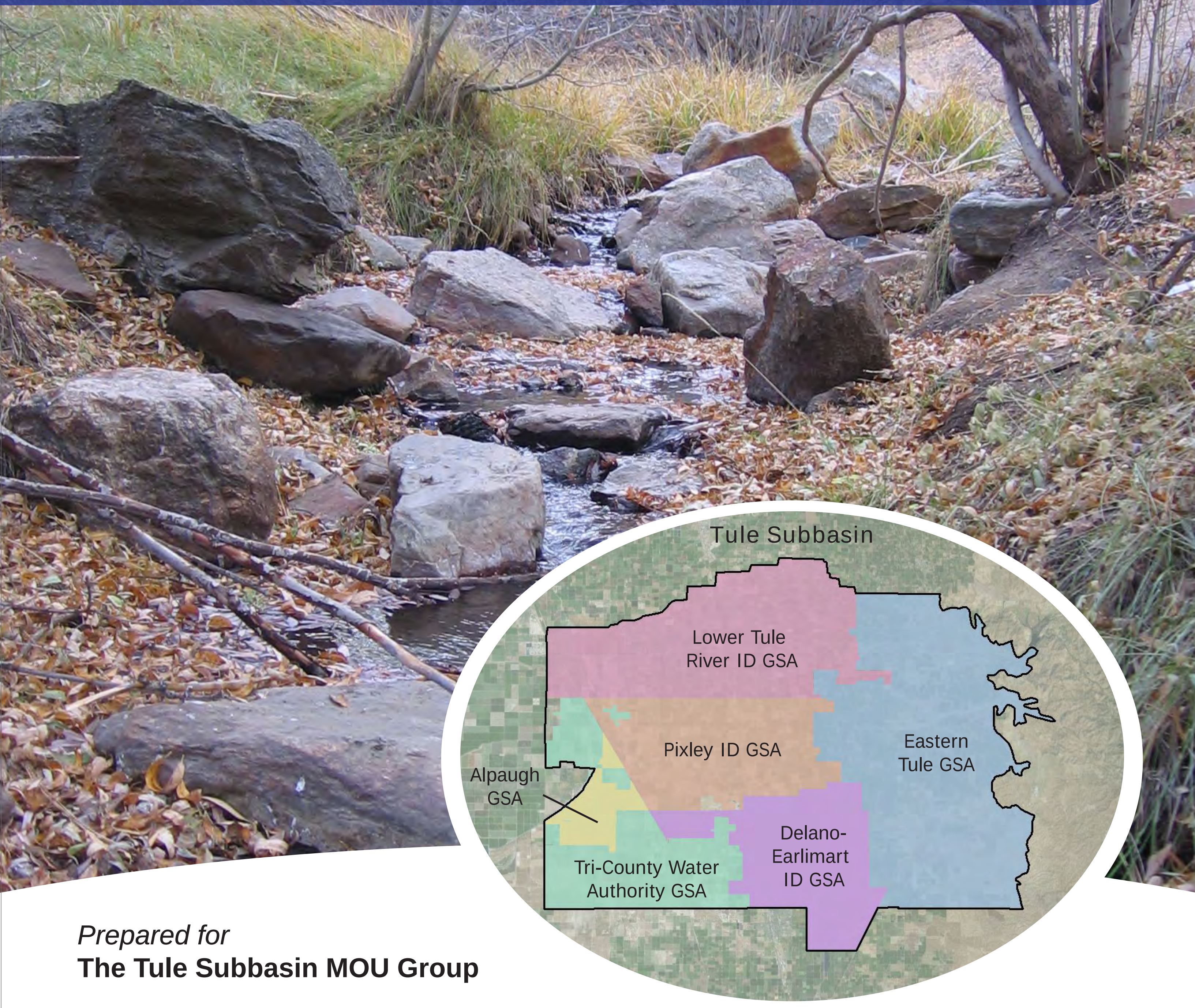
APPENDIX I

HYDROGEOLOGICAL CONCEPTUAL MODEL AND WATER BUDGET OF THE TULE SUBBASIN, VOLUME 1, TH&CO., AUGUST 1, 2017

Hydrogeological Conceptual Model and Water Budget of the Tule Subbasin

Volume 1

August 1, 2017



Prepared for

The Tule Subbasin MOU Group

Thomas Harder & Co.

Groundwater Consulting

Hydrogeological Conceptual Model and Water Budget of the Tule Subbasin

August 1, 2017

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Executive Summary

This report presents a hydrogeological conceptual model and water budget of the Tule Subbasin of the Southern San Joaquin Valley Groundwater Basin (see Figure 1). This work has been conducted as one of the initial steps necessary for the six Groundwater Sustainability Agencies (GSAs) within the subbasin to develop their Groundwater Sustainability Plans (GSPs), as required by the Sustainable Groundwater Management Act of 2014 (SGMA).

In addition to describing the hydrogeological setting of the Tule Subbasin, a primary purpose of the analysis presented in this report was to develop estimates of the subsurface inflow and outflow to/from the subbasin for use in refining a groundwater budget previously developed and reported in TH&Co, 2015. The groundwater budget was further refined through a detailed analysis of the surface water budget for the subbasin. The surface water and groundwater budgets formed the basis for a preliminary estimate of the Sustainable Yield of the subbasin.

The subsurface inflow and outflow analysis relied on a hydrogeological conceptual model of the Tule Subbasin that includes four general aquifers:

- Shallow Aquifer
- Deep Aquifer
- Very Deep Aquifer
- Santa Margarita Formation of the Southeastern Subbasin

The shallow aquifer occurs across the entire Tule Subbasin area. This aquifer is generally unconfined to semi-confined. The shallow aquifer occurs in the upper 450 ft of sediments on the western side of the basin and shallows to the east to approximately 300 ft of sediments. The deep aquifer extends across the entire western portion of the Tule Subbasin and beneath the northeastern portion of the subbasin. The total depth of this aquifer is conceptualized to be approximately 1,200 ft below ground surface. This aquifer is confined beneath the Corcoran Clay where this confining layer exists. The deep aquifer system is conceptualized to be semi-confined in the northeastern portion of the subbasin east of the Corcoran Clay. The very deep aquifer is conceptualized to occur at depths below 1,200 ft to the deepest reported depths of wells in the area.

The Santa Margarita Formation underlying the alluvial sediments of the Tulare Formation forms a localized aquifer in the southeastern portion of the Tule Subbasin. Until additional data are collected, this localized aquifer is conceptualized as hydrologically separate from the deep aquifer in the rest of the subbasin.

An analysis of subsurface groundwater inflow and outflow for the shallow and deep aquifer of the Tule Subbasin for the time period 1998 to 2007 and 2010 resulted in the following findings:

Year	Subsurface Inflow (acre-ft/yr)			Subsurface Outflow (acre-ft/yr)	Net Inflow (acre-ft/yr)
	South and West Boundaries	East Boundary	Total	North Boundary	
1998	43,991	20,000	63,991	-11,662	52,329
1999	47,173	20,000	67,173	-8,211	58,962
2000	44,940	20,000	64,940	-13,766	51,174
2001	49,797	20,000	69,797	-17,422	52,375
2002	51,107	20,000	71,107	-13,564	57,543
2003	49,994	20,000	69,994	-19,183	50,811
2004	49,742	20,000	69,742	-8,654	61,088
2005	47,283	20,000	67,283	-16,814	50,469
2006	44,128	20,000	64,128	-16,411	47,717
2007	42,936	20,000	62,936	-12,330	50,606
2010	60,164	20,000	80,164	-24,472	55,692
		Average:	**68,296**	**-14,772**	**53,524**

The values of subsurface inflow and outflow were based on a groundwater flow net analysis for the southern, western and northern boundaries of the Tule Subbasin. The subsurface inflow along the eastern boundary was inferred as mountain-block recharge developed from a detailed groundwater budget.

In order to better develop estimates of groundwater recharge from water applied at various locations and from various sources at the surface, TH&Co developed a detailed surface water budget to describe and estimate the surface water inflow and outflow within the Subbasin. The surface water budget was developed for the time period from 1990/91 to 2009/10. Inflow terms for the surface water budget include:

1. Precipitation.
2. Stream inflow.
3. Imported water.
4. Discharge to the land surface from wells.

Surface water outflow terms include:

1. Infiltration of precipitation.
2. Evapotranspiration of precipitation from native vegetation and crops.
3. Stream infiltration.
4. Infiltration in canals.
5. Recharge in basins.
6. Return flow.
7. Consumptive use.

Of the surface water outflow terms that become groundwater recharge, many are associated with water diverted in accordance with pre-1914 water rights or purchased imported water. The Tule MOU Group has indicated a desire to exclude these sources of groundwater recharge from the subbasin-wide Sustainable Yield estimate.

The detailed surface water budget and subsurface inflow and outflow data from the flow net analysis were used to update and refine a previously existing detailed groundwater budget that included the following recharge sources:

1. Areal recharge from precipitation.
2. Recharge within stream and river channels.
3. Artificial recharge in man-made basins.
4. Canal infiltration.
5. Return flow from municipal water use and agricultural irrigation.
6. Release of water from compression of aquitards.
7. Subsurface inflow.

The groundwater budget also included the following sources of discharge:

1. Municipal groundwater pumping.
2. Agricultural groundwater pumping.
3. Groundwater pumping for export out of the subbasin.

4. Evapotranspiration.
5. Subsurface outflow.

The groundwater budget incorporated the time period from 1990/91 water year 2009/10. Over that time period, the cumulative change in groundwater storage, based on the groundwater budget, was estimated to be –2,351,000 acre-ft.

In addition to the subsurface inflow/outflow analysis, the following additional findings have been made based on the evaluation of groundwater conditions in the Tule Subbasin and the available data:

- Analysis of groundwater contour maps developed from groundwater levels measured in the shallow aquifer between 1998 and 2007 has indicated a persistent pumping depression in the northwestern portion of the Tule Subbasin. This pumping depression has reversed the natural westward gradient resulting in the capture of water that would have otherwise flowed out of the subbasin.
- Analysis of groundwater contour maps developed from groundwater levels measured in the deep aquifer in 1998, 1999 and 2010 indicate a more southwestward pumping depression that shifts to the west in 2010.
- The cumulative change in groundwater storage between 1990/91 and 2009/10, as estimated from the detailed groundwater budget is approximately –2,351,000 acre-ft.
- The Sustainable Yield of the Tule Subbasin based on the water budget reported herein is approximately 257,725 acre-ft/yr. This estimate does not include recharge and losses from the delivery of imported water, recharge and losses associated with Tule River and Deer Creek surface water diversions, or release of water from compression of aquitards. This Sustainable Yield is equal to approximately 0.54 acre-ft/acre when applied equally across the entire Tule Subbasin area.

It is anticipated that as additional data are collected, the water budget and associated Sustainable Yield estimate will become more refined. Changes in the estimate of agricultural groundwater pumping, which is based on consumptive use estimates for the crops, would have the greatest impact on the change in storage and Sustainable Yield estimate. Areal recharge of precipitation and mountain-block recharge estimates, which are also uncertain, may also impact the Sustainable Yield estimate.

1.0 Introduction

This report presents a hydrogeological conceptual model and water budget of the Tule Subbasin of the Southern San Joaquin Valley Groundwater Basin (see Figure 1). This work has been conducted for the Tule MOU Group, which includes six individual Groundwater Sustainability Agencies (GSAs) within the subbasin. The GSAs include:

1. The Eastern Tule Subbasin GSA
2. The Lower Tule River Irrigation District GSA
3. The Pixley Irrigation District GSA
4. The Delano-Earlimart GSA
5. The Alpaugh GSA
6. The Tri-Counties GSA

As required by the Sustainable Groundwater Management Act (SGMA) of 2014, each GSA will be required to prepare a Groundwater Sustainability Plan (GSP) by January 31, 2020. SGMA defines sustainable groundwater management as:

The management of and use of groundwater in a manner that can be maintained during the planning and implementation horizon without causing undesirable results.

Undesirable results, as defined by the California Water Code, are:

- Chronic lowering of groundwater levels
- Significant and unreasonable reduction of groundwater storage
- Significant and unreasonable seawater intrusion
- Significant and unreasonable degraded water quality
- Significant and unreasonable land subsidence
- Depletions of interconnected surface water

Development of the hydrogeological conceptual model and water budget are Best Management Practices (BMPs) identified by the California Department of Water Resources (CDWR) for informing the GSPs. These BMPs are also necessary initial steps for development of a subbasin-wide groundwater flow model to be used as a planning tool for the GSAs. The hydrogeological conceptual model and water budget address the entire Tule Subbasin as defined in CDWR Bulletin 118 (CDWR, 2016). This provides a common dataset, analyses and interpretation that all of the individual GSAs can reference for developing their respective GSPs with the goal of providing technical continuity between the GSPs.

In addition to describing the hydrogeological setting of the Tule Subbasin, a primary purpose of the analysis presented in this report was to develop estimates of the subsurface inflow and outflow to/from the subbasin for use in refining a groundwater budget previously developed and reported in TH&Co, 2015. The groundwater budget was further refined through a detailed analysis of the surface water budget for the subbasin. The surface water and groundwater budgets formed the basis for a preliminary estimate of the Sustainable Yield of the subbasin.

Sustainable Yield is defined in SGMA as:

…the maximum quantity of water, calculated over a base period representative of long-term conditions in the basin and including any temporary surplus, that can be withdrawn annually from a groundwater supply without causing an undesirable result.

Ch. 2 Definitions Section 10721 v.

The scope of work to conduct the analyses presented herein consisted of:

1. Obtaining and reviewing hydrogeological data.
2. Analyzing aquifer properties.
3. Preparing of hydrogeological cross sections.
4. Preparing groundwater contour maps.
5. Analyzing subsurface inflow and outflow to/from the Tule Subbasin.
6. Developing a detailed surface water budget.
7. Updating a previously developed detailed groundwater budget.
8. Preparing a preliminary estimate of Sustainable Yield.
9. Preparing this report documenting the hydrogeological conceptual model, water budget and preliminary Sustainable Yield.

The surface and groundwater budgets used to develop the preliminary Sustainable Yield estimate are specific to the 20-yr period from water years 1990/91 through 2009/10. This period represents a close approximation of average hydrological conditions on the Tule River.

1.1 Tule Subbasin Area

The area of the Tule Subbasin is defined by the latest version of CDWR Bulletin 118 (CDWR, 2016) and is shown on Figures 1 and 2. The Tule Subbasin area is approximately 744 square miles (475,895 acres). The Tule Subbasin includes the jurisdictional areas of multiple water management and service entities, which have been grouped into six individual GSAs (see Figure 3).

In order to fully analyze the water budget of the Tule Subbasin, a larger Study Area was identified to include the watersheds tributary to the subbasin as well as adjacent areas to the north, south and west. The Study Area extends from the top of the Tule River, Deer Creek and White River drainage basins (i.e. watersheds) in the Sierra Nevada Mountains to the east to the eastern portion of the Tulare Lakebed on the west. The northern boundary encompasses the northern extent of the Tule River Drainage Basin. The southern boundary is approximately ten miles south of the Tulare County/Kern County boundary and encompasses the White River Drainage Basin and the City of Delano.

1.2 Types and Sources of Data

Compilation, review and analysis of multiple types of data were necessary to develop the hydrogeological conceptual model and surface water and groundwater budgets. The various types of data included geology, soils/lithology, hydrogeology, surface water hydrology, climate, crop types/land use, topography, remote sensing, and groundwater recharge and recovery. Data were obtained from multiple sources:

Geological Data including geologic maps and cross sections were obtained from the United States Geological Survey (USGS) and the California Geological Survey (CGS).

Soils/Lithological Data from drillers' logs and reports from the CDWR, the City of Porterville, and the USGS.

Hydrogeological Data including groundwater levels and pumping tests were obtained from the CDWR, Deer Creek and Tule River Authority (DCTRA), Angiola Water District, the City of Porterville, Kern County Water Agency, 4Creeks Inc., and the California Statewide Groundwater Elevation Monitoring (CASGEM) website.

Groundwater Recharge and Recovery Data including spreading basin locations and dimensions, artificial recharge, water well construction, well locations, groundwater production, surface water diversions, canal losses, and river losses were obtained from Lower Tule River Irrigation District (LTRID), CDWR, Tule River Association (TRA) annual reports, and DCTRA annual reports.

Hydrological (i.e. Surface Water) Data consisting of stream gage data along the Tule River, Deer Creek, and White River were obtained from the USGS, DCTRA reports and TRA annual reports. Imported water deliveries were obtained from the United States Bureau of Reclamation (USBR) and the individual agencies within the subbasin.

Climate Data was acquired from CDWR's California Irrigation Management Information System (CIMIS) and the Western Regional Climate Center website.

Land Use Data was obtained from the CDWR, LTRID, the Kern County Department of Agriculture and Measurement Stands, and the USGS Earth Resources Observation and Science Center. Political boundaries were obtained from the California Cal-Atlas Geospatial Clearinghouse, Kern-Tulare Water District, and the LTRID.

In addition to the various types of data, TH&Co reviewed numerous historical reports on the geology, hydrogeology and groundwater management of the Tule Subbasin. These reports included USGS publications, CDWR reports and bulletins, consultant reports, and academic publications. Publications relied on for the hydrogeological conceptual model and water budget are summarized in the References Section (Section 10).

2.0 Hydrological Setting of the Tule Subbasin

2.1 Location

The Tule Subbasin is located in the southern portion of the San Joaquin Valley Groundwater Basin in the Great Central Valley of California (see Figure 1). Communities within the subbasin include Porterville, Tulare, Tipton, Pixley, Earlimart, Richgrove, Ducor and Terra Bella (see Figure 2). Neighboring CDWR Bulletin 118 subbasins include the Kern County Subbasin to the south, the Tulare Lake Subbasin to the west, and the Kaweah Subbasin to the north.

2.2 Historical Precipitation Trends

Average annual precipitation across the Tule Subbasin ranges from approximately 13 inches per year on the east side in the Sierra Nevada Mountains to approximately six inches per year in the valley areas on the west side (see Figure 4). Historical annual precipitation at the Porterville Precipitation Station (based on water years from October 1 through September 30 and a period of record from 1926 to 2016) has ranged from 2.96 inches in 2013/14 to 22.03 inches in 1977/78 with an annual average of 10.4 inches/year (see Figure 5). Analysis of the cumulative departure from mean precipitation at this station indicates the following historical trends:

- The period from approximately 1927 through 1935 was relatively dry;
- The period from 1935 through 1945 was relatively wet;
- The period from 1945 through 1951 was relatively dry;
- The period from 1951 through 1966 was approximately average;
- The period from 1966 through 1983 was relatively wet;
- The period from 1983 through 1992 was relatively dry;
- The period from 1992 through 1999 was relatively wet; and
- The period from 1999 to 2016 was relatively dry.

2.3 Historical Land Use

Land use in the Tule Subbasin is dominated by agricultural fields interspersed with dairies, urban areas and fallow land (see Figure 6). Crops grown in the Tule Subbasin between 1990 and 2010 have included cotton, grapes, fruit trees, nut trees, dairy support crops (alfalfa, wheat and corn) and truck crops (see Figure 7). Between 1990 and 2010, the amount of acreage dedicated to growing cotton has generally decreased. The amount of acreage dedicated to growing nuts and dairy support crops has increased over this time period.

Changes in crop patterns between 1990 and 2010 have been, in large part, due to an increase in the number of dairies in the Tule Subbasin. Total area specific to the dairies (the barnyards and cattle holding and feeding areas) has increased from approximately 5,000 acres in 1990 to approximately 11,100 acres in 2010. However, the more significant land use change over this time period has been the increase in area for dairy support crops such as corn, alfalfa and wheat. Annual growing cycles for dairy support crops typically include multiple crops (i.e. double cropping), which results in a higher water demand relative to areas where only a single crop is grown (Provost and Pritchard, 2010).

2.4 Surface Water Features

2.4.1 Tulare Lake

Although now largely a dry lake bed, prior to the mid-1800s Tulare Lake was the largest fresh water lake, by area, west of the Mississippi River. The original area of the lake was approximately 570 square miles and was fed from surface water discharges at the terminus of the Kern River, Tule River, and Kaweah River. Beginning in the mid-1800s, surface water from the rivers feeding the lake was diverted for agricultural irrigation and municipal supply. By 1900, the lake was dry except for residual marshes and wetlands and occasional flooding. This condition continues to the present.

2.4.2 Lake Success

Lake Success is a manmade reservoir that was completed in 1961 and serves as a flood control and water conservation basin for the Tule River. The reservoir is managed by the United States Army Corps of Engineers. Water storage in Lake Success, releases of water at the dam, and downstream water diversions are administered by the Tule River Association (TRA), in accordance with the Tule River Water Diversion Schedule and Storage Agreement (TRA, 1966).

2.4.3 Tule River

The Tule River is the largest natural drainage feature in the Study Area. From its headwaters in the Sierra Nevada Mountains, the Tule River flows first into Lake Success and then, through controlled releases at the dam, flows through Porterville and into the LTRID, ultimately discharging onto the Tulare Lake Bed during periods of above-normal precipitation. Stream flow is measured via gages located below Success Dam, at Oettle Bridge downstream of Porterville, and at Turnbull Weir (see Appendix A and Figure 8). Stream flow below the Lake Success dam has ranged from 34,325 acre-ft/yr to 439,125 acre-ft/yr with an annual average from water year 1990/91 through water year 2009/10 of 132,249 acre-ft.

Releases of water at the Lake Success dam are diverted from the Tule River channel at various locations in accordance with TRA (1966). Diversion points along the river are located at the

Porter Slough headgate, Vandalia Ditch, Poplar Ditch, and Woods Central. The lower portion of the Tule River channel is also used as a conveyance mechanism to convey imported water from the Friant-Kern Canal to the LTRID. Within the LTRID, a combination of natural stream flow and imported water are further diverted from the river channel into unlined canals for distribution to artificial recharge basins and farmers. Any residual stream flow left in the Tule River after diversions is measured at the Turnbull Weir, located at the west end of the LTRID (see Figure 8).

2.4.4 Deer Creek

Deer Creek is a natural drainage that originates in the Sierra Nevada Mountains, flowing in a westerly direction north of Terra Bella and into Pixley (see Figure 8). Although the Deer Creek channel extends past Pixley, discharges rarely reach the historical Tulare Lake bed. Stream flow in Deer Creek has been measured at the USGS gaging station at Fountain Springs from 1968 to present time. Average annual flow at this gage between water year 1990/91 and 2009/10 was approximately 19,728 acre-ft/yr with a low of 4,080 acre-ft in water year 1991/92 and a high of 88,360 acre-ft in water year 1997/98 (see Appendix A). Stream flow has also been measured at a second USGS gaging station on Deer Creek at Terra Bella although the period of record (1971 through 1987) is not as complete as the station at Fountain Springs. Friant-Kern Canal water is also diverted into Deer Creek at Trenton Weir before being delivered to farmers via unlined canals (see Figure 8).

2.4.5 White River

The White River drains out of the Sierra Nevada Mountains east of the community of Richgrove in the southern portion of the Tule Subbasin (see Figure 8). Stream flow in the White River has been measured at the USGS gaging station near Ducor from 1971 to 2005. Data after 2005 has been interpolated. Average annual flow between water year 1990/91 and 2009/10 was approximately 6,900 acre-ft/yr with a low of 739 acre-ft in water year 1991/91 and a high of 36,764 acre-ft in 1997/98. The White River channel extends as far as State Highway 99 but does not reach the historical Tulare Lake bed.

2.4.6 Conveyance Facilities (Canals and Pipelines)

Distribution of stream flow diversions and imported water occur via a system of manmade canals that extend throughout the Tule Subbasin. The largest of these is the Friant-Kern Canal, which supplies imported water through the Federal Central Valley Project (CVP). The Friant-Kern Canal is concrete lined and trends approximately north-south through the eastern part of the Tule Subbasin (see Figure 8). Numerous other canals are located within the Study Area to convey surface water from the Friant-Kern Canal, Tule River and Deer Creek to various recharge facilities and agricultural areas. These canals are unlined and occur primarily in the LTRID, Pixley Irrigation District, Porterville Irrigation District, Alpaugh Irrigation District, and Atwell Island Water District. It is noted that Alpaugh Irrigation District receives imported water deliveries from the Friant-Kern Canal via Deer Creek.

Many of the irrigation districts and water districts in the Study Area that receive imported water from the Friant-Kern Canal distribute the water exclusively via pipelines. These districts include the Delano-Earlimart Irrigation District, Kern-Tulare Water District, Terra Bella Irrigation District, Saucelito Irrigation District, and Teapot Dome Water District.

2.5 Groundwater Wells

Numerous groundwater wells are located throughout the Study Area. Most of the wells are production wells used to pump water for agricultural irrigation. The City of Porterville and other smaller communities also operate production wells for municipal supply. Finally, there are three dedicated monitoring wells located adjacent to a recharge basin near Deer Creek, which are monitored by DCTRA.

Well locations from various monitoring databases and other sources are shown on Figure 9. Most of the well locations are based on the groundwater level monitoring databases from DCTRA and the CASGEM program. Additional well locations were identified via CDWR driller's logs. City of Porterville production well locations were obtained from the City of Porterville's latest General Plan (accessed from their website).

3.0 Geology

The eastern boundary of the Tule Subbasin is defined by the surface contact between crystalline rocks of the Sierra Nevada and surficial alluvial sediments that make up the groundwater basin (see Figure 10). The subsurface alluvial sediment beneath the Tule Subbasin is derived from erosion of the Sierra Nevada Mountains. In general, alluvial sediments have been grouped into younger alluvium, flood plain deposits and older alluvium of the Tulare Formation.

Younger alluvium is associated with geologically recent stream channel deposits that were deposited by the Tule River, Deer Creek and White River. Flood plain deposits of the historical Tulare Lake Bed are also recent and occur in the western portion of the Tule Subunit. Subsurface alluvial sediments in the Study Area are generally correlated with the Tulare Formation and consist of highly stratified layers of more permeable sand and gravel interbedded with lower permeability silt and clay. Clear correlation of individual sand or clay layers laterally across the Study Area is difficult due to the interbedded nature of the sediments. However, it is noted that the thickness of clay sediments in the upper 1,000 ft bgs generally increases in the vicinity of Tulare Lake.

The only regionally extensive sediment layer that has been previously identified in the Study Area is the Corcoran Clay or "E-Clay" unit of the Tulare Formation (Frink and Kues, 1954; Kern County Water Agency, 1991). The Corcoran Clay consists of a Pleistocene diatomaceous fine-grained lacustrine deposit (primarily clay; Faunt, 2009). In the Study Area, the Corcoran Clay is as much as 150 ft thick beneath the Tulare Lake bed but becomes progressively thinner to the east, eventually pinching out immediately east of Highway 99 (Lofgren and Klausing, 1969).

Underlying the alluvial sediments in the southeastern portion of the Tule Subbasin is a sequence of Tertiary-age semi-consolidated sediments consisting of interbedded siltstone and sandstone. One well defined sandstone unit, referred to as the Santa Margarita Formation by Diepenbrock (1933) and Logfren and Klausing (1969), occurs at a depth of approximately 1,500 ft in wells constructed near Richgrove. The formation is permeable and yields economic quantities of water to wells but is localized to the southeastern portion of the subbasin.

4.0 Hydrogeology

4.1 Tule Groundwater Subbasin

The analysis of the hydrogeology and water budget for this study is specific to the Tule Subbasin, as defined in CDWR Bulletin 118 (see Figure 3). The northern boundary of the Tule Subbasin is defined as the northern boundary of the LTRID and Porterville Irrigation District. The eastern boundary is defined as the alluvium/bedrock contact at the base of the Sierra Nevada Mountains. The southern boundary is the Tulare County/Kern County line with an extension for the inclusion of the entire Delano-Earlimart Irrigation District. The western boundary is the Tulare County/Kings County line, with the exception of a relatively small area where the Tulare Lake Basin Water Storage District extends east across the county line to the Homeland Canal (see Figures 3 and 8).

4.2 Aquifer Conceptualization

Where saturated in the subsurface, the permeable sand and gravel layers form the principal aquifers in the Tule Subbasin and adjacent areas to the north, south and west. Individual aquifer layers consist of lenticular sand and gravel deposits of varying thickness and lateral extent. The aquifer layers are interbedded with low permeability silt and clay confining layers. In general, shallow saturated sediments in the Tule Subbasin are unconfined to semi-confined. The aquifer beneath the Corcoran Clay unit in the western portion of the basin is confined. The hydrologic characteristics of the deeper aquifer system in the western portion of the subbasin are unknown but are expected to change with depth.

In general, the aquifer system in the Tule Subbasin can be subdivided into four general aquifer units (see Plates 1 through 5):

- Shallow Aquifer
- Deep Aquifer
- Very Deep Aquifer
- Santa Margarita Formation of the Southeastern Subbasin

The shallow aquifer occurs across the entire Tule Subbasin area. This aquifer is generally unconfined to semi-confined. The shallow aquifer occurs in the upper 450 ft of sediments on the western side of the basin and shallows to the east to approximately 300 ft of sediments. In the southeastern portion of the basin, the shallow aquifer is generally considered unsaturated although there may be local areas of groundwater.

The deep aquifer extends across the entire western portion of the Tule Subbasin and beneath the northeastern portion of the subbasin. The total depth of this aquifer is conceptualized to be approximately 1,200 ft below ground surface (bgs). This aquifer is confined beneath the Corcoran Clay where this confining layer exists. The deep aquifer system is conceptualized to be semi-confined in the northeastern portion of the subbasin east of the Corcoran Clay.

In the western portion of the Tule Subbasin and west of the subbasin boundary, CDWR driller's logs indicate wells that extend deeper than 1,200 ft bgs. This deeper aquifer is herein referred to as the very deep aquifer and is conceptualized to extend from 1,200 ft bgs to 2,300 ft bgs, to include the perforation intervals of the deepest wells observed in the well database.

The Santa Margarita Formation underlying the alluvial sediments of the Tulare Formation forms a localized aquifer in the southeastern portion of the Tule Subbasin. Based on data published in Lofgren and Klausing (1969), the formation dips steeply to the west and is overlain by marine siltstone of low permeability. Until additional data are collected, this localized aquifer is conceptualized as hydrologically separate from the deep aquifer in the rest of the subbasin.

4.3 Aquifer Characteristics

The ability of aquifer sediments to transmit and store water is described in terms of the aquifer parameters transmissivity, hydraulic conductivity, and storativity. The most reliable estimates of these parameters are obtained from long-term (e.g. 24-hr or more constant rate) controlled pumping tests in wells. In the absence of this type of test, estimates can be obtained through short-term pumping tests and/or assignment of literature values based on the soil types observed in driller's logs. As no long-term pumping test data was available for this report, aquifer parameters were estimated based on short-term pumping test data reported on driller's logs and literature values from interpretation of sediment types on driller's logs.

Transmissivity is a measure of the ability of groundwater to flow within an aquifer and is defined as the rate of groundwater flow through a unit width of aquifer under a unit hydraulic gradient (Fetter, 1994). Transmissivity estimates was estimated from short-term pumping test data based on Theis et al., 1963 and the following relationship:

$$T = \frac{S_c \ x \ 2{,}000}{E}$$

Where:

T	=	Transmissivity (gpd/ft);
S_c	=	Specific Capacity (gpm/ft);
E	=	Well Efficiency (assumed to be 0.7)

Transmissivity values at individual wells were converted into hydraulic conductivity (i.e. aquifer permeability) by dividing by the aquifer thickness (in this case the perforation interval of the well). Hydraulic conductivity was used as a basis for estimating subsurface inflow and outflow to/from the subbasin (see Section 5). Hydraulic conductivity values for the shallow aquifer are shown on Figure 11 and range from less than 6 ft/day to greater than 80 ft/day, the higher values indicating more permeable sediments. Hydraulic conductivity values for the deep aquifer are shown on Figure 12 and range from less than 6 ft/day to greater than 50 ft/day. In general, the deep aquifer sediments are less permeable than the shallow aquifer sediments.

For areas where no pumping test data were available, hydraulic conductivity was estimated through a textural analysis of the shallow and deep aquifer as published in Faunt (2009). Textural descriptions describe the percent coarse-grained sediment as inferred from drillers' logs from boreholes or wells drilled within or immediately outside the Tule Subbasin. Higher percent coarse-grained sediment descriptions are correlated with higher permeability and associated hydraulic conductivity. The data are presented on Figures 11 and 12 as zones of equal percent coarse sediment for the shallow and deep aquifer, respectively. As shown, higher percent coarse-grained sediments are observed in the shallow aquifer through most of the Tule Subbasin with the exception of the southwestern portion. In the deep aquifer, sediments in the eastern portion of the subbasin are generally more coarse-grained than sediments in the western portion.

Another aquifer parameter important for this study was specific yield. Specific yield is the ratio of the volume of water sediment will yield by gravity drainage to the volume of the sediment. Estimates of changes in groundwater storage reported herein were, in part, based on estimates of specific yield for the aquifer sediments in the Tule Subbasin. Specific yield values used for groundwater storage change estimates were based on the texture analysis published in Faunt (2009).

4.4 Groundwater Movement

4.4.1 Groundwater Flow Direction

In general, groundwater in the Tule Subbasin flows from areas of natural recharge along the base of the Sierra Nevada Mountains on the eastern boundary towards a groundwater pumping depression in the west-central portion of the subbasin (see Figures 13 and 14; Appendix B). The pumping depression has reversed the natural groundwater flow direction in the western portion of the subbasin, inducing subsurface inflow along the southern and western boundaries.

In the shallow aquifer, the pumping depression is more pronounced in the northwestern portion of the Tule Subbasin and has persisted in this area since at least 1987, even during periods of above-normal precipitation when groundwater levels temporarily recovered. Recharge from the Tule River results in a groundwater flow divide in the shallow aquifer along the northern boundary of the Tule Subbasin. As such, shallow aquifer groundwater on the north side of the river flows to the north and out of the subbasin. Groundwater flow patterns in the shallow aquifer have generally not changed significantly since 1990.

In the deep aquifer, groundwater flows to the southwest toward a pumping depression in the southwest portion of the subbasin (see Figure 14). This pumping depression has shifted to the west over time, presumably as a result of increased pumping west of the Tule Subbasin (see Appendix B; Figure B14).

4.4.2 Historical Changes in Groundwater Elevation

Groundwater level changes over time can be observed from hydrographs developed from wells monitored in the Tule Subbasin (see Figures 15 and 16). Despite a relatively wet hydrologic period between 1991 and 1999 (see Figure 5), shallow aquifer groundwater levels generally show a persistent downward trend between approximately 1990 and 2010. Groundwater levels in the deep aquifer do not show as great a decline, which may be a result of sustained recharge from the shallow aquifer, capture of water from outside the basin, or both.

Groundwater level change in the shallow aquifer across the Tule Subbasin between 1987 and 2010 is shown on Figure 17. The time period represents the change in groundwater level between a relatively high groundwater condition and the most recent low groundwater condition for which a contour map was prepared for this study (2010). The map shows declining groundwater levels throughout most of the central portion of the Tule Subbasin during this time period with as much as 175 ft of decline occurring in some areas.

Comparisons of hydrographs from wells perforated in the shallow aquifer with wells perforated predominantly in the deep aquifer and in close proximity show that groundwater levels in the shallow aquifer are higher than groundwater levels in the deep aquifer (see Figure 18). This indicates a downward hydraulic gradient and suggests that it is possible that the shallow aquifer is recharging the deep aquifer in some areas of the Tule Subbasin. This is corroborated by depth-specific isolated aquifer zone testing conducted by the City of Porterville in three wells in which the equilibrated groundwater level (i.e. hydraulic head) in the deepest isolated zones, which also correspond to the deep aquifer, were as much as 180 ft lower than the groundwater level in the shallowest isolated zones (Schmidt, 2009). Faunt (2009) has suggested that the recharge of the deep aquifer via wells that are perforated across both aquifers has increased with the number of deep wells constructed in the San Joaquin Valley.

4.4.3 Historical Changes in Groundwater Storage from Groundwater Level Changes

Changes in groundwater storage over time, for any given area, can be estimated using the following equation:

$$V_w = S_y A \Delta h$$

Where:

V_w = the volume of groundwater storage change

S_y = specific yield of aquifer sediments

A = the surface area of the aquifer within the Tule Subbasin

Δh = the change in hydraulic head (i.e. groundwater level)

TH&Co estimated the change in groundwater storage in the Tule Subbasin between 1987 and 2010 using the above relationship. The change in storage estimate is specific to the shallow aquifer as the groundwater level in the deep aquifer has never dropped below the top of the aquifer, as defined herein. The calculations were made on a Geographic Information System (GIS) map of the Tule Subbasin that was discretized into 300 ft by 300 ft grids to allow for spatial representation of aquifer specific yield and groundwater level change.

The area of the Tule Subbasin where the shallow aquifer was saturated during the 1987 to 2010 time period was used as the area of the subbasin for the storage change analysis. This area includes all of the Tule Subbasin except for a small, 42 square mile (26,995-acre) area in the southeastern corner where the shallow aquifer is reported to have been dry since at least the late 1960s (Lofgren and Klausing, 1969). The total area used for the storage change calculation was 450,558 acres.

The areal and vertical distribution of specific yield for the shallow aquifer was obtained from the textural analysis published in Faunt (2009). The vertical specific yield distribution included values at 50-ft intervals. Thus, storage changes in any given grid cell were discretized vertically at 50-ft intervals.

For the areal distribution of change in hydraulic head within the Tule Subbasin, groundwater contours for 1987 were digitized and overlain on the grid map of the Tule Subbasin in GIS. Groundwater levels were then assigned to each grid. A contour map with groundwater elevation contours from 2010 were also digitized and overlain on the grid map. Change in hydraulic head (groundwater level) at each grid was calculated as the difference in groundwater level between 1987 and 2010.

The complete GIS files of specific yield and groundwater levels were exported into a spreadsheet program for the final analysis of groundwater storage change. The change in groundwater storage was calculated for each grid cell by multiplying the change in groundwater level by the specific yield at 50-ft intervals and then by the area of the cell. Summation of the cell-by-cell change in groundwater storage showed a decline of approximately -5,806,000 acre-ft from 1987 to 2010.

5.0 Estimates of Tule Subbasin Subsurface Inflow and Outflow

The Tule Subbasin is not a closed basin and the aquifer is in hydrologic connection with adjacent subbasins to the north, west and south. Groundwater flow into and out of the Tule Subbasin along these boundaries varies over time in accordance with the groundwater level conditions and flow patterns within and outside the subbasin. The only source of subsurface inflow to the Tule Subbasin on along the eastern boundary is mountain-block inflow resulting from infiltration of precipitation in the secondary porosity features (joints and fractures) of the bedrock east of the basin. This recharge enters the alluvial groundwater basin where the alluvium is in hydrologic connection with the fractures in the bedrock in the subsurface.

For this analysis, the subsurface inflow and outflow along the southern, western and northern boundaries was evaluated for the period from 1998 through 2007 and 2010, which is approximately representative of long-term average surface flow conditions in the Tule River. The inflow/outflow was evaluated along these boundaries using a flow net analysis applied to groundwater contours developed for both the shallow and deep aquifers, as defined in this report (see Plates 3 through 5).

For the shallow aquifer, which is conceptualized as being unconfined, subsurface inflow/outflow was estimated using the Dupuit Equation (Fetter, 1994), which is expressed as:

$$Q = 0.5K\left(\frac{(h_1 - h_2)^2}{L}\right)$$

Where:

Q	=	Subsurface flow, (acre-ft)
K	=	Hydraulic Conductivity, (ft/day)
h_1	=	Initial Hydraulic head, (ft amsl)
h_2	=	Ending Hydraulic head, (ft amsl)
L	=	Flow Length (ft)

For the deep aquifer, which is conceptualized as being semi-confined/confined, subsurface inflow/outflow was estimated using the Darcy Equation (Fetter, 1994), which is expressed as:

$$Q = KA\left(\frac{dh}{dl}\right)$$

Where:

Q	=	Subsurface flow, (acre-ft)
K	=	Hydraulic Conductivity, (ft/day)
A	=	Aquifer Cross-Sectional Area, (ft^2)
$\frac{dh}{dl}$	=	Hydraulic gradient

The flow net analysis consisted of first developing groundwater elevation contour maps for each of the years 1998 through 2007 and 2010 (see Figures 19 and 20; Appendix C). It is noted that groundwater contours of the deep aquifer were only developed for 1998, 1999 and 2010 due to lack of data for the other years of the period of interest. Flow lines were drawn perpendicular to groundwater elevation contours along the southern, western and northern boundaries. As shown on the contour maps, groundwater flow along the southern and western boundaries is predominantly toward the Tule Subbasin and is inflow. Groundwater flow along the northern boundary is predominantly outflow.

As the groundwater flow lines into and out of the subbasin do not generally occur at right angles to the subbasin boundary, it was necessary to correct the subsurface flow by the angle (degrees) of the flow line relative to the basin boundary (Bear, 1979). This was conducted by multiplying the subsurface inflow value by the sine of the angle of flow relative to the boundary.

A summary of subsurface inflow and outflow values estimated for each of the years of interest is provided in Table 1. As shown, inflow through the southern and western boundary across both the shallow and deep aquifers ranges from 42,936 acre-ft in 2007 to 60,164 acre-ft with an average over the years of interest of 48,296 acre-ft/yr. Outflow ranges from 8,211 acre-ft in 1999 to 24,472 acre-ft in 2010, with an average of 14,772 acre-ft/yr. The average net inflow into the Tule Subbasin along these three boundaries for the time period is approximately 33,524 acre-ft/yr.

For the eastern Tule Subbasin boundary, it was not possible to estimate the subsurface inflow from the bedrock into the alluvium using the flow net analysis. From the available data, it was not possible to construct a groundwater contour map specific to the fractured rock aquifer system east of the alluvial basin. Likewise, there is no available information regarding the hydraulic properties of the fractured rock system or the depth at which the fractures become sealed and impermeable due to lithostatic pressure. As such, the subsurface inflow along this boundary was inferred based on the detailed groundwater budget described in Section 7.