S.S. PAPADOPULOS & ASSOCIATES, INC.
Environmental & Water-Resource Consultants

Technical Memorandum

Date: February 3, 2017

From: Deborah L. Hathaway, P.E.

To: S. Craig Tucker, Karuk Tribe

Subject: **Preliminary Analysis of Groundwater Management Options for Improved Instream Flow on the Scott River**

Summary
Hypothetical groundwater management options were analyzed to provide a screening-level comparison of the magnitude and timing of flow increase to the Scott River associated with various actions. Additional analysis with fine-tuning of location/timing assumptions is recommended for any groundwater management option that appears potentially useful. While additional data will be important for design, implementation and monitoring, the screening-level results provide information useful in prioritizing options based on the potential flow benefit and the scale of the project required to achieve a desired benefit. Focusing on the monthly distribution of net flow increases, one may assess the potential for specific actions or combinations of actions to benefit river flows, if needed, to satisfy existing water rights and protect aquatic resources.

The following hypothetical groundwater management options were assessed with groundwater model simulation; other identified options as desired may be similarly evaluated.

- Delayed Groundwater Pumping: Surface water, in lieu of groundwater, is used to meet irrigation demand in May and June. This action involves additional surface water diversion in May and June, but reduces effects of groundwater pumping on the river. Crop water use and recharge of excess applied irrigation water in May/June are unchanged.

- Winter Recharge: Surface water is diverted into the canal system during winter months and spread on potentially suitable farm lands; infiltration provides additional recharge to groundwater with lagged flow benefits to the river. Crop water use, recharge of excess applied irrigation water, groundwater pumping and surface water diversion during the irrigation season are unchanged.

- Augmentation Wells: Three eastside locations are considered for augmentation wellfields. Under this option, water pumped from the wells would be conveyed directly to the river to meet critical flow needs; the effects of pumping on the river would be spread over a subsequent period of time, depending on the well location and aquifer characteristics. Crop water use, recharge of excess applied irrigation water, irrigation groundwater pumping and surface water diversion are unchanged.

- Reduced Groundwater Pumping for Irrigated Lands: Reduction in groundwater pumping for irrigated lands is associated with reduced on-farm recharge, with a net increase in stream flow in amounts dependent on the location, degree of groundwater use and aquifer characteristics.

The assessment shows that the actions differ notably in the timing of benefits. The timing of benefits is a critical factor in judging the suitability of management actions for meeting management objectives. For example, if the months of August, September or October are targeted for flow enhancement, the lagged accretion from winter recharge may be insufficient to meet management objectives. Flow benefits from winter recharge decline rapidly following the period of implementation, largely reflecting the location and aquifer characteristics of the potentially suitable lands. As such, winter recharge is an inefficient approach for achieving late summer flow augmentation. Delayed groundwater pumping in May and June provides more favorable timing for attaining flow benefits in late summer/early fall months, but is also inefficient due to the brevity of the potential implementation period where surface water can be used in lieu of groundwater on irrigated lands. On the other hand, augmentation wells placed distant from the river can provide an immediate benefit if pumped water is conveyed directly to the river, with the "cost" of lagged stream depletion spread over a long period with the greatest depletion impacts falling in winter months when flows are high. Finally, reduced irrigation groundwater pumping provides timely flow benefits because reduction occurs in the irrigation season, but entails cost associated with impacts to crop production. This preliminary assessment does not address feasibility, cost and other factors that may affect the desirability of actions. This evaluation solely provides a screening-level analysis of the potential timing and magnitude of flow benefits.

An interactive spreadsheet-based tool is described that allows comparison of simulation results from selected groundwater management options, including user-controlled on/off switches and the ability to scale the magnitude of projects, while comparing the flow benefit to a user-specified monthly flow target. This tool may be helpful to stakeholders in considering actions or combinations of actions to support sustainable groundwater management. As a screening-level tool, modifications to the actions illustrated in this effort or entirely different actions may be identified. The analyses presented herein can be adapted to include evaluation of additional scenarios.

Methods

Incremental flow increases (flow benefits) associated with hypothetical groundwater management options were quantified through groundwater model simulation. The model simulations for each option involved comparison of base conditions to modified conditions under the management option, and evaluation of the difference between simulations to identify the flow benefits attributable to each option. Placeholder targets, as desired increase in monthly flow, were identified to provide a point of comparison to simulated results; placeholder values can be replaced to consider other objectives. The model code, the simulation base case, groundwater management options and placeholder targets are described below.

Model Code

Model simulation of hypothetical groundwater management options were implemented with the Scott Valley Groundwater Model, prepared by S.S. Papadopulos & Associates, Inc. (SSPA, 2012), a 2-layer finite difference groundwater model using a modified version of MODFLOW (Harbaugh et al., 2000, Baird and Maddock, 2005; Maddock and Baird, 2003); and, for augmentation well options, the model was transitioned into the U.S. Geological Survey's One-Water Hydrologic Model (MF-OWHM), a MODFLOW-based integrated hydrologic flow model (Hanson, R.T. et al., 2014), providing advanced capabilities useful for these simulations. This transition, while benefiting evaluation of these options, also positions the model for continued refinement in evaluating conjunctive use issues in future work efforts. The model is temporally discretized with monthly stress periods and bi-weekly timesteps.

Base Case Conditions

Analysis of the net flow benefit to the Scott River from selected groundwater management options is premised on a Base Case condition that represents water and land use assumptions developed by the California Department of Water Resources, as reflected in their 2010 land and water use survey. The 2010 survey includes field assessment of irrigated lands and crop patterns. River conditions for the Base Case reflect average monthly discharge for the period 1990-2010, with averaging or smoothing of discharge in adjacent months with similar magnitude. The calendar year and water year average for this period, respectively, are 569 and 565 cfs. For the year 2010, these values are 580 and 465 cfs, respectively. Base Case assumptions can be characterized as relating to a year with dry-normal hydrologic conditions and are reasonably contemporary in terms of irrigated lands, crop patterns and water use.

Hypothetical Groundwater Management Options

Seven hypothetical groundwater management options were simulated. These are described below.

Management Option A1, A2, Delayed Groundwater Pumping: Under this option, irrigation demand in May and June is entirely met by diversions from surface water. There is no change to crop water use nor to recharge of excess applied irrigation water. The MODFLOW Well Package is modified to exclude Base Case pumping that would otherwise occur in these months, and the groundwater model simulates the resulting, incremental, accretion to river flow over the remainder of the year and beyond. Direct surface water diversion equal to the amount of Base Case groundwater pumping in May and June is subtracted from the simulated accretion in those months to obtain the net flow benefit, which becomes negative during the months of increased diversion. The option is structured to occur repetitively over a 3-year period but is not simulated in this exercise as a permanent action. Options A1 and A2 differ by the location of lands identified for this hypothetical option, with A1 associated with lands to the north of Ft. Jones and A2 with lands to the south of Ft. Jones (Figure 1). These locations were adopted from lands marked for an exploratory analysis by UC Davis of a preliminary "In Lieu Recharge" scenario (Tolley, 2016). The lands were carried into this analysis because they are located in areas that may have access to or could (physically) develop access to direct diversion from the river thus developing an alternate source to groundwater pumping for irrigated lands. It is assumed, for our initial analysis, that surface water conveyed to the lands for irrigation in lieu of groundwater pumping would incur no additional transit losses. Approximately 1,300 irrigated acres are associated with Option A1. For the Base Case, the rate of applied groundwater to these lands was approximately 2.2 cfs in May and 11.9 cfs in June; these amounts were replaced with surface water for the Option A1 simulation. Approximately 4,000 irrigated acres are associated with Option A2. For the Base Case, the rate of applied groundwater to these lands was approximately 6.6 cfs in May and 32.2 cfs in June; these amounts were replaced with surface water for the Option A2 simulation.

Management Option B, Winter Recharge: Under this option, pre-irrigation season on-farm recharge is simulated considering 2016 SVID Temporary Permit conditions and potentially suitable lands considered for exploratory analysis of the Managed Aquifer Recharge scenario by UC Davis (Tolley, 2016). The lands used for this option are shown on Figure 2. For Option B, it is assumed that the existing SVID infrastructure would be used to divert river water to lands for recharge in January, February and March at a steady rate of 28 cfs. This water is applied to approximately 950 acres each winter. No transit or consumptive losses are simulated. This assumption can be modified in future scenarios if this option is further studied.

Management Option C1, C2, C3, Augmentation Wells: Under this option, three locations are marked for augmentation wellfields. Each is located towards the east side of the Scott Valley floor in the vicinity of the eastside gulches: Hamlin, Shell and Heartstrand. The augmentation wellfields are simulated as pumping 6, 2, and 4 cfs, respectively, in August and September of the first year. The amount pumped is considered a direct augmentation to the river; lagged depletion impacts in the following 3 years are tallied as negative benefit. Details of this hypothetical option have not been examined with respect to number of wells required for the wellfields, groundwater declines or feasibility with respect to landowner/infrastructure issues.

Management Option D, Reduction in Irrigated Land: Under this option, groundwater pumping and associated recharge of excess applied water is reduced across all irrigated lands in the Scott Valley. This option is conceptually similar to the "Partial Build-Out" case previously described (S.S. Papadopulos & Associates, Inc., 2012), but differs in details because the Base Case represents the monthly model and uses the crop pattern and water use conditions associated with the 2010 DWR survey. Under this option, irrigation in each month is limited to 60% of the maximum monthly applied groundwater reported by crop in the DWR 2010 water use survey. The net effect is a reduction in the total applied groundwater of approximately 25%, with reductions to groundwater pumping in July through September. On-farm irrigation recharge is adjusted consistent with the reduced applied groundwater, also using the DWR 2010 reported unit values. Crop production would correspondingly be reduced as there is no replacement of groundwater with surface water simulated under this hypothetical option. For this exercise, this change is simulated as a recurring action.

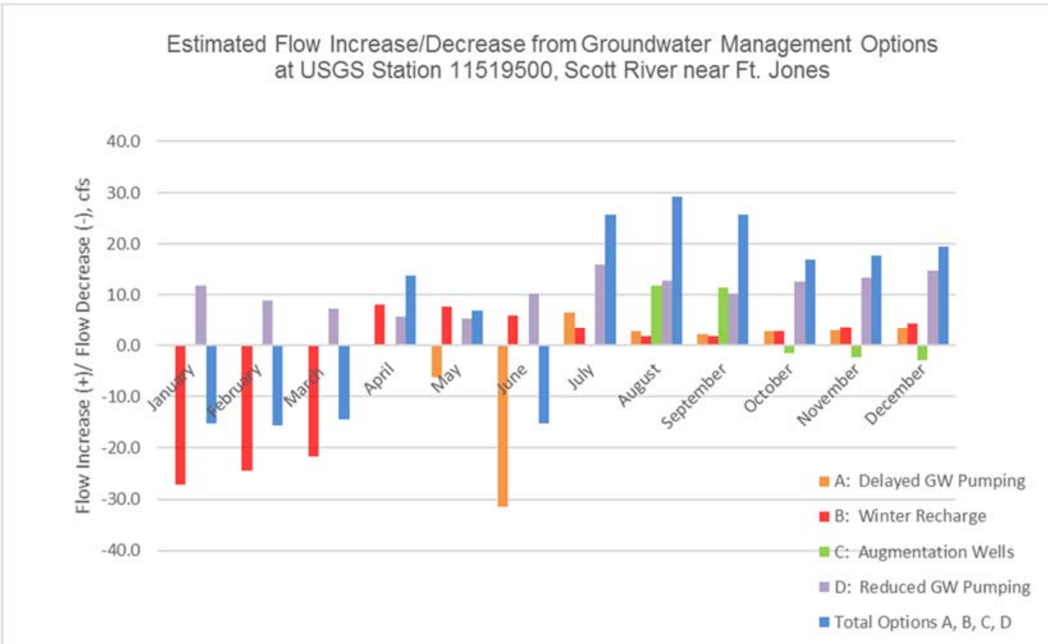
Flow Benefit Comparison to Monthly Flow Targets

Simulation results are compared to incremental monthly flow targets for discharge at the U.S. Geological Survey Station 11519500, Scott River near Ft. Jones. The net flow benefit from management options is derived by comparison of total river/tributary flux (groundwater/surface water exchanges) from the Base Case simulation to the total river/tributary flux from an Option simulation, including adjustment for any change in direct diversion from the river or direct augmentation to the river associated with the Option. The calculated net benefit includes the total accretion (and depletion) that occurs to all of the simulated Scott River or tributary reaches. For example, a net flow benefit at the USGS gage of 20 cfs may be derived from a variety of reaches, depending on the management option. It is possible that some upstream reaches of interest will not receive a specific desired benefit because benefits accrue to other reaches. Additional analysis of simulation results can provide information on the spatial distribution of benefits, which also exhibit dependency in time until steady state is achieved.

Placeholder incremental monthly flow targets of 20 cfs for August and September are used in this analysis. The incremental flow target of 20 cfs is consistent with a desired flow of 50 cfs for August and September in a dry-normal year, and with the Base Case August and September discharge of 30 cfs. Placeholder incremental monthly flow targets are provided for illustrative purposes as it is understood that work towards better defining instream flow needs is in progress. Other targets also may be considered for specific management objectives.

Results

The simulated results provide a means of comparing one option to another in terms of net benefit to flows of the Scott River at the USGS gage. The benefits describe aggregate benefits to all reaches of the Scott River and tributaries that flow to the river upstream of the gage. As shown on the figure below, none of the options alone meet the placeholder target value for flow augmentation of 20 cfs in August and September. If this magnitude of flow increase is needed, a combination of actions would be required.



<u>A1, Delayed Groundwater Pumping North of Ft. Jones</u>: This option provides a net benefit to the river except in the months of direct diversion. The maximum net benefit occurs in July at approximately 2 cfs. The net benefit in August and September is in the range of 0.5-0.7 cfs over the three-year period. These results are lagged benefits of the simulated reduction in groundwater pumping by 2.2 cfs in May and 11.9 cfs in June.

<u>A2, Delayed Groundwater Pumping South of Ft. Jones</u>: This option provides a net benefit to the river except in the months of direct diversion. The maximum net benefit occurs in July at approximately 5 cfs. Net benefit in August and September is in the range of 1.8-2.3 cfs over the three-year period. These results are lagged benefits of the simulated reduction in groundwater pumping by 6.6 cfs in May and 32.2 cfs in June.

<u>A1 and A2 Combined</u>: The summary figure, above, and Figure 4, attached, show detail on the combined results for options A1 and A2. Combining these options, the maximum net benefit occurs in July at approximately 7 cfs. The net benefit in August and September is in the range of 2.3 - 3.1 cfs over the three-year period. These results are lagged benefits of the simulated reduction in groundwater pumping by 8.8 cfs in May and 44.1 cfs in June. During a critically dry period, the net benefits may be lagged due to presence of dry reaches of the river or tributaries, and net benefits in August and September may be less than those projected in this analysis.

Management Option B, Winter Recharge: The maximum net benefit occurs in April at 8 - 11 cfs. The net benefit for August and September is in the range of 1.8 - 2.5 cfs over the three-year period. The benefits represent lagged stream accretion resulting from recharge at a rate of 28 cfs in the months of January, February and March. Detail for this option over the three-year period analyzed is provided on Figure 5.

Management Option C1, C2, C3, Augmentation Wells: This option offers the capability of adding 12 cfs directly to the river when most needed; the "cost" of this option is a continuing small depletion impact to the river. Figure 6 shows the depletion "cost" as it would play out in subsequent months of a three-year period. If the wellfield were to pump in sequential years, for example, in an extended drought period, the "cost" would begin again in each year of implementation and add to any remaining depletion from prior years.

Management Option D, Reduced Irrigation Groundwater Pumping: The average annual net benefit of this option is 10.8 cfs. The maximum net benefit occurs in July at 16 cfs; the net benefit in August and September is 13 and 10 cfs, respectively (Figure 7). These results assume a multi-year action and reflect differences after several years of reduced pumping. Consideration of the impacts of this action as a one time or occasional action can be extracted from the simulations if of interest for future study.

Combining Options with the **I**nteractive **G**roundwater **M**anagement **A**ccretion **Estimator**, or, *IGMA Estimator, v.1*

IGMA Estimator v1.xlsx (***I**nteractive **G**roundwater **M**anagement **A**ccretion **Estimator)*** is a spreadsheet-based tool we prepared for review and comparison of the net flow benefit from individual groundwater management options or various combinations, drawing from groundwater model simulation output. Screenshots from the *IGMA Estimator* profiling results from single options were referenced above (Figures 4-7). Figure 8 provides a screenshot for results of combining all of the above-mentioned options. Some caution is required in building combined scenarios due to non-linear aquifer characteristics, particularly in drier periods, nonetheless, these methods are useful in a screening-level analysis.

User instructions for using the *IGMA Estimator* are provided on the front sheet – essentially, fields for user specification are shaded in yellow. Other fields contain simulation output or functions that convey the results in terms of net benefit to the river, and indicate progress towards meeting the user-specified incremental flow target goals. The user has the ability to select one or more options using an On/Off (1/0) designation, and the user may scale the magnitude of the simulated option using a slider bar that modifies the Base Option change over a range of 50-150%. After setting these values, the spreadsheet updates and displays the net benefit in tables and bar charts.

The *IGMA Estimator* also offers an off-channel storage option, which is simply implemented with two fields within the instruction section on the front page. The user may specify a quantity, in cfs, and a consumptive loss, as a percent of the diverted amount. If this option is specified by identification of a diversion amount, this amount is diverted from the river in the 4-month period January to April; and the specified amount, minus consumptive loss, is returned to the river in the 4-month period July to October. This option is not presently set up to interact with the aquifer in any lagged fashion; this assumption can be modified in future work if storage ponds are likely to generate seepage at locations distant from the river.

Figures 4, 5, 6, 7 and 8 illustrate the estimated accretion and net flow benefit, by month, for Options A, B, C, D and for all options combined, respectively. As shown on these figures and on the figure provided above within this memorandum, the options are notably different in their ability to generate flow benefits in the late summer months when flow augmentation may be needed in drier years. When developing plans for sustainable groundwater use, careful attention to these elements is recommended so that efforts are directed towards actions that may prove most beneficial.

The results of the screening-level analyses described above should be informative in considering these and related groundwater management options. Modified options, based on the hypothetical options reviewed here, may be readily assessed building on the material developed for this analysis. These results, and those previously prepared showing spatial attributes of depletion (depletion maps), offer significant information to support discussion going forward to identify and frame viable approaches as stakeholders develop plans for sustainable groundwater management in the Scott Valley. Finally, additional refinement to the simulation approach, assumptions and inputs specific to options may be helpful in pinning down details of any options that are carried forward.

References

Hanson, R.T., Boyce, S.E., Schmid, W., Hughes, J.D., Mehl, S.M., Leake, S.A, Maddock, T.,III, and Niswonger, R.G., 2014. ***One-Water Hydrologic Flow Model (MODFLOW-OWHM)***: U.S. Geological Survey Techniques ad Methods 6-A51, 120 p., http://dx.doi.org/10.3133/tm6A51.

Maddock, III, T, Baird, K.J., Hanson, R.T., Schmid, W. and Ajami, Hl, 2012. ***RIP-ET: A riparian evapotranspiration package for MODFLOW-2005***, U.S. Geological Survey Techniques and Methods 6-A39 p. 39.

S.S. Papadopulos & Associates, Inc, 2012. ***Groundwater Conditions in Scott Valley, California.*** Prepared for the Karuk Tribe, July 2012.

Tolley, Gus, 2016. ***Scott Valley pioneers instream flow and groundwater management for reconciled water use.*** UC Davis Center for Watershed Sciences blog, posted August 21, 2016.

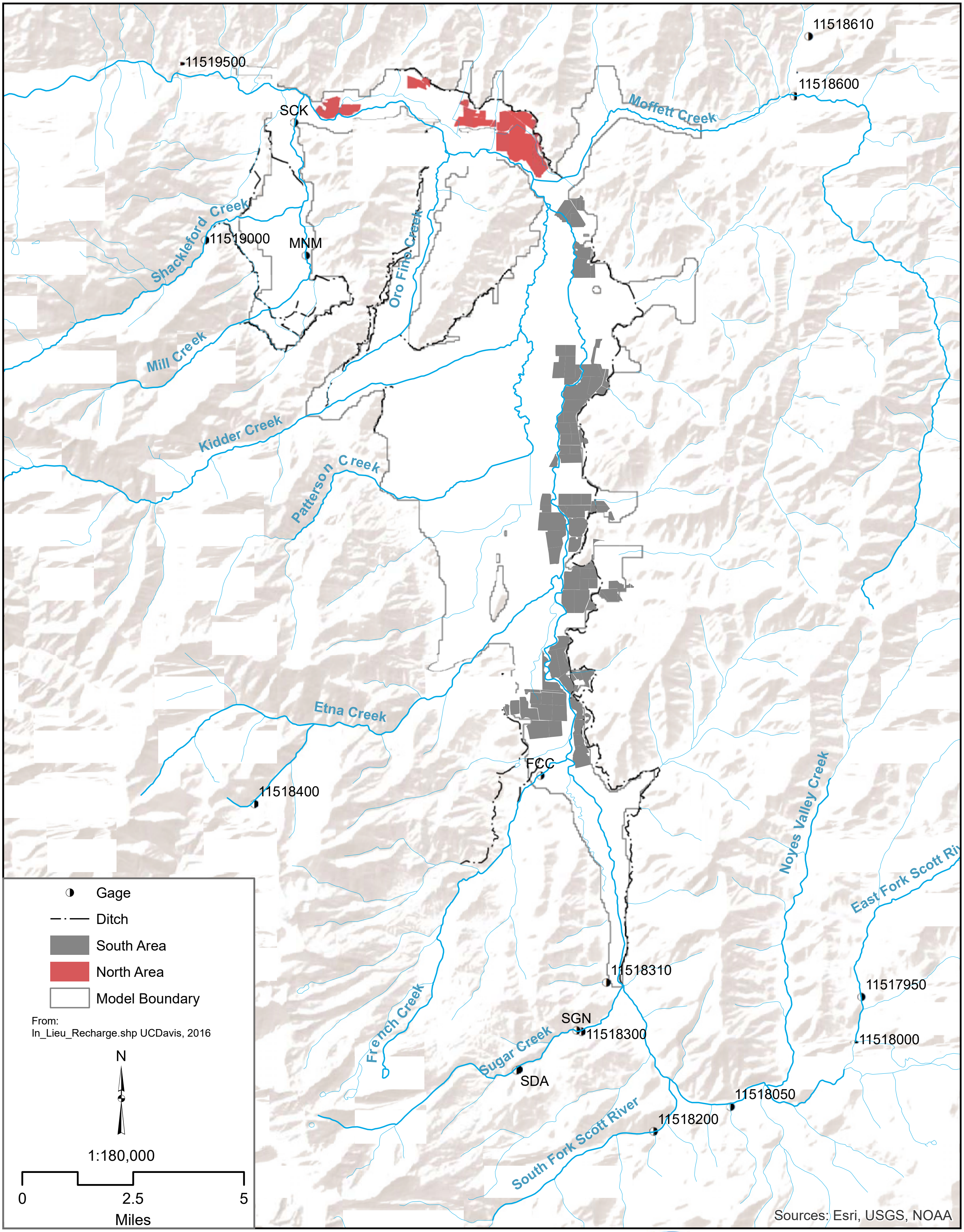


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Figure 1 Hypothetical Management Areas for Option A, Delayed Ground Water Pumping

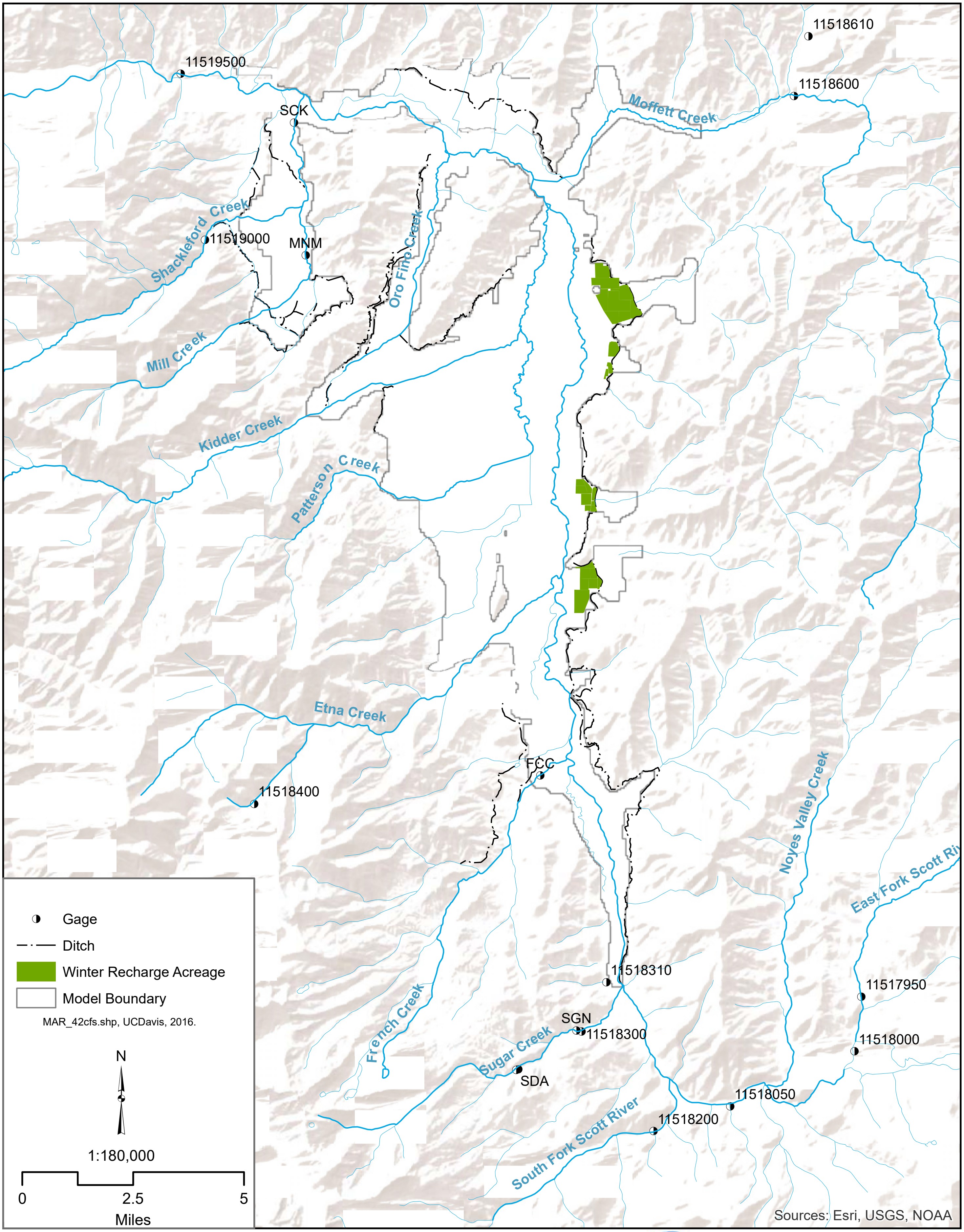

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Figure 2 Hypothetical Managment Areas for Option B, Winter Recharge

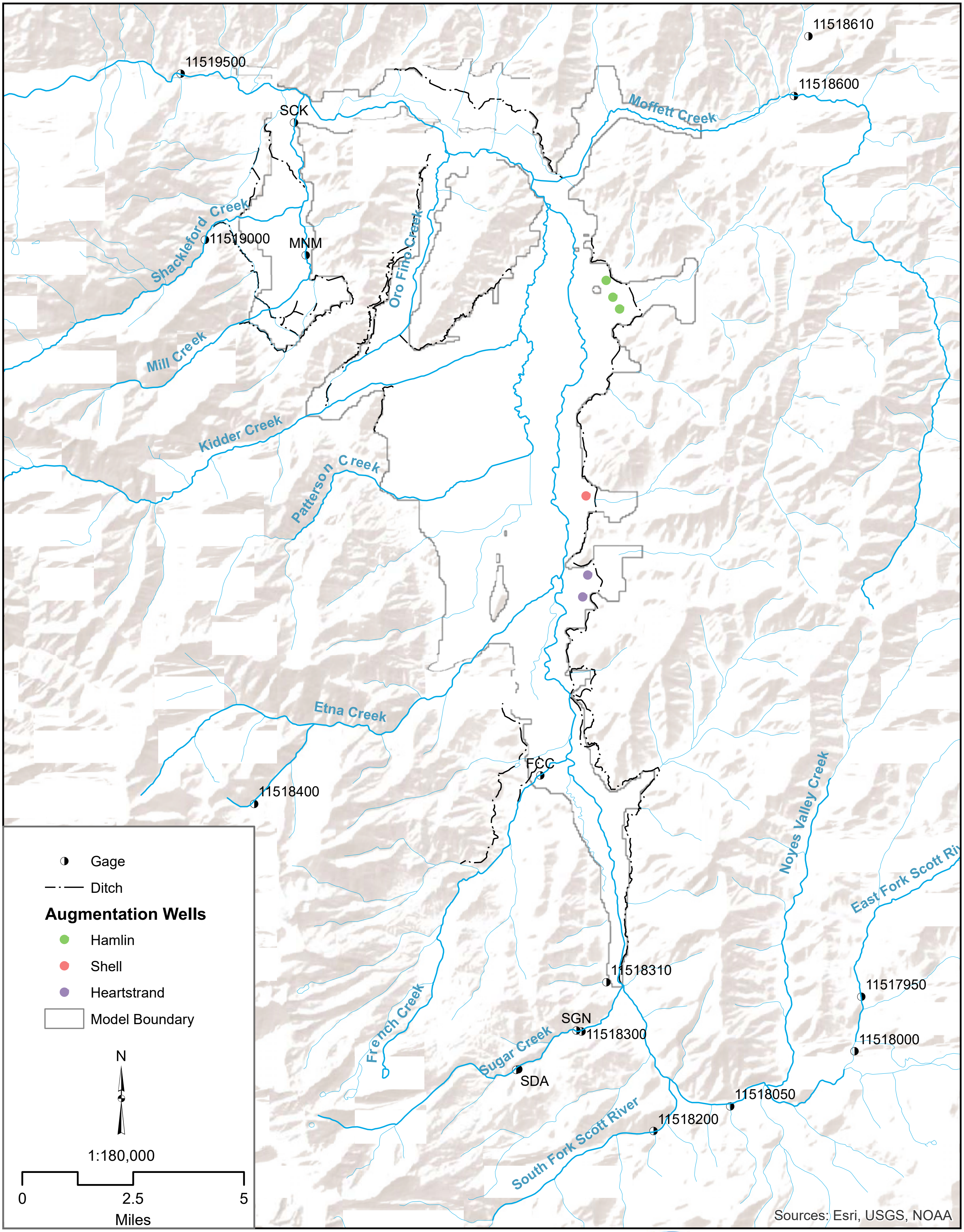

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Figure 3 Hypothetical Well Locations for Option C, Augmentation Wells

Figure 4. Options A1 and A2, Delayed Groundwater Pumping, Net Flow Benefit from IGMA Estimator

PRELIMINARY DRAFT

12/30/2016

Screening-Level Estimates of Flow Accretion to Scott River from Hypothetical Groundwater Management Options

Normal-Dry Conditions

OBJECTIVE

This workbook assembles simulation results for hypothetical groundwater management actions, focusing on the incremental increase or decrease in flow of the Scott River and tributaries associated with the hypothetical action. These results are assembled solely as screening-level estimates to assist in developing packages of actions that may be of interest for further evaluation. Additional evaluation may refine scenario assumptions or evaluate the actions under a different range of conditions. This sheet provides a summary of flow accretion estimates associated with seven hypothetical groundwater management actions. Subsequent sheets provide additional information and summary tables relating to the individual, preliminary, groundwater management simulations.

Notes/Disclaimers:

1. Under lower flow conditions than assumed for this exercise, flow accretion may be delayed beyond the month shown; i.e., the summer/fall monthly benefit may be overestimated.
2. The interactive screening-level approach evaluates a range of inputs for given actions; however, the estimate is most representative at the simulated (base) value.
3. The options have not been vetted with respect to land ownership, feasibility, permitting or environmental/flow impacts below Young's Dam.
4. Flow benefits may occur to specific Scott River reaches, tributaries, or some combination; the benefiting reaches vary among options; see simulation details.
5. Canal loss associated with surface water delivered replacing groundwater (Options A1, A2) is neglected; canal loss associated with winter recharge (Option B) is neglected. Identification and routing of losses that may occur is deferred to a more detailed analysis phase.
6. Estimated impacts of Options A1, A2, and B are provided for a 36-month period following the initiation of actions; it is assumed that the action is applied in each of the 3 years.
7. The estimated impacts of Options C (1, 2, 3) are provided for 36-months; it is assumed this action is implemented in and only benefits the 1st year, although lagged stream depletion continues.
8. The estimated benefits of Option D assume permanent reduction of selected irrigated lands, distributed uniformly, per scenario detail described separately.
9. Table 1 (separate sheet) identifies diversions associated with management actions and direct augmentation.
10. Table 2 (separate sheet) shows estimated Scott River accretion or depletion from simulated (base) groundwater management options. This table is provided for reference.
11. Details concerning this screening-level analysis and assumptions, separately provided, should be reviewed prior to using the ***Interactive Groundwater Management Estimator***
12. It may not be possible to simultaneously implement all of the options as identified; evaluation of multi-option packages may require special handling.

INTERACTIVE GROUNDWATER MANAGEMENT ACCRETION ESTIMATOR

INSTRUCTIONS

*******WARNING: Do not change any spreadsheet entries except those highlighted yellow*******

The ***Interactive Groundwater Management Accretion Estimator*** modifies the net benefit of combined selected groundwater management actions based on user input:

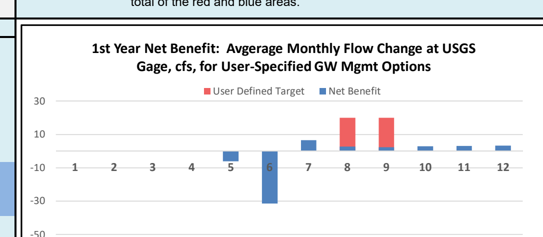
* Set incremental flow targets, for months of concern, in table at right. These are desired incremental flows above the expected flow condition at USGS gage Scott River near Ft. Jones.
* Activate the hypothetical options using a value of "1" for ON, and a value of "0" for OFF; change the value and hit *Enter* on the keyboard.
* Move the slider bars (in yellow) within the range of 50 - 150% to modify the base value for actions under each option. (The new base value and multiplier % is displayed above the slider bar).
* *Net Benefi* t to the flow of the Scott River at the approximate location of the USGS gage is shown in blue shaded area of the table and on corresponding charts.
* To include a hypothetical *Off-Channel Storage Option* , enter vaues as follows:
  - Input percent consumptive loss for off-channel storage: 10 %
  - Input base value diversion for months of January - April for off-channel storage Option E, to be returned to channel in July-October, minus consumptive loss. 0 cfs
* Option E is set up as a placeholder for an additional option; not activated in this version.

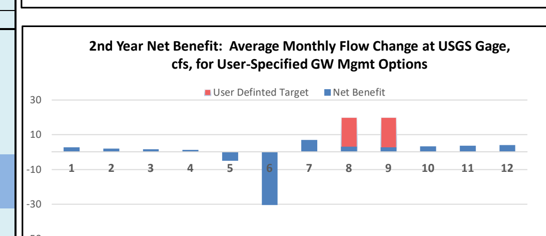
Target Flow Increase, cfs	
January	
February	
March	
April	
May	
June	
July	
August	20
September	20
October	
November	
December	

OPTION:	A1	A2	B	C1	C2	C3	D	E	Combined Accretion (+) and Depletion (-)	Incremental Diversion (-) or Augmentation (+)	Net Benefit
	Delayed GW Pumping, North of Ft. Jones (May, June)	Delayed GW Pumping, South of Ft. Jones (May, June)	Winter Recharge (Jan, Feb, Mar)	Augmentation Wellfield, Example 1, Hamlin	Augmentation Wellfield, Example 2, Shell	Augmentation Wellfield, Example 3, Heartstrand	Reduced GW Pumping, Distributed	Other, tbd	Adjusted Options Combined	Adjusted Options Combined (Table 1)	Increase (+) in Flow at USGS Gage (see charts)
On (1)/Off(0)	**1**	**1**	**0**	**0**	**0**	**0**	**0**	**0**			
Base Action, cfs, average over affected months	7.1	19.4	28.0	6.0	2.0	4.0	10.8	0.0			
Multiplier, %	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**			
Adjusted Action, cfs	7.1	19.4	28.0	6.0	2.0	4.0	10.8	0.0			
Slide to Change % Multiplier Applied to Base Management Action, range 50 to 150%											

RESULTS: Estimated net benefit (+), cfs, for selected options, compared to user-defined monthly incremental flow targets. For months exhibiting a positive net benefit, the unsatisfied portion of the incremental flow target is shaded in red. For months with negative net benefit, the unsatisfied target flow is represented by the total of the red and blue areas.

Year	Month	A1	A2	B	C1	C2	C3	D	E	Combined	Incremental, cfs	Net Benefit, cfs
		Adjusted Accretion (+) or Depletion (-) affecting Scott River flow above USGS gage, cfs									cfs	cfs
1	January	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	**0.0**
	February	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	**0.0**
	March	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	**0.0**
	April	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	**0.0**
	May	0.8	1.8	0.0	0.0	0.0	0.0	0.0	0.0	2.5	-8.75	**-6.2**
	June	4.3	8.4	0.0	0.0	0.0	0.0	0.0	0.0	12.7	-44.1	**-31.4**
	July	1.9	4.7	0.0	0.0	0.0	0.0	0.0	0.0	6.5	0	**6.5**
	August	0.7	2.0	0.0	0.0	0.0	0.0	0.0	0.0	2.8	0	**2.8**
	September	0.5	1.8	0.0	0.0	0.0	0.0	0.0	0.0	2.3	0	**2.3**
	October	0.9	2.0	0.0	0.0	0.0	0.0	0.0	0.0	2.8	0	**2.8**
	November	0.6	2.4	0.0	0.0	0.0	0.0	0.0	0.0	3.1	0	**3.1**
	December	0.5	2.8	0.0	0.0	0.0	0.0	0.0	0.0	3.3	0	**3.3**
	AVERAGE	**0.9**	**2.1**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**3.0**	**-4.4**	**-1.4**
2	January	0.4	2.2	0.0	0.0	0.0	0.0	0.0	0.0	2.6	0	**2.6**
	February	0.3	1.6	0.0	0.0	0.0	0.0	0.0	0.0	1.9	0	**1.9**
	March	0.3	1.2	0.0	0.0	0.0	0.0	0.0	0.0	1.5	0	**1.5**
	April	0.3	1.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0	**1.2**
	May	1.0	2.6	0.0	0.0	0.0	0.0	0.0	0.0	3.6	-8.75	**-5.2**
	June	4.5	9.0	0.0	0.0	0.0	0.0	0.0	0.0	13.5	-44.1	**-30.6**
	July	2.0	5.0	0.0	0.0	0.0	0.0	0.0	0.0	7.0	0	**7.0**
	August	0.8	2.2	0.0	0.0	0.0	0.0	0.0	0.0	3.1	0.0	**3.1**
	September	0.6	2.0	0.0	0.0	0.0	0.0	0.0	0.0	2.6	0.0	**2.6**
	October	1.0	2.2	0.0	0.0	0.0	0.0	0.0	0.0	3.2	0.0	**3.2**
	November	0.8	2.8	0.0	0.0	0.0	0.0	0.0	0.0	3.5	0.0	**3.5**
	December	0.6	3.3	0.0	0.0	0.0	0.0	0.0	0.0	3.9	0.0	**3.9**
	AVERAGE	**1.1**	**2.9**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**4.0**	**-4.4**	**-0.4**
3	January	0.5	2.5	0.0	0.0	0.0	0.0	0.0	0.0	3.0	0	**3.0**
	February	0.4	1.9	0.0	0.0	0.0	0.0	0.0	0.0	2.3	0	**2.3**
	March	0.4	1.5	0.0	0.0	0.0	0.0	0.0	0.0	1.8	0	**1.8**
	April	0.3	1.2	0.0	0.0	0.0	0.0	0.0	0.0	1.5	0	**1.5**
	May	1.1	2.8	0.0	0.0	0.0	0.0	0.0	0.0	3.8	-8.75	**-4.9**
	June	4.6	9.1	0.0	0.0	0.0	0.0	0.0	0.0	13.7	-44.1	**-30.4**
	July	2.1	5.0	0.0	0.0	0.0	0.0	0.0	0.0	7.1	0	**7.1**
	August	0.9	2.3	0.0	0.0	0.0	0.0	0.0	0.0	3.1	0	**3.1**
	September	0.7	2.0	0.0	0.0	0.0	0.0	0.0	0.0	2.7	0	**2.7**
	October	1.0	2.3	0.0	0.0	0.0	0.0	0.0	0.0	3.3	0	**3.3**
	November	0.8	2.9	0.0	0.0	0.0	0.0	0.0	0.0	3.7	0	**3.7**
	December	0.7	3.4	0.0	0.0	0.0	0.0	0.0	0.0	4.1	0	**4.1**
	YEAR AVERAGE	**1.1**	**3.1**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**4.2**	**-4.4**	**-0.2**





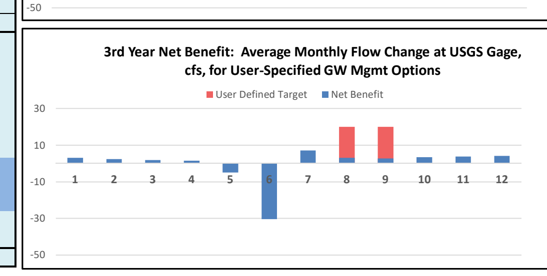


Figure 5. Option B, Winter Recharge, Net Benefit to River from IGMA Estimator

PRELIMINARY DRAFT

12/30/2016

Screening-Level Estimates of Flow Accretion to Scott River from Hypothetical Groundwater Management Options

Normal-Dry Conditions

OBJECTIVE

This workbook assembles simulation results for hypothetical groundwater management actions, focusing on the incremental increase or decrease in flow of the Scott River and tributaries associated with the hypothetical action. These results are assembled solely as screening-level estimates to assist in developing packages of actions that may be of interest for further evaluation. Additional evaluation may refine scenario assumptions or evaluate the actions under a different range of conditions. This sheet provides a summary of flow accretion estimates associated with seven hypothetical groundwater management actions. Subsequent sheets provide additional information and summary tables relating to the individual, preliminary, groundwater management simulations.

Notes/Disclaimers:

1. Under lower flow conditions than assumed for this exercise, flow accretion may be delayed beyond the month shown; i.e., the summer/fall monthly benefit may be overestimated.
2. The interactive screening-level approach evaluates a range of inputs for given actions; however, the estimate is most representative at the simulated (base) value.
3. The options have not been vetted with respect to land ownership, feasibility, permitting or environmental/flow impacts below Young's Dam.
4. Flow benefits may occur to specific Scott River reaches, tributaries, or some combination; the benefiting reaches vary among options; see simulation details.
5. Canal loss associated with surface water delivered replacing groundwater (Options A1, A2) is neglected; canal loss associated with winter recharge (Option B) is neglected. Identification and routing of losses that may occur is deferred to a more detailed analysis phase.
6. Estimated impacts of Options A1, A2, and B are provided for a 36-month period following the initiation of actions; it is assumed that the action is applied in each of the 3 years.
7. The estimated impacts of Options C (1, 2, 3) are provided for 36-months; it is assumed this action is implemented in and only benefits the 1st year, although lagged stream depletion continues.
8. The estimated benefits of Option D assume permanent reduction of selected irrigated lands, distributed uniformly, per scenario detail described separately.
9. Table 1 (separate sheet) identifies diversions associated with management actions and direct augmentation.
10. Table 2 (separate sheet) shows estimated Scott River accretion or depletion from simulated (base) groundwater management options. This table is provided for reference.
11. Details concerning this screening-level analysis and assumptions, separately provided, should be reviewed prior to using the ***Interactive Groundwater Management Estimator***
12. It may not be possible to simultaneously implement all of the options as identified; evaluation of multi-option packages may require special handling.

INTERACTIVE GROUNDWATER MANAGEMENT ACCRETION ESTIMATOR

INSTRUCTIONS

*******WARNING: Do not change any spreadsheet entries except those highlighted yellow*******

The ***Interactive Groundwater Management Accretion Estimator*** modifies the net benefit of combined selected groundwater management actions based on user input:

* Set incremental flow targets, for months of concern, in table at right. These are desired incremental flows above the expected flow condition at USGS gage Scott River near Ft. Jones.
* Activate the hypothetical options using a value of "1" for ON, and a value of "0" for OFF; change the value and hit *Enter* on the keyboard.
* Move the slider bars (in yellow) within the range of 50 - 150% to modify the base value for actions under each option. (The new base value and multiplier % is displayed above the slider bar).
* *Net Benefit* to the flow of the Scott River at the approximate location of the USGS gage is shown in blue shaded area of the table and on corresponding charts.
* To include a hypothetical *Off-Channel Storage Option*, enter vaues as follows:

Input percent consumptive loss for off-channel storage: 10 %

Input base value diversion for months of January - April for off-channel storage Option E, to be returned to channel in July-October, minus consumptive loss. 0 cfs

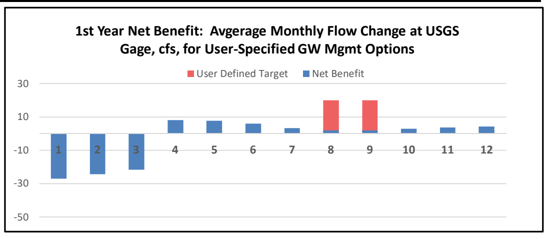
* Option E is set up as a placeholder for an additional option; not activated in this version.

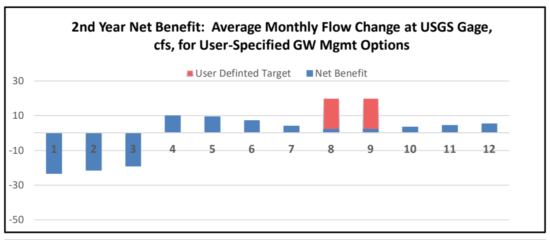
Target Flow Increase, cfs	
January	
February	
March	
April	
May	
June	
July	
August	20
September	20
October	
November	
December	

OPTION:	A1	A2	B	C1	C2	C3	D	E	Combined Accretion (+) and Depletion (-)	Incremental Diversion (-) or Augmentation (+)	Net Benefit
	Delayed GW Pumping, North of Ft. Jones (May, June)	Delayed GW Pumping, South of Ft. Jones (May, June)	Winter Recharge (Jan, Feb, Mar)	Augmentation Wellfield, Example 1, Hamlin	Augmentation Wellfield, Example 2, Shell	Augmentation Wellfield, Example 3, Heartstrand	Reduced GW Pumping, Distributed	Other, tbd	Adjusted Options Combined	Adjusted Options Combined (Table 1)	Increase (+) in Flow at USGS Gage (see charts)
On (1)/Off(0)	0	0	1	0	0	0	0	0			
Base Action, cfs, average over affected months	7.1	19.4	28.0	6.0	2.0	4.0	10.8	0.0			
Multiplier, %	100	100	100	100	100	100	100	100			
Adjusted Action, cfs	0.0	19.4	28.0	6.0	2.0	4.0	10.8	0.0			
Slide to Change % Multiplier Applied to Base Management Action, range 50 to 150%											

RESULTS: Estimated net benefit (+), cfs, for selected options, compared to user-defined monthly incremental flow targets. For months exhibiting a positive net benefit, the unsatisfied portion of the incremental flow target is shaded in red. For months with negative net benefit, the unsatisfied target flow is represented by the total of the red and blue areas.

Year	Month	A1	A2	B	C1	C2	C3	D	E	Combined	Incremental (cfs)	Net Benefit (cfs)
		Adjusted Accretion (+) or Depletion (-) affecting Scott River flow above USGS gage, cfs									cfs	cfs
1	January	0.0	0.0	0.9	0.0	0.0	0.0	0.0	0.0	0.9	-28	**-27.1**
	February	0.0	0.0	3.5	0.0	0.0	0.0	0.0	0.0	3.5	-28	**-24.5**
	March	0.0	0.0	6.4	0.0	0.0	0.0	0.0	0.0	6.4	-28	**-21.6**
	April	0.0	0.0	8.1	0.0	0.0	0.0	0.0	0.0	8.1	0	**8.1**
	May	0.0	0.0	7.8	0.0	0.0	0.0	0.0	0.0	7.8	0	**7.8**
	June	0.0	0.0	5.9	0.0	0.0	0.0	0.0	0.0	5.9	0.0	**5.9**
	July	0.0	0.0	3.3	0.0	0.0	0.0	0.0	0.0	3.3	0	**3.3**
	August	0.0	0.0	1.9	0.0	0.0	0.0	0.0	0.0	1.9	0	**1.9**
	September	0.0	0.0	1.8	0.0	0.0	0.0	0.0	0.0	1.8	0	**1.8**
	October	0.0	0.0	2.9	0.0	0.0	0.0	0.0	0.0	2.9	0	**2.9**
	November	0.0	0.0	3.7	0.0	0.0	0.0	0.0	0.0	3.7	0	**3.7**
	December	0.0	0.0	4.3	0.0	0.0	0.0	0.0	0.0	4.3	0	**4.3**
	AVERAGE	**0.0**	**0.0**	**4.2**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**4.2**	**-7.0**	**-2.8**
2	January	0.0	0.0	4.4	0.0	0.0	0.0	0.0	0.0	4.4	-28	**-23.6**
	February	0.0	0.0	6.2	0.0	0.0	0.0	0.0	0.0	6.2	-28	**-21.8**
	March	0.0	0.0	8.6	0.0	0.0	0.0	0.0	0.0	8.6	-28	**-19.4**
	April	0.0	0.0	10.0	0.0	0.0	0.0	0.0	0.0	10.0	0	**10.0**
	May	0.0	0.0	9.4	0.0	0.0	0.0	0.0	0.0	9.4	0	**9.4**
	June	0.0	0.0	7.2	0.0	0.0	0.0	0.0	0.0	7.2	0.0	**7.2**
	July	0.0	0.0	4.1	0.0	0.0	0.0	0.0	0.0	4.1	0	**4.1**
	August	0.0	0.0	2.3	0.0	0.0	0.0	0.0	0.0	2.3	0.0	**2.3**
	September	0.0	0.0	2.3	0.0	0.0	0.0	0.0	0.0	2.3	0.0	**2.3**
	October	0.0	0.0	3.6	0.0	0.0	0.0	0.0	0.0	3.6	0.0	**3.6**
	November	0.0	0.0	4.6	0.0	0.0	0.0	0.0	0.0	4.6	0.0	**4.6**
	December	0.0	0.0	5.5	0.0	0.0	0.0	0.0	0.0	5.5	0.0	**5.5**
	AVERAGE	**0.0**	**0.0**	**5.7**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**5.7**	**-7.0**	**-1.3**
3	January	0.0	0.0	5.4	0.0	0.0	0.0	0.0	0.0	5.4	-28	**-22.6**
	February	0.0	0.0	7.1	0.0	0.0	0.0	0.0	0.0	7.1	-28	**-20.9**
	March	0.0	0.0	9.3	0.0	0.0	0.0	0.0	0.0	9.3	-28	**-18.7**
	April	0.0	0.0	10.6	0.0	0.0	0.0	0.0	0.0	10.6	0	**10.6**
	May	0.0	0.0	10.0	0.0	0.0	0.0	0.0	0.0	10.0	0	**10.0**
	June	0.0	0.0	7.7	0.0	0.0	0.0	0.0	0.0	7.7	0.0	**7.7**
	July	0.0	0.0	4.4	0.0	0.0	0.0	0.0	0.0	4.4	0	**4.4**
	August	0.0	0.0	2.5	0.0	0.0	0.0	0.0	0.0	2.5	0	**2.5**
	September	0.0	0.0	2.5	0.0	0.0	0.0	0.0	0.0	2.5	0	**2.5**
	October	0.0	0.0	3.8	0.0	0.0	0.0	0.0	0.0	3.8	0	**3.8**
	November	0.0	0.0	5.0	0.0	0.0	0.0	0.0	0.0	5.0	0	**5.0**
	December	0.0	0.0	6.0	0.0	0.0	0.0	0.0	0.0	6.0	0	**6.0**
	YEAR AVERAGE	**0.0**	**0.0**	**6.2**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**6.2**	**-7.0**	**-0.8**





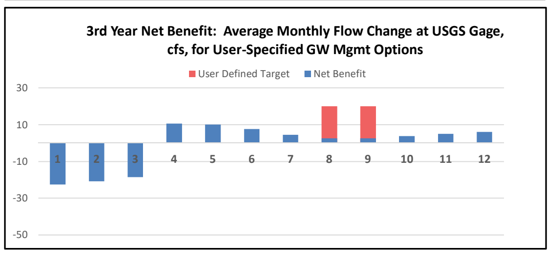


Figure 6. Options C1, C2 and C3, Augmentation Wells Single Year Pumping, Net Flow Benefit from IGMA Estimator

PRELIMINARY DRAFT

12/30/2016

Screening-Level Estimates of Flow Accretion to Scott River from Hypothetical Groundwater Management Options

Normal-Dry Conditions

OBJECTIVE

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7. The estimated impacts of Options C (1, 2, 3) are provided for 36-months; it is assumed this action is implemented in and only benefits the 1st year, although lagged stream depletion continues.
8. The estimated benefits of Option D assume permanent reduction of selected irrigated lands, distributed uniformly, per scenario detail described separately.
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10. Table 2 (separate sheet) shows estimated Scott River accretion or depletion from simulated (base) groundwater management options. This table is provided for reference.
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INTERACTIVE GROUNDWATER MANAGEMENT ACCRETION ESTIMATOR

INSTRUCTIONS

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* Activate the hypothetical options using a value of "1" for ON, and a value of "0" for OFF; change the value and hit *Enter* on the keyboard.
* Move the slider bars (in yellow) within the range of 50 - 150% to modify the base value for actions under each option. (The new base value and multiplier % is displayed above the slider bar).
* *Net Benefi* t to the flow of the Scott River at the approximate location of the USGS gage is shown in blue shaded area of the table and on corresponding charts.
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  - Input percent consumptive loss for off-channel storage: 10 %
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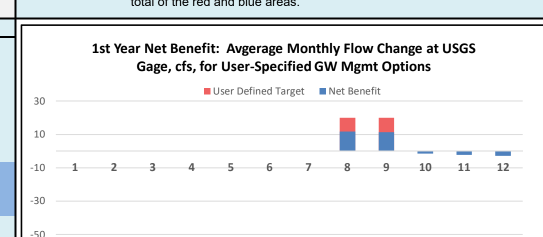
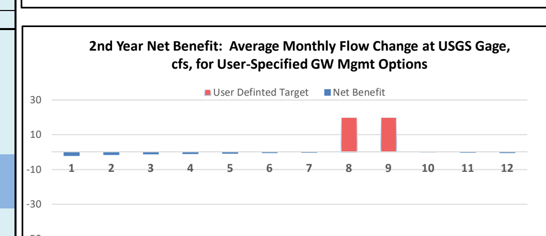
* Option E is set up as a placeholder for an additional option; not activated in this version.

Target Flow Increase, cfs	
January	
February	
March	
April	
May	
June	
July	
August	20
September	20
October	
November	
December	

OPTION:		A1	A2	B	C1	C2	C3	D	E	Combined Accretion (+) and Depletion (-)	Incremental Diversion (-) or Augmentation (+)	Net Benefit
		Delayed GW Pumping, North of Ft. Jones (May, June)	Delayed GW Pumping, South of Ft. Jones (May, June)	Winter Recharge (Jan, Feb, Mar)	Augmentation Wellfield, Example 1, Hamlin	Augmentation Wellfield, Example 2, Shell	Augmentation Wellfield, Example 3, Heartstrand	Reduced GW Pumping, Distributed	Other, tbd	Adjusted Options Combined	Adjusted Options Combined (Table 1)	Increase (+) in Flow at USGS Gage (see charts)
On (1)/Off(0)		**0**	**0**	**0**	**1**	**1**	**1**	**0**	**0**			
Base Action, cfs, average over affected months		7.1	19.4	28.0	6.0	2.0	4.0	10.8	0.0			
Multiplier, %		**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**			
Adjusted Action, cfs		0.0	19.4	28.0	6.0	2.0	4.0	10.8	0.0			
Slide to Change % Multiplier Applied to Base Management Action, range 50 to 150%												
Year	**Month**	**Adjusted Accretion (+) or Depletion (-) affecting Scott River flow above USGS gage, cfs**									**cfs**	**cfs**
1	**January**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	**0.0**
	February	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	**0.0**
	March	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	**0.0**
	April	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	**0.0**
	May	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	**0.0**
	June	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
	July	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	**0.0**
	August	0.0	0.0	0.0	-0.1	-0.1	-0.1	0.0	0.0	-0.2	12	**11.8**
	September	0.0	0.0	0.0	-0.1	-0.2	-0.3	0.0	0.0	-0.6	12	**11.4**
	October	0.0	0.0	0.0	-0.6	-0.4	-0.6	0.0	0.0	-1.5	0	**-1.5**
	November	0.0	0.0	0.0	-0.9	-0.5	-0.9	0.0	0.0	-2.3	0	**-2.3**
	December	0.0	0.0	0.0	-1.2	-0.6	-1.1	0.0	0.0	-2.9	0	**-2.9**
	AVERAGE	**0.0**	**0.0**	**0.0**	**-0.2**	**-0.2**	**-0.2**	**0.0**	**0.0**	**-0.6**	**2.0**	**1.4**
2	**January**	0.0	0.0	0.0	-1.1	-0.5	-0.8	0.0	0.0	-2.4	0	**-2.4**
	February	0.0	0.0	0.0	-0.9	-0.3	-0.6	0.0	0.0	-1.8	0	**-1.8**
	March	0.0	0.0	0.0	-0.7	-0.2	-0.5	0.0	0.0	-1.4	0	**-1.4**
	April	0.0	0.0	0.0	-0.6	-0.2	-0.4	0.0	0.0	-1.2	0	**-1.2**
	May	0.0	0.0	0.0	-0.5	-0.1	-0.3	0.0	0.0	-1.0	0	**-1.0**
	June	0.0	0.0	0.0	-0.4	-0.1	-0.2	0.0	0.0	-0.7	0.0	**-0.7**
	July	0.0	0.0	0.0	-0.3	0.0	-0.1	0.0	0.0	-0.4	0	**-0.4**
	August	0.0	0.0	0.0	-0.1	0.0	-0.1	0.0	0.0	-0.2	0.0	**-0.2**
	September	0.0	0.0	0.0	-0.1	0.0	-0.1	0.0	0.0	-0.2	0.0	**-0.2**
	October	0.0	0.0	0.0	-0.3	0.0	-0.1	0.0	0.0	-0.4	0.0	**-0.4**
	November	0.0	0.0	0.0	-0.3	0.0	-0.1	0.0	0.0	-0.5	0.0	**-0.5**
	December	0.0	0.0	0.0	-0.4	-0.1	-0.2	0.0	0.0	-0.6	0.0	**-0.6**
	AVERAGE	**0.0**	**0.0**	**0.0**	**-0.5**	**-0.1**	**-0.3**	**0.0**	**0.0**	**-0.9**	**0.0**	**-0.9**
3	**January**	0.0	0.0	0.0	-0.3	-0.1	-0.2	0.0	0.0	-0.5	0	**-0.5**
	February	0.0	0.0	0.0	-0.2	0.0	-0.1	0.0	0.0	-0.4	0	**-0.4**
	March	0.0	0.0	0.0	-0.2	0.0	-0.1	0.0	0.0	-0.3	0	**-0.3**
	April	0.0	0.0	0.0	-0.2	0.0	-0.1	0.0	0.0	-0.3	0	**-0.3**
	May	0.0	0.0	0.0	-0.1	0.0	-0.1	0.0	0.0	-0.3	0	**-0.3**
	June	0.0	0.0	0.0	-0.1	0.0	-0.1	0.0	0.0	-0.2	0.0	**-0.2**
	July	0.0	0.0	0.0	-0.1	0.0	0.0	0.0	0.0	-0.1	0	**-0.1**
	August	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	0	**-0.1**
	September	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	0	**-0.1**
	October	0.0	0.0	0.0	-0.1	0.0	0.0	0.0	0.0	-0.1	0	**-0.1**
	November	0.0	0.0	0.0	-0.1	0.0	0.0	0.0	0.0	-0.2	0	**-0.2**
	December	0.0	0.0	0.0	-0.1	0.0	-0.1	0.0	0.0	-0.2	0	**-0.2**
	YEAR AVERAGE	**0.0**	**0.0**	**0.0**	**-0.1**	**0.0**	**-0.1**	**0.0**	**0.0**	**-0.2**	**0.0**	**-0.2**

RESULTS: Estimated net benefit (+), cfs, for selected options, compared to user-defined monthly incremental flow targets. For months exhibiting a positive net benefit, the unsatisfied portion of the incremental flow target is shaded in red. For months with negative net benefit, the unsatisfied target flow is represented by the total of the red and blue areas.





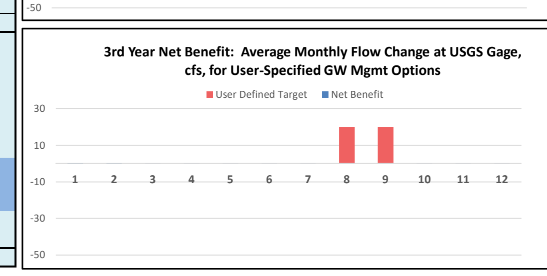


Figure 7. Option D, Reduced Groundwater Pumping, Net Flow Benefit from IGMA Estimator

PRELIMINARY DRAFT

12/30/2016

Screening-Level Estimates of Flow Accretion to Scott River from Hypothetical Groundwater Management Options

Normal-Dry Conditions

OBJECTIVE

This workbook assembles simulation results for hypothetical groundwater management actions, focusing on the incremental increase or decrease in flow of the Scott River and tributaries associated with the hypothetical action. These results are assembled solely as screening-level estimates to assist in developing packages of actions that may be of interest for further evaluation. Additional evaluation may refine scenario assumptions or evaluate the actions under a different range of conditions. This sheet provides a summary of flow accretion estimates associated with seven hypothetical groundwater management actions. Subsequent sheets provide additional information and summary tables relating to the individual, preliminary, groundwater management simulations.

Notes/Disclaimers:

1. Under lower flow conditions than assumed for this exercise, flow accretion may be delayed beyond the month shown; i.e., the summer/fall monthly benefit may be overestimated.
2. The interactive screening-level approach evaluates a range of inputs for given actions; however, the estimate is most representative at the simulated (base) value.
3. The options have not been vetted with respect to land ownership, feasibility, permitting or environmental/flow impacts below Young's Dam.
4. Flow benefits may occur to specific Scott River reaches, tributaries, or some combination; the benefiting reaches vary among options; see simulation details.
5. Canal loss associated with surface water delivered replacing groundwater (Options A1, A2) is neglected; canal loss associated with winter recharge (Option B) is neglected. Identification and routing of losses that may occur is deferred to a more detailed analysis phase.
6. Estimated impacts of Options A1, A2, and B are provided for a 36-month period following the initiation of actions; it is assumed that the action is applied in each of the 3 years.
7. The estimated impacts of Options C (1, 2, 3) are provided for 36-months; it is assumed this action is implemented in and only benefits the 1st year, although lagged stream depletion continues.
8. The estimated benefits of Option D assume permanent reduction of selected irrigated lands, distributed uniformly, per scenario detail described separately.
9. Table 1 (separate sheet) identifies diversions associated with management actions and direct augmentation.
10. Table 2 (separate sheet) shows estimated Scott River accretion or depletion from simulated (base) groundwater management options. This table is provided for reference.
11. Details concerning this screening-level analysis and assumptions, separately provided, should be reviewed prior to using the ***Interactive Groundwater Management Estimator***
12. It may not be possible to simultaneously implement all of the options as identified; evaluation of multi-option packages may require special handling.

INTERACTIVE GROUNDWATER MANAGEMENT ACCRETION ESTIMATOR

INSTRUCTIONS

*******WARNING: Do not change any spreadsheet entries except those highlighted yellow*******

The ***Interactive Groundwater Management Accretion Estimator*** modifies the net benefit of combined selected groundwater management actions based on user input:

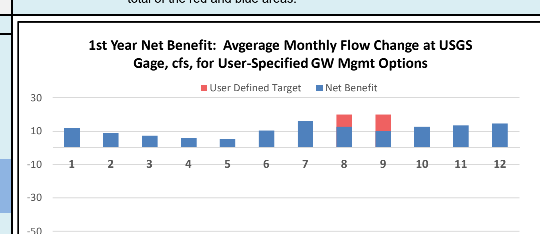
* Set incremental flow targets, for months of concern, in table at right. These are desired incremental flows above the expected flow condition at USGS gage Scott River near Ft. Jones.
* Activate the hypothetical options using a value of "1" for ON, and a value of "0" for OFF; change the value and hit *Enter* on the keyboard.
* Move the slider bars (in yellow) within the range of 50 - 150% to modify the base value for actions under each option. (The new base value and multiplier % is displayed above the slider bar).
* *Net Benefit* to the flow of the Scott River at the approximate location of the USGS gage is shown in blue shaded area of the table and on corresponding charts.
* To include a hypothetical *Off-Channel Storage Option* , enter vaues as follows:
  - Input percent consumptive loss for off-channel storage: 10 %
  - Input base value diversion for months of January - April for off-channel storage Option E, to be returned to channel in July-October, minus consumptive loss. 0 cfs
* Option E is set up as a placeholder for an additional option; not activated in this version.

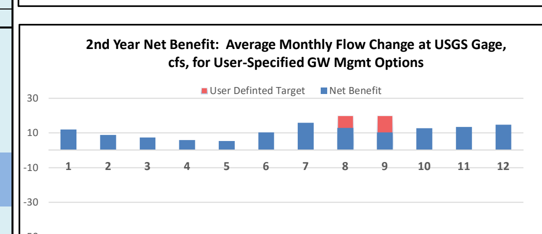
Target Flow Increase, cfs	
January	
February	
March	
April	
May	
June	
July	
August	20
September	20
October	
November	
December	

OPTION:	A1	A2	B	C1	C2	C3	D	E	Combined Accretion (+) and Depletion (-)	Incremental Diversion (-) or Augmentation (+)	Net Benefit
	Delayed GW Pumping, North of Ft. Jones (May, June)	Delayed GW Pumping, South of Ft. Jones (May, June)	Winter Recharge (Jan, Feb, Mar)	Augmentation Wellfield, Example 1, Hamlin	Augmentation Wellfield, Example 2, Shell	Augmentation Wellfield, Example 3, Heartstrand	Reduced GW Pumping, Distributed	Other, tbd	Adjusted Options Combined	Adjusted Options Combined (Table 1)	Increase (+) in Flow at USGS Gage (see charts)
On (1)/Off(0)	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**			
Base Action, cfs, average over affected months	7.1	19.4	28.0	6.0	2.0	4.0	10.8	0.0			
Multiplier, %	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**			
Adjusted Action, cfs	0.0	19.4	28.0	6.0	2.0	4.0	10.8	0.0			
Slide to Change % Multiplier Applied to Base Management Action, range 50 to 150%											

RESULTS: Estimated net benefit (+), cfs, for selected options, compared to user-defined monthly incremental flow targets. For months exhibiting a positive net benefit, the unsatisfied portion of the incremental flow target is shaded in red. For months with negative net benefit, the unsatisfied target flow is represented by the total of the red and blue areas.

Year	Month	A1	A2	B	C1	C2	C3	D	E	Combined	cfs	cfs
		Adjusted Accretion (+) or Depletion (-) affecting Scott River flow above USGS gage, cfs										
1	January	0.0	0.0	0.0	0.0	0.0	0.0	11.9	0.0	11.9	0	**11.9**
	February	0.0	0.0	0.0	0.0	0.0	0.0	8.8	0.0	8.8	0	**8.8**
	March	0.0	0.0	0.0	0.0	0.0	0.0	7.2	0.0	7.2	0	**7.2**
	April	0.0	0.0	0.0	0.0	0.0	0.0	5.8	0.0	5.8	0	**5.8**
	May	0.0	0.0	0.0	0.0	0.0	0.0	5.3	0.0	5.3	0	**5.3**
	June	0.0	0.0	0.0	0.0	0.0	0.0	10.3	0.0	10.3	0.0	**10.3**
	July	0.0	0.0	0.0	0.0	0.0	0.0	15.9	0.0	15.9	0	**15.9**
	August	0.0	0.0	0.0	0.0	0.0	0.0	12.8	0.0	12.8	0	**12.8**
	September	0.0	0.0	0.0	0.0	0.0	0.0	10.3	0.0	10.3	0	**10.3**
	October	0.0	0.0	0.0	0.0	0.0	0.0	12.7	0.0	12.7	0	**12.7**
	November	0.0	0.0	0.0	0.0	0.0	0.0	13.4	0.0	13.4	0	**13.4**
	December	0.0	0.0	0.0	0.0	0.0	0.0	14.7	0.0	14.7	0	**14.7**
	AVERAGE	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**10.7**	**0.0**	**10.7**	**0.0**	10.7
2	January	0.0	0.0	0.0	0.0	0.0	0.0	11.9	0.0	11.9	0	**11.9**
	February	0.0	0.0	0.0	0.0	0.0	0.0	8.8	0.0	8.8	0	**8.8**
	March	0.0	0.0	0.0	0.0	0.0	0.0	7.2	0.0	7.2	0	**7.2**
	April	0.0	0.0	0.0	0.0	0.0	0.0	5.8	0.0	5.8	0	**5.8**
	May	0.0	0.0	0.0	0.0	0.0	0.0	5.3	0.0	5.3	0	**5.3**
	June	0.0	0.0	0.0	0.0	0.0	0.0	10.3	0.0	10.3	0.0	**10.3**
	July	0.0	0.0	0.0	0.0	0.0	0.0	15.9	0.0	15.9	0	**15.9**
	August	0.0	0.0	0.0	0.0	0.0	0.0	12.8	0.0	12.8	0.0	**12.8**
	September	0.0	0.0	0.0	0.0	0.0	0.0	10.3	0.0	10.3	0.0	**10.3**
	October	0.0	0.0	0.0	0.0	0.0	0.0	12.7	0.0	12.7	0.0	**12.7**
	November	0.0	0.0	0.0	0.0	0.0	0.0	13.4	0.0	13.4	0.0	**13.4**
	December	0.0	0.0	0.0	0.0	0.0	0.0	14.7	0.0	14.7	0.0	**14.7**
	AVERAGE	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**10.7**	**0.0**	**10.7**	**0.0**	10.7
3	January	0.0	0.0	0.0	0.0	0.0	0.0	11.9	0.0	11.9	0	**11.9**
	February	0.0	0.0	0.0	0.0	0.0	0.0	8.5	0.0	8.5	0	**8.5**
	March	0.0	0.0	0.0	0.0	0.0	0.0	7.2	0.0	7.2	0	**7.2**
	April	0.0	0.0	0.0	0.0	0.0	0.0	5.8	0.0	5.8	0	**5.8**
	May	0.0	0.0	0.0	0.0	0.0	0.0	5.3	0.0	5.3	0	**5.3**
	June	0.0	0.0	0.0	0.0	0.0	0.0	10.3	0.0	10.3	0.0	**10.3**
	July	0.0	0.0	0.0	0.0	0.0	0.0	15.9	0.0	15.9	0	**15.9**
	August	0.0	0.0	0.0	0.0	0.0	0.0	12.8	0.0	12.8	0	**12.8**
	September	0.0	0.0	0.0	0.0	0.0	0.0	10.3	0.0	10.3	0	**10.3**
	October	0.0	0.0	0.0	0.0	0.0	0.0	12.7	0.0	12.7	0	**12.7**
	November	0.0	0.0	0.0	0.0	0.0	0.0	13.4	0.0	13.4	0	**13.4**
	December	0.0	0.0	0.0	0.0	0.0	0.0	14.7	0.0	14.7	0	**14.7**
	YEAR AVERAGE	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**10.7**	**0.0**	**10.7**	**0.0**	10.7





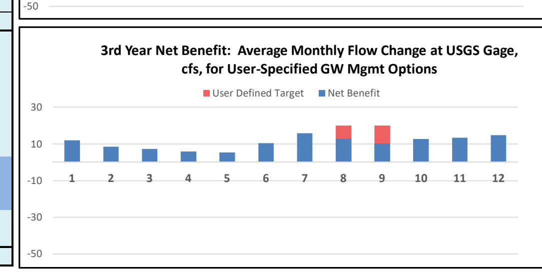


Figure 8. Options A, B, C and D Combined, Net Flow Benefit from IGMA Estimator

PRELIMINARY DRAFT

12/30/2016

Screening-Level Estimates of Flow Accretion to Scott River from Hypothetical Groundwater Management Options

Normal-Dry Conditions

OBJECTIVE

This workbook assembles simulation results for hypothetical groundwater management actions, focusing on the incremental increase or decrease in flow of the Scott River and tributaries associated with the hypothetical action.   These results are assembled solely as screening-level estimates to assist in developing packages of actions that may be of interest for further evaluation.   Additional evaluation may refine scenario assumptions or evaluate the actions under a different range of conditions. This sheet provides a summary of flow accretion estimates associated with seven hypothetical groundwater management actions. Subsequent sheets provide additional information and summary tables relating to the individual, preliminary, groundwater management simulations.

Notes/Disclaimers:

1. Under lower flow conditions than assumed for this exercise, flow accretion may be delayed beyond the month shown; i.e., the summer/fall monthly benefit may be overestimated.
2. The interactive screening-level approach evaluates a range of inputs for given actions; however, the estimate is most representative at the simulated (base) value.
3. The options have not been vetted with respect to land ownership, feasibility, permitting or environmental/flow impacts below Young's Dam.
4. Flow benefits may occur to specific Scott River reaches, tributaries, or some combination; the benefiting reaches vary among options; see simulation details.
5. Canal loss associated with surface water delivered replacing groundwater (Options A1, A2) is neglected; canal loss associated with winter recharge (Option B) is neglected. Identification and routing of losses that may occur is deferred to a more detailed analysis phase.
6. Estimated impacts of Options A1, A2, and B are provided for a 36-month period following the initiation of actions; it is assumed that the action is applied in each of the 3 years.
7. The estimated impacts of Options C (1, 2, 3) are provided for 36-months; it is assumed this action is implemented in and only benefits the 1st year, although lagged stream depletion continues.
8. The estimated benefits of Option D assume permanent reduction of selected irrigated lands, distributed uniformly, per scenario detail described separately.
9. Table 1 (separate sheet) identifies diversions associated with management actions and direct augmentation.
10. Table 2 (separate sheet) shows estimated Scott River accretion or depletion from simulated (base) groundwater management options. This table is provided for reference.
11. Details concerning this screening-level analysis and assumptions, separately provided, should be reviewed prior to using the ***Interactive Groundwater Management Estimator***
12. It may not be possible to simultaneously implement all of the options as identified; evaluation of multi-option packages may require special handling.

INTERACTIVE GROUNDWATER MANAGEMENT ACCRETION ESTIMATOR

INSTRUCTIONS

*******WARNING: Do not change any spreadsheet entries except those highlighted yellow*******

The ***Interactive Groundwater Management Accretion Estimator*** modifies the net benefit of combined selected groundwater management actions based on user input:

* Set incremental flow targets, for months of concern, in table at right. These are desired incremental flows above the expected flow condition at USGS gage Scott River near Ft. Jones.
* Activate the hypothetical options using a value of "1" for ON, and a value of "0" for OFF; change the value and hit *Enter* on the keyboard.
* Move the slider bars (in yellow) within the range of 50 - 150% to modify the base value for actions under each option.   (The new base value and multiplier % is displayed above the slider bar).
* *Net Benefit* to the flow of the Scott River at the approximate location of the USGS gage is shown in blue shaded area of the table and on corresponding charts.
* To include a hypothetical *Off-Channel Storage Option* , enter vaues as follows:
  - Input percent consumptive loss for off-channel storage: 10 %
  - Input base value diversion for months of January - April for off-channel storage Option E, to be returned to channel in July-October, minus consumptive loss. 0 cfs
* Option E is set up as a placeholder for an additional option; not activated in this version.

Target Flow Increase, cfs	
January	
February	
March	
April	
May	
June	
July	
August	20
September	20
October	
November	
December	

OPTION:	A1	A2	B	C1	C2	C3	D	E	Combined Accretion (+) and Depletion (-)	Incremental Diversion (-) or Augmentation (+)	Net Benefit
	Delayed GW Pumping, North of Ft. Jones (May, June)	Delayed GW Pumping, South of Ft. Jones (May, June)	Winter Recharge (Jan, Feb, Mar)	Augmentation Wellfield, Example 1, Hamlin	Augmentation Wellfield, Example 2, Shell	Augmentation Wellfield, Example 3, Heartstrand	Reduced GW Pumping, Distributed	Other, tbd	Adjusted Options Combined	Adjusted Options Combined (Table 1)	Increase (+) in Flow at USGS Gage (see charts)
On (1)/Off(0)	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**0**			
Base Action, cfs, average over affected months	7.1	19.4	28.0	6.0	2.0	4.0	10.8	0.0			
Multiplier, %	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**			
Adjusted Action, cfs	7.1	19.4	28.0	6.0	2.0	4.0	10.8	0.0			
Slide to Change % Multiplier Applied to Base Management Action, range 50 to 150%											

RESULTS: Estimated net benefit (+), cfs, for selected options, compared to user-defined monthly incremental flow targets. For months exhibiting a positive net benefit, the unsatisfied portion of the incremental flow target is shaded in red. For months with negative net benefit, the unsatisfied target flow is represented by the total of the red and blue areas.

Year	Month	A1	A2	B	C1	C2	C3	D	E	Combined	Incremental Diversion/Augmentation, cfs	Net Benefit, cfs
		Adjusted Accretion (+) or Depletion (-) affecting Scott River flow above USGS gage, cfs									cfs	cfs
1	January	0.0	0.0	0.9	0.0	0.0	0.0	11.9	0.0	12.8	-28	**-15.2**
	February	0.0	0.0	3.5	0.0	0.0	0.0	8.8	0.0	12.3	-28	**-15.7**
	March	0.0	0.0	6.4	0.0	0.0	0.0	7.2	0.0	13.6	-28	**-14.4**
	April	0.0	0.0	8.1	0.0	0.0	0.0	5.8	0.0	13.9	0	**13.9**
	May	0.8	1.8	7.8	0.0	0.0	0.0	5.3	0.0	15.6	-8.75	**6.9**
	June	4.3	8.4	5.9	0.0	0.0	0.0	10.3	0.0	28.9	-44.1	**-15.2**
	July	1.9	4.7	3.3	0.0	0.0	0.0	15.9	0.0	25.7	0	**25.7**
	August	0.7	2.0	1.9	-0.1	-0.1	-0.1	12.8	0.0	17.2	12	**29.2**
	September	0.5	1.8	1.8	-0.1	-0.2	-0.3	10.3	0.0	13.8	12	**25.8**
	October	0.9	2.0	2.9	-0.6	-0.4	-0.6	12.7	0.0	16.9	0	**16.9**
	November	0.6	2.4	3.7	-0.9	-0.5	-0.9	13.4	0.0	17.8	0	**17.8**
	December	0.5	2.8	4.3	-1.2	-0.6	-1.1	14.7	0.0	19.4	0	**19.4**
	AVERAGE	**0.9**	**2.1**	**4.2**	**-0.2**	**-0.2**	**-0.2**	**10.7**	**0.0**	**17.3**	**-9.4**	**7.9**
2	January	0.4	2.2	4.4	-1.1	-0.5	-0.8	11.9	0.0	16.5	-28	**-11.5**
	February	0.3	1.6	6.2	-0.9	-0.3	-0.6	8.8	0.0	15.1	-28	**-12.9**
	March	0.3	1.2	8.6	-0.7	-0.2	-0.5	7.2	0.0	15.9	-28	**-12.1**
	April	0.3	1.0	10.0	-0.6	-0.2	-0.4	5.8	0.0	15.8	0	**15.8**
	May	1.0	2.6	9.4	-0.5	-0.1	-0.3	5.3	0.0	17.3	-8.75	**8.6**
	June	4.5	9.0	7.2	-0.4	-0.1	-0.2	10.3	0.0	30.2	-44.1	**-13.9**
	July	2.0	5.0	4.1	-0.3	0.0	-0.1	15.9	0.0	26.5	0	**26.5**
	August	0.8	2.2	2.3	-0.1	0.0	-0.1	12.8	0.0	17.9	0.0	**17.9**
	September	0.6	2.0	2.3	-0.1	0.0	-0.1	10.3	0.0	15.0	0.0	**15.0**
	October	1.0	2.2	3.6	-0.3	0.0	-0.1	12.7	0.0	19.1	0.0	**19.1**
	November	0.8	2.8	4.6	-0.3	0.0	-0.1	13.4	0.0	21.0	0.0	**21.0**
	December	0.6	3.3	5.5	-0.4	-0.1	-0.2	14.7	0.0	23.4	0.0	**23.4**
	AVERAGE	**1.1**	**2.9**	**5.7**	**-0.5**	**-0.1**	**-0.3**	**10.7**	**0.0**	**19.5**	**-11.4**	**8.1**
3	January	0.5	2.5	5.4	-0.3	-0.1	-0.2	11.9	0.0	19.9	-28	**-8.1**
	February	0.4	1.9	7.1	-0.2	0.0	-0.1	8.5	0.0	17.4	-28	**-10.6**
	March	0.4	1.5	9.3	-0.2	0.0	-0.1	7.2	0.0	18.1	-28	**-9.9**
	April	0.3	1.2	10.6	-0.2	0.0	-0.1	5.8	0.0	17.6	0	**17.6**
	May	1.1	2.8	10.0	-0.1	0.0	-0.1	5.3	0.0	18.9	-8.75	**10.2**
	June	4.6	9.1	7.7	-0.1	0.0	-0.1	10.3	0.0	31.4	-44.1	**-12.7**
	July	2.1	5.0	4.4	-0.1	0.0	0.0	15.9	0.0	27.3	0	**27.3**
	August	0.9	2.3	2.5	0.0	0.0	0.0	12.8	0.0	18.3	0	**18.3**
	September	0.7	2.0	2.5	0.0	0.0	0.0	10.3	0.0	15.4	0	**15.4**
	October	1.0	2.3	3.8	-0.1	0.0	0.0	12.7	0.0	19.8	0	**19.8**
	November	0.8	2.9	5.0	-0.1	0.0	0.0	13.4	0.0	21.9	0	**21.9**
	December	0.7	3.4	6.0	-0.1	0.0	-0.1	14.7	0.0	24.5	0	**24.5**
	YEAR AVERAGE	**1.1**	**3.1**	**6.2**	**-0.1**	**0.0**	**-0.1**	**10.7**	**0.0**	**20.9**	**-11.4**	**9.5**