Luhdorff & Scalmanini
Consulting Engineers

electronic submittal

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Technical Memorandum

DATE: February 5, 2020 PROJECT: 10-1-074

TO: Mr. Jason Smith, Teichert Aggregates (JSmith@teichert.com)

FROM: Till Angermann, Principal Hydrogeologist
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SUBJECT: SUPPLEMENTAL ANALYSIS OF GROUNDWATER CONDITIONS, PLANNED MINING AND RECLAMATION ACTIVITIES, SHIFLER PROPERTY, WOODLAND, YOLO COUNTY

Background

Per your request, Luhdorff & Scalmanini Consulting Engineers (LSCE) conducted additional analyses supplementing previous modeling efforts (MODFLOW) that investigated potential effects of planned initial mining activities and advanced mining activities[1] on groundwater resources in the vicinity of Teichert's Shifler property (LSCE 2016 and 2019). In a December 5, 2019 stakeholder meeting, two concerns were voiced. The first concern pertains to potential effects of the planned mining and reclamation activities on groundwater levels and quality in water production wells of the Wild Wings community that supply water for domestic and community landscaping use. The previous modeling efforts of LSCE did not include groundwater extraction from the Wild Wings community wells because they are located outside of the County specified radii of influence for model analyses (i.e., 1,000 and 500 feet from wet pit boundaries for water level and water quality concerns, respectively). The second concern pertains to the comparability of two different laboratory analytical methods used for groundwater quality testing at the Wild Wings community and at the Teichert Woodland properties in Teichert's long-term monitoring effort.

Regarding both concerns, the Wild Wings community has two productions wells, Pintail and Canvas Back (**Figure 1**). Of those, the Canvas Back well is closer to the Shifler property, approximately 1,150 feet from the planned western mining boundary. The well extends to a depth of 425 feet below ground surface (bgs) and the well screen resides between 364 to 415 feet (bgs). For model analyses, this well production is simulated from Layer 3 of the model. The

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[1] These are Scenarios 1 and 2, respectively, see description under *Methods*.

Pintail well is significantly deeper than the Canvas Back well with well screens extending from 935 to 992 and from 1021 to 1061 feet (bgs). This well produces groundwater from aquifer zones far below the base of model domain (580 feet, bgs). Both wells produce groundwater with total arsenic concentrations that have been gradually increasing, such that operation of the Canvas Back well ceased in 2019 due to concentrations exceeding arsenic's Maximum Contaminant Level (MCL) for regulated drinking water contaminants in California (10 μg/L). Arsenic concentrations in the Pintail well have been approaching, but remain below, the MCL. As a result of proximity and construction, potential effects from mining and reclamation activities would first manifest in the Canvas Back well. Therefore, regarding the first concern, model analysis was conducted focusing on predicted effects on the Canvas Back well. For comparison, mining and reclamation activities are planned to occur in the aggregate materials of Layer 1 of the model. Teichert's main production well (i.e., Teichert plant well) is completed in model Layer 3. Regarding the second concern, LSCE consulted with the laboratory director of California Laboratory Services (CLS), Dr. James Liang about descriptions and comparison of analytical methods for arsenic in water (personal communication, J. Liang, CLS, December 10, 2019).

Methods for Model Analysis

The analysis provided herein follows several lines of investigation to examine potential effects of planned mining and reclamation activities on groundwater levels and quality in the Canvas Back well. It also revisits mining pit water budgets and the model domain water budget to ascertain mutual interference between mining/reclamation activities and operation of the Canvas Back well. Specifically, this document provides:

1. Comparison of simulated versus observed head for the calibrated Baseline Model (i) without Canvas Back extraction and (ii) with Canvas Back extraction at 125 gallons per minute (gpm)
2. Comparison of mining pit water budgets (volumetric flow rates and water level elevations)
3. Comparison of model domain water budgets (volumetric flow rates)
4. Proportional sources of Canvas Back well extraction
5. Canvas Back well particle tracking analysis

The Canvas Back well extraction rate of 125 gpm is a steady-state model rate based on available well production data provided by Wild Wings representatives. Specifically, the well produced a total of 58, 62, and 69 million gallons per year (MGY) in years 2011, 2012, and 2013, respectively. Most recently, total well production was about 65 MGY in 2018 and was "on-track" for 65 MGY in 2019 (until ceasing production in September). From these production data, a typical annual production was designated as 65 MGY. The model rate of 125 gpm then derives from this typical annual production, with 65 MGY converted to an average 125 gpm continuously produced for 60 minutes per hour, 24 hours per day, every day of the year into the future. Given the pump operating capacity of about 1,380 gpm, and typical annual production of 65 MGY, then it appears the pump has been operated on average 2 to 2.5 hours per day.

The fate of all extraction was assumed to be consumptive use (i.e., no return flows to groundwater). In practice, a portion of the extracted water applied to landscaping (e.g. irrigation for Wild Wings golf course and residential landscaping) returns to groundwater via deep percolation. Attribution of all groundwater extraction to consumptive use p rovides "worst-case" scenarios predicting maximum potential impacts.

To facilitate comparison to the predictive model scenarios presented in LSCE (2019), the same terminology is used herein. Specifically, mining activities are examined with Scenarios A, B, and AB, where

- "A" denotes that all water used for aggregate processing and dust control is obtained directly from the active mining pit,
- "B" denotes that 50% of this supply is obtained from the active mining pit and 50% is provided by the on-site production well (Teichert plant well), and
- "AB" denotes that all water supply is derived from the Teichert plant well.

Scenario 1 pertains to the initial mining phase (only the west portion of Shifler property is mined) and Scenario 2 pertains to an advanced mining phase where the central portion of the Shifler property is actively mined and the west portion has been reclaimed to agricultural land.

Results

Calibration Check

Comparison of simulated versus observed heads from the original model calibration for Baseline conditions, which did not include extraction from the Canvas Back well, to a new calibration run including extraction from the Canvas Back well indicates almost indistinguishable results (**Figure 2**). Therefore, the model does not need to be recalibrated for the examinations herein.

Initial Mining Phase (Scenario 1)

Mining Pit Water Budget and Stage

Model results indicate that groundwater extraction at the Canvas Back well is too small to have a discernable effect on the mining pit water budget (**Figure 3**). This is expected due to the distant location of Canvas Back well (up- and crossgradient of the mining pit) and its pumping from a deeper aquifer horizon (Layer 3) compared with the mining pit (Layer 1). Water budget differences between Scenarios 1A, 1B, and 1AB are consistent with water sources. Specifically, Scenario 1A shows a small net negative mining pit water withdrawal consistent with the pit supplying 100% of water for plant operations. Scenario 1B shows a net positive withdrawal because groundwater extracted from the Teichert Plant well is discharged to the pit and, overall, more water is added to the pit than is removed in this scenario. Scenario 1AB shows a greater net positive withdrawl consistent with all water being supplied by the Teichert plant well and discharged to the mining pit. These operational differences also manifest themselves in the predicted wet pit stages (**Table 1**) with no significant elevation difference (0.1 ft) between the two cases (i.e., without and with Canvas Back well pumping) and mining pit water stage increases from A to AB.

Table 1: Mining pit water stage, initial mining phase (feet, NAVD88) † (from Table 1, LSCE, 2019)

Canvas Back Well Pumping	Scenario 1A	Scenario 1B	Scenario 1AB
Without Canvas Back Pumping	53.9 †	57.7 †	61.2
With Canvas Back Pumping at 125 gpm	53.8	57.6	61.1

Model Domain Water Budget and Sources of Pumped Groundwater

Quantitative evaluation of the model domain's water budget shows that pumping from the Canvas Back well is compensated by a decrease in groundwater outflow from the model domain (i.e., flow across lateral boundaries, **Figure 4**). This is supported by a detailed analysis of the source of groundwater extracted by the Canvas Back well, which suggests that 99% comes from lateral boundaries and 1% from Cache Creek (modeled as river package in MODFLOW) for Scenarios 1A, B, and AB, while none derives from the planned wet pit (**Figure 5**).

Consistent with the above, individual particle paths computed for Scenario 1AB show southeastern groundwater flow toward the Canvas Back well, identifying the upgradient lateral model domain boundary as the predominant source (**Figure 6**). The mining pit does not contribute any flow to the Canvas Back well.[2] Scenario 1AB constitutes the most aggressive scenario compared to the A and B Scenarios (source for plant water supply solely from the mining pit and split between pit and Teichert plant well, respectively) and Scenario 2 (increased distance to Canvas Back well because the active mining pit is farther east). Therefore, particle tracing analysis was only carried out for Scenario 1AB.

Advanced Mining Phase with Partial Reclamation (Scenario 2)

Mining Pit Water Budget and Stage

Model results indicate that groundwater extraction at the Canvas Back well is too small to have a discernable effect on the mining pit water budget for Scenarios 2A, 2B, and 2AB (**Figure 7**). This is expected because there were no discernable effects associated with Scenarios 1A, 1B, and 1AB and the mining pit under the advanced mining phase is farther away from the Canvas Back well. Water budget differences between Scenarios 2A, 2B, and 2AB are due to the same water source differences described for Scenario 1 above. As with Scenario 1, this result

[2] Model results suggest that even a 10-fold increase of the pumping rate at Canvas Back well (i.e., 1,250 gpm, 24/7/365) would not lead to the mining pit contributing any water to the well.

manifests itself in the predicted wet pit stages (**Table 2**) with no significant difference without or with the Canvas Back well pumping.

Table 2: Mining pit water stage, advanced mining phase (feet, NAVD88) † (from Table 2, LSCE, 2019)

Canvas Back Well Pumping	Scenario 2A	Scenario 2B	Scenario 2AB
Without Canvas Back Pumping	23.9 †	45.3 †	62.3
With Canvas Back Pumping at 125 gpm	23.8	45.2	62.2

Model Domain Water Budget and Sources of Pumped Groundwater

The Scenario 2 water budgets for the model domain are very similar to Scenario 1. Pumping from the Canvas Back well is compensated by a decrease in groundwater outflow from the model domain (**Figure 8**). Detailed analysis of the source of groundwater extracted by the Canvas Back well yields the same results as for Scenarios 1A, 1B, and 1AB (i.e., with no water derived from the planned wet pit, **Figure 9**).

Modeled Groundwater Level Effects at Canvas Back Well

Model results for Scenario 1A (without Canvas Back well) indicate a water level rise of 0.42 foot at the Canvas Back well over the Baseline scenario (**Table 3**). This is consistent with Figure 4c (LSCE 2019) and attributed to the change in water supply under this scenario (i.e., no plant well pumping; all water demand met by extraction from the mining pit). Scenario 1B results in a smaller water level rise (0.23 foot) at the Canvas Back well because only 50% of plant water demand is met by extraction from the mining pit (and 50% from the Teichert Plant well). Even Scenario 1AB indicates a slight water level increase despite the fact that Teichert plant well pumping is greater than during the Baseline scenario associated with the projected increased aggregate production. This result is attributed to the discharge of recycled groundwater to the wet pit, which is located between the Teichert plant well and the Wild Wings community. This causes groundwater mounding in Layer 1; and this signal appears, greatly moderated, in Layer 3.

Model results for Scenario 2A (without Canvas Back well) indicate a water level rise of 0.17 foot at the Canvas Back well. This is consistent with Figure 6c (LSCE 2019) and with the increased distance to the mining pit. Scenarios 2B and 2AB result in successively smaller water level rises at the Canvas Back well commensurate with the change in water supply.

Table 3: Water level effects on Canvas Back Well in feet

Scenario	A	B	AB
Scenario 1 minus Baseline	0.42	0.23	0.03
Scenario 2 minus Baseline	0.17	0.11	0.01

Comparison of Laboratory Analytical Methods for Arsenic

Arsenic analysis has been part of Teichert Aggregates' historical and ongoing long-term groundwater monitoring and reporting efforts at their properties along Cache Creek. Groundwater analyses are carried out by California Laboratory Services (CLS) in Rancho Cordova and the method of choice for arsenic has been EPA Method 6020/7000. The analytical reporting limit is 5.0 µg/L. This method is typically used in the context of groundwater and surface water studies including environmental assessment and cleanup. In contrast, for drinking water applications (e.g., municipal supply wells), EPA Method 200.8 is typically used. The analytical reporting limit is 2.0 µg/L.

Both methods are NIST certified (National Institute of Standards and Technology; www.nist.gov) and they produce the same results (i.e., same accuracy and precision) (J. Liang, December 10, 2019). This is an acceptance criterion for EPA. EPA's only acceptable difference for analytical methods quantifying the same constituent is the methods' sensitivity, as reflected by their reporting limit. The reporting limit of EPA Method 6020/7000 accounts for the potential of matrix interferences often associated with environmental studies due to the presence of multiple metals, high constituent concentrations, turbidity, and complex chemical makeup. In drinking water applications, such interferences are very rare, and in the absence of interferences, EPA Method 200.8 achieves a lower reporting limit. If interference is a concern, EPA Method 200.8 employs a dynamic reaction chamber (DRC) to improve results and must state so in the laboratory documentation. The DRC can also be used with EPA Method 6020/7000, but it need not state so in the laboratory documentation.

Summary

Concern 1 Detailed water level, water budget, and particle tracking analyses were conducted. The results indicate that Teichert's planned mining operations at the Shifler property will not cause any water level declines or water quality impacts at the Canvas Back well of the Wild Wings community. These findings are mainly attributed to (i) the well's upgradient location with respect to the Shifler property and (ii) it's completion in an aquifer zone that is deeper than the depth of the planned mining activities. These results were found to not be sensitive to the well's pumping rate. Even a 10-fold increase of the pumping rate at the Canvas Back well to 1,250 gpm (comparable to daily operation at capacity of approximately 22 hours, every day of the year) did not change these findings.

Concern 2 EPA Methods 6020/7000 and 200.8 for arsenic yield the same results (in accuracy and precision). The reporting limit of EPA Method 200.8 is lower (2.0 µg/L) because it is the standard for drinking water analysis where matrix interference is not expected. EPA Method 6020/7000 is the standard for environmental applications (such as at Teichert's Woodland properties), where the potential for matrix interferences is higher. This method is less sensitive, meaning that it cannot quantify arsenic concentrations below 5.0 µg/L.

Attached Figures

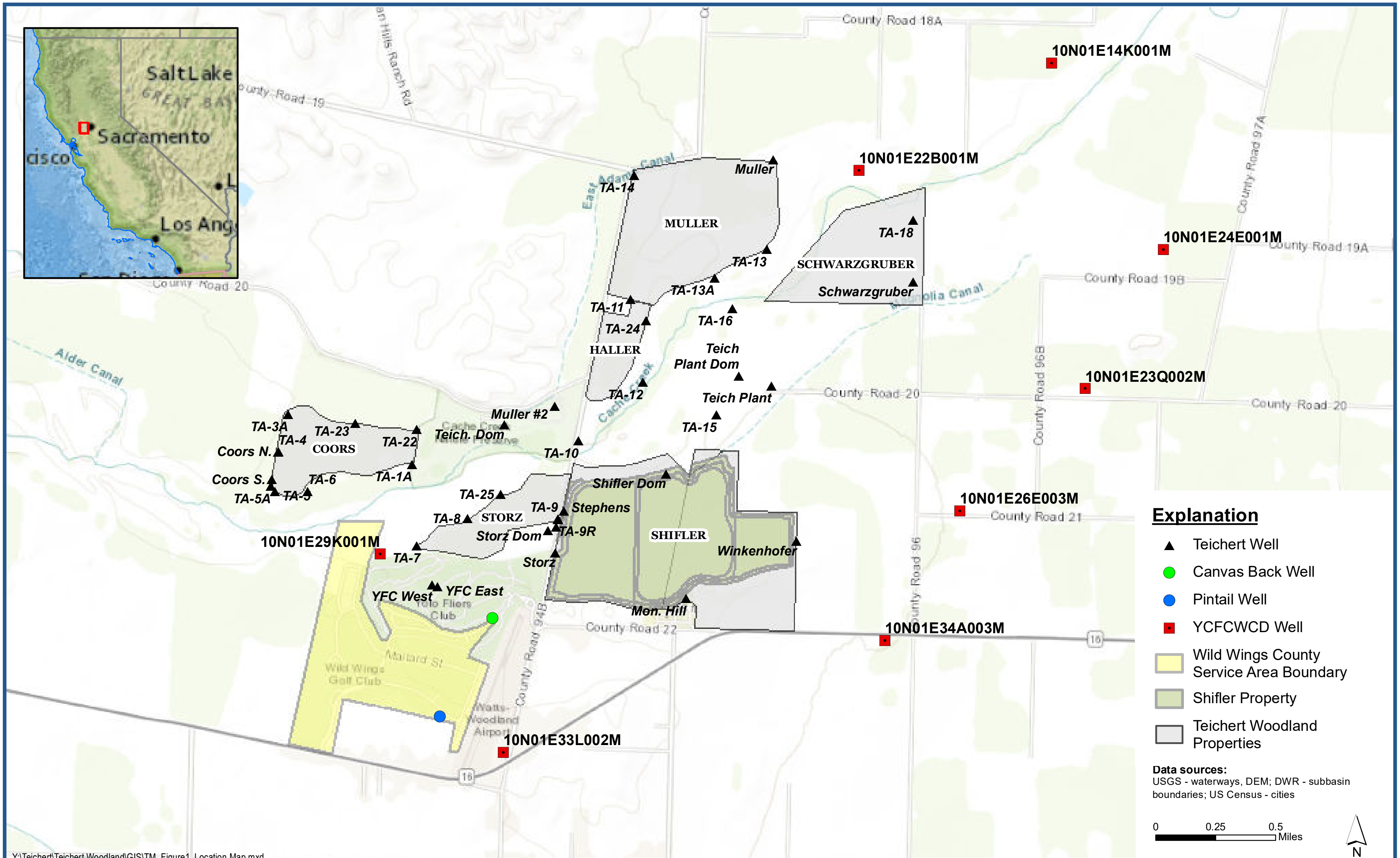
Figure 1	Location map
Figure 2	Baseline calibration, simulated versus observed head, without and with pumping from Canvas Back well
Figure 3	Mining pit water budgets, Scenarios 1A, 1B, and 1AB
Figure 4	Model domain water budgets, Scenarios 1A, 1B, and 1AB
Figure 5	Sources of Canvas Back well pumping, Scenarios 1A, 1B, and 1AB
Figure 6	Backward particle tracking, plan view, Scenario 1A
Figure 7	Mining pit water budgets, Scenarios 2A, 2B, and 2AB
Figure 8	Model domain water budgets, Scenarios 2A, 2B, and 2AB
Figure 9	Sources of Canvas Back well pumping, Scenarios 2A, 2B, and 2AB

References

Liang, J., CLS, December 10, 2019. Personal communication.

Luhdorff and Scalmanini Consulting Engineers. 2016. Groundwater conditions in the vicinity of planned wet pit mining operations, Shifler property. Report. February 8, 2016. LSCE file 10-1-074.

Luhdorff and Scalmanini Consulting Engineers. 2019. Groundwater conditions in the vicinity of planned wet pit mining operations, Shifler property, Woodland. Technical Memorandum. December 9, 2019. LSCE file 10-1-074.



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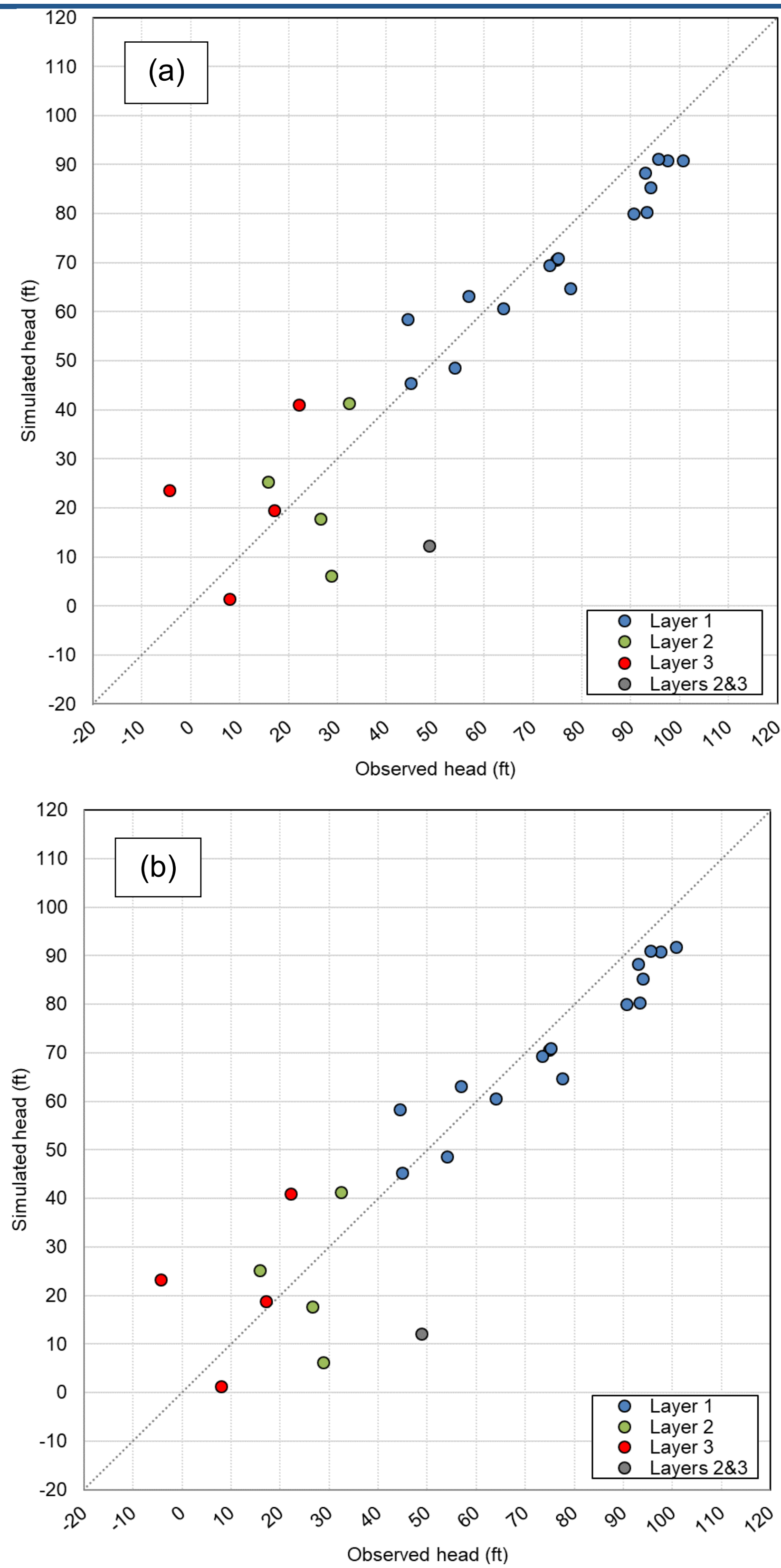
Location Map, Teichert Woodland

Teichert Aggregates/Woodland, Yolo County

Figure 1



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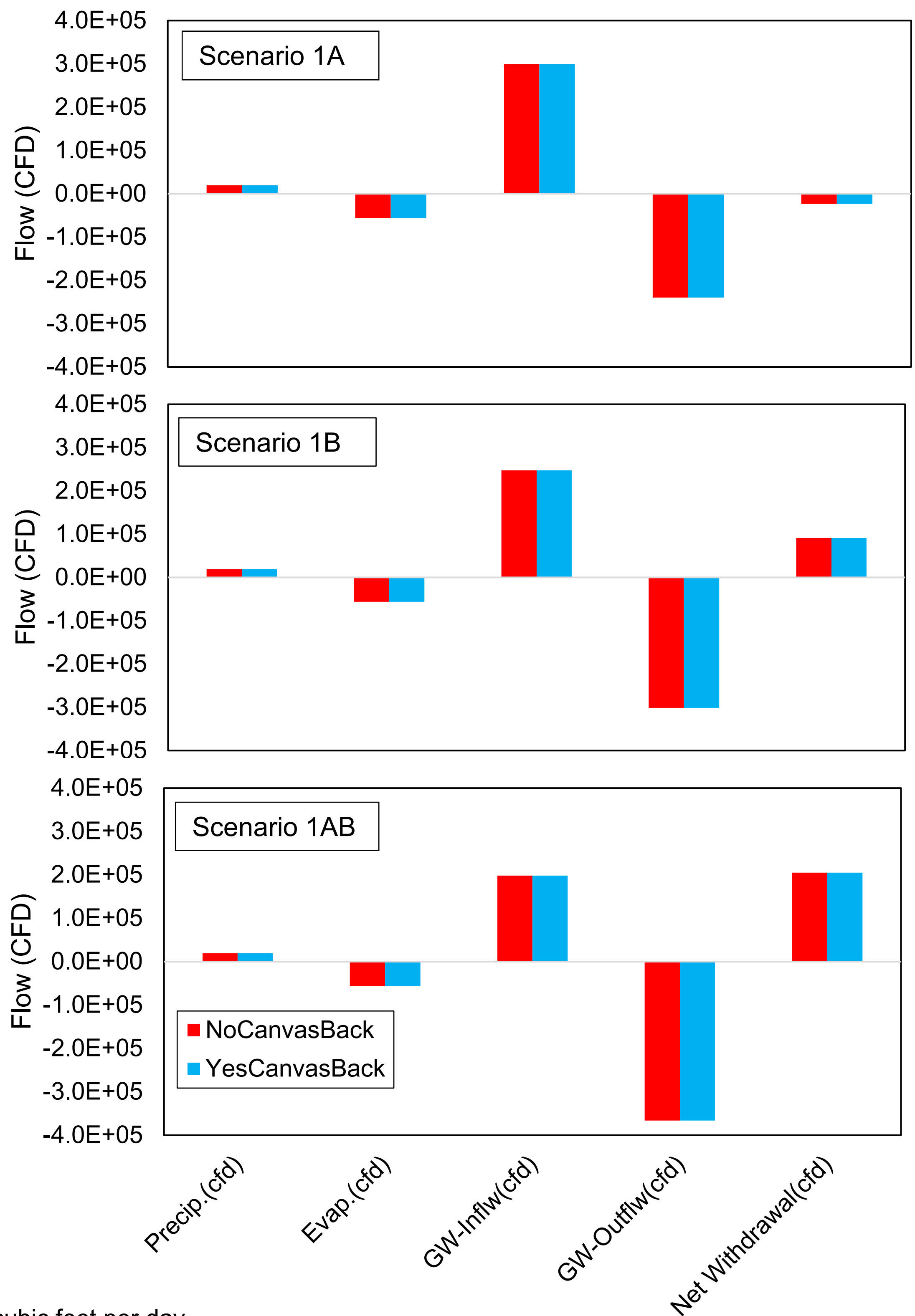
Baseline calibration, simulated versus observed head without (a) and with (b) pumping from Canvas Back well

Figure 2

Teichert Aggregates/Woodland, Yolo County



CFD = cubic feet per day

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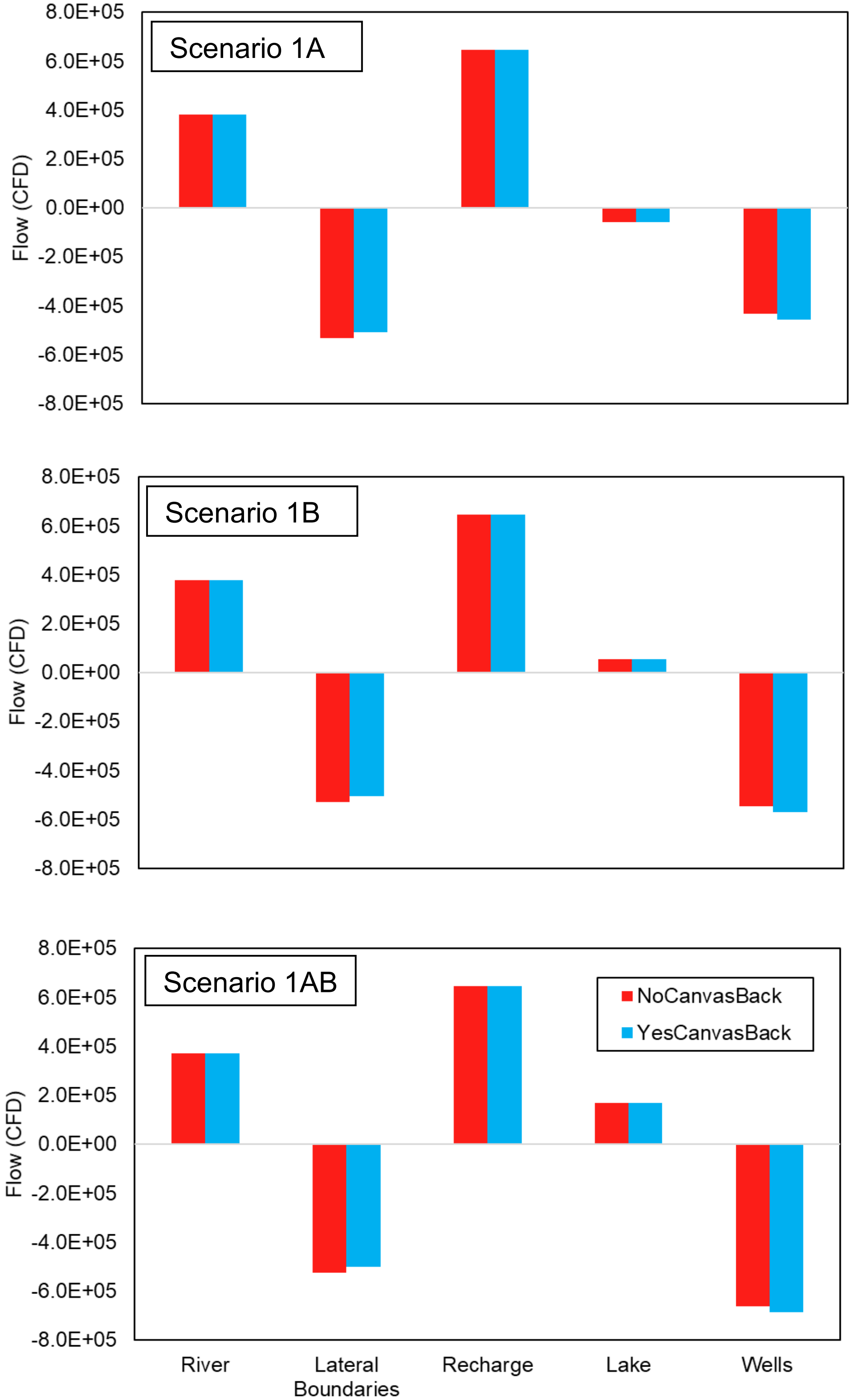
Mining pit water budgets, Scenarios 1A, 1B, and 1AB

Figure 3

Teichert Aggregates/Woodland, Yolo County



CFD = Cubic feet per day; Lake = planned wet pit

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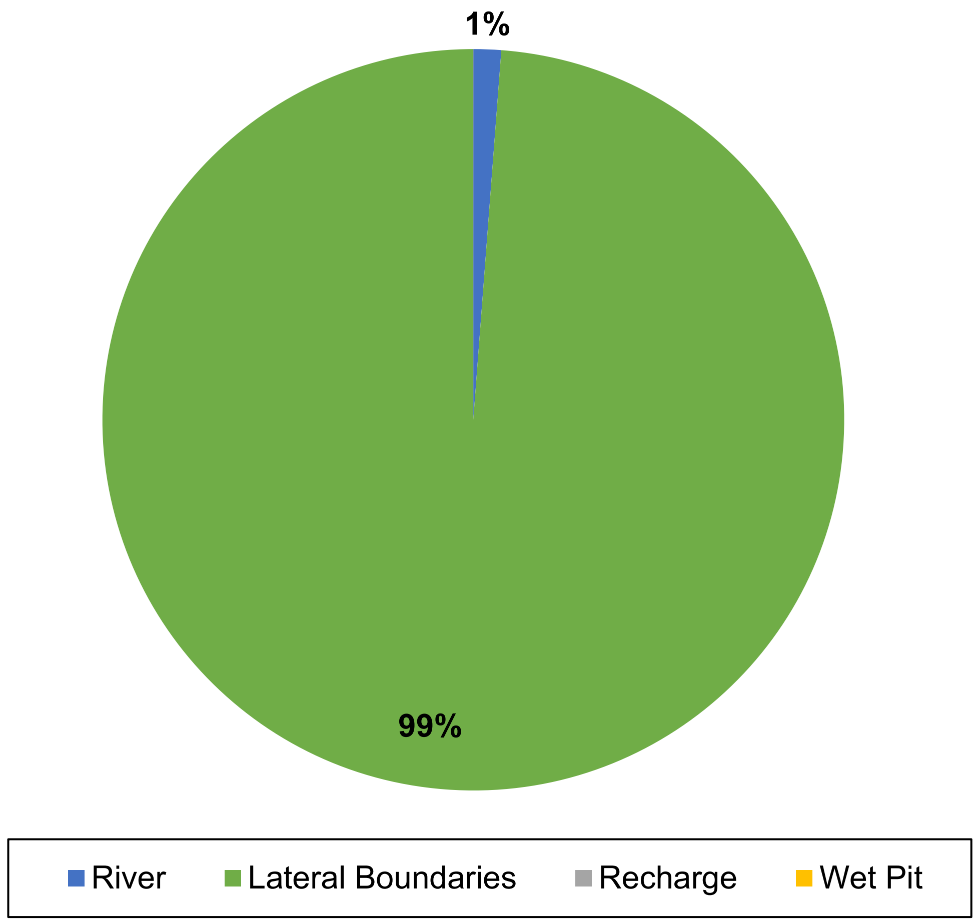
Model domain water budgets, Scenarios 1A, 1B, and 1AB

Teichert Aggregates/Woodland, Yolo County

Figure 4



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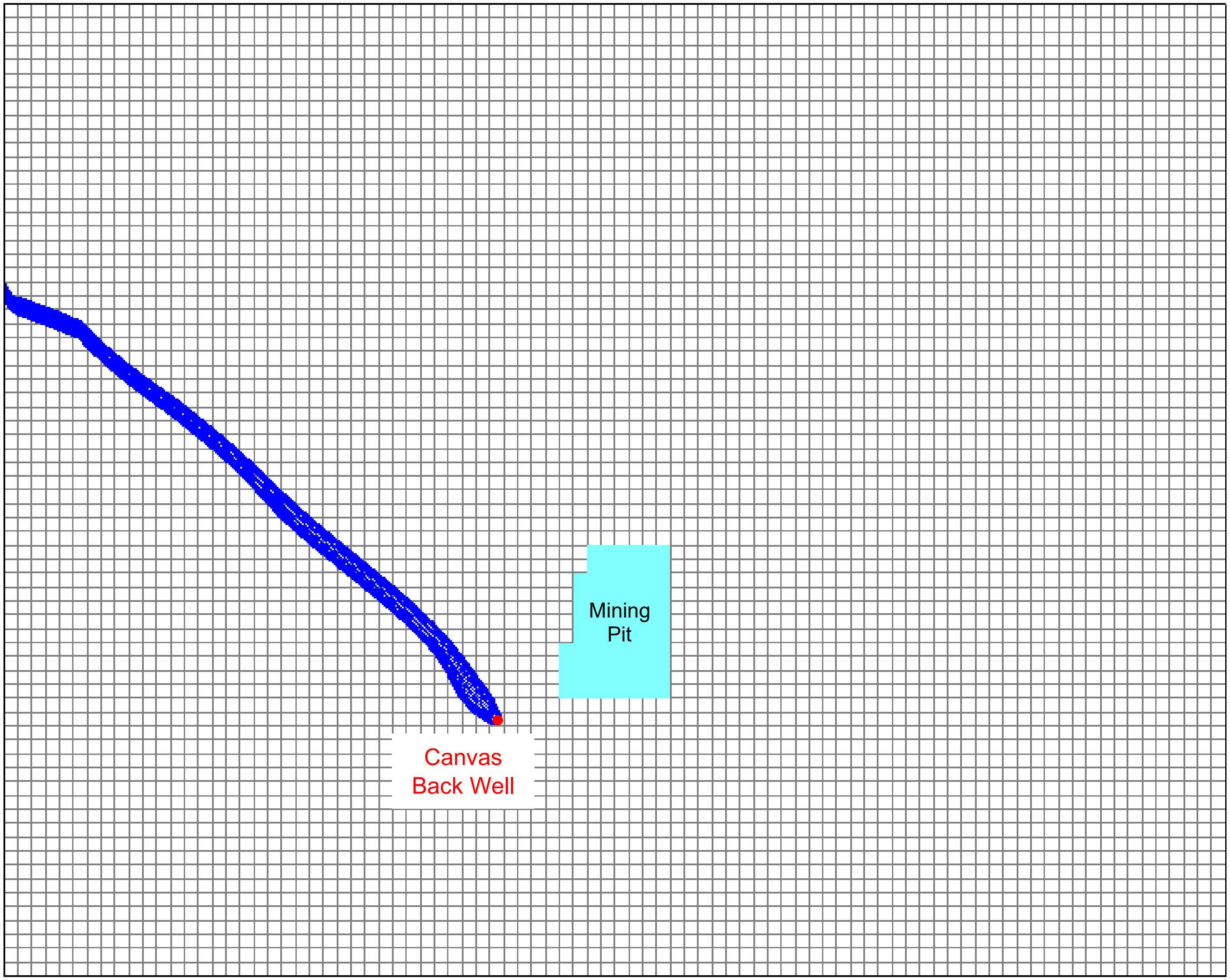
Sources of Canvas Back well pumping

Scenarios 1A, 1B, and 1AB

Teichert Aggregates/Woodland, Yolo County

Figure 5



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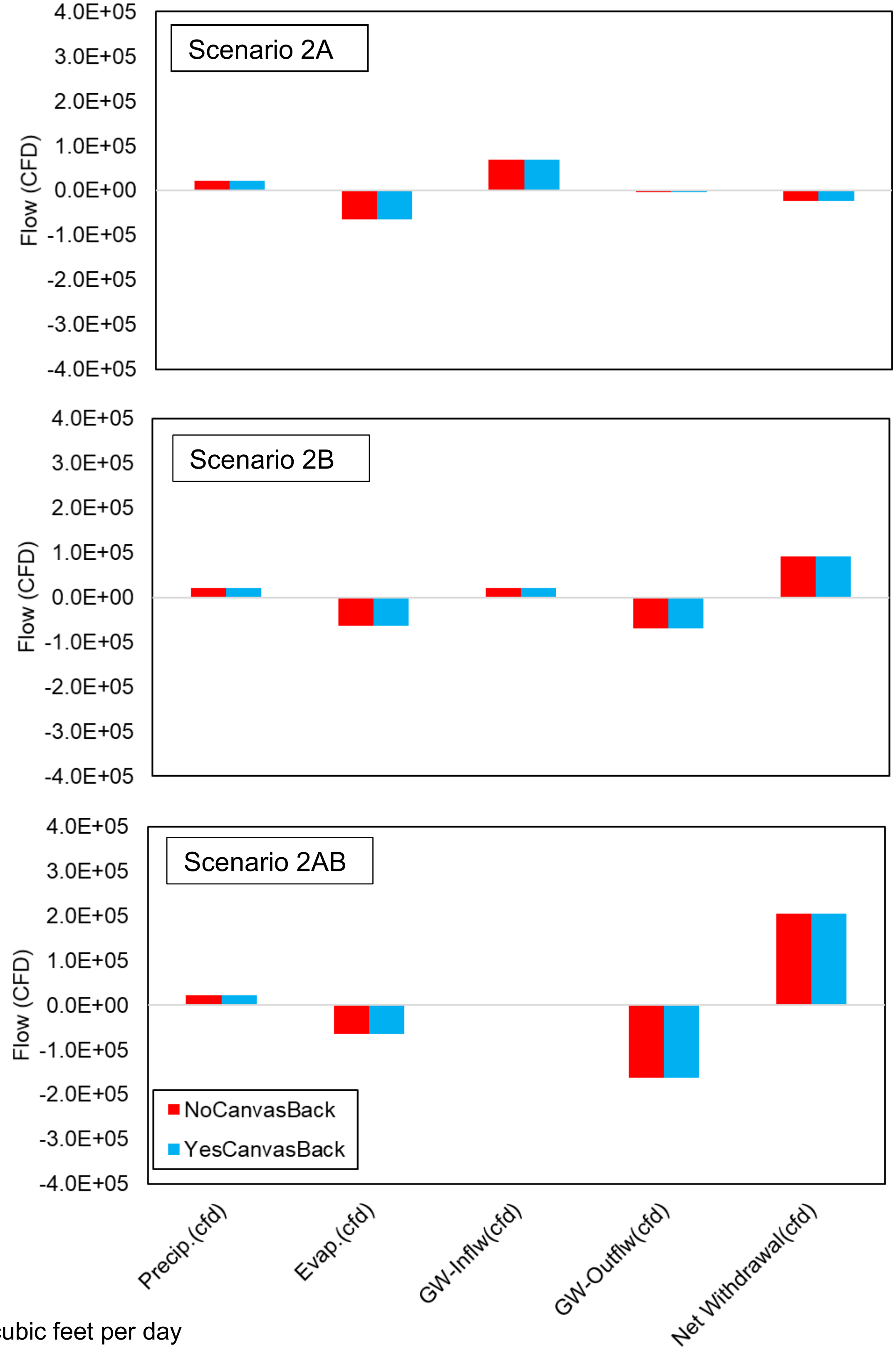
Backward particle tracking, plan view, Scenario 1AB
(Model grid dimension (250 ft by 250 ft))

Figure 6

Teichert Aggregates/Woodland, Yolo County



CFD = cubic feet per day

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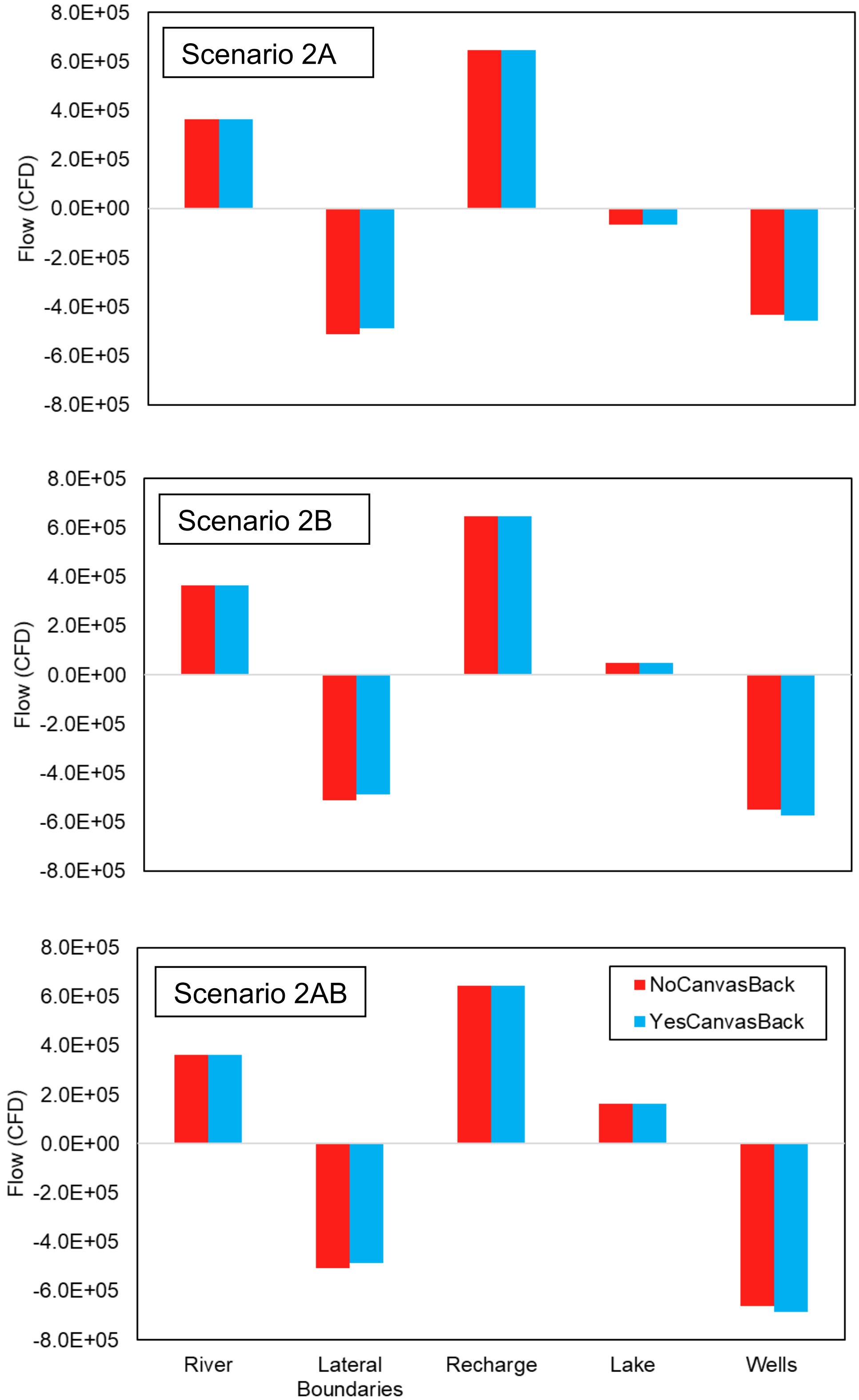
Mining pit water budgets, Scenarios 2A, 2B, and 2AB

Figure 7

Teichert Aggregates/Woodland, Yolo County



CFD = cubic feet per day; Lake = planned mining pit

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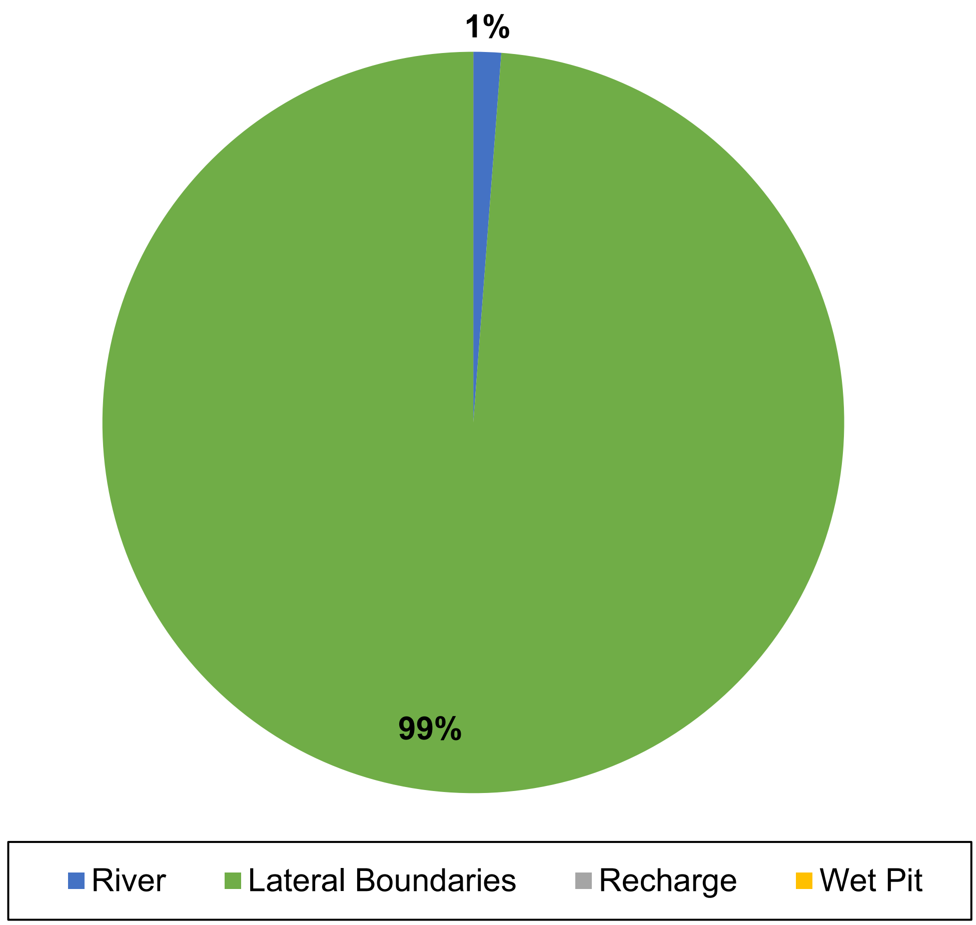
Model domain water budgets, Scenarios 2A, 2B, and 2AB

Teichert Aggregates/Woodland, Yolo County

Figure 8



Sources of Canvas Back well pumping

Scenarios 2A, 2B, and 2AB

Figure 9

Teichert Aggregates/Woodland, Yolo County

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