Groundwater Management District #5

Technical Assessment of City of Hays Water Transfer/

R9 Ranch Development Scenarios

and

Commentary on WaterPACK Analysis

BALLEAU GROUNDWATER, INC.

TECHNICAL ASSESSMENT

Inspection of Burns & McDonnell (BMcD) Analysis

- Background
- Setting
- Reproduction of scenarios

Comments on BMcD Analysis

1) Stream Stage Change/ Kinsley Gage
2) Stream routing/Elimination of local runoff
3) Control Volume Approach
4) Scenario 6 Drought Irrigation Stress
5) Stability Analysis/Sustainability

Comments on WaterPACK (Keller-Bliesner Engineering, LLC Analysis

- Overall result

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R9 RANCH SETTING

The Cities of Hays and Russell, Kansas purchased the R9 Ranch to potentially develop an alternative source of municipal water supply.

On February 20, 2018, GMD#5 provided Balleau Groundwater, Inc. (BGW) a Burns & McDonnell (BMcD) analysis of wellfield development at the R9 Ranch and the associated hydrologic effects on the surrounding aquifer.

Balleau Groundwater, Inc. (BGW) reviewed the BMcD analysis and developed this presentation to provide GMD#5 information to assess the change in water use.

R9 RANCH SETTING

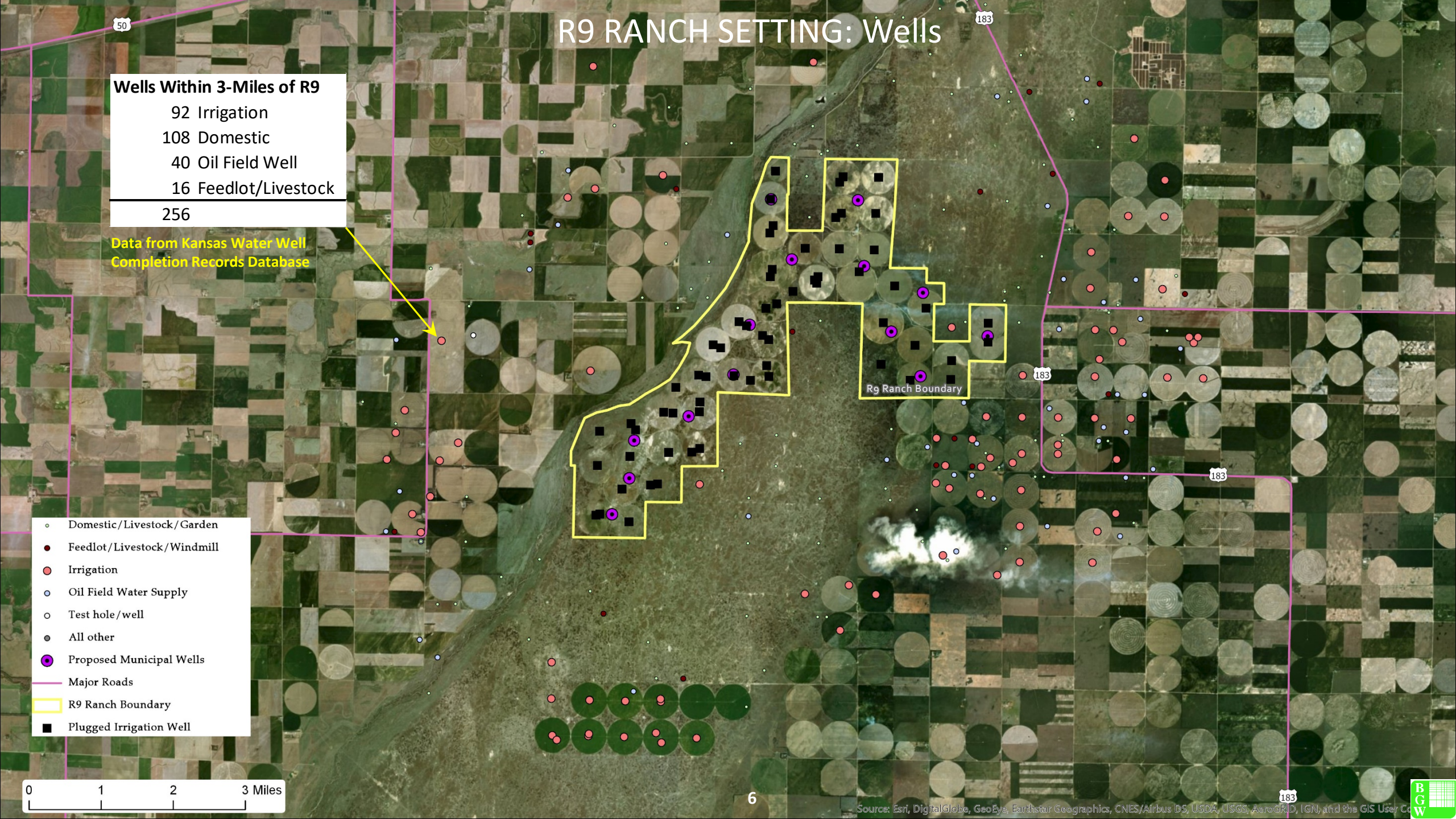
BMcD description of R9 Ranch water transfer (report dated Feb 13, 2018):

"The R9 Ranch covers approximately 6,900 acres and is located approximately five miles southeast of Kinsley, Kansas (Figure 1). The R9 Ranch has historically been used for irrigated agricultural purposes, such as growing corn, alfalfa, and soybeans. Irrigation was accomplished using 53 irrigation wells supplying water to 41 center-pivot irrigation areas. Perfected irrigation water rights on the R9 Ranch total 7,719 acre-feet per year. Change applications have been filed with the Kansas Department of Agriculture, Division of Water Resources (DWR) and the total quantity of water available for municipal use after DWR's reductions for consumptive use is 6,756.8 acre-feet per year."

R9 RANCH SETTING: Wells

Wells Within 3-Miles of R9	
92	Irrigation
108	Domestic
40	Oil Field Well
16	Feedlot/Livestock
256	

Data from Kansas Water Well Completion Records Database

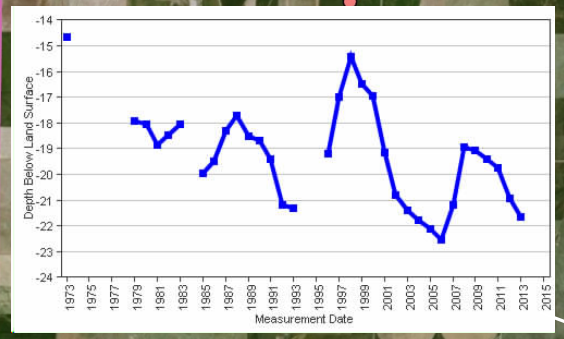


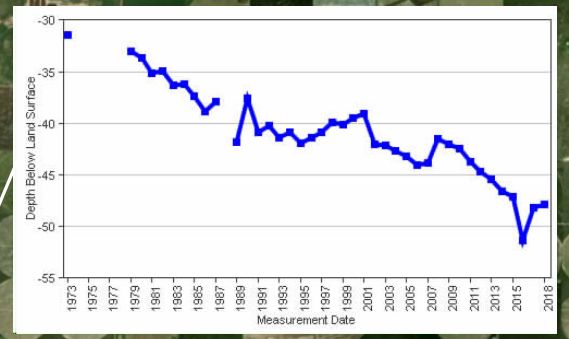
- Domestic/Livestock/Garden
- Feedlot/Livestock/Windmill
- Irrigation
- Oil Field Water Supply
- Test hole/well
- All other
- Proposed Municipal Wells
- Major Roads
- R9 Ranch Boundary
- Plugged Irrigation Well

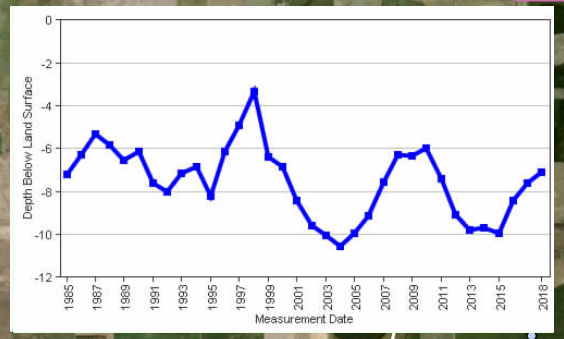
0 1 2 3 Miles

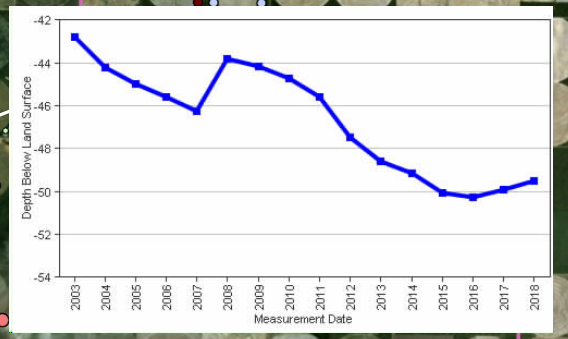
R9 RANCH SETTING: Water-Level Trends

Trends are generally stable near the Arkansas and decline at a rate of about ½ ft/year to the south and east of the R9 Ranch.









R9 Ranch Boundary

- Domestic/Livestock/Garden
- Feedlot/Livestock/Windmill
- Irrigation
- Oil Field Water Supply
- Test hole/well
- All other
- Proposed Municipal Wells
- Major Roads
- R9 Ranch Boundary
- Plugged Irrigation Well
- WIZARD Data

0 1 2 3 Miles

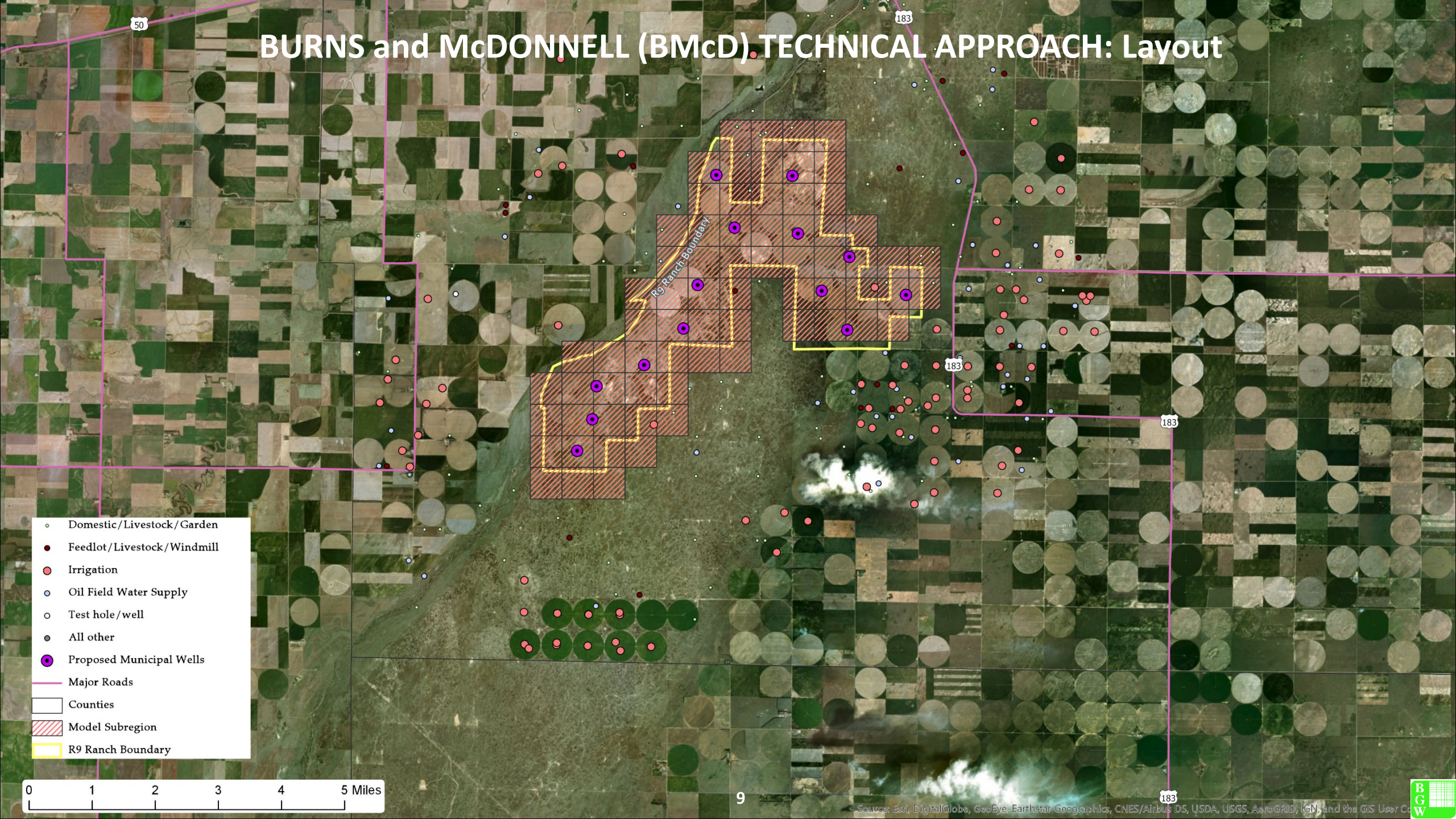
BURNS and McDONNELL (BMcD) TECHNICAL APPROACH

BGW understanding of approach is derived from inspecting BMcD, February 13, 2018 Letter Report to Mr. Toby Dougherty and BMcD Model files provided to BGW by KDA/DWR in March of 2018.

Model examination of the R9 water transfer project includes retrospective (1991 to 2007 = 17 yrs) and prospective (repeat 1991 to 2007 x 3 = 51 yrs) scenarios performed using an adapted version of the GMD#5 model (BBGMDMOD).

BMcD's method adopts a model sub-region that encompasses the R9 Ranch to examine model fluxes, water-level changes and sustainability. BMcD's analysis considers water-level changes outside of the sub-region, but reports the groundwater flow budget within the boundary of the sub-region. BGW quantifies effects to hydrologic features both inside and outside of the sub-region in this presentation.

BURNS and McDONNELL (BMcD) TECHNICAL APPROACH: Layout



BURNS and McDONNELL (BMcD) TECHNICAL APPROACH

Retrospective Runs

1) Iterative run to "…Evaluate the maximum annual pumping rate for R9 Ranch."
2) Scenario 1 -- Baseline irrigation use (4,054 AFY net pumping at irrigation wells).
3) Scenario 2 -- Maximum average municipal use (4,800 AFY at municipal wells).

Prospective Runs

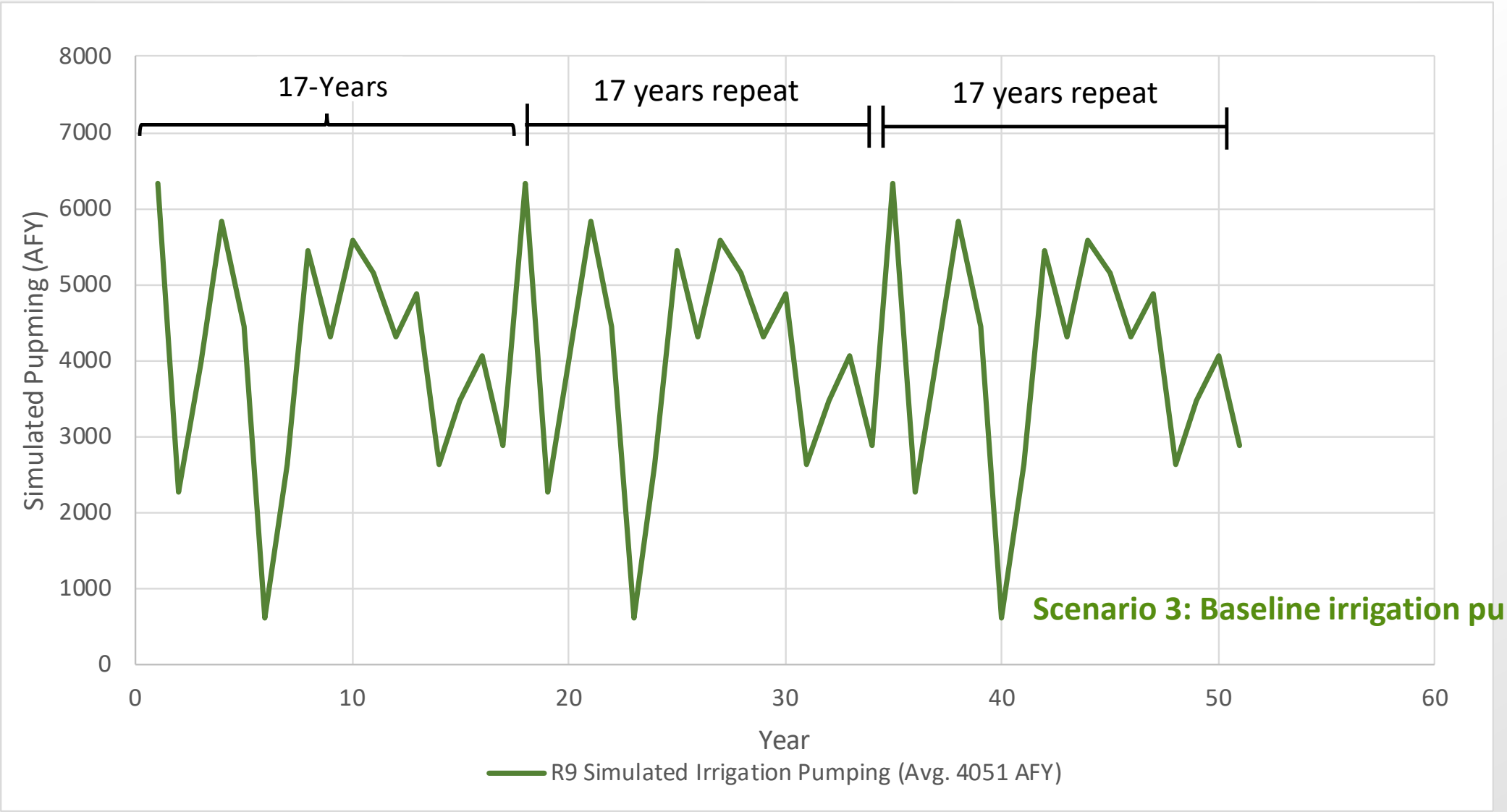
1) Scenario 3 -- Baseline irrigation use (4,054 AFY net pumping at irrigation wells).
2) Scenario 4 -- Maximum average municipal use (4,800 AFY at municipal wells).
3) Scenario 5 -- Build out and growth of anticipated actual municipal use (average 2,476 AFY at municipal wells).
4) 5-Year Drought Baseline -- Baseline irrigation use, includes a 5-year drought period during years 35 to 39 of simulation (4,054 AFY net pumping at irrigation wells). Used as baseline for Scenario 6.
5) Scenario 6 -- Build out and growth of anticipated actual municipal use, includes a 5-year drought period during years 35 to 39 of simulation (average 2,476 AFY at municipal wells).

BURNS and McDONNELL (BMcD) TECHNICAL APPROACH

BGW examined both the retrospective and the prospective BMcD simulations. The prospective analyses have the most utility as they consider a long-term analysis over 51 years.

The following slides show pumping schedules and results of the BMcD prospective analyses.

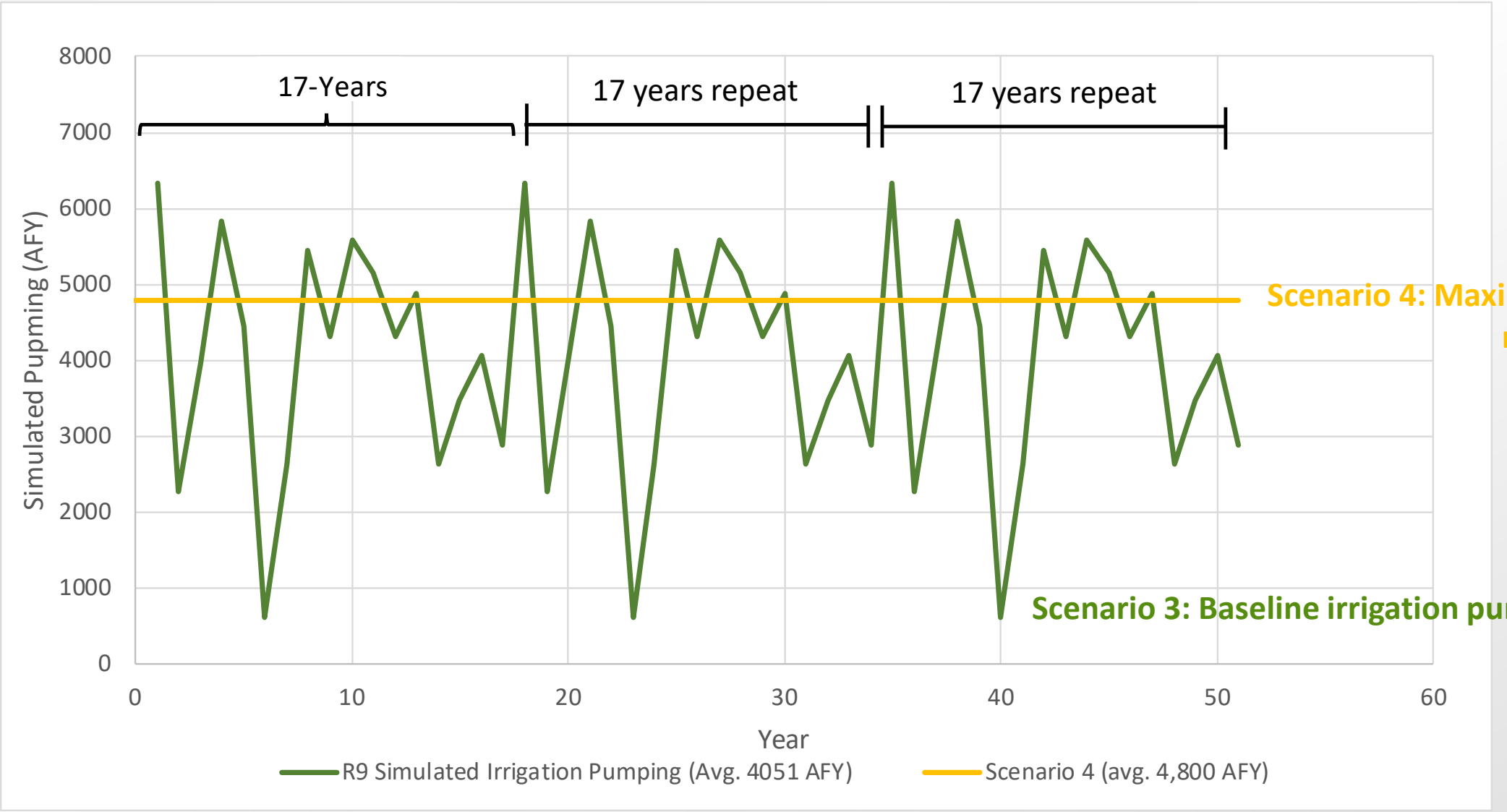
BURNS and McDONNELL (BMcD) TECHNICAL APPROACH: Baseline Irrigation



Scenario 3: Baseline irrigation pumping

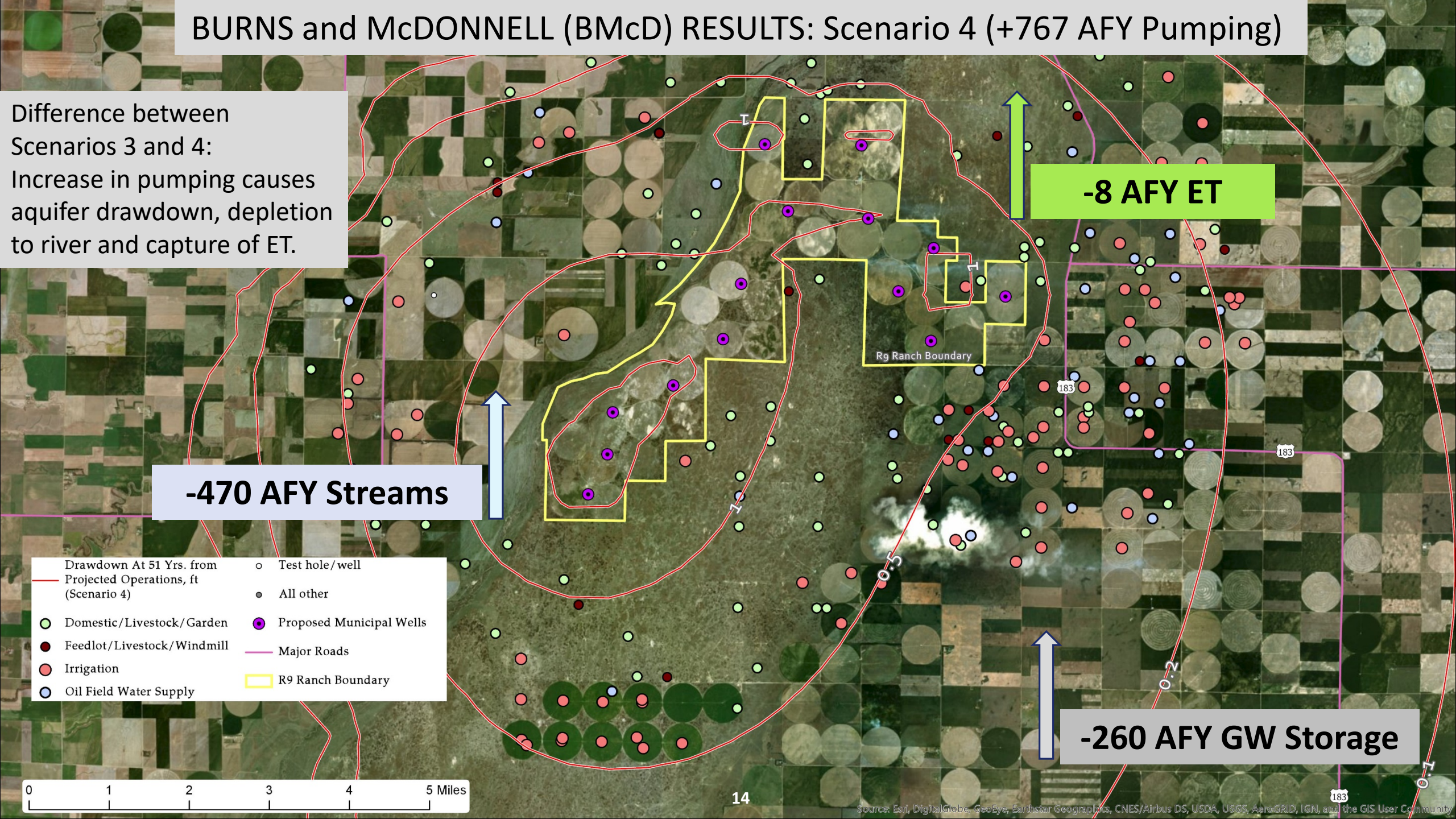
Historical pumping 1991 to 2007 is a 17-year period Repeated 3x to make a 51-year baseline (prospective).

BURNS and McDONNELL (BMcD) TECHNICAL APPROACH: Baseline Irrigation

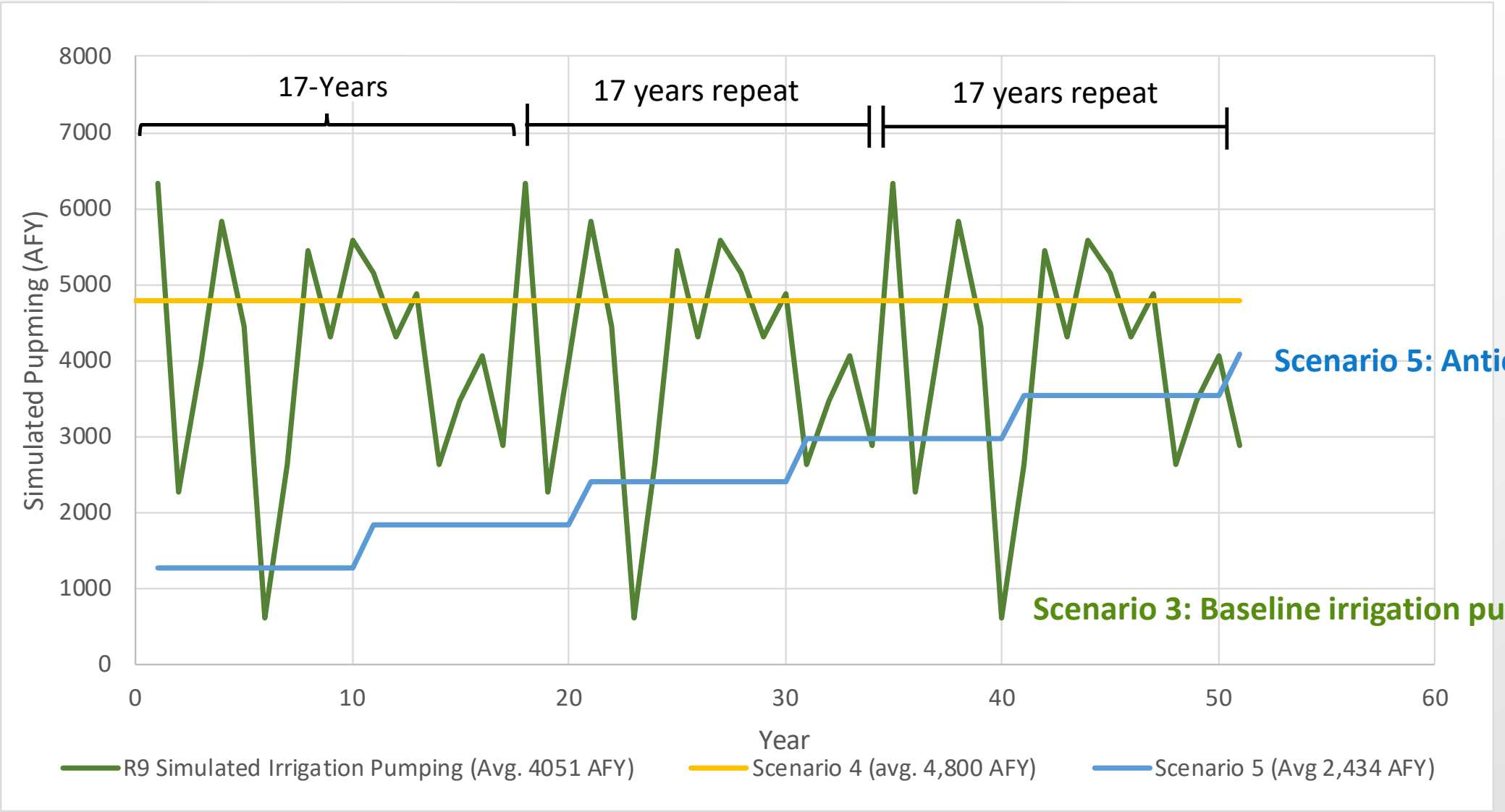


BURNS and McDONNELL (BMcD) RESULTS: Scenario 4 (+767 AFY Pumping)

Difference between Scenarios 3 and 4:
Increase in pumping causes aquifer drawdown, depletion to river and capture of ET.



BURNS and McDONNELL (BMcD) TECHNICAL APPROACH: Baseline Irrigation

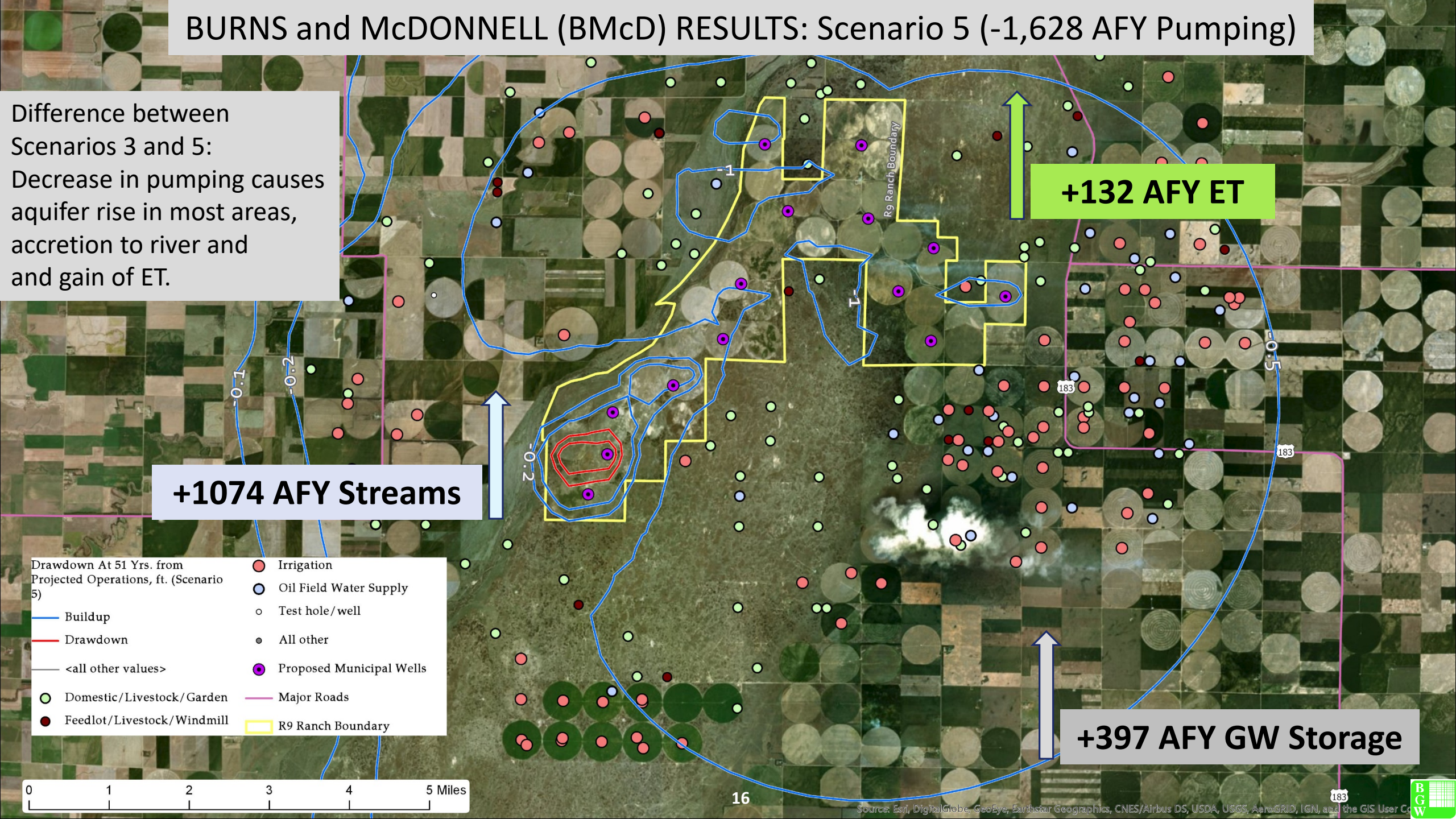


Scenario 5: Anticipated actual municipal use

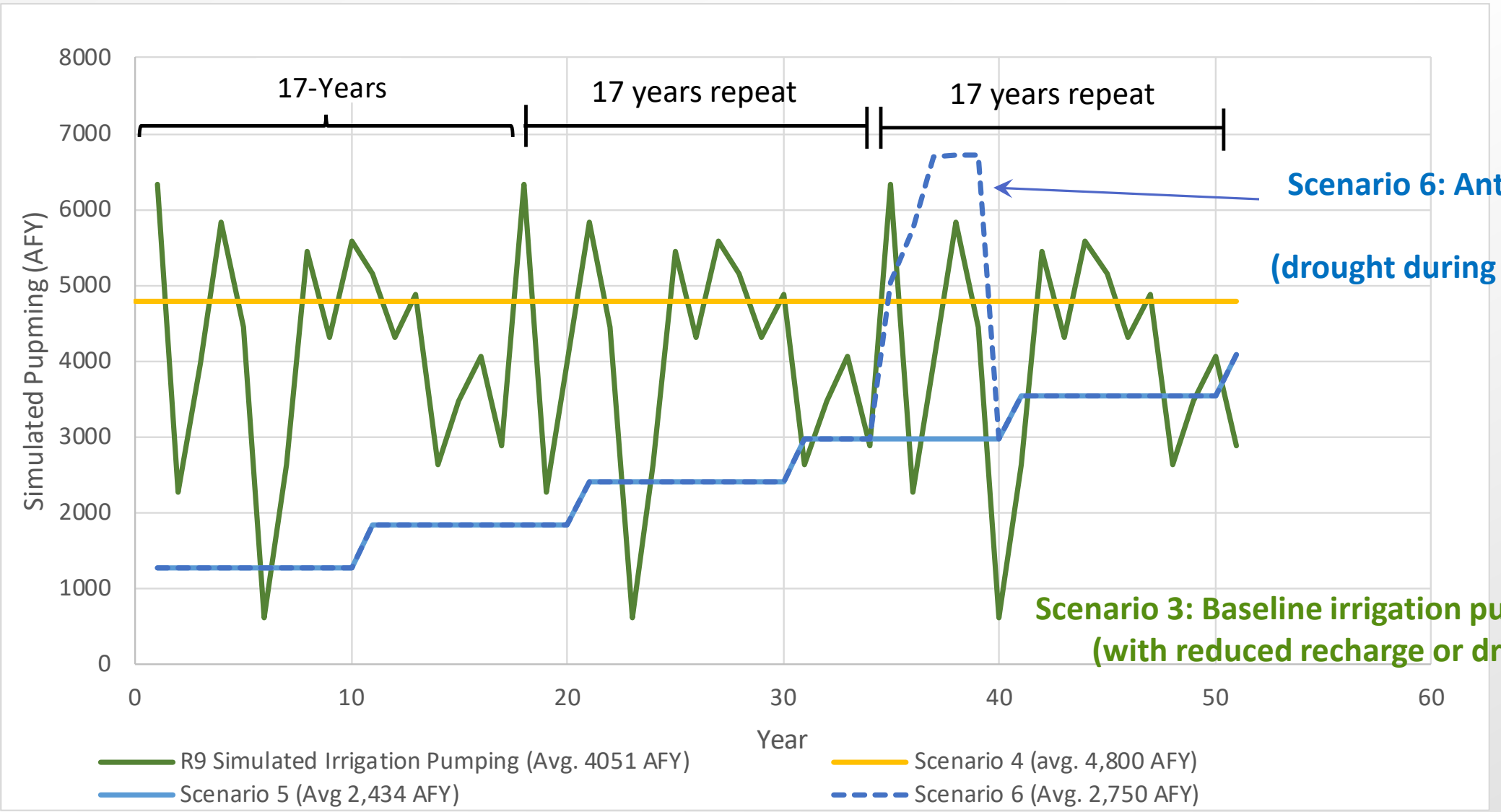
Scenario 3: Baseline irrigation pumping

BURNS and McDONNELL (BMcD) RESULTS: Scenario 5 (-1,628 AFY Pumping)

Difference between Scenarios 3 and 5: Decrease in pumping causes aquifer rise in most areas, accretion to river and and gain of ET.



BURNS and McDONNELL (BMcD) TECHNICAL APPROACH: Baseline Irrigation

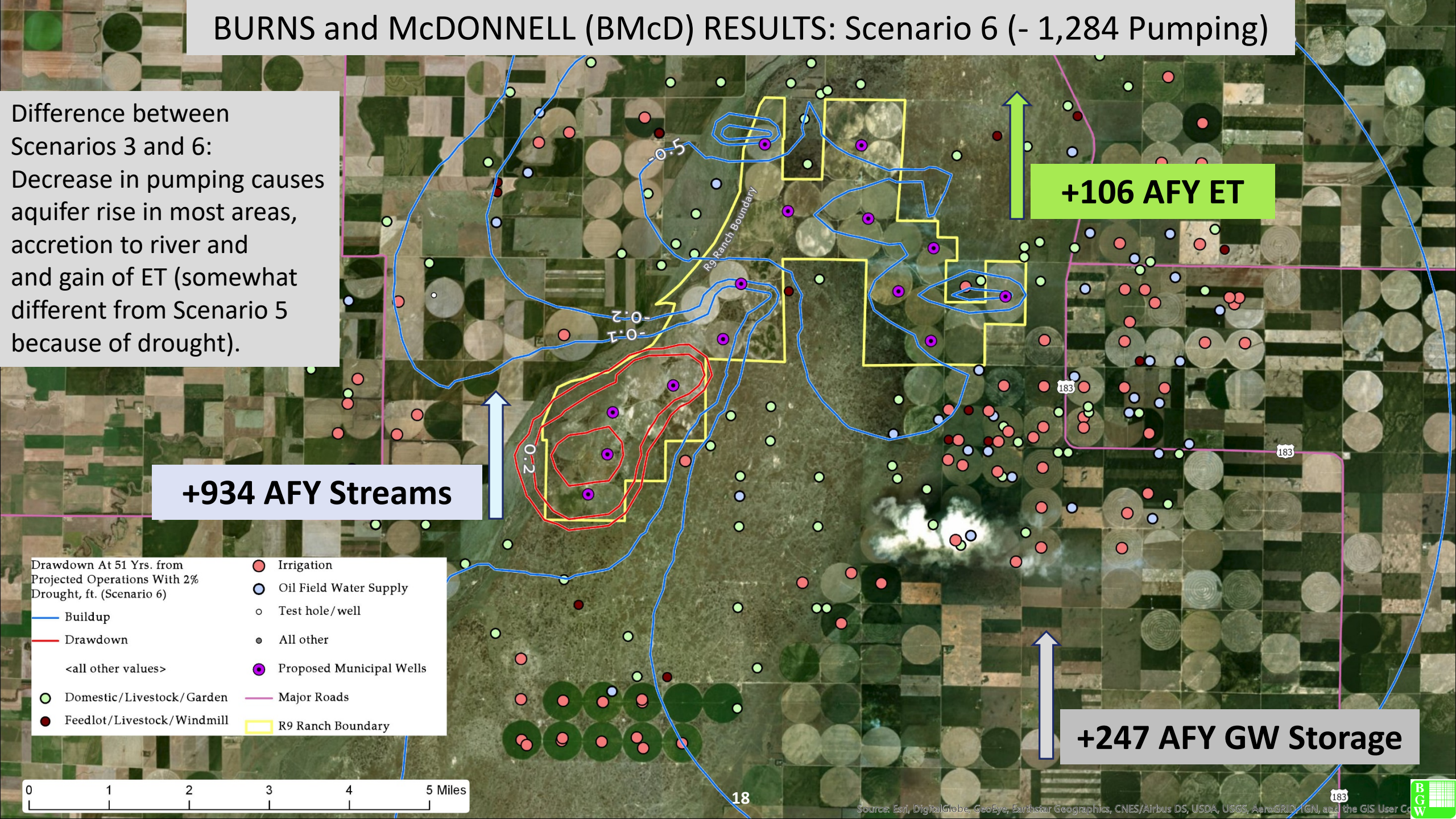


Scenario 6: Anticipated actual municipal use (drought during years 35 to 39)

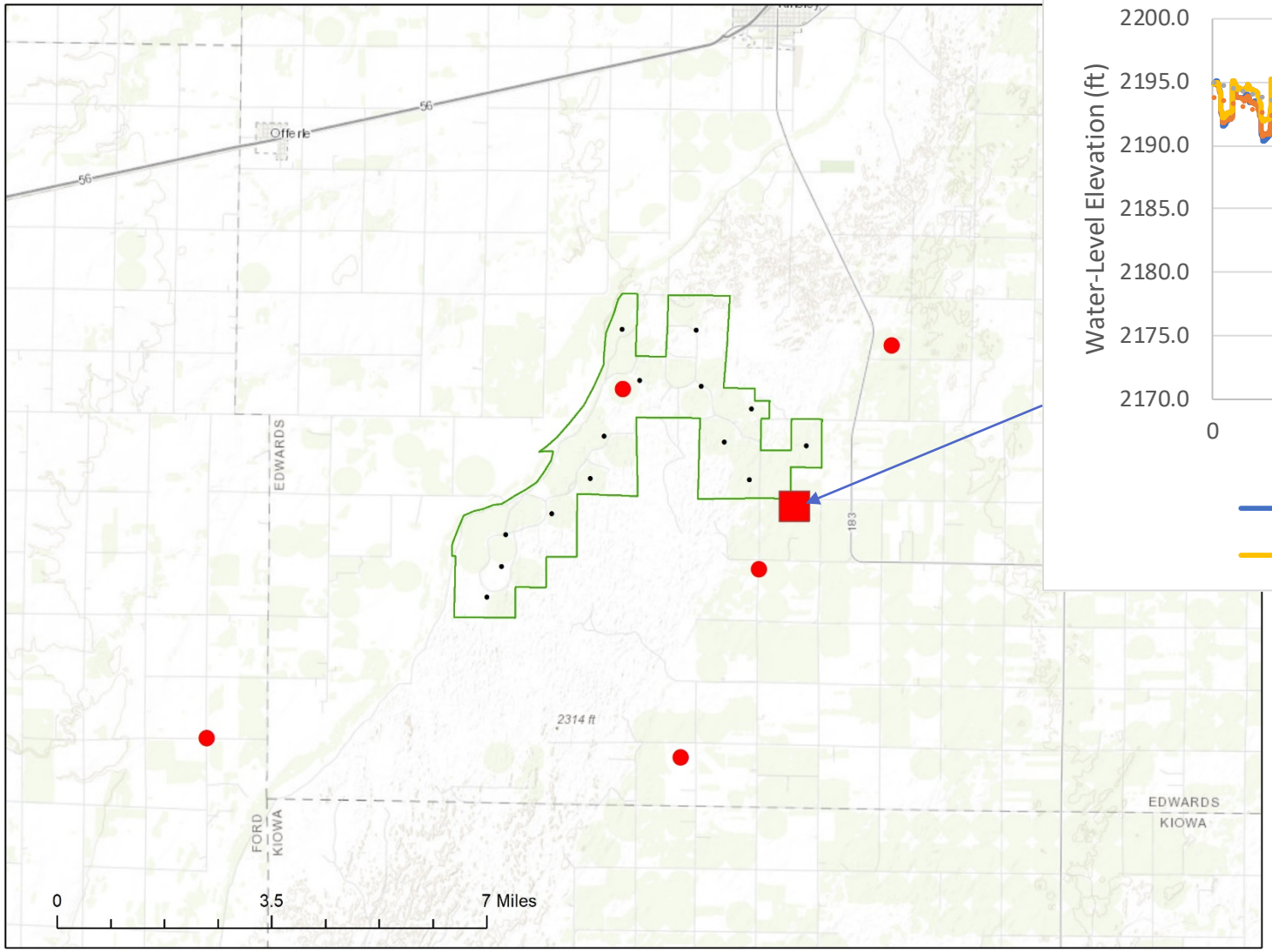
Scenario 3: Baseline irrigation pumping (with reduced recharge or drought)

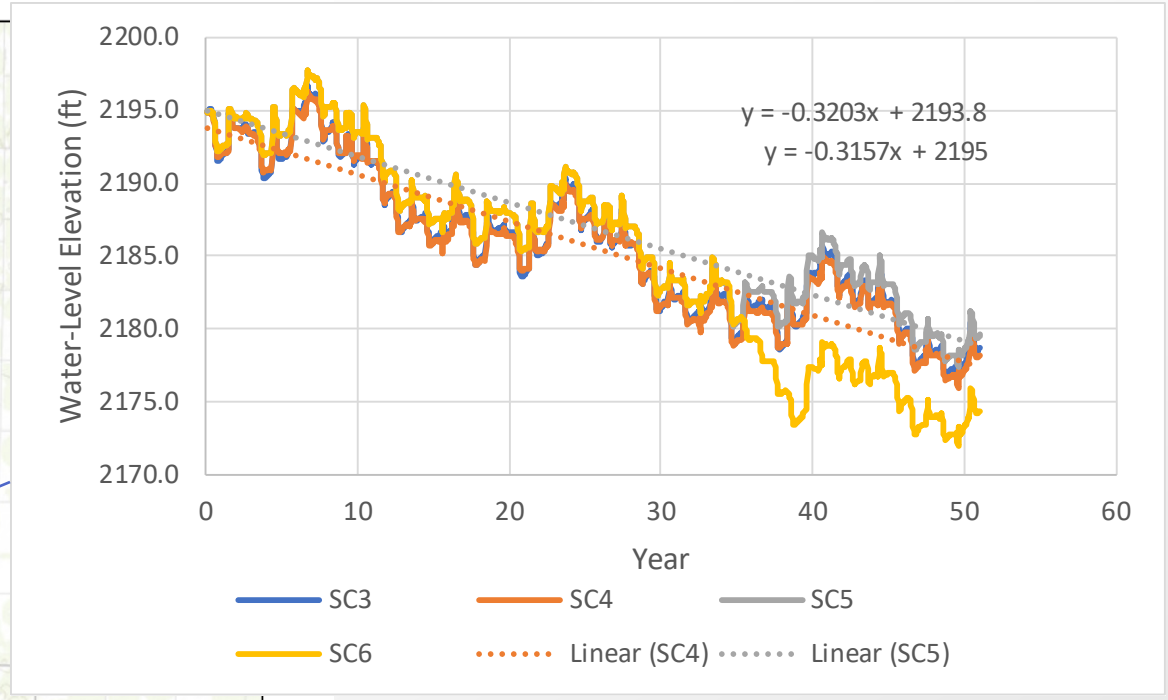
BURNS and McDONNELL (BMcD) RESULTS: Scenario 6 (- 1,284 Pumping)

Difference between Scenarios 3 and 6: Decrease in pumping causes aquifer rise in most areas, accretion to river and and gain of ET (somewhat different from Scenario 5 because of drought).



BURNS and McDONNELL (BMcD) RESULTS: Water-Level Trends





Over a 51-year projection, the simulated trend of water-level change for scenarios 3 through 6 indicates 15 to 20 feet of drawdown near the eastern boundary of R9 Ranch.

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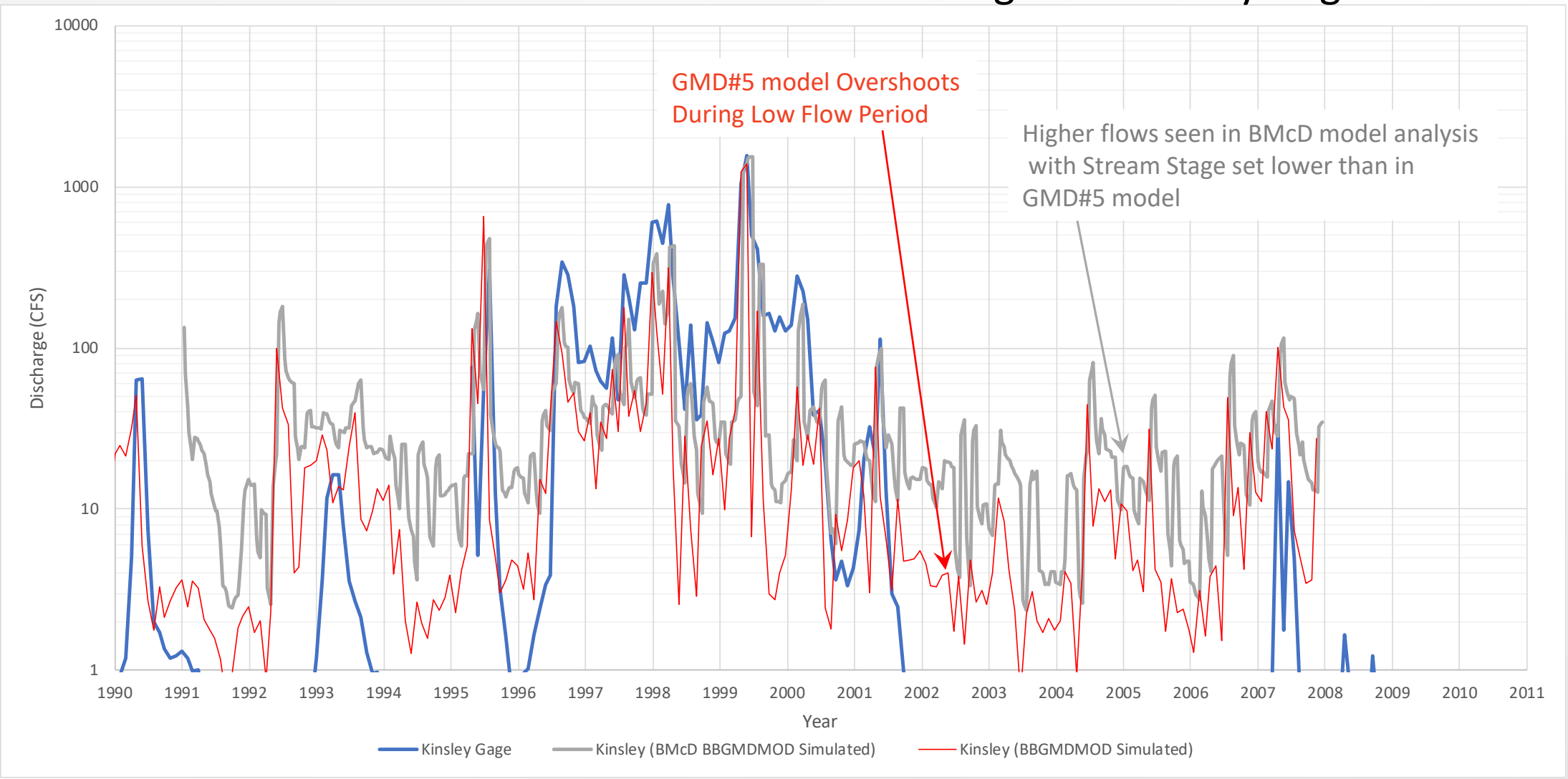
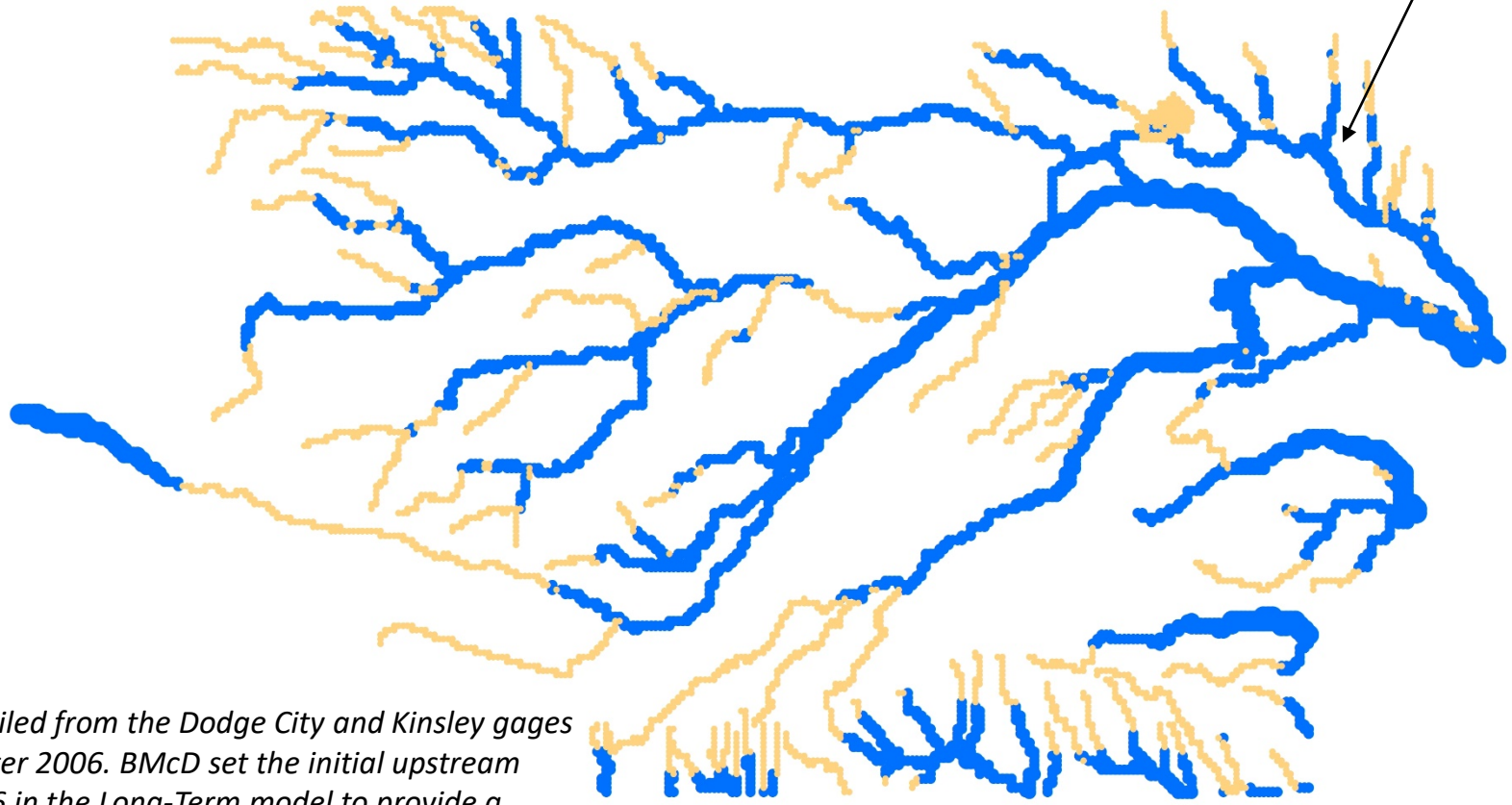
REVIEW OF BMcD ANALYSIS: Stream Stage and Kinsley Gage Flow



BMcD adjusted the simulated river stages (an average of 1.6 ft lower regionally). The adjustment may have been inadvertent as BMcD reports *"BMcD did not make any changes to … the GMD5 model."* We found that, during low flows, the adjustment To the stream stages results in increased flow at the Kinsley gage on the Arkansas River (about five miles downstream of R9 Ranch).

REVIEW OF BMcD ANALYSIS: Stream routing/Elimination of local runoff

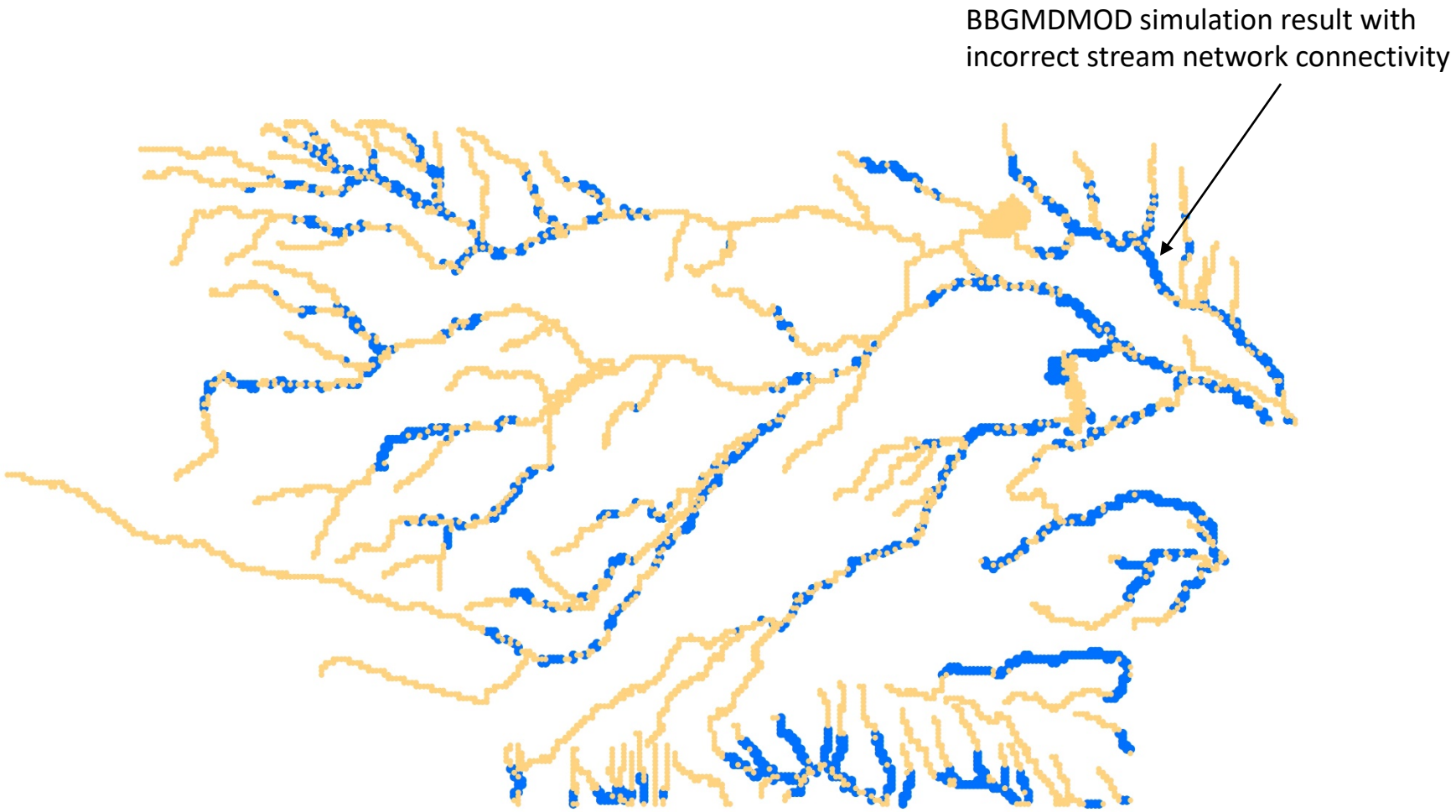
The GMD#5 model is calibrated with recharge from streams that requires routing of downstream flow.



BMcD report, P. 8

"Historic flow data in the Arkansas River compiled from the Dodge City and Kinsley gages reflect a significant decrease in streamflow after 2006. BMcD set the initial upstream flow in the Arkansas River to zero after year 16 in the Long-Term model to provide a conservative estimate and to recognize changing conditions resulting in reduced flows in the Arkansas River. Baseflow can still occur if the model calculated water level elevation in the aquifer rises high enough to cause the aquifer to discharge to the River. If that occurs, the streamflow routing package will calculate a discharge from the aquifer to the stream and generate baseflow for the River."

REVIEW OF BMcD ANALYSIS: Stream routing/Elimination of local runoff



When BMcD set the initial upstream flow in the simulated river to zero (at year 16), the streamflow routing was disabled to create the incorrect stream network connectivity shown above.

Comment on BMcD Simulation of Stream Stage and Stream Flow Routing

Stream Stage:

On the average, the simulated stream stages in the BMcD analysis results in regionally incising the streambed a couple of feet in comparison to the calibrated model. This can explain the increased flow simulated at Kinsley gage during low-flow periods (lowering the streambed would induce river flow from shallow groundwater). The issue occurs in both the retrospective and the prospective BMcD analyses.

Stream Flow Routing (SFR):

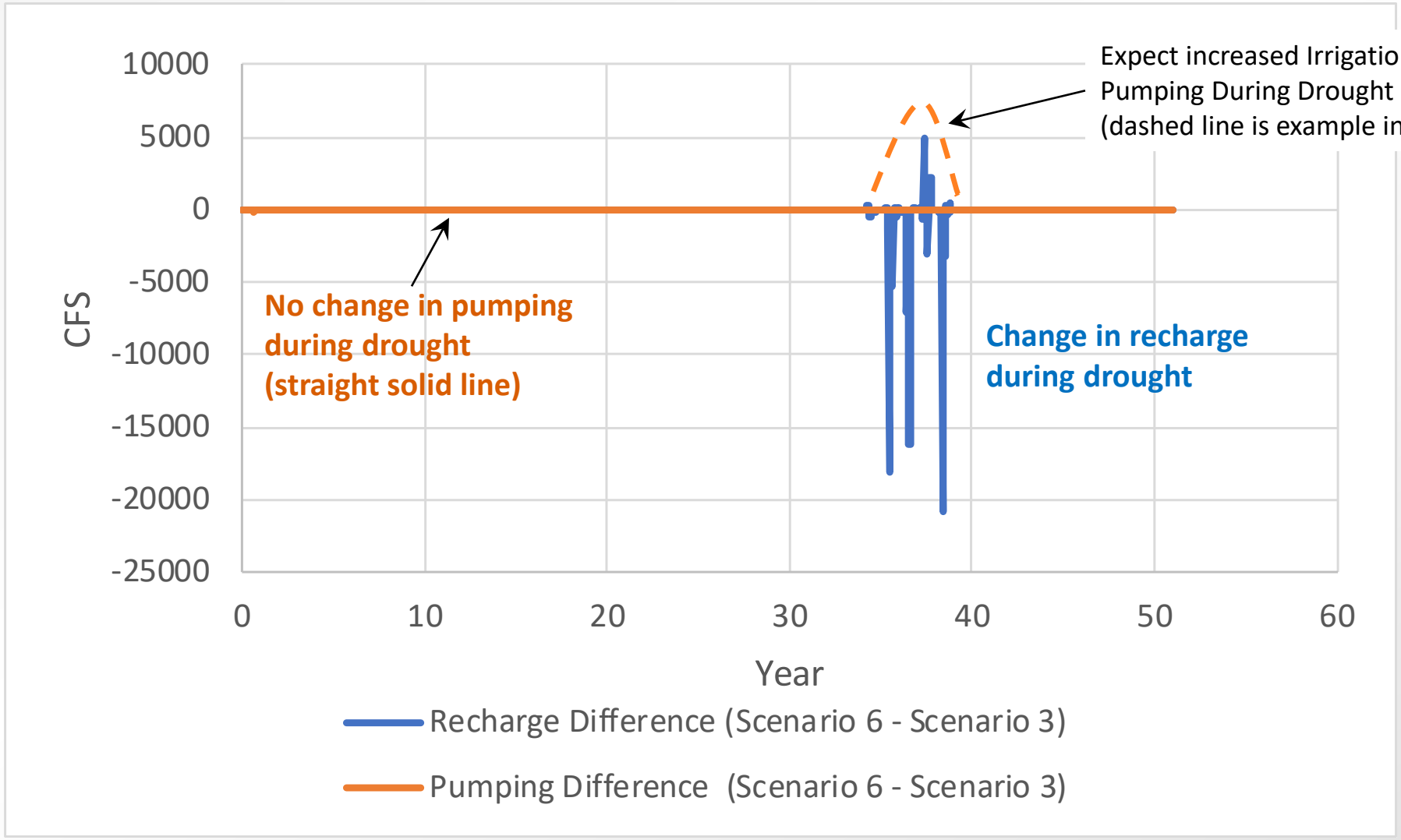
SFR in the GMD#5 model is the mechanism for aquifer recharge along streams (derived from regional runoff) in the model area. SFR also accounts for flow in the modeled streams. The issue occurs in the BMcD prospective analyses.

The two model adjustments above change the model in a way that may or may not significantly alter the simulated flow regime. The bottom line is that if BMcD were to address the issues by repairing the modeled stream stage and the SFR, their updated results might not be significantly different. The reason is the BMcD model scenarios are based on a difference between two simulations and even though each simulation has an issue with stream stage and SFR, the difference between the scenarios may not be very different from the difference between two simulations with corrected issues. This point can be definitively clarified by re-running the BMcD scenarios with stream stages and SFR that matches the original GMD#5 model (as BMcD reportedly intended).

Comment on BMcD Simulation of Stream Stage and Stream Flow Routing <cont.>

In a July 23, 2018 email from David Traster of Foulson Siefkin, LLP, to Orrin Feril, GMD#5 Manager, Mr. Traster generally characterizes the SFR issue as *"Because the model in its current form accounts for less than all of the water in the system, correcting this technical error will only favor the Cities."* From a technical standpoint, it is not clear whether a corrected analysis will favor the Cities until a corrected scenario is simulated. Mr. Traster acknowledges the SFR issue is a technical error that should be corrected.

REVIEW OF BMcD ANALYSIS: Scenario 6 Drought Pumping Stress



BMcD analysis considers a 5-year drought (Scenario 6) over years 35 to 39 of the simulation. The drought condition is represented by reduced recharge, but without an associated increase in pumping at regional irrigation wells.

Comment on BMcD Simulation of Scenario 6 Drought Condition

It is odd to apply drought conditions to simulated recharge and to the R9 Ranch municipal wells, but not to the other irrigation wells in the area.

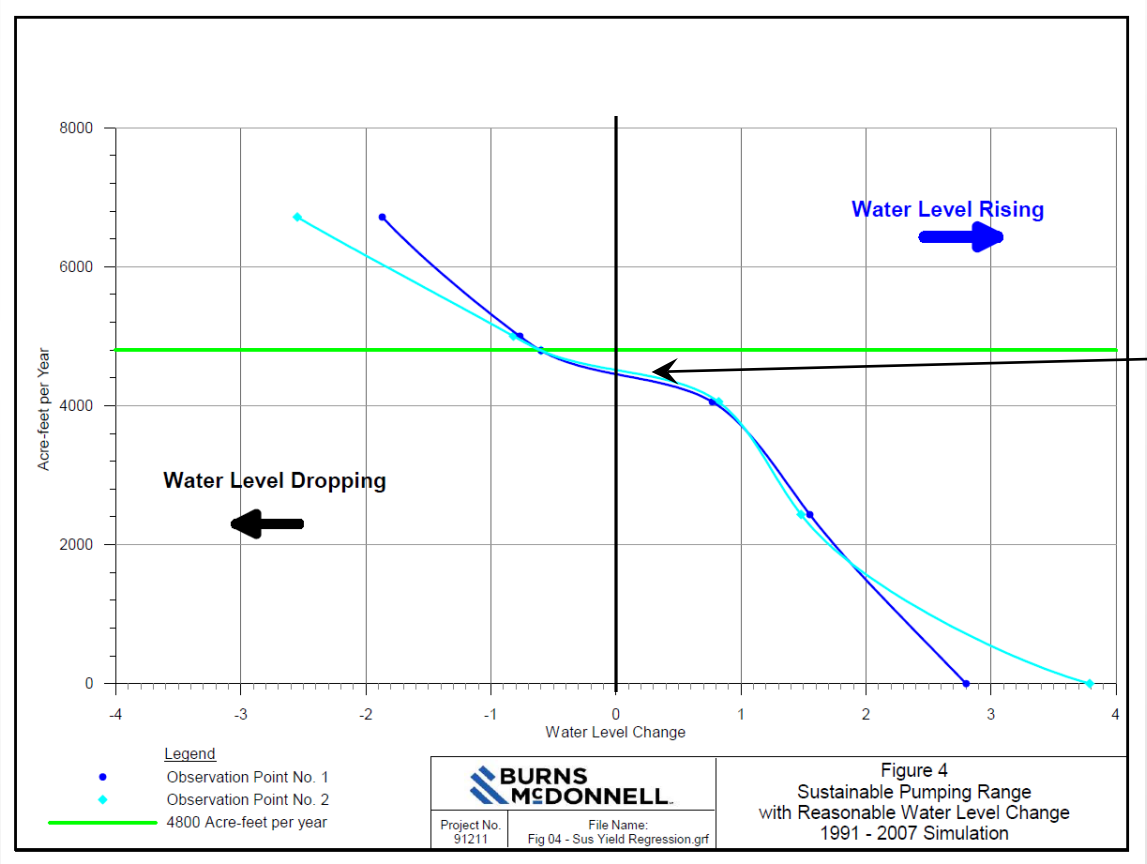
In a July 23, 2018 email from David Traster of Foulson Siefkin, LLP, to Orrin Feril, GMD#5 Manager, Mr. Traster indicates the drought scenario was developed at the request of the Chief Engineer and that ultimately the CE *"…elected not to modify nearby irrigation pumping because doing so involved simply too many unknown variables…"* Mr. Traster further characterizes the increased pumping at other irrigation wells to be associated with an inability to predict how it would happen and that it creates uncertainty suggesting the simulation would be speculative. We clarify that the drought simulation would not be an attempt to predict the future, but a scenario to understand the sensitivity of results to an increase in regional pumping associated with drought conditions for planning purposes.

The same technical concept of a difference between two scenarios, previously described for the stream stages and SFR, occurs here. That is, it is possible that if BMcD were to add drought conditions to area irrigation wells and re-run Scenario 6, the results might not significantly change. An actual simulation is necessary to clarify this.

REVIEW OF BMcD ANALYSIS: Sustainable Pumping

Iterative run to *"…Evaluate the maximum annual pumping rate for R9 Ranch."* BMcD identified 4,800 AFY as a maximum pumping target. 4,800 AFY caused a *"reasonable water-level change"* of 0.6 ft in the sub-region over the 17 year retrospective analysis period. The iterative runs were not included in DWR model file delivery.

Sustained pumping is estimated at 4,800 AFY.



Note:
The rate for sustainable pumping with no decline is nearer 4,400 AFY on the chart.

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COMMENTARY ON WaterPACK ANALYSIS

Keller-Bliesner Engineering, LLC, *R9 Ranch CU Analysis (Nov 24, 2016)*

The Cities of Hays and Russell request per acre transfer quantities of 20.9 inches for alfalfa and 18.9 inches for corn.

Initial findings of the Chief Engineer (CE) are generally 18.0 inches for alfalfa and 13.0 inches for corn.

An independent analysis by Keller-Bliesner (K-B) estimates crop CIR of 17.7 inches for alfalfa and 13.6 inches for corn (comparable to CE initial finding).

However, K-B considers an additional factor. Consumption of precipitation by unmanaged vegetation (prairie grass) at the R9 Ranch after the water transfer. Consequently, K-B reduces the transferrable quantity to the cities by post-transfer consumption of water at the R9 Ranch to maintain a hydrologic balance of water consumption. The result is a *net* transferrable quantity.

K-B's resulting net transferrable quantity is 12.0 inches for alfalfa and 4.7 inches for corn.

BGW has not reviewed details of the K-B analysis; however, the general approach, of considering post-transfer consumption of precipitation water at the R9 Ranch, maintains a hydrologic balance with baseline irrigation water consumption associated with water transfer.

CONSIDERATIONS

The BMcD stream stage and streamflow routing (SFR) issues constitute a breakdown in running the GMD#5 model in its calibrated form. It is possible that if the issues are addressed, the BMcD analysis results will not significantly change. However, a technical addendum that addresses the issues should be made to confirm the analysis results as part of the record.

BMcD Scenario 6 considers drought conditions on use of the municipal wells at the R9 Ranch. However, the drought condition is not considered at other area irrigation wells. Consideration of drought conditions in that context would provide a more comprehensive drought analysis for planning purposes. It is possible that re-running may produce similar results despite the better scenario.

BMcD results suggest that the stress change in use from irrigation to municipal will have a small impact on nearby wells and Mid-Ark stream conditions. We agree with this assessment in the context of the scenarios presented. However, we recommend addressing the simulated stream issues and analyzing a more comprehensive drought condition as described above to confirm analysis results.

CONSIDERATIONS

Analysis suggests that 4,800 AFY is prospective for long term production from the R9 Ranch area. However, it is important to clarify that a long-term pumping quantity is not the only factor to consider. The 4,800 AFY may become less if the river is managed to maintain a specific quantity of flow for downstream use.

The transfer should reasonably maintain a balance with previous conditions. Keller-Bliesner Engineering, LLC assessed consumptive use at the R9 Ranch in the context of the proposed water transfer. Their analysis reduces the transferrable quantity to the cities by post-transfer consumption of water at the R9 Ranch (assuming the lands will revert to prairie grass). BGW has not reviewed details of the K-B analysis; however, the general approach, of considering post-transfer water consumption, maintains hydrologic balance of water consumption compared to baseline agricultural use.

Quantification of the City of Hays R9 water rights and historic use are not addressed in this review.

Discussion/Questions?