Map-Based Open-Source Stream Depletion Tools

Assessing impacts and exploring options with rapid stream depletion estimates

Session 28: Capturing Nuances of Surface Water/Groundwater Interactions to Quantify Stream Depletion
Wednesday April 19th, 8 - 9:45 am PT

Jessica Rogers, Ph.D.; Gilbert Barth, Ph.D.; Doug Hayes; Mashrur Chowdhury (all with SSP&A)

S.S. Papadopulos & Associates, Inc.

Overview

- Objective
  - Estimate stream depletion impacts of proposed diversion transfers
  - Provide learning opportunities to improve the process
  - Better questions lead to better solutions…
- Methods: analytical or numerical evaluation
  - Glover Balmer and Theis
  - Groundwater model with surface water representation
- Tool: Open-source map-based interface
  - Menus
  - Standardized format
  - Maps, graphs and tables

Proposed Transfer

- Move From
  - Location and formation
  - Type of use
  - Quantity
  - Return flow
- Move To

TECHNICAL MEMORANDUM
OFFICE OF THE STATE ENGINEER
HYDROLOGY BUREAU

DATE: May 23, 2018

TO: Maureen Dolan, Attorney, Administrative Litigation Unit
William Duemling, District 2 Engineering Specialist Supervisor

THROUGH: Ghassan Musharrafieh, Chief, Hydrology Bureau GRM

FROM: Eric Keyes, Hydrologist, Hydrology Bureau EJK

SUBJECT: [redacted] and [redacted] Application, C-[redacted], C-[redacted] and C-[redacted] into C-[redacted] and C-[redacted], HU[redacted]

Evaluation Summary

A 10-year transfer to C-[redacted] does not negatively impact the Pecos River during the transfer period but will negatively impact the Pecos River after the transfer period.

A 10-year transfer to C-[redacted] negatively impacts the Pecos River to year 4 of the transfer.

The transfers do not cause significant drawdown at nearby wells.

Evaluation Details

[redacted] and [redacted] have filed an application for a 10-year temporary transfer of water from C-[redacted], C-[redacted] and C-[redacted] into C-[redacted] and C-[redacted]. The locations of the wells are shown in figure 1. The move-to wells are 3 and 22 miles southeast of the move-from wells. The move-to wells are 19 miles apart and will require separate analyses.

The pumping would transfer use from irrigation to commercial.

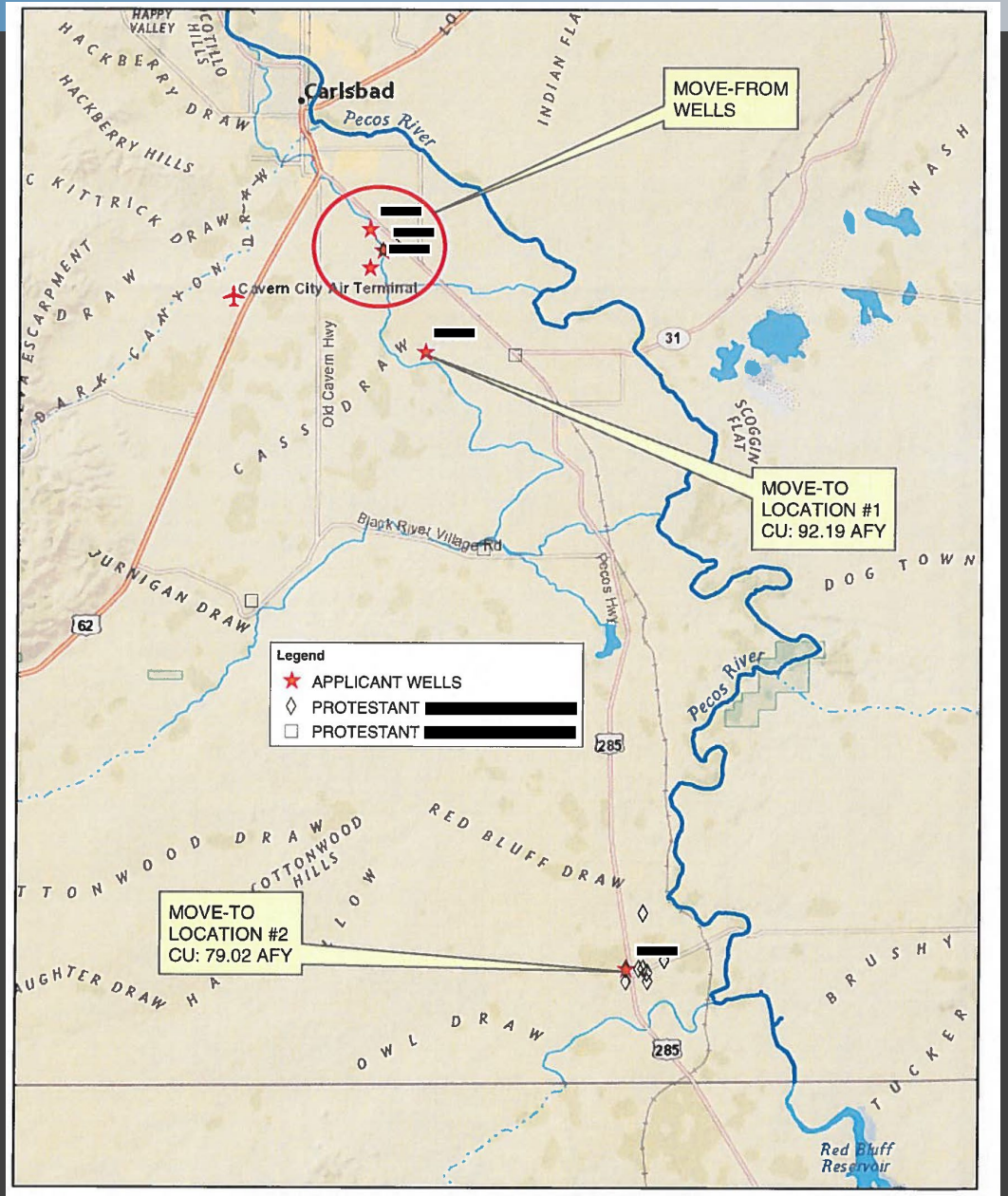
The move-from and the move-to #1 (C-[redacted]) are in the Carlsbad Basin. The Carlsbad Basin is administered with a consumptive irrigation requirement (CIR) of 2.1 acre-feet/acre.

The move-to #2 (C-[redacted]) is in the Delaware Basin. The Delaware Basin is administered with a consumptive irrigation requirement (CIR) of 1.8 acre-feet/acre.

The move-from locations have an irrigation diversion of 131.7 AFY with a consumptive use of 92.19 AFY. The consumptive rate of the right, 92.19 AFY, is to be diverted at move-to #1. The Delaware Basin consumptive portion of the right, 79.02 AFY, is to be diverted at move-to #2.

After 10-years ending on December 31, 2026, pumping reverts back to the licensed points of diversion and places of use.

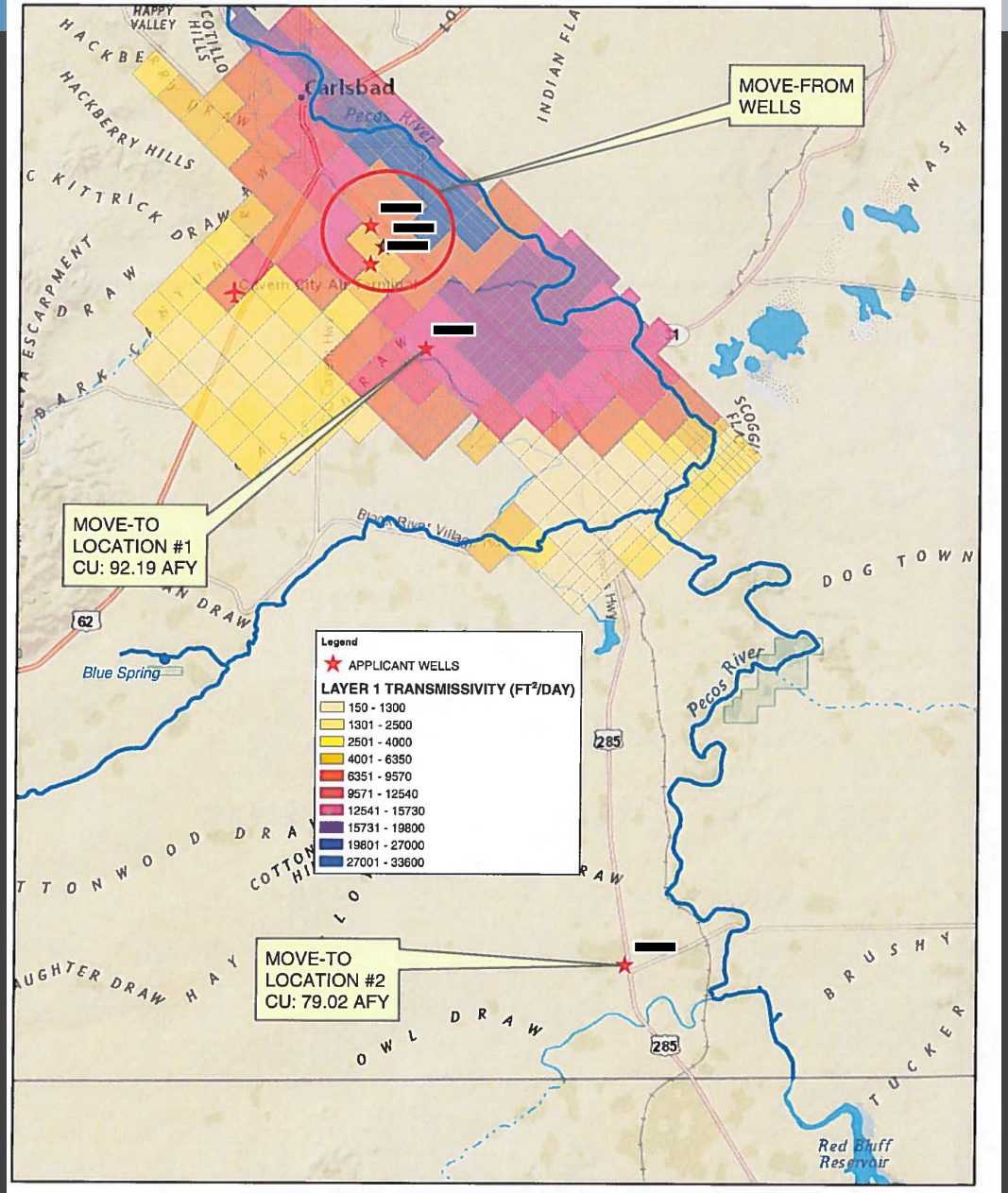
The application is protested by [redacted] and by [redacted]. There are concerns that the transfer would impair existing water rights and impact flow on the Pecos River. [redacted] has water rights on the C-[redacted] et al wells including the applicant



TEMPORARY 10-YEAR TRANSFER THRU 12/31/2026
DIV: 131.7 AFY, CU: 92.19 AFY ==> 79.02 AFY CU DELAWARE BASIN

FIGURE 1
LOCATION MAP
FOR THE [redacted] SALES APPLICATION
C-[redacted], C-[redacted] & C-[redacted] COMBINED INTO C-[redacted] & C-[redacted]

ocation2.mxd



TEMPORARY 10-YEAR TRANSFER THRU 12/31/2026
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MAP AREA

FIGURE 2
MODEL LOCATION

FOR THE [redacted] APPLICATION
C-[redacted], C-[redacted] & C-[redacted] COMBINED INTO C-[redacted] & C-[redacted]

model2.mxd

FIGURE 3

TOTAL PECOS RIVER IMPACT AND THE MOVE-FROM AND MOVE-TO COMPONENTS

FOR THE [redacted] 10-YEAR TEMPORARY TRANSFER TO MOVE-TO #1, C-[redacted]

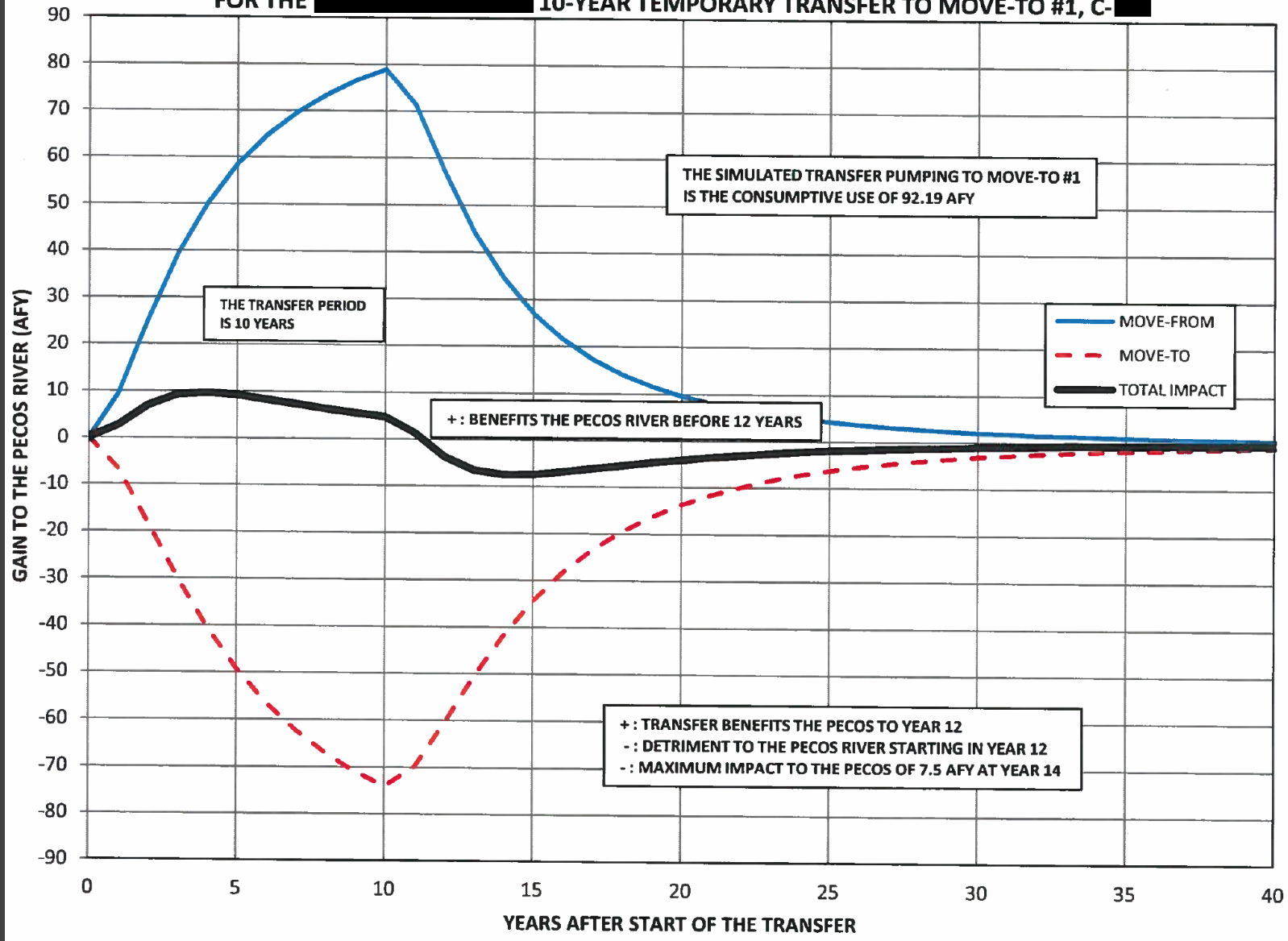
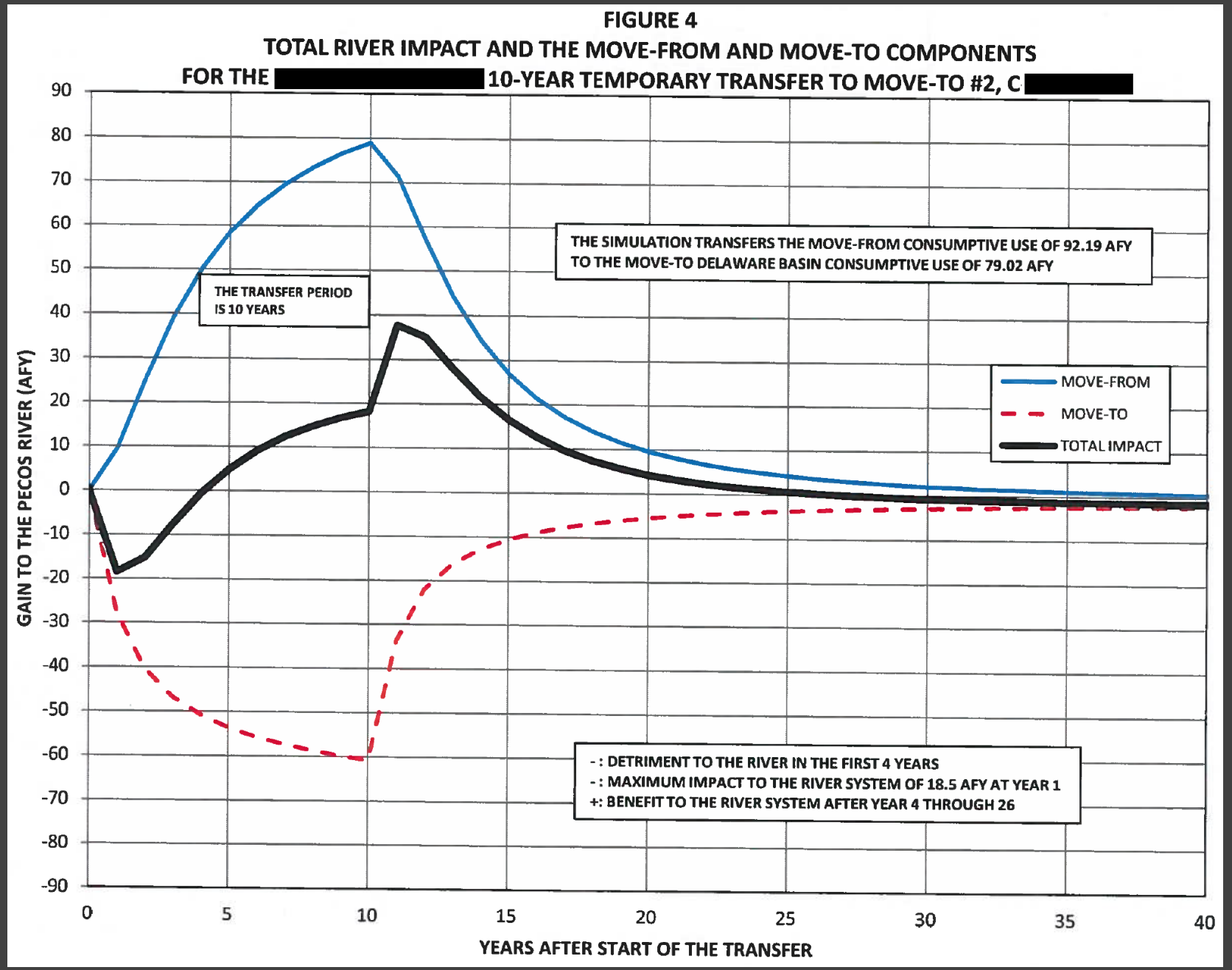
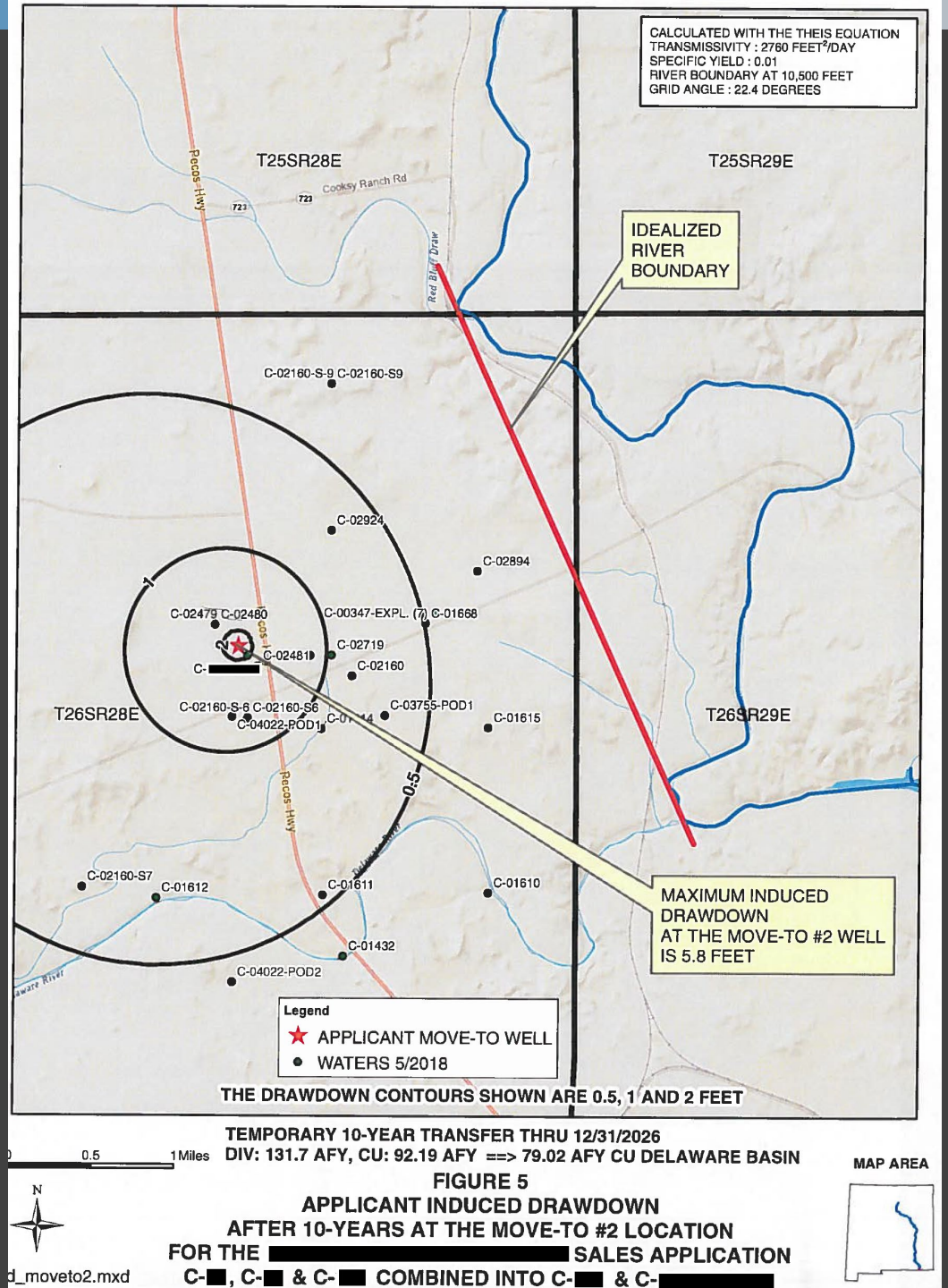


FIGURE 4

TOTAL RIVER IMPACT AND THE MOVE-FROM AND MOVE-TO COMPONENTS

FOR THE [redacted] 10-YEAR TEMPORARY TRANSFER TO MOVE-TO #2, C[redacted]





TEMPORARY 10-YEAR TRANSFER THRU 12/31/2026
DIV: 131.7 AFY, CU: 92.19 AFY ==> 79.02 AFY CU DELAWARE BASIN

FIGURE 5
APPLICANT INDUCED DRAWDOWN
AFTER 10-YEARS AT THE MOVE-TO #2 LOCATION
FOR THE [redacted] SALES APPLICATION
C-[redacted], C-[redacted] & C-[redacted] COMBINED INTO C-[redacted] & C-[redacted]

d_moveto2.mxd

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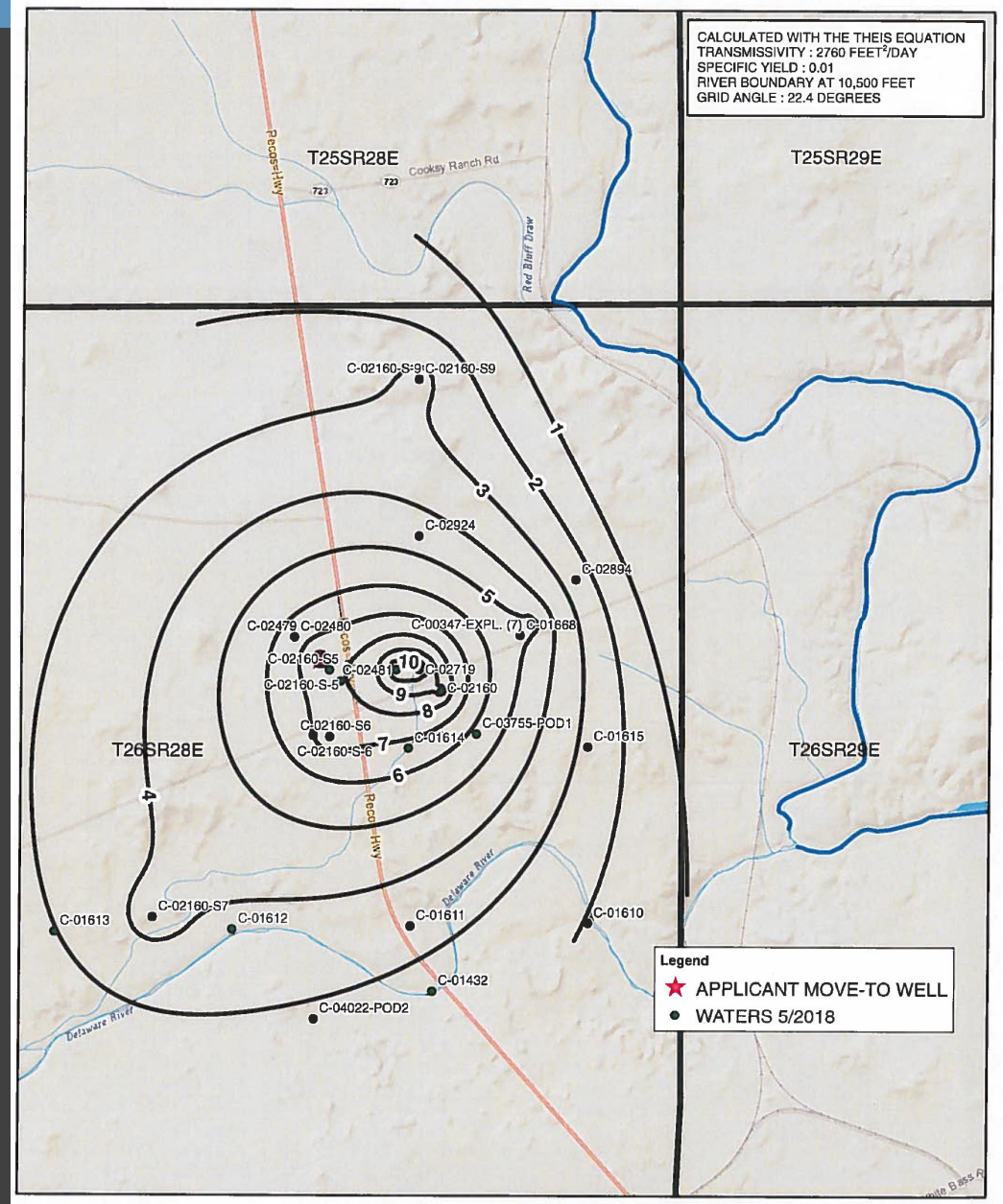


SIMULATED FULLY DECLARED PUMPING OF 407 AFY

0 0.5 1 Miles

N

MAP AREA

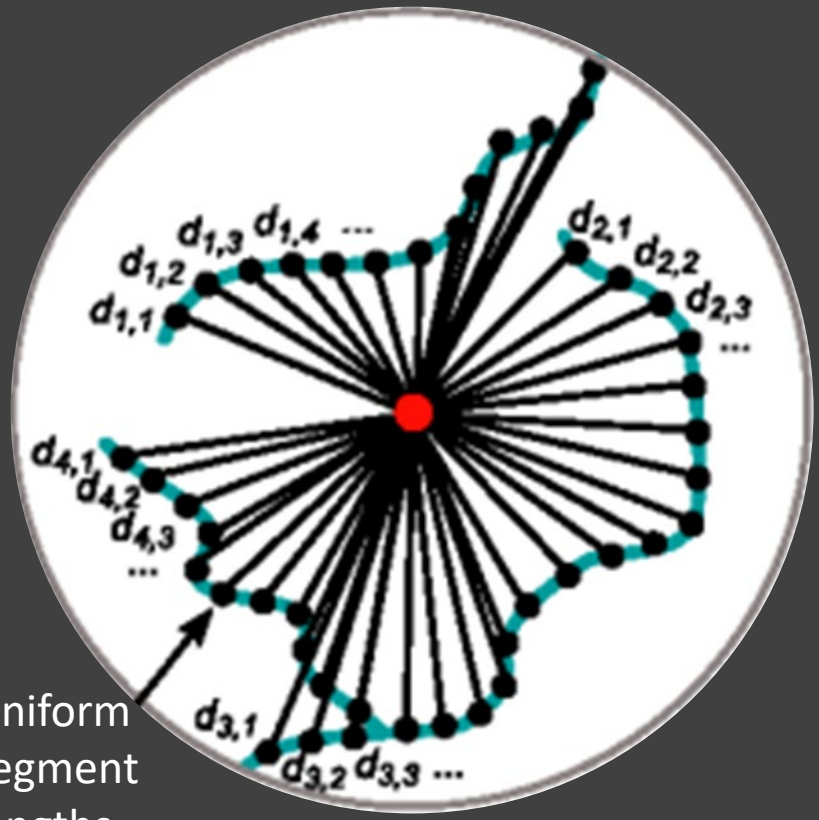
FIGURE 6
10-YEAR PROJECTED DRAWDOWN WITH PUMPING OF ALL DECLARATIONS AND WITHOUT APPLICANT PUMPING
FOR THE [redacted] APPLICATION
C-[redacted] C-[redacted] & C-[redacted] COMBINED INTO C-[redacted] & C-[redacted]

d_fullydepl2.mxd

What Does the Interface Need to Do?

Analytical: Glover Balmer

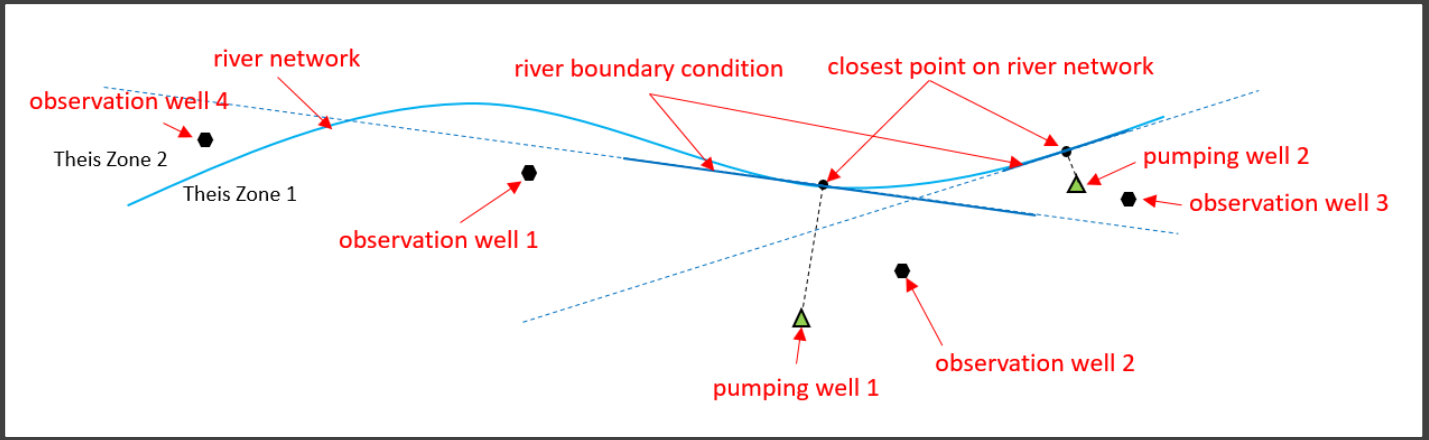
- Proportion of pumped which is captured stream flow
- Analytical Depletion Function (*Zipper et al.*, 2019) approach
  - Streams broken into segments
  - Aggregate Glover Balmer from each included segment



Uniform segment lengths

Analytical: Theis

- Theis with river boundary condition:
  - Shortest well-to-river distance
  - River perpendicular to shortest distance
- Analytical solution
  - Independent “Theis Zones”
  - Pumping side of river
  - Constant hydraulic properties
- Drawdown output
  - Grided timeseries
  - Timeseries at observation points

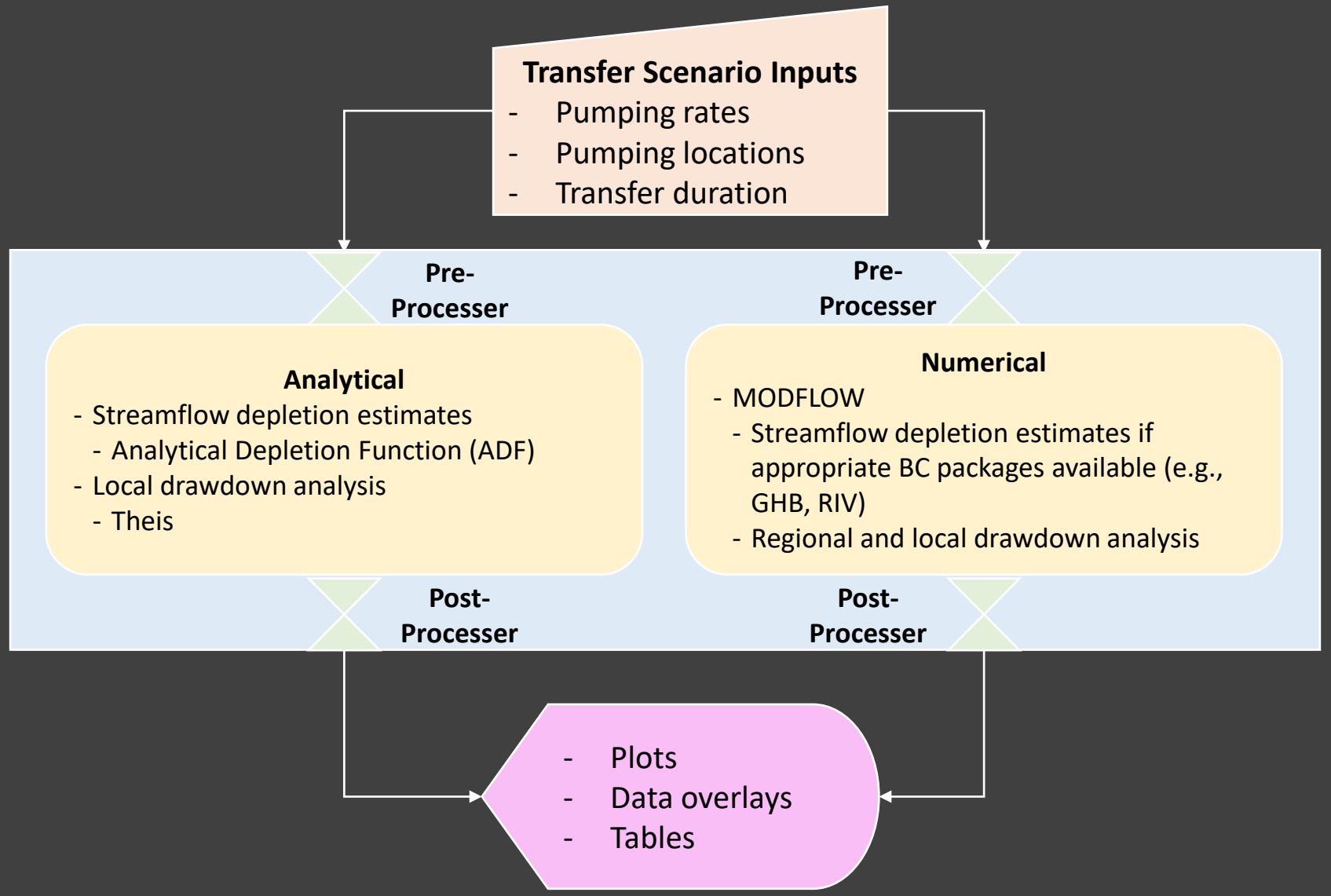


Numerical Evaluation

- Calibrated groundwater flow model
- Review of superposition assumptions
- Review objectives (isolated vs. projected)
- Baseline simulation
  - No pumping
  - Existing pumping
- Transfer simulation: baseline plus proposed pumping
- Net results
  - Drawdown
  - Depletion

Interface Schematic

- User inputs
- Methods/ Processing
- Graphical/ tabular outputs



Ani

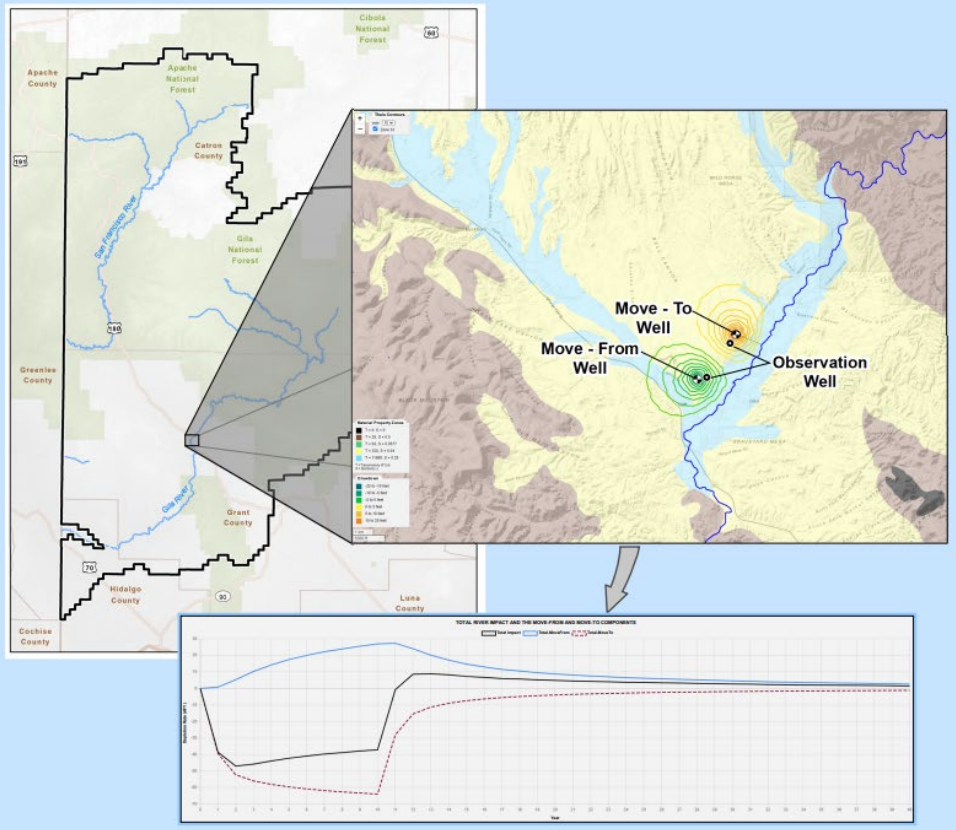
The Analytical Interface (Ani)

An Analytical-Solution Interface for Streamlining New Mexico OSE Evaluation of Transfer Applications in Basins Without Numerical Models

Office of the State Engineer
NM
Interstate Stream Commission

Created for

The New Mexico Office of the State Engineer



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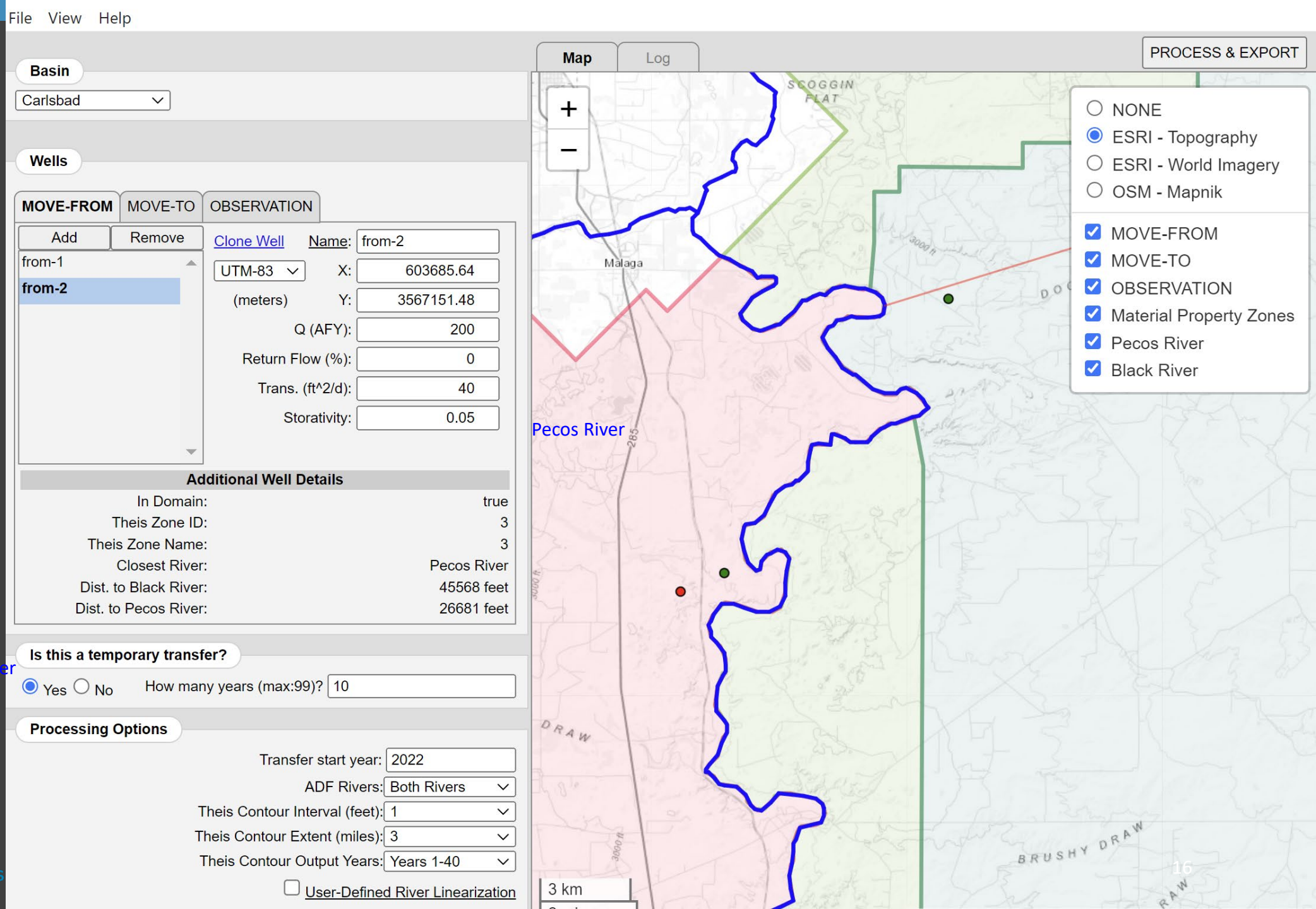
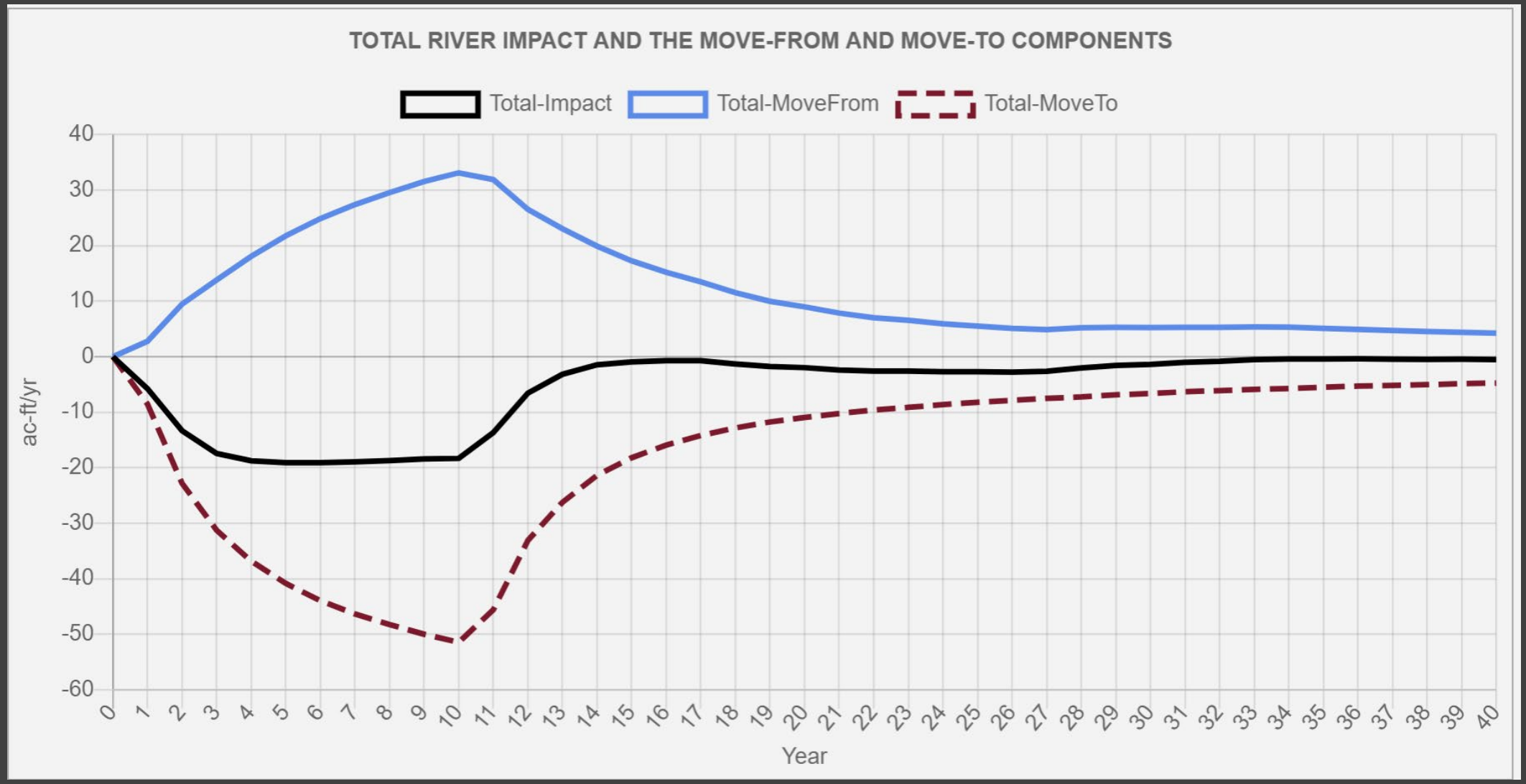
Ani Example

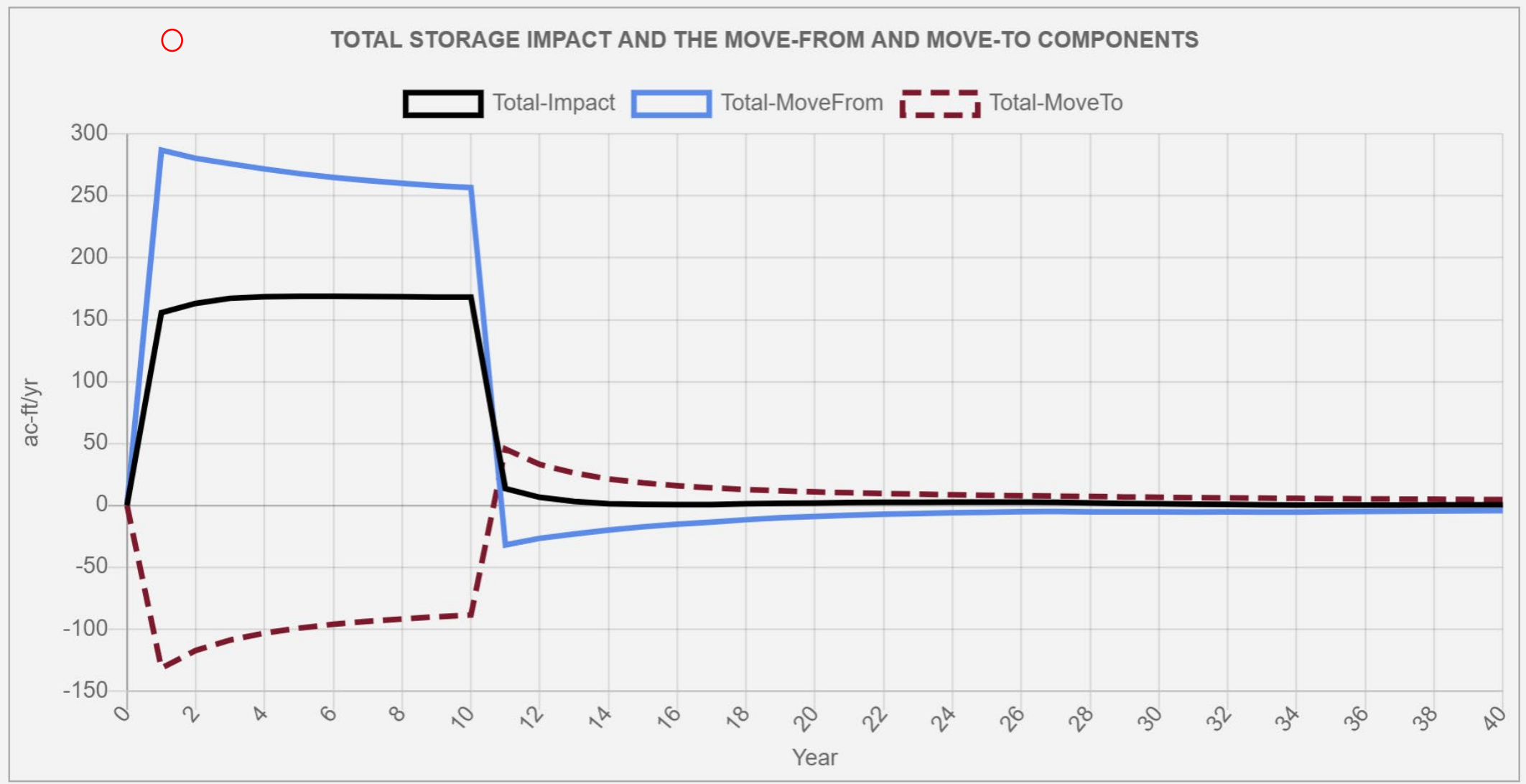
- 10-year tranfer
- Two Move-From and Move-To
- Different: pumping, return, sides, properties,



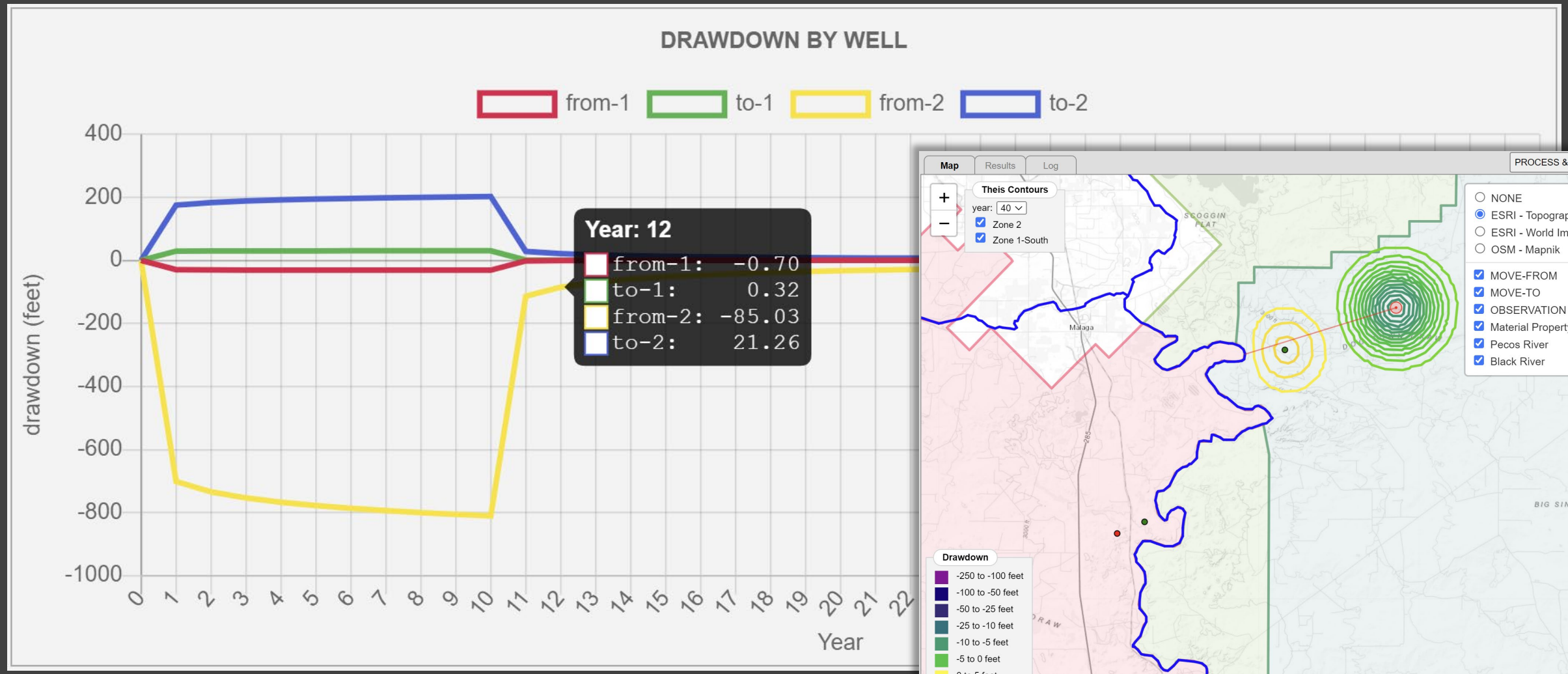
Total River Impact

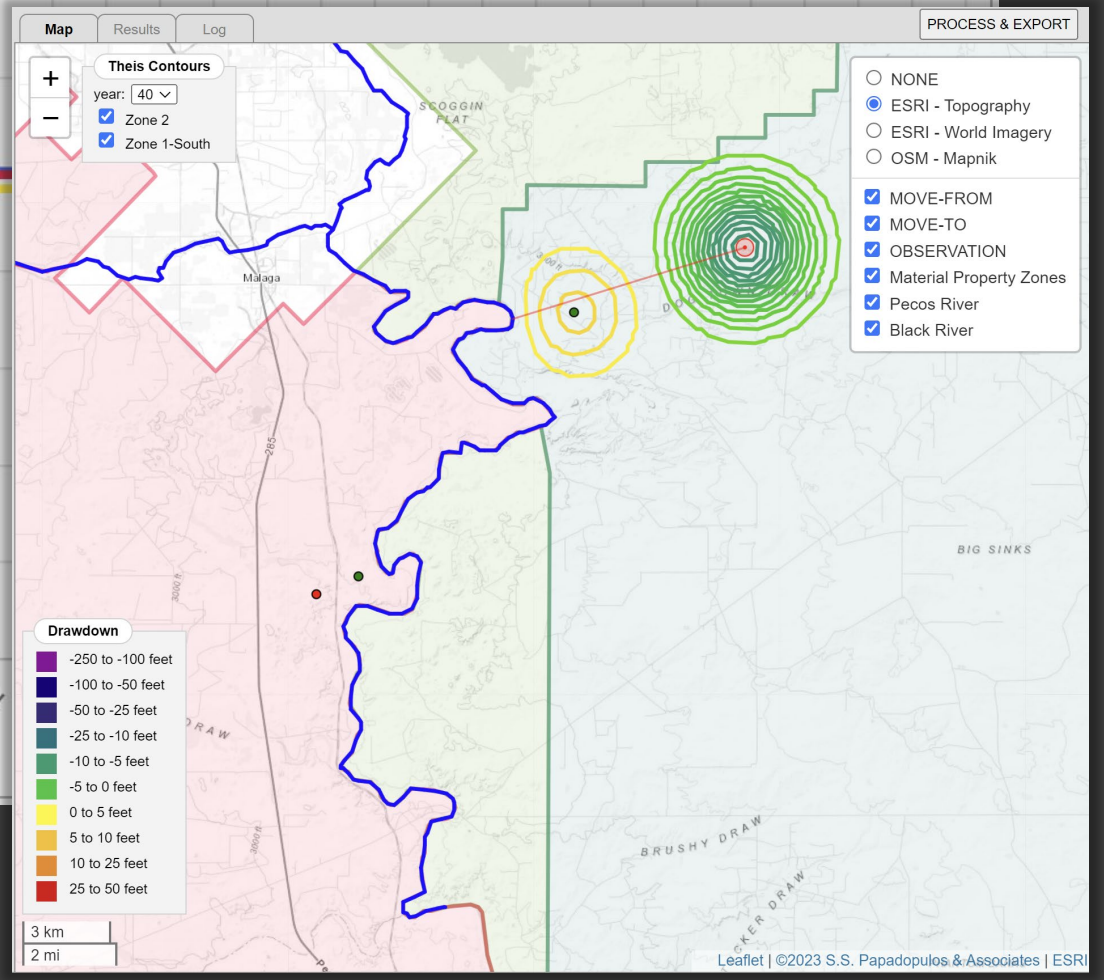


Total Storage Impact (residual term)



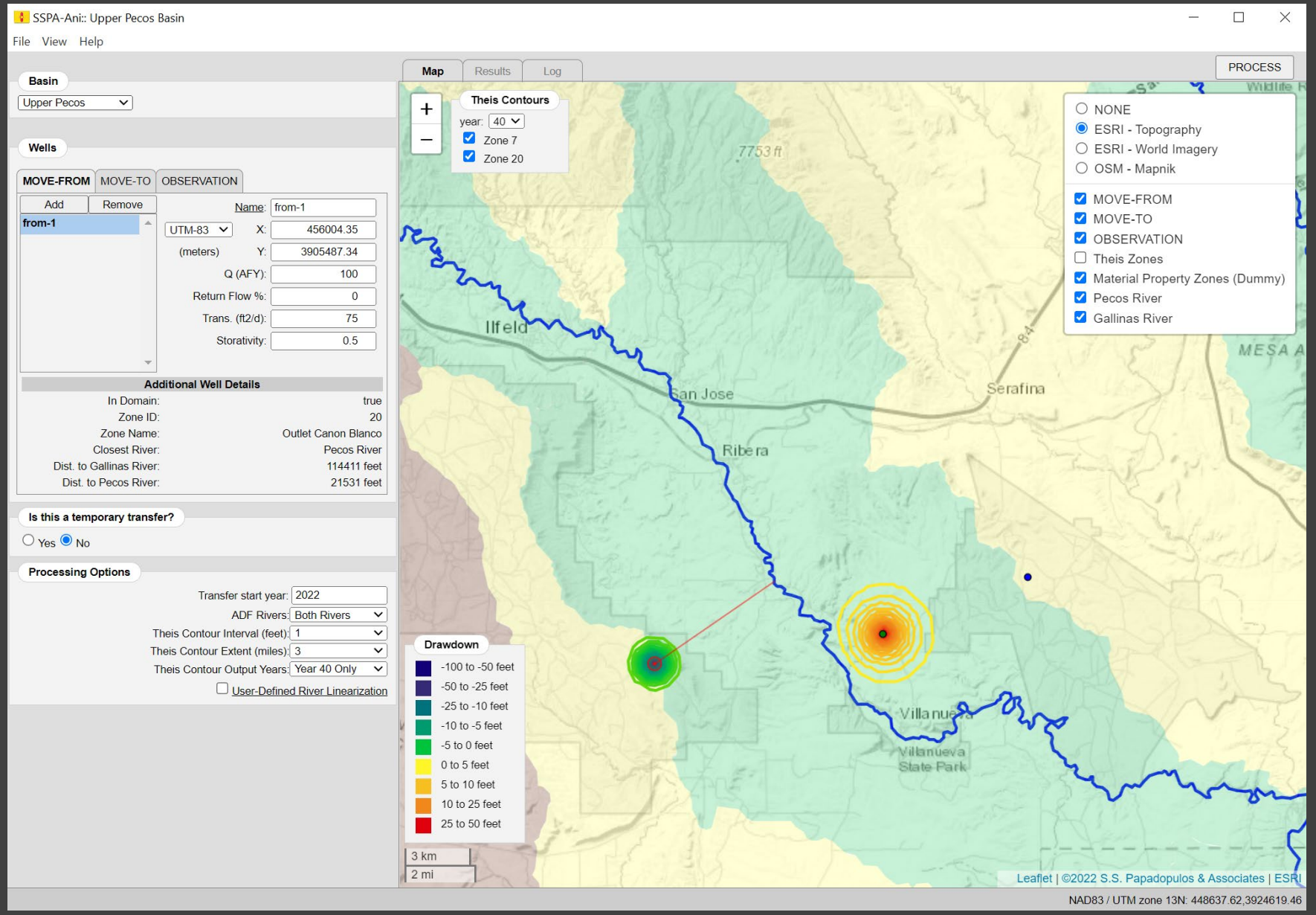
Drawdown Time Series





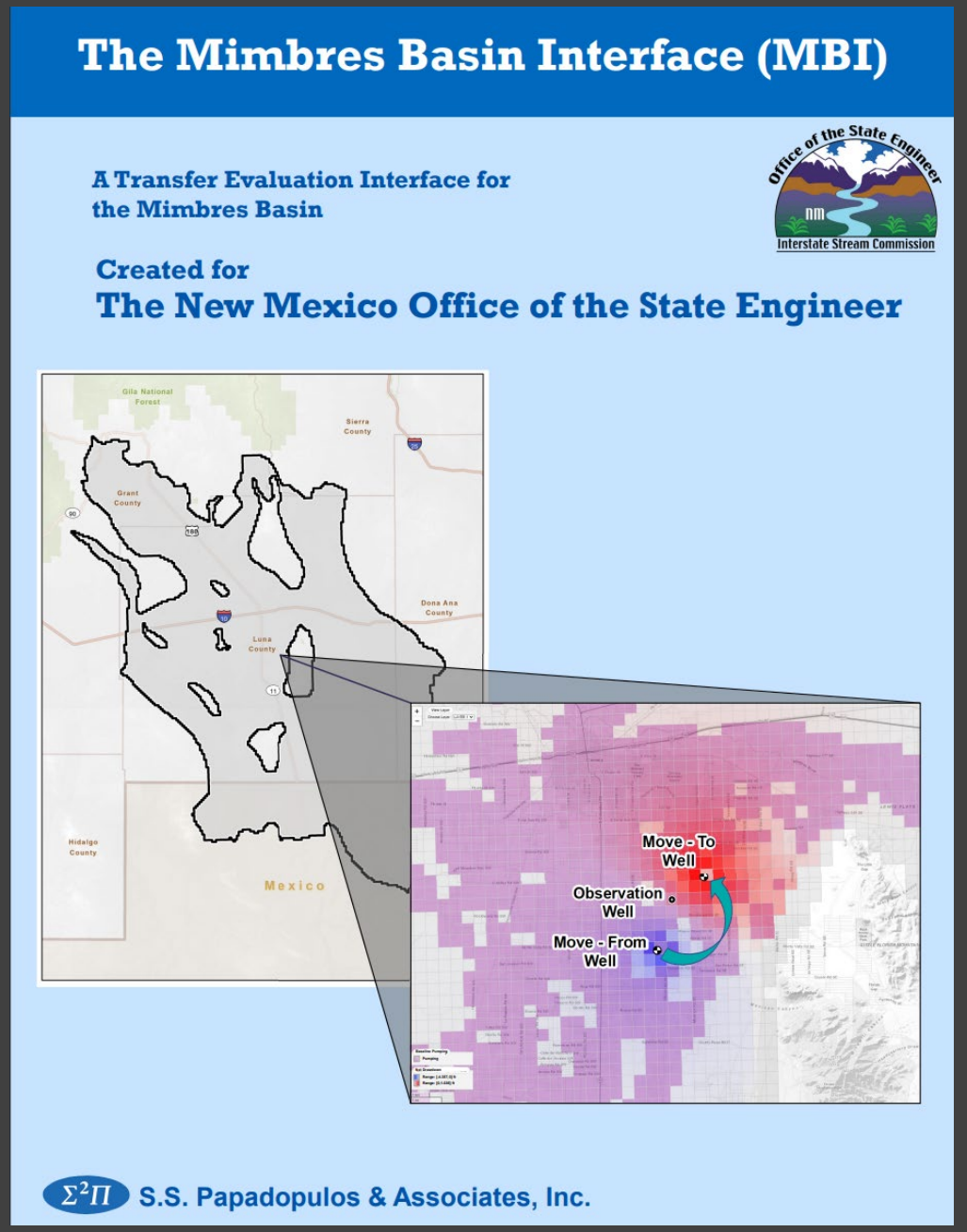
Ani (Analytical Interface)

- Upper Pecos Basin
- Move-From (left)
- Move-To (right)
- Theis results: mounding and drawdown contours



Mimbres Interface

- Move-From (left)
- Move-To (right)
- Numerical model results
  - mounding (blue shading)
  - drawdown (red shading)
- Purple shading indicates existing pumping
- Development continues…



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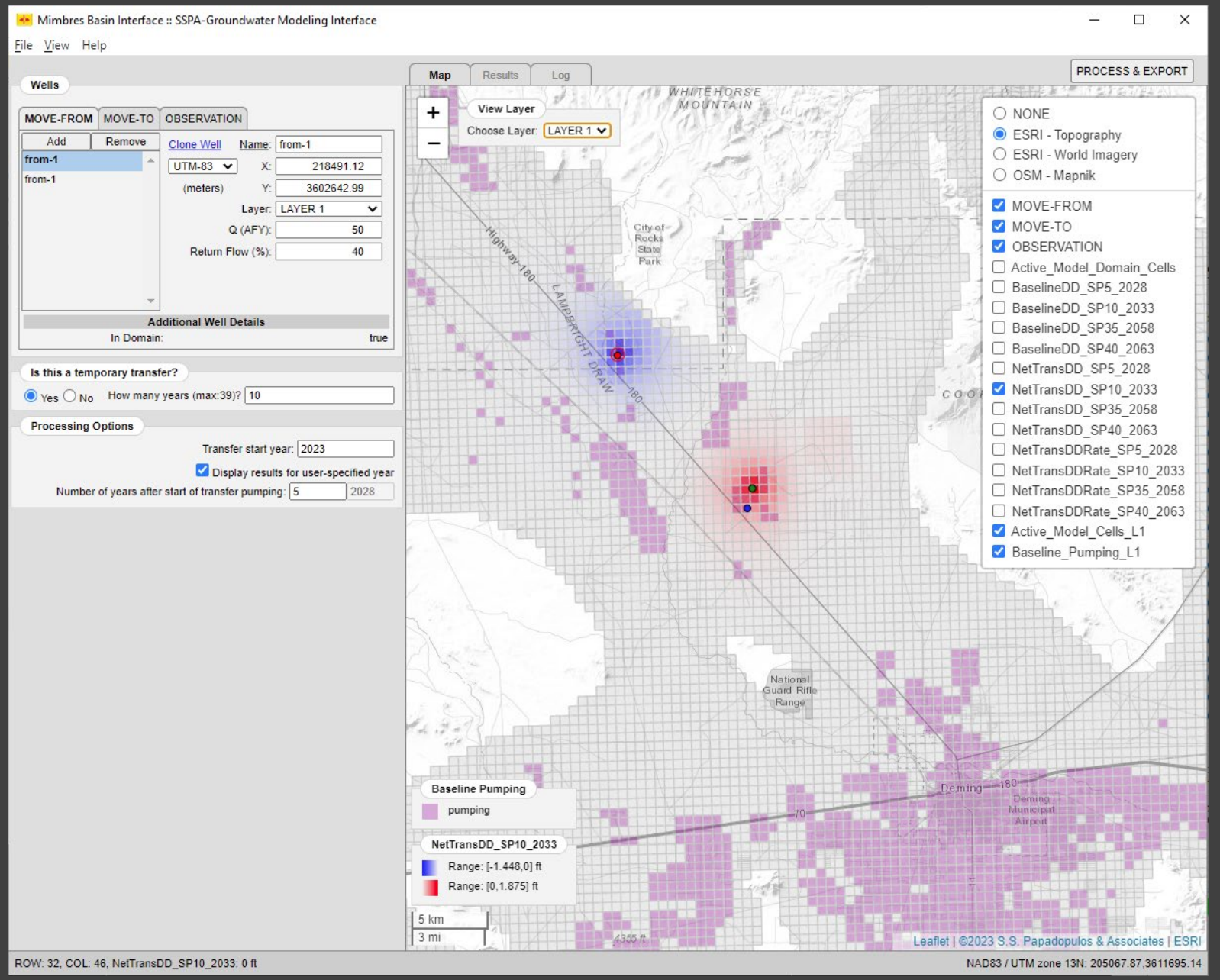
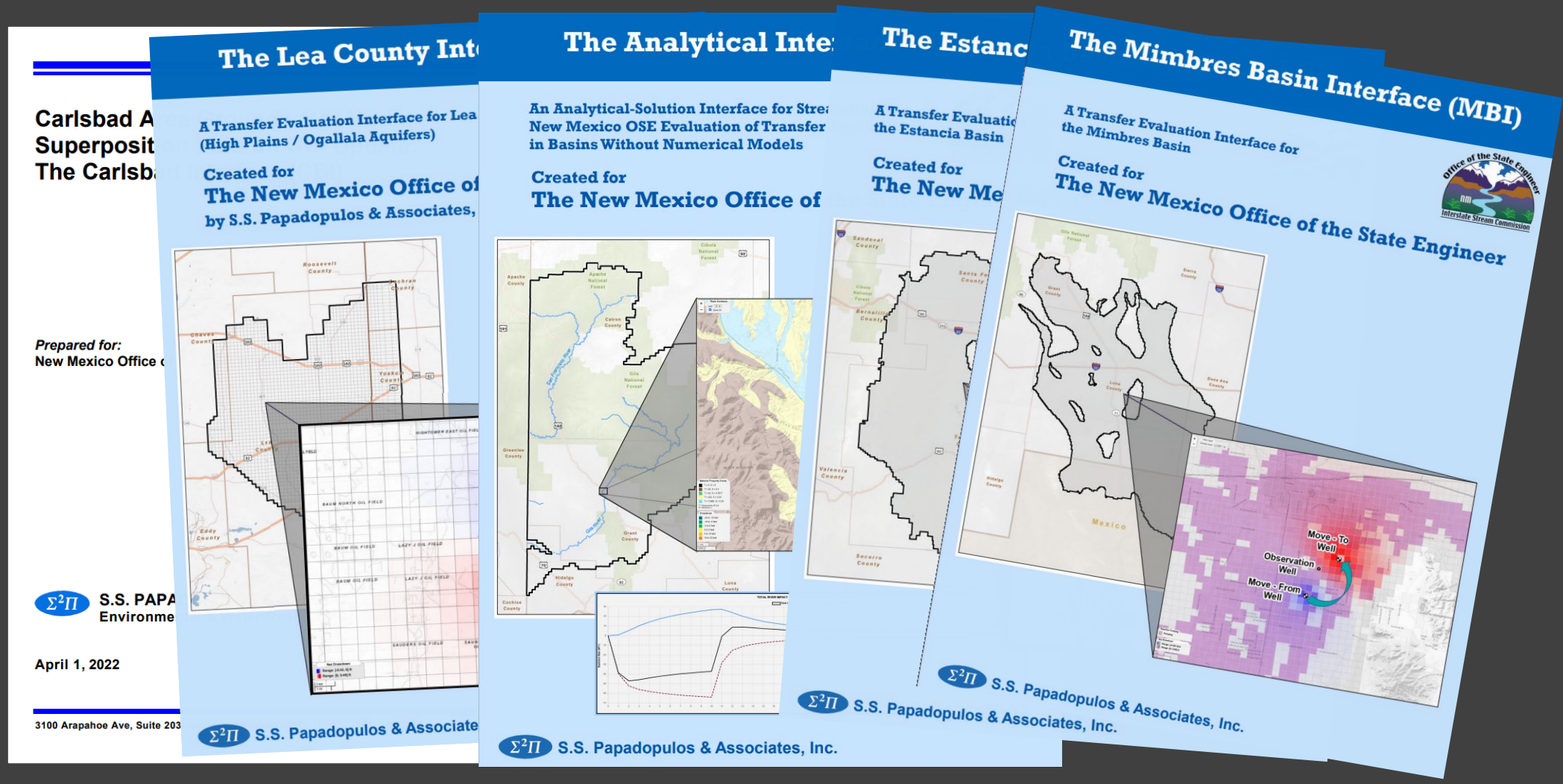


Existing Interfaces

(Includes ongoing development)

- Numerical
  - Lea County
  - Estancia
  - Mimbres
- Analytical (Ani)
  - Carlsbad
  - Upper Pecos
  - Gila/San Francisco
- Hybrid
  - Carlsbad



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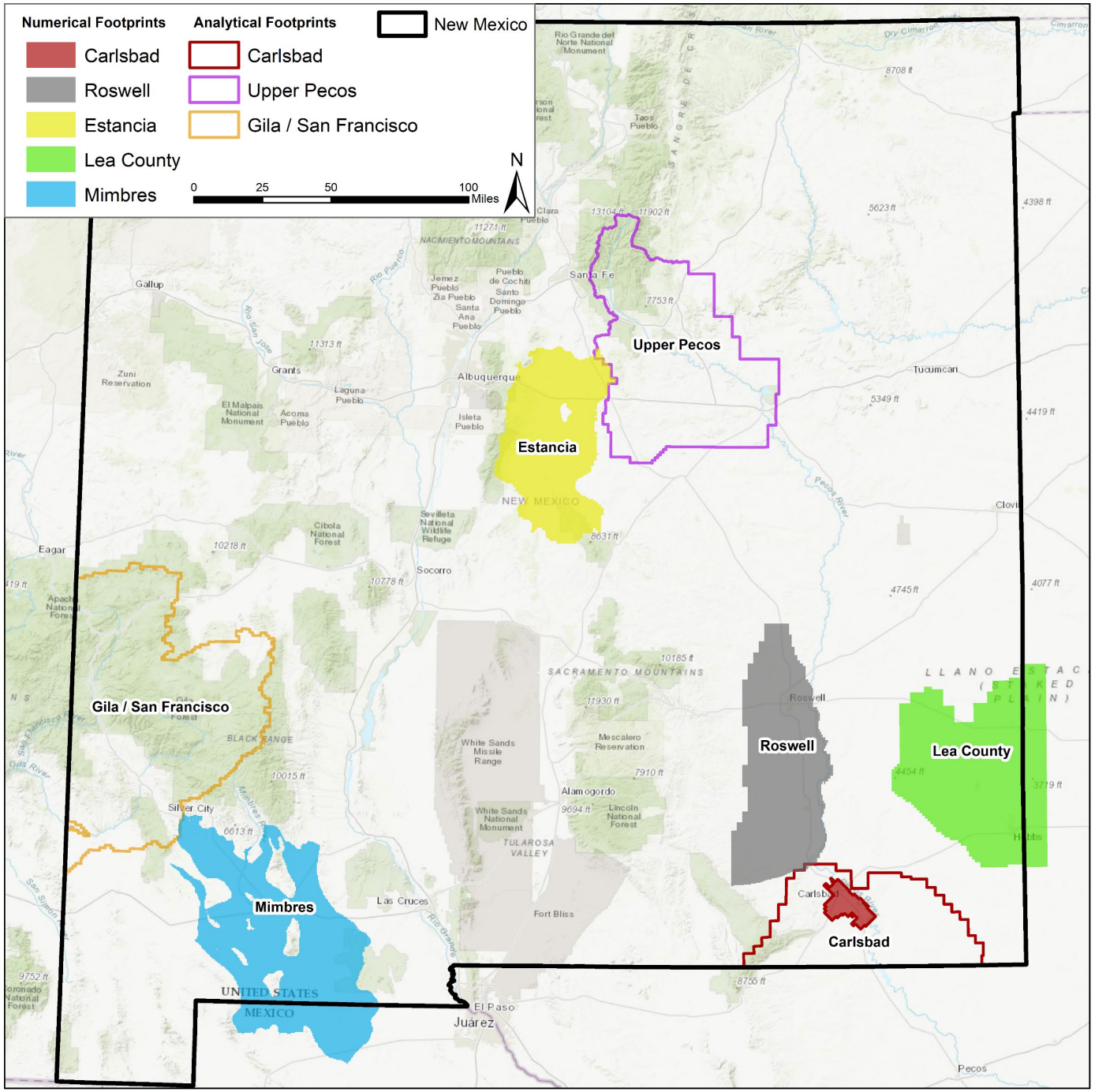
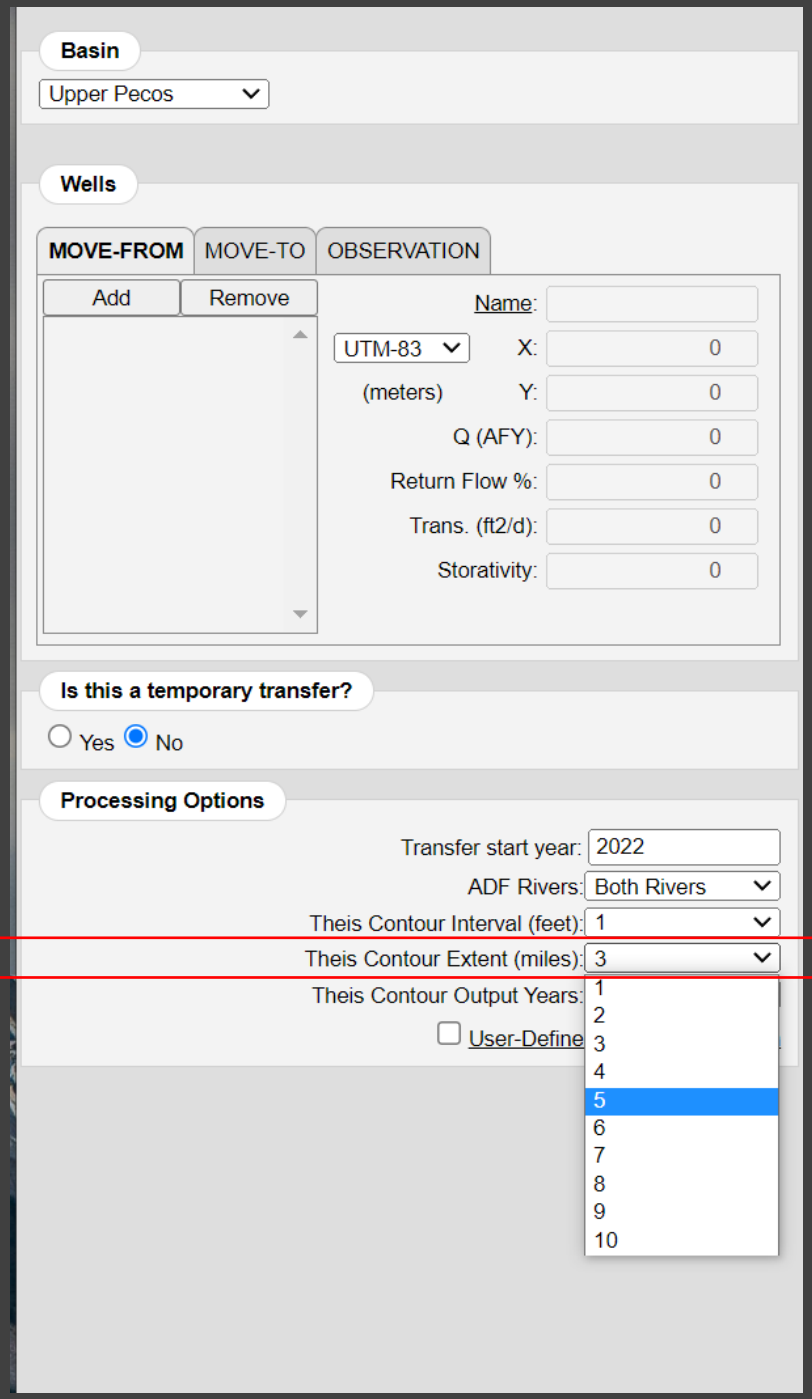


Other Features/Controls

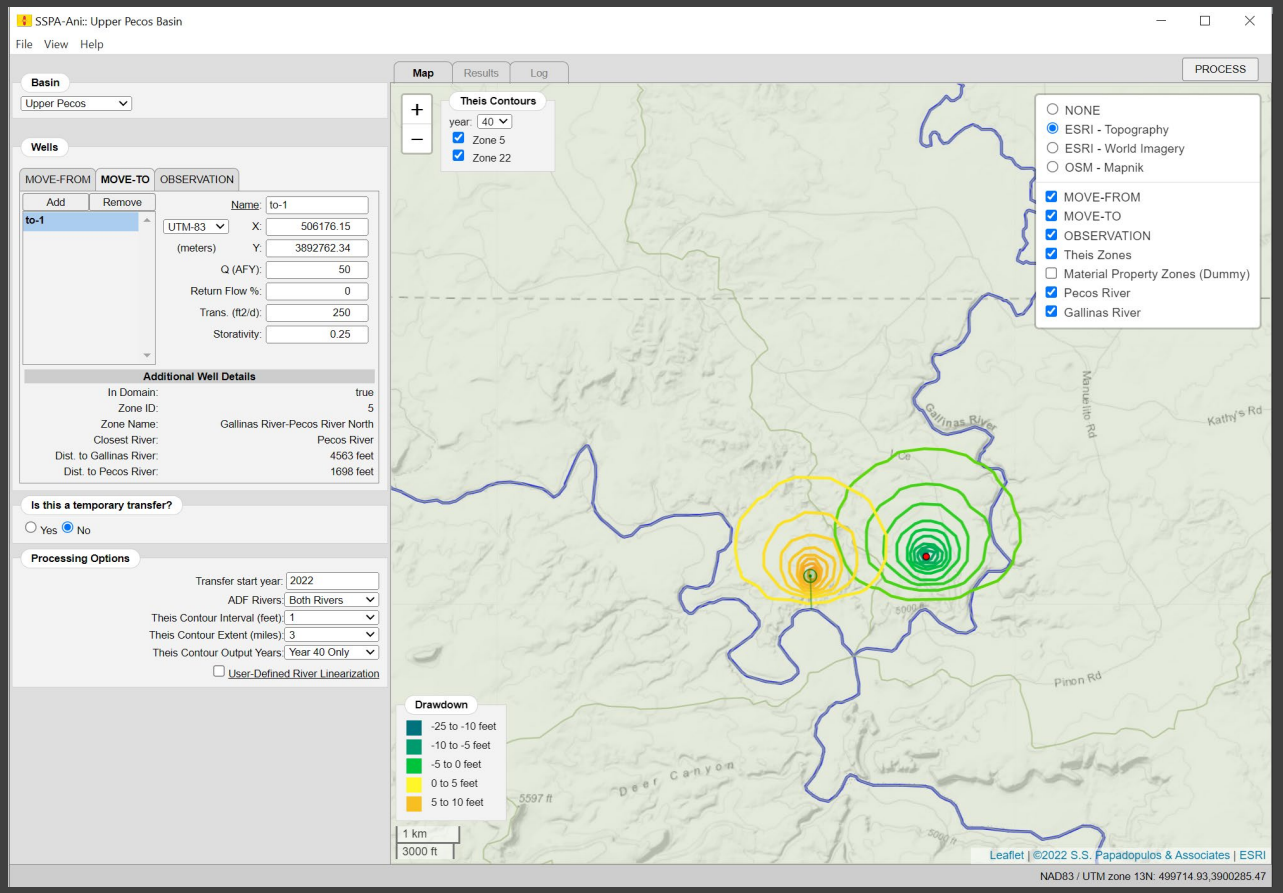
Contouring Extents

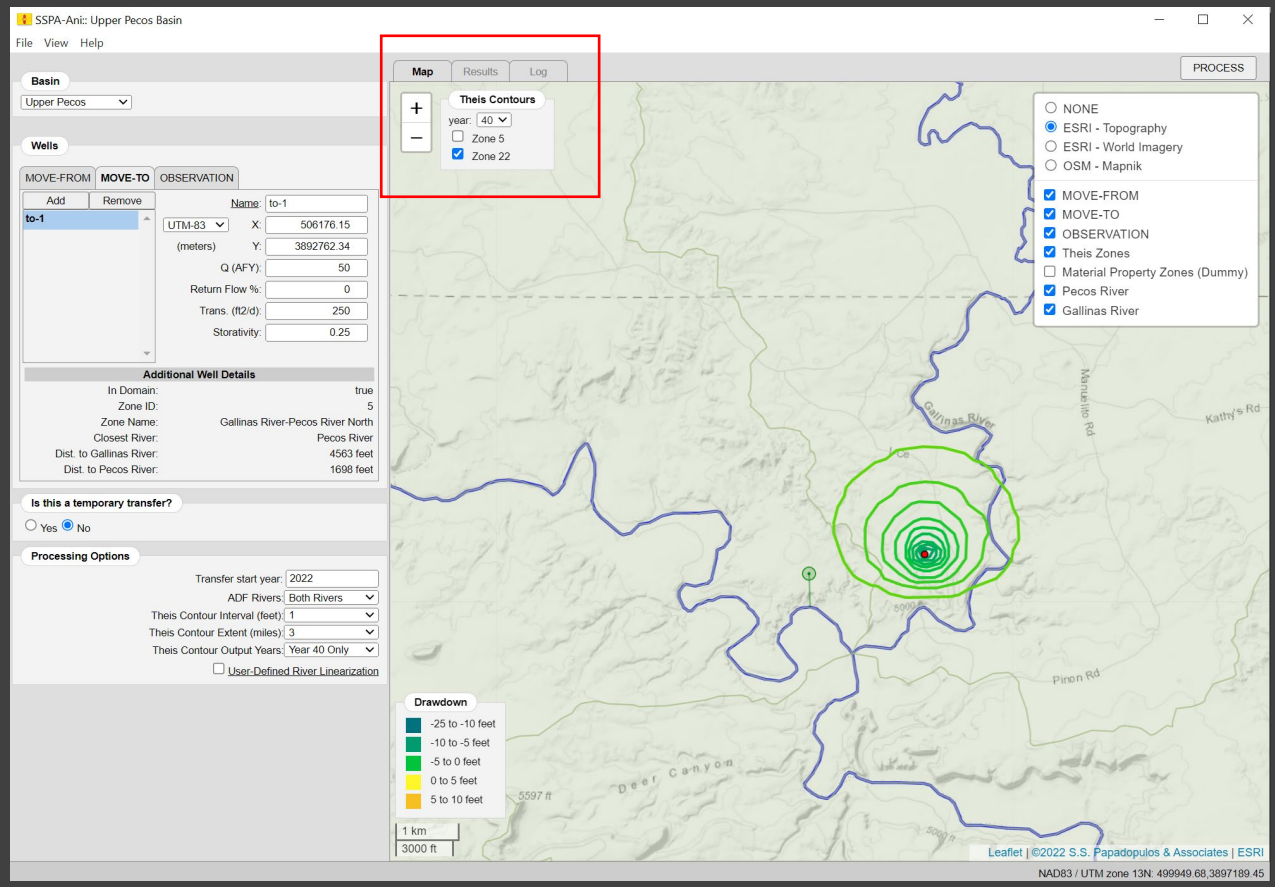
- Select limits drawdown contours
- Reduce computation time
- Decrease interval



Contour Display Control

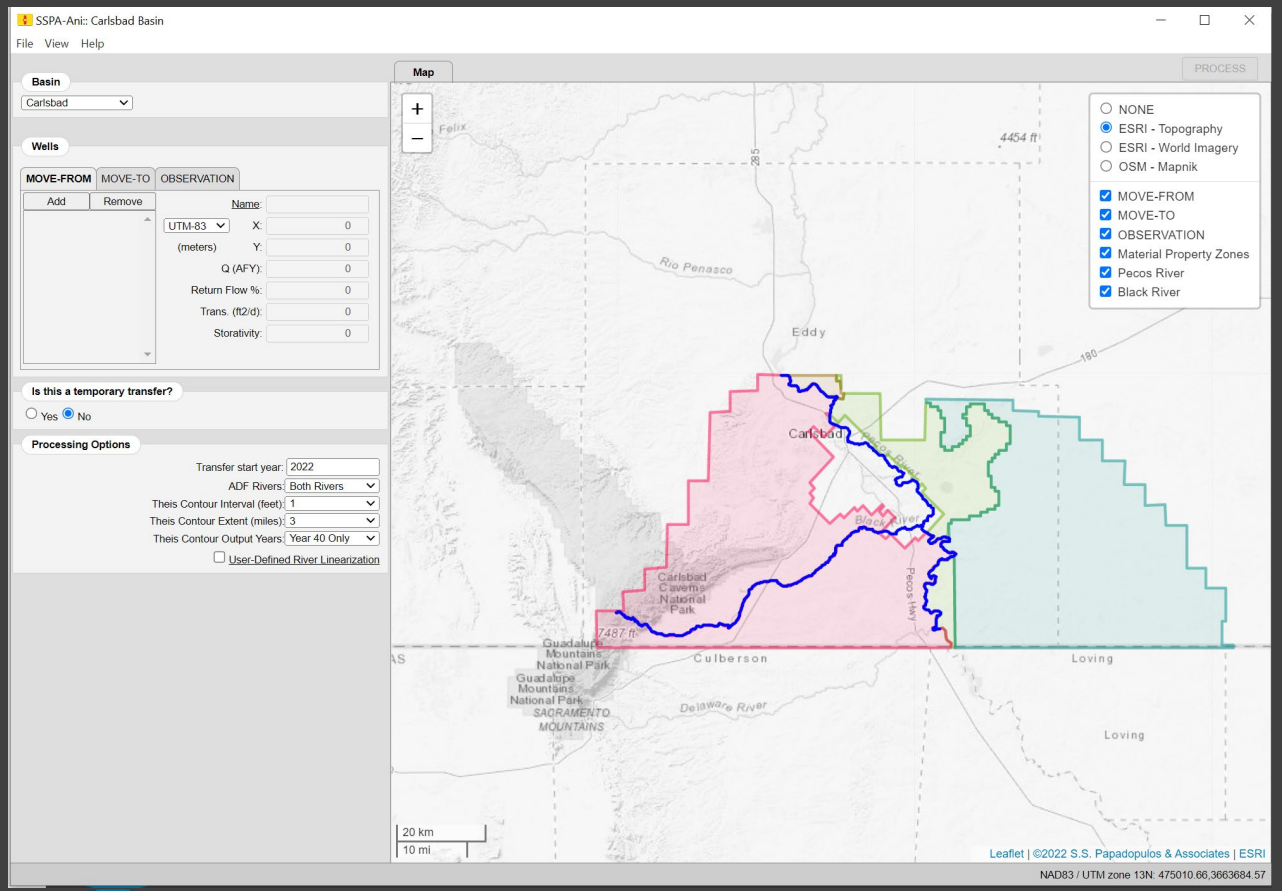
- Pumping wells across multiple Theis Zones
- Select individual zones for display

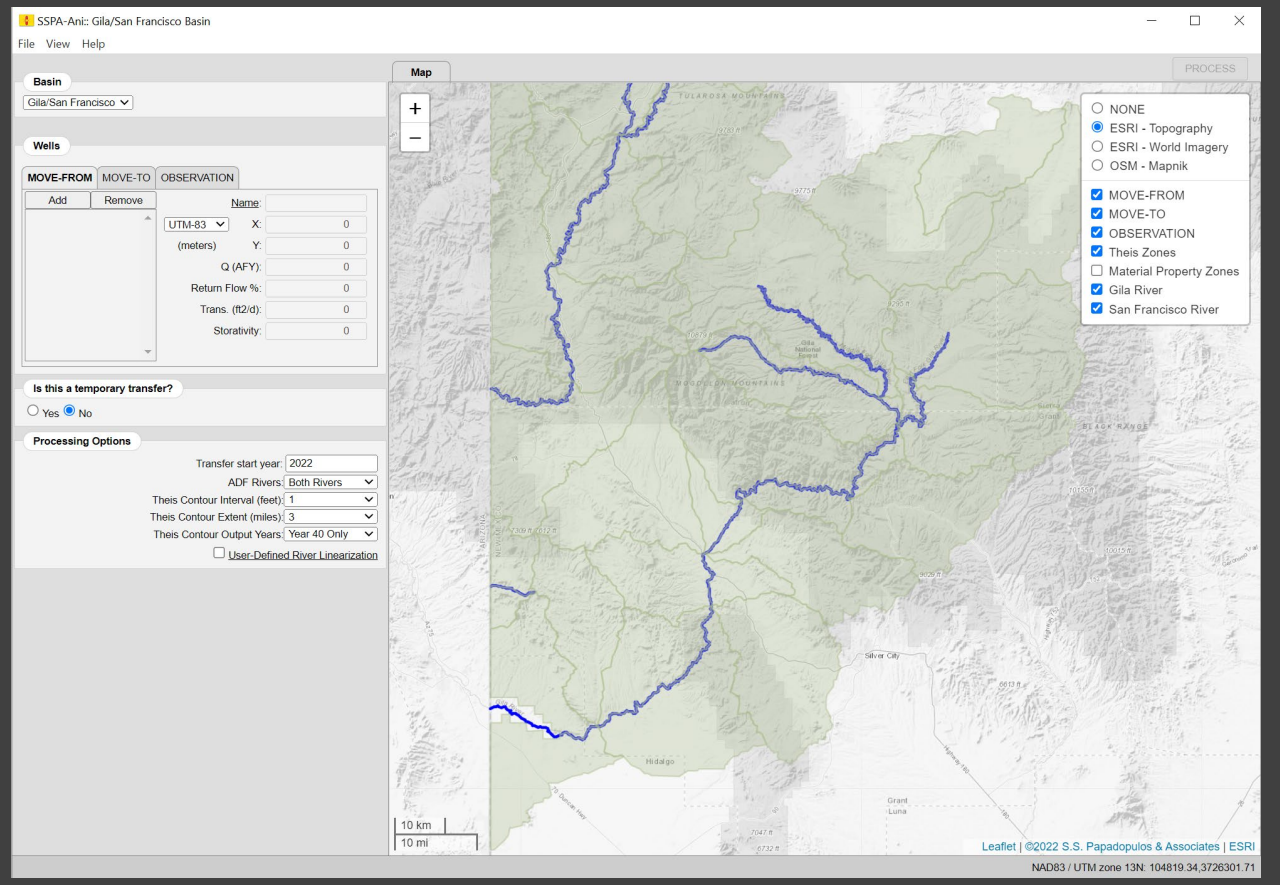




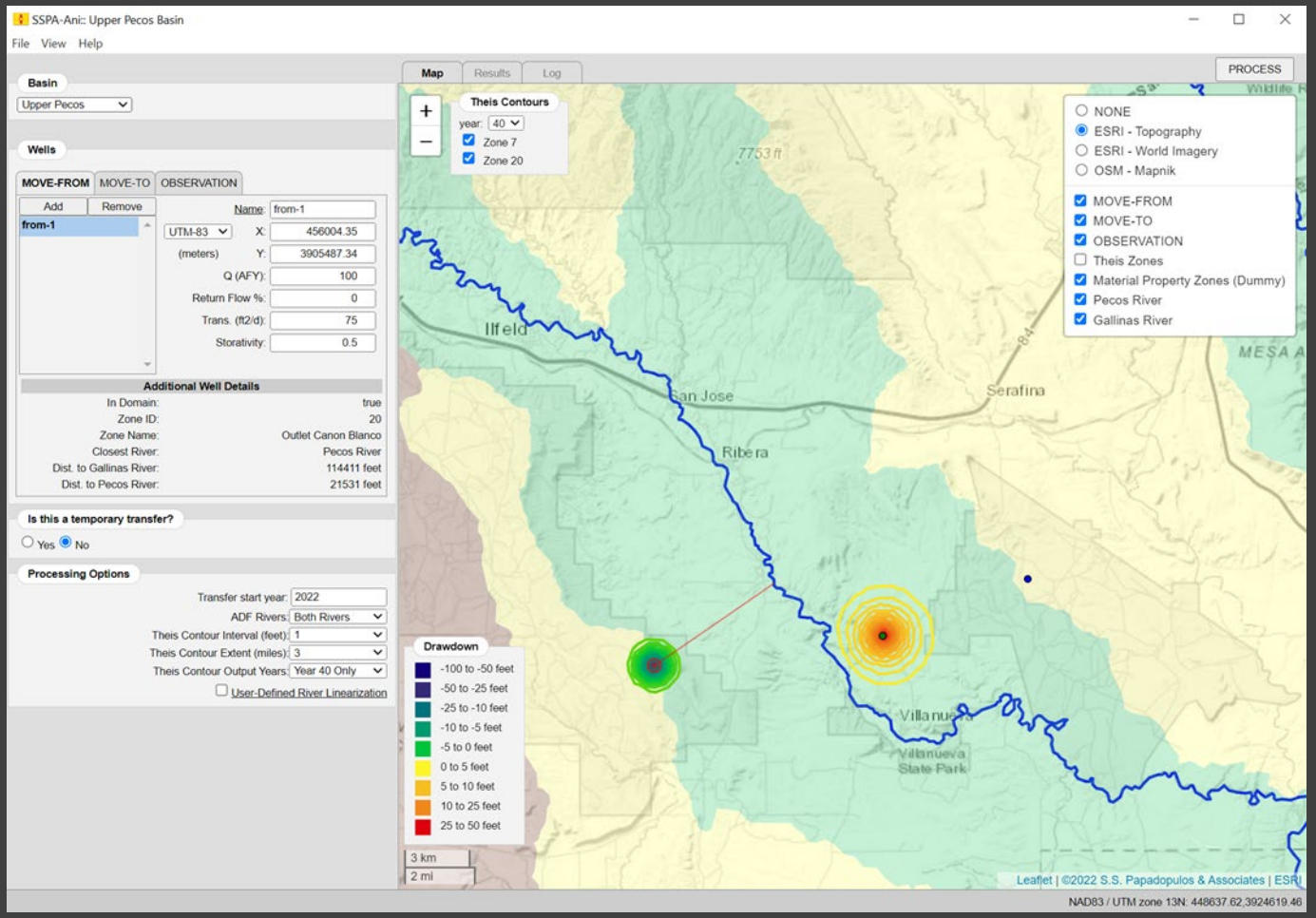
Map-based Hydraulic Properties

- Assign uniform properties within each “Theis Zone”
- Delineate extents with HUC-10, then simplify appropriately:
  - Surface geology maps
  - Local expertise

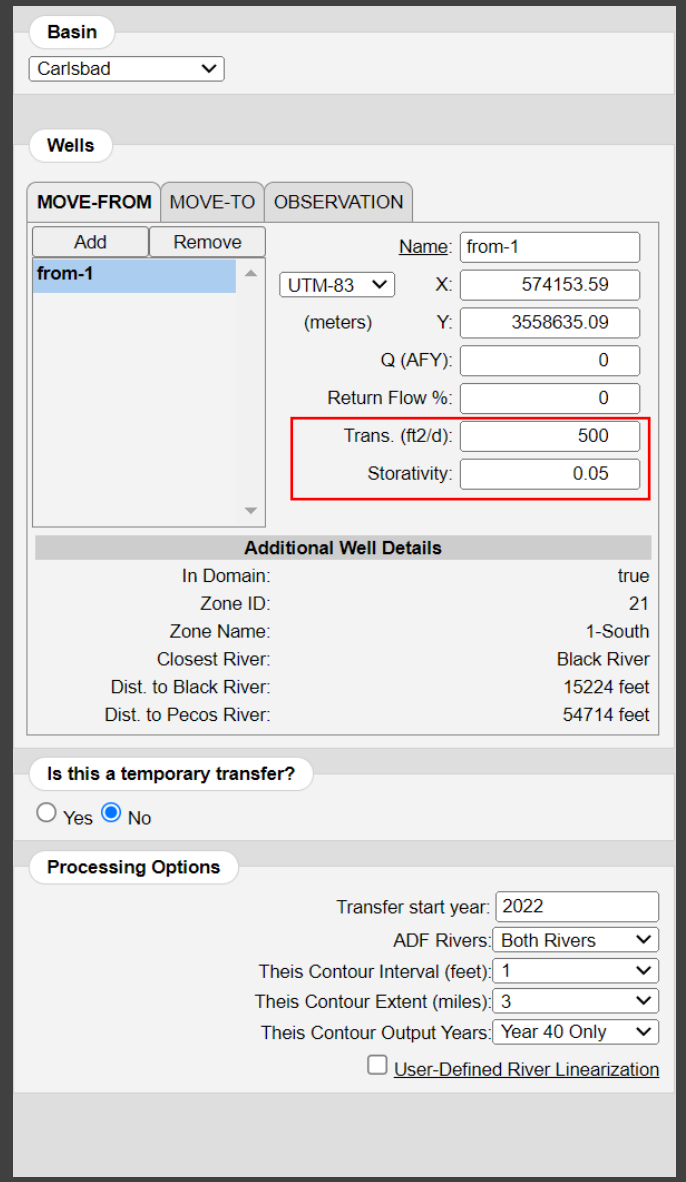




Hydraulic Properties



- Interface uses properties at the pumping well location
- Operator has the ability to override the map-based values: effective T/S for the site
- Developing-implementing map-based effective T/S values



Refinements in progress

- Improving Theis implementation
  - Coordinate transformation for stream
  - Superposition of Theis segments (Zipper Theis)
- Continue expanding messaging (e.g., zone-limited drawdown)
- Effective hydraulic properties
- Other post-processing, evaluating other boundary conditions

Process

- Identify the needs
- Develop the tool
- Test and document assumptions
- Train users (use and limitations)
- Employ: investigate, forensics and iterate
  - Refine the question…

Questions

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