

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. PAPADOPOULOS
& 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 *GMH*

FROM: Eric Keyes, Hydrologist, Hydrology Bureau *ESK*

SUBJECT: [REDACTED] and [REDACTED] Application, C-[REDACTED], C-[REDACTED] and C-[REDACTED]
[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.

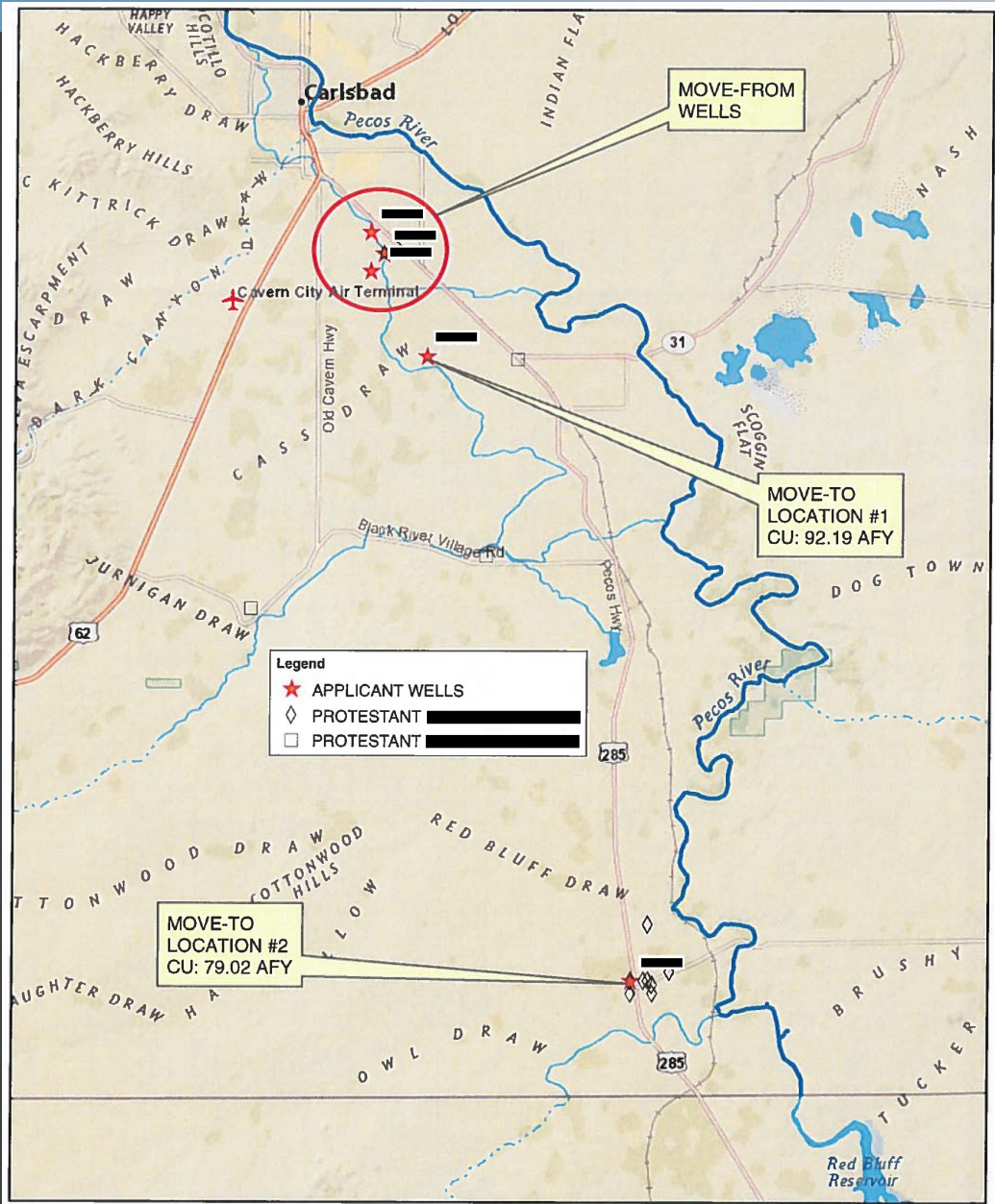
The move-from and the move-to #1 (C-[REDACTED]) are in the Carlsbad Basin. The Carlsbad Basin is administered with a consumptive irrigation requirement (CIR) of 2.1 acre-feet/acre.

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

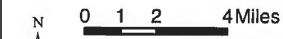
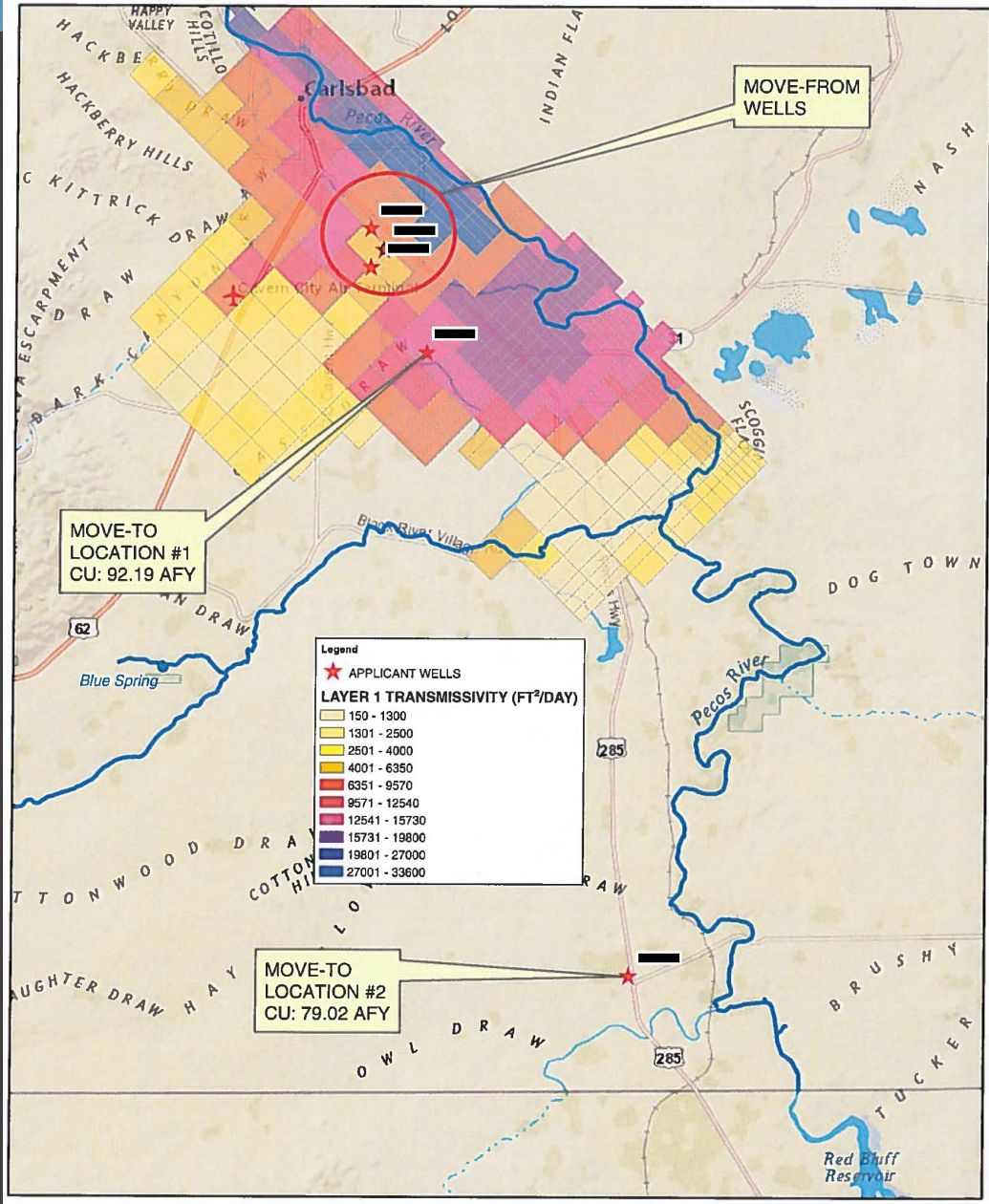


FIGURE 1
LOCATION MAP

FOR THE [REDACTED] SALES APPLICATION
 C-[REDACTED], C-[REDACTED] & C-[REDACTED] COMBINED INTO C-[REDACTED] & C-[REDACTED]

MAP AREA





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

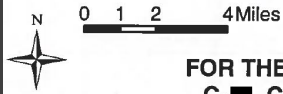


FIGURE 2
MODEL LOCATION

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

MAP AREA

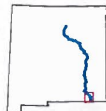


FIGURE 3
TOTAL PECOS RIVER IMPACT AND THE MOVE-FROM AND MOVE-TO COMPONENTS
FOR THE ██████████ 10-YEAR TEMPORARY TRANSFER TO MOVE-TO #1, C-█████████

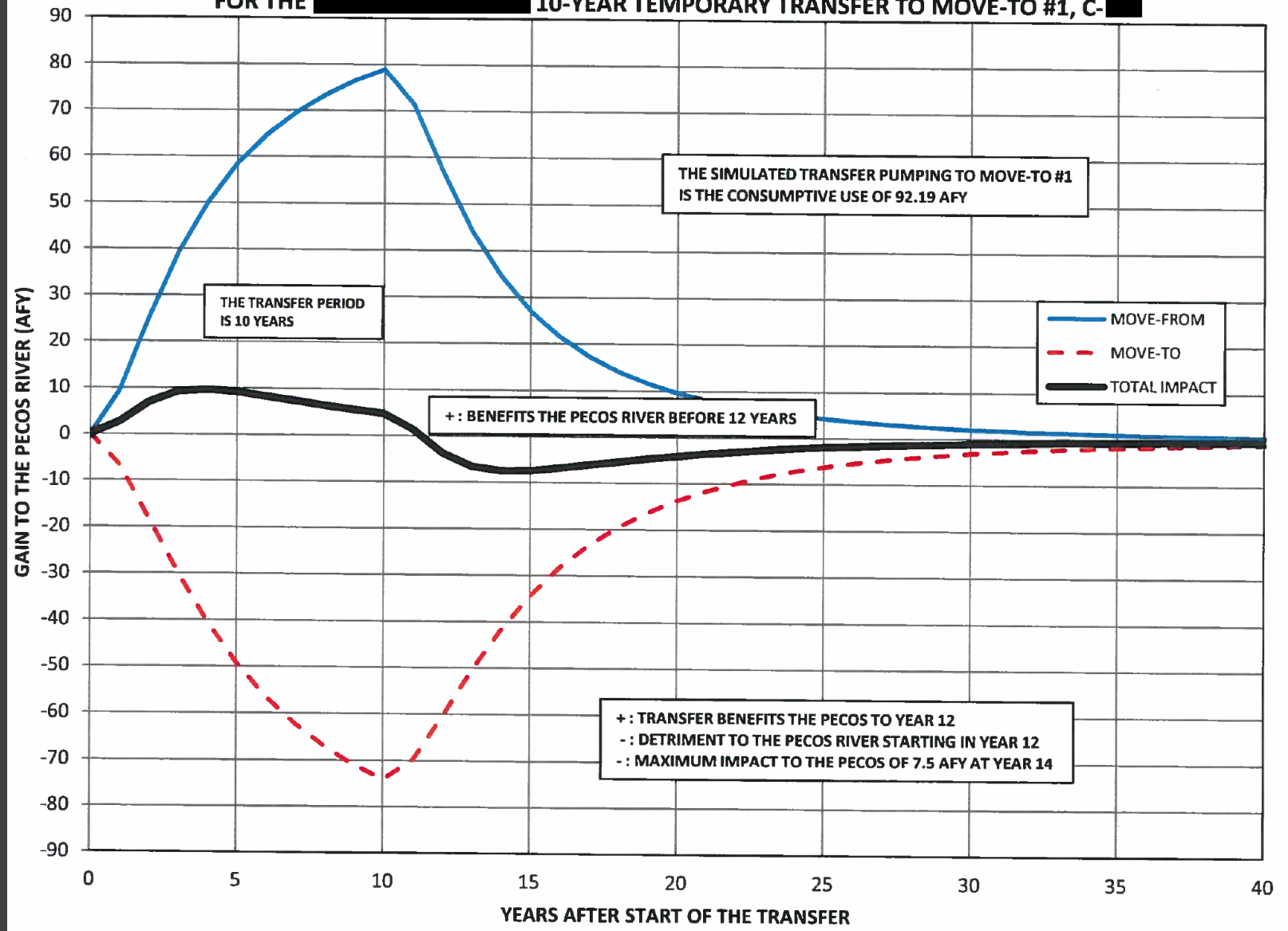
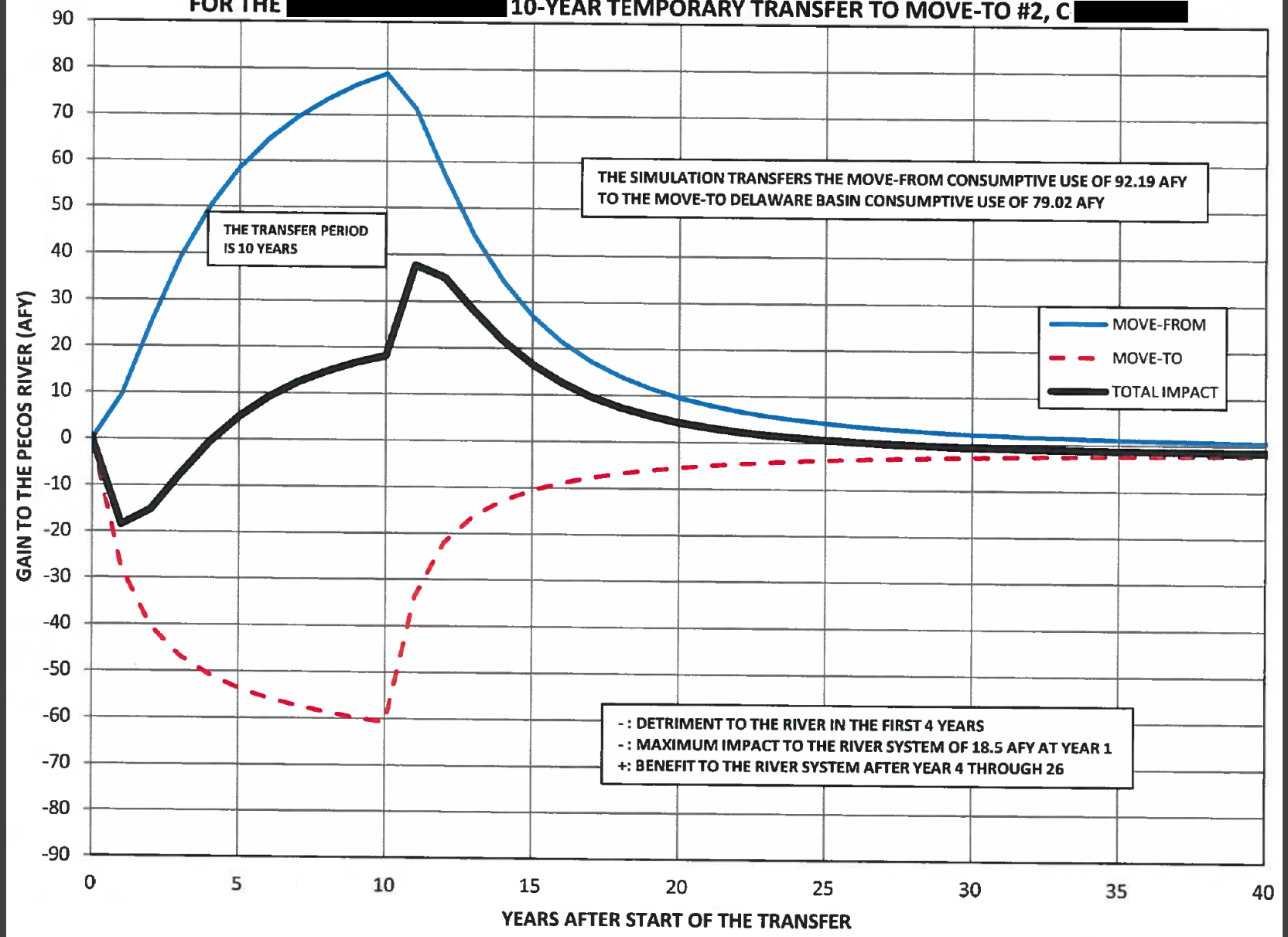
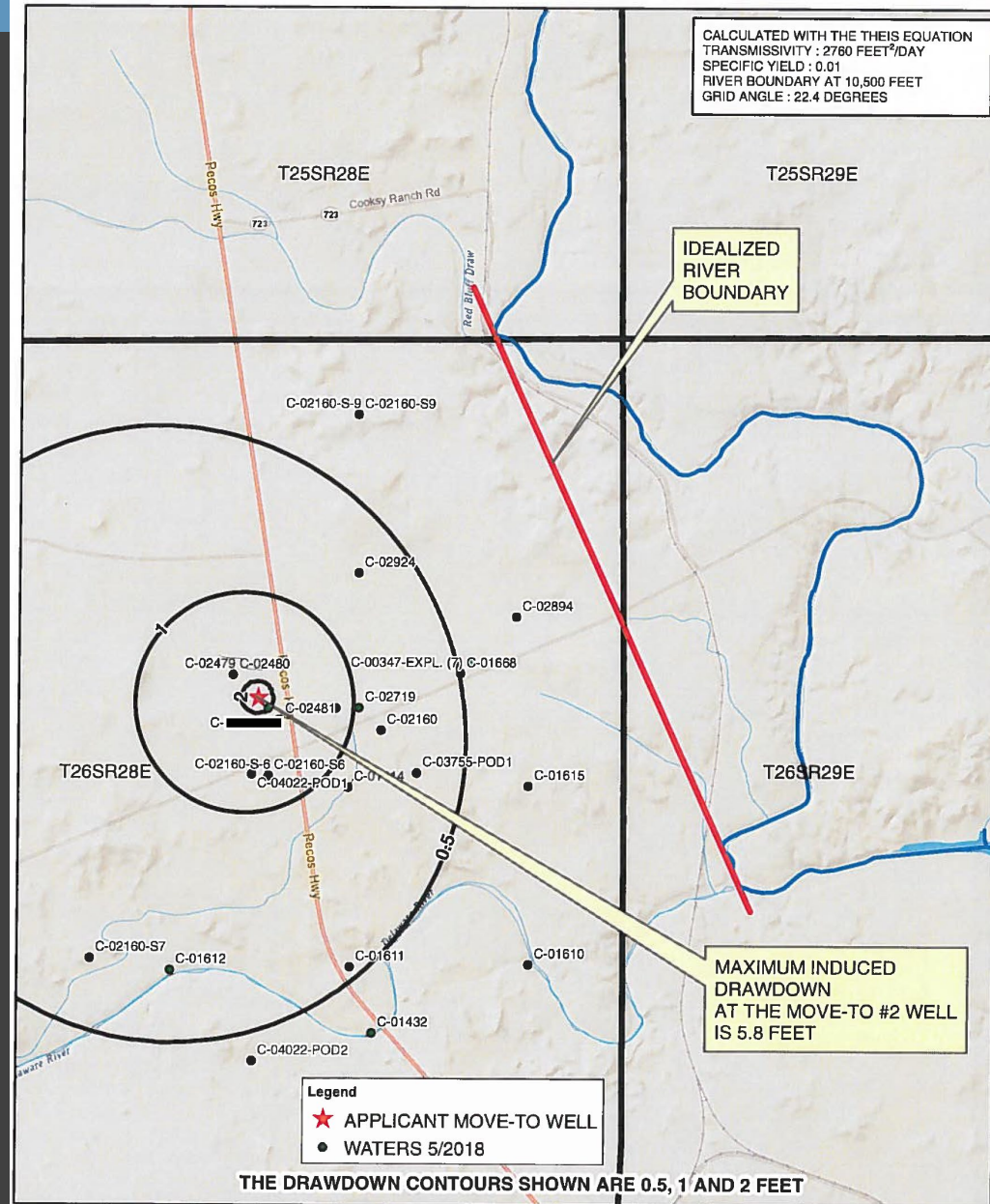


FIGURE 4
TOTAL RIVER IMPACT AND THE MOVE-FROM AND MOVE-TO COMPONENTS
FOR THE ██████████ 10-YEAR TEMPORARY TRANSFER TO MOVE-TO #2, C ██████████



CALCULATED WITH THE THEIS EQUATION
 TRANSMISSIVITY : 2760 FEET²/DAY
 SPECIFIC YIELD : 0.01
 RIVER BOUNDARY AT 10,500 FEET
 GRID ANGLE : 22.4 DEGREES



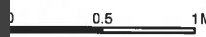
IDEALIZED RIVER BOUNDARY

MAXIMUM INDUCED DRAWDOWN AT THE MOVE-TO #2 WELL IS 5.8 FEET

Legend
 ★ APPLICANT MOVE-TO WELL
 ● WATERS 5/2018

THE DRAWDOWN CONTOURS SHOWN ARE 0.5, 1 AND 2 FEET

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

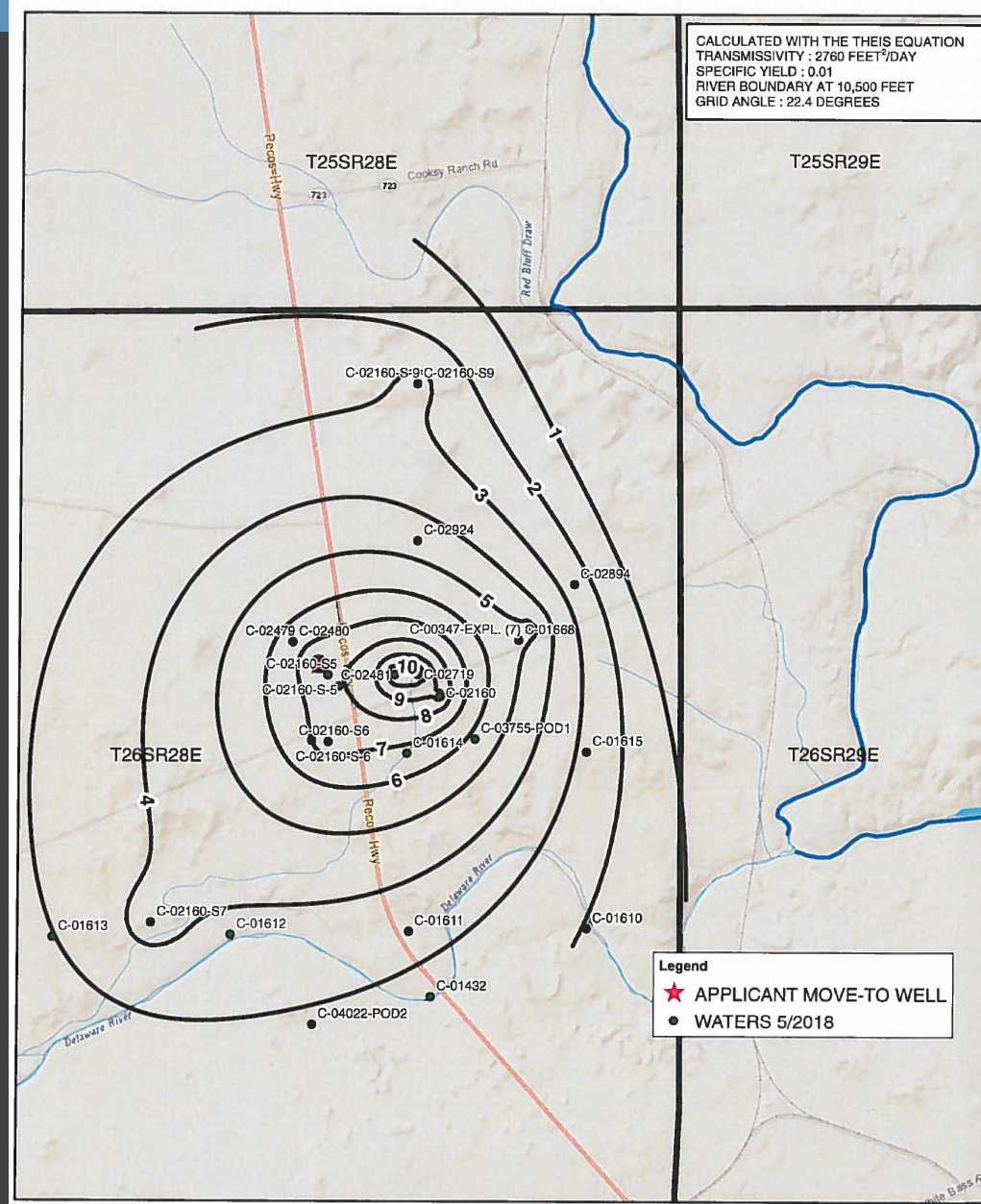


MAP AREA



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]

CALCULATED WITH THE THEIS EQUATION
 TRANSMISSIVITY : 2760 FEET²/DAY
 SPECIFIC YIELD : 0.01
 RIVER BOUNDARY AT 10,500 FEET
 GRID ANGLE : 22.4 DEGREES



SIMULATED FULLY DECLARED PUMPING OF 407 AFY

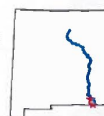
0 0.5 1 Miles



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]

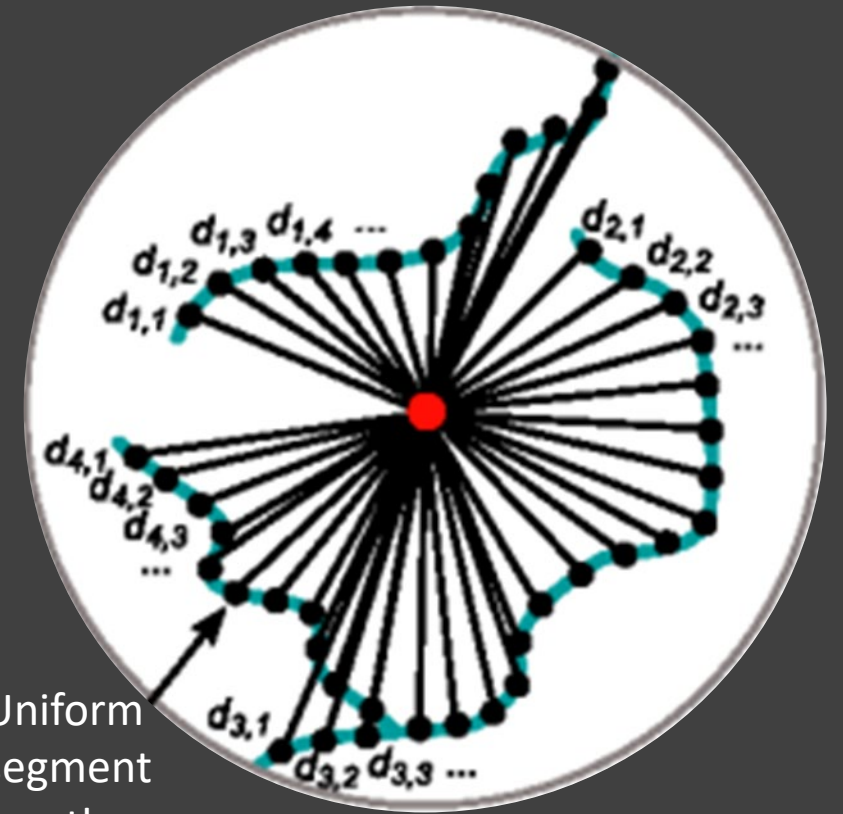
MAP AREA



What Does the Interface Need to Do?

Analytical: Glover Balmer

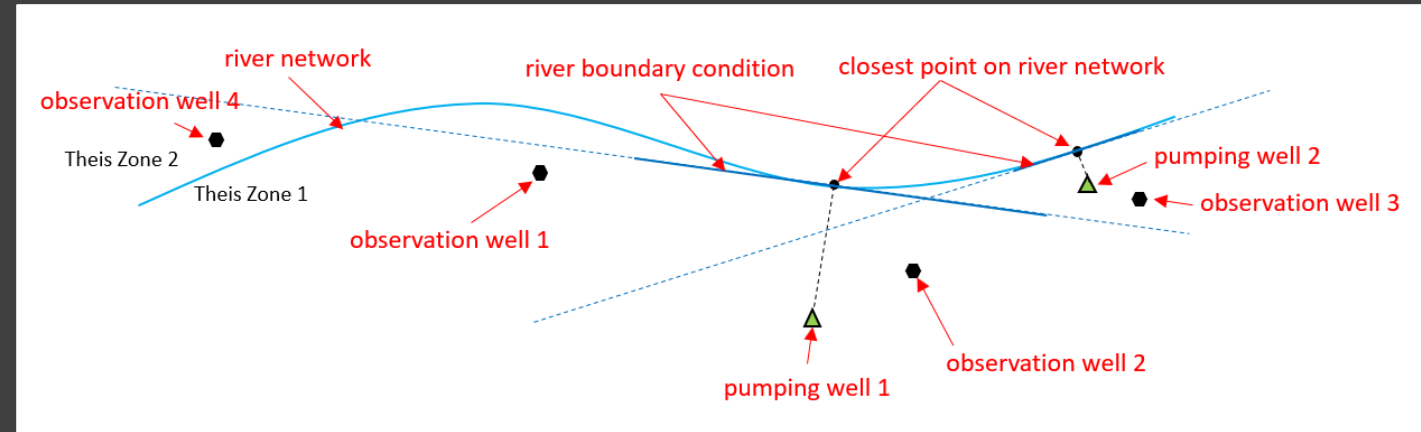
- Proportion of pumped which is captured stream flow
- Analytical Depletion Function (*Zipper et al., 2019*) approach
 - Streams broken into segments
 - Aggregate Glover Balmer from each included segment



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

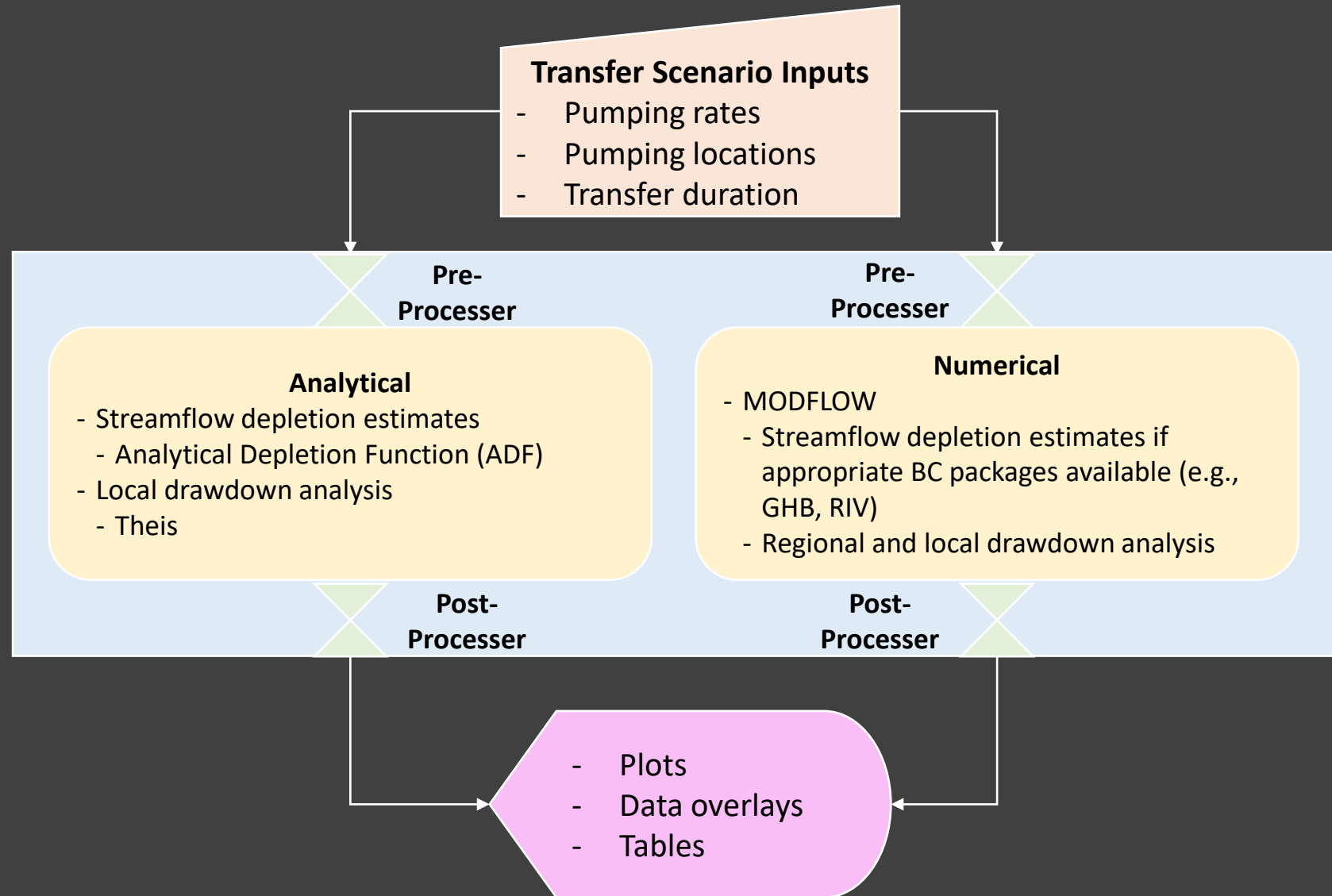
- Calibrated groundwater flow model
- Review of superposition assumptions
- Review objectives (isolated vs. projected)
- Baseline simulation
 - No pumping
 - Existing pumping
- Transfer simulation: baseline plus proposed pumping
- Net results
 - Drawdown
 - Depletion

Interface Schematic

- User inputs

- Methods/
Processing

- Graphical/
tabular outputs

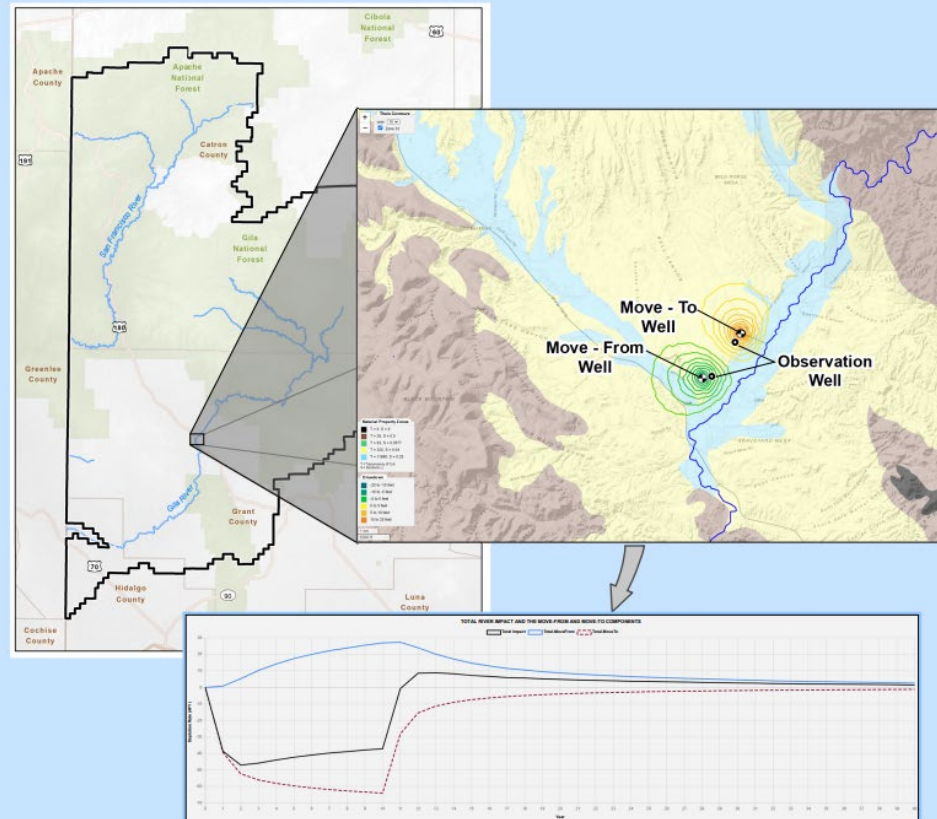


The Analytical Interface (Ani)

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



Created for
The New Mexico Office of the State Engineer



Ani Example

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

Black River

Map
Log
PROCESS & EXPORT

Basin

Carlsbad v

Wells

MOVE-FROM	MOVE-TO	OBSERVATION
Add	Remove	Clone Well Name: <input type="text" value="from-2"/>
from-1		UTM-83 v X: <input type="text" value="603685.64"/>
from-2		(meters) Y: <input type="text" value="3567151.48"/>
		Q (AFY): <input type="text" value="200"/>
		Return Flow (%): <input type="text" value="0"/>
		Trans. (ft ² /d): <input type="text" value="40"/>
		Storativity: <input type="text" value="0.05"/>

Additional Well Details

In Domain:	true
This Zone ID:	3
This Zone Name:	3
Closest River:	Pecos River
Dist. to Black River:	45568 feet
Dist. to Pecos River:	26681 feet

Is this a temporary transfer?

Yes No How many years (max:99)?

Processing Options

Transfer start year:

ADF Rivers: v

This Contour Interval (feet): v

This Contour Extent (miles): v

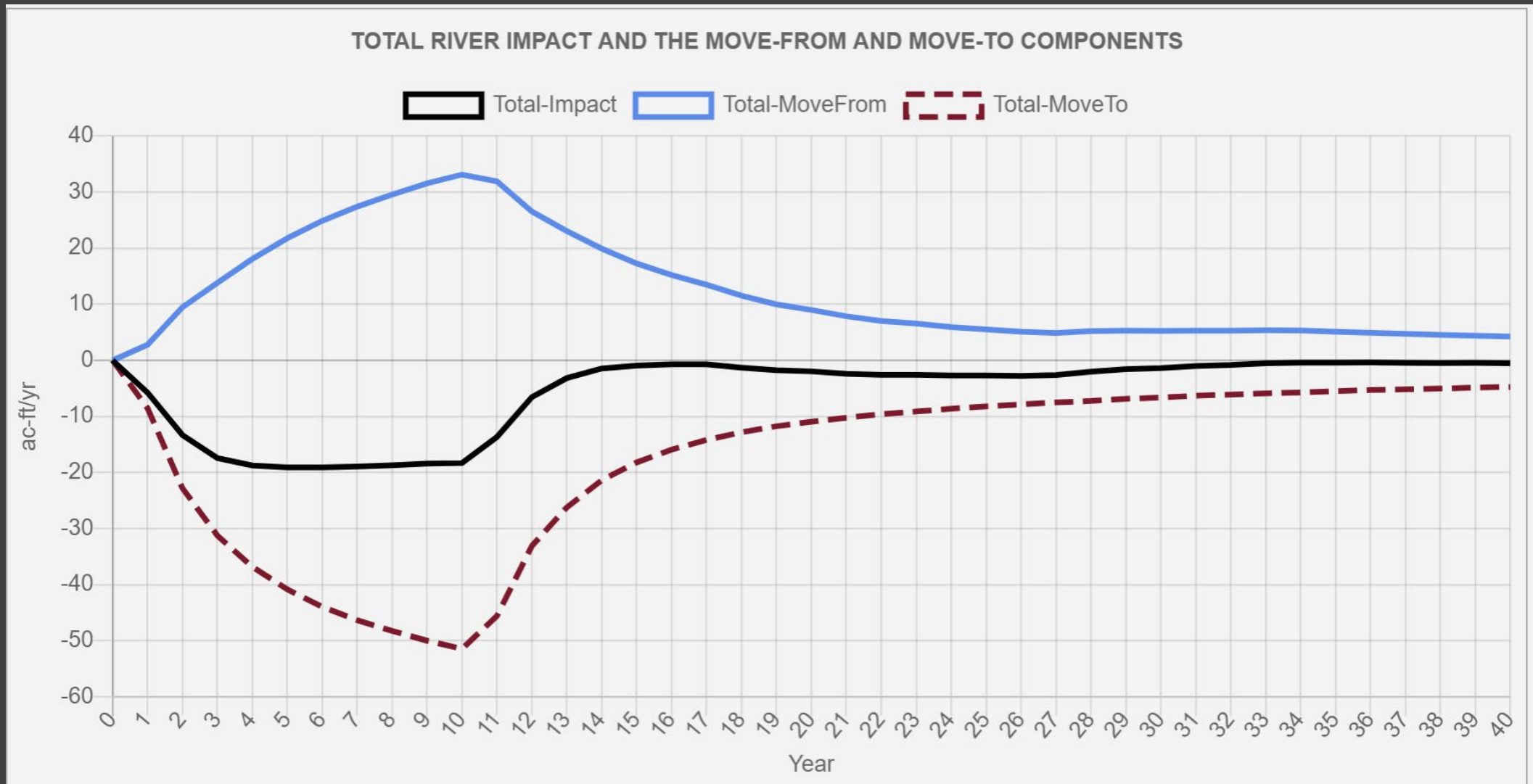
This Contour Output Years: v

User-Defined River Linearization

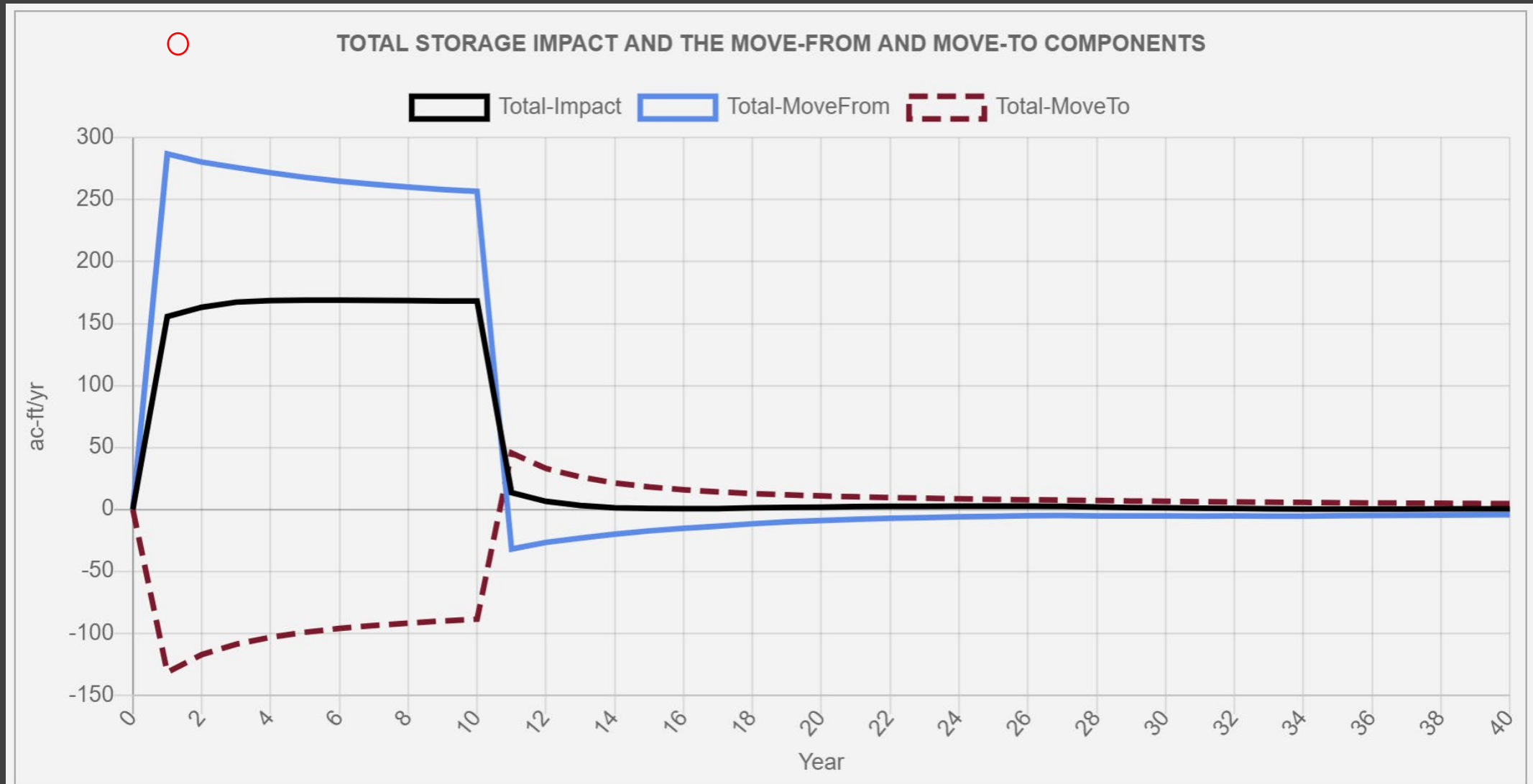
Legend:

- NONE
- ESRI - Topography
- ESRI - World Imagery
- OSM - Mapnik
- MOVE-FROM
- MOVE-TO
- OBSERVATION
- Material Property Zones
- Pecos River
- Black River

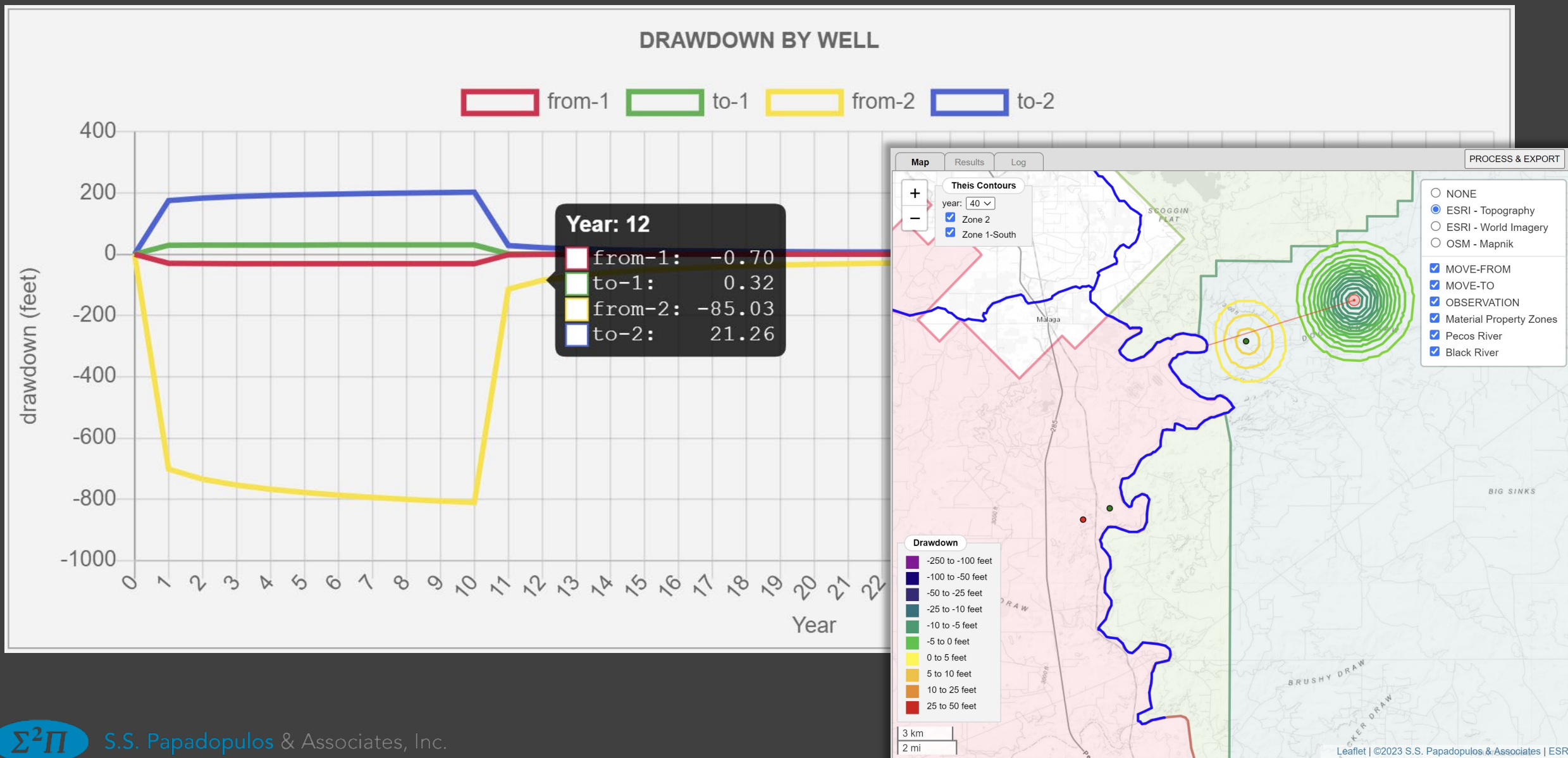
Total River Impact



Total Storage Impact (residual term)

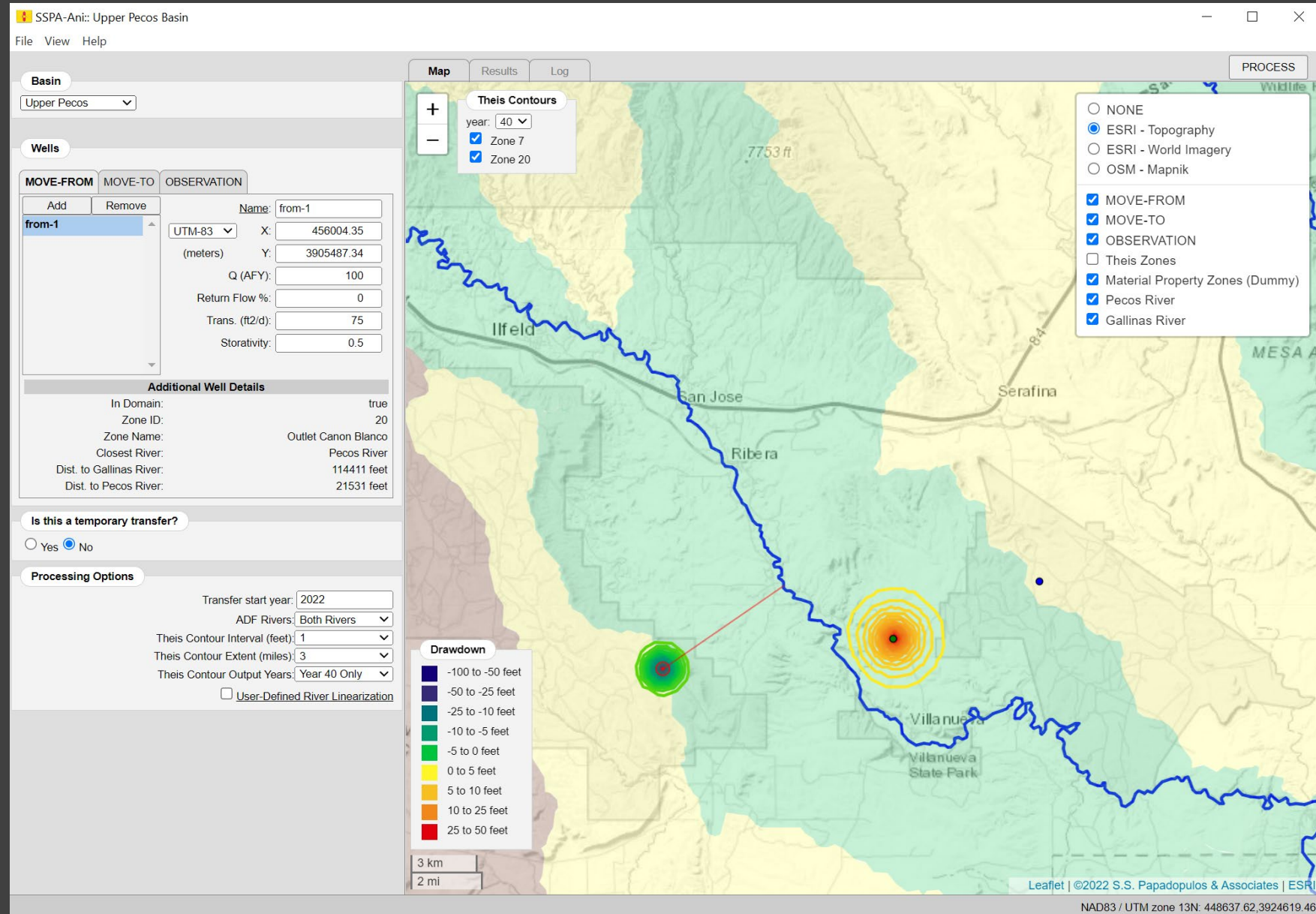


Drawdown Time Series



Ani (Analytical Interface)

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



Mimbres Interface

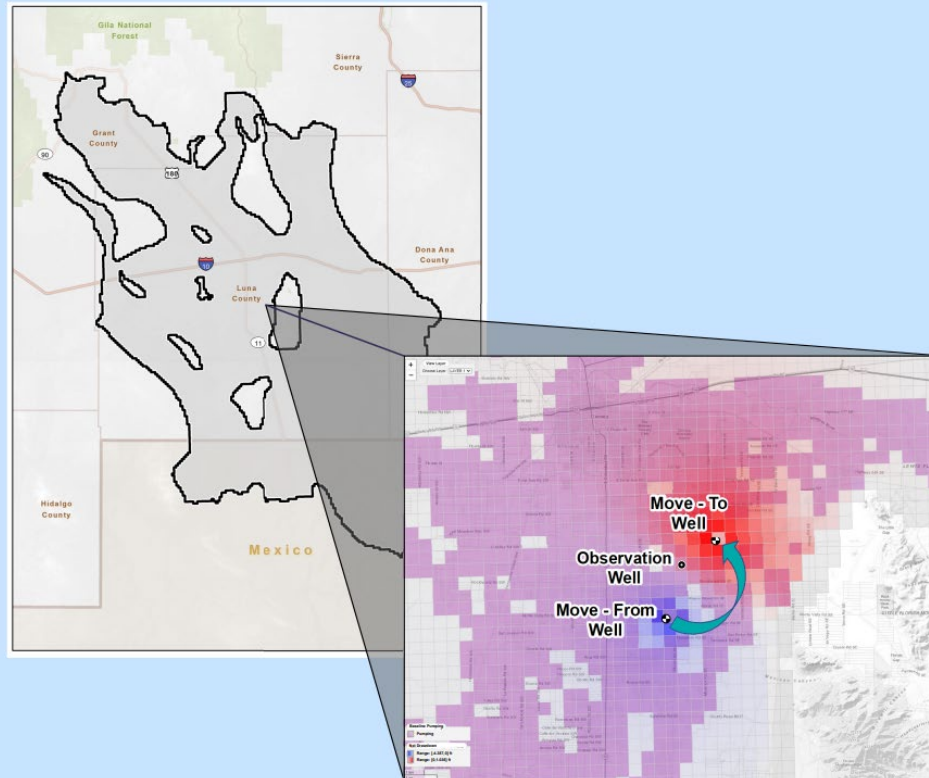
- Move-From (left)
- Move-To (right)
- Numerical model results
 - mounding (blue shading)
 - drawdown (red shading)
- Purple shading indicates existing pumping
- Development continues...

The Mimbres Basin Interface (MBI)

A Transfer Evaluation Interface for
the Mimbres Basin

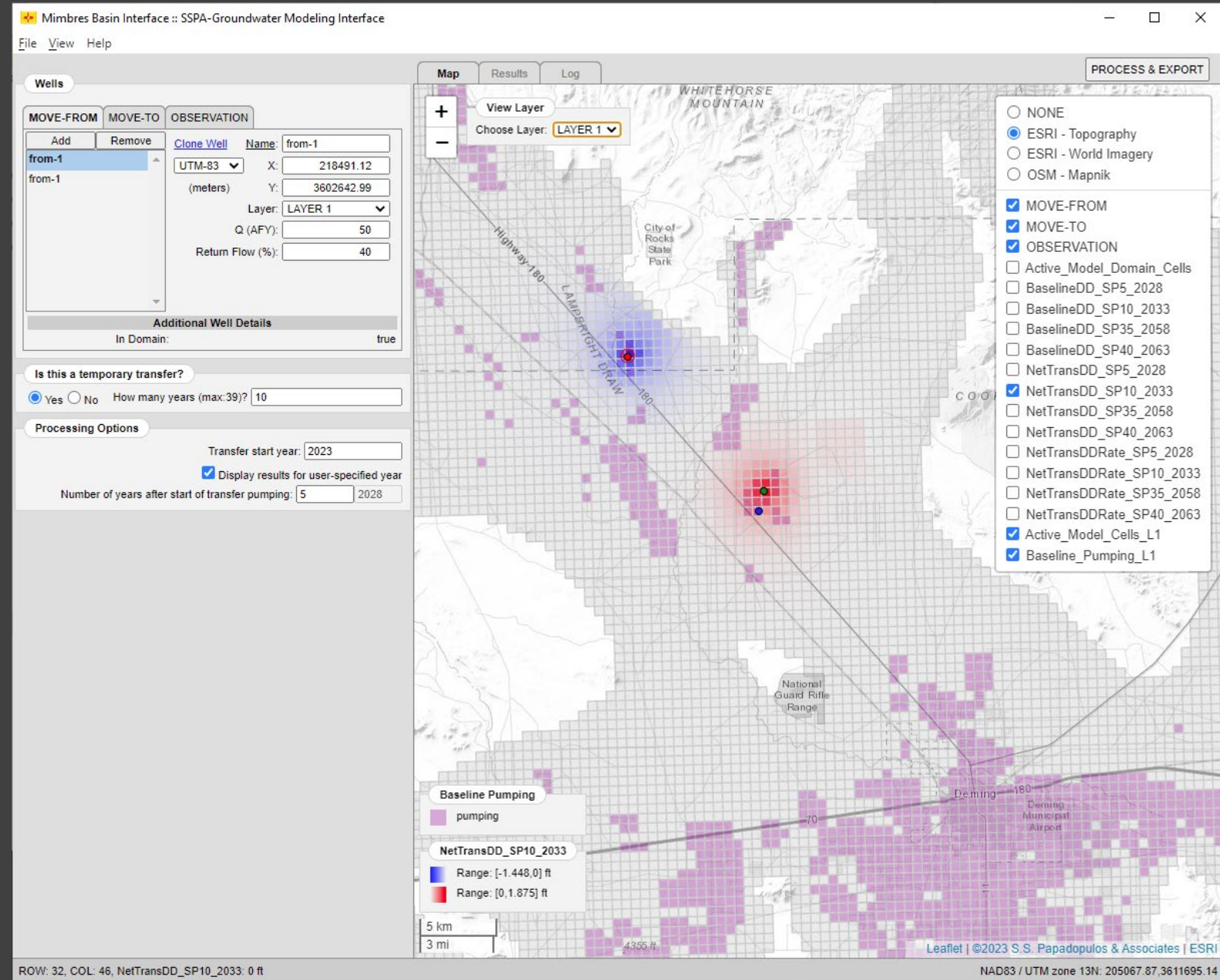


Created for
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Mimbres Interface

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



Existing Interfaces

(Includes ongoing development)

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

Carlsbad A Superposit The Carlsb

Prepared for:
New Mexico Office of

Σ²Π S.S. PAPA Environme

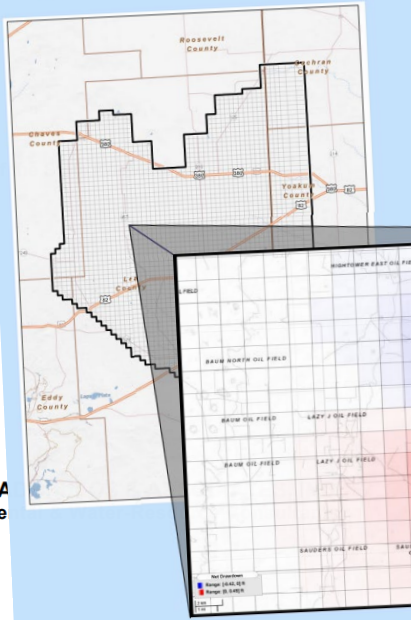
April 1, 2022

3100 Arapahoe Ave, Suite 203

The Lea County Int

A Transfer Evaluation Interface for Lea (High Plains / Ogallala Aquifers)

Created for
The New Mexico Office of
by S.S. Papadopulos & Associates,

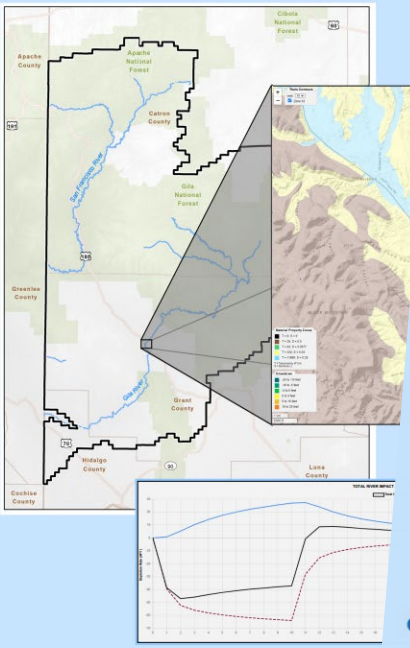


Σ²Π S.S. Papadopulos & Associate

The Analytical Inte

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

Created for
The New Mexico Office of

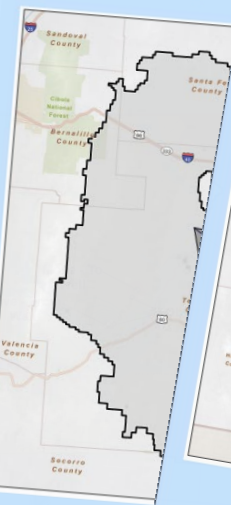


Σ²Π S.S. Papadopulos & Associates, Inc.

The Estancia

A Transfer Evaluation Interface for the Estancia Basin

Created for
The New Me

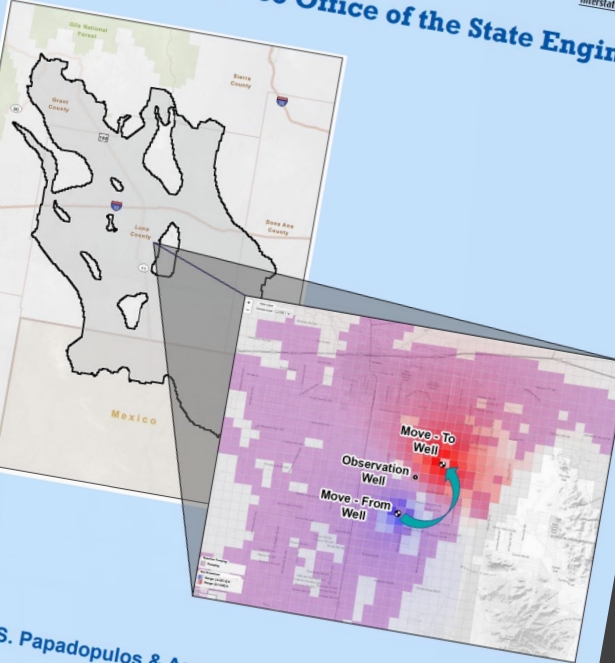


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The Mimbres Basin Interface (MBI)

A Transfer Evaluation Interface for the Mimbres Basin

Created for
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**Office of the State Engineer
Interstate Stream Commission**

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Other Features/Controls

Contouring Extents

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

Basin
Upper Pecos

Wells

MOVE-FROM **MOVE-TO** **OBSERVATION**

Add Remove

Name:

UTM-83 (meters) X: Y:

Q (AFY):

Return Flow %:

Trans. (ft2/d):

Storativity:

Is this a temporary transfer?

Yes No

Processing Options

Transfer start year:

ADF Rivers:

This Contour Interval (feet):

This Contour Extent (miles):

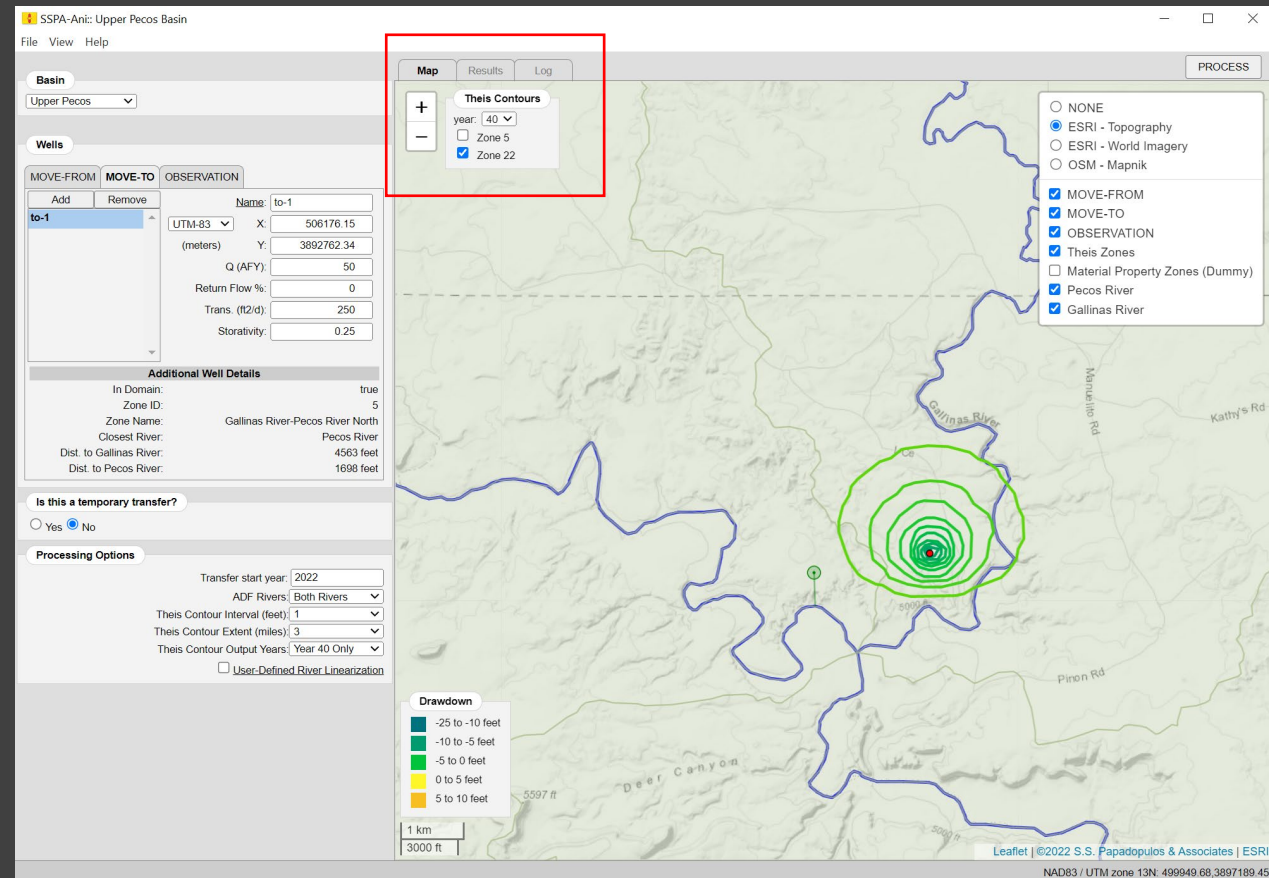
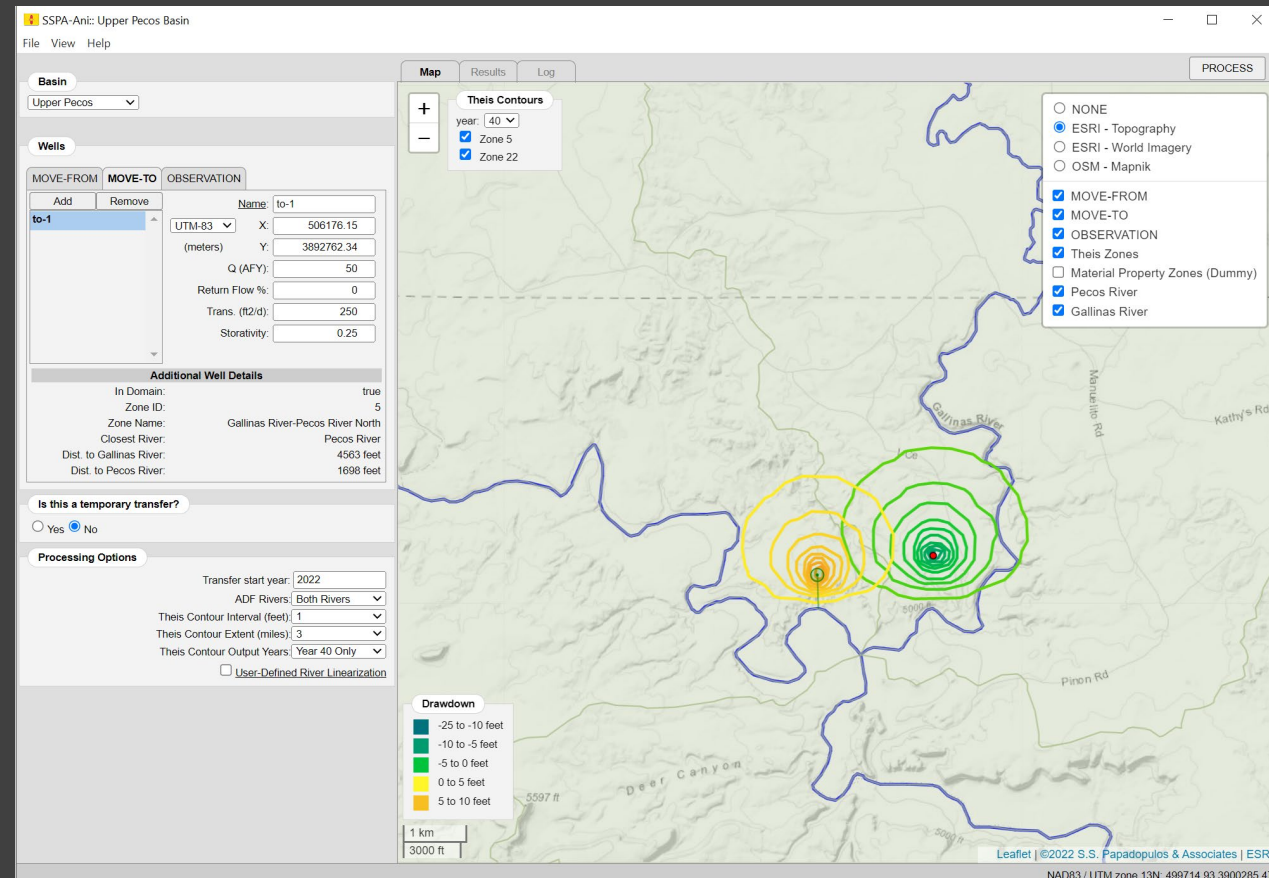
This Contour Output Years:

User-Define

1
2
3
4
5
6
7
8
9
10

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

SSQA-Ani: Carlsbad Basin

Basin: Carlsbad

MOVE-FROM	MOVE-TO	OBSERVATION
Add	Remove	Name:
		UTM-83 X: 0
		(meters) Y: 0
		Q (AFY): 0
		Return Flow %: 0
		Trans. (ft/d): 0
		Storativity: 0

Is this a temporary transfer?
 Yes No

Processing Options

Transfer start year: 2022

ADF Rivers: Both Rivers

This Contour Interval (feet): 1

This Contour Extent (miles): 3

This Contour Output Years: Year 40 Only

User-Defined River Linearization

Legend:

- NONE
- ESRI - Topography
- ESRI - World Imagery
- OSM - Mapnik
- MOVE-FROM
- MOVE-TO
- OBSERVATION
- Material Property Zones
- Pecos River
- Black River

Map: Carlsbad Basin showing Rio Pecos, Eddy, Carlsbad, Culberson, Loving, and Delaware River. Scale: 20 km / 10 mi.

SSQA-Ani: Gila/San Francisco Basin

Basin: Gila/San Francisco

MOVE-FROM	MOVE-TO	OBSERVATION
Add	Remove	Name:
		UTM-83 X: 0
		(meters) Y: 0
		Q (AFY): 0
		Return Flow %: 0
		Trans. (ft/d): 0
		Storativity: 0

Is this a temporary transfer?
 Yes No

Processing Options

Transfer start year: 2022

ADF Rivers: Both Rivers

This Contour Interval (feet): 1

This Contour Extent (miles): 3

This Contour Output Years: Year 40 Only

User-Defined River Linearization

Legend:

- NONE
- ESRI - Topography
- ESRI - World Imagery
- OSM - Mapnik
- MOVE-FROM
- MOVE-TO
- OBSERVATION
- Material Property Zones
- Theis Zones
- Gila River
- San Francisco River

Map: Gila/San Francisco Basin showing Tularosa Mountains, Gila Mountains, Sacramento Mountains, Silver City, Hidalgo, and Grant Luna. Scale: 10 km / 10 mi.

Hydraulic Properties

SSAPA-Ani: Upper Pecos Basin

Basin: Upper Pecos

Wells: MOVE-FROM, MOVE-TO, OBSERVATION

Well Name: from-1

UTM-83 X: 456004.35 Y: 3905487.34

Q (AFY): 100

Return Flow %: 0

Trans. (ft2/d): 75

Storativity: 0.5

Additional Well Details:

- In Domain: true
- Zone ID: 20
- Zone Name: Outlet Canon Blanco
- Closest River: Pecos River
- Dist. to Gallinas River: 114411 feet
- Dist. to Pecos River: 21531 feet

Is this a temporary transfer? Yes No

Processing Options:

- Transfer start year: 2022
- ADF Rivers: Both Rivers
- This Contour Interval (feet): 1
- This Contour Extent (miles): 3
- This Contour Output Years: Year 40 Only
- User-Defined River Linearization

Theis Contours:

- NONE
- ESRI - Topography
- ESRI - World Imagery
- OSM - Mapnik
- MOVE-FROM
- MOVE-TO
- OBSERVATION
- Theis Zones
- Material Property Zones (Dummy)
- Pecos River
- Gallinas River

Drawdown:

- 100 to -50 feet
- 50 to -25 feet
- 25 to -10 feet
- 10 to -5 feet
- 5 to 0 feet
- 0 to 5 feet
- 5 to 10 feet
- 10 to 25 feet
- 25 to 50 feet

- 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

Basin: Carlsbad

Wells: MOVE-FROM, MOVE-TO, OBSERVATION

Well Name: from-1

UTM-83 X: 574153.59 Y: 3558635.09

Q (AFY): 0

Return Flow %: 0

Trans. (ft2/d): 500

Storativity: 0.05

Additional Well Details:

- In Domain: true
- Zone ID: 21
- Zone Name: 1-South
- Closest River: Black River
- Dist. to Black River: 15224 feet
- Dist. to Pecos River: 54714 feet

Is this a temporary transfer? Yes No

Processing Options:

- Transfer start year: 2022
- ADF Rivers: Both Rivers
- This Contour Interval (feet): 1
- This Contour Extent (miles): 3
- This Contour Output Years: Year 40 Only
- User-Defined River Linearization

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

gbarth@sspa.com



S.S. Papadopoulos & Associates, Inc.