Water Withdrawal and Consumptive Use Estimates for the Delaware River Basin (1990-2017) With Projections Through 2060

DRBC Advisory Committee on Climate Change

January 26, 2022

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and

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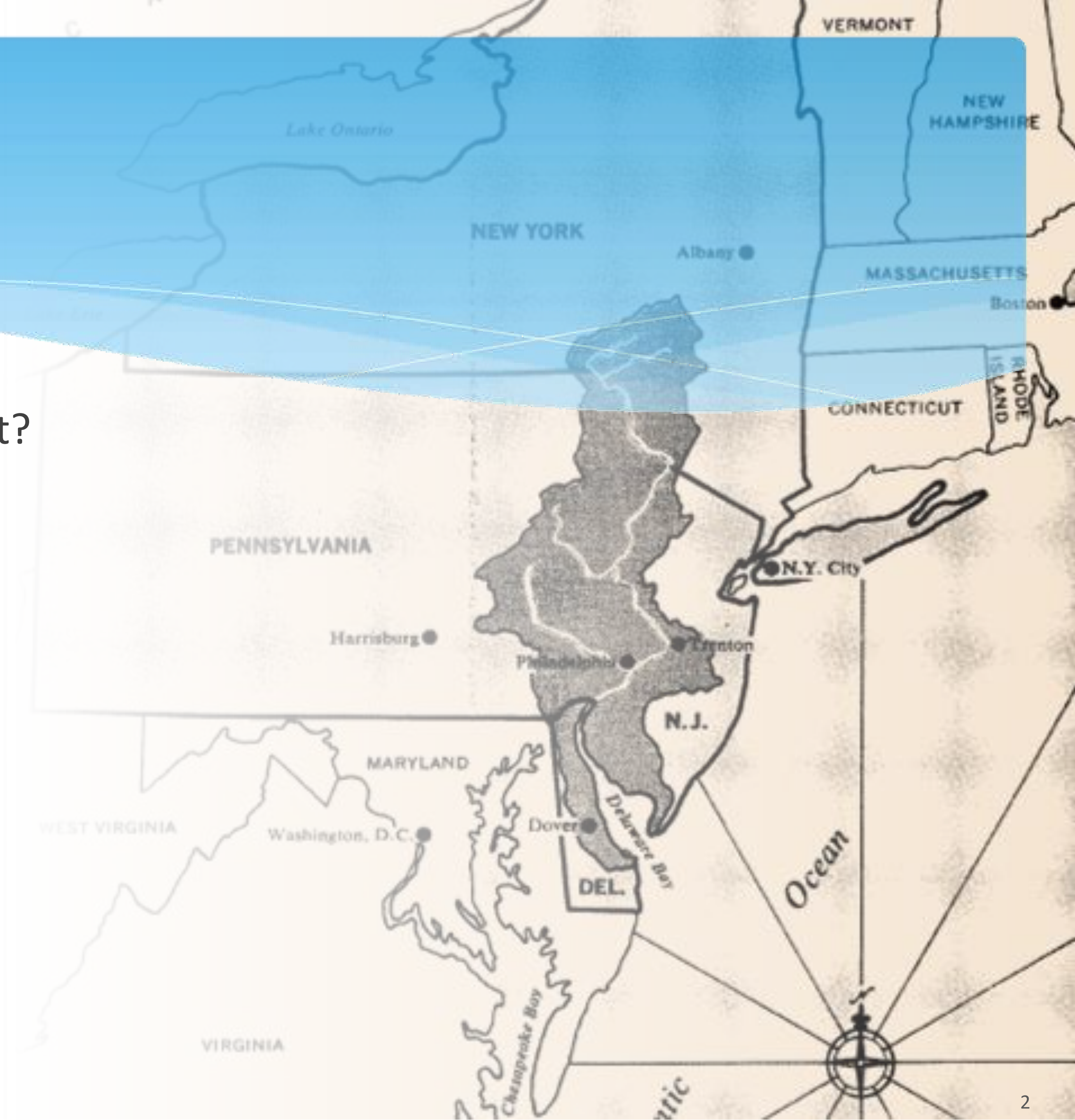
Outline

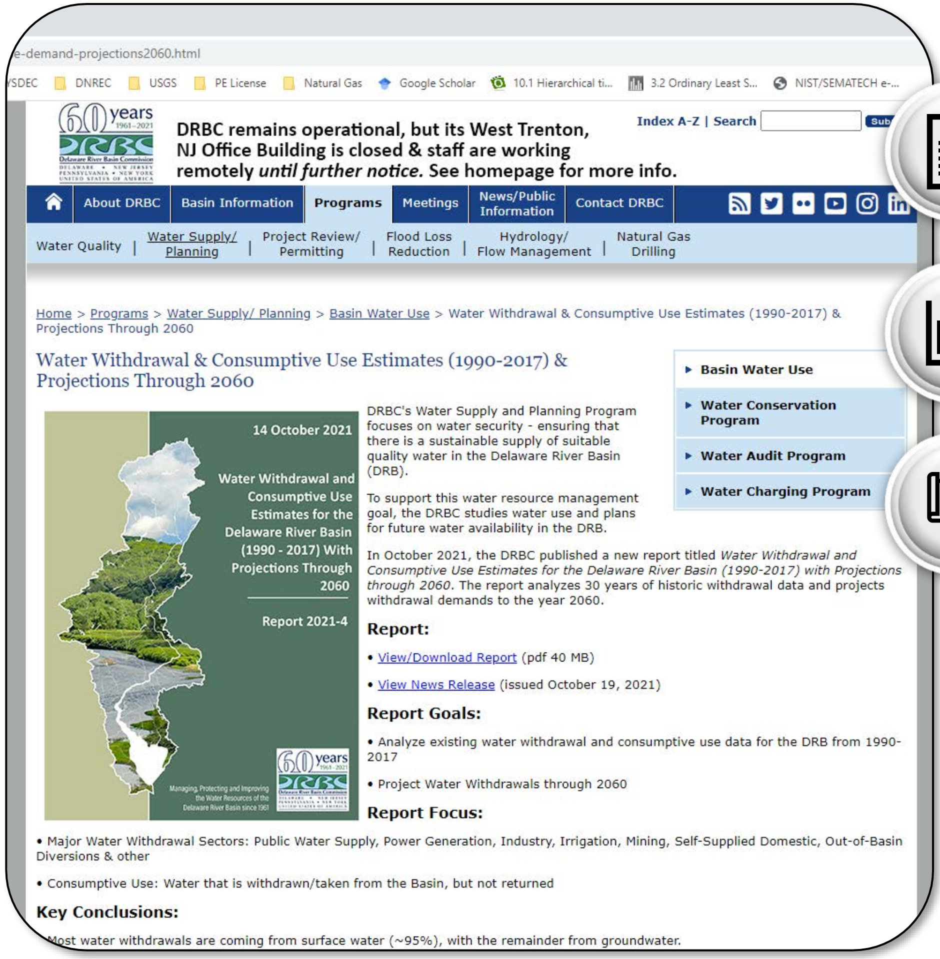
1. Publication and data deliverables
2. Water Supply Planning – Why and What?
3. Methodology
4. Results
5. Supplemental analysis: irrigation
6. How will this be used?
7. Other supplemental analyses
8. Questions



1. Publication & Data Deliverable

Report webpage:

https://www.nj.gov/drbc/programs/supply/use-demand-projections2060.html



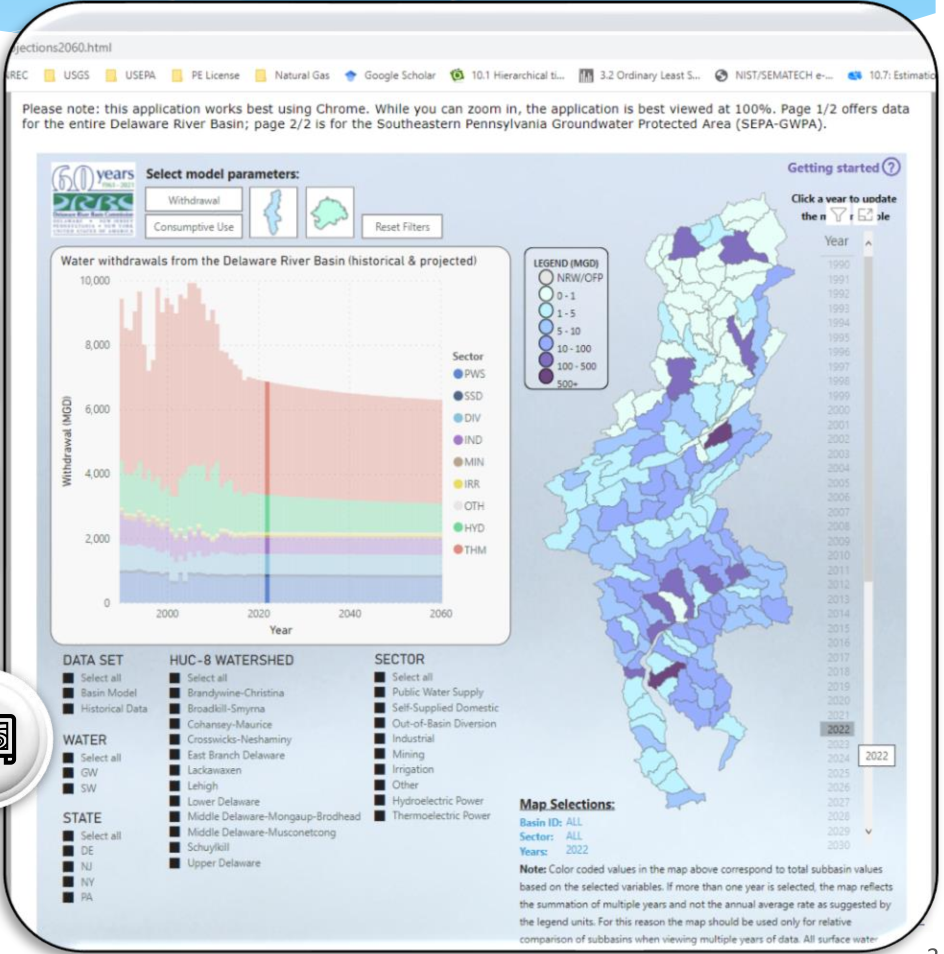
You can:

Download the report (~40 MB) (Best viewed with Adobe)

Download the dataset (~10 MB) MS Excel File (no macros)

Download high resolution maps from the report

Interact with the Power BI data visualization tool



2. Water Supply Planning – Why and What?

Ontelaunee Reservoir Dam
near Reading, Pennsylvania.
Credit: © Melissa Kopf
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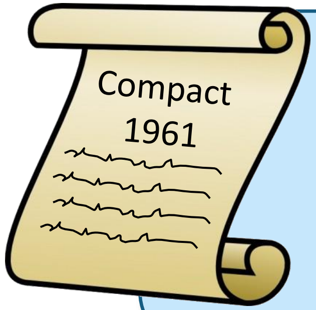
2. Water Supply Planning: Why are we projecting withdrawal data?

Is there enough water to meet future demands?

1. What are the current/future demands?
2. How does it compare against current allocations?
3. What about a repeat of the Drought of Record?
4. What about climate change?



DELAWARE RIVER BASIN COMPACT (1961)

3.6 General Powers.

- Conduct and sponsor research on water resources
- Collect, compile, correlate, analyze, report and interpret data on water resources and uses in the basin

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2. Water Supply Planning: What are the planning objectives?

Provide projections of future average annual water use in the Delaware River Basin, through the year 2060, to be used in future planning assessments.

Represent each water use *sector* at the Basin-wide scale.

Apply GW results to the 147 sub-watersheds (Sloto & Buxton, 2006) and the sub-watersheds of SEPA-GWPA.

Apply SW results at the source level for future availability analyses.

Relate results to regulatory approvals.

3. Methodology

Cape Henlopen, Delaware.
Credit: Delaware State Parks
https://destateparks.com/Beaches/CapeHenlopen

3. Methodology: Breakdown by sector

The primary method is extrapolation of historic reported withdrawal data

Water Withdrawals in the Delaware River Basin

- Public Water Supply
- Out-of-Basin Diversion
- Self-supplied Domestic
- Power Generation
- Industrial
- Mining
- Irrigation
- Other

Public Water Supply	Out-of-Basin Diversion	Self-supplied Domestic	Power Generation	Industrial	Mining	Irrigation	Other
Report Link: Section 3	**Report Link:** Section 3	**Report Link:** Section 4	**Report Link:** Section 5	**Report Link:** Section 6	**Report Link:** Section 7	**Report Link:** Section 8	**Report Link:** Section 9
Primary Method: Extrapolation of historic water withdrawal data	**Primary Method:** Mean value based on a five-year average.	**Primary Method:** Population estimate and per-capita rates.	**Primary Method:** Extrapolation of historic water withdrawal data	**Primary Method:** Extrapolation of historic water withdrawal data	**Primary Method:** Extrapolation of historic water withdrawal data	**Primary Method:** Multivariate regression for temperature and precipitation.	**Primary Method:** Extrapolation of historic water withdrawal data

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3. Methodology: A plan for projecting data?

NOTE:
Not the method for self-supplied domestic withdrawals, and irrigation withdrawals

Where do we start?

Time-series hierarchy

Aggregate to results here

Perform projections here

Level 1
(Sector level)..

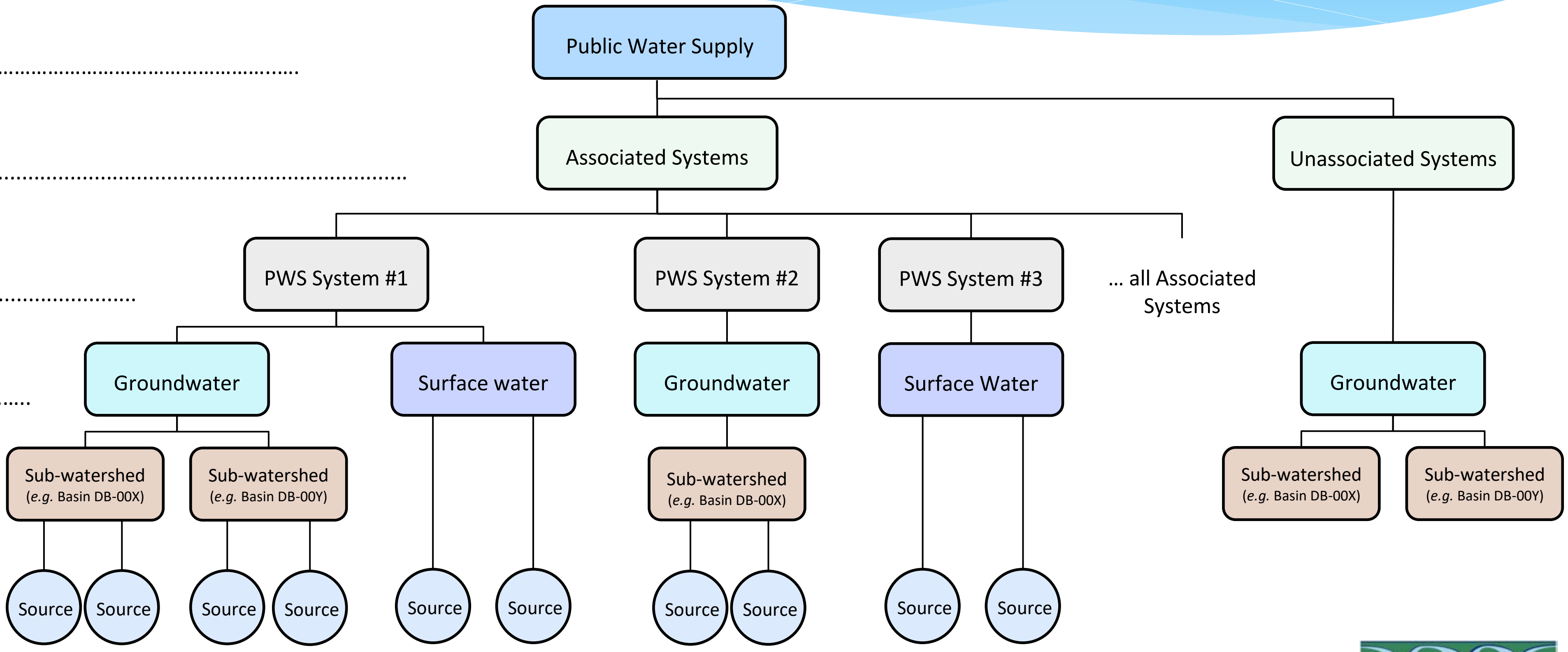
Level 2
(Regulatory level)..

Level 3
(System level)..

Level 4
(Source-type level)...............................

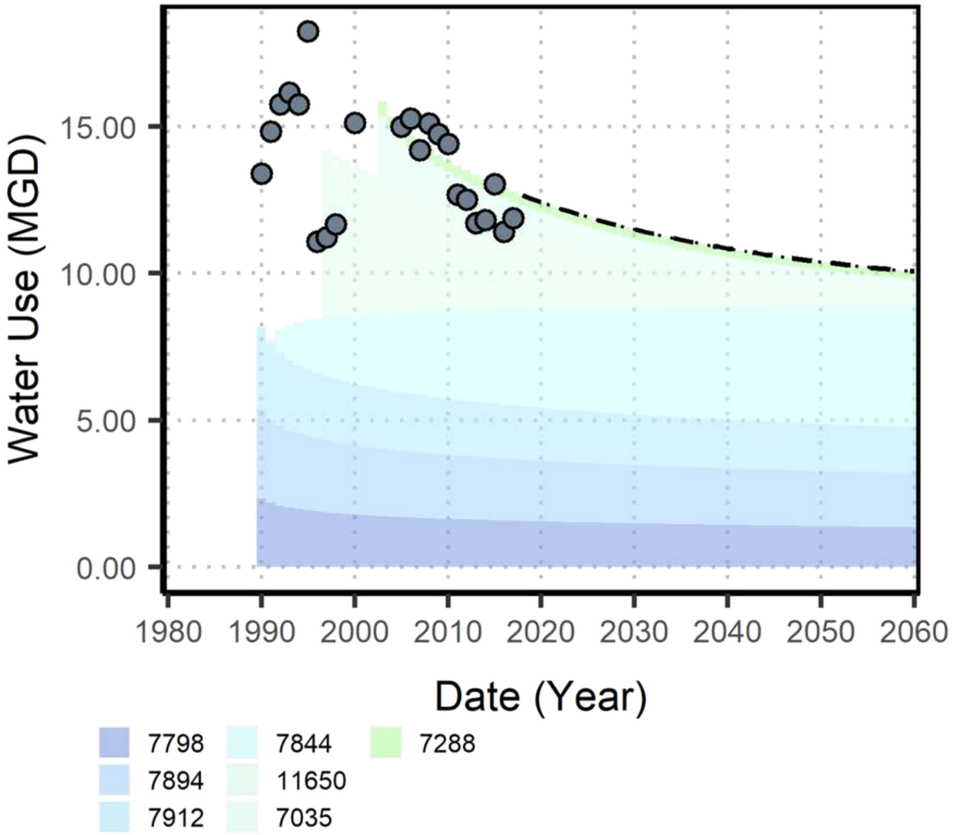
Level 5
(Sub-watershed level).............

Level 6
(Source level)...........................



Hyndman, R., & Athanasopoulos, G. (2018). *Forecasting: principles and practice* (2nd ed.). Melbourne, Australia: OTexts. https://otexts.com/fpp2/

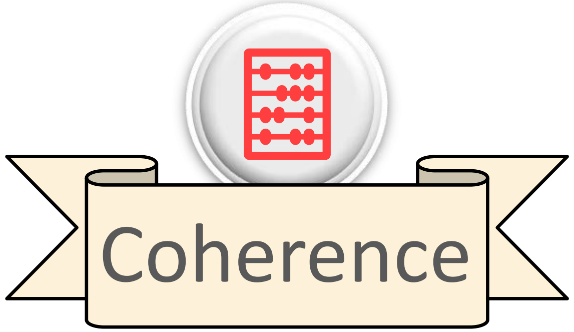
3. Methodology: How do you aggregate projections?



"Bottom-up approach"

$$\boldsymbol{Total} = \overbrace{f_{1,1}(x) + f_{1,2}(x) + f_{1,3}(x) + f_{1,4}(x)}^{\text{PWS System \#1}} + \overbrace{f_{2,1}(x)}^{\text{PWS System \#2}} + \overbrace{f_{3,1}(x) + f_{3,2}(x)}^{\text{PWS System \#3}} + \ldots$$

DB-00X DB-00Y SW 1 SW 2 | DB-00X "System Level" | SW 1 SW 2



Do projections aggregate in a manner consistent with the time series?

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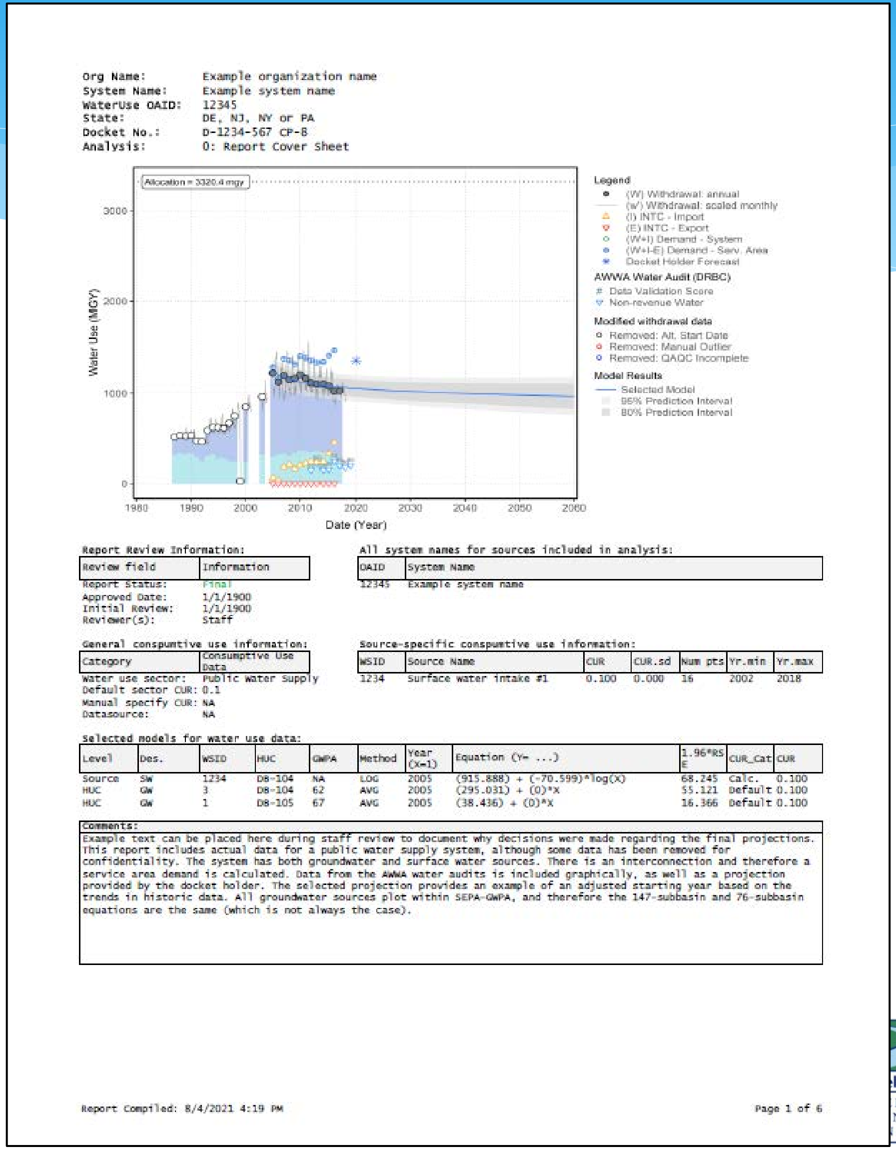
3. Methodology: A plan for projecting data?

The main model is based on extrapolating historic withdrawal data.

- Significant QAQC of historic data
- 600+ system reports
- 1,100+ equations

Method		Associated		Unassociated		Subtotal
		GW	SW	GW	SW	
Mean Value		218	71	147	0	436
OLS	Exponential	72	17	36	0	125
	Linear	83	11	11	0	105
	Logarithmic	250	74	69	0	393
Other		62	48	4	0	114
Subtotal		685	221	267	0	1,173

- OLS = Ordinary Least Squares
- Associated means system operate above review thresholds and has allocation regulatory approval.
- Does not include agriculture and self-supplied domestic analyses


Org Name: Example organization name
System Name: Example system name
WaterUse OAID: 12345
State: DE, NJ, NY or PA
Docket No.: D-1234-567 CP-B
Analysis: 0: Report Cover Sheet

Report Review Information:

Review field	Information
Report Status:	Final
Approved Date:	1/1/1900
Initial Review:	1/1/1900
Reviewer(s):	Staff

All system names for sources included in analysis:

OAID	System Name
12345	Example system name

General conspumtive use information:

Category	Consumptive Use Data
Water use sector:	Public water supply
Default sector CUR:	0.1
Manual specify CUR:	NA
Datasource:	NA

Source-specific conspumtive use information:

WSID	Source Name	CUR	CUR.sd	Num pts	Yr.min	Yr.max
1234	Surface water intake #1	0.100	0.000	16	2002	2018

Selected models for water use data:

Level	Des.	WSID	HUC	GWPA	Method	Year (X=1)	Equation (Y= ...)	1.96*RSE	CUR_Cat	CUR
Source	SW	1234	D8-104	NA	LOG	2005	(915.888) + (-70.599)*log(X)	68.245	Calc.	0.100
HUC	GW	3	D8-104	62	AVG	2005	(295.031) + (0)*X	55.121	Default	0.100
HUC	GW	1	D8-105	67	AVG	2005	(38.436) + (0)*X	16.366	Default	0.100

Comments:
Example text can be placed here during staff review to document why decisions were made regarding the final projections. This report includes actual data for a public water supply system, although some data has been removed for confidentiality. The system has both groundwater and surface water sources. There is an interconnection and therefore a service area demand is calculated. Data from the AWWA water audits is included graphically, as well as a projection provided by the docket holder. The selected projection provides an example of an adjusted starting year based on the trends in historic data. All groundwater sources plot within SEPA-GWPA, and therefore the 147-subbasin and 76-subbasin equations are the same (which is not always the case).

Report Compiled: 8/4/2021 4:19 PM

Page 1 of 6

3. Methodology: Quantifying uncertainty?

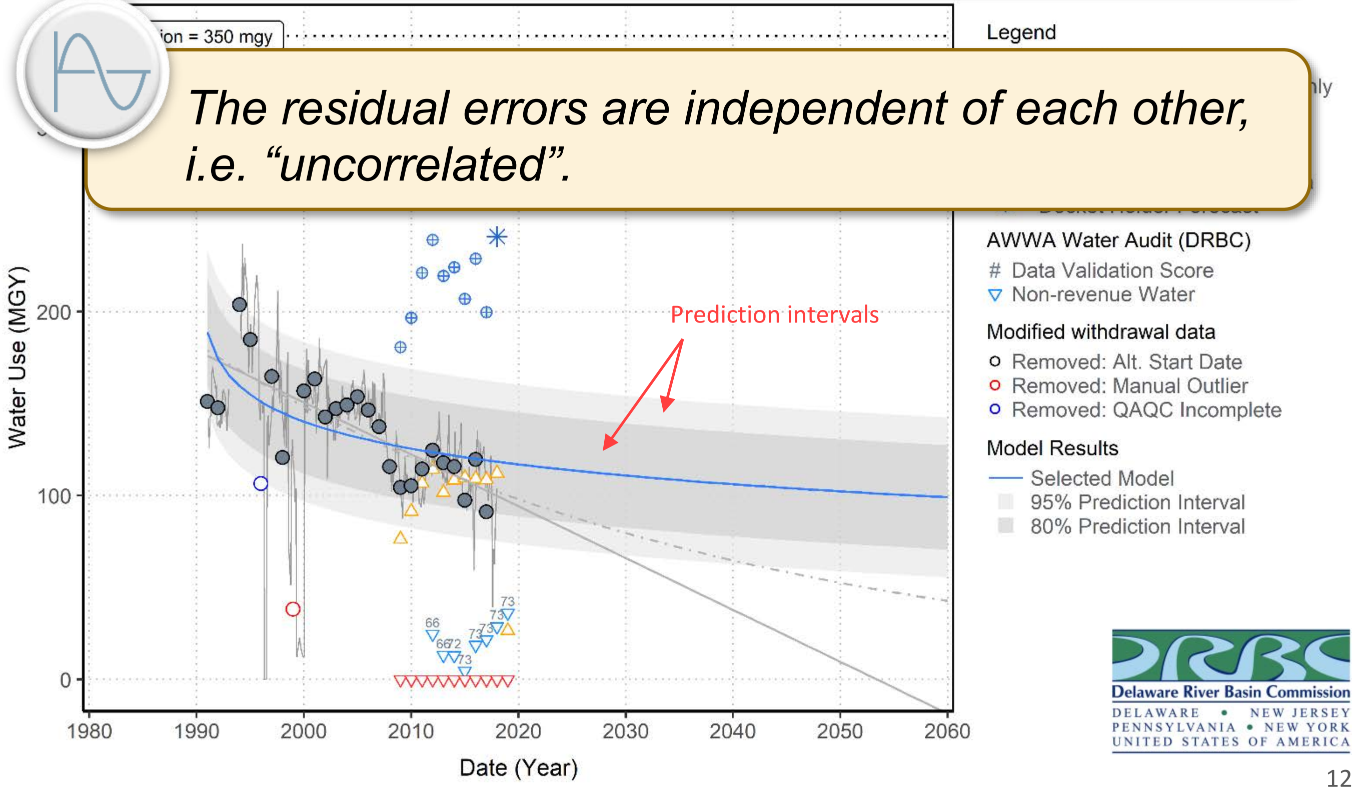
$$\hat{y} \pm t_{\alpha,v} * \hat{\sigma}_e \sqrt{1 + \frac{1}{n} + \frac{(x - \bar{x})^2}{(n-1)s_x^2}}$$

$\hat{y}$	= the projected withdrawal volume (mgy)
x	= (Year – Start Year + 1) i.e. x=1,2,3…n
$\bar{x}$	= mean of the observed x values
$t_{\alpha,v}$	= Student t-statistic
$\hat{\sigma}_e$	= residual standard error
n	= total number of observations
s_x^2	= standard deviation of observed x values

The model follows the general form $\hat{y} = \hat{\beta}_0 + \hat{\beta}_1 x$

The residual errors are normally distributed

The residual errors are independent of each other, i.e. "uncorrelated".



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4. Results

The Walt Whitman Bridge over the Delaware River.
Philadelphia in the background.
Credit: © Brian Kushner
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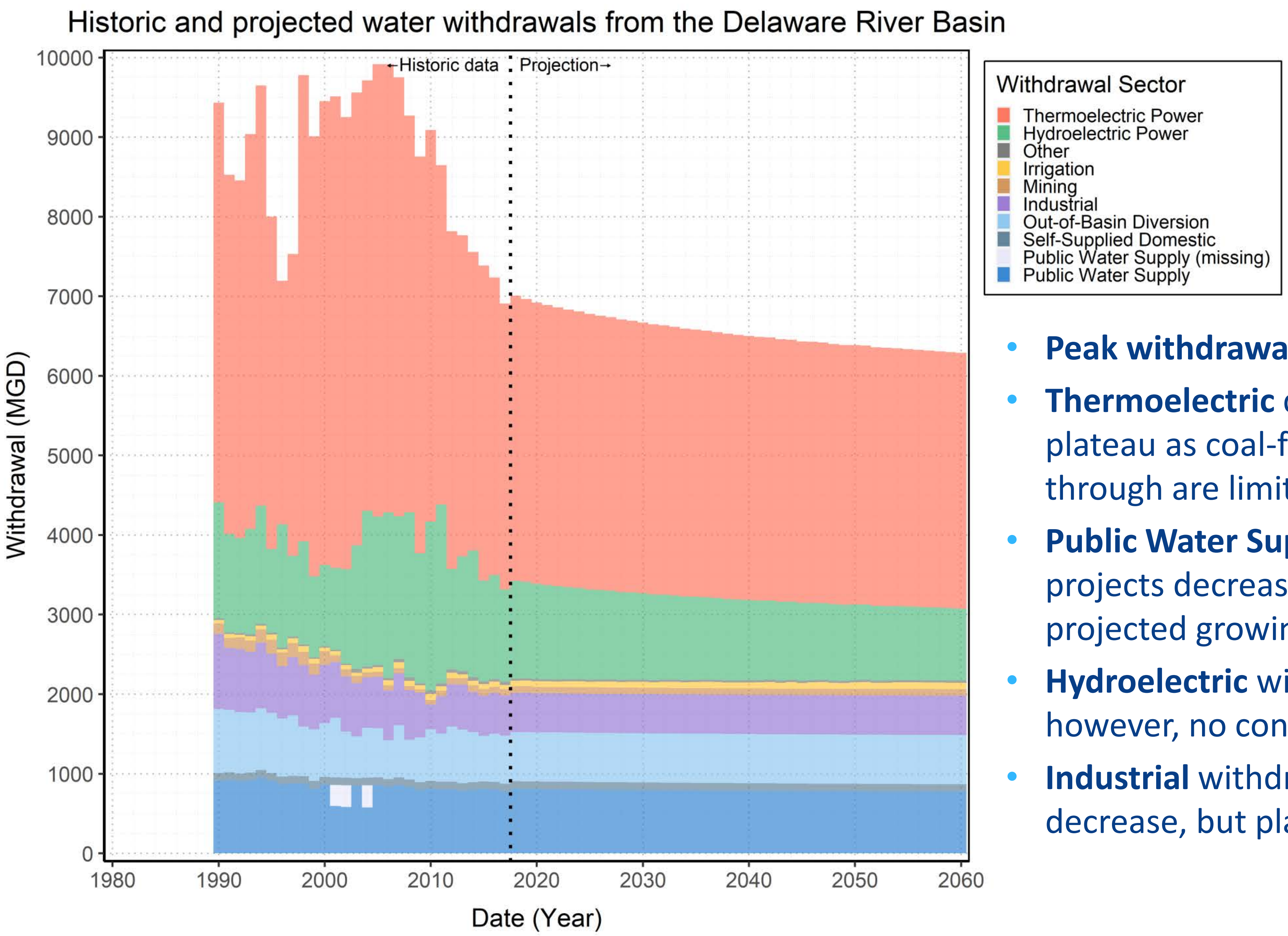

- **Peak withdrawals have occurred**
- **Thermoelectric** decreases since 2007 will plateau as coal-fired facilities using once-through are limiting
- **Public Water Supply** has shown and projects decreases despite historic and projected growing in-Basin population
- **Hydroelectric** withdrawals are significant; however, no consumptive use
- **Industrial** withdrawals historically decrease, but plateau

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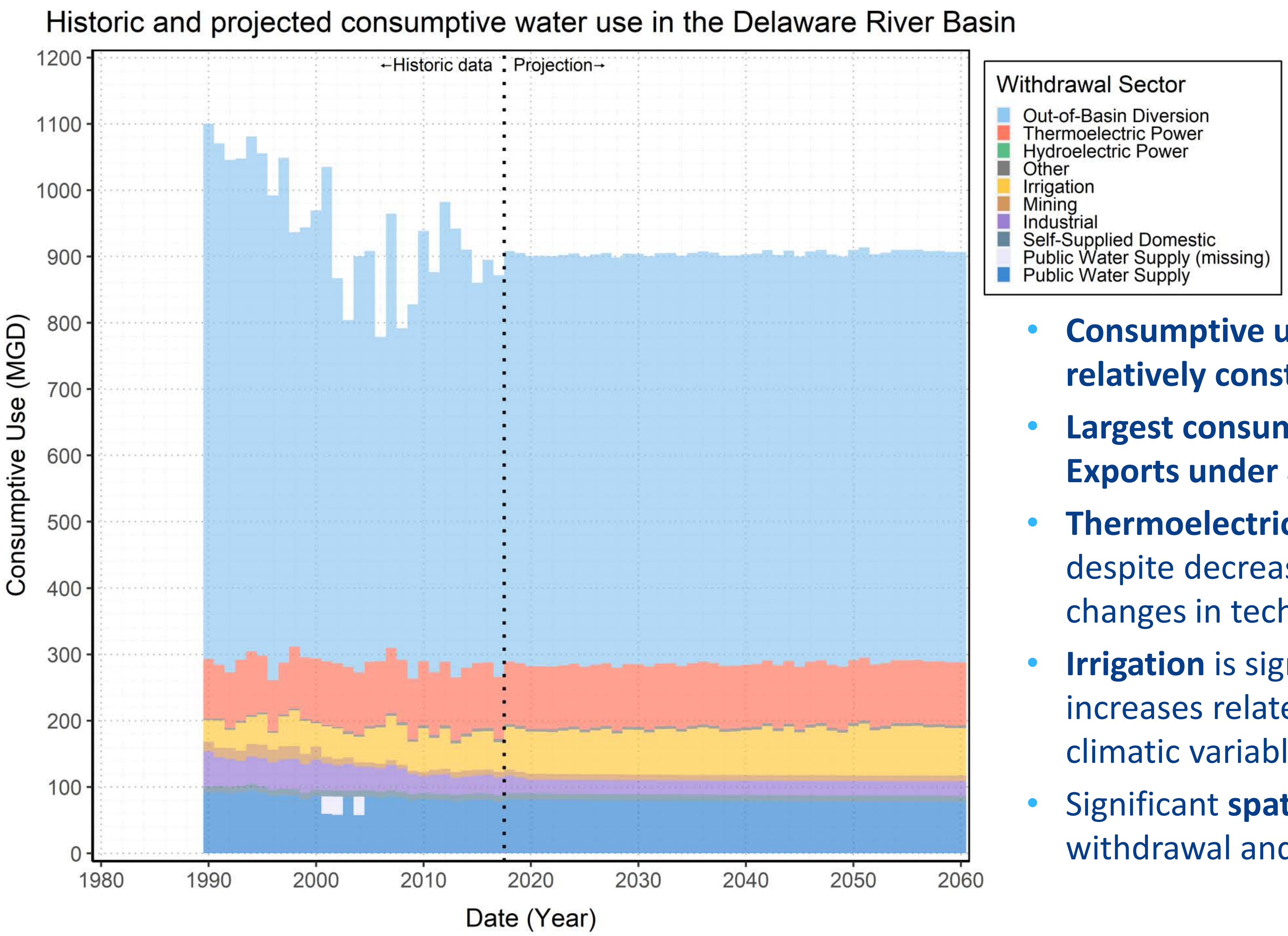
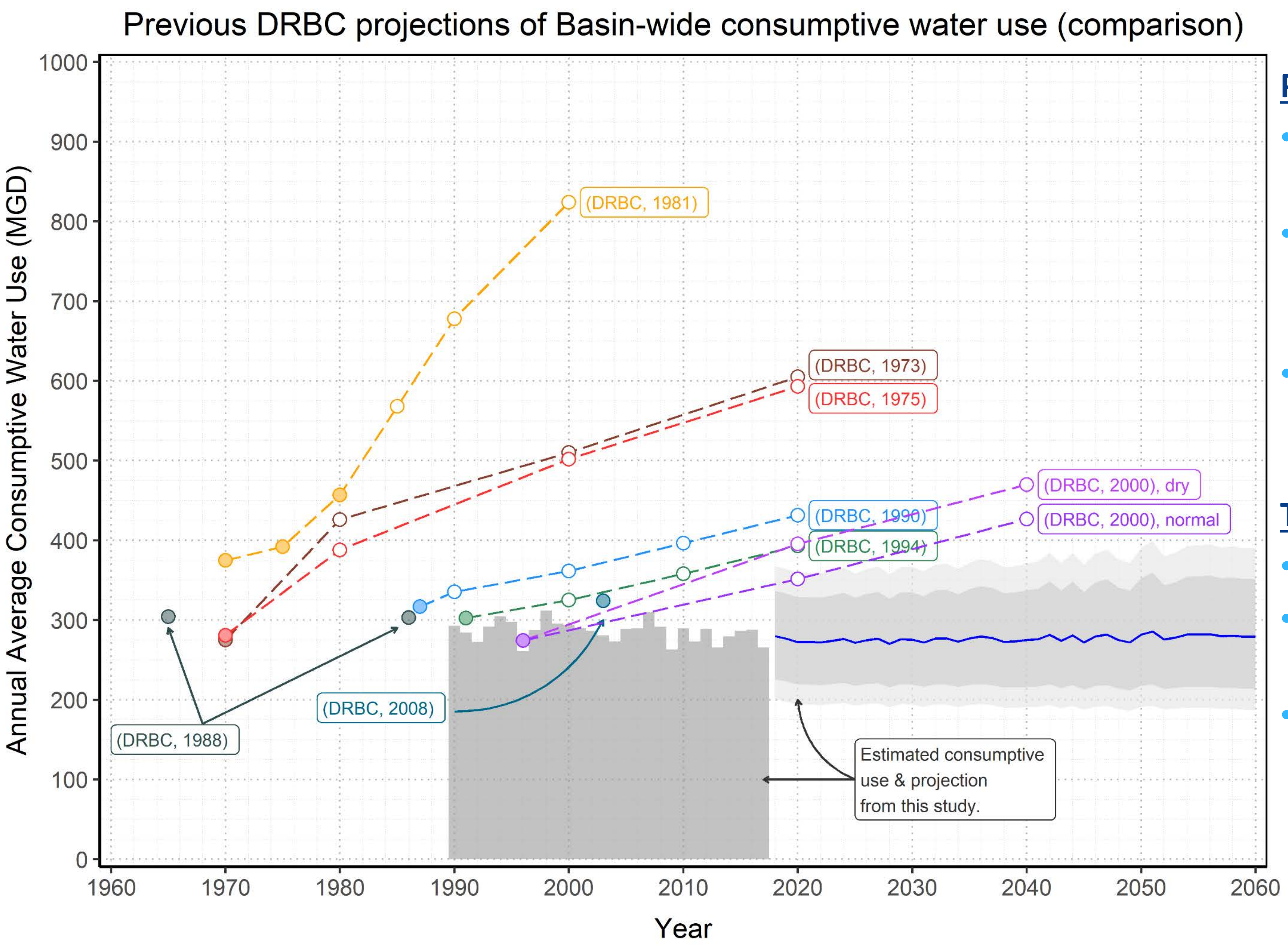


- **Consumptive use projected to remain relatively constant**
- **Largest consumptive use is Out-of-Basin Exports under a U.S. Supreme Court Decree**
- **Thermoelectric** consumptive use constant despite decreased withdrawals due to changes in technology
- **Irrigation** is significant and shows slight increases related to projected changes in climatic variables
- Significant **spatial variation** in terms of both withdrawal and consumptive use



Prior projections often:

- Work from one estimated year of withdrawal data
- Are performed indirectly (e.g., applying population projections)
- May have considered/ accounted for planned facilities (e.g., power)

This study:

- Almost 30 years of data
- Aligns with previous *estimates*
- Most conservative projection

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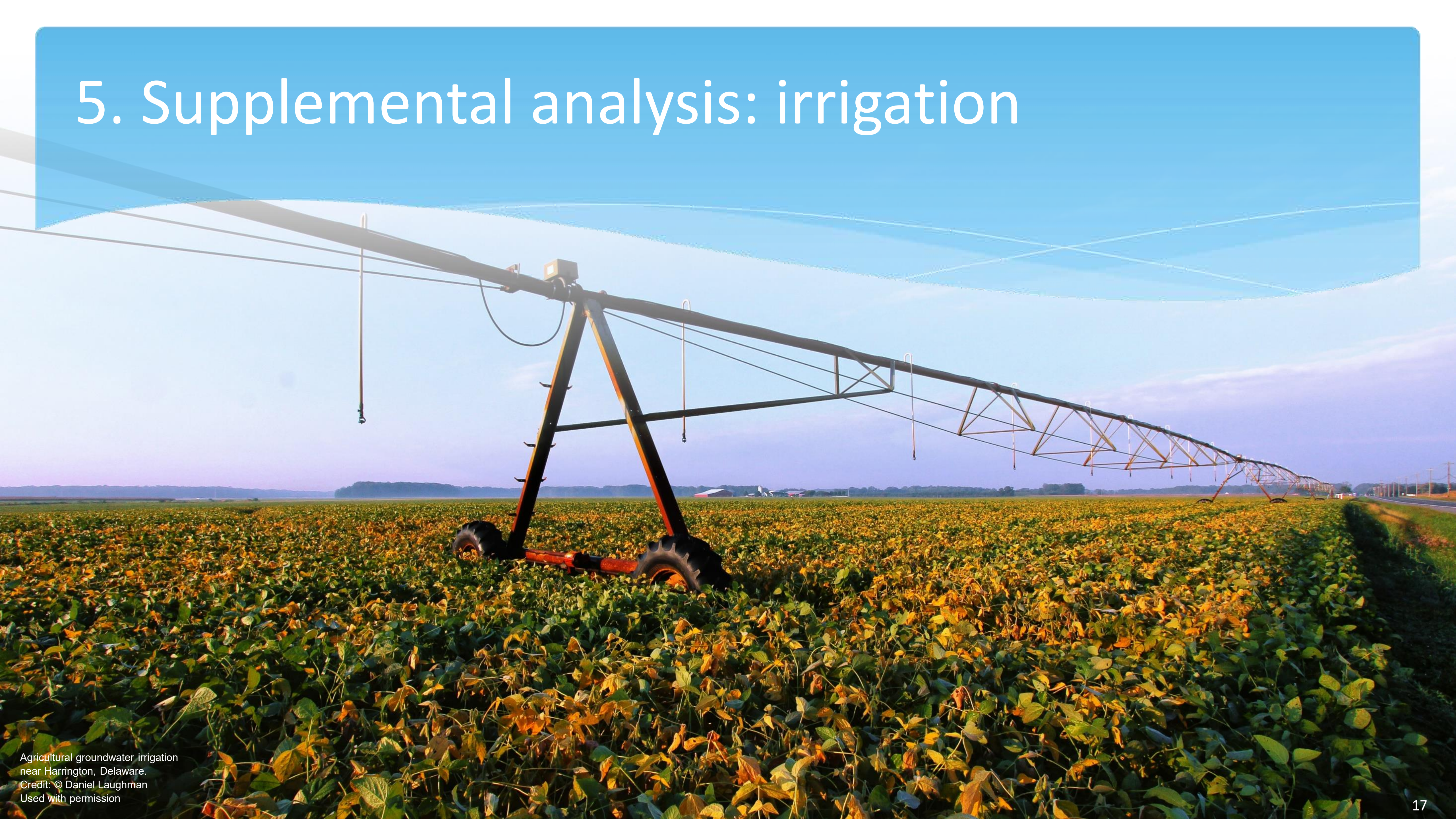
5. Supplemental analysis: irrigation



Agricultural groundwater irrigation
near Harrington, Delaware.
Credit: © Daniel Laughman
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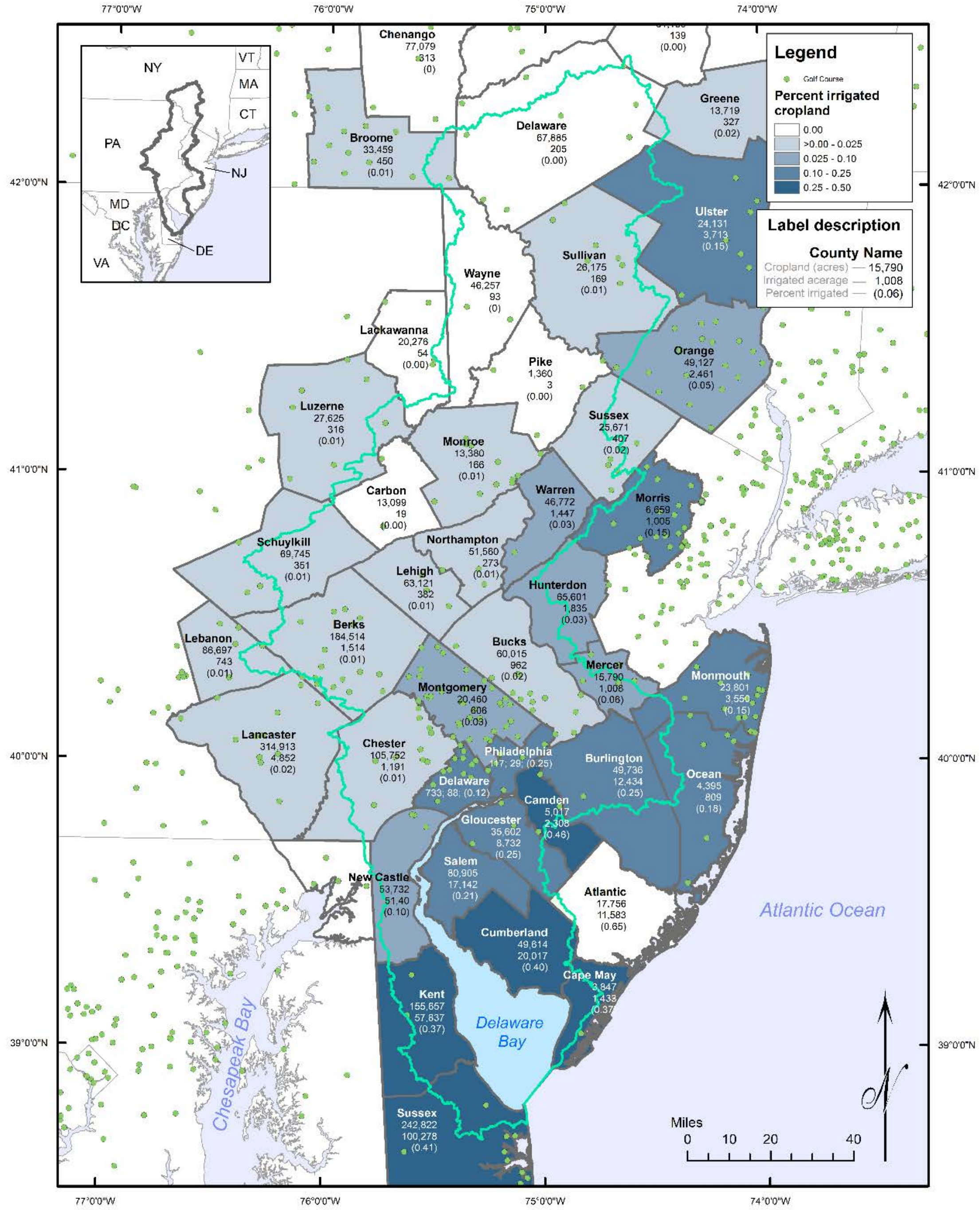
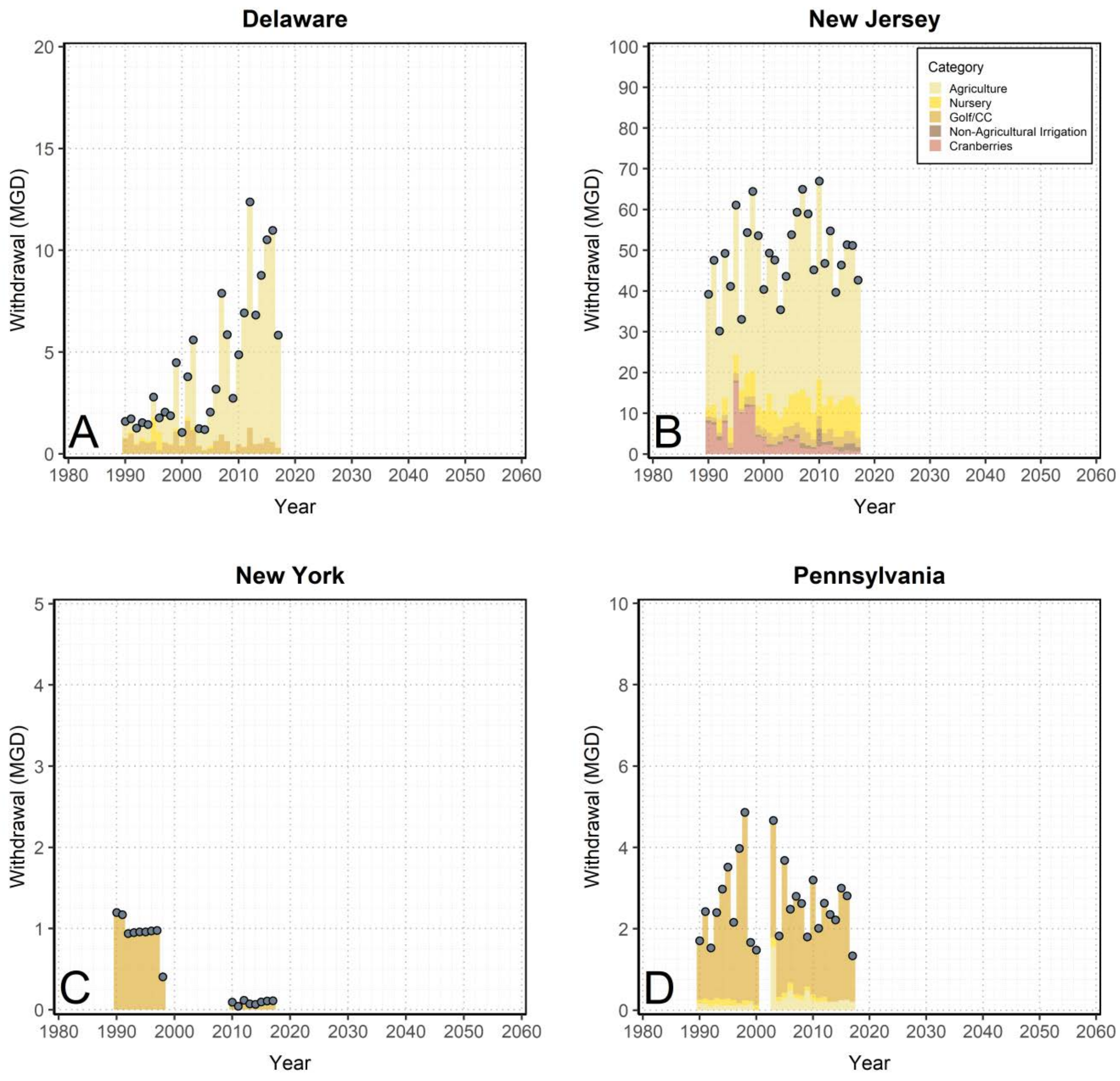
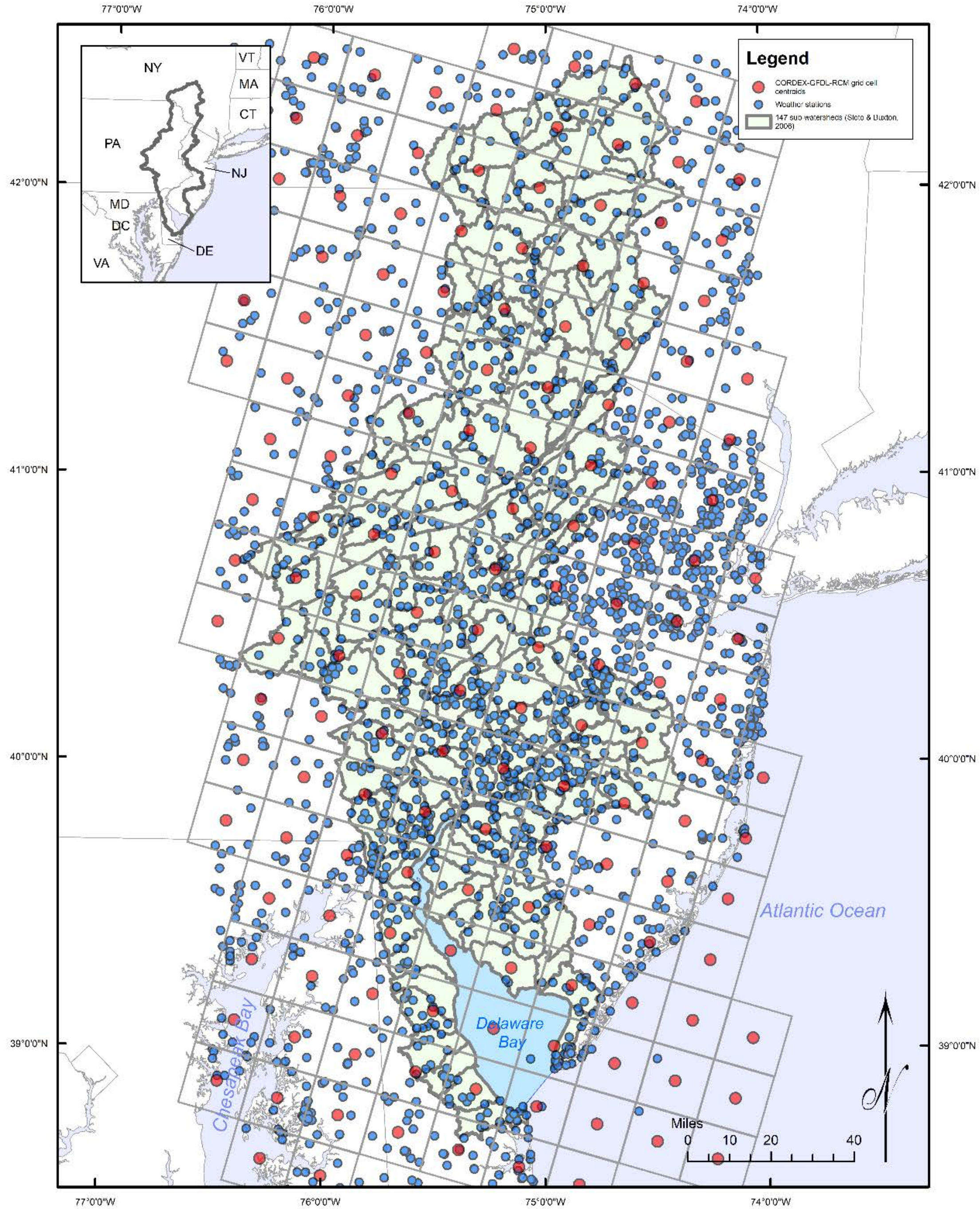
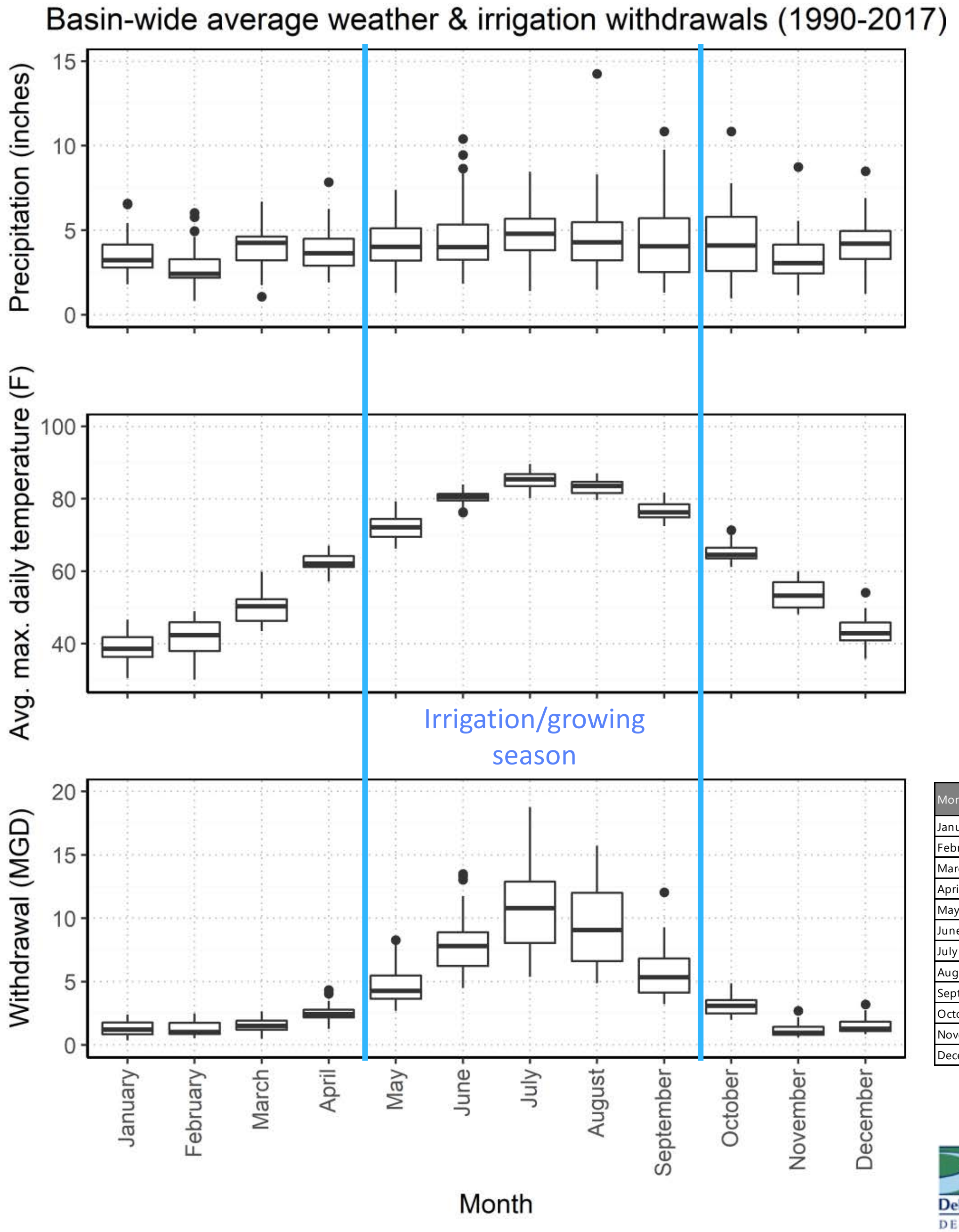


Irrigation water withdrawals from the Delaware River Basin states







Month	Median MGD	Percent
January	1.235	2.52%
February	1.044	2.13%
March	1.531	3.13%
April	2.452	5.01%
May	4.285	8.75%
June	7.817	15.96%
July	10.804	22.06%
August	9.078	18.53%
September	5.357	10.94%
October	3.095	6.32%
November	0.978	2.00%
December	1.301	2.66%

56.6% 76.2% 87.6% 92.7%

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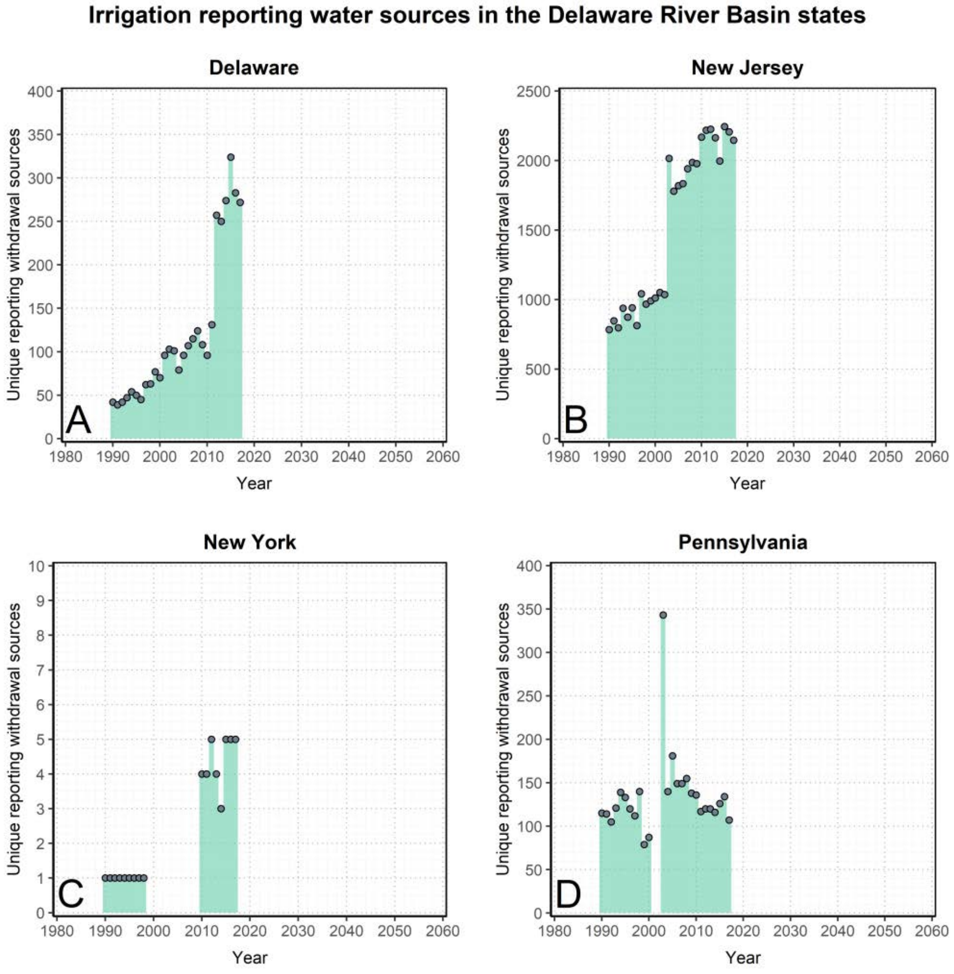

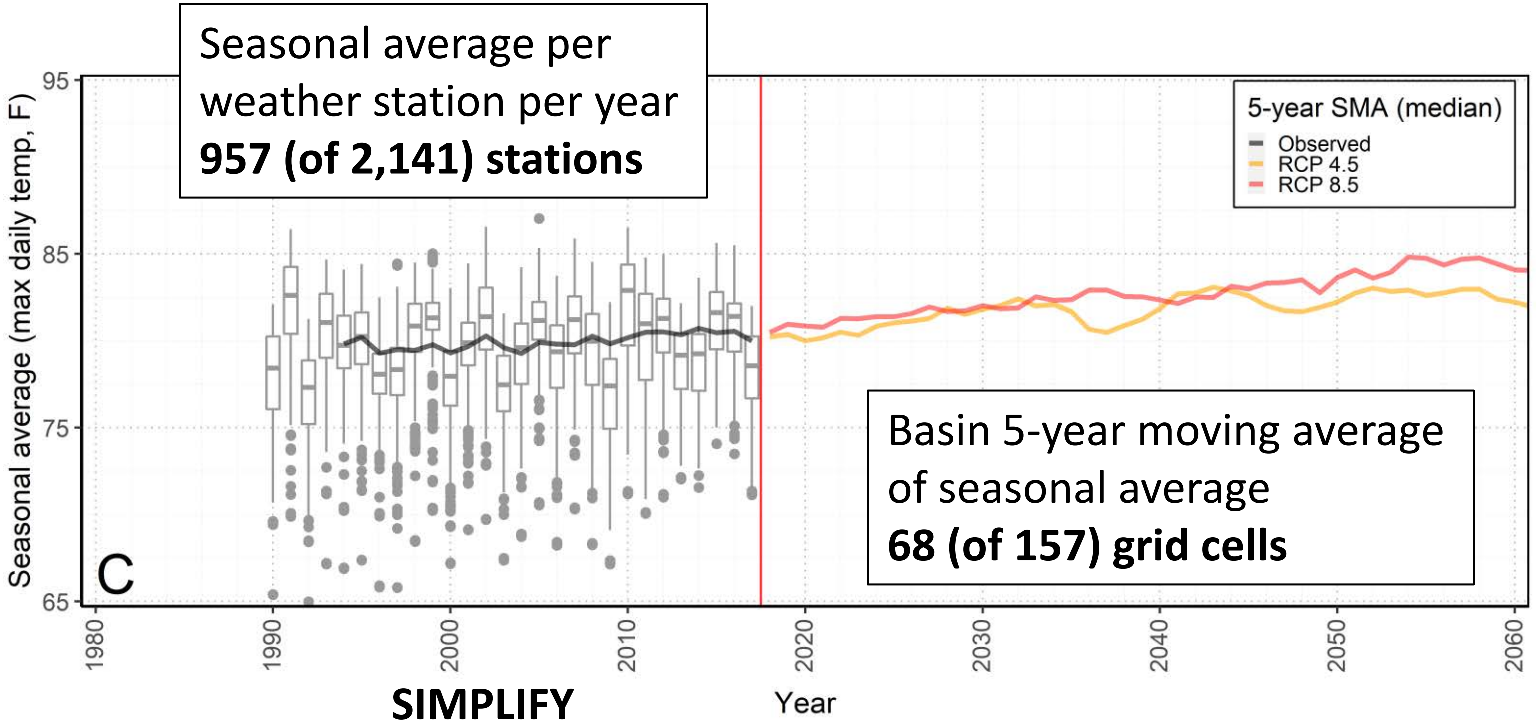

SIMPLIFY

CALIBRATE

PROJECT

Constant Temperature Precipitation No. Sources

$$W_{i,j,t} = \alpha_j + \beta_j T_{i,t} + \gamma_j P_{i,t} + \delta_j S_{i,j,t}$$

$$W_{i,j,t} = \alpha_j^* + \beta_j T_{i,t}$$

where,

$W_{i,j,t}$	=	The annual withdrawal from subbasin *i* at year *t*, where *j* is either GW or SW
$\alpha, \beta, \gamma, \delta$	=	Constants from a linear regression, where *j* is either GW or SW
$T_{i,t}$	=	Seasonal average daily max temperature (°F) for subbasin *i*, at year *t*
$P_{i,t}$	=	Seasonal total precipitation (inches) for subbasin *i*, at year *t*
$S_{i,j,t}$	=	The number of sources resulting in the annual withdrawal for $W_{i,j,t}$

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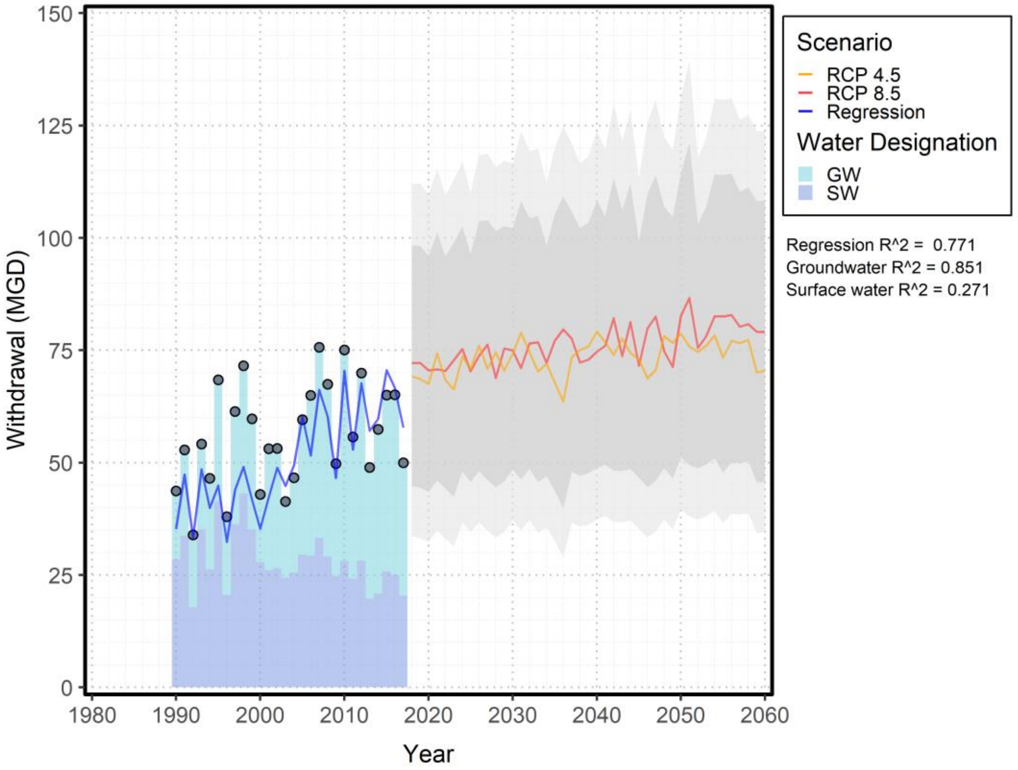
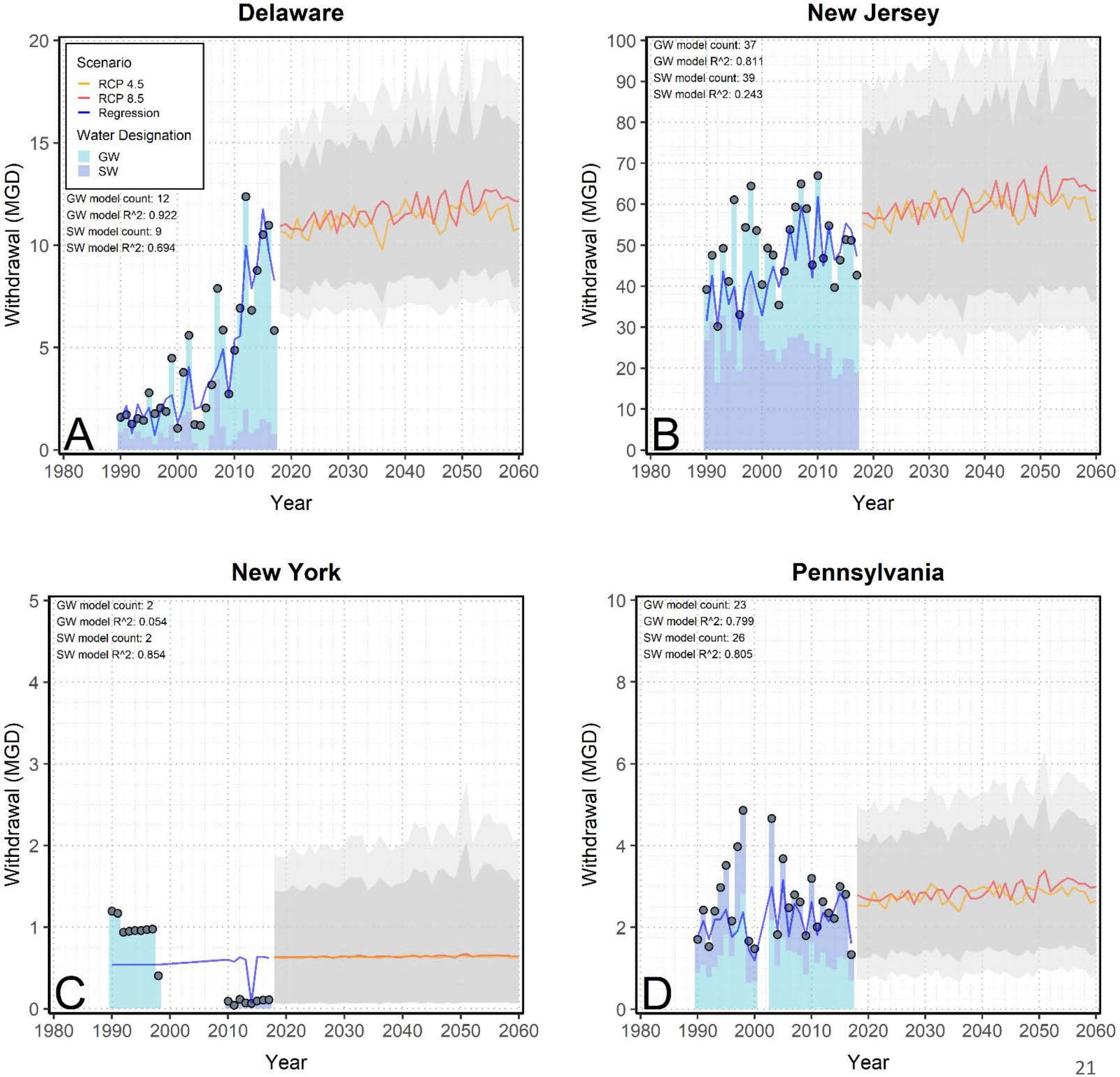
Projected irrigation water withdrawals from the Delaware River Basin



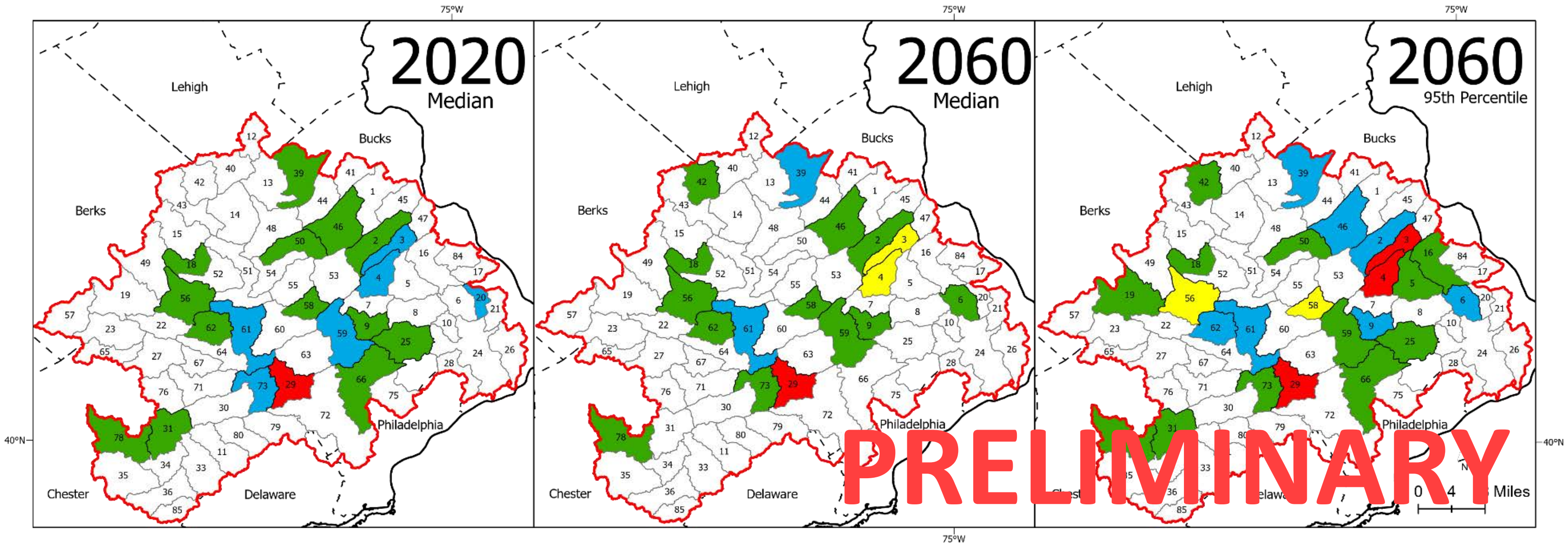
Projected irrigation water withdrawals from the Delaware River Basin states



6. How will this be used?

The Delaware River viewed from Hawk's Nest
in Sullivan County, New York.
Credit: © Joseph Halliday

Percent of Groundwater Use for 25-Year Annual Baseflow Recurrence



EQUAL TO OR GREATER THAN 100 PERCENT USE OF AVAILABLE GROUNDWATER
EQUAL TO OR GREATER THAN 75 AND LESS THAN 100 PERCENT USE OF AVAILABLE GROUNDWATER
EQUAL TO OR GREATER THAN 50 AND LESS THAN 75 PERCENT USE OF AVAILABLE GROUNDWATER
EQUAL TO OR GREATER THAN 25 AND LESS THAN 50 PERCENT USE OF AVAILABLE GROUNDWATER
LESS THAN 25 PERCENT USE OF AVAILABLE GROUNDWATER

Sloto, Ronald A., and Debra E. Buxton. "Estimated Groundwater Availability in the Delaware River Basin,1997-2000." USGS Scientific Investigations Report, 25 May 2007, doi:10.3133/sir20065125.
Coordinate System: NAD 1983 UTM Zone 18N

Groundwater availability

- 147 HUC scale
- SEPA GWPA scale

Surface water availability

- Consider effects of climate change
- Consider reservoir operations
- Consider the Drought of Record

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7. Other supplemental analyses

Hope Creek and Salem Generating Stations
in Salem County, New Jersey.
Credit: © John Beatty
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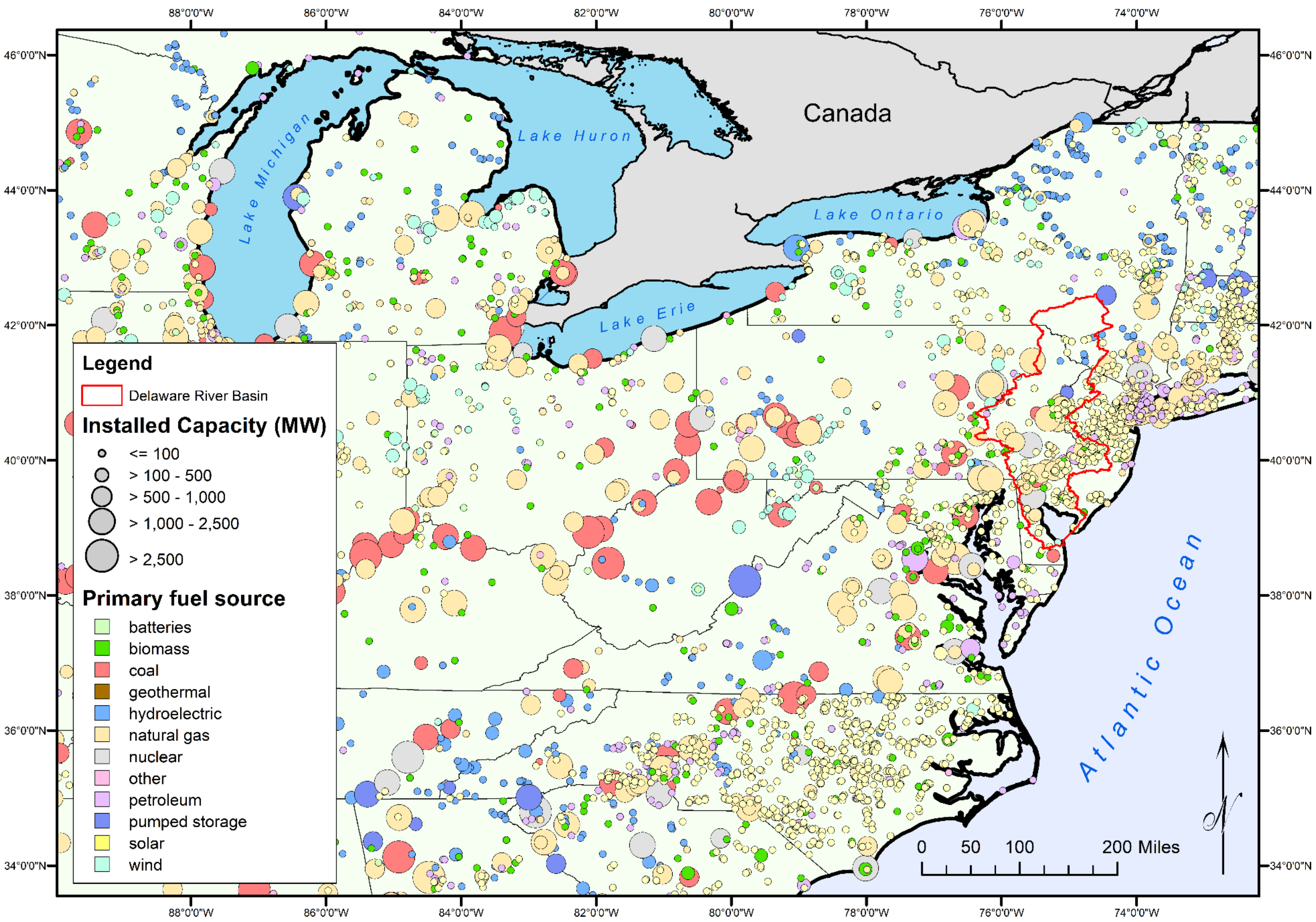
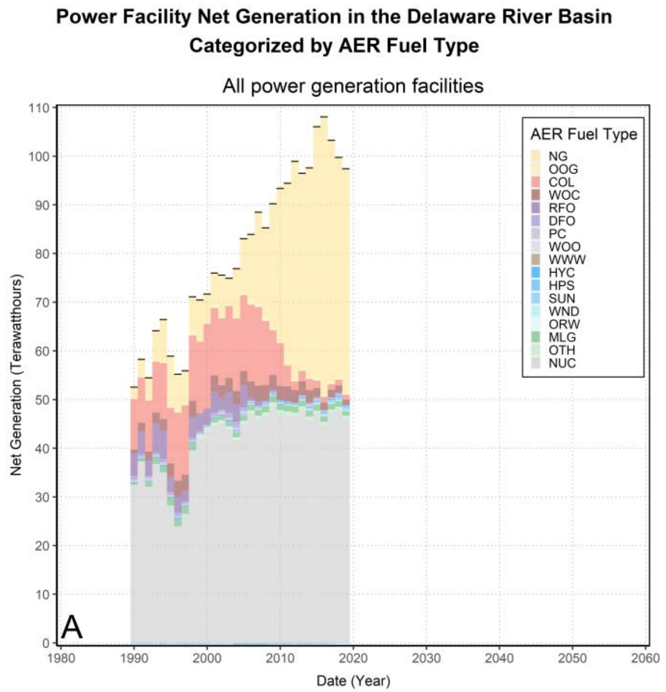
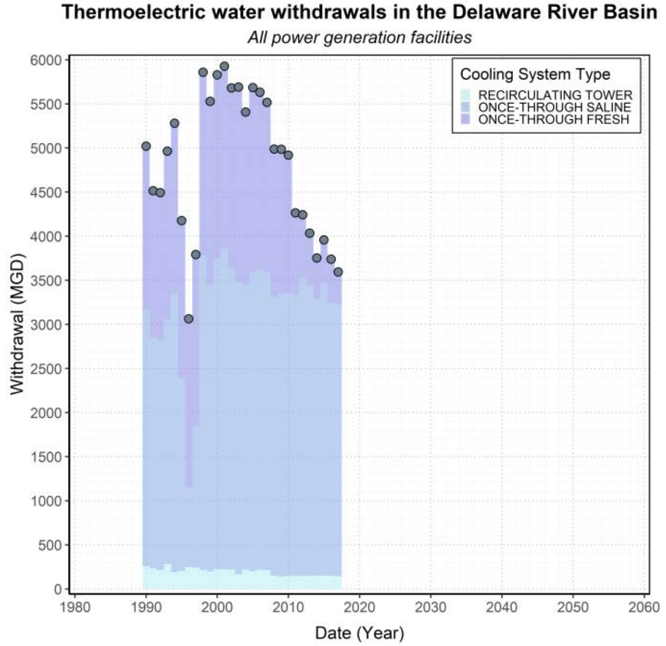
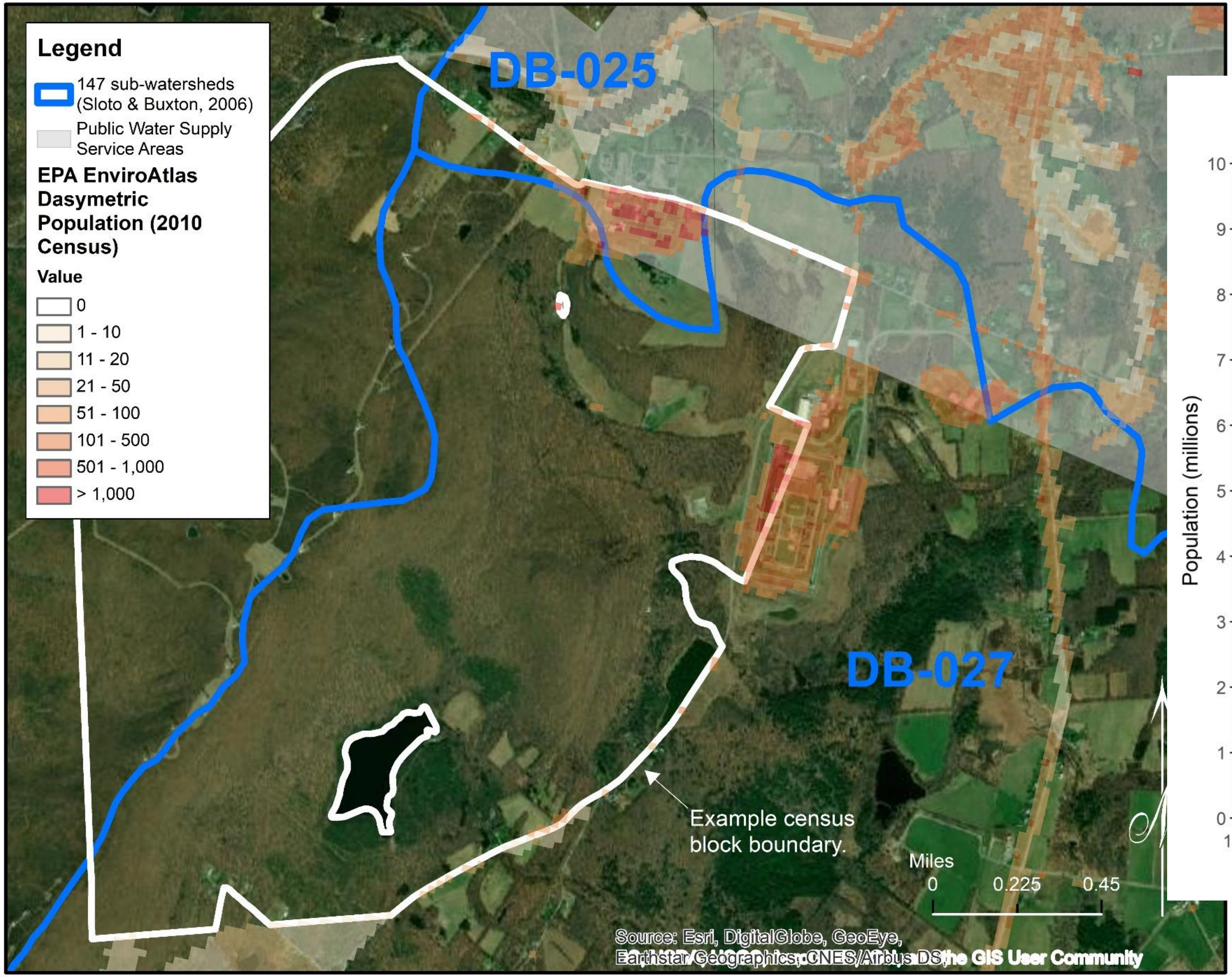
Power generation and water use

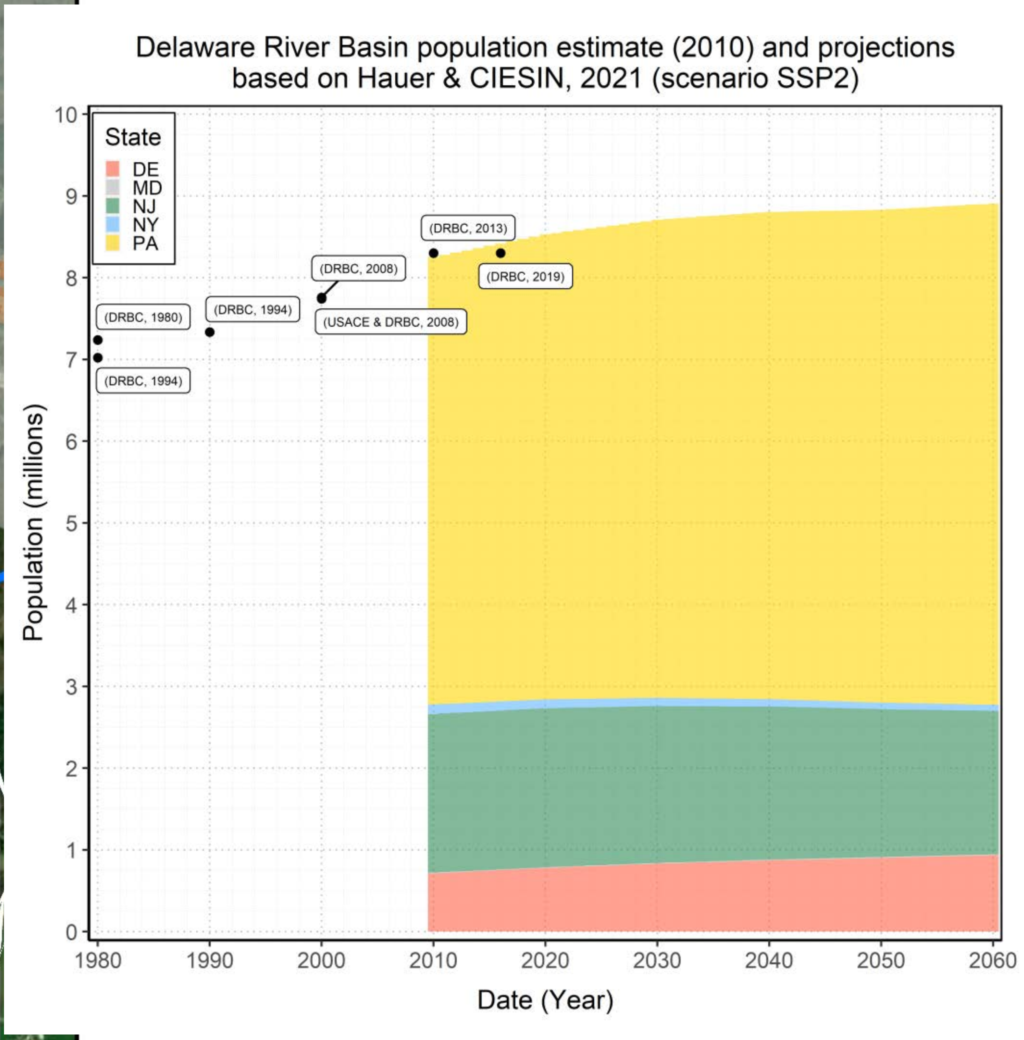






Population and self-supplied water use





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8. Questions

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