Water Use in New England and Massachusetts-- An Overview

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USGS New England Water Science Center

Massachusetts Water Resources Commission
April 11, 2019

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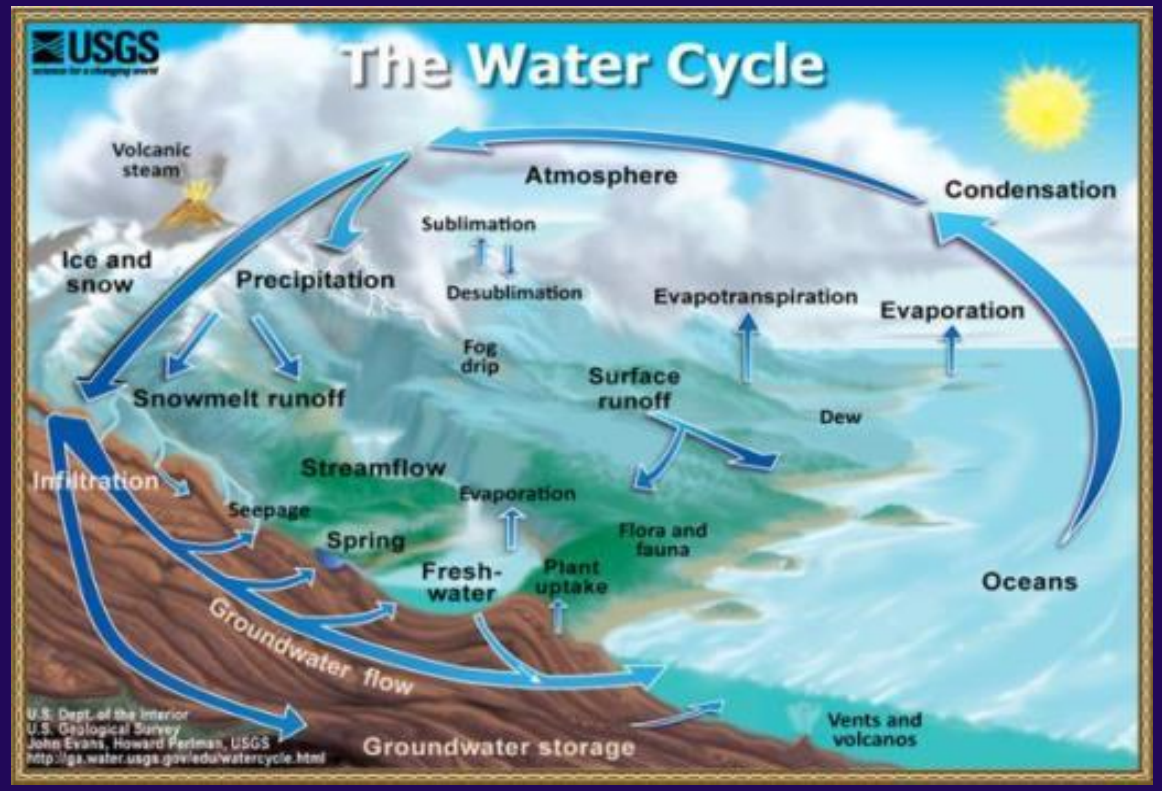
Why does USGS study water use?

- Mandated by Congress: national compilations every 5 years
- Water use: a key part of the *water cycle* and *water budget*



$$P = Q + E + dS/dt$$

P	:	Precipitation [mm a^{-1}]
Q	:	Discharge [mm a^{-1}]
E	:	Evaporation [mm a^{-1}]
dS/dt	:	Storage changes per time step [mm a^{-1}]

Inflow = Outflow + Change in Storage

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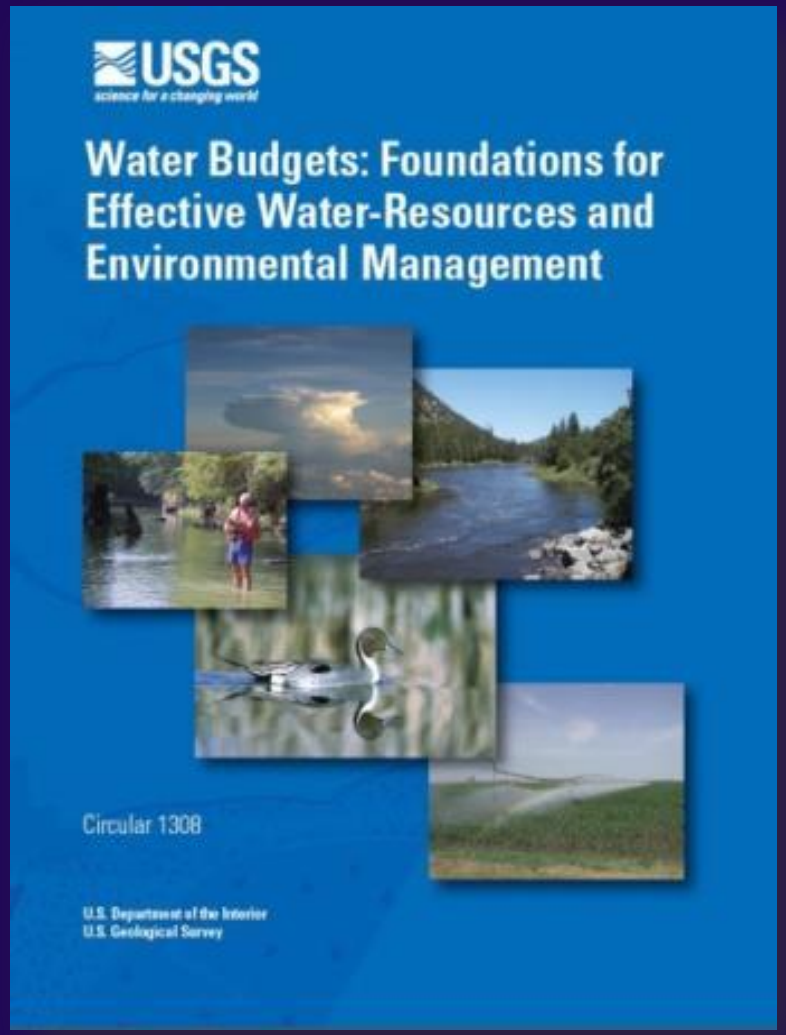
How much water is available? … Water Budgets



"Water budgets are tools that water users and managers use to quantify the hydrologic cycle….

Understanding of water budgets and underlying hydrologic processes provide a foundation for effective water-resource and environmental planning and management."

http://pubs.usgs.gov/circ/2007/1308/pdf/C1308_508.pdf

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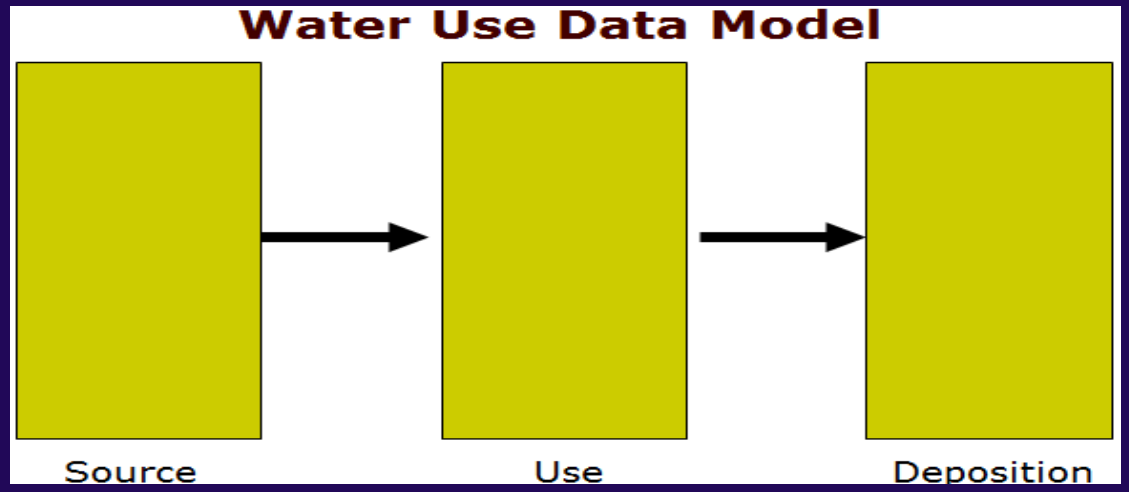
The success of USGS water-use science depends on:

- Partnerships with State and other Federal agencies,
- Support to States from national USGS grant funds.

USGS National Water Use Compilation

- *A snapshot every 5 years*
- *Key source of information on state and national trends*
- *Summarizes estimated amount of water withdrawn, used and deposited from/to Groundwater (GW) and Surface-Water (SW) resources*



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USGS National Water Use Reports

Water use estimated at 5-year intervals since 1950

2015 report: https://pubs.er.usgs.gov/publication/cir1441

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2015 Report:

*Data aggregated by county, state, gw vs. sw, and **water use category***

https://pubs.er.usgs.gov/publication/cir1441

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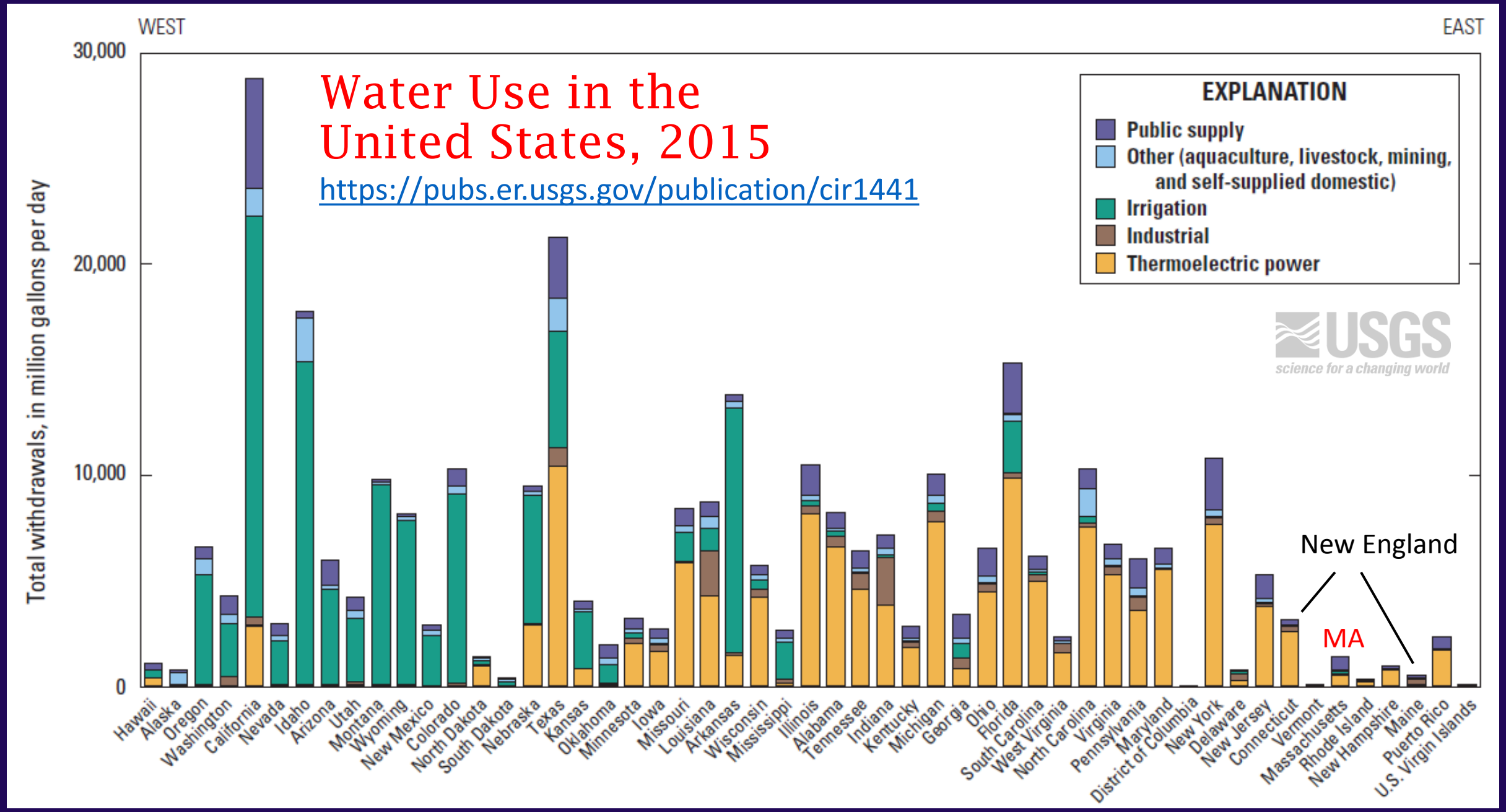
Water Use in the United States, 2015
https://pubs.er.usgs.gov/publication/cir1441
WEST
EAST
Total withdrawals, in million gallons per day
30,000
20,000
10,000
0
EXPLANATION
Public supply
Other (aquaculture, livestock, mining, and self-supplied domestic)
Irrigation
Industrial
Thermoelectric power
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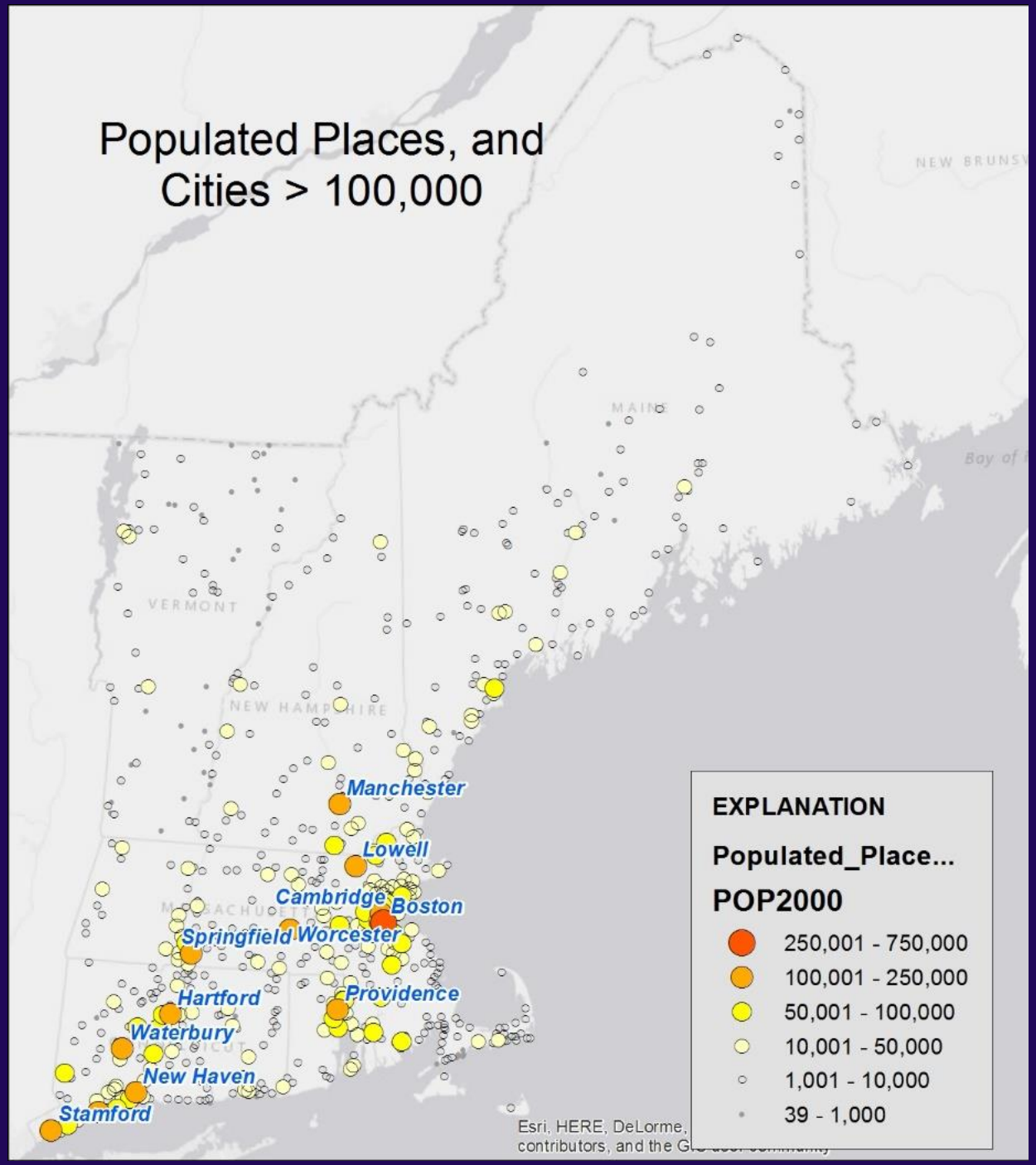
New England
MA
Hawaii
Alaska
Oregon
Washington
California
Nevada
Idaho
Arizona
Utah
Montana
Wyoming
New Mexico
Colorado
North Dakota
South Dakota
Nebraska
Texas
Kansas
Oklahoma
Minnesota
Iowa
Missouri
Louisiana
Arkansas
Wisconsin
Mississippi
Illinois
Alabama
Tennessee
Indiana
Kentucky
Michigan
Georgia
Ohio
Florida
South Carolina
West Virginia
North Carolina
Virginia
Pennsylvania
Maryland
District of Columbia
New York
Delaware
New Jersey
Connecticut
Vermont
Massachusetts
Rhode Island
New Hampshire
Maine
Puerto Rico
U.S. Virgin Islands

New England Population, 2015



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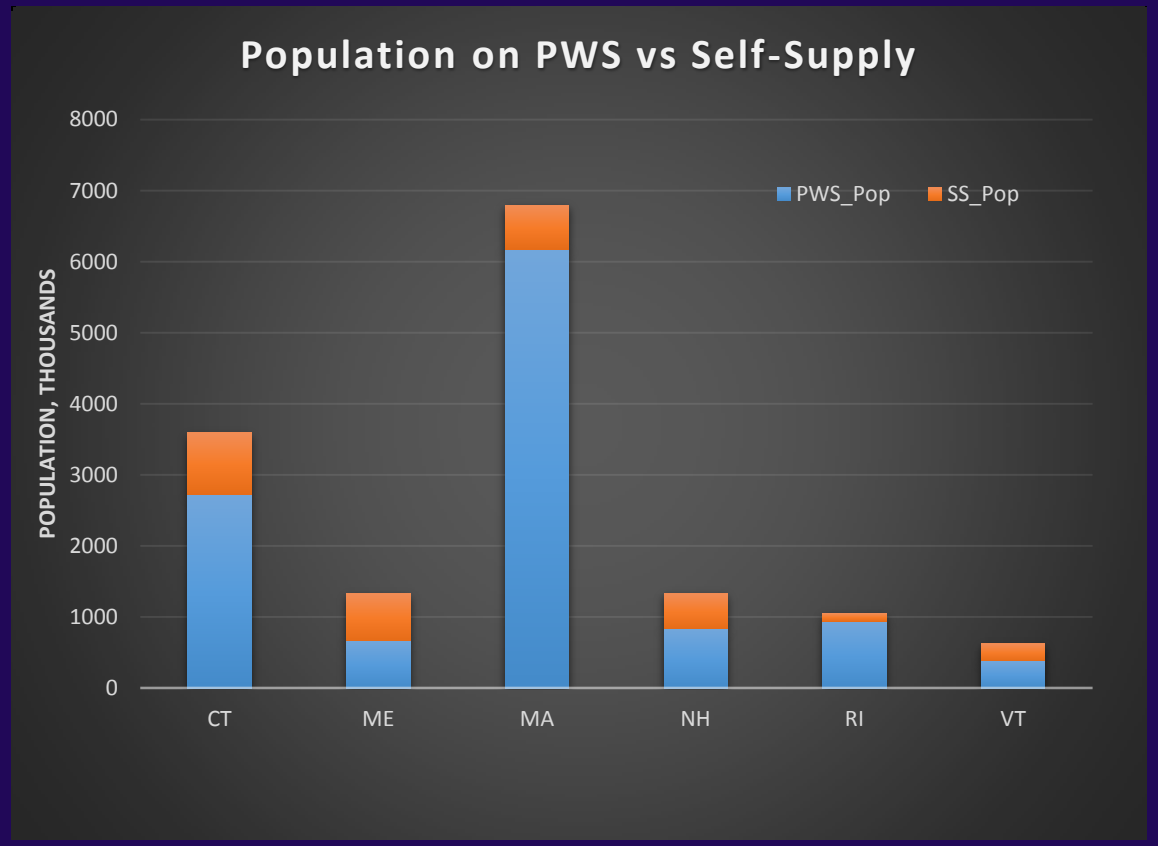
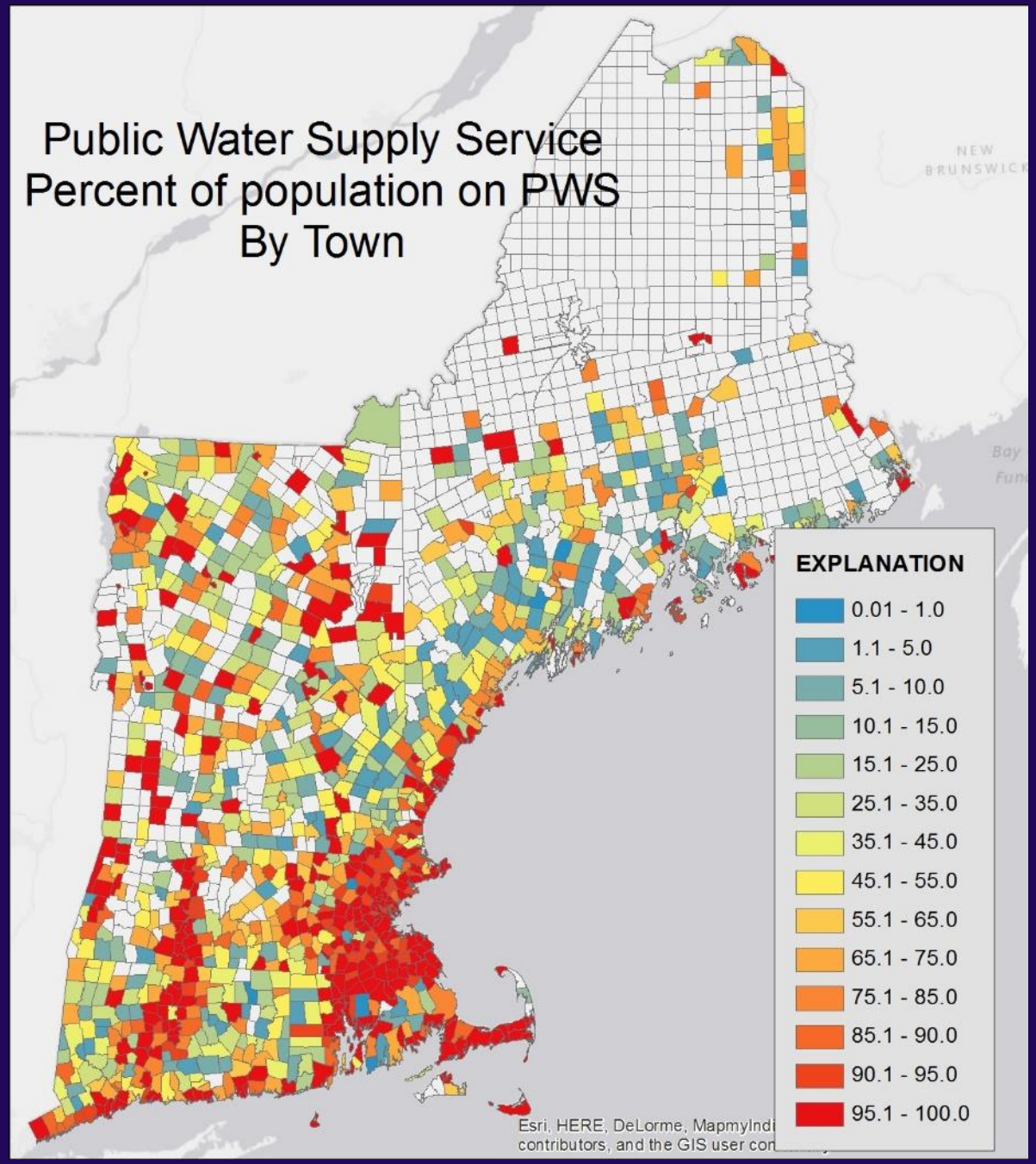
Public vs Self-Supply Populations, 2015





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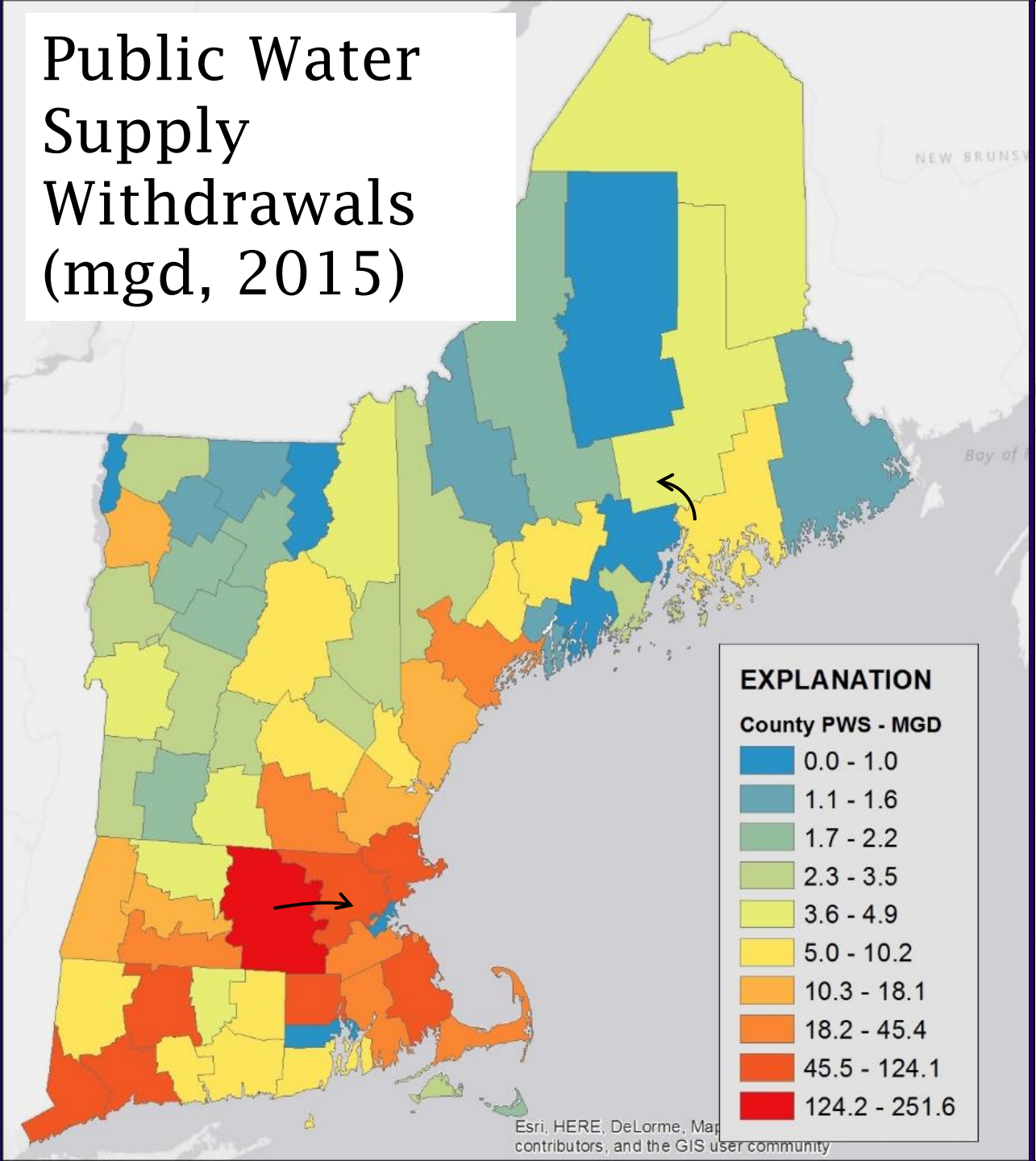
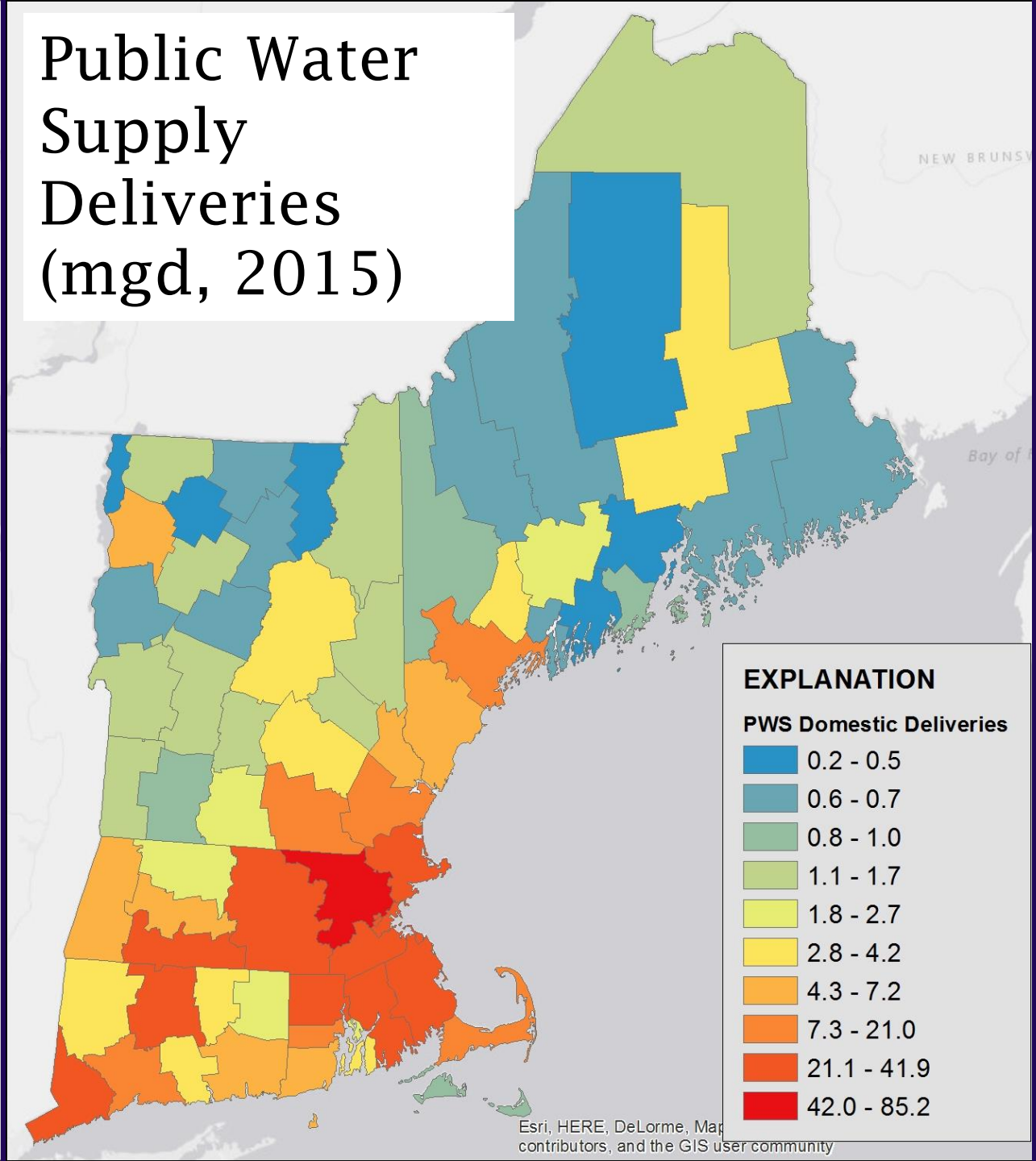
Public Water Supply Withdrawals (mgd, 2015)



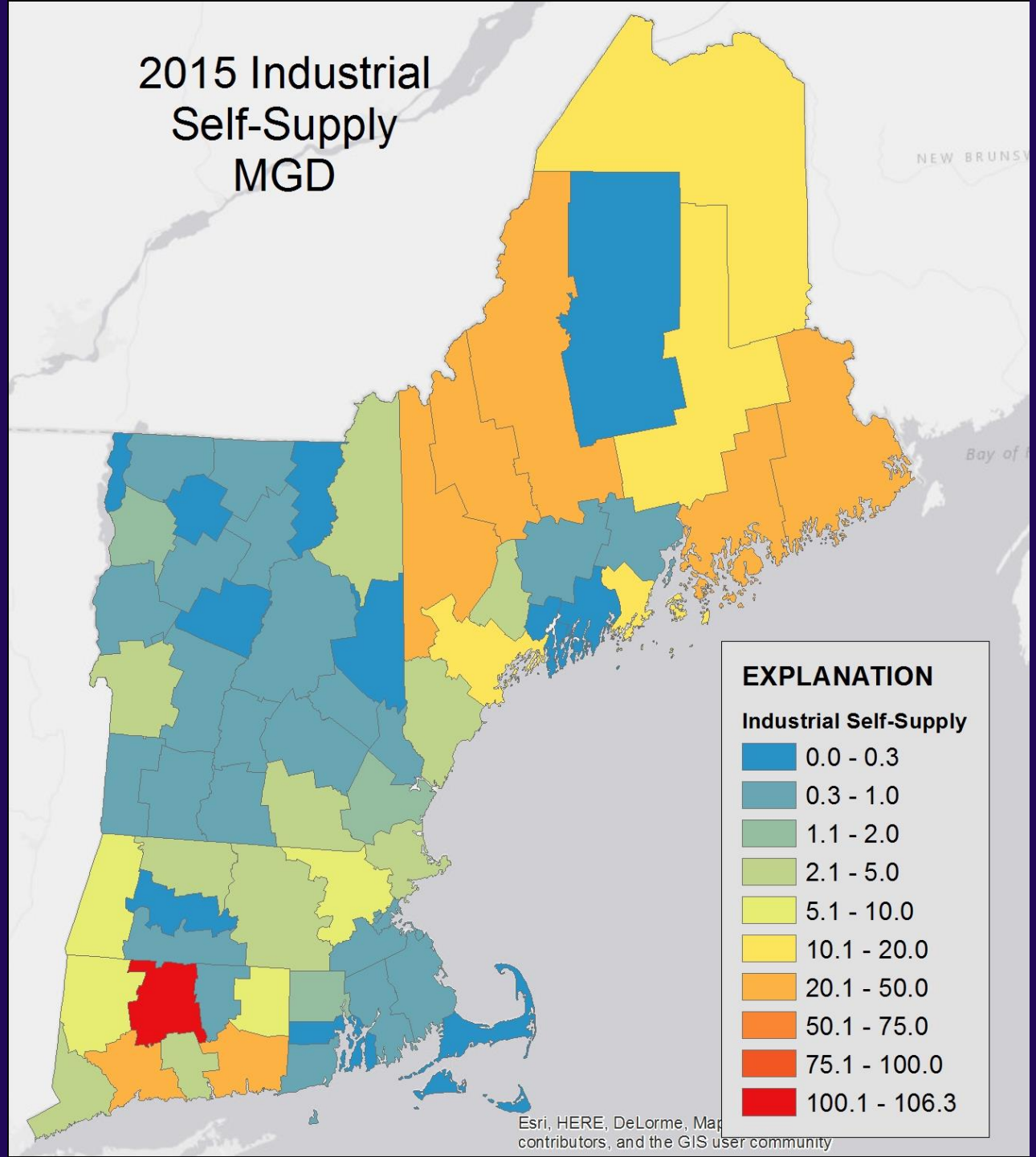
Public Water Supply Deliveries (mgd, 2015)



Industrial
(self-supplied)

- MA, 2015:

  Less self-supplied industrial water use in MA than in CT and ME.



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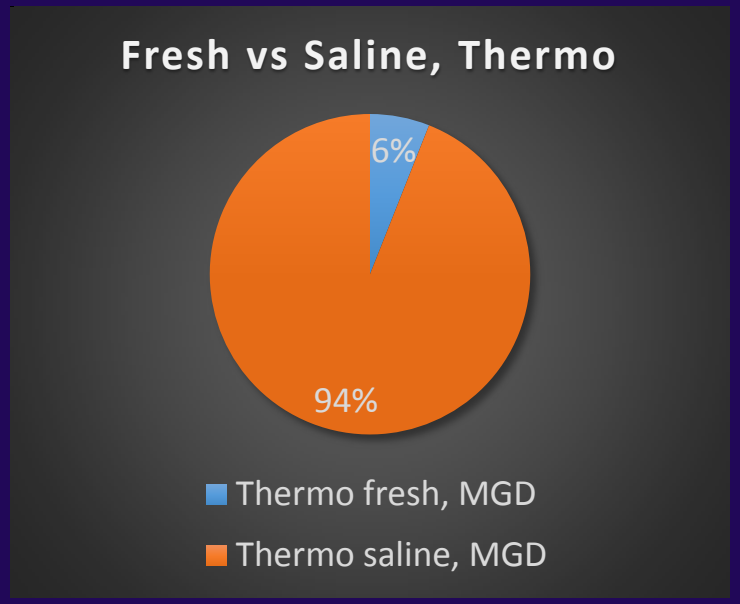
Thermoelectric Power (self-supplied)

- Data from USGS national sources
- Need: better site-specific data in the future



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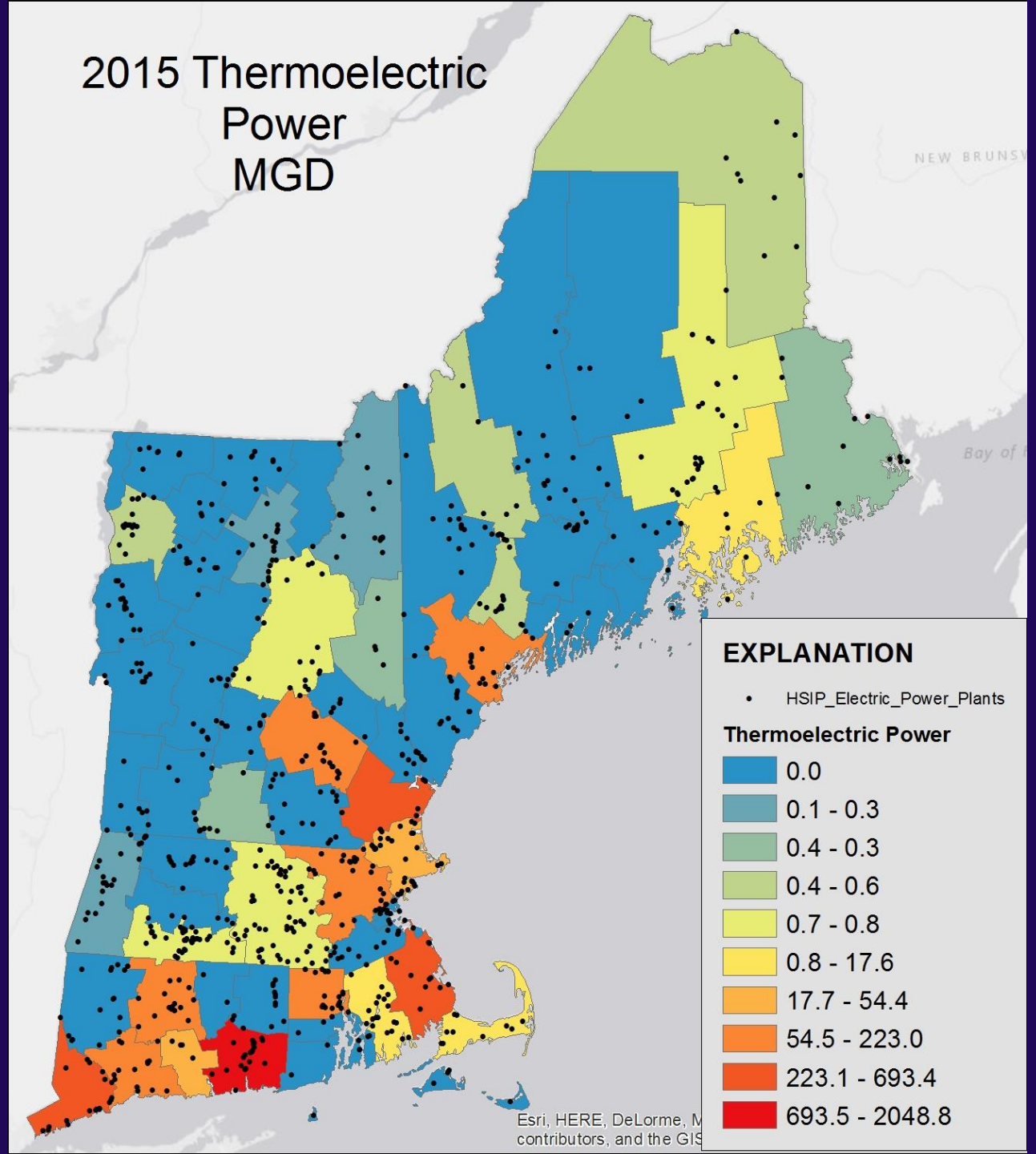
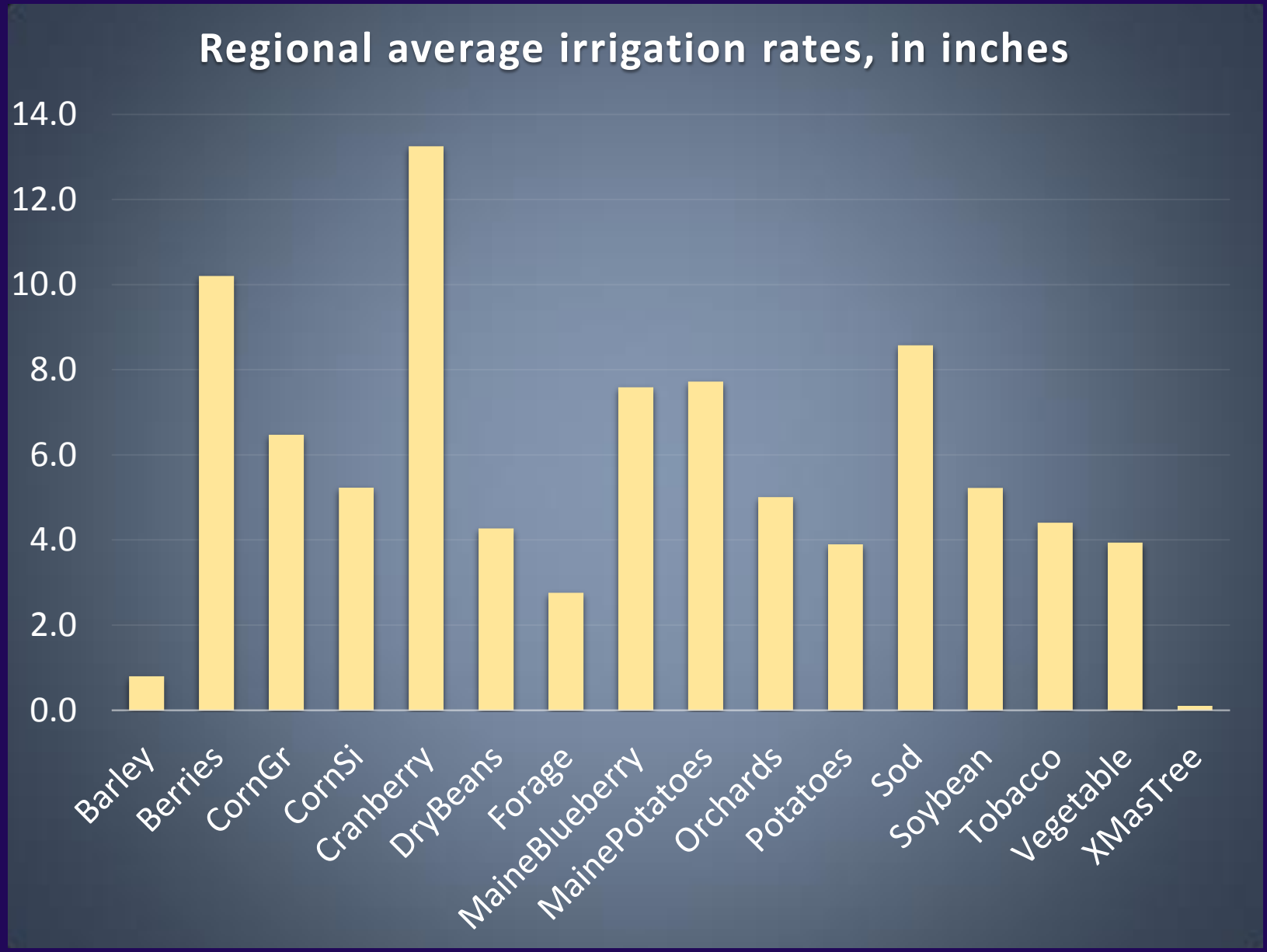


Irrigation rates

- inches/yr,

- by crop



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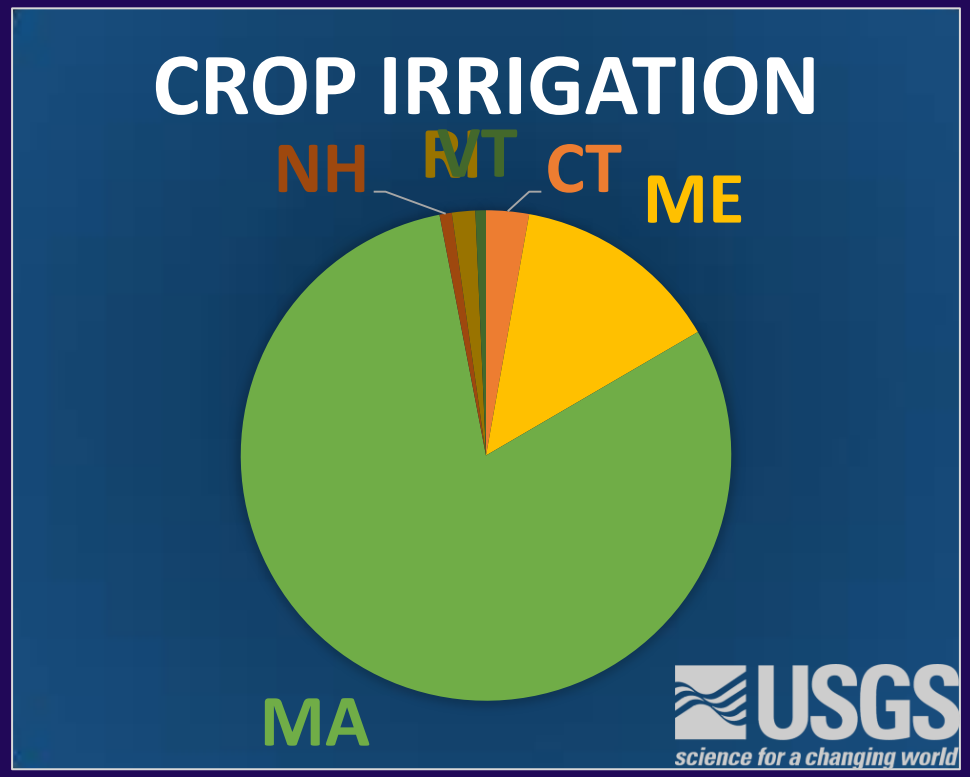
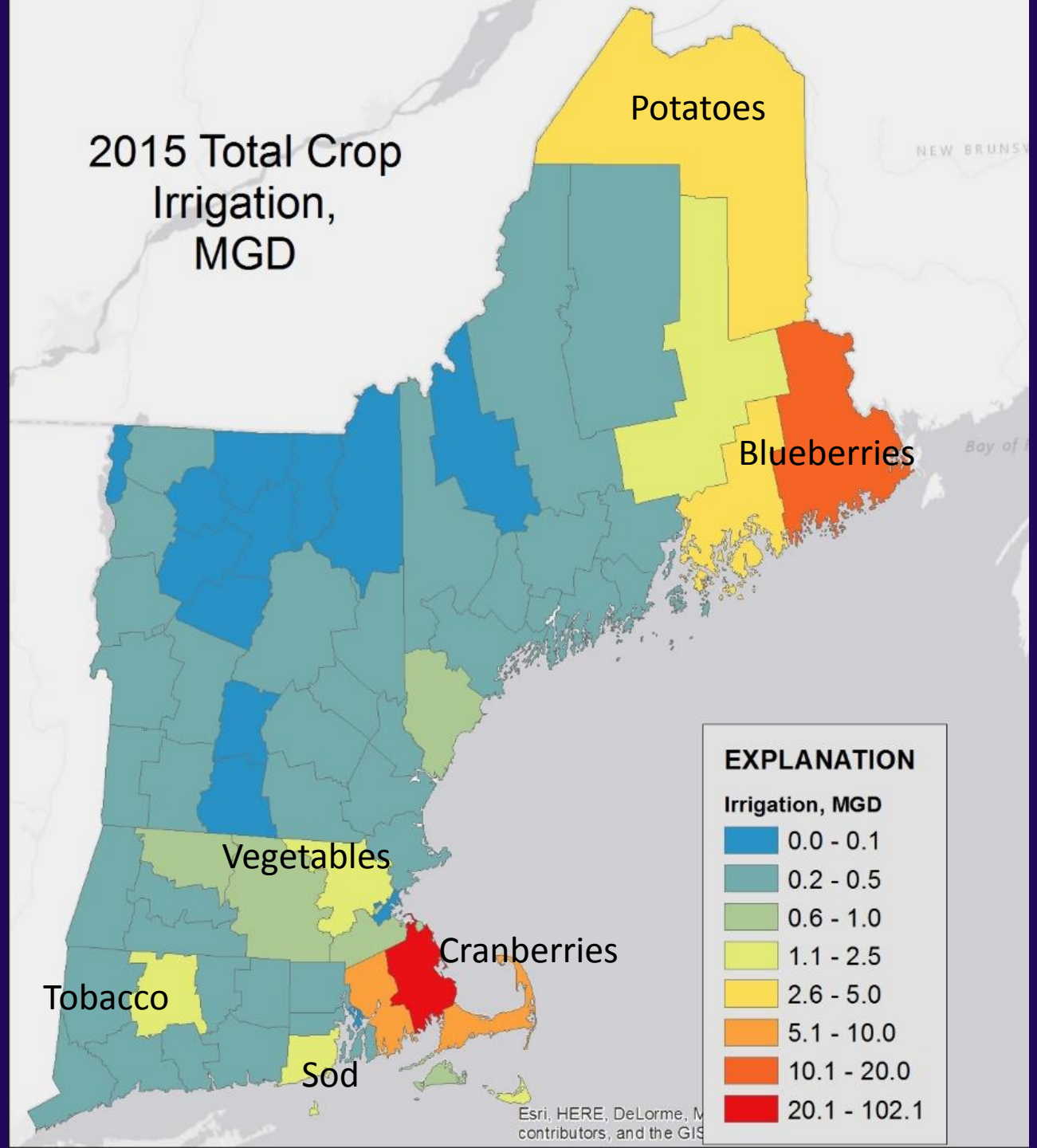
Irrigation volumes

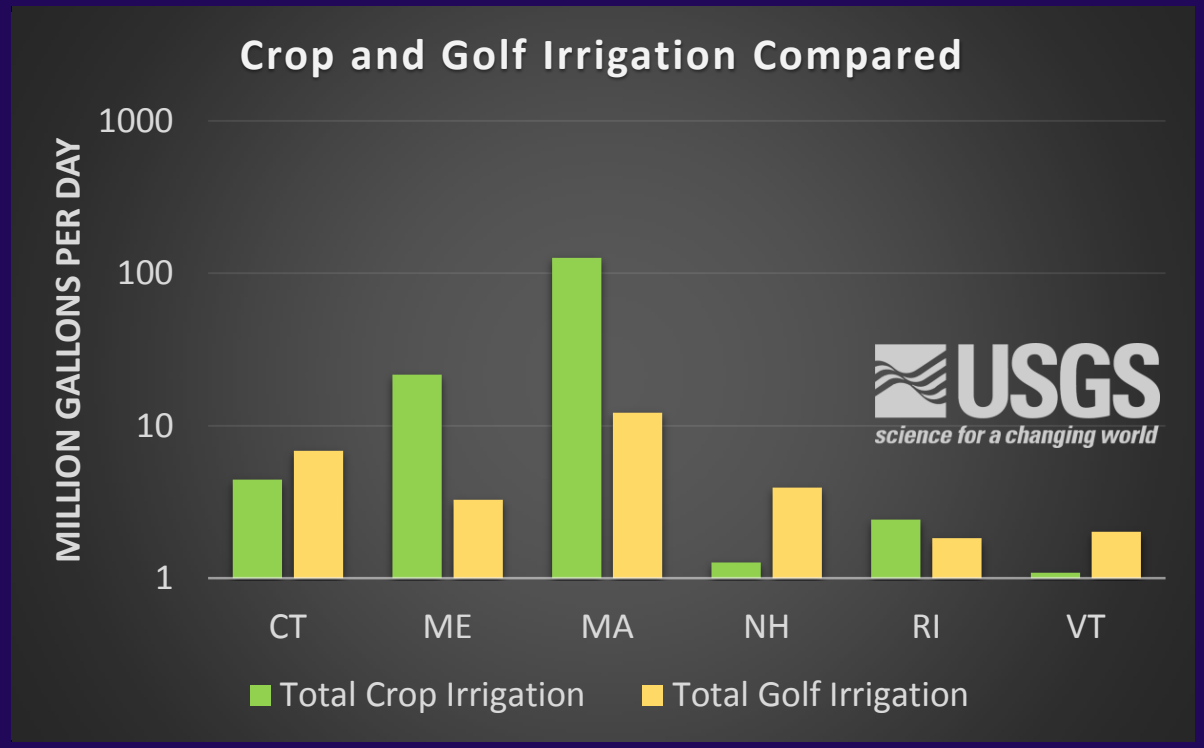
- Average daily, mgd

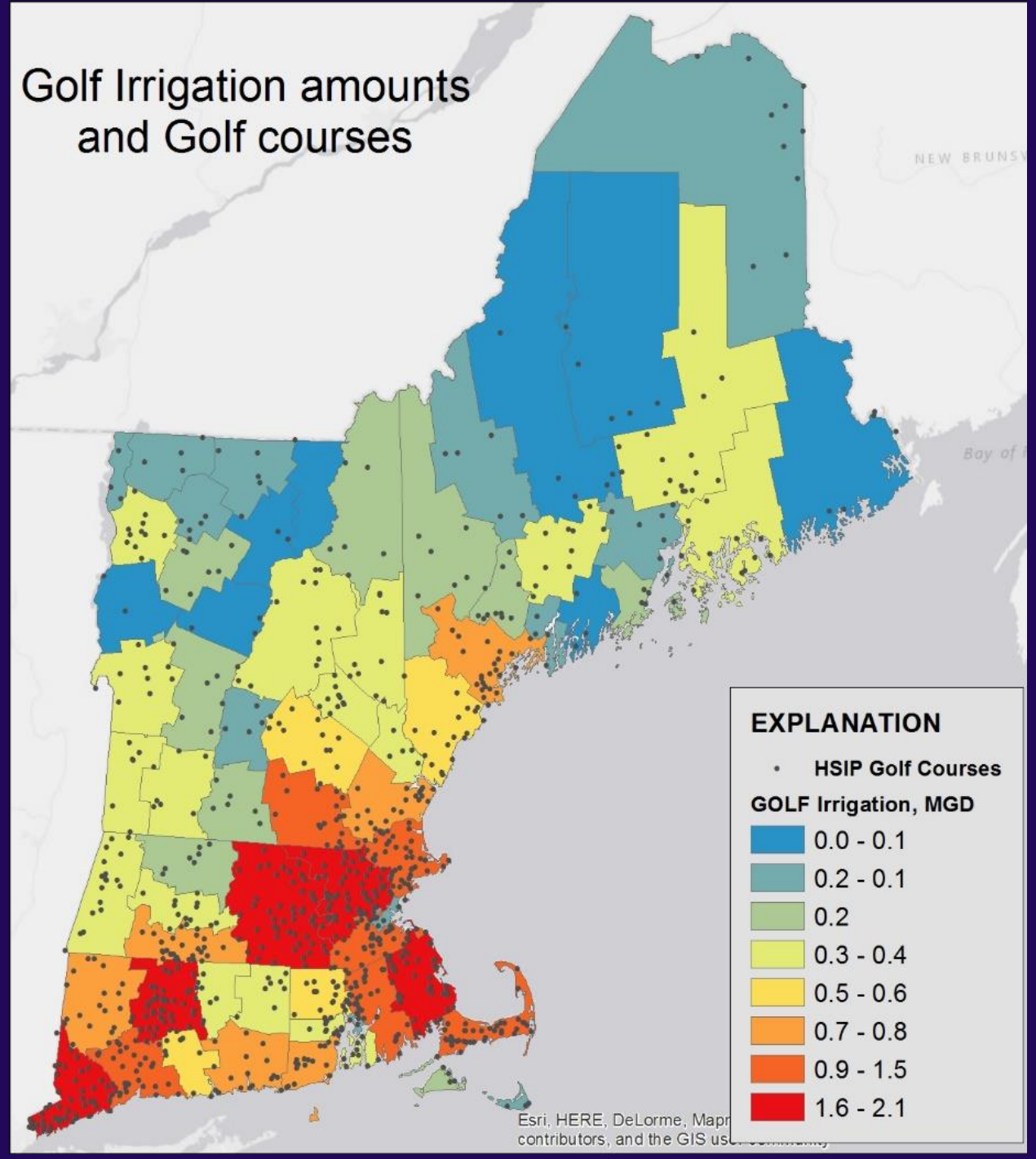




Irrigation:

- Golf courses
- average daily, mgd





All USGS compilation data available online

USGS Water Data for the Nation

Search for Sites With Data

Current Conditions — Sites with real-time or recent surface-water, groundwater,or water-quality data.

Site Information — Descriptive site information for all sites with links to all available water data for individual sites.

Map of all sites with links to all available water data for individual sites.

Frequent Searches By Data Category

Surface Water — Water flow and levels in streams and lakes.

Groundwater — Water levels in wells.

Water Quality — Chemical and physical data for streams, lakes, springs, wells and other sites.

Water Use — Water use information.

Introduction

These pages provide access to water-resources data collected at approximately 1.5 million sites in all 50 States, the District of Columbia, Puerto Rico, the Virgin Islands, Guam, American Samoa and the Commonwealth of the Northern Mariana Islands. Online access to this data is organized around the categories listed to the left.

The USGS investigates the occurrence, quantity, quality, distribution, and movement of surface and underground waters and disseminates the data to the public, State and local governments, public and private utilities, and other Federal agencies involved with managing our water resources.

About Us | Help | Tutorial

https://waterdata.usgs.gov/usa/nwis/

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Massachusetts water use trends

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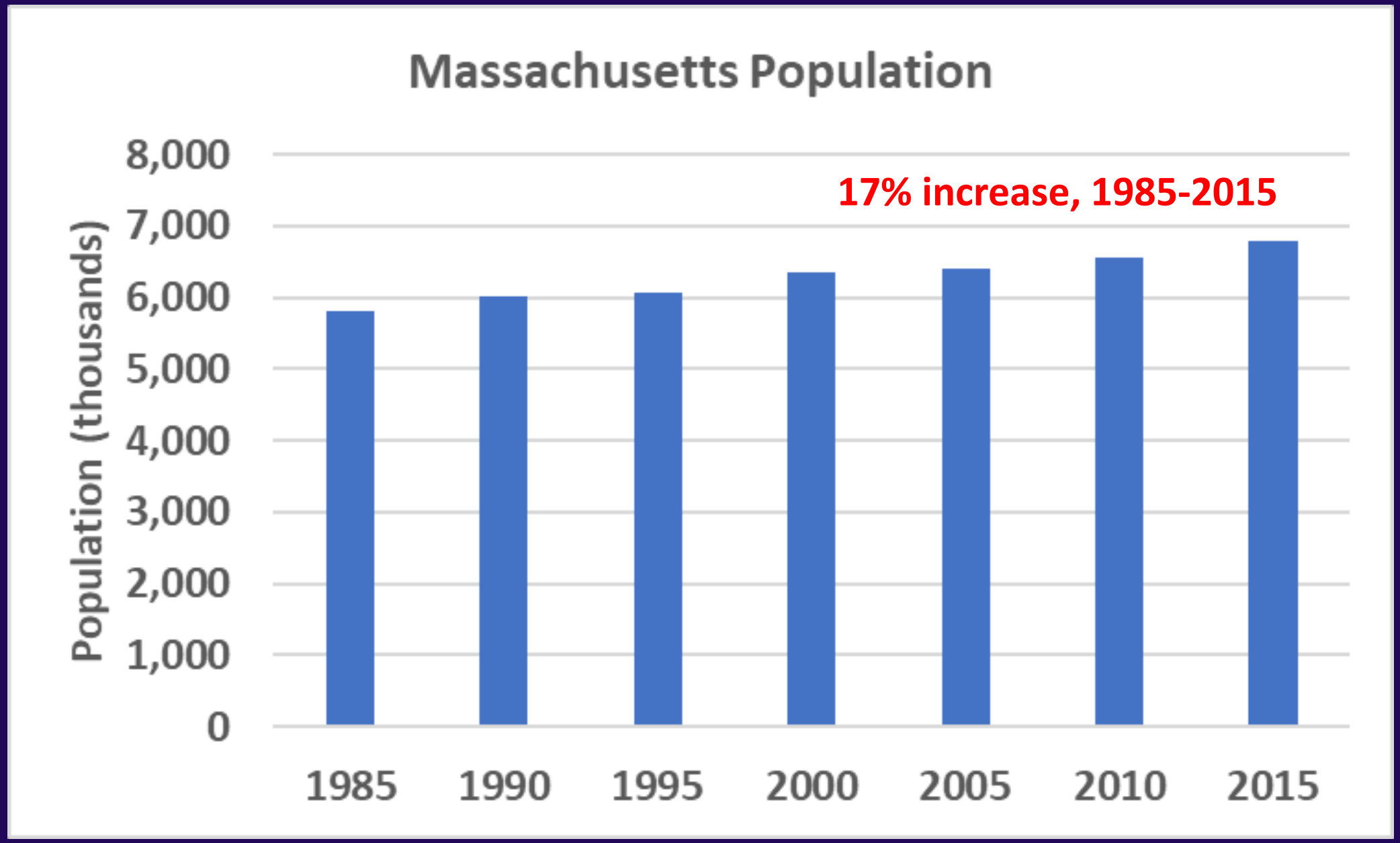

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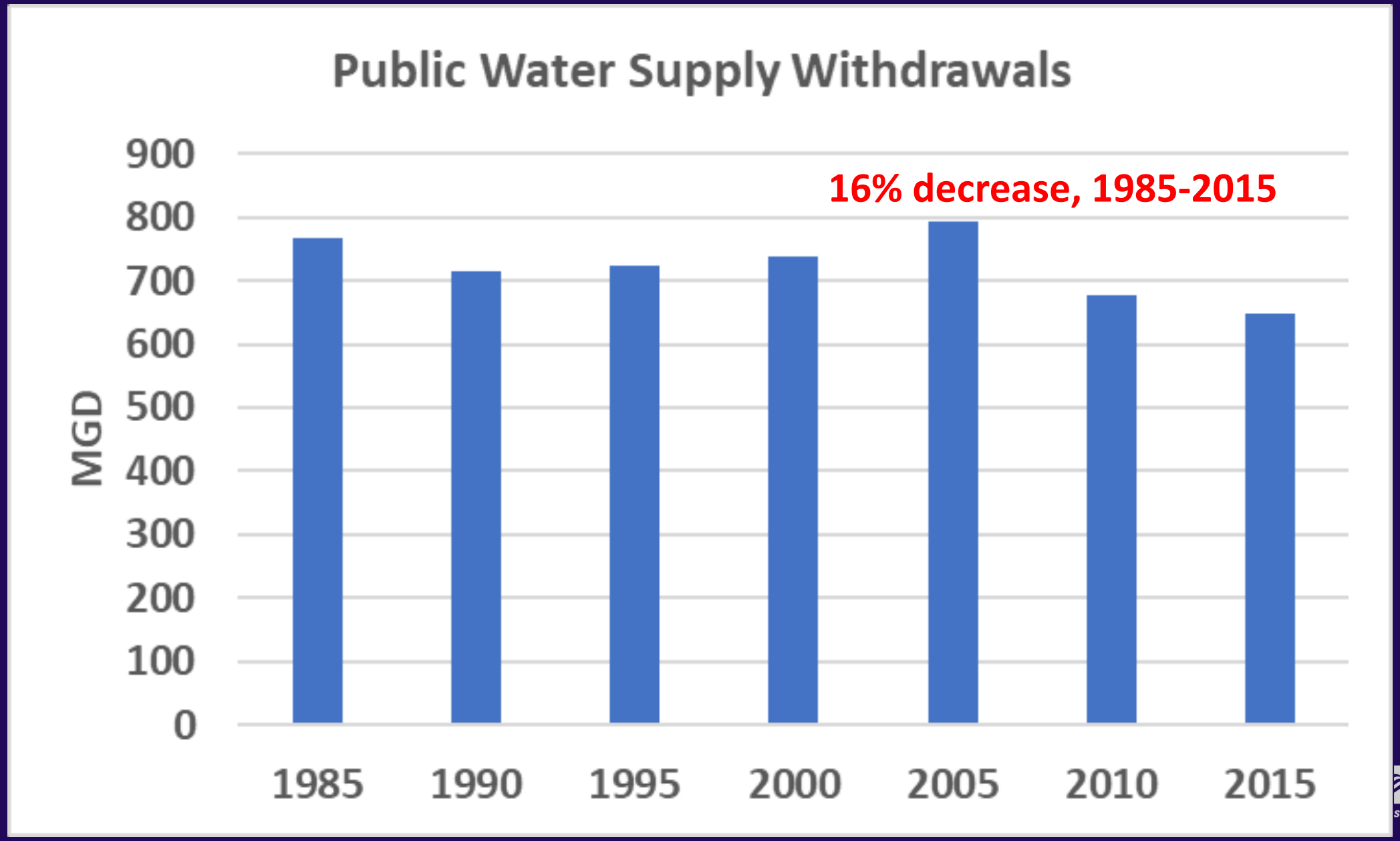

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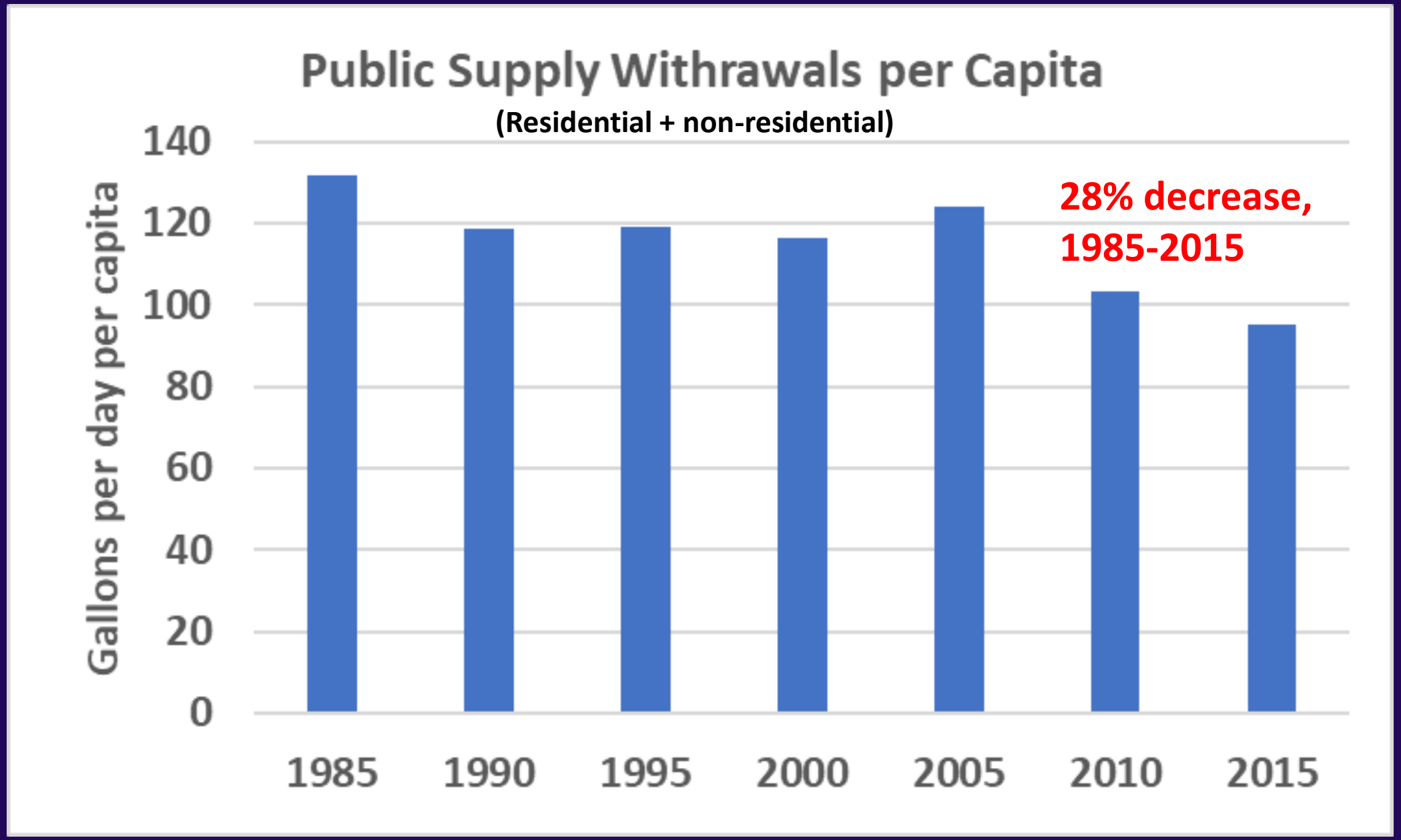

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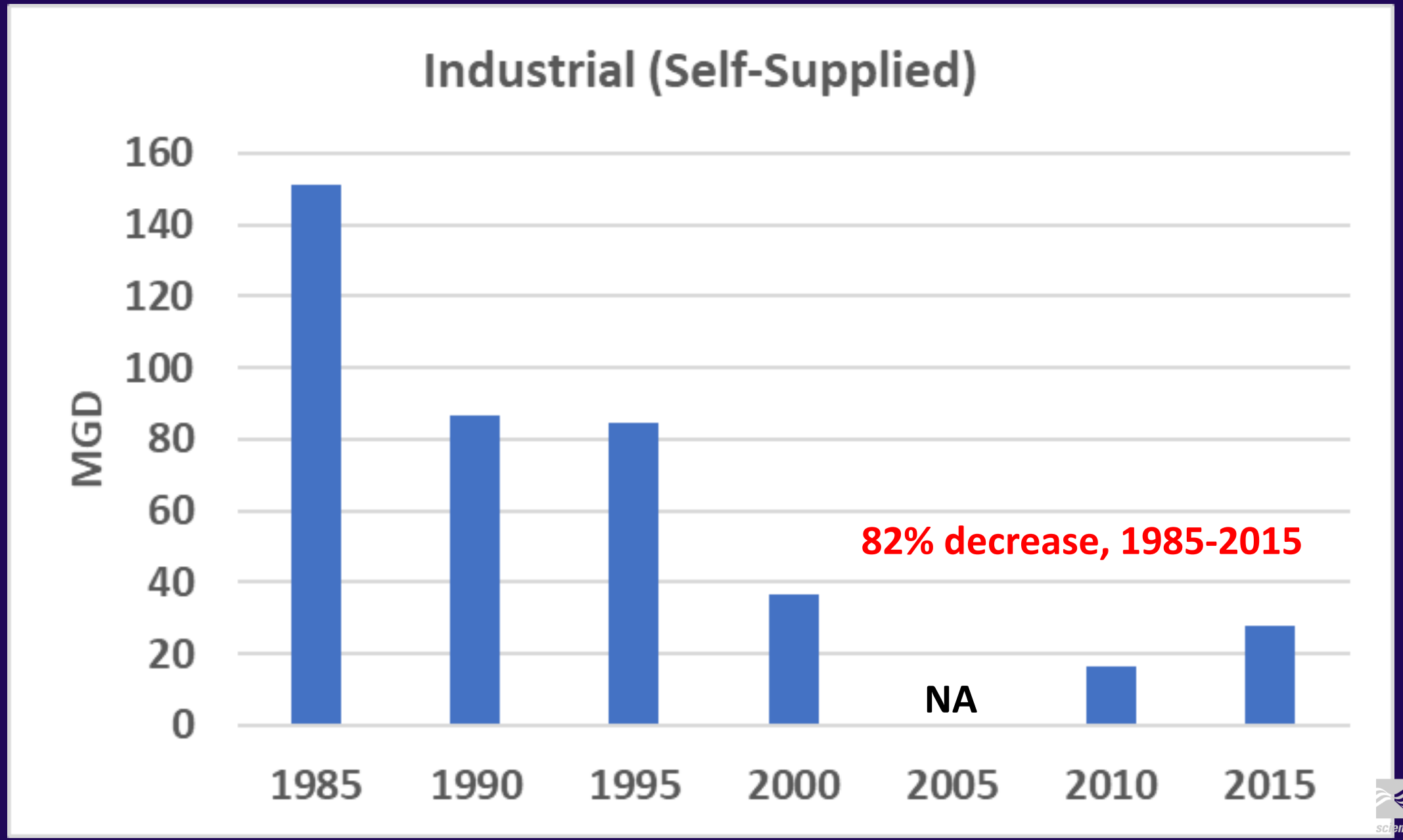
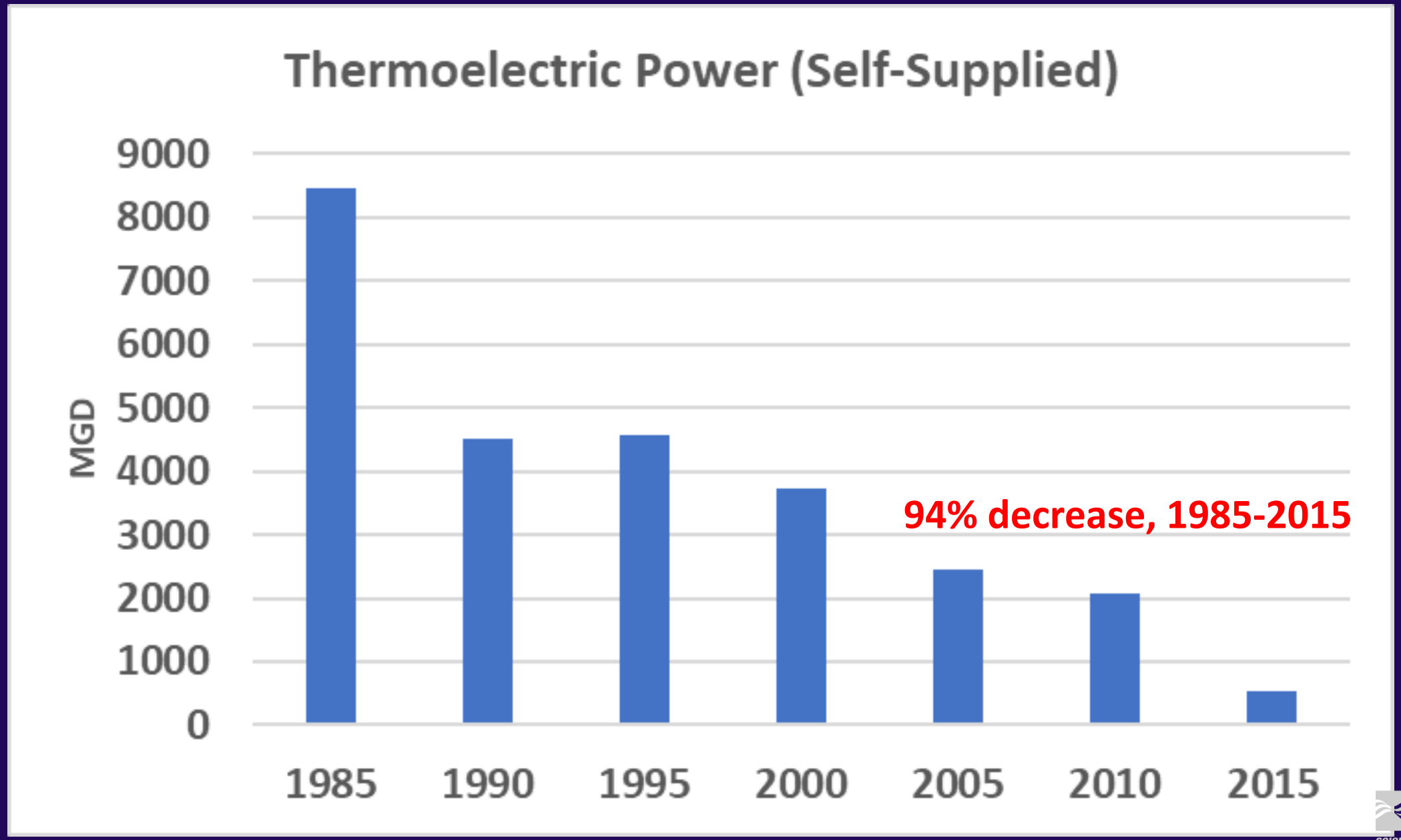

Industrial (Self-Supplied)
MGD
160
140
120
100
80
60
40
20
0
1985
1990
1995
2000
2005
2010
2015
82% decrease, 1985-2015
NA



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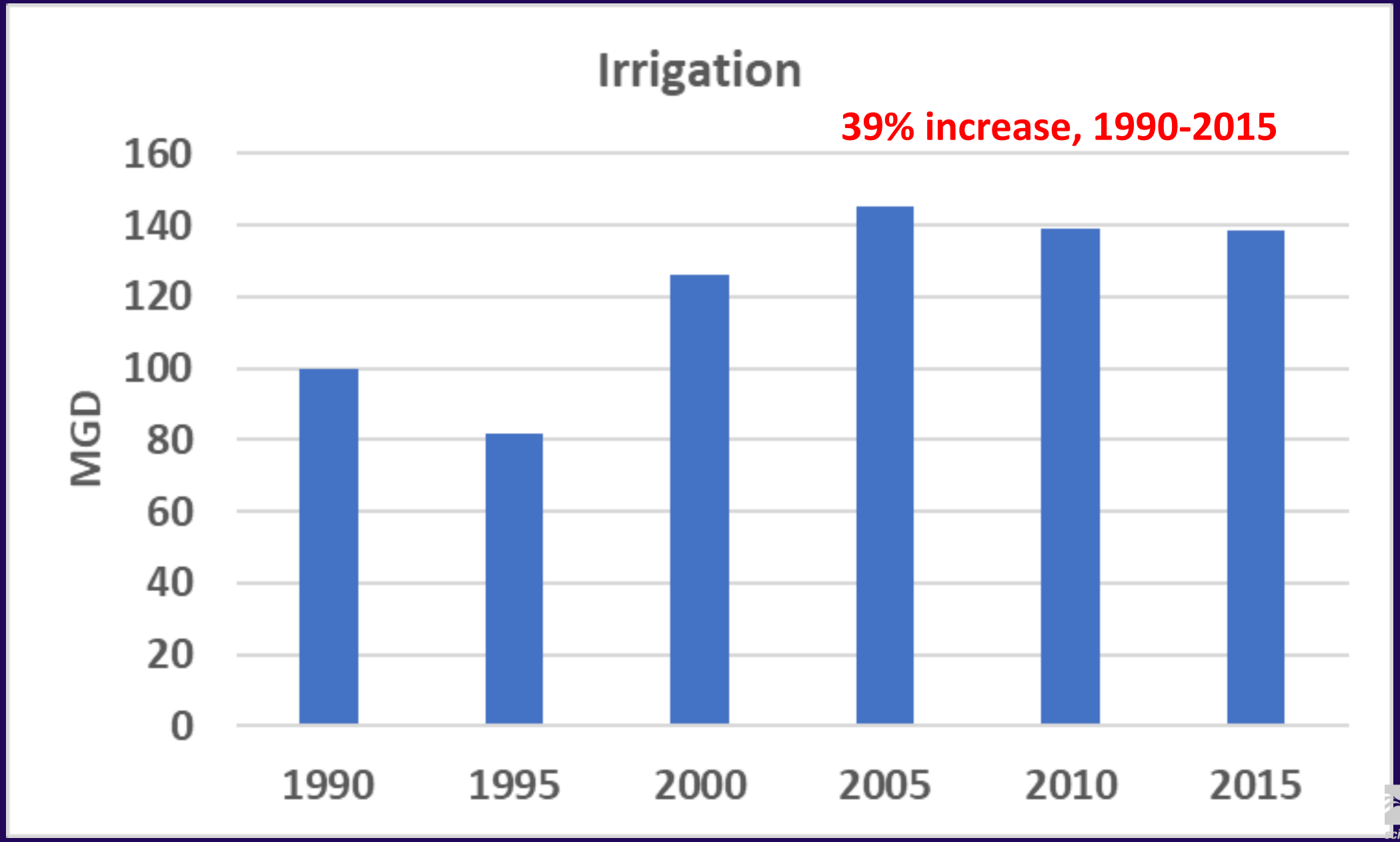

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Key research needs:

- Seasonal communities:
  Resident vs non-resident populations and per capita volumes served by PWS in seasonal communities
- Allocating irrigation withdrawals from GW vs. SW
- Better estimates of withdrawals below threshold (< 100,000 gpd).
- Better data for non-residential PWS deliveries
- Development of improved site-specific databases

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Questions…?

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Update on the MassDEP Water Use Data and Research Program Grant

April 11, 2019
Water Resources Commission Meeting
100 Cambridge Street, Boston

Julie Butler, Water Management Program
MA Department of Environmental Protection

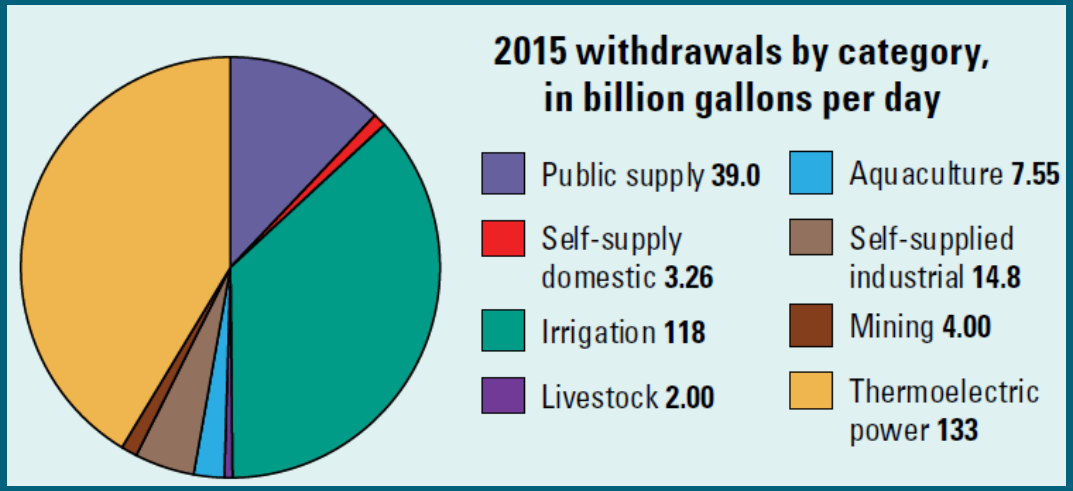
Outline

- USGS Water Use Data & Research (WUDR) Program

- MassDEP Project
  - Background & Timeline
  - Objectives
  - Progress

Water Use Data & Research Program (WUDR)

- USGS National Grant Initiative, 2015-present
  - SECURE Water Act (2009)
  - Workplan funding up to $26,000
  - Project funding up to $100,000
- Assist States to improve water-use data
  - Collection
  - Management
  - Analysis
  - Sharing
    - 5-year USGS National Compilation



Maupin, M.A., *Summary of Estimated Water Use in the United States in 2015,* USGS Fact Sheet 2018-3035, June 2018, 2 p. https://doi.org/10.3133/fs20183035

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Water Availability and Use Science Program

Estimated Use of Water in the United States in 2015

Circular 1441
Supersedes USGS Open-File Report 2017–1131

MassDEP WUDR Project

- Led by WMA Program
  - Julie Butler, Richard Friend & Shi Chen
  - Addis Abebe & Jamie Dawson

WUDR Phases	Timeframe
Workplan Development	Sept 2015 – Sept 2016
Project Application	April 2017
Project Implementation	Sept 2017 – Sept 2019

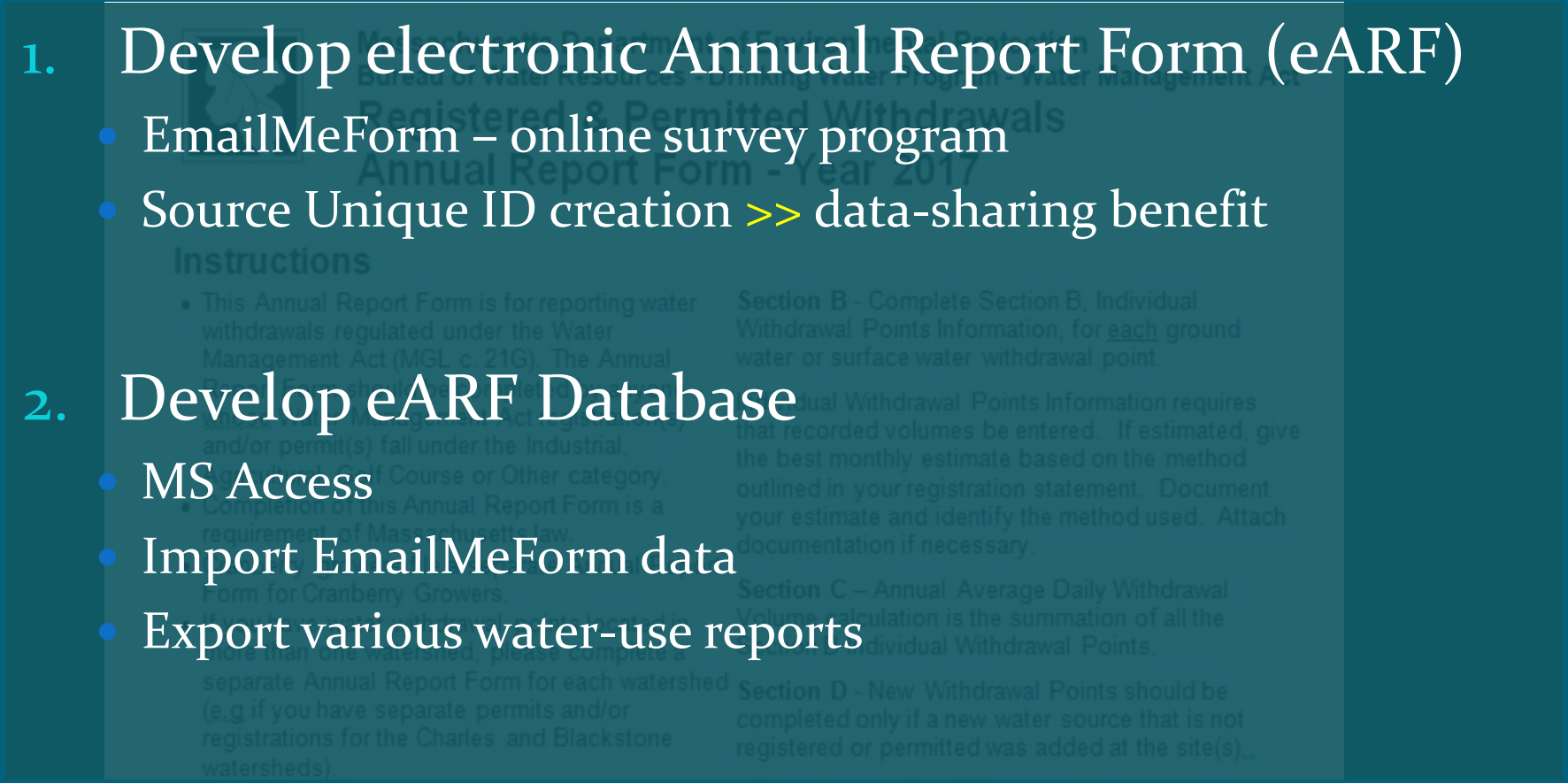
- Project Deliverables
  - Progress Reports
  - Final Technical Report

MassDEP WUDR Project

OBJECTIVES*	
1. **Electronic Non-PWS Data**	5. WMA Database QA/QC
2. Non-PWS Survey	6. ASR Data Validation Rules
3. WMA Withdrawal Points update	7. Data-sharing procedures
4. Aquifer Designations	8. **Private well use estimation**

*Update cranberry bog water use method – not pursued

MassDEP WUDR Project: Objective 1
Collect non-PWS data electronically



1. Develop electronic Annual Report Form (eARF)
   - EmailMeForm – online survey program
   - Source Unique ID creation >> data-sharing benefit
2. Develop eARF Database
   - MS Access
   - Import EmailMeForm data
   - Export various water-use reports

MassDEP WUDR Project: Objective 1
Collect non-PWS data electronically

Benefits: improve data analysis and data sharing

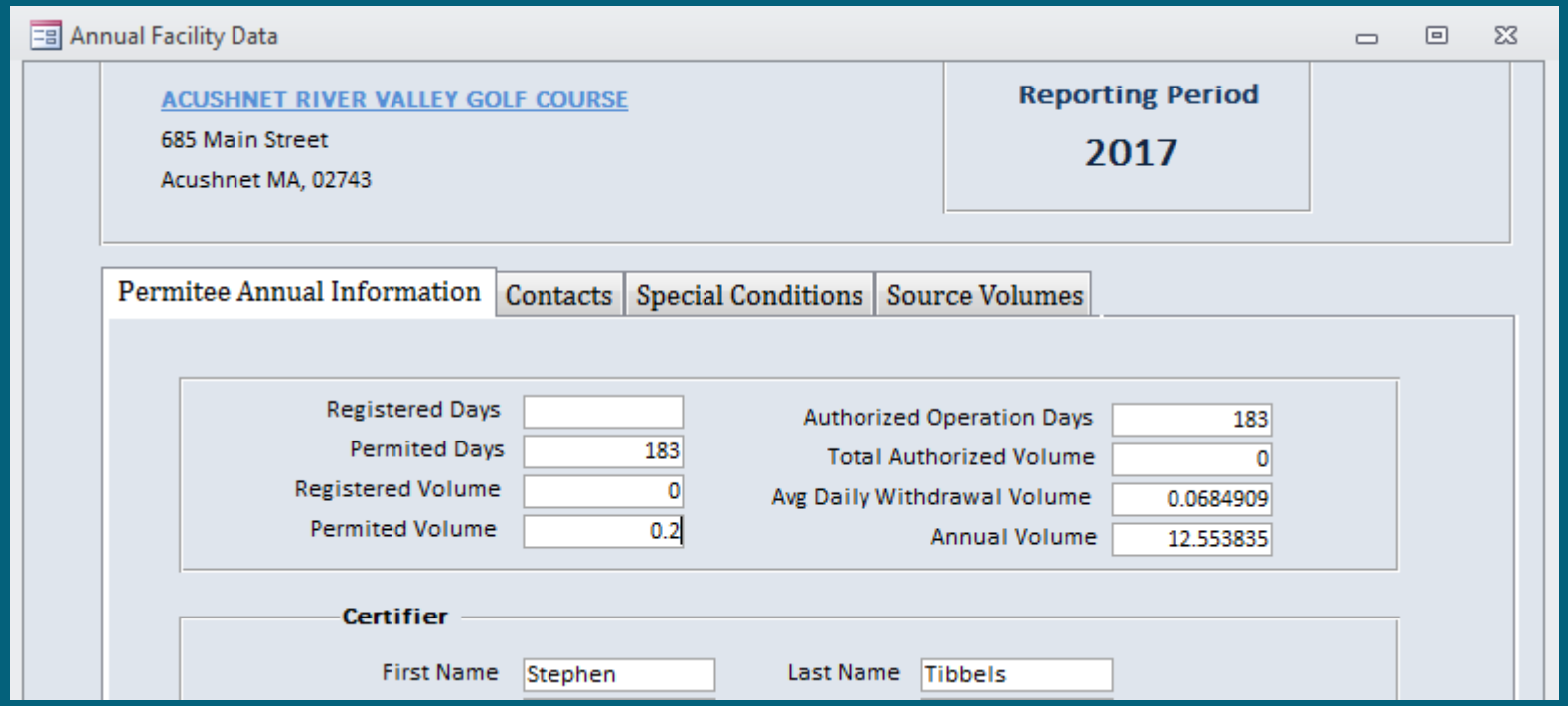
- Monthly (vs. annual) withdrawals
- Per-source (vs. system-wide) withdrawals
- Up-to-date source IDs and contact information
- Maximum daily withdrawal per year
- Withdrawal measurement method
- Meter calibration status
- New source tracking
- Reporting requirement checks
- Automated PDF generation

Rollout:
December 2017

MassDEP WUDR Project: Objective 1
Collect non-PWS data electronically

eARF Database

- Generate Excel reports by basin, town, water-use; deliverable to USGS by county



MassDEP WUDR Project: Objective 1
Collect non-PWS data electronically

Challenges:

1. EmailMeForm limitations
   - Lacking basic arithmetic, error flags
   - Export reformatting

2. Low response rates (70-80%)
   - Ongoing outreach

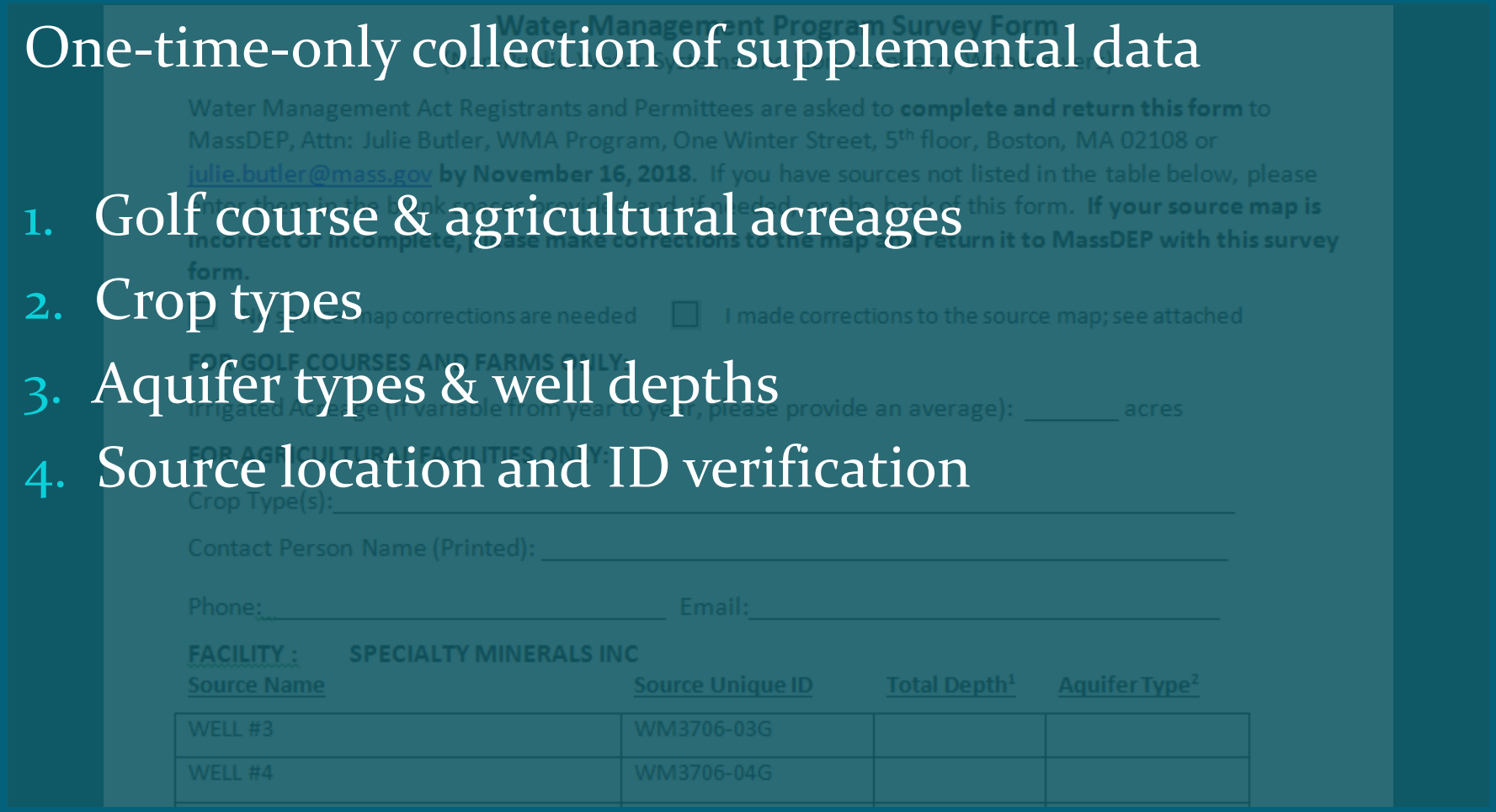
3. eARF Database cannot "talk" to WMA Database

Facility Withdrawal Report		
Facility Name	**ACUSHNET RIVER VALLEY GOLF COURSE**	
Reg Perm ID	**4880**	
Registration Number	**N/A**	
Permit Number	**9P2-4-24-003.01**	
Town	**Acushnet**	
Basin	**Buzzards Bay**	
Water Use	**Golf**	
Reporting Year	**2017**	
	Irrigaton Well	
Period	**WM4880-01G**	**Monthly Totals**
January	0	0
February	0	0
March	0	0
April	0.523	0.523
May	0.980	0.980
June	1.937	1.937
July	3.189	3.189
August	3.798	3.798
September	1.485	1.485
October	0.642	0.642
November	0.001	0.001
December	0	0
Total	12.554	12.554

MassDEP WUDR Project: Objective 2 *Non-PWS survey*

One-time-only collection of supplemental data

1. Golf course & agricultural acreages
2. Crop types
3. Aquifer types & well depths
4. Source location and ID verification



Water Management Program Survey Form

Water Management Act Registrants and Permittees are asked to **complete and return this form** to MassDEP, Attn: Julie Butler, WMA Program, One Winter Street, 5th floor, Boston, MA 02108 or julie.butler@mass.gov **by November 16, 2018**. If you have sources not listed in the table below, please enter them in the blank spaces provided and, if needed, on the back of this form. **If your source map is incorrect or incomplete, please make corrections to the map and return it to MassDEP with this survey form.**

☐ No source map corrections are needed ☐ I made corrections to the source map; see attached

FOR GOLF COURSES AND FARMS ONLY:

Irrigated Acreage (if variable from year to year, please provide an average): _____ acres

FOR AGRICULTURAL FACILITIES ONLY:

Crop Type(s): _____

Contact Person Name (Printed): _____

Phone: _____ Email: _____

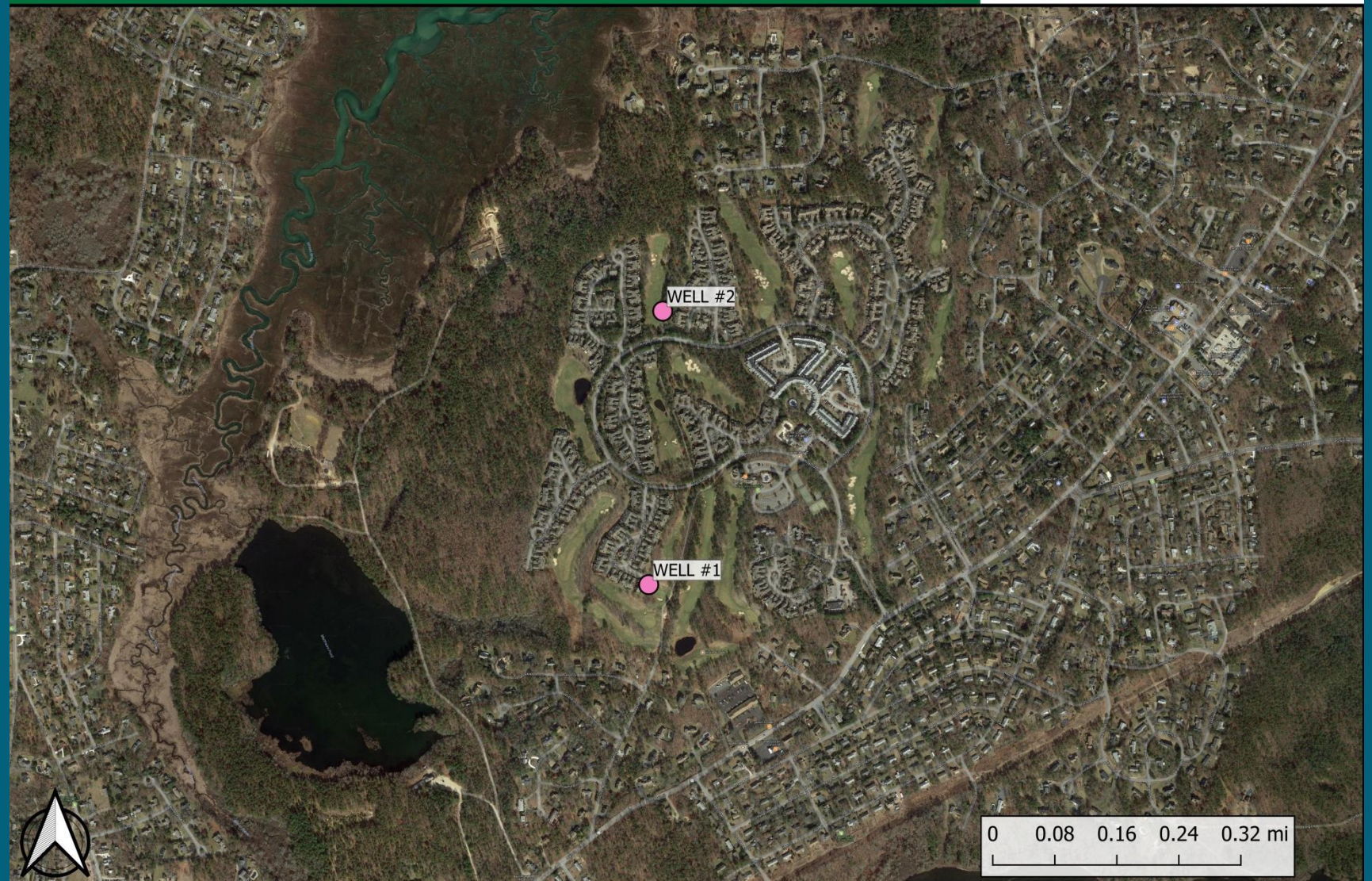
FACILITY : SPECIALTY MINERALS INC

Source Name	Source Unique ID	Total Depth[1]	Aquifer Type[2]
WELL #3	WM3706-03G		
WELL #4	WM3706-04G		

Water Management Act Program

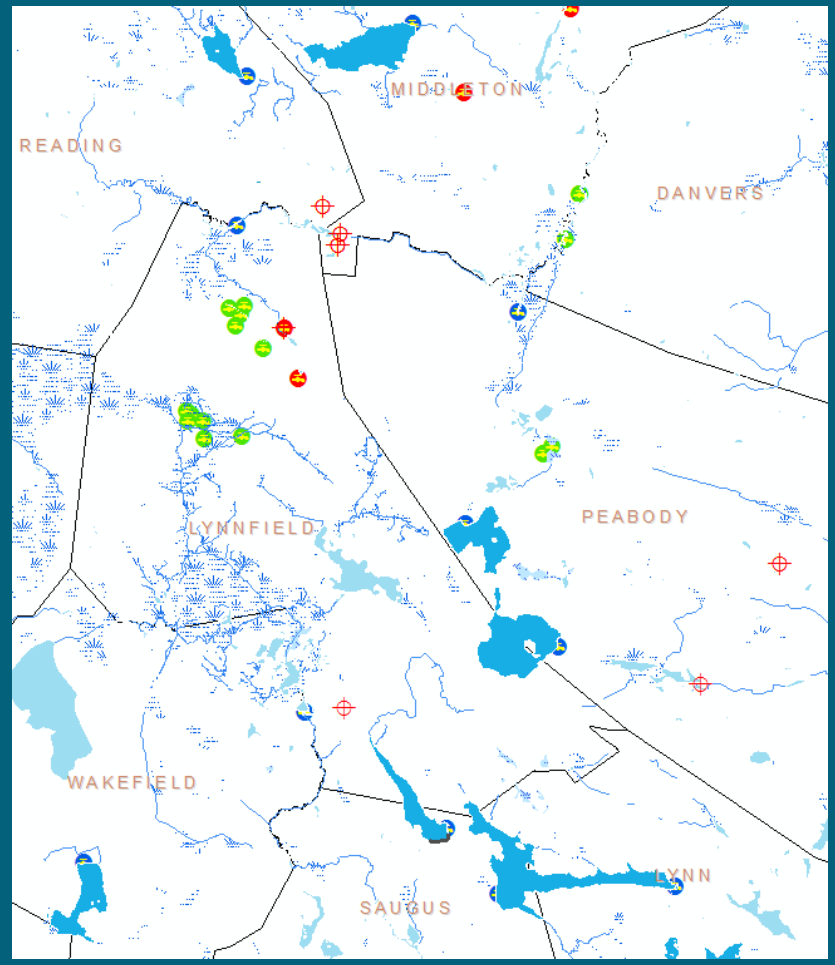
WMA Registration/Permit #: WMA-9P42235104

MassDEP
Commonwealth of Massachusetts
Department of Environmental Protection



MassDEP WUDR Project: Objective 3
Withdrawal points update

- Add new sources since 2004
- Correct locations of older points
- PWS points
  - DEP GIS Program
  - DWP Database
- Non-PWS points
  - Survey results (Objective 2)
  - WMA Database
  - eARF Database

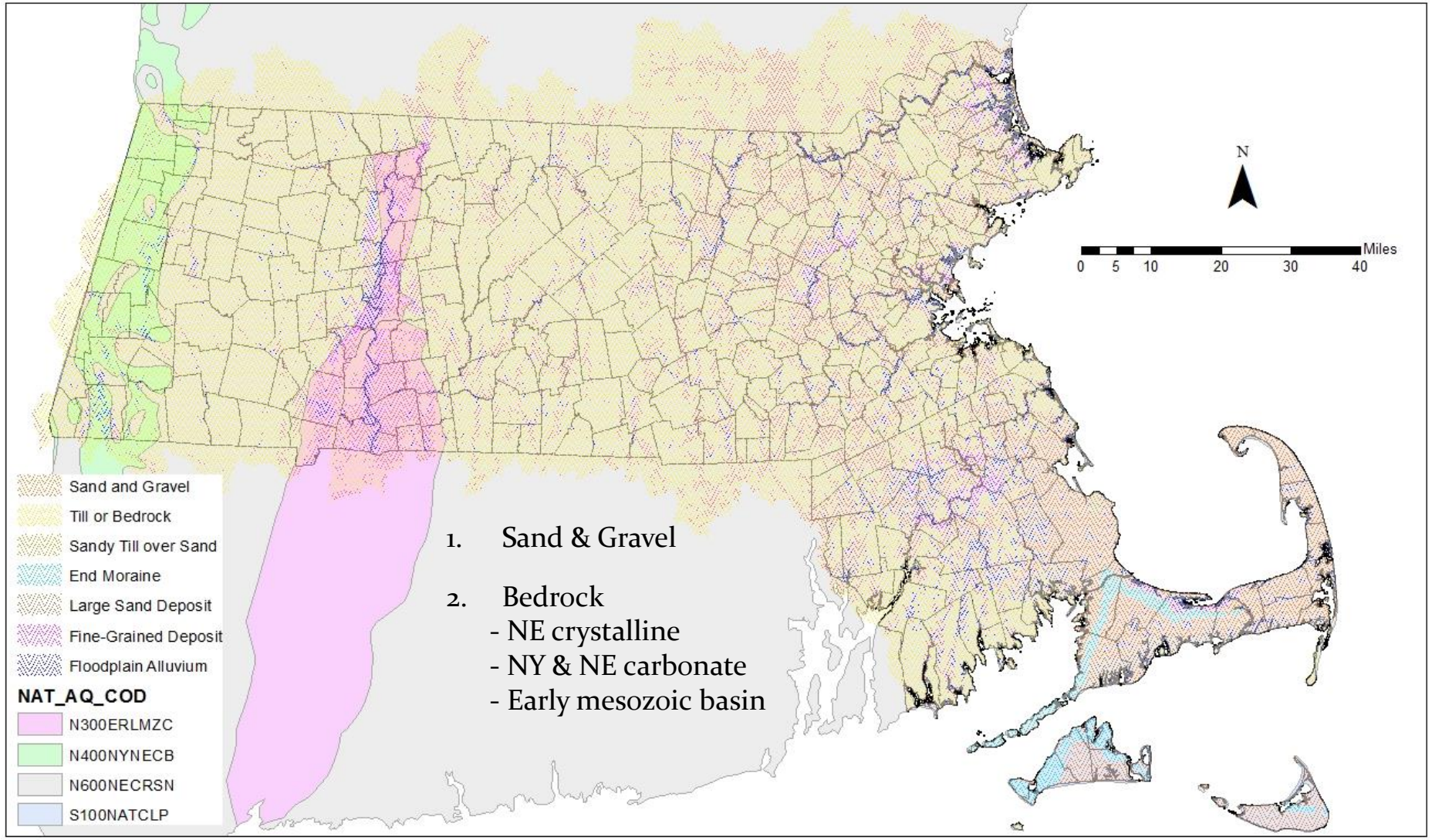


MassDEP WUDR Project: Objective 4 *Aquifer Designations*

Assign USGS aquifer codes to groundwater sources

- Bedrock or Sand & Gravel in Massachusetts
- PWS sources: based on well types reported in ASRs
  - bedrock
  - spring >> refer to USGS WRIR 2003-4266
  - gravel-packed, tubular, hand-dug, horizontal, rainey >> sand & gravel

- Non-PWS sources
  - GIS: groundwater sources with USGS surficial geology & bedrock maps
  - survey results (Objective 2)
  - well depths


Sand and Gravel
Till or Bedrock
Sandy Till over Sand
End Moraine
Large Sand Deposit
Fine-Grained Deposit
Floodplain Alluvium
NAT_AQ_COD
N300ERLMZC
N400NYNECB
N600NECRSN
S100NATCLP
1. Sand & Gravel
2. Bedrock
- NE crystalline
- NY & NE carbonate
- Early mesozoic basin
N
0 5 10 20 30 40
Miles

MassDEP WUDR Project: Objectives 5 & 6
Database QA/QC & ASR validation rules

WMA Database QA/QC

- Authorized withdrawal volumes
- Annual reported volumes since 2000
- Contact information
- Water uses >> align with USGS uses
  - Recategorize as needed (mining, aquaculture, hydroelectric, snow making)

ASR Validation Rules

- Add rules to reduce data-entry errors
  - Unit errors (gallons vs. MG)
  - One-month-only entries
- Test ASR form

		Withdrawal Units:	MG
Latitude:	41.832969	January:	0.000000
Longitude: -	70.778426	February:	0.000000
Source Watershed:	BUZZARDS BAY	March:	0.000000
Well Type:	TUBULAR (OR LARGER DIAMETER) WELLFIELD	April:	0.000000
Well Depth (ft.):	50	May:	0.000000
Well Casing Height (ft.):	0	June:	0.000000
Well Casing Depth (ft.):	0	July:	0.000000
Screen Length (ft.):	0	August:	0.000000
Construction Type:	GRAVEL	September:	0.000000
Pump Setting (ft):	0	October:	0.000000
Safe Yield (MGD):	.0001	November:	0.000000
Approved Daily Pumping Volume (MGD):	0	December:	4.500000
Source Metered:	Yes	Total Amount Pumped:	4.5

MassDEP WUDR Project: Objective 7
Data sharing procedures

Facilitate data-sharing with USGS via clear & consistent

- Site identifiers
- Terminology
- File formats
- Data types

New England USGS staff feedback has been very helpful

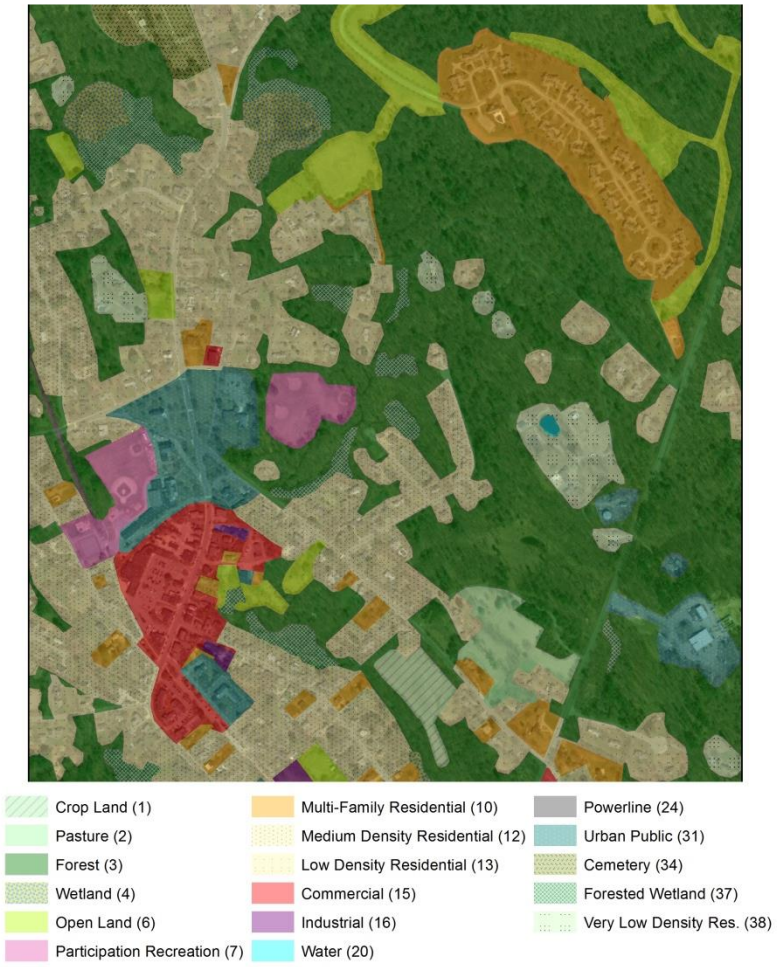
MassDEP WUDR Project: Objective 8
Private well use estimation

GIS Data Sources

- Tax Parcels
- National/Town Census
- Land Use (2005)
- DEP SearchWell Database
- Realty site web-scraping
- DEP Water Utility Resilience Program
  - *Critical Infrastructure GIS Mapping Initiative*

Non-GIS Data sources

- ASR population estimates
- Study: *Inventory of Below WMA Threshold Water Withdrawal Sources in the Ipswich and Parker River Watersheds* (CEI, 2018)



Enhancing Resilience & Emergency Preparedness of Water Utilities

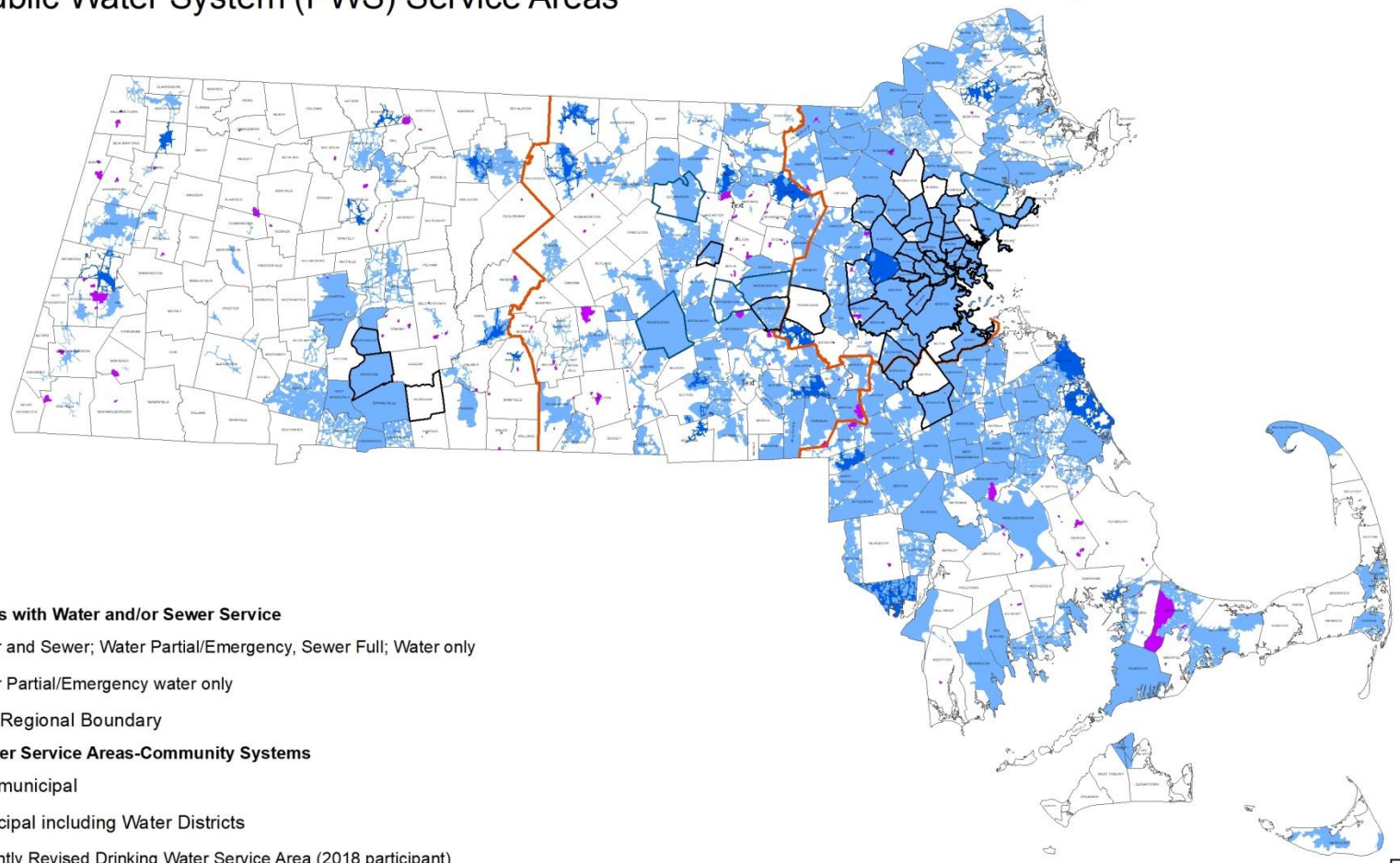
MassDEP

Enhancing drinking water & wastewater resilience in the Commonwealth

WATER UTILITY RESILIENCE PROGRAM

mass.gov/guides/water-utility-resilience-program

Public Water System (PWS) Service Areas*



Legend

MWRA Towns with Water and/or Sewer Service

- Water and Sewer; Water Partial/Emergency, Sewer Full; Water only
- Water Partial/Emergency water only
- DEP Regional Boundary

Drinking Water Service Areas-Community Systems

- Non-municipal
- Municipal including Water Districts
- Recently Revised Drinking Water Service Area (2018 participant)

*Only Community (COM) PWSs were included in the data development of this project.

0 5 10 20 30 40 Miles

DRAFT

Date: 4/5/2019

MassDEP WUDR Project: Objective 8
Private well use estimation

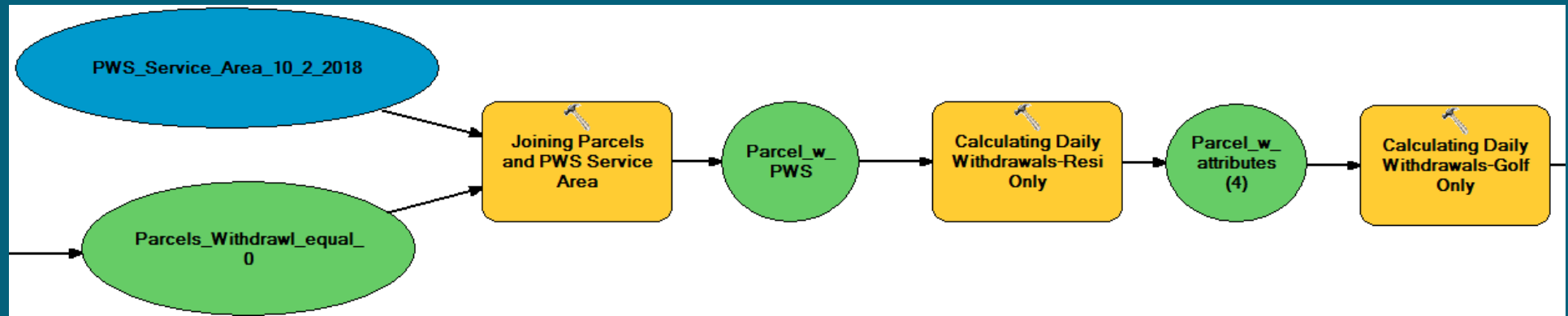
Approach:

1. Merge layer attributes
   - land use codes
   - building style
   - household size
2. Filter by attributes
   - land use, tax parcel codes
   - WMA sources excluded
   - "Resi well" = 1 if criteria are met
3. Run Model Builder
   - Subtract PWS areas
   - Resi, golf, lawn irrigation
   - Other uses (time permitting)

MassDEP WUDR Project: Objective 8
Private well use estimation

Preliminary Model Builder Steps

- Residential withdrawal: subtract PWS areas & commercial parcels
  - 65 rgpcd * household size if "Resi Well" = 1
- Golf course withdrawal:
  - Acreage * 0.74 in/week * 21 weeks (~5 months) if "Golf" = 1
- Irrigation wells within PWS areas:
  - Acreage * 5-20% parcel area * 0.6 in/week * 12 week if "Irrigation Well" = 1
- Simplifying assumptions
- May make adjustments following review of results – Feedback welcome



Questions?

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References

- Dieter, C.A., Maupin, M.A., Caldwell, R.R., Harris, M.A., Ivahnenko, T.I., Lovelace, J.K., Barber, N.L., and Linsey, K.S., 2018, Estimated use of water in the United States in 2015: U.S. Geological Survey Circular 1441, 65 p., https://doi.org/10.3133/cir1441.

- Hansen, B.P., Smith, K.P., 2004, Characteristics of and Areas Contributing Recharge to Public-Supply Springs in Massachusetts: U.S. Geological Survey Water-Resources Investigations Report 03-4266, 76 p.

- Evenson, E.J., Jones, S.A., Barber, N.L., Barlow, P.M., Blodgett, D.L., Bruce, B.W., Douglas-Mankin, K., Farmer, W.H., Fischer, J.M., Hughes, W.B., Kennen, J.G., Kiang, J.E., Maupin, M.A., Reeves, H.W., Senay, G.B., Stanton, J.S., Wagner, C.R., and Wilson, J.T., 2018, Continuing progress toward a national assessment of water availability and use: U.S. Geological Survey Circular 1440, 64 p., https://doi.org/10.3133/cir1440.

- MassDEP Water Utility Resilience Program: https://www.mass.gov/guides/water-utility-resilience-program#critical-infrastructure-gis-mapping-initiative