Source Water Protection Citizen Technical Advisory Committee (CTAC)
Source Water Assessment Plan Update - Subcommittee Meeting

August 29, 2019
Final Meeting Minutes
Meeting Location: Tidewater Utilities Conference Room

WELCOME & INTRODUCTIONS – Douglas Rambo, P.G., DNREC, Division of Water

Mr. Rambo called the meeting to order at 10:05 a.m. and welcomed everyone. He asked for introductions around the table. The attendance list is included at the end of the meeting minutes.

REVIEW AND APPROVAL OF THE JULY 24, 2019 DRAFT MEETING MINUTES

Mr. Rambo asked if anyone had any edits to the July draft meeting minutes. There were no suggested edits.

Final meeting minutes are posted online at https://publicmeetings.delaware.gov/Meeting/63140 .

FOLLOW-UP DISCUSSION FROM THE JULY 24, 2019 MEETING – Sea Level Rise Mapping and Discussion – Bob Scarborough, DNREC, Division of Climate, Coastal, & Energy

Mr. Scarborough presented a Power Point presentation (see attachment titled *Preparing Delaware's Water Supply for Climate Change*). He said, "I want to talk about climate change and sea level rise and how it's going to affect source water, groundwater, and surface water. Things are changing."

As stated in the presentation on the slide titled *There's Something Happening Here…*:
Mr. Scarborough said, "The last 40 years have been the hottest on record."

- 2015, 2016, 2017, and 2018 are hottest years on record
- 20 hottest years on record have occurred since 1995
- Sea levels in DE are rising at a rate of 1.14 ft/century
- Number of flood advisories issued by NWS increasing

He added, "What's causing all of this? Mostly greenhouse gases."

As stated in the presentation on the slide titled *Global CO2 Concentrations*: Mr. Scarborough said, "You can see for the last 800,000 years it varied a little bit but if you look at the last 100,000 to 200,000 it's really skyrocketed. We're at record levels now and there's no sign of it decreasing at all." Mr. Hassan Mirsajadi asked, "What was the cause of previous increases?" Mr. Scarborough replied, "Milankovitch Cycles, which is the rotation of the earth around the sun and its distance which causes some of it." He continued to state that there are other factors such as ice age and other things going on that also affect it. He added, "There is a natural

variation but we've never seen this spike like this before and this is all pretty much since the industrial revolution." Mr. Rambo added that volcanic activity sends a whole lot of greenhouse gas into the atmosphere, too. Discussion continued.

As stated in the presentation on the slide titled *Climate Change Impacts in Delaware*: Mr. Scarborough said, "So how does that impact Delaware?"

- Increasing Temps
- Heavy Precipitation ("We're seeing more frequent and more intense storms."
- Sea Level Rise

As stated in the presentation on the slides titled *Delaware Average Temperature* and *Temperatures Will Continue to Increase*: Mr. Scarborough said, "Temperatures will continue to increase. Looking at temperatures, it's increasing about +0.2°F every decade." Mr. Scarborough continued to discuss the statistics that appear on the slides.

As stated in the presentation on the slide titled *Delaware Sea Levels*: Mr. Scarborough said, "This shows the Lewes site over the last 200 years. Up 13" which is about 3.48 mm per year which is actually double the global sea level rise which right now is about 1.7." Mr. Scarborough continued to discuss and stated that they are looking to fund a study to DGS where they can resurvey and see if there has been any change because the data shown is from a 1970's study." Mr. Scarborough continued to discuss.

As stated in the presentation on the slide titled *The Rate of Sea Level Rise Will Increase in the Future*: Mr. Scarborough discussed the IPCC Global Sea Level Rise Projections.

As stated in the presentation on the slide titled *SLR Exposure: Water Supply Wells*: Mr. Scarborough said, "Back in 2009 we started these studies and 2011 we did a vulnerability assessment for the State of Delaware looking at all kinds of infrastructures, locations, anything that can be impacted by sea level rise. One of them we looked at was water supply wells."

- Potentially inundated:
    - Industrial wells: 3% - 7%
    - Irrigation wells: 1% - 2%
    - Public wells: 2% - 10%

As stated in the presentation on the slide titled *SLR Exposure: Domestic Wells*:

- Potentially inundated:
    - 3-7% of domestic wells statewide (2,000-4,000)
    - 5-10% of domestic wells in Sussex (1,700-3,500)
- Loss of domestic wells may increase demand for public water supply

Mr. Andrew Homsey asked, "When the sea level rises and how buildings are going to be affected and the infrastructure and everything else, is this all included in a resilience plan?" Mr. Scarborough replied, "We'll look at every individual component that we have data sets for." Mr. Scarborough and Mr. Homsey continued to discuss. Mr. Homsey asked, "If a well is inundated,

does that increase the danger of salt water intrusion?" Mr. Scarborough, Mr. Rambo, and Mr. Homsey discussed further and Mr. Scarborough added how some sort of wellhead protection aspect should be added to the revised Plan.

As stated in the presentation on the slide titled *2017 Sea Level Rise Scenarios*: Mr. Scarborough said, "We contracted with DGS to update those. It was part of what was in Governor Markell's Executive Order on the sea level rise adaptation that we would update these.

- Developed by DE SLR Technical Committee
- Updated 2009 scenarios
- Reflect higher resolution models, more data
- Assigns confidence levels

As stated in the presentation on the slide titled *2017 DE Sea Level Rise Scenarios*: Mr. Scarborough said, "The blue line is the 95% confidence level, the red line is the 5%, and the green line is 50/50." Mr. Scarborough continued to discuss. Mr. Mirsajadi asked if it makes a difference in the State if it's the northern part or southern part. Mr. Scarborough replied, "Not too much" and continued to discuss.

Mr. Scarborough discussed the next few slides titled *New Coastal Inundation Maps and GIS Layers* and also the sea level rise maps that DGS did for New Castle County, Kent County, and Sussex County.

As stated in the presentation on the slide titled *Groundwater Impacts*: Mr. Scarborough stated he had Mr. Changming He and Mr. Tom McKenna from DGS do a report on the groundwater impacts. The report is titled *Using Numerical Models to Evaluate Impacts of Sea Level Rise on Groundwater Resources in the Delaware Coastal Plain* and was submitted to the Delaware National Estuarine Research Reserve in September 2014.

- Water Table Rise
    - 3 to 9 times more area is impacted by rising water table than from surface water inundation
- Salt Water Intrusion
    - With 1.0 m SLR salt water in the base of the aquifer migrates 6.2 km inland under the rivers
    - At 1 km upriver, salt water in the base of the aquifer migrates 2.3 km inland

As stated in the presentation on the slide titled *SLR Exposure: Contaminated Sites*:

- 41% - 54% of 60,000 acres potentially inundated
- 33% - 44% of 785 sites
- Exposure focused in:
    - Wilmington region
    - Bombay Hook
    - Inland Bays

- Potential for contaminant releases
- Groundwater and surface water implications?

As stated in the presentation on the slide titled *Delaware Climate Projections Portal*: Mr. Scarborough said for more information to refer to the following:

- Web-based data library
- View and download climate projection data developed for the State of Delaware
- Based on historic data from 14 Delaware weather stations and 9 global climate models

Mr. Scarborough also referred to www.declimateinfo.org for more Delaware specific data that is updated by the University of Delaware and includes funding opportunities, projects and reports, outreach and events, data, tools and applications, and agencies and organizations. He said this portal shows current information pertaining to Delaware.

Mr. Scarborough asked if there were any questions. There were none. Mr. Homsey added how this information could be pertinent to the Water Supply Coordinating Council as well as the regular Citizen Technical Advisory Committee.

Mr. Rambo stated that he looked at the mapping that was done almost a decade ago and he looked at the Superfund sites, Underground Storage Tank sites, and Leaking Underground Storage Tank sites to see how its changed.

Mr. Rambo presented a Power Point presentation (see attachment titled *Sea Level Rise and Sources of Contamination*).

As stated in the presentation on the slide titled *At the "Worst Case Scenario" (7-ft (2m) Sea Level Rise)*:

- Sea Level Rise could affect:
    - 425 Superfund Sites
        - Approximately 50% of what is catalogued in Delaware (approx.. 1000 sites overall)
    - 320 Regulated Underground Storage Tank Sites
    - 220 Leaking Underground Storage Tanks

Mr. Rambo then showed the Superfund sites, Registered Underground Storage Tank sites, and Leaking Underground Storage Tank sites and said the pictures on the left side are all sites in Delaware and the pictures on the right side are sites affected by sea level rise. Mr. Rambo stated these are worst case scenarios.

FLOOD MAPPING DATA and STORM WATER MANAGEMENT DATA – Douglas Rambo, P.G., DNREC, Division of Water

Mr. Rambo stated he did not have a chance to "play around" with the flood mapping tools that was stated on the agenda. He also said that Mr. Scott Andres could not attend today's meeting to discuss the Storm Water Management Data that was also listed on the agenda. Mr. Rambo said this will be discussed at the October meeting. Mr. Homsey asked if those just referenced to DNREC or is there an inventory and Mr. Rambo said we have the inventory of DelDOT's. Mr. Rambo and Mr. Homsey discussed further.

DISCUSSION OF CHAPTER 2: SOURCE WATER ASSESSMENT AREA DELINEATION – Douglas Rambo, P.G., DNREC, Division of Water

Mr. Rambo asked the Subcommittee if there were any additional comments and stated that he and Ms. Nicole Minni have been working together to incorporate maps into the document and said they are currently working on the headings to match with the text. He continued, "We do have the locations of the public water supplies and the delineation showing the extent of the watershed outside of State." Mr. Rambo stated there are some images that still need to be added. He mentioned Table 2-1 has been updated and show the City of Newark reservoir which was not in the last assessment. He also said he didn't change too much in the text of the surface water but in the groundwater delineation section the table showing the number of wells by water system type by County has been updated. Mrs. Anita Beckel addressed the year of 1999 that appeared at the top of the table and Mr. Rambo fixed it. Mr. Homsey said, "It looks like the non-transient/non-community wells were down." Mr. Rambo said, "It's not surprising because when public water comes into an area businesses hookup." Mr. Rambo and Mr. Homsey continued to discuss and Mr. Rambo said there was discussion about confined, unconfined, semi-confined aquifers and said he found on the DGS website an info-graphic that will help explain this to some extent. He said, "I think it's worthwhile putting into the document so that there's a little bit of understanding about the confinement of aquifers and I've been working at getting the images for the delineated areas by County primarily for New Castle County. We'll be using the WRPA mapping as the example and that's shown on the figures and I'll be working on the figures for Kent County and Sussex County to go in immediately after those." He added, "We are trying to schedule an internal meeting amongst Water Supply, Surface Water Discharges, Ground Water Discharges, DGS, and Public Health to talk about the section on Conjunctive Delineations. There's a fine line between groundwater under the direct influence of surface water and then groundwater that is under the influence of surface water and the key item there is time. How rapidly a source is affected by changes in surface water. We're trying to figure out if the statement that was in the last Plan was true that no groundwater under direct influence conditions have been recognized in Delaware. I have a couple of suspected water systems that could potentially fall under this category but I don't know how much investigative effort wants to be placed into that." Ms. Sheila Shannon asked, "Are these suspected wells in something like the Columbia?" Mr. Rambo replied, "They could be in the Columbia and they could also be in coastal confined aquifers." He continued to discuss with Ms. Shannon and she asked if Tidewater Utilities has any and Mr. Rambo said he has not looked at major water suppliers but

he has looked at violation notices for smaller water suppliers. Ms. Shannon asked Mr. Rambo, "Violation of what?" Mr. Rambo answered, "Bacteria." Mr. Homsey asked if that was the main concern and Mr. Rambo said, "Yes." The Subcommittee continued to discuss and Mrs. Beckel stated she is very concerned for the City of Dover where they're mining for sand and gravel and stones right up to the wells. Mrs. Beckel and Mr. Homsey continued to discuss. Mr. Rambo said, "The problem is currently Kent County only protects 150 foot around public wells. For the larger modeled wellhead protection areas you're out of luck 150 to the outer edge and I'm trying to get that fixed. We had very good success with them putting in an excellent recharge protection ordinance that I think that method that we used for that can work as well for those larger wellhead protection areas." The Subcommittee continued to discuss.

OPEN DISCUSSION / PUBLIC COMMENT

Mr. Rambo asked if there were any questions or comments to please contact him. Mr. Mirsajadi told Mr. Rambo that on Page 6, Section 2.A.2 "Delineation of Source Water Assessment Area for Surface Water Systems" the last line that says 'will be established' should read 'have been established'. Mr. Rambo made the change.

Mr. Homsey asked, "When is the Plan due?" Mr. Rambo replied, "Ideally we would like to have a final draft by the end of the year but it could go into 2020."

Mr. Rambo stated there is no meeting in September and the next Subcommittee meeting is scheduled for October 23, 2019, at 10:00 a.m. in the Tidewater Conference Room.

ADJOURN – Douglas Rambo, P.G., DNREC, Division of Water

Meeting adjourned at 10:58 a.m.

These minutes are not intended to be a detailed record. They are for the use of the Source Water Assessment and Protection Program, Source Water Assessment Plan Subcommittee members in supplementing their personal notes and recall of Committee discussions and presentations and to provide information to Committee members unable to attend. Minutes recorded and submitted by Kimberly Burris.

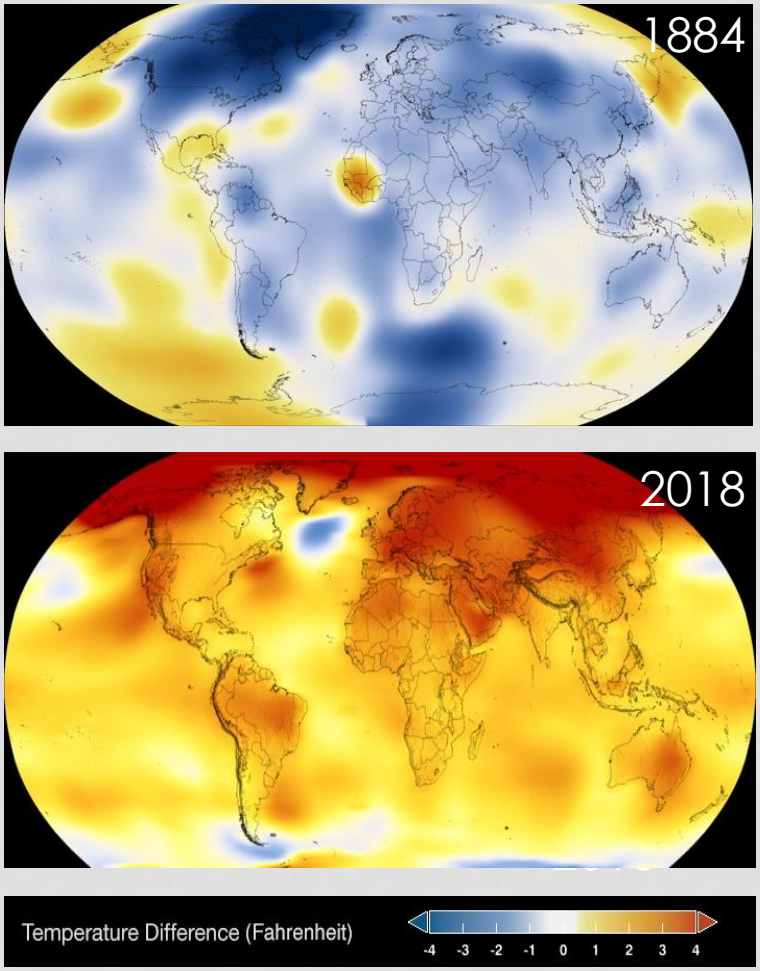
<u>Attendees are listed below alphabetically, last name first:</u>
Beckel, Anita – Delaware Rural Water
Burris, Kimberly – DNREC, Division of Water, Administration
Elliott, Ross – DNREC, Tanks
Homsey, Andrew – DGS, Water Resources Agency
Mirsajadi, Hassan – DNREC, Watershed Assessment
Rambo, Douglas – DNREC, Division of Water, Source Water Protection Program
Shannon, Sheila – Tidewater Utilities
Scarborough, Bob – DNREC, Division of Climate, Coastal, and Energy

PREPARING DELAWARE'S WATER SUPPLY FOR CLIMATE CHANGE

JULY 18, 2019

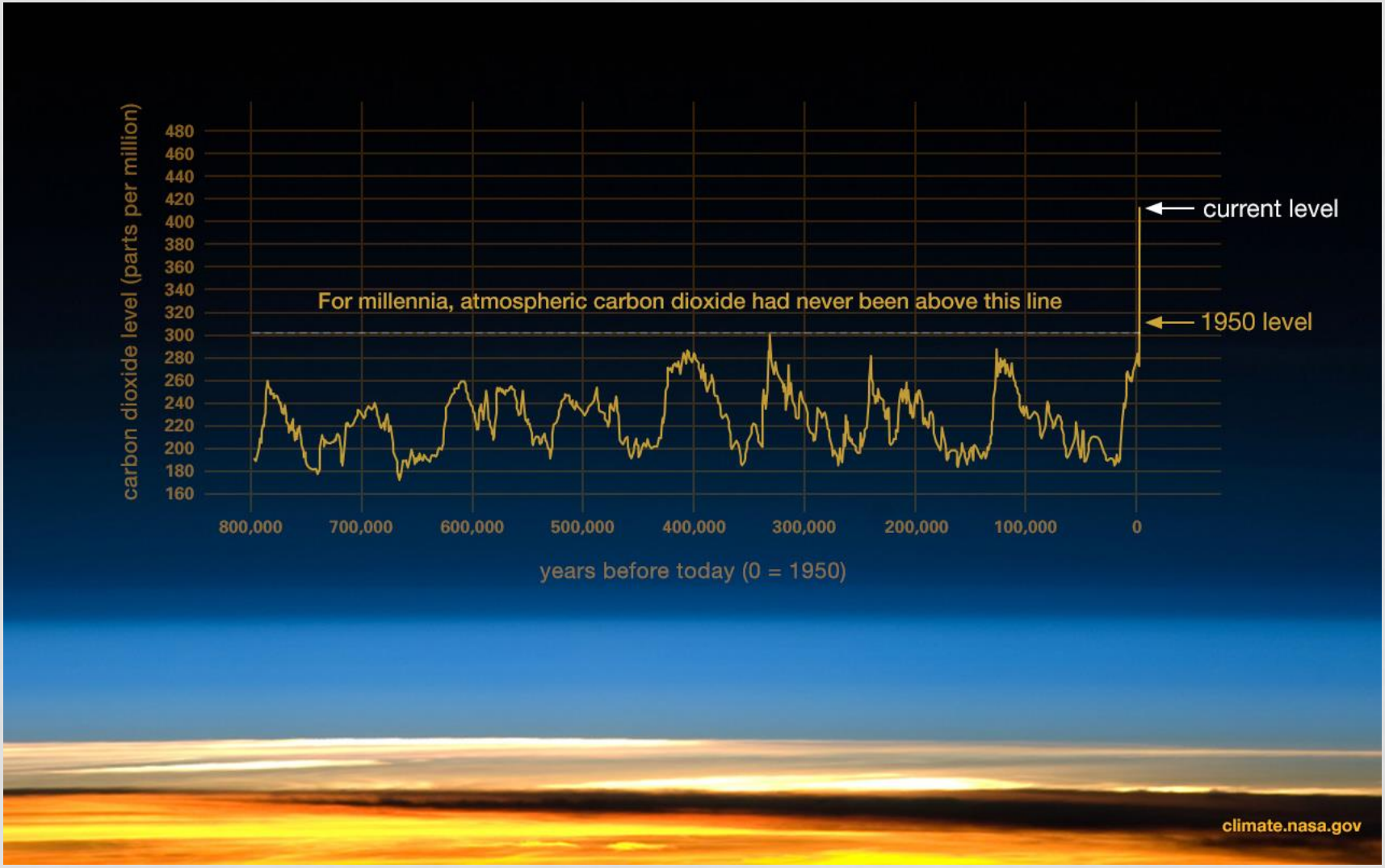
THERE'S SOMETHING HAPPENING HERE…

- 2015, 2016, 2017, and 2018 are hottest years on record
- 20 hottest years on record have occurred since 1995
- Sea levels in DE are rising at a rate of 1.14 ft/century
- Number of flood advisories issued by NWS increasing



Images courtesy of NASA

GLOBAL CO2 CONCENTRATIONS



CLIMATE CHANGE IMPACTS IN DELAWARE

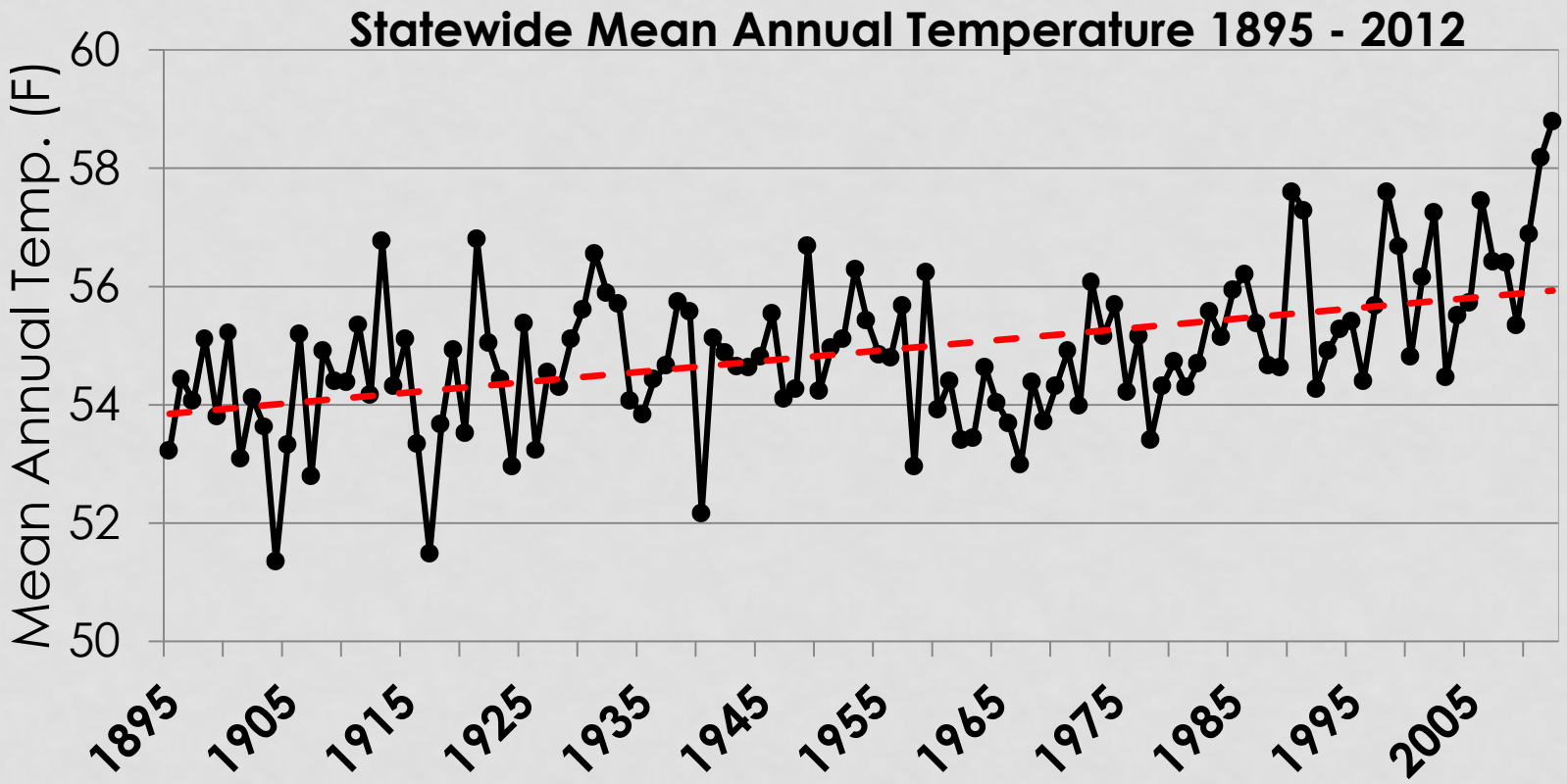
Increasing Temps

Heavy Precipitation

Sea Level Rise

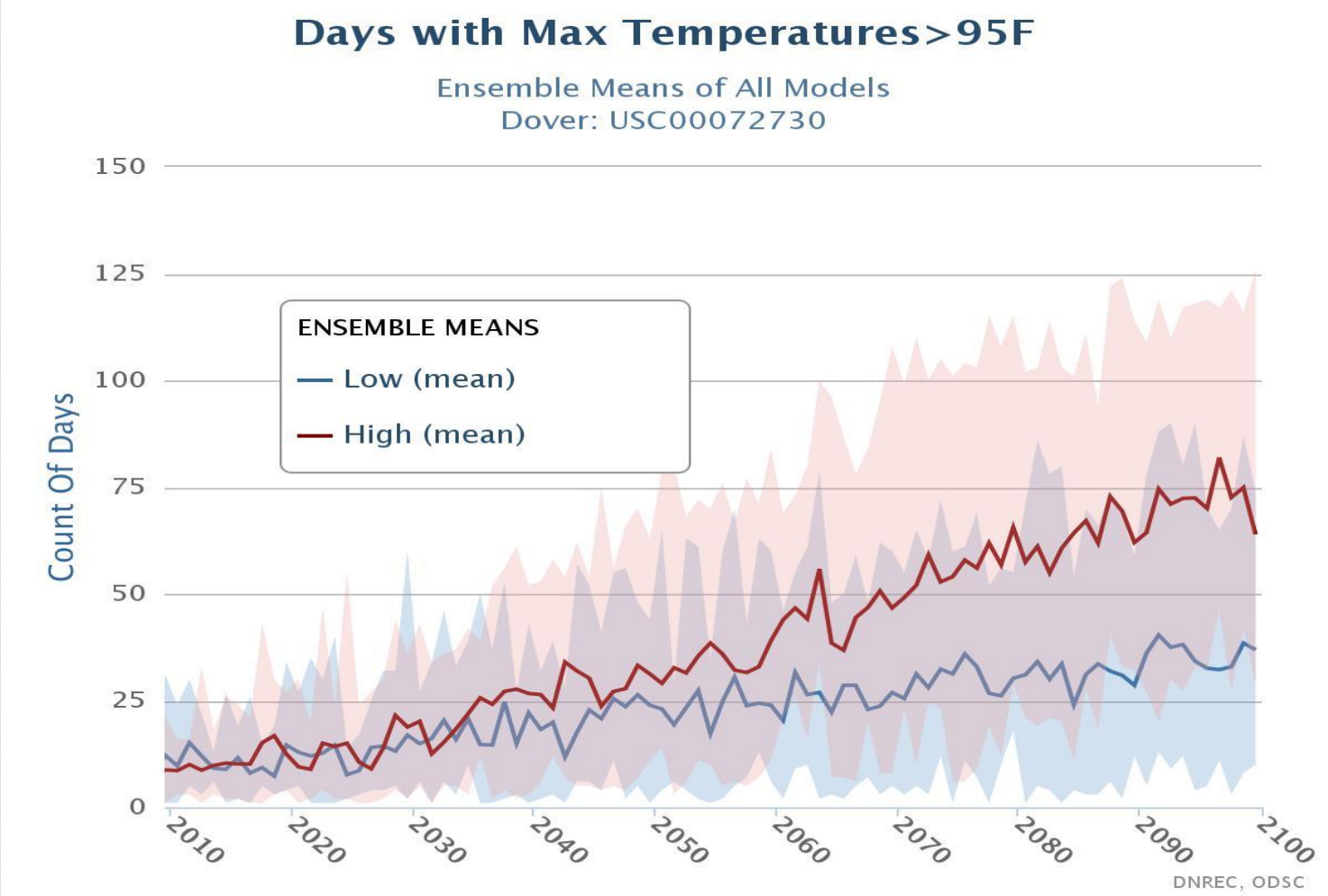
DELAWARE AVERAGE TEMPERATURE

+0.2°F per decade in every season except Autumn

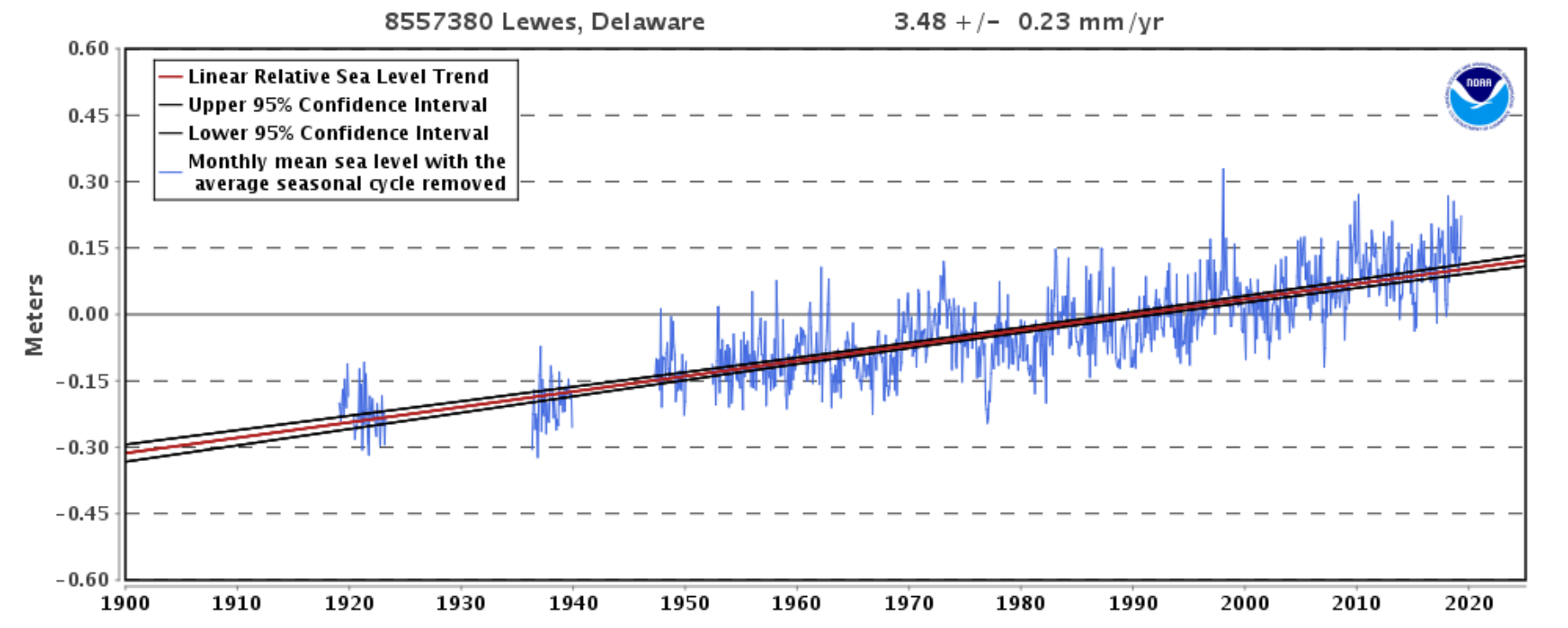


Source: Dr. Daniel J. Leathers, State Climatologist

TEMPERATURES WILL CONTINUE TO INCREASE

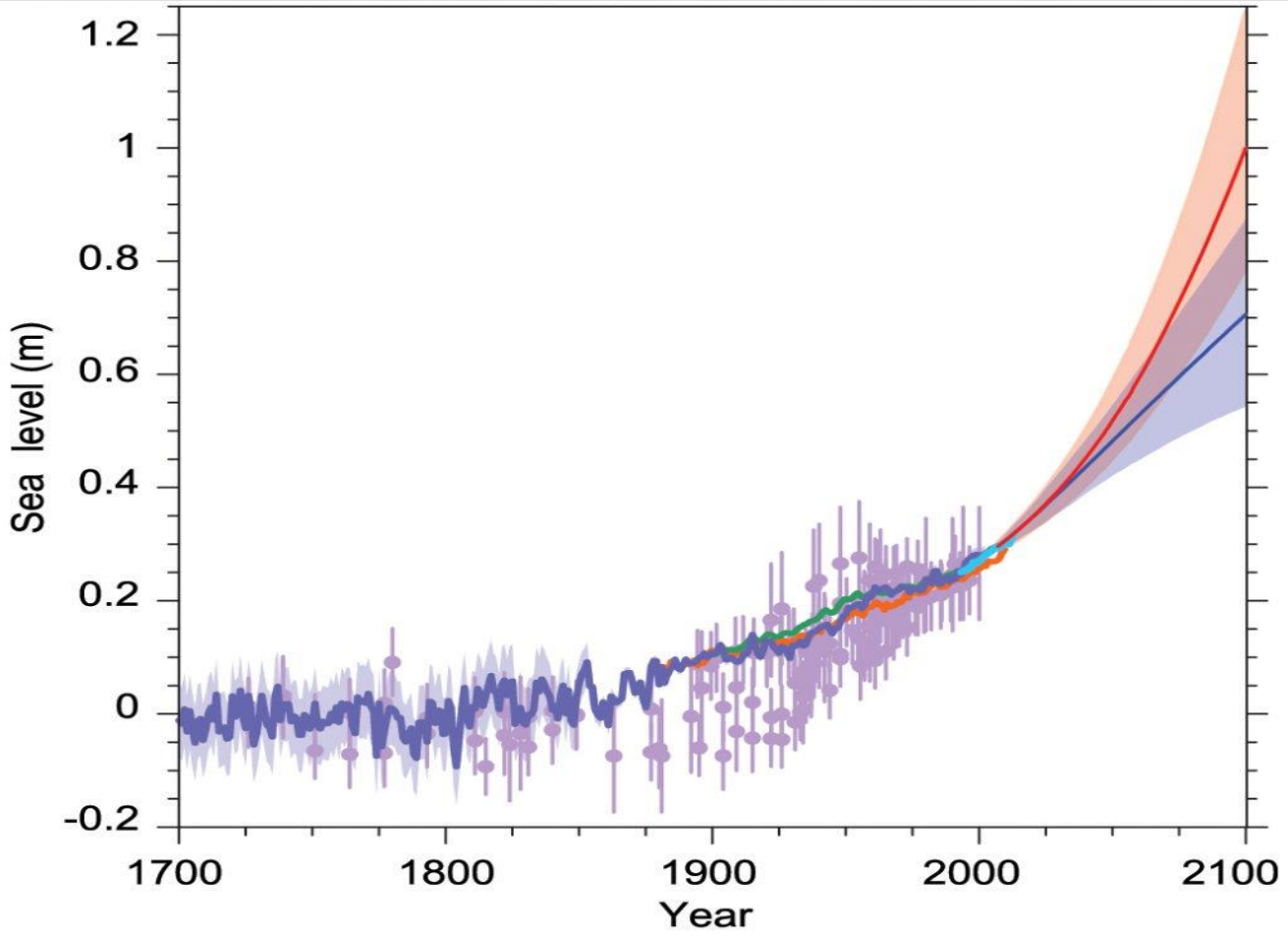


DELAWARE SEA LEVELS



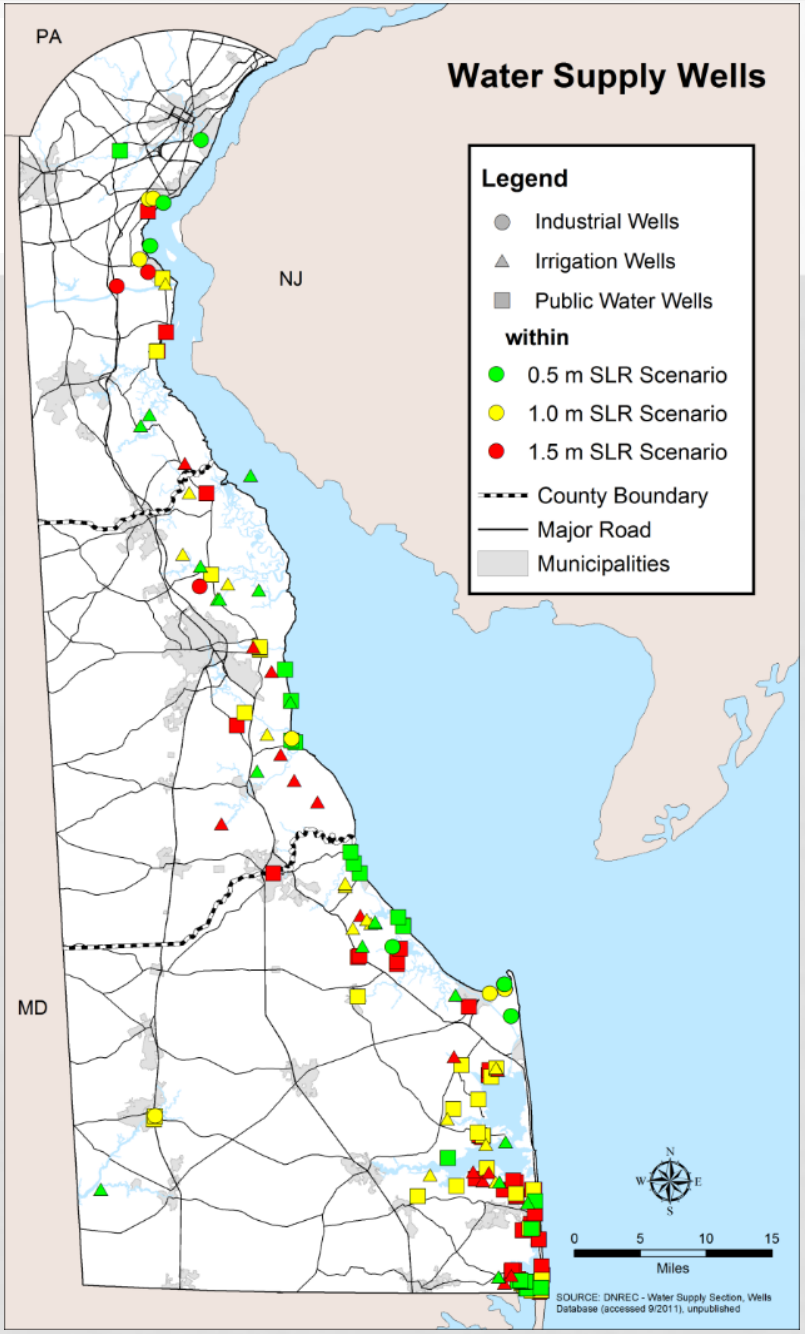
THE RATE OF SEA LEVEL RISE WILL INCREASE IN THE FUTURE

IPCC Global Sea Level Rise Projections



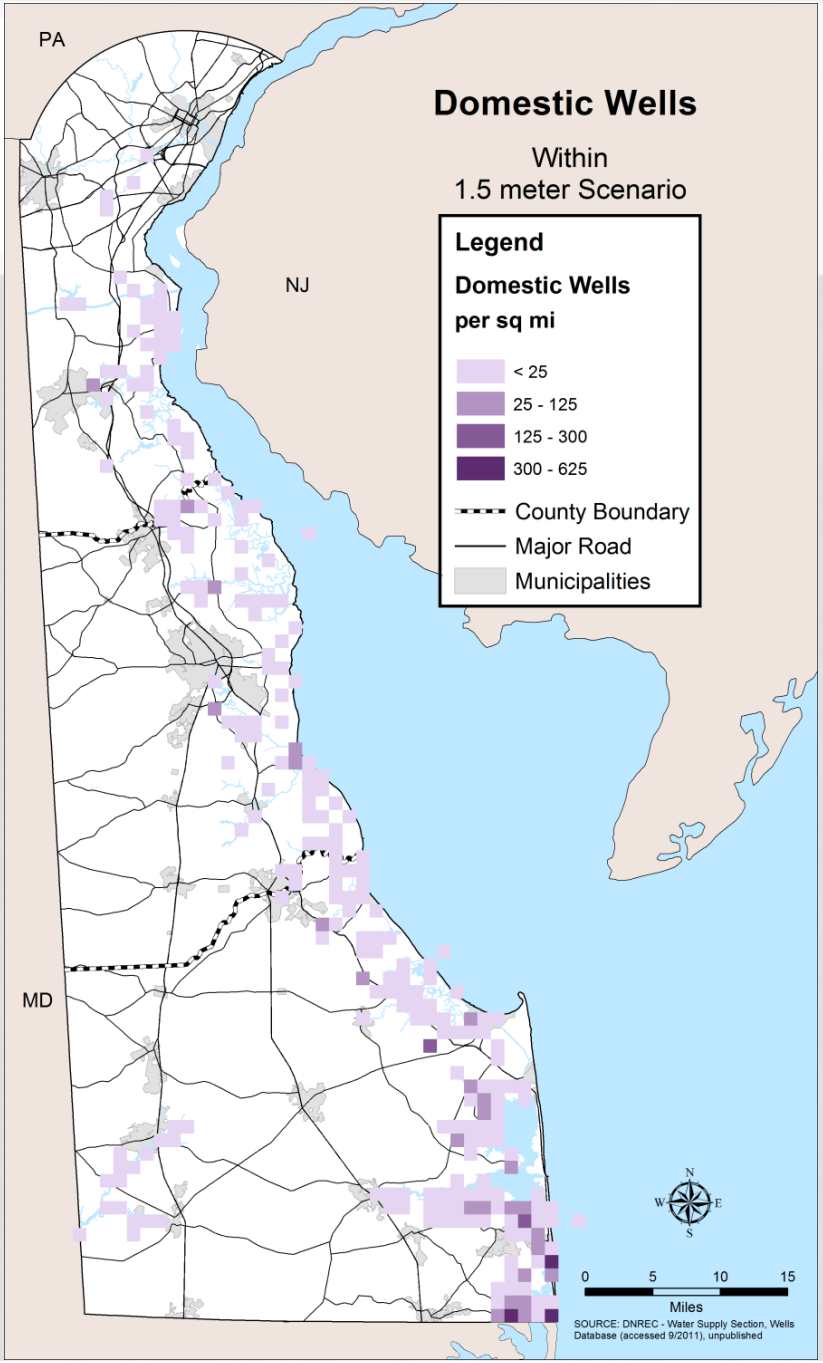
SLR EXPOSURE: WATER SUPPLY WELLS

- Potentially inundated:
  - Industrial wells: 3% - 7%
  - Irrigation wells: 1% - 2%
  - Public wells: 2% - 10%



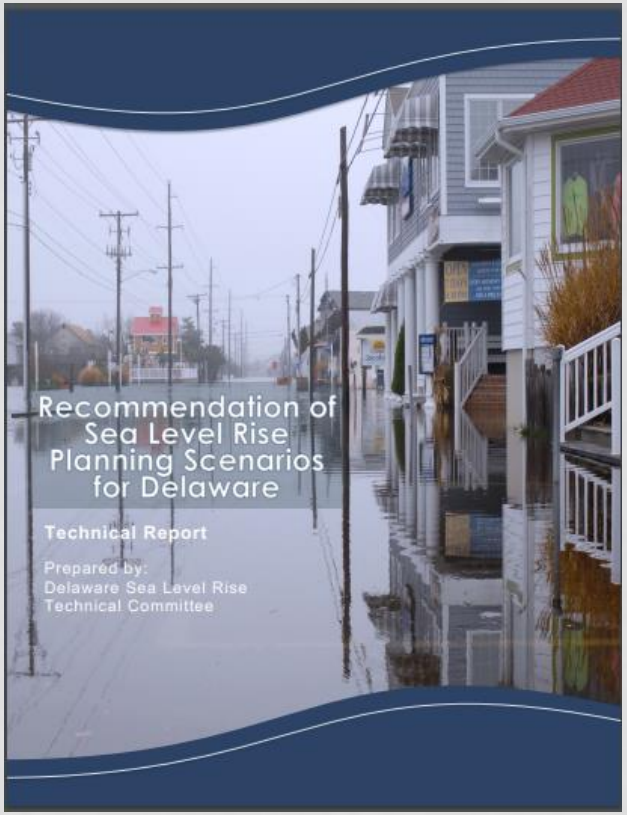
SLR EXPOSURE: DOMESTIC WELLS

- Potentially inundated:
  - 3-7% of domestic wells statewide (2,000-4,000)
  - 5-10% of domestic wells in Sussex (1,700 – 3,500)
- Loss of domestic wells may increase demand for public water supply



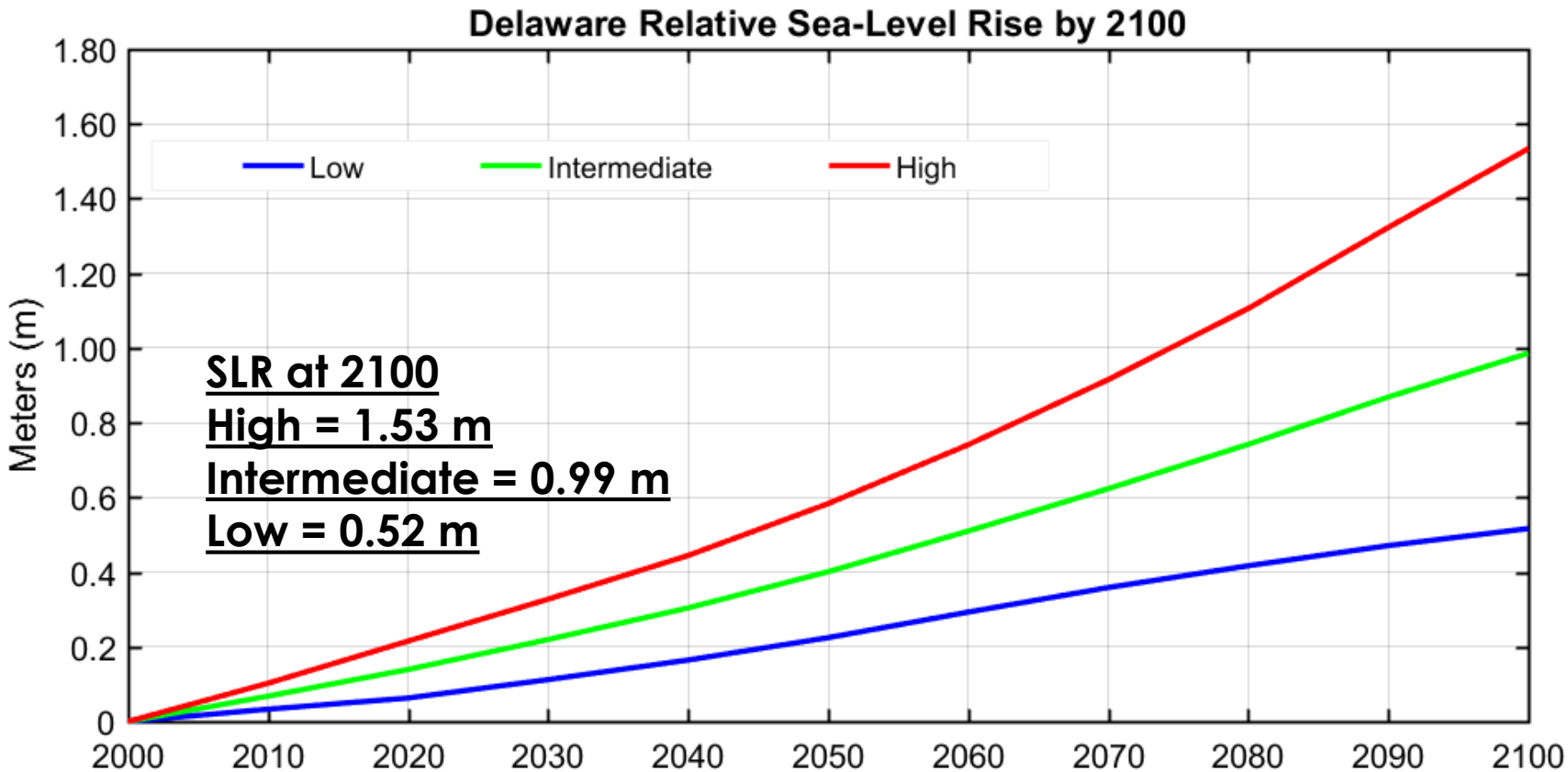
2017 SEA LEVEL RISE SCENARIOS

- Developed by DE SLR Technical Committee
- Updated 2009 scenarios
- Reflect higher resolution models, more data
- Assigns confidence levels



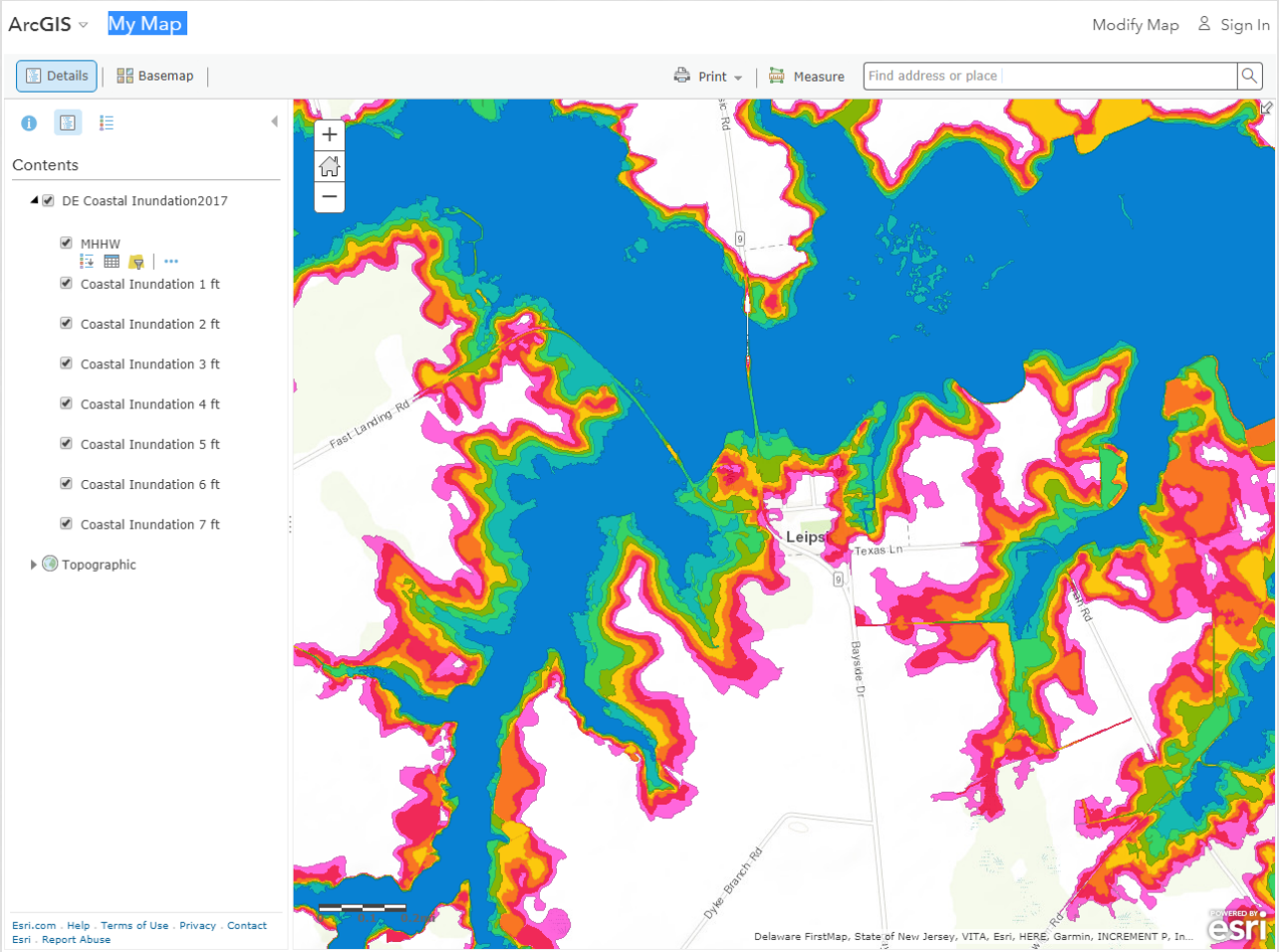
DOWNLOAD THE FULL REPORT: http://www.dgs.udel.edu/slr

2017 DE SEA LEVEL RISE SCENARIOS



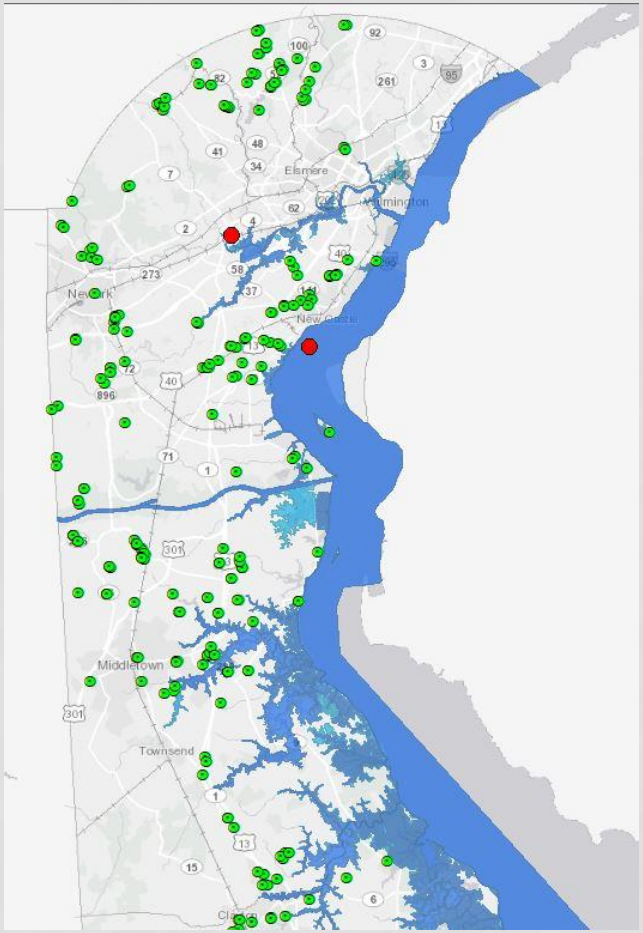
Based upon "business as usual" greenhouse gas emissions future

NEW COASTAL INUNDATION MAPS AND GIS LAYERS

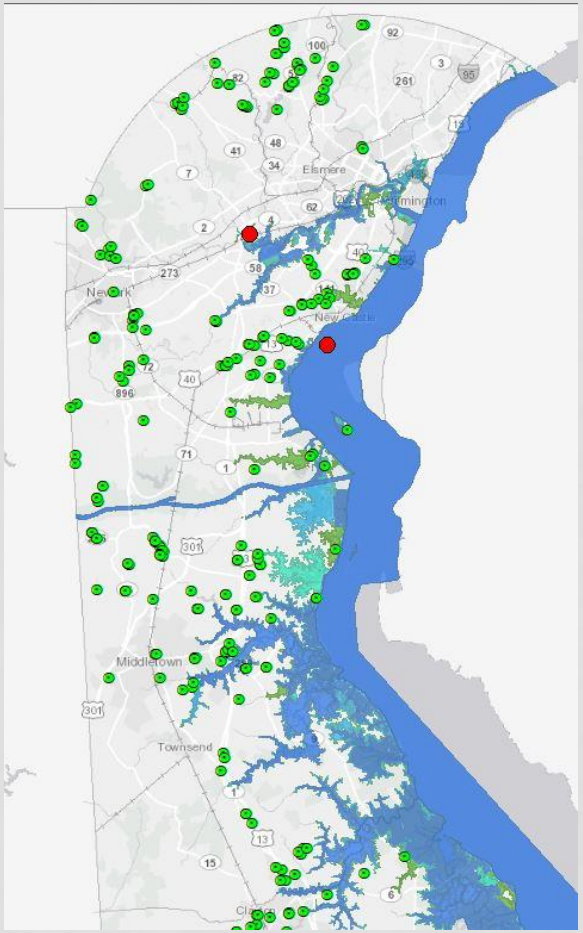


http://www.dgs.udel.edu/slr

NEW CASTLE COUNTY WELLS

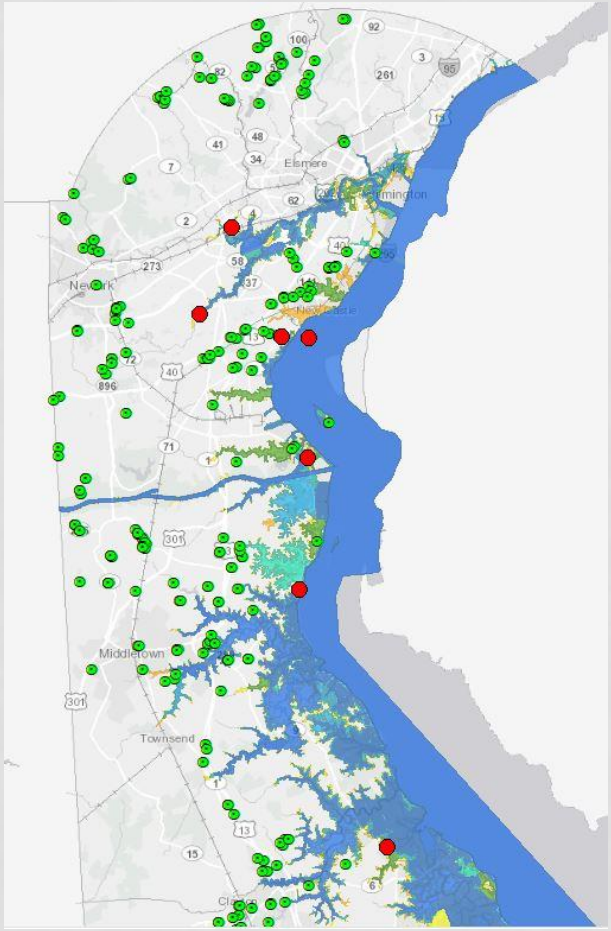


1 ft. SLR

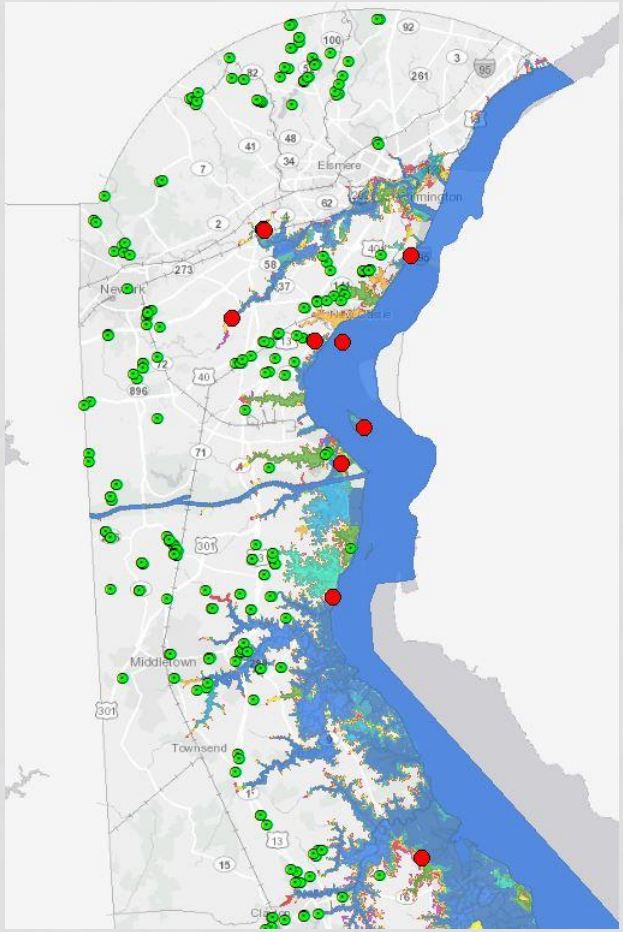


3 ft. SLR

NEW CASTLE COUNTY WELLS

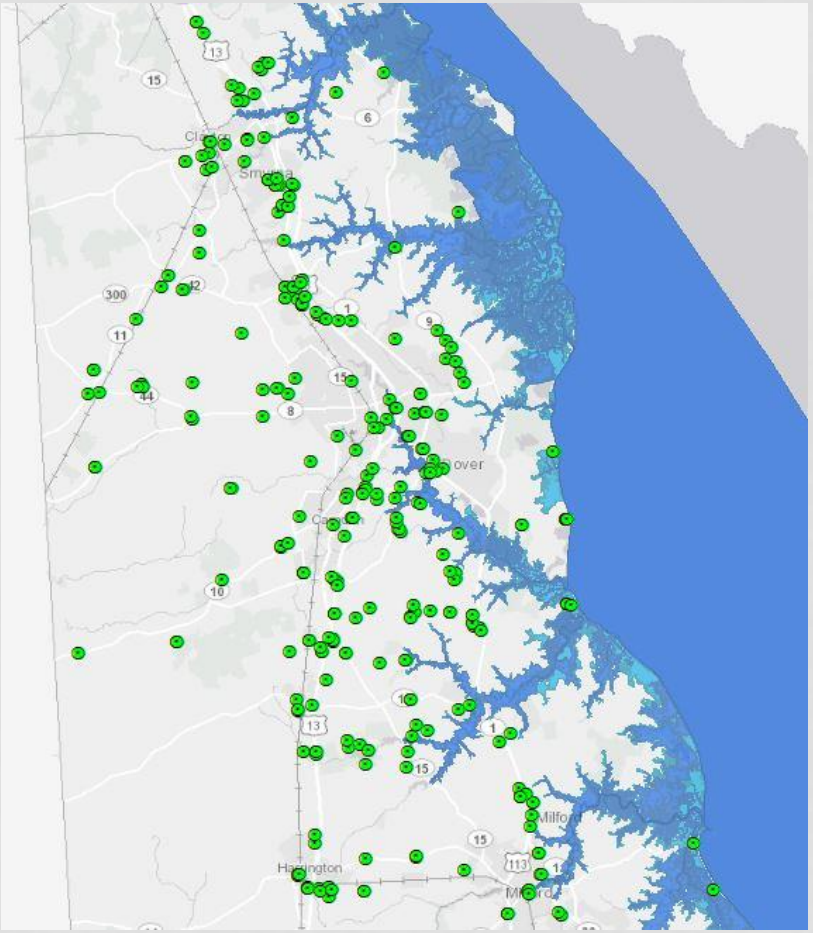


5 ft. SLR

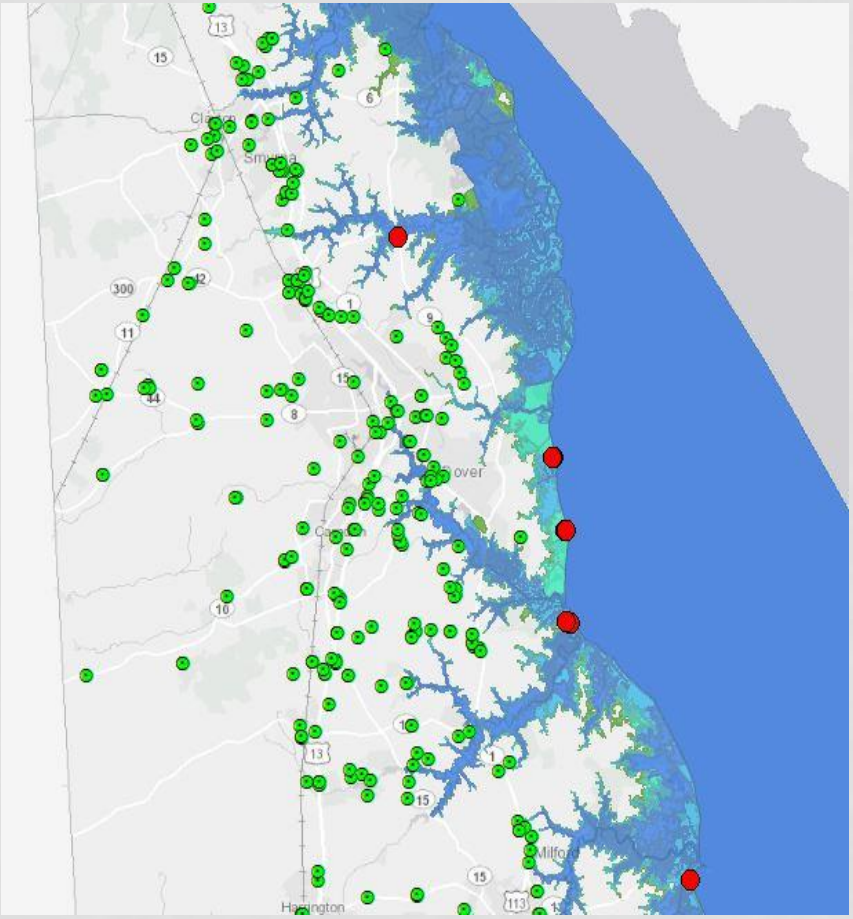


7 ft. SLR

KENT COUNTY WELLS

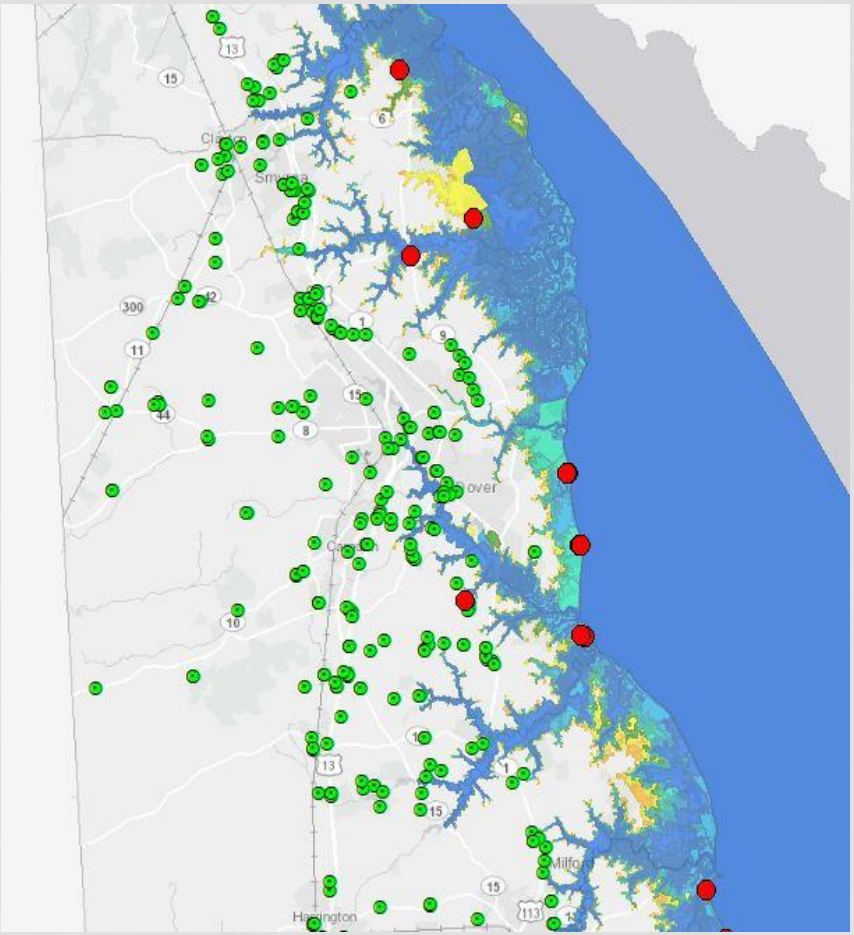


1 ft. SLR

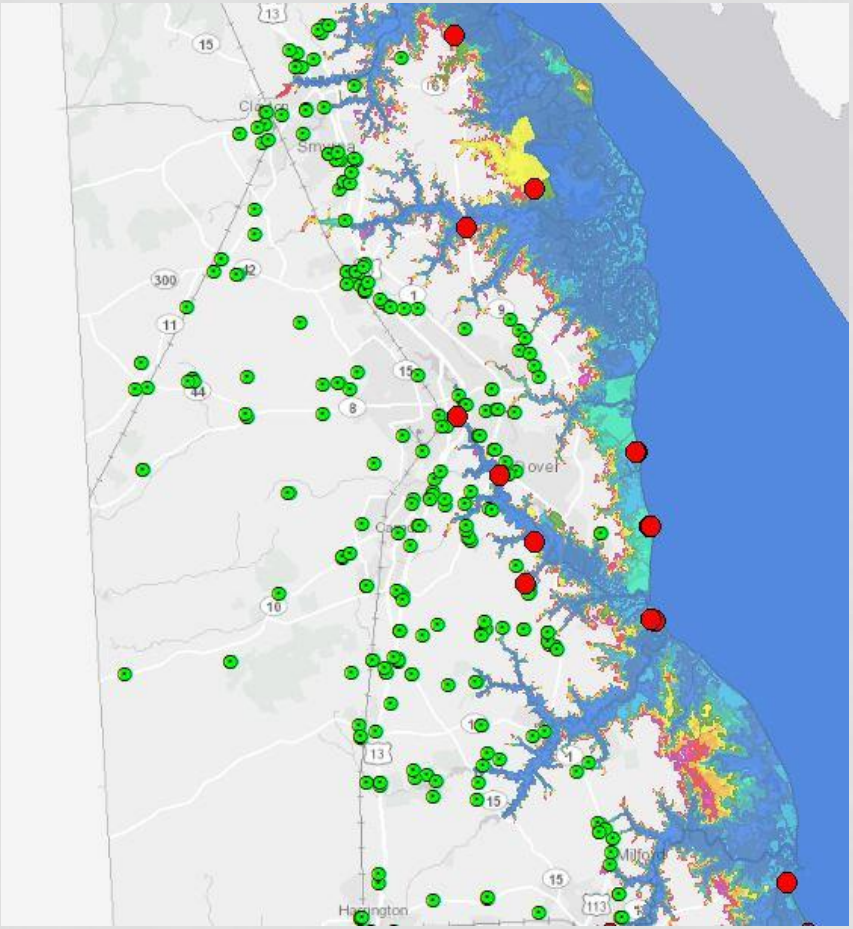


3 ft. SLR

KENT COUNTY WELLS

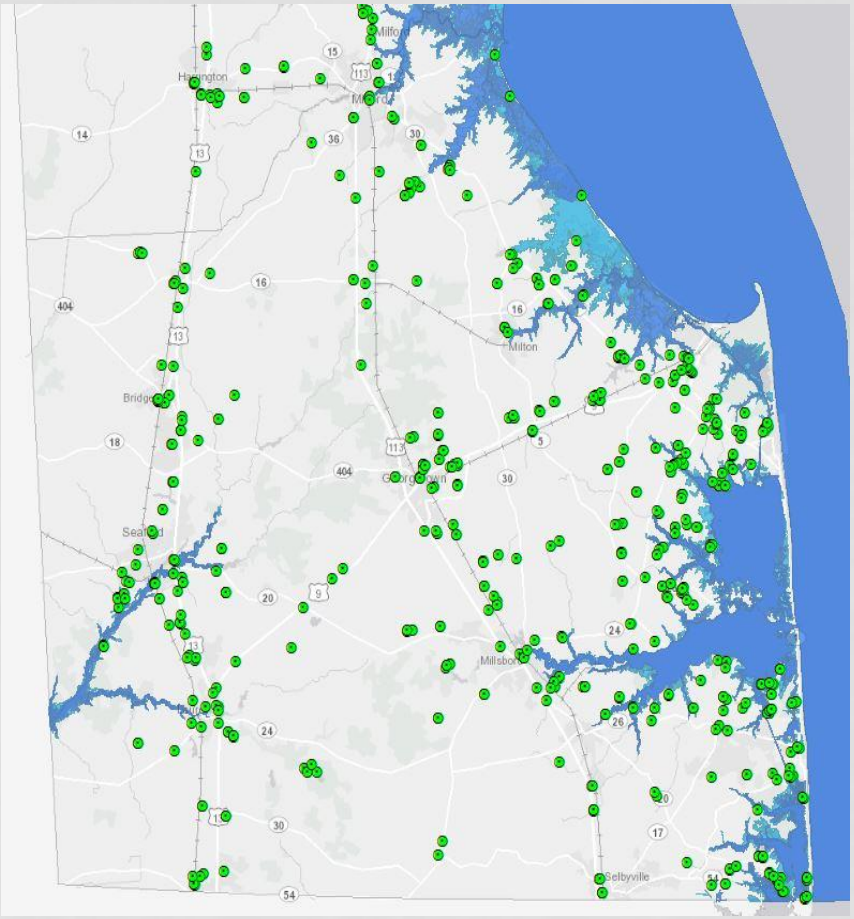


5 ft. SLR

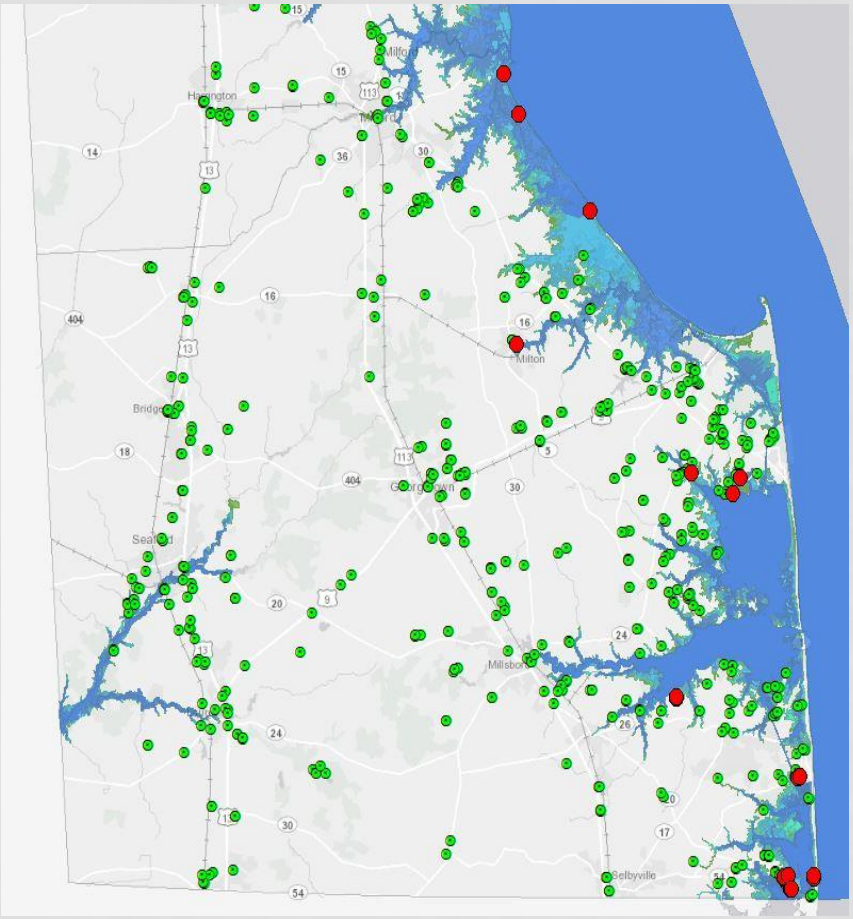


7 ft. SLR

SUSSEX COUNTY WELLS

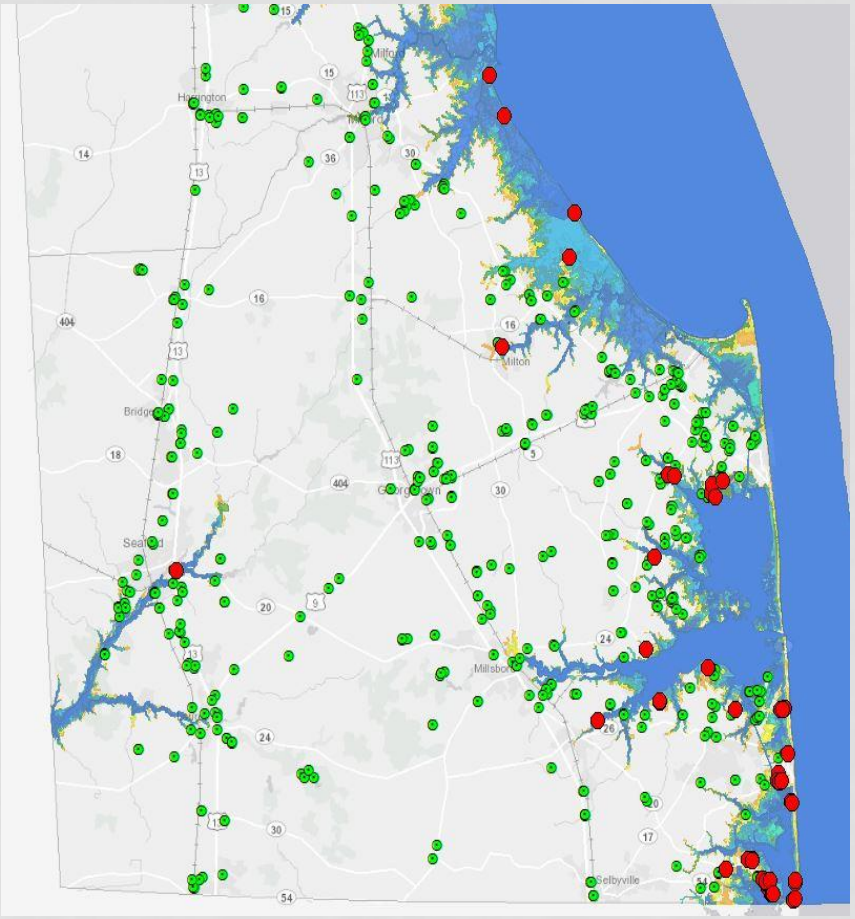


1 ft. SLR

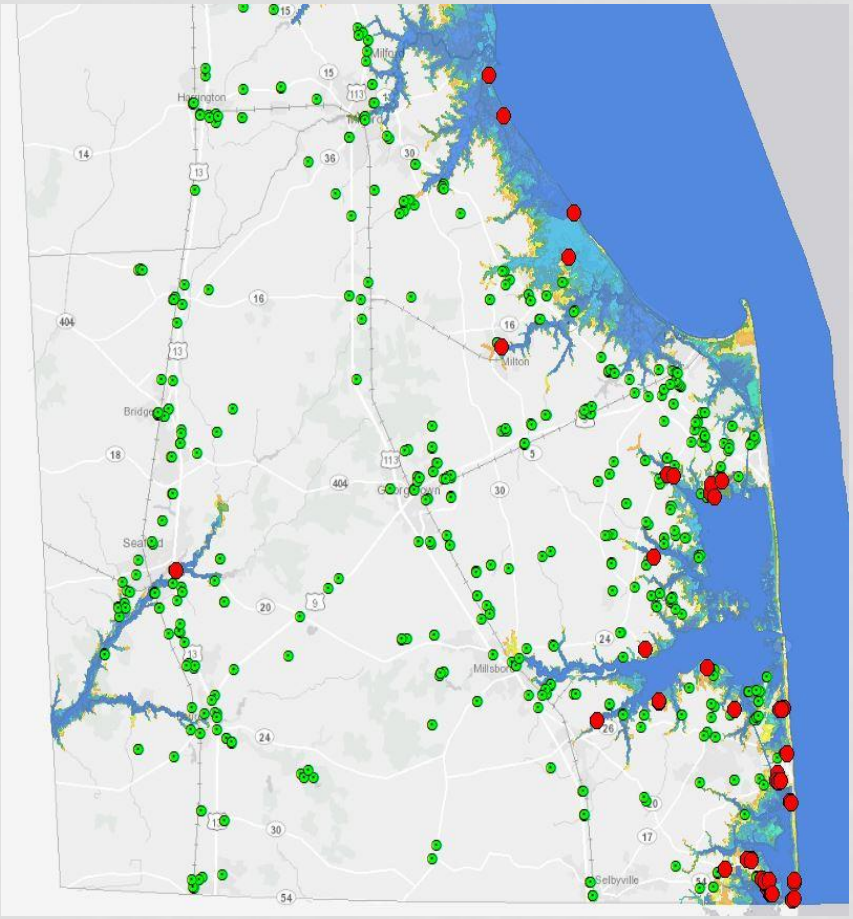


3 ft. SLR

SUSSEX COUNTY WELLS

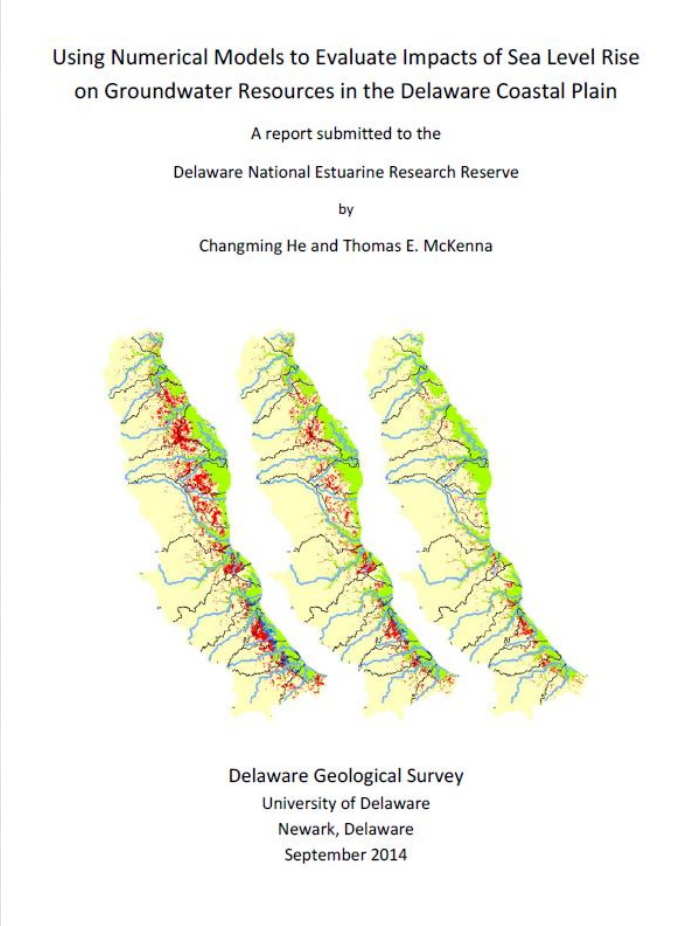


5 ft. SLR



7 ft. SLR

GROUNDWATER IMPACTS



Using Numerical Models to Evaluate Impacts of Sea Level Rise on Groundwater Resources in the Delaware Coastal Plain

A report submitted to the

Delaware National Estuarine Research Reserve

by

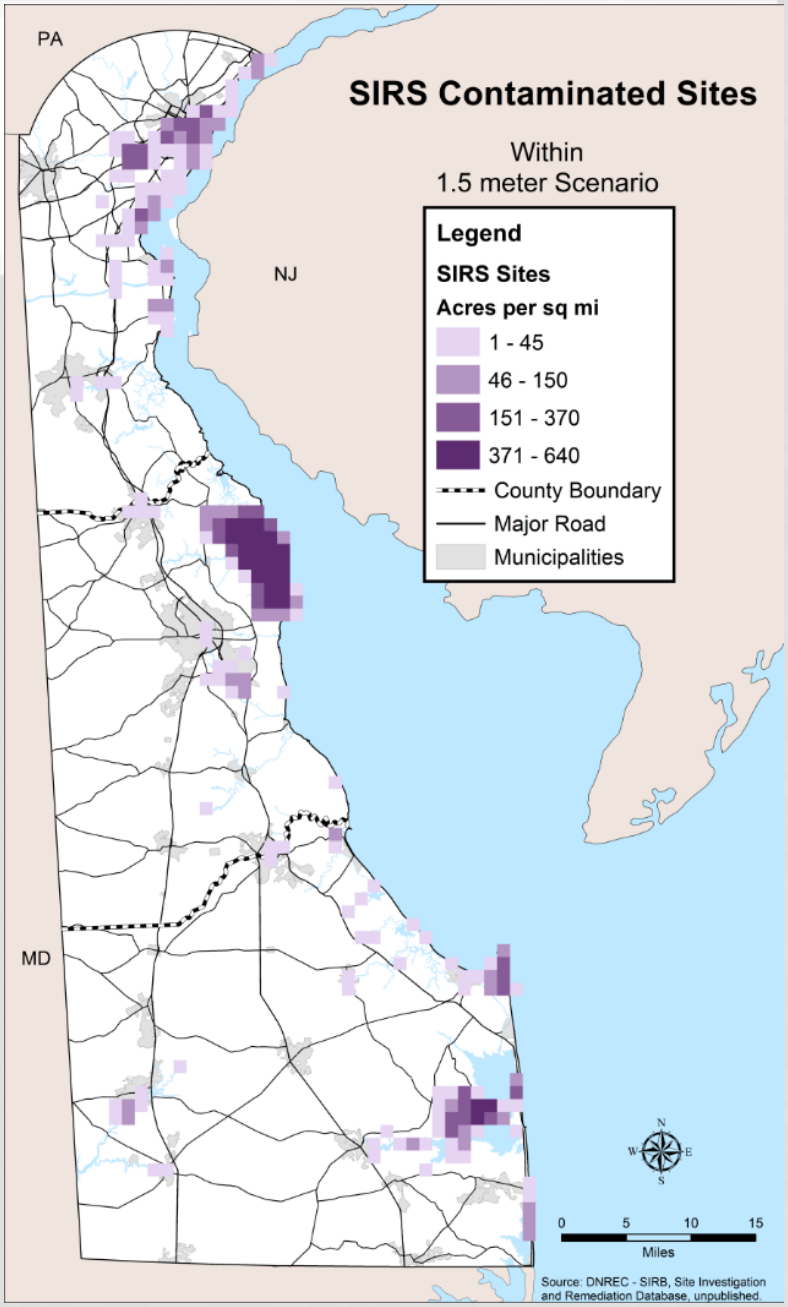
Changming He and Thomas E. McKenna

Delaware Geological Survey
University of Delaware
Newark, Delaware
September 2014

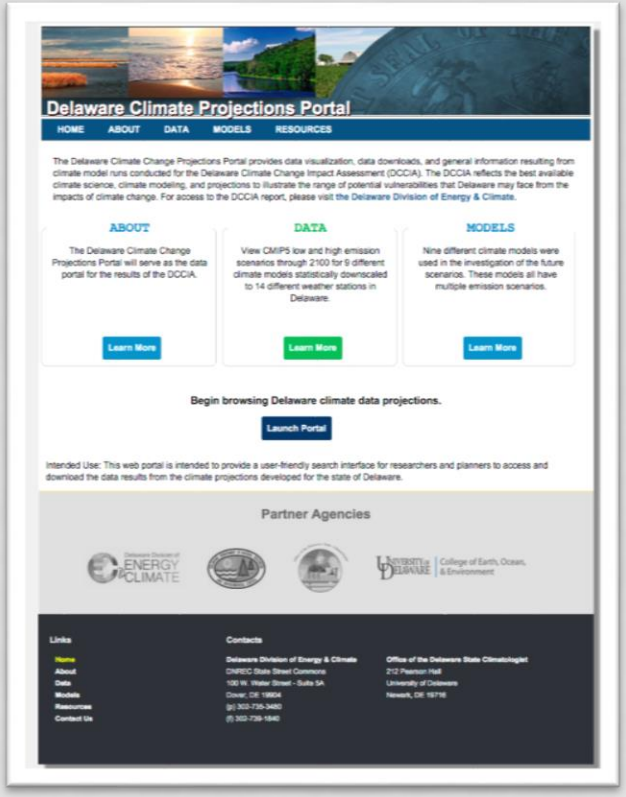
- Water Table Rise
  - 3 to 9 times more area is impacted by rising water table than from surface water inundation
- Salt Water Intrusion
  - With 1.0 m SLR salt water in the base of the aquifer migrates 6.2 km inland under the rivers
  - At 1 km upriver, salt water in the base of the aquifer migrates 2.3 km inland

SLR EXPOSURE: CONTAMINATED SITES

- 41% - 54% of 60,000 acres potentially inundated
- 33% - 44% of 785 sites
- Exposure focused in:
  - Wilmington region
  - Bombay Hook
  - Inland Bays
- Potential for contaminant releases
- Groundwater and surface water implications?



DELAWARE CLIMATE PROJECTIONS PORTAL

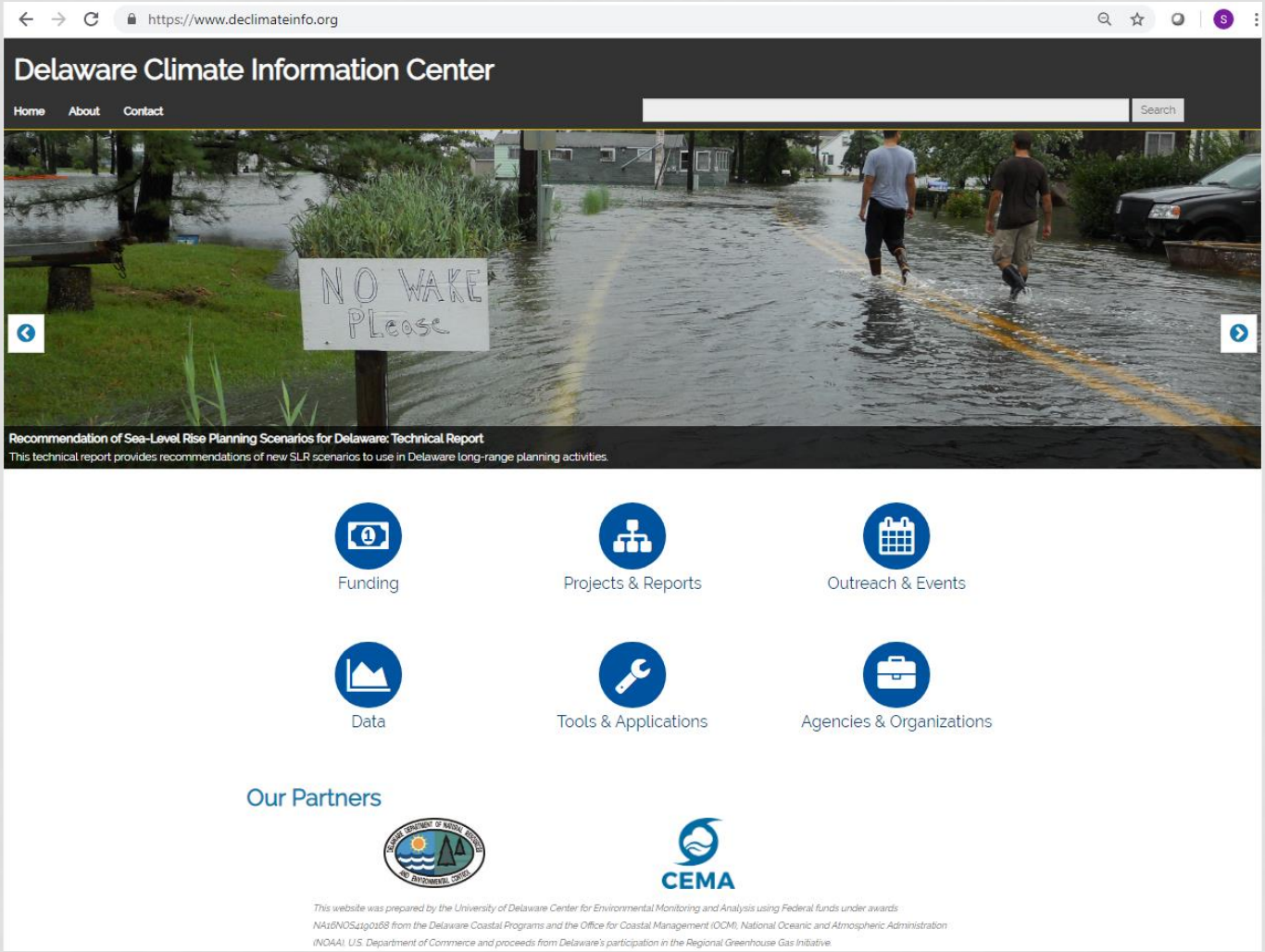


- Web-based data library
- View and download climate projection data developed for the state of Delaware
- Based on historic data from 14 Delaware weather stations and 9 global climate models

Climate.udel.edu/declimateprojections/portal/

http://climate.udel.edu/declimateprojections/portal/

WWW.DECLIMATEINFO.ORG



THANK YOU

For more info:

DNREC Division of Climate, Coastal, and Energy

Bob.Scarborough@Delaware.gov
Susan.Love@Delaware.gov

www.de.gov/dcce

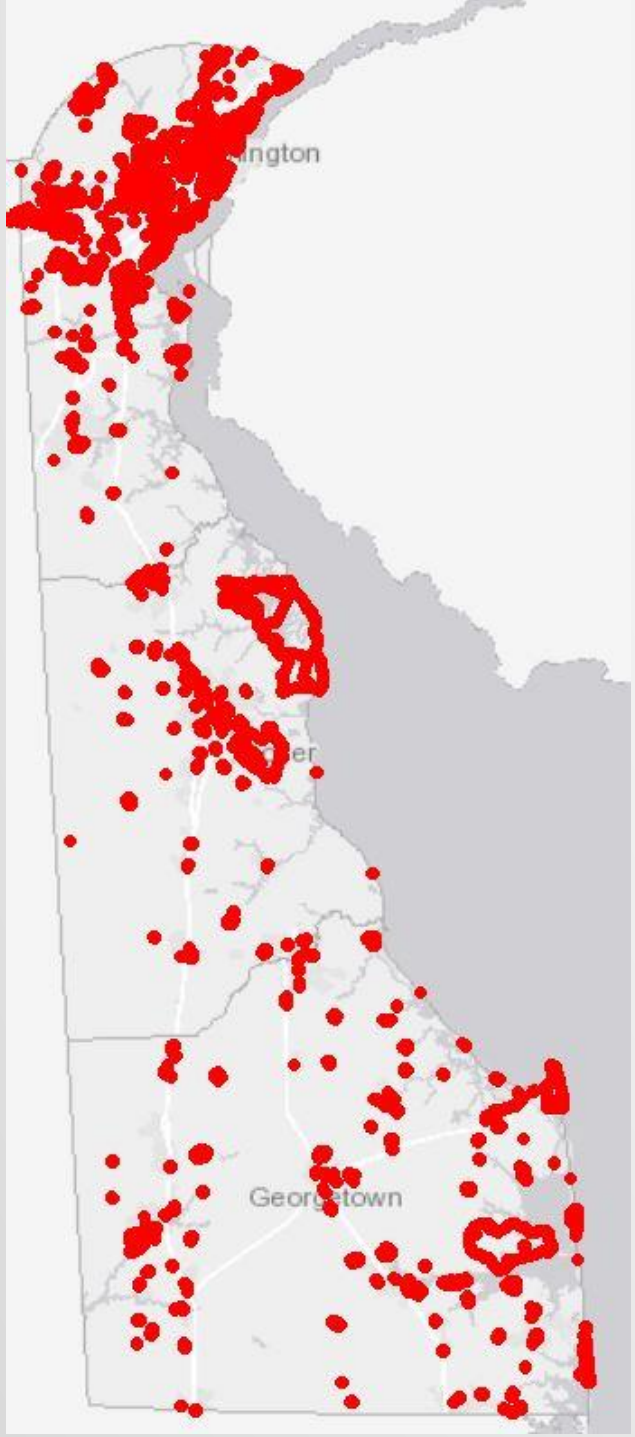
SEA LEVEL RISE
AND
SOURCES OF CONTAMINATION

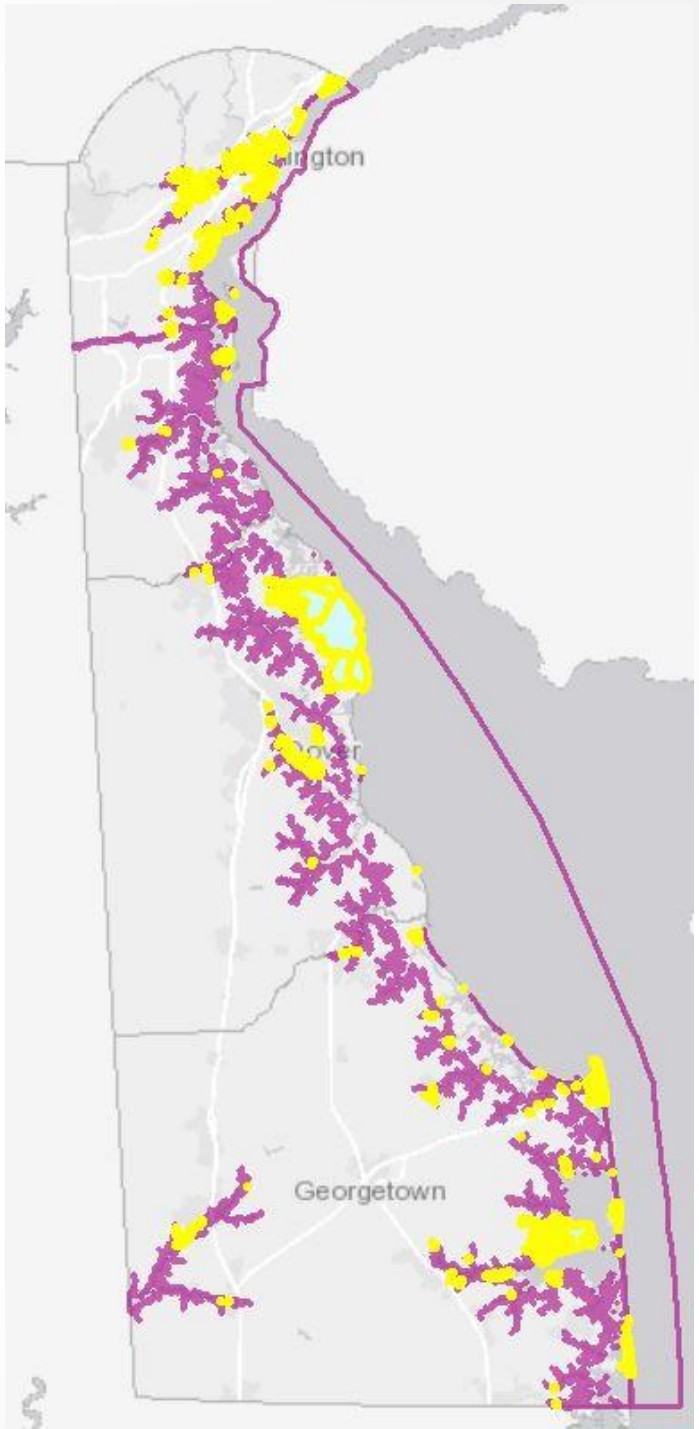
Subtitle

AT THE "WORST CASE SCENARIO" (7-FT (2M) SEA LEVEL RISE)

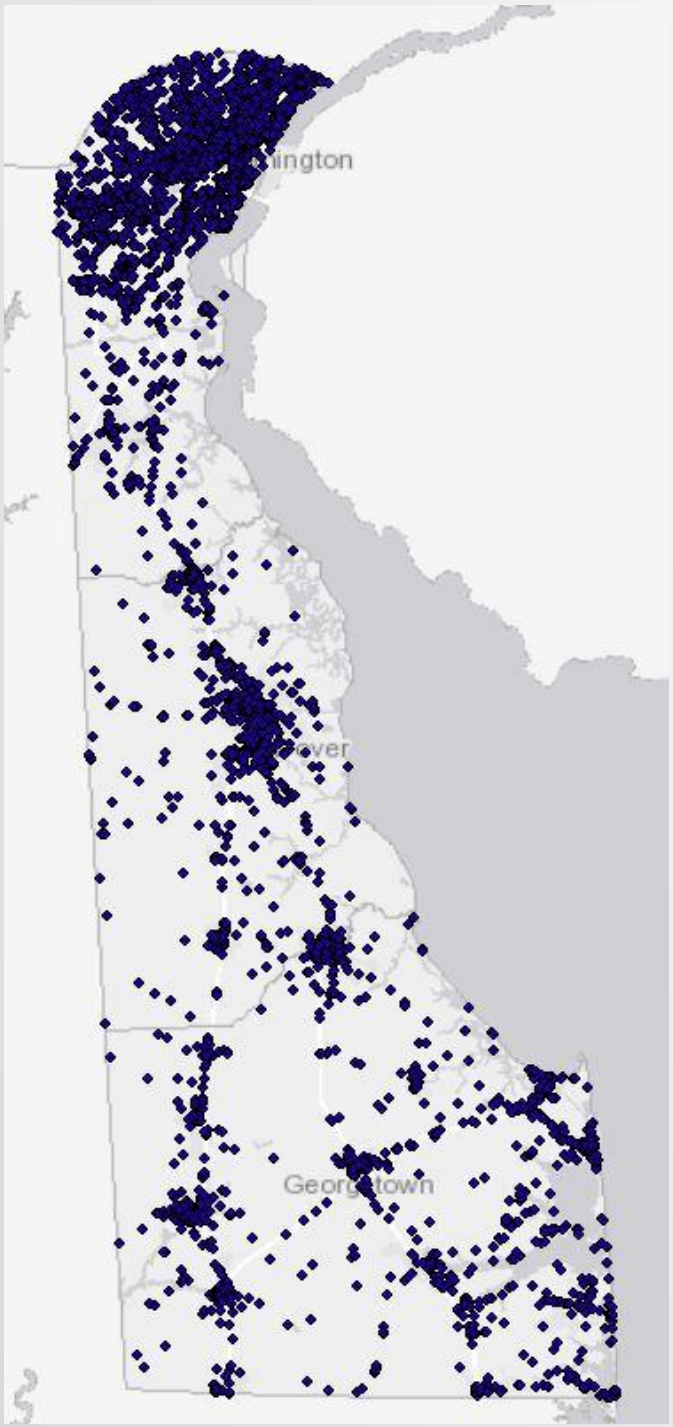
- Sea Level Rise could affect:
  - 425 Superfund Sites
    - approximately 50% of what is catalogued in Delaware (approx. 1000 sites overall)
  - 320 Regulated Underground Storage Tank Sites
  - 220 Leaking Underground Storage Tanks

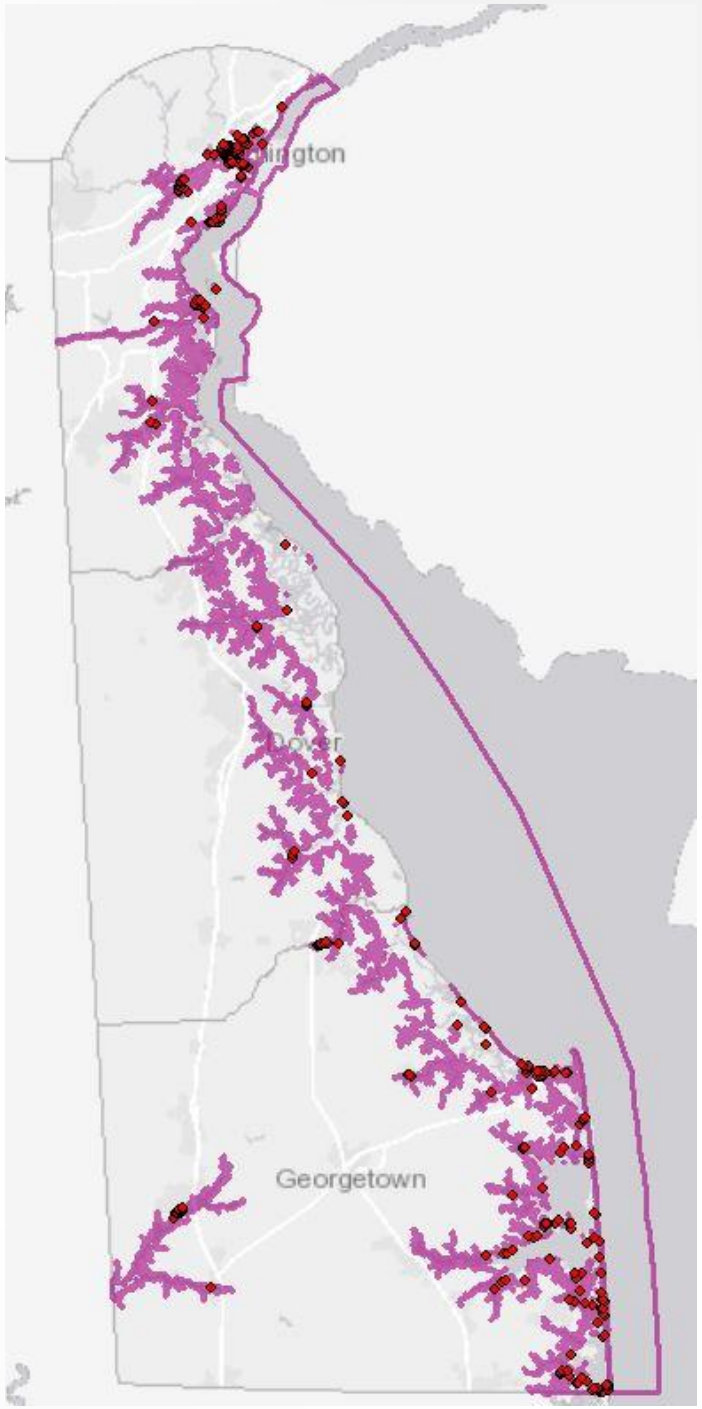
SUPERFUND SITES



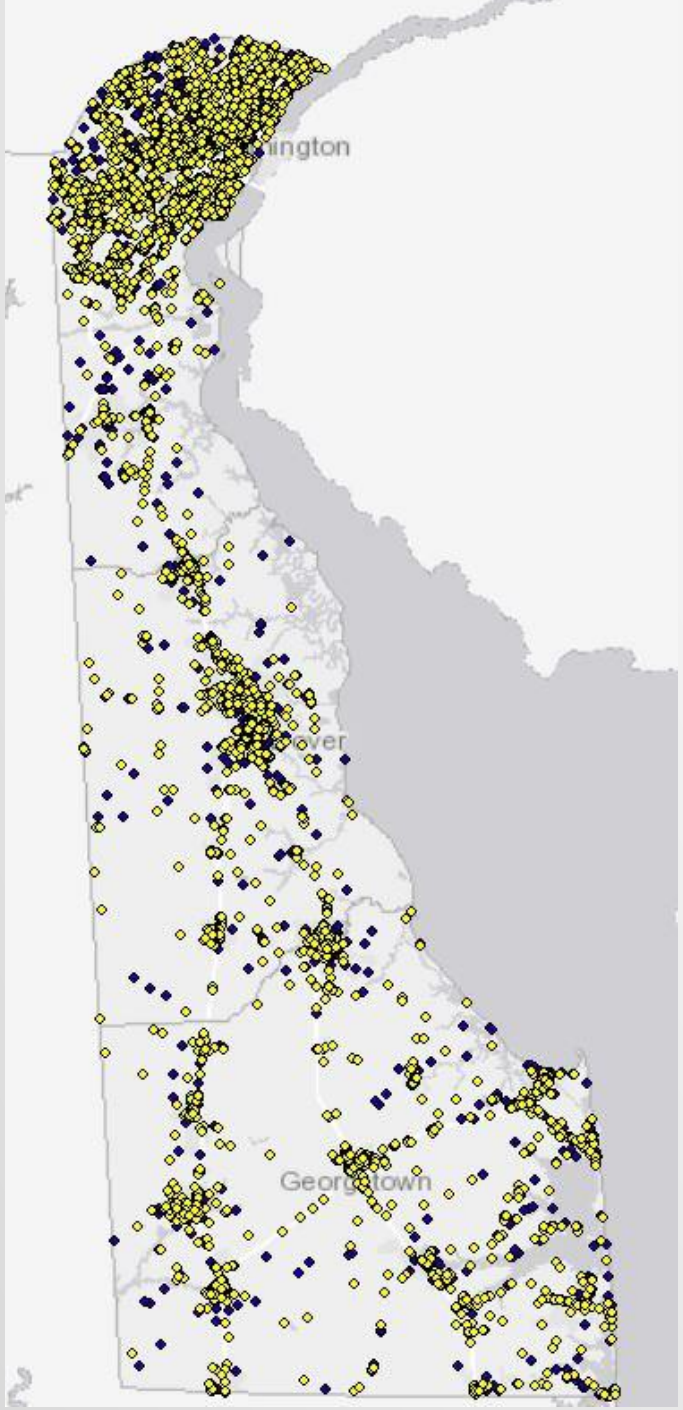


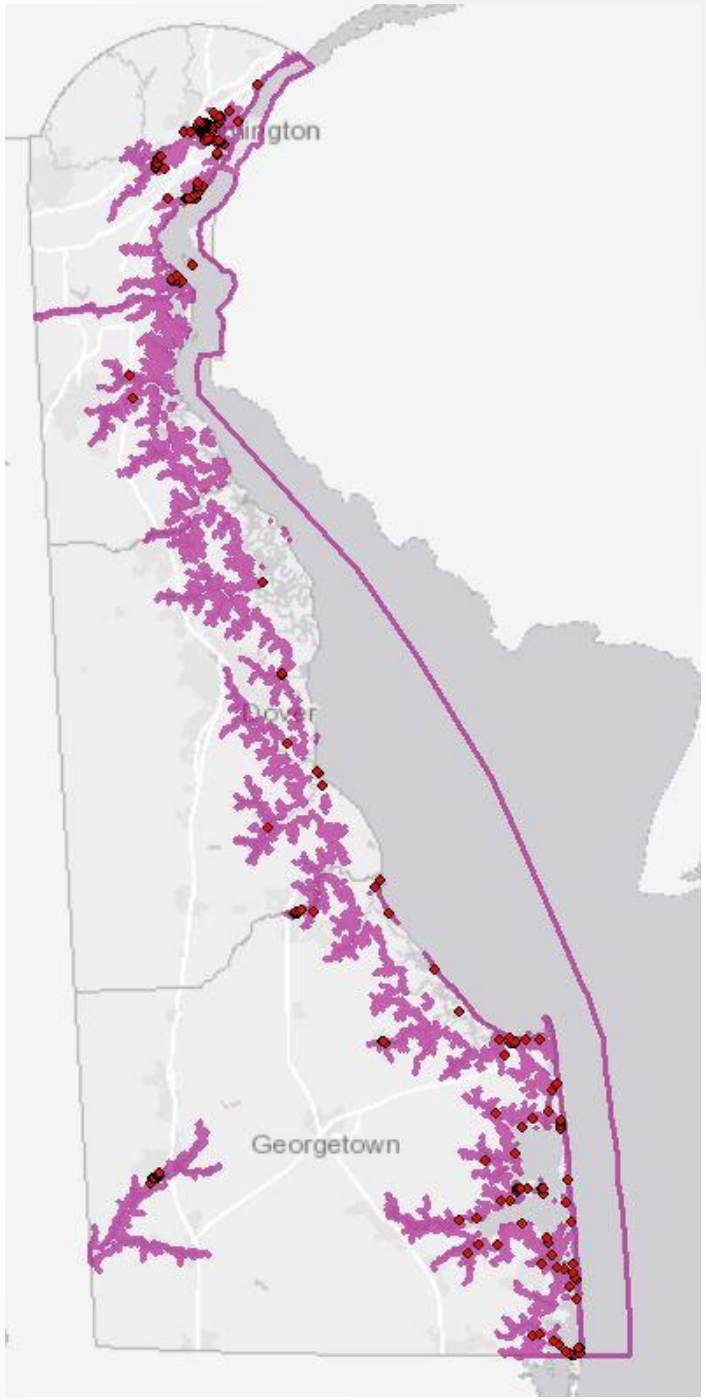
REGISTERED UNDERGROUND STORAGE TANKS





LEAKING UNDERGROUND STORAGE TANKS

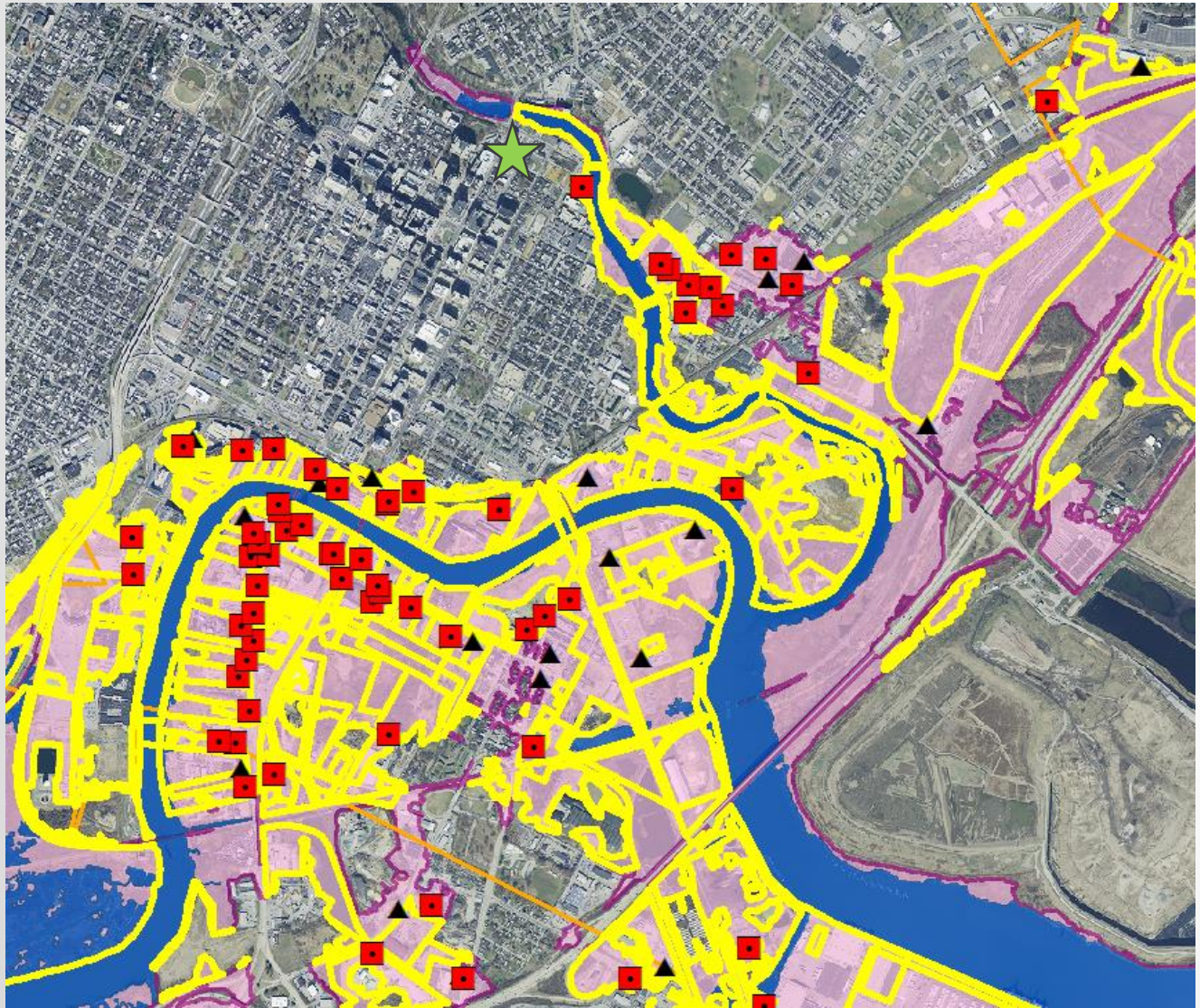




EXAMPLE 1: LEWES AREA

- Many UST/LUST sites in the expected inundated area.
- Fort Miles / Lewes Boat Ramp/Boat Yard Superfund Sites.

EXAMPLE 2: WILMINGTON AREA



- Many UST/LUST sites in the expected inundated area.
- Dozens of Superfund Sites.

CHAPTER 2: SOURCE WATER ASSESSMENT AREA DELINEATION

The USEPA has provided the states with guidance (EPA, August 1997) on the items that must be included in a state's SWAP submittal. The guidance, however, allowed for a large degree of flexibility between the states. The initial step in developing the program is the delineation of areas that contribute to and could impact public drinking water surface intakes, raw water storage facilities (reservoirs), and public water supply wells. These source water assessment areas are the geographic extent for conducting the contaminant inventory and lastly, determining the susceptibility of each public water source. For surface water source water assessment areas, the delineations will utilize existing information maintained in the geographic information systems (GIS) of the State of Delaware and the Water Resources Agency/University of Delaware (WRA). For others, particularly the groundwater systems, the modeling and delineation of the boundaries of these areas will need to be accomplished through the source water assessment activities. Groundwater delineations will be provided by the DNREC SWAPP utilizing simple GIS related methods or more complex computer simulations.

Each State is required to identify the locations of the sources of public drinking water supplies and delineate a source water area based upon those locations. The Delaware DNREC has been working since the 1990's to capture the locations of public water supplies (surface water intake, well, or reservoir) using high-accuracy global positioning system (GPS) units with a horizontal accuracy of one-meter (or less) after post-processing.

Part A of this chapter will detail the methods and techniques employed by the State of Delaware for the delineation of surface water sources of drinking water, meanwhile Part B of this chapter will go into detail regarding the delineation of wellhead protection areas for groundwater derived sources of drinking water.

PART A:

SOURCE WATER PROTECTION AREA DELINEATION OF SURFACE WATER SYSTEMS

2.A.1 Surface Water Supply Sources in Delaware

There are only three public water suppliers in the State of Delaware that have surface water intakes for their source of drinking water, and all are located in New Castle County (Figure 2.A.1). These are the City of Wilmington, the City of Newark, and SUEZ Water Delaware. The surface waters used by these three suppliers are Brandywine Creek, White Clay Creek, Red Clay Creek, and the Christina River. Although these streams vary in size, they all share a common trait - the headwaters of these waterways are in another state, Pennsylvania (Figure 2.A.2). In addition, much of the drainage basin for three of the four waterways are also within Pennsylvania. A small portion of the Christina River watershed is in the State of Maryland. This major drainage basin, called the Christina River Basin, ultimately flows into the Delaware River.

Figure 2.A.1 Public Surface Water Supplies in Delaware

Figure 2.A.2 Delaware Surface Water Supply Drinking Water Watersheds

Additionally, there are two large surface water impoundment facilities in Delaware, the Edgar M. Hoopes Reservoir, which is owned and operated by the City of Wilmington, and the Newark Reservoir which is owned and operated by the City of Newark (Figure 2.A.3). Hoopes Reservoir is a two billion gallon off-stream pumped storage facility located on a tributary of the Red Clay Creek, although the water stored in the Hoopes Reservoir is pumped from the Brandywine Creek. The entire 2 square mile watershed for Hoopes Reservoir is within Delaware. Hoopes Reservoir is principally an emergency storage facility utilized by Wilmington when conditions on the Brandywine Creek are impaired by quality or quantity. Hoopes Reservoir is also used by SUEZ Water Delaware, the Artesian Water Company, and the City of Newark through an agreement with the City of Wilmington to release raw water from the reservoir into the Red Clay Creek to be withdrawn, treated, and distributed by SUEZ Water when needed. The Newark Reservoir is a 340 Million Gallon off-stream pumped storage facility located adjacent to the White Clay Creek which serves as its source of supply. The total watershed area for the Newark Reservoir consists of 349 acres (0.54 square miles). The Newark Reservoir is principally an emergency storage facility utilized by the City of Newark when conditions on the White Clay Creek are impaired by degraded quality or low flows.

<INSERT FIGURE 2.A.3>

One other surface water source that is used daily in Delaware is the Octoraro Creek in the Susquehanna River Basin of Pennsylvania. Water from this out-of-state source enters Delaware as finished water through pipelines from the Chester Water Authority (CWA) in Pennsylvania. One of the pipelines connects the CWA to the Artesian Water Company and another pipeline connects the CWA to SUEZ Water Delaware. The following table summarizes the public water suppliers that utilize surface water for public supplies in Delaware and shows the percentage of each watershed that is within Delaware's state boundaries.

Table 2.A-1 Summary of Watersheds Used for Public Drinking Water in Delaware

Water Supplier	Source Water/ Watershed	Maximum Withdrawal	Total Watershed Area	% of Watershed in Delaware
City of Wilmington	Brandywine Creek	44 MGD	320 Sq. Miles	10%
City of Wilmington	Hoopes Reservoir	24 MGD	2 Sq. Miles	100%
City of Newark	White Clay Creek (above Newark)	Up to 5 MGD	69 Sq. Miles	14%
City of Newark	Newark Reservoir	18 MGD	0.54 Sq. Miles	100%
SUEZ Water Delaware	Red Clay/ White Clay Creek	30 MGD	155 Sq. Miles	40%
SUEZ Water Delaware	Christina River at Smalley's Pond	6 MGD	56 Sq. Miles	81%
Chester Water Authority, Pennsylvania	Octorora Creek	8 MGD	140 Sq. Miles	0%

2.A.2 Delineation of Source Water Assessment Areas for Surface Water Systems

According to US EPA's document "State Methods for Delineating Source Water Protection Areas for Surface Water Supplied Sources of Drinking Water" (August 1997) there are three main methods states utilize to delineate surface water assessment areas upstream of a public supply intake:

- Topographic boundary delineation,
- Setback/buffer zone delineation,
- Time-of-travel calculation.

Topographic boundaries are determined by the contour of the land. These boundaries are commonly referred to as the watershed or drainage basin for the stream. A setback/buffer zone is an area along the banks of a stream established by a policy decision considering such factors as the slope of the land adjoining a stream, size of stream, and local land uses along the stream. According to US EPA, a typical buffer zone is a strip of land up to about 200 feet wide. The third method for delineating a surface water assessment area is by developing time-of-travel calculations. This approach is used to determine how long it would take for a contaminant moving at the same speed of the stream water to reach the supply intake(s). This method is very useful for emergency response activities and most important for places where there are sources of contamination located directly adjacent to the stream or its tributaries with little overland flow needed to enter the watercourse.

The State of Delaware's approach to delineating surface source water assessment areas will utilize topographic boundaries, physical land characteristics (soils), and setback/buffer zones in a hierarchical arrangement. Initially, all lands upstream of the public surface water supply intakes will be divided into watersheds based on the topography of the land. The US EPA's Final Guidance document requires states to delineate the source water assessment area for surface water sources based on the watershed upstream of the suppliers' intakes up to the state's borders. For Delaware, the watersheds of the four streams used for water supply - the Brandywine Creek, the White Clay Creek, the Red Clay Creek, and the Christina River, have been delineated (Figure 2.A.1). However, since such a large portion of the watersheds for these surface water sources for Delaware are in Pennsylvania, the watershed delineations have been extended into Pennsylvania (Figure 2.A.2) up to the next drinking water intake. It is the intention of Delaware to work closely through existing interstate relationships with the Commonwealth of Pennsylvania and Chester County, Pennsylvania personnel to implement elements involved in Delaware's source water assessment activities, including the delineation, potential contaminant inventory, and susceptibility determinations.

Delaware has been working with Pennsylvania agencies on a project called the Christina Basin Clean Water Partnership (CWP). The CWP is a regional management committee that has been established consisting of representatives from Pennsylvania, Delaware, USEPA, the Delaware River Basin Commission, as well as water utilities and environmental organizations. The goal of this program is to address water quality problems through a regional, watershed-based approach. TMDLs, as required by Section 303 (d) of the Clean Water Act, have been established for these four streams in the Christina River Basin through the development of a

watershed water quality model. The TMDLs will be limits established on discharges that will result in improving the quality of these surface water sources including those used for public drinking water. Through this program and the work of various DNREC programs, the basic delineation of the entire watershed and the sub-basins for each of these streams has been completed and is maintained in a Geographic Information System (GIS) database at the WRA and at DNREC. A base map has been developed that shows the hydrology, road network, major/minor watersheds, and the state/county/municipal boundaries of the 565 square mile Christina River Basin. The SWAPP will utilize the most up-to-date data from the following sources to maintain the base map:

Roadway and Stream Network

Delaware Department of Transportation (DELDOT)
Pennsylvania Department of Transportation (PENNDOT)
Maryland Department of Transportation (MDOT)

State/County/Municipal Boundaries

DELDOT
PENNDOT
MDOT

Watershed Boundaries

Delaware - Water Resources Agency
Pennsylvania - Chester County Planning Commission watershed maps by WRA
Maryland - Digitized from the USGS Newark West Quadrangle by WRA

Additionally, a variety of GIS data layers have been developed to characterize the watershed and provide a foundation for assessing these source waters. This data includes impervious cover, land use, zoning, topography, and soil classifications. This program and information will be utilized for surface water delineation in the Delaware SWAP and to coordinate interstate source water assessment and protection efforts within the Christina River Basin area.

Although the entire watershed area is important, and will be considered, for source water assessment, different land areas have varying impacts to surface water quality, usually related to relative distance from the stream. To delineate the areas of most value to surface water quality, the State will use an approach based on natural land characteristics and a buffer area of 200 feet. The methodology using floodplains, adjacent steep slopes, and soil characteristics used by the Water Resources Agency in developing the Water Resource Protection Area (WRPA) Program in New Castle County will be employed. The WRPAs are areas that were determined by the Delaware Geologic Survey, DNREC, and WRA to be most important to maintaining the quality and quantity of the sources of public drinking water - both ground and surface water supplies. These areas were delineated, mapped and adopted into the land development code for New Castle County in 1991 and were subsequently updated.

Delaware's surface water assessment areas are lands upstream of public water supply intakes that are in the 100-year floodplain, erosion prone slopes contiguous to and draining towards a floodplain, and areas that drain directly to public water supply reservoirs. The erosion prone slope areas consist of lands with soils that easily erode as mapped in the United States Department Agriculture Soil Survey for New Castle County. These areas, used for the WRPA program in New Castle County, will be utilized for delineating surface water source water assessment areas. In areas along tributaries where there are no delineated erosion-prone slope areas or 100 year floodplain on the New Castle County WRPA maps, a fixed distance of 200 feet from both edges of the stream will be established.

<Insert Figure 2.A.4>

Lastly, consideration will be given to some of the area downstream of the surface water intake for United Water Delaware at Stanton in the delineated assessment area. The stream used for source water, the White Clay Creek, is influenced by tidal action up to the intake. The contaminant inventory and vulnerability analysis may need to consider some portion of this downstream area since contaminants could migrate upstream by tidal movement under certain flow conditions. A likely point downstream is the tidal control structure.

It is recommended that a similar stream buffer approach be used in Pennsylvania to target areas of higher importance to surface water quality. It should be noted that there will be gaps between the last downstream intake in Pennsylvania and the Delaware state line for the Brandywine Creek. Also, there are no public water system intakes in Pennsylvania on the Red Clay, White Clay, and the Christina River. Data from the Christina River Basin Clean Water Partnership will be used for these assessments.

2.A.3 Surface Water Delineation Classification Hierarchy

A two-zone delineation classification approach will be used for source water assessment areas for all surface supply sources in Delaware (Figure 2.A.4). Each delineation level (1A, 1B, 2) will have an impact on the contaminant source inventory and the susceptibility determination to be described in the remaining chapters.

CATEGORY	DELINEATED AREA
Level 1A	100-year floodplains, and/or erosion-prone slopes;
Level 1B	Buffer areas 200 feet from each side of streams;
Level 2	All watershed areas above public drinking water supply intakes

See Appendix I, page I-3 for an example of this approach

PART B:

SOURCE WATER PROTECTION AREA DELINEATION OF GROUNDWATER SYSTEMS

2.B.1 Groundwater Supply Sources in Delaware

With the exception of the six (6) surface water intakes and the associated three systems, all of the rest of Delaware's public water systems rely on groundwater as the only source of public drinking water. Table 2.B.1 summarizes the approximately 1098 public supply wells in Delaware by county and by system type.

These public water supply wells have been drilled to a wide range of depths and draw water from various aquifers. For source water assessment purposes, a key factor need to delineate the source water area is whether a well is screened in an unconfined, semi-confined, or confined aquifer. Semi-confined and confined aquifers are generally, but not always, deeper than the unconfined aquifer and are separated from the overlying geologic formation by a layer of clay-like materials. These materials, termed confining layers, impede the vertical movement of water making confined aquifers less susceptible to contamination than unconfined aquifers. A listing of all current public water supply systems is provided in Appendix D. Additionally, the wells currently within the DNREC database for Kent, Sussex, and New Castle Counties are illustrated in Figures 2.B.1, 2.B.2 and 2.B.3, respectively. DNREC began locating all public supply wells using global positioning system (GPS) units. The Delaware SWAP will delineate the source waters of the following groundwater-based public water supply systems:

- Community Public Water Systems
  - Municipalities
  - Investor-owned purveyors
  - Privately-owned purveyors

- Non-Transient Non-Community Public Water Systems
  - Schools/Day Care Centers
  - Offices/Factories

- Transient Non-Community Public Water Systems
  - Restaurants and Stores
  - Hotels/Recreation Areas

Table 2.B.1: Summary of Public Water Supply Wells in Delaware (August 2019)

	Community PWS Wells	Non-Transient / Non-Community PWS Wells	Transient PWS Wells	TOTAL Wells
Kent County	**217**	**27**	**58**	**302**
New Castle County	**134**	**29**	**35**	**198**
Sussex County	**378**	**73**	**147**	**598**
Total	**729**	**129**	**240**	**1098**

<INSERT Figure 2.B.1 New Castle County>

<INSERT Figure 2.B.2 Kent County>

<INSERT Figure 2.B.3 Sussex County>

2.B.2 Delineation of Source Water Assessment Areas for Groundwater Systems

As with surface water sources, the delineation of areas critical to protecting the quality and quantity of groundwater sources has been underway for several years. In 1990, Delaware's Wellhead Protection Program was approved by the USEPA. This program established the methodology used in Delaware for delineating wellhead protection areas in the SWAP. The areas that will be delineated are divided into two categories: wellhead protection areas (the surface or sub-surface area surrounding a water well or wellfield through which contaminants are likely to move toward and reach such well or wellfield) and recharge-potential areas (areas where the soil and rock characteristics are favorable for water on the land surface to pass into an aquifer). A July 1994 draft report written by the Delaware DNREC entitled *"Wellhead Protection Area Delineation Manual*" provides additional detail on the following explanation of the State's approach to wellhead protection area delineation.

The DNREC policy for delineating wellhead protection areas provides the guidance for delineating the source water assessment areas around public water supply wells. This policy applies to all of the categories of wells listed previously. All public supply wells pumping at or less than 50,000 gallons per day (gpd) are assigned a circular wellhead area of 150 feet radius centered on the well. For most low pumping-rate wells the 150-foot radius would include the 5-year time of travel. Also more detailed wellhead protection area (WHPA) delineations at low system-wide water use are not credible due to their sensitivity to varying groundwater flow direction. On the other hand, all public water system wells withdrawing more than 50,000 gpd would have a wellhead protection area delineated using various modeling techniques such as, but not limited to, USEPA's Wellhead Analytical Element Model (WhAEM) and the United States Geological Survey's MODFLOW computer models.

Another important factor in delineating the wellhead protection area is the determination of whether the well is drawing water from a confined, unconfined, or semi-confined aquifer. Many aquifers in Delaware are considered confined if the aquifer has an impermeable layer over the top of it that significantly reduces the downward vertical flow of water from above. In most cases, a well screened in one of these aquifers may be considered confined by DNREC and the wellhead area would be a 150 foot radius circle centered to the well. The exception to this is where these otherwise confined aquifers subcrop (i.e. are in limited, but direct hydraulic connection with) beneath the unconfined aquifer, and thus they will be considered semi-confined in these locations. The aquifers that have subcrop areas include the Rancocas, Magothy, Potomac, Pocomoke, Ocean City, Manokin, Cheswold, and Frederica aquifer units of the Chesapeake Group. Semi-confined wells will be evaluated on a case-by-case basis through their location, water use, well construction, and water quality to determine if they should be delineated using a fixed radius or a more complex groundwater model.

Coastal Plain Hydrostratigraphic Chart

The following table displays the correlation of hydrologic units to geologic units recognized by the Delaware Geological Survey in the Atlantic Coastal Plain. PDF version is also available below.

Age	Geologic Units	Hydrologic Units	County
Pleistocene	Delaware Bay Group Nanticoke River Group Assawoman Bay Group	Columbia/unconfined aquifer - poor to excellent yield; minor confining beds	Kent, Sussex
		Confining unit over Columbia aquifer only in southeastern Sussex County - minor, poor aquifer	Sussex
	Columbia Fm.	Columbia/unconfined aquifer - poor to excellent yield; minor confining beds	New Castle, Kent and Sussex
Pliocene	Beaverdam Fm.		
Miocene	Bethany Fm.	Pocomoke aquifer - fair to excellent yield; interbedded confining beds	Sussex
	Cat Hill Fm.	Manokin aquifer - fair to excellent yield; confining beds	Sussex
	St. Marys Fm.	Confining beds - minor, poor aquifer	
	Choptank Fm.	Interbedded unnamed aquifer - fair to good yield; confining units	Kent, Sussex
		Milford aquifer - fair to good yield	Kent, Sussex
	Calvert Fm.	Confining beds Frederica aquifer - fair to good yield Confining beds Federalsburg aquifer - fair to good yield Confining beds Cheswold aquifer - fair to excellent yield Confining beds	Kent, Sussex
Oligocene	Oligocene glauconitic unit		
Eocene	upper Eocene glauconitic unit		
	Piney Point Fm.	Piney Point aquifer - poor to excellent yield; interbedded confining beds	Kent
	Shark River Fm. Deal Fm.	Confining beds	
	Manasquan Fm. Vincentown Fm.	Rancocas aquifer - fair to good yield; interbedded confining beds	New Castle, northern Kent
Paleocene	Hornerstown Fm. Navesink Fm.	Confining beds	
Cretaceous	Mount Laurel Fm.	Mount Laurel aquifer - poor to good yield	New Castle, northern Kent
	Marshalltown Fm.	Confining beds	
	Englishtown Fm.	Englishtown aquifer - locally fair to good yield	New Castle
	Merchantville Fm.	Confining beds	
	Magothy Fm.	Magothy aquifer - fair to good yield	New Castle
	Potomac Fm.	Potomac aquifers and confining units - fair to excellent yield	New Castle
Jurassic to Triassic	Post-rift unconformity rocks (Jurassic) Rift basin rocks (inferred)		

The unconfined aquifer covers the surface of much of Delaware and consists mainly of a sand layer of varied depth that generally thickens from 0 to 130 feet as you move from north to south. This aquifer is usually referred to as the Columbia or water table aquifer. Wells screened in an unconfined or semi-confined aquifer are treated the same when considering wellhead protection delineation. If the pumping rate is at or less than 50,000 gpd, the wellhead is again the 150-foot radius circle centered on the well. If the pumping rate exceeds 50,000 gpd, hydrogeologic modeling is required to determine the wellhead protection area. Water use reports required by the DNREC Water Allocation Program will be used to determine the pumping rate for existing wells.

The Delaware DNREC is using groundwater models to delineate wellhead protection areas for wells pumping greater than 50,000 gpd. As described in Delaware's Wellhead Protection Plan, DNREC uses a 5-year time of travel in the modeling, meaning that it would take 5 years for a drop of water to travel from the outer boundary of the resulting wellhead protection area boundary to the well. These models vary in complexity, detail, and cost and the one selected for a well will depend on the individual conditions related to the underlying geology. Necessary inputs to the models include transmissivity, saturated thickness, effective porosity, groundwater flow direction, and hydraulic gradient.

DNREC will also be using the groundwater recharge-potential mapping project to provide additional information needed to better define the local conditions for input into the wellhead models. This project characterizes the ease with which recharging water (or other liquids) can move through the subsurface and into the unconfined aquifer. The Delaware Geological Survey (DGS) utilizes a "stack-unit" methodology to rank areas as either poor, fair, good, or excellent (Andres, 1991). This method is basically a detailed lithologic characterization of the top 25 feet of soils and sediments from which an inference can be made about the intrinsic permeability of the material.

In New Castle County, the wellhead protection areas to be used for the SWAP include delineations through work by the Delaware Geological Survey, DNREC, the Water Resources Agency, and New Castle County Council. Wellhead protection areas were delineated and adopted into law by New Castle County Council as part of the New Castle County WRPA program. The State DNREC included the wellhead protection program provisions of the NCC WRPA Program in its USEPA approved Wellhead Protection Program. The areas (Figure 2.B.4) are defined as:

- Class A Wellhead Areas - - The area within a 300 foot radius circle around all public water supply wells which are classified as water systems, as defined by Section 22.146 (Public Water Systems) in the State of Delaware Regulations Governing Public Drinking Water Systems. Class A wells are community, transient non-community, and non-transient non-community.;

- Class B Wellhead Areas - The Glendale and Eastern States Wellfields. These Wellhead Protection Areas have been delineated through the use of hydrogeologic mapping, analytical methods, and application of U.S. EPA modular semi-analytical models using a five year time-of travel by the Delaware Geological Survey as discussed in a report prepared by the Delaware Geological Survey entitled "Application of the EPA WHPA Models for Delineation of Wellhead Protection Areas in the Glendale and Eastern States Wellfields, New Castle County, Delaware" dated January 1993.;

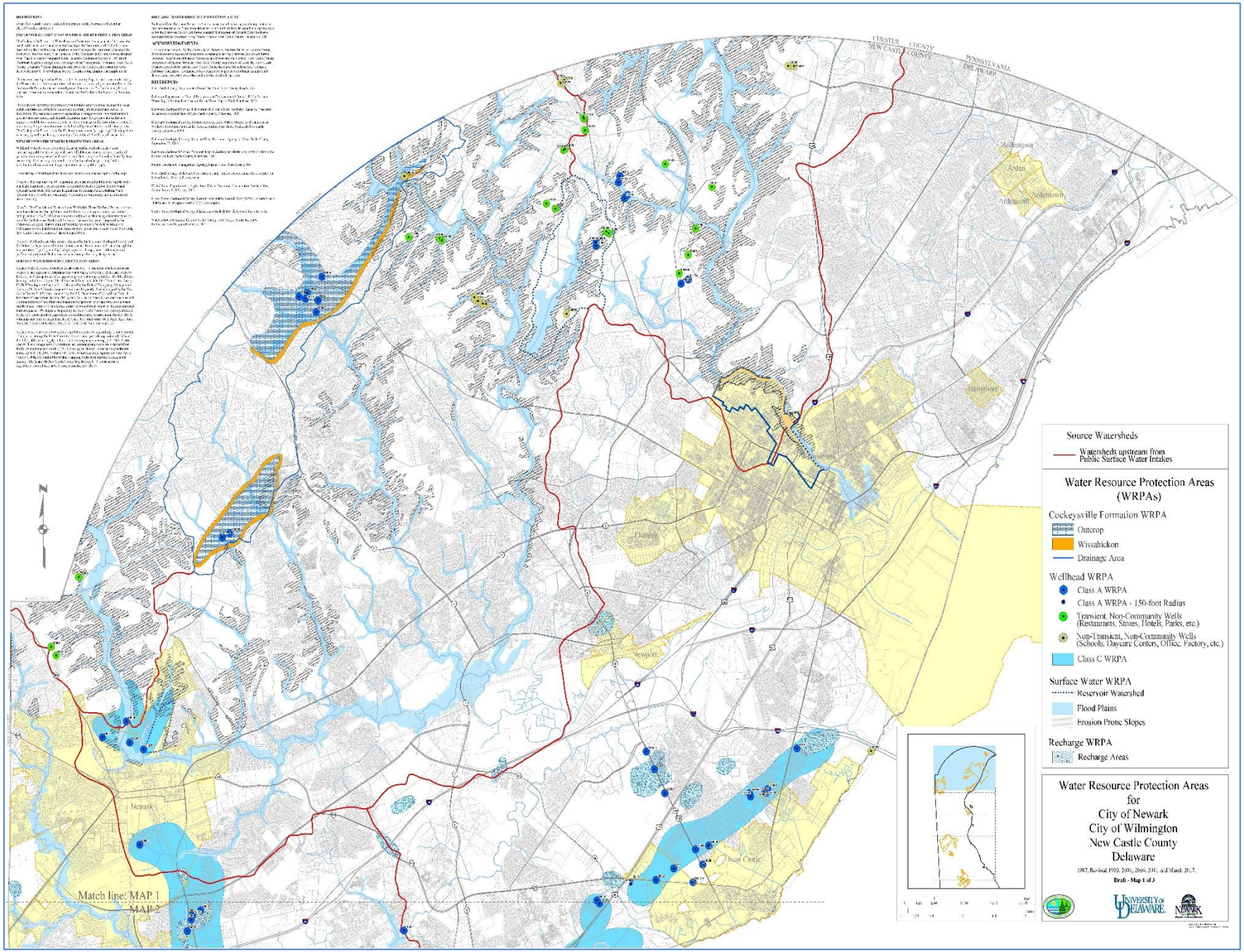
- Class C Wellhead Areas - Wellhead Protection Areas delineated by the Delaware Geological Survey and the Delaware Department of Natural Resources and Environmental Control through the interpretation of geologic and hydrologic reports and maps, water-table maps, and professional judgment. Such areas

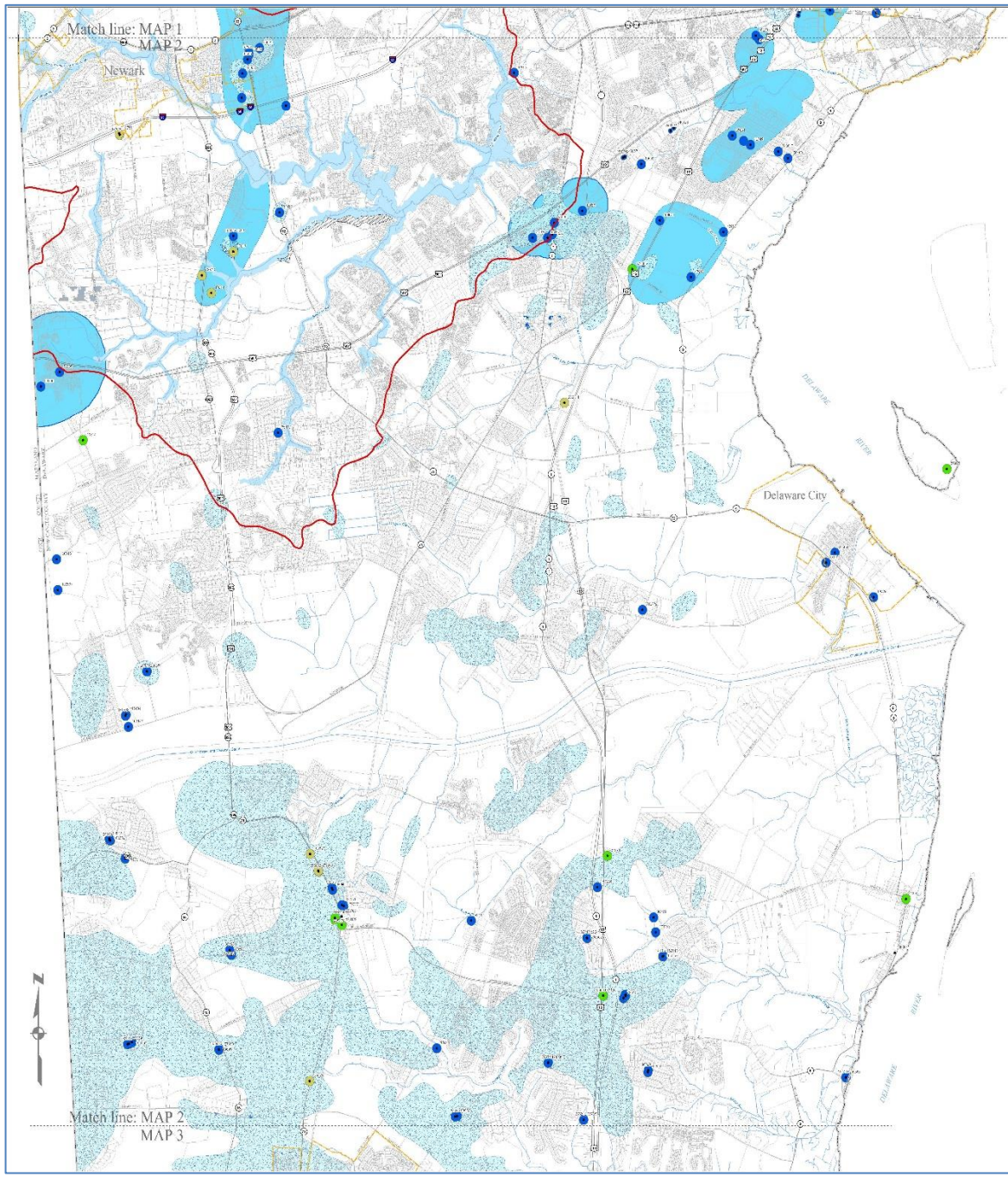
are considered preliminary designations;

- The Cockeysville Formation Water Resource Protection Areas consist of: (1) areas that are directly underlain (outcrop) by the Cockeysville Formation, and (2) land surface areas which drain to the areas underlain by the Cockeysville Formation (Cockeysville Formation Drainage Area). The locations of the Cockeysville Formation were obtained from Plate 1 of a report prepared by the Delaware Geological Survey in 1991 titled "Summary Report, Geology and Hydrology of the Cockeysville Formation, New Castle County, Delaware." Areas draining to and across the Cockeysville Formation were derived from the U. S. Geological Survey 7.5 minute topographic quadrangle maps

These areas will be included in the Delaware SWAP for the delineation of community public water supply wells in New Castle County. They are consistent with the DNREC approach for the State with the exception of the wellhead area surrounding a well, which can be up to a 300 foot radius in New Castle County. Additionally, the Class C wellhead areas may be included in the State wellhead delineation work using ground water models. The State will also add the NTNC PWS wells and the TNCPWS wells to the mapped wellhead areas in New Castle County for inclusion in the SWAPP. A 150-foot radius wellhead area will be assigned to them unless the system-wide water use exceeds 50,000 gpd.

<INSERT Figure 2.B.4a, 2.B.4b, 2.B.4c New Castle County Groundwater WRPAs>


CHESTER COUNTY
NEW CASTLE COUNTY
PENNSYLVANIA
DELAWARE
Ardentown
Arden
Ardencroft
Bellefonte
Elsmere
Newport
Newark
New Castle
Match line: MAP 1
MAP 2
Source Watersheds
Watersheds upstream from Public Surface Water Intakes
Water Resource Protection Areas (WRPAs)
Cockeysville Formation WRPA
Outcrop
Wissahickon
Drainage Area
Wellhead WRPA
Class A WRPA
Class A WRPA - 150-foot Radius
Transient, Non-Community Wells (Restaurants, Stores, Hotels, Parks, etc.)
Non-Transient, Non-Community Wells (Schools, Daycare Centers, Office, Factory, etc.)
Class C WRPA
Surface Water WRPA
Reservoir Watershed
Flood Plains
Erosion Prone Slopes
Recharge WRPA
Recharge Areas
Water Resource Protection Areas
for
City of Newark
City of Wilmington
New Castle County
Delaware
1987, Revised 1993, 2001, 2006, 2011, and March 2012.
Draft - Map 1 of 3
UNIVERSITY OF DELAWARE
NEWARK



DEFINITIONS

[illegible]

EXISTING WELLHEAD PROTECTION WATER RESOURCE PROTECTION AREAS

[illegible]

VULNERABLE WATER RESOURCE PROTECTION AREAS

[illegible]

SURFACE WATER RESOURCE PROTECTION AREAS

[illegible]

RECHARGE WATER RESOURCE PROTECTION AREAS

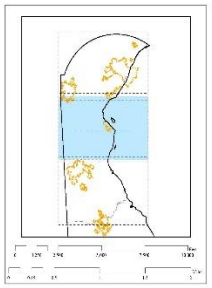
[illegible]

ACKNOWLEDGEMENTS

[illegible]

REFERENCES

[illegible]



Source Watersheds

Watersheds upstream from Public Surface Water Intakes

Water Resource Protection Areas (WRPAs)

Wellhead WRPA

- Class A WRPA
- Class A WRPA - 150-foot Radius
- Transient, Non-Community Wells (Restaurants, Stores, Hotels, Parks, etc.)
- Non-Transient, Non-Community Wells (Schools, Daycare Centers, Office, Factory, etc.)
- Class B WRPA
- Class C WRPA

Surface Water WRPA

- Reservoir Watershed
- Flood Plains
- Erosion Prone Slopes

Recharge WRPA

- Recharge Areas

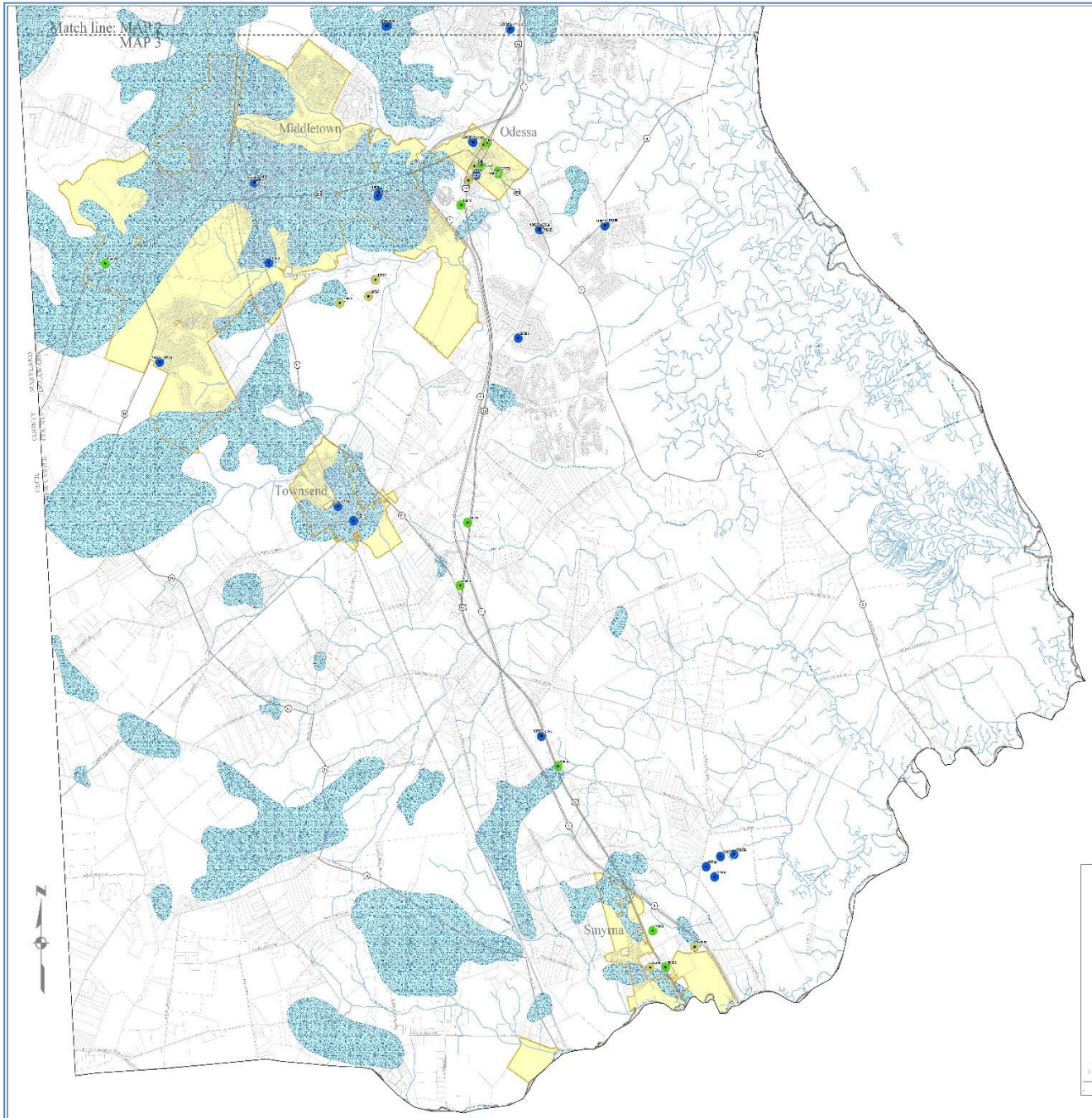
Water Resource Protection Areas for City of Newark City of Wilmington New Castle County Delaware

1987, Revised 1993, 2001, 2006, 2011, and March 2017

Map 2 of 3

UNIVERSITY OF DELAWARE

NEWARK



DEFINITIONS

[illegible]

COLLINSVILLE PORTSMOUTH WATERSHEDS PRIVILEDGE AREAS

[illegible]

WELLHEAD WATERSHEDS PRIVILEDGE AREAS

[illegible]

SURFACE WATERSHEDS PROTECTION AREAS

[illegible]

RECHARGE WATER RESOURCE PROTECTION AREAS

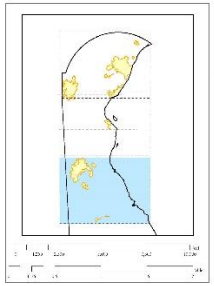
[illegible]

APPROVED REQUIREMENTS

[illegible]

REFERENCES

[illegible]



Source Watersheds

Watersheds upstream from Public Surface Water Intakes

Water Resource Protection Areas (WRPAs)

Wellhead WRPA

- Class A WRPA
- Class A WRPA - 150-foot Radius
- Transient, Non-Community Wells (Restaurants, Stores, Hotels, Parks, etc.)
- Non-Transient, Non-Community Wells (Schools, Daycare Centers, Office, Factory, etc.)

Recharge WRPA

- Recharge Areas

Water Resource Protection Areas for City of Newark City of Wilmington New Castle County Delaware

1987, Revised 1993, 2001, 2006, 2011, and March 2017

Map 3 of 3

UNIVERSITY OF DELAWARE

NEWARK

2.B.3 Delineation of Wells where Little Information is Known

There may be instances in the records of wells housed at the DNREC that the only known information about a well is its location and a total depth based upon word-of-mouth conversations with the well owner/operator. It is not uncommon for the SWAPP to run across these wells in the process of inspecting a water system since the DNREC did not begin formally issuing well permits until approximately 1971. Prior to then the Department has relied upon the records of the Delaware Geological Survey (DGS) or the Unites States Geological Survey (USGS) for information on wells – if such information exists.

In the case where little information is known about the well, the Department may use the Calculated Fixed Radius (CFR) method to determine the WHPA for a well or wells on a water system screened in the unconfined aquifer. The CFR method draws a circular protection area for a specified time-of-travel threshold (5-years). A simple volumetric flow equation is used to calculate the radius (Figure 2). Data required are 1) well pumping rate, 2) porosity of aquifer and 3) open or screened interval of the well. (If the actual screened interval is unknown, or if the well is constructed with an open interval at its base, a minimum value of 10 feet should be used.)

$$r = \sqrt{\frac{Q \cdot t}{\pi \cdot n \cdot H}}$$

where: r = calculated fixed wellhead radius

Q = pumping rate of well in ft^3/yr (provided well is pumping greater than 50,000 GPD)

n = aquifer porosity: typically 30% in Delaware (dimensionless)

H = *length of well screen/ thickness of unsaturated aquifer in ft*

t = time of travel in years (5 per DE SWAP)

This delineation method is easy to apply and relatively inexpensive, it requires a minimum level of technical expertise. Because of its simplicity it can be used as a delineation method for moderate and smaller systems. It could be used by many systems as a first cut method for identifying immediate threats to the water quality. The one drawback to the CFR method is that rarely does groundwater behave as simply as this method predicts.

2.B.4 Conjunctive Delineations (needs further discussion)

USEPA has described the need to consider situations where surface water is closely tied to ground water. Delineations that consider this situation have been termed "conjunctive delineations." This concept is particularly useful in instances where ground water is under the direct influence of surface water (GWUDI). **At this time, no GWUDI conditions have been**

recognized in Delaware for any public water supply systems; hence, no conjunctive delineations are warranted.

The U.S. EPA has strict criteria of what constitutes as GWUDI as it pertains to public drinking water systems. If through examination of water quality data a well has been determined to be under GWUDI conditions, the DNREC will take steps as part of its susceptibility determination to re-evaluate the vulnerability of the source and include the surrounding surface water drainage areas as part of the wellhead protection area delineation areas and contaminant source identification.