Maine Geological Survey: Recent and on-going water resources studies

1. National Groundwater Monitoring Network (NGWMN)
2. Statewide Recharge Model using a Soil Water Balance (SWB)
3. USGS Water Census and Water-Use Data and Research (WUDR)
4. Agriculture water use survey and irrigation demand model
National Groundwater Monitoring Network (NGWMN)

USGS Cooperative Agreement to improve the groundwater level network in Maine
Current Water Level Monitoring Wells

- The USGS maintains only 18 monitoring wells in Maine.
- 2018: MGS participation in the NGWMN program added 32 new wells at 22 sites.
- All new wells are at DEP monitored sites.
NGWMN Portal

cida.usgs.gov/ngwmn/

Available data:
• Water levels (10+ years)
• Location and elevation
• Lithology and well construction details
• …and more!
2019: Information gap filling for Maine’s NGWMN network

Information that is required or desired for the National network was missing from many well records

• Visited 29 wells at 21 sites
• Documented measuring points, access, and construction details
• Measured water levels, total depths, casing dimensions
• Collected survey-grade GPS coordinates:
  National network benefits from high-accuracy elevations in a consistent national datum (NAVD 88)
We will again visit the wells to perform a downhole camera survey:

- Record screen and casing details
- Assess the condition and function of wells
- Observe fracture patterns and lithology in bedrock
USGS Recharge Model using the Soil Water Balance (SWB)

Statewide gridded estimates of groundwater recharge have been released
Recharge model development

Martha Nielsen (USGS) has been working on this project since 2015:
• Selection of Soil Water Balance (SWB) model
• Pilot development and calibration
• Statewide development
• Calibration to gauged, unregulated river basins
• Monte Carlo uncertainty analysis

Calibration and Monte Carlo were run on the HTCondor parallel computer cluster at the USGS Wisconsin office
USGS Soil Water Balance (SWB) Model

• A climate-based water balance model for estimating potential groundwater recharge
• Statewide, grid-based calculations
• Calculates snowmelt, direct runoff, evapotranspiration, snow and soil moisture storage
• Calculates infiltration beyond root zone (potential recharge)
• Output is a 250-m grid of annual total potential recharge
Mass Balance Plot: 1992

**Temperature**

**Net Precip and Snowmelt**

**Soil moisture and snow storage**

**Actual ET**

**Recharge**
Mean annual potential recharge

250-m grid

Provisional Data
Uncertainty grid:
Standard Deviation of all Monte Carlo Runs

250-m grid

Provisional Data
Final datasets have been released:


Final report will be available online very soon.
Water-Use Data and Research (WUDR) program

Program to help states help the USGS – 5 year National Water Census
MGS is currently in the second of two USGS Cooperative Agreements
Water Use Data and Research (WUDR) Program

MGS projects funded by the USGS program:
• 2016: Development of our Water Use Workplan
• 2017-2018: Cooperative grant on agricultural water use
• 2019-2020: Cooperative grant on domestic water use
Agricultural water use survey and irrigation demand model

Part 1: Survey results have been published in MGS Circular 18-9
Part 2: Gridded estimates of irrigation water demand have been produced
Ag Part 1:

Survey response rate

<table>
<thead>
<tr>
<th>County</th>
<th>farms contacted</th>
<th>total survey responses</th>
<th>response rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Androscoggin &amp; Sagadahoc</td>
<td>212</td>
<td>54</td>
<td>25%</td>
</tr>
<tr>
<td>Aroostook</td>
<td>207</td>
<td>43</td>
<td>21%</td>
</tr>
<tr>
<td>Franklin</td>
<td>136</td>
<td>32</td>
<td>24%</td>
</tr>
<tr>
<td>Kennebec</td>
<td>160</td>
<td>59</td>
<td>37%</td>
</tr>
<tr>
<td>Penobscot</td>
<td>200</td>
<td>53</td>
<td>27%</td>
</tr>
<tr>
<td>Somerset</td>
<td>68</td>
<td>25</td>
<td>37%</td>
</tr>
<tr>
<td>Waldo</td>
<td>115</td>
<td>40</td>
<td>35%</td>
</tr>
<tr>
<td>Washington</td>
<td>203</td>
<td>8</td>
<td>4%</td>
</tr>
<tr>
<td>York</td>
<td>146</td>
<td>5</td>
<td>3%</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>1,447</strong></td>
<td><strong>319</strong></td>
<td><strong>22%</strong></td>
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</tbody>
</table>

Irrigated farms reporting

<table>
<thead>
<tr>
<th>County</th>
<th>USDA 2012 irrigated farms</th>
<th>farms reporting an irrigated crop</th>
<th>percent of USDA irrigated farms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Androscoggin &amp; Sagadahoc</td>
<td>158</td>
<td>26</td>
<td>16%</td>
</tr>
<tr>
<td>Aroostook</td>
<td>89</td>
<td>12</td>
<td>13%</td>
</tr>
<tr>
<td>Franklin</td>
<td>37</td>
<td>16</td>
<td>43%</td>
</tr>
<tr>
<td>Kennebec</td>
<td>90</td>
<td>13</td>
<td>14%</td>
</tr>
<tr>
<td>Penobscot</td>
<td>129</td>
<td>18</td>
<td>14%</td>
</tr>
<tr>
<td>Somerset</td>
<td>60</td>
<td>12</td>
<td>20%</td>
</tr>
<tr>
<td>Waldo</td>
<td>118</td>
<td>9</td>
<td>8%</td>
</tr>
<tr>
<td>Washington</td>
<td>75</td>
<td>6</td>
<td>8%</td>
</tr>
<tr>
<td>York</td>
<td>152</td>
<td>2</td>
<td>1%</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>908</strong></td>
<td><strong>114</strong></td>
<td><strong>13%</strong></td>
</tr>
</tbody>
</table>
Survey results

Figure 2. Total irrigated acres of each crop type reported by survey respondents, and area-weighted mean inches of water applied to each type of irrigated crop in all of 2016. Vertical axis scale is logarithmic.
Survey results

...and much more!
Ag Part 2: Irrigation Demand Model

- Uses the same underlying Soil Water Balance (SWB) Model code
  - Grid only defined in crop areas according to the USDA Cropland Data Layer
  - Additional module implementing the FAO-56 crop evapotranspiration method (Allen et al., 1998)
- Calibrated to both USDA Census of Ag (2013) and results of our ag survey (2016)
- Output consists of potential annual irrigation demand in inches
- Multiply the demand by the actual irrigated land area
### Irrigation water use estimates (Statewide)

Table A3. Statewide irrigation water application volume estimated in years 2013, 2016, and 2017, by crop type and in total. The estimated irrigated area of each crop in Maine is multiplied by the mean irrigation water demand depth from Table A1 to arrive at the total water volume for each crop.

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Alfalfa</td>
<td>1,261</td>
<td>0.0</td>
<td>0.4</td>
<td>1.8</td>
<td>62</td>
<td>1.5</td>
<td>50</td>
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<tr>
<td>Apples</td>
<td>490</td>
<td>5.8</td>
<td>77</td>
<td>16.8</td>
<td>223</td>
<td>13.0</td>
<td>173</td>
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<tr>
<td>Blueberries</td>
<td>28,095</td>
<td>7.0</td>
<td>5,324</td>
<td>8.3</td>
<td>6,351</td>
<td>8.1</td>
<td>6,189</td>
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<tr>
<td>Broccoli</td>
<td>3,600</td>
<td>3.8</td>
<td>374</td>
<td>3.6</td>
<td>351</td>
<td>5.2</td>
<td>504</td>
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<tr>
<td>Christmas Trees</td>
<td>298</td>
<td>0.2</td>
<td>2</td>
<td>1.3</td>
<td>10</td>
<td>1.6</td>
<td>13</td>
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</tr>
<tr>
<td>Corn</td>
<td>1,023</td>
<td>1.4</td>
<td>39</td>
<td>2.9</td>
<td>81</td>
<td>2.6</td>
<td>72</td>
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<tr>
<td>Cranberries</td>
<td>30</td>
<td>14.0</td>
<td>11</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
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<tr>
<td>Grains</td>
<td>1,388</td>
<td>0.4</td>
<td>16</td>
<td>0.9</td>
<td>32</td>
<td>3.9</td>
<td>146</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grass/Pasture</td>
<td>0</td>
<td>2.4</td>
<td>0</td>
<td>4.9</td>
<td>0</td>
<td>5.2</td>
<td>0</td>
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<td></td>
</tr>
<tr>
<td>Hay (Non Alfalfa)</td>
<td>0</td>
<td>7.4</td>
<td>0</td>
<td>12.8</td>
<td>0</td>
<td>10.9</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Misc Fruits and Veggies</td>
<td>369</td>
<td>9.6</td>
<td>97</td>
<td>12.4</td>
<td>125</td>
<td>13.7</td>
<td>137</td>
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<tr>
<td>Potatoes</td>
<td>9,438</td>
<td>4.7</td>
<td>1,206</td>
<td>5.3</td>
<td>1,355</td>
<td>7.8</td>
<td>2,008</td>
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<tr>
<td>Sod/Grass Seed</td>
<td>562</td>
<td>7.1</td>
<td>108</td>
<td>11.3</td>
<td>172</td>
<td>9.5</td>
<td>145</td>
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<tr>
<td>Soybeans</td>
<td>0</td>
<td>3.4</td>
<td>0</td>
<td>5.8</td>
<td>0</td>
<td>7.7</td>
<td>0</td>
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<tr>
<td>Sweet Corn</td>
<td>451</td>
<td>1.0</td>
<td>12</td>
<td>3.9</td>
<td>48</td>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>47,005</strong></td>
<td><strong>7,266</strong></td>
<td><strong>8,810</strong></td>
<td><strong>9,436</strong></td>
<td><strong>8,810</strong></td>
<td><strong>9,436</strong></td>
<td><strong>9,436</strong></td>
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</tr>
</tbody>
</table>
Domestic and public supply water use

Ongoing WUDR project, completion in late 2020
Ongoing domestic water use work

1. Automated programmatic method for compiling and analyzing data from public water utilities (collaboration with the Maine PUC).
3. Analyze patterns of use in billing data donated by a few water companies – develop per capita coefficients for domestic use.
Future work:
Watershed supply-and-demand analysis

• Will look at the balance between water supply (annual runoff) and demand (human use and minimum stream flows)
• The analysis will cover all 12-digit HUC watersheds in Maine
• A revision and update to the “watersheds-at-risk” analysis from 2006