Simulation of Groundwater Flow in the Edisto River Basin, South Carolina

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Groundwater Model Area

Model Area

EXPLANATION

GW Model Area Boundary
Grid Outline

Sources: Esri HERE, DeLorme, USGS, Intermap, increment P Corp. NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), MapmyIndia, & OpenStreetMap contributors and the GIS User Community.
Objectives

• 2015 calibrated groundwater flow model
• Add recent groundwater use data (2016-2020)
• Include recharge from Soil-Water Balance (SWB) Model (2016-2020)
• Use existing model to simulate a series of scenarios
New GW Water-Use Data

• Well and water-use data from SCDHEC database
  • 1900 – 2015 (original model)
  • 1983-2020 (updated well and water use)
• Recharge rates from Soil Water Balance model (2016 – 2020)
Primary inputs:
- Model Grid
- Hydrogeologic Framework
- Aquifer Properties
- Observation Data
- Boundaries
- Wells – Water Use Data

Primary Outputs:
- Groundwater Levels
- Budgets
Groundwater Simulations

**Predevelopment Conditions**
Remove withdrawals and simulate levels prior to GW development
- Recharge rates from SWB model
- Focused on Edisto Basin

**Historical Groundwater Conditions**
- Simulated groundwater conditions from 1900-2020
Groundwater Flow Model Limitations

- Based on limited data
- Simplification of the actual groundwater flow system
- Can limit the ability of the model to predict actual hydraulic conditions over time
- Accuracy and prediction capabilities of this model are affected by the finite-difference discretization, boundary conditions, hydraulic properties, and observations used in the model calibration
- Groundwater withdrawals simulated in the model underrepresent actual historical water use because pumping rates less than 3 million gallons per month are not required to be reported to the State agencies and, therefore, are unknown.
Groundwater Scenarios

Current groundwater use
• Constant pumping rates from 2021-2070 using average pumping rates derived from groundwater use from 2016-2020

Permitted groundwater use
• Constant pumping rates from 2021-2070 using fully permitted pumping rates

Business-as-usual water demand
• Projections from 2021-2070 based on assumption moderate population and economic growth

High water demand trend
• Projections from 2021-2070 based on assumption high population and economic growth
The SWB model requires orthogonal grids, Modflow grids are often rotated to better fit model domain.
**Notation description**

Example = **12:60** in **27**

- **12** is the value of the SWB cell (estimated recharge)
- **60** is the area of SWB grid cell that intersects with a given Modflow cell (in map units)
- **27** is the Modflow cell ID

This calculation was done on a cell-by-cell basis for each cell in the Modflow domain so that all Modflow cells had area weighted average SWB recharge values assigned.
Provisional – All data is considered provisional and subject to revision.
Recharge: pre-development - 2020

Provisional – All data is considered provisional and subject to revision.
Recharge: 2021 - 2070

Provisional – All data is considered provisional and subject to revision.
Hydrogeologic Framework

Generalized hydrogeologic framework of South Carolina along dip.

EXPLANATION

Staed Pond aquifer, Upper Three Runs aquifer, surficial aquifer, Upper Floridan aquifer, Middle Floridan aquifer, Upper Floridan confining unit, Middle Floridan confining unit, McQueen Branch aquifer, Crouch Branch aquifer, Gordon aquifer, Gordon confining unit, Charleston aquifer, Charleston confining unit, McQueen Branch confining unit, Charleston confining unit, McQueen Branch confining unit, Charleston confining unit, McQueen Branch confining unit, Charleston confining unit.

Middle Floridan, Upper Floridan, and surficial aquifers projected updip in this report.
Groundwater use in model

WEL package - 3,079 wells

Multi-node well package (MNW2) – 700 wells

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Simulated pumping – Predevelopment - 2020

Provisional – All data is considered provisional and subject to revision.
Simulated pumping – Current Scenario model

- Crouch Branch (52 MGD)
- McQueen Branch (14 MGD)
- Gordon (7.4 MGD)

Provisional – All data is considered provisional and subject to revision.
Simulated pumping – Permitted Scenario model

Provisional – All data is considered provisional and subject to revision.
GW use in Gordon aquifer (model layer 7)

South Carolina - 330 wells

Edisto Basin – 113 wells

Provisional – All data is considered provisional and subject to revision.
GW use in Crouch Branch aquifer (model layer 9)

South Carolina – 1,128 wells

Edisto Basin – 493 wells

Provisional – All data is considered provisional and subject to revision.
GW use in McQueen Branch aquifer (model layer 11)

South Carolina – 648 wells

Edisto Basin – 97 wells

Provisional – All data is considered provisional and subject to revision.
GW use in the Multi-Node Well package (MNW2)

South Carolina – 700 wells

Edisto Basin – 91 wells

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Current Scenario - Gordon aquifer (model layer 7)

2020 (6.7 MGD) 2070 (7.4 MGD)

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Permitted Scenario - Gordon aquifer (model layer 7)

2020 (6.7 MGD)  
2070 (13 MGD)

Provisional – All data is considered provisional and subject to revision.
Drawdown Permitted Scenario - Gordon aquifer (model layer 7)

2020-2070

Provisional – All data is considered provisional and subject to revision.
Current Scenario – Crouch Branch aquifer (model layer 9)

2020 (40 MGD)  
2070 (52 MGD)

Provisional – All data is considered provisional and subject to revision.
Drawdown Current Scenario – Crouch Branch aquifer (model layer 9)

2020-2070

Provisional – All data is considered provisional and subject to revision.
Permitted Scenario – Crouch Branch aquifer (model layer 9)

2020 (40 MGD) 2070 (83 MGD)

Provisional – All data is considered provisional and subject to revision.
Drawdown Permitted Scenario – Crouch Branch aquifer (model layer 9)

2020-2070

Provisional – All data is considered provisional and subject to revision.
Current Scenario – McQueen Branch aquifer (model layer 11)

2020 (10 MGD) 2070 (14 MGD)

Provisional – All data is considered provisional and subject to revision.
Drawdown Current Scenario – McQueen Branch aquifer (model layer 11)

2020-2070

Provisional – All data is considered provisional and subject to revision.
Permitted Scenario – McQueen Branch aquifer (model layer 11)

2020 (10 MGD) 2070 (22 MGD)

Provisional – All data is considered provisional and subject to revision.
Drawdown Permitted Scenario – McQueen Branch aquifer (model layer 11)

2020-2070

Provisional – All data is considered provisional and subject to revision.
Simulated water levels in the Gordon aquifer

Provisional – All data is considered provisional and subject to revision.
Simulated water levels in the Crouch Branch aquifer

Provisional – All data is considered provisional and subject to revision.
Simulated water levels in the McQueen Branch aquifer

Provisional – All data is considered provisional and subject to revision.
Simulated 2020 water budget in the Surficial aquifer

2020 - Edisto Basin

2,023 (Inflow from recharge) 0.12 (Discharge to wells) 1,289 (Outflow to streams)

155 (Inflow) 77 816 (Outflow)

Surficial aquifer (Layer 1)

Upper Floridan confining unit (Layer 2)

EXPLANATION

Groundwater-flow direction and rate, in millions of gallons per day

Provisional – All data is considered provisional and subject to revision.
Simulated 2070 water budget in the Surficial aquifer (Current Scenario)

2070 - Edisto Basin

405 (Inflow from recharge) 0.13 (Discharge to wells) 1,149 (Outflow to streams)

994 (Inflow) Surficial aquifer (Layer 1) 160 (Outflow)

162 Upper Floridan confining unit (Layer 2) 72

EXPLANATION

Groundwater-flow direction and rate, in millions of gallons per day

Provisional – All data is considered provisional and subject to revision.
Simulated 2070 water budget in the Surficial aquifer (Permitted Scenario)

**2070 - Edisto Basin**

- 405 (Inflow from recharge)
- 0.44 (Discharge to wells)
- 1,138 (Outflow to streams)
- 1,018 (Inflow)
- 159 (Outflow)
- 189
- 63

Surficial aquifer (Layer 1)

Upper Floridan confining unit (Layer 2)

**EXPLANATION**

Groundwater-flow direction and rate, in millions of gallons per day

Provisional – All data is considered provisional and subject to revision.
Simulated 2020 water budget in the Gordon aquifer

Provisional – All data is considered provisional and subject to revision.
Simulated 2070 water budget in the Gordon aquifer (Current Scenario)

EXPLANATION

Groundwater-flow direction and rate, in millions of gallons per day

Provisional – All data is considered provisional and subject to revision.
Simulated 2070 water budget in the Gordon aquifer (Permitted Scenario)

EXPLANATION
Groundwater-flow direction and rate, in millions of gallons per day

Provisional – All data is considered provisional and subject to revision.
Simulated 2020 water budget in the Crouch Branch aquifer

**EXPLANATION**

Groundwater-flow direction and rate, in millions of gallons per day

Provisional – All data is considered provisional and subject to revision.
Simulated 2070 water budget in the Crouch Branch aquifer (Current Scenario)

2070 - Edisto Basin

Crouch Branch confining unit (Layer 8)

102

14 (Inflow)

Crouch Branch aquifer (Layer 9)

20 (Outflow)

29

17

McQueen Branch confining unit (Layer 10)

1.6

52 (Discharge to wells)

EXPLANATION

Groundwater-flow direction and rate, in millions of gallons per day

Provisional – All data is considered provisional and subject to revision.
Simulated 2070 water budget in the Crouch Branch aquifer (Permitted Scenario)

2070 - Edisto Basin

- Crouch Branch confining unit (Layer 8)
  - Inflow: 129
  - Outflow: 25

- Crouch Branch aquifer (Layer 9)
  - Inflow: 20
  - Outflow: 21
  - Discharge to wells: 83

- McQueen Branch confining unit (Layer 10)
  - Inflow: 21
  - Outflow: 1.8

Explanation:
Groundwater-flow direction and rate, in millions of gallons per day

Provisional – All data is considered provisional and subject to revision.
Simulated 2020 water budget in the McQueen Branch aquifer

**EXPLANATION**

Groundwater-flow direction and rate, in millions of gallons per day

Provisional – All data is considered provisional and subject to revision.
Simulated 2070 water budget in the McQueen Branch aquifer (Current Scenario)

EXPLANATION

Groundwater-flow direction and rate, in millions of gallons per day

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Simulated 2070 water budget in the McQueen Branch aquifer (Permitted Scenario)

2070 - Edisto Basin

- McQueen Branch confining unit (Layer 10)
  - 1.7
- McQueen Branch aquifer (Layer 11)
  - 21
- Charleston confining unit (Layer 12)
  - 2.1

EXPLANATION

Groundwater-flow direction and rate, in millions of gallons per day

- 2.1
- 22 (Discharge to wells)
- 9.7 (Outflow)

Provisional – All data is considered provisional and subject to revision.
Flow budget in the Edisto Basin
Surficial aquifer (in MGD)

<table>
<thead>
<tr>
<th></th>
<th>2020</th>
<th>2070</th>
<th>2070</th>
<th>2070</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Current</td>
<td>Permitted</td>
<td>Difference</td>
<td></td>
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<tr>
<td>Recharge</td>
<td>2,023</td>
<td>405</td>
<td>405</td>
<td>0.0</td>
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<tr>
<td>Outflow to streams</td>
<td>-1,289</td>
<td>-1,149</td>
<td>-1,138</td>
<td>11</td>
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<tr>
<td>Discharge to wells</td>
<td>-0.1</td>
<td>-0.1</td>
<td>-0.4</td>
<td>-0.3</td>
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<tr>
<td>Lateral inflow</td>
<td>156</td>
<td>994</td>
<td>1,018</td>
<td>24</td>
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<tr>
<td>Lateral outflow</td>
<td>-815</td>
<td>-160</td>
<td>-159</td>
<td>1.0</td>
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<tr>
<td>Vertical inflow</td>
<td>77</td>
<td>72</td>
<td>63</td>
<td>-9.0</td>
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<tr>
<td>Vertical outflow</td>
<td>-151</td>
<td>-162</td>
<td>-189</td>
<td>-27</td>
</tr>
</tbody>
</table>

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Flow budget in the Edisto Basin
Gordon aquifer (in MGD)

<table>
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<tr>
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<th>2070 Current</th>
<th>2070 Permitted</th>
<th>2070 Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discharge to wells</td>
<td>-6.7</td>
<td>-7.4</td>
<td>-13</td>
<td>-5.6</td>
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<tr>
<td>Lateral inflow</td>
<td>4.3</td>
<td>4.4</td>
<td>4.7</td>
<td>0.3</td>
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<tr>
<td>Lateral outflow</td>
<td>-8.9</td>
<td>-8.9</td>
<td>-9.4</td>
<td>-0.5</td>
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<tr>
<td>Vertical inflow</td>
<td>152</td>
<td>162</td>
<td>188</td>
<td>26</td>
</tr>
<tr>
<td>Vertical outflow</td>
<td>-141</td>
<td>-150</td>
<td>-171</td>
<td>-21</td>
</tr>
</tbody>
</table>

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Flow budget in the Edisto Basin
Crouch Branch aquifer (in MGD)

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<tr>
<td></td>
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<td>Current</td>
<td>Permitted</td>
<td>Difference</td>
</tr>
<tr>
<td>Discharge to wells</td>
<td>-40</td>
<td>-52</td>
<td>-83</td>
<td>-31</td>
</tr>
<tr>
<td>Lateral inflow</td>
<td>15</td>
<td>14</td>
<td>20</td>
<td>6.2</td>
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<tr>
<td>Lateral outflow</td>
<td>-21</td>
<td>-20</td>
<td>-21</td>
<td>-1.0</td>
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<tr>
<td>Vertical inflow</td>
<td>91</td>
<td>104</td>
<td>131</td>
<td>27</td>
</tr>
<tr>
<td>Vertical outflow</td>
<td>-45</td>
<td>-46</td>
<td>-46</td>
<td>0</td>
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Flow budget in the Edisto Basin
McQueen Branch aquifer (in MGD)

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<tr>
<td>Discharge to wells</td>
<td>-10</td>
<td>-14</td>
<td>-22</td>
<td>-8.0</td>
</tr>
<tr>
<td>Lateral inflow</td>
<td>7.0</td>
<td>9.1</td>
<td>13</td>
<td>3.9</td>
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<tr>
<td>Lateral outflow</td>
<td>-10</td>
<td>-9.9</td>
<td>-9.7</td>
<td>0.2</td>
</tr>
<tr>
<td>Vertical inflow</td>
<td>17</td>
<td>18</td>
<td>24</td>
<td>5.2</td>
</tr>
<tr>
<td>Vertical outflow</td>
<td>-3.3</td>
<td>-3.3</td>
<td>-3.8</td>
<td>-0.5</td>
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Groundwater Scenarios

**Current groundwater use**
- Constant pumping rates from 2021-2070 using average pumping rates derived from groundwater use from 2015-2019

**Permitted groundwater use**
- Constant pumping rates from 2021-2070 using fully permitted pumping rates

**Business-as-usual water demand**
- Projections from 2021-2070 based on assumption moderate population and economic growth

**High water demand trend**
- Projections from 2021-2070 based on assumption high population and economic growth

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Summary

- Simulated recharge rates were estimated with the SWB model output. Rates varied from 0.09 to 1.22 feet per year.
- Simulated pumping for 2021 to 2070 was 75.3 and 121.2 MGD for the Current and Permitted Scenarios, respectively.
- The number of simulated wells in the SC aquifers: Gordon (330), Crouch Branch (1,128), and McQueen Branch (648), and 700 wells in the multi-node package.
- The number of simulated wells in the SC aquifers for the Edisto Basin: Gordon (113), Crouch Branch (493), and McQueen Branch (97), and 91 wells in the multi-node package.
• Maximum drawdowns over 10, 50, and 75 feet are seen in the Gordon, Crouch Branch, and McQueen Branch aquifers for the Current Scenario in the Edisto Basin.

• Maximum drawdowns over 75, 150, and 100 feet are seen in the Gordon, Crouch Branch, and McQueen Branch aquifers for the Permitted Scenario in the Edisto Basin.

• Simulated results indicate possible declines below the top of the aquifer for the Current and Permitted Scenarios in the McQueen Branch aquifer (Lexington County) and in the Permitted Scenario for the Crouch Branch aquifer (Calhoun and Orangeburg Counties).
Summary - continued

• The largest flow budget components are recharge and outflow to streams within the surficial aquifer.
• Vertical and lateral inflow into the aquifers likely provides the water needed due to the increased pumping simulated in the Permitted Scenario.
Questions?

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