Eastern Shore Groundwater 2017 Progress

1. A-N PDC well-logging program
   - third logging run
   - log-analysis advances

2. DEQ-funded study
   - hydrogeologic framework
   - paleochannels
   - salinity
   - 2017-2019
Groundwater Flow

PRECIPITATION

LAND SURFACE

CHESAPEAKE BAY

WATER TABLE

FRESH

SALTY

ATLANTIC OCEAN

*** VERTICAL SCALE GREATLY EXAGGERATED ***
Pumping-Induced Saltwater Movement

*** VERTICAL SCALE GREATLY EXAGGERATED ***
2016 Confined Groundwater Levels
2016
Confined
Groundwater Levels
2016 Confined Groundwater Levels

PUMPING CENTERS

TOTAL WITHDRAWAL 2003-15 (MGAL)
- < 100
- 100 - 1,000
- 1,000 - 10,000
- 10,000 - 20,000
- > 20,000

BELOW SEA LEVEL
Saltwater Position

PREDEVELOPMENT

POT. SURFACE

EQUILIBRUM POSITION

BAY

AQUIFER TOP

FRESH

SALTY

OCEAN
Saltwater Position

Predevelopment

Equilibrium Position

Drawdown Above Sea Level

New Equilibrium Position

New Equilibrium Position
Saltwater Position

PREDEVELOPMENT

POT. SURFACE

EQUILIBIRUM POSITION

FRESH

SALTY

AQUIFER TOP

DYKEDOWN ABOVE SEA LEVEL

DRAWDOWN BELOW SEA LEVEL

UPCONING NEW EQUILIBIRUM POSITION

INTRUSION

UPCONING
Saltwater Position

PREDEVELOPMENT

DRAWDOWN ABOVE SEA LEVEL

DRAWDOWN BELOW SEA LEVEL

NEW EQUILIBIRUM POSITION

UPCONING

INLAND INTRUSION
Potential Inland Intrusion

BELOW SEA LEVEL
Eastern Shore Groundwater 2017 Progress

1. A-N PDC well-logging program
   - third logging run
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   - salinity
   - 2017-2019
Well-Log Monitoring

LAND SURFACE

ELECTRICAL CONDUCTIVITY

WELL SCREEN

PROBE

"SEES OUT"

TIME 1

TIME 2

TIME 3
**Well-Log Monitoring**

**LAND SURFACE**  
**WELL**  
**PROBE**  
**SCREEN**  

**INCREASING SALINITY**  
**DECREASING SALINITY**

"SEES OUT"

**ELECTRICAL CONDUCTIVITY**

TIME 1  
TIME 2  
TIME 3
Well-Logging Network

- 12 USGS-DEQ observations wells
- sampled 2003
- logged 2008, 2016, 2017
Well 66K 2 Baylys Neck

LOG

CONDUCTIVITY MMOHs/M

2008
2016
2017

WELL SCREEN

2003 CHLORIDE 96 mg/L

DIFFERENCE BETWEEN LOGS

CONDUCTIVITY DIFFERENCE MMOHs/M

2016-17
2008-16
Log Analysis Advances

USGS Open-File Report 2016-1194
South Florida Well Logging

UNADJUSTED LOGS
South Florida Well Logging

UNADJUSTED LOGS

ADJUSTED LOGS

18-YEAR RECORD

1996

2014
**Well 66K 2 Baylys Neck**

**LOG**

- Conductivity MMOHS/M

**DIFFERENCE BETWEEN LOGS**

- Conductivity Difference MMOHS/M
  - 2008-16
  - 2016-17

**WATER LEVELS**

- Depth to water level, feet below land surface
  - Period of approved data
  - Period of provisional data
  - Sea level
  - 2008
  - 2016
  - 2017

**Map**

- Location of Well 66K 2 Baylys Neck

**2003 CHLORIDE**

- 96 mg/L
Water Levels
High Recharge or Low Withdrawal

Precipitation

Chesapeake Bay

Fresh

Depress

Salty

Atlantic Ocean
Low Recharge or High Withdrawal

PRECIPITATION

CHESAPEAKE BAY

SALTY

FRESH

ATLANTIC OCEAN

SALTY

DROP

RISE
Water Levels and Salinity

Water Levels and Salinity over a 1-year period.
Shallow Effects

*** VERTICAL SCALE GREATLY EXaggerated ***
Well 63J 3 Concord Wharf

**LOG**

- **2003 CHLORIDE**: 14 mg/L (WELL 63J 1)
- **1987 CHLORIDE**: 6200 mg/L

**DIFFERENCE BETWEEN LOGS**

- **2008-16**
- **2016-17**

**WATER LEVELS**

- Depth to water level, feet below land surface
- SEA LEVEL
- **2008**, **2016**, **2017**

- Period of approved data
- Period of provisional data

- Well location on map
Well 64K 7 Hacks Neck

---

**LOG**

- Conductivity in mohs/m
- 2008: Red line
- 2016: Black line
- 2017: Gray line

**DIFFERENCE BETWEEN LOGS**

- 2016-17: +80 mg/L chloride
- 2008-16: +520 mg/L chloride

**WATER LEVELS**

- Sea level
- Depth to water level, feet below land surface
- Period of approved data
- Period of provisional data

---

2003 CHLORIDE: 393 mg/L

2008: estim. +520 mg/L chloride

2016: +80 mg/L chloride

2017: +80 mg/L chloride

2016: +80 mg/L chloride

2017: +80 mg/L chloride

USGS 3738450/5922581 64K 7 S0H 106C
**Well 66M 18 Withams**

**LOG**

**DIFFERENCE BETWEEN LOGS**

2016-17
estim. -10 mg/L chloride
estim. +30 mg/L chloride

2008-16
estim. -30 mg/L chloride
estim. -40 mg/L chloride

**WELL SCREEN**

2003 CHLORIDE 741 mg/L

**SEA LEVEL**

- Depth to water level, feet below land surface
- Green: Period of approved data
- Pink: Period of provisional data

- 2008
- 2016
- 2017

**MAP**

- Location of well 66M 18 Withams
Well 62G 15 Bay Creek Resort

**LOG**

<table>
<thead>
<tr>
<th>Conductivity (mM/m)</th>
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<tbody>
<tr>
<td>2008</td>
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<tr>
<td>2016</td>
</tr>
<tr>
<td>2017</td>
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</tbody>
</table>

**DIFFERENCE BETWEEN LOGS**

- **2003 CHLORIDE:** 165 mg/L
- **2008**
  - 20 mg/L chloride (estim.)
  - 40 mg/L chloride (estim.)
- **2016-17**
  - 30 mg/L chloride (estim.)
  - 20 mg/L chloride (estim.)
- **2017**
  - Sea level

**Graphs and Data**

- USGS 371549076083481 626 15 SW 121
- Depth to water level, feet below land
- Period of approved data
- Period of provisional data
Well 63G 15 Oyster

LOG

CONDUCTIVITY MMOHS/M

0 10 20 30 40 50 60 70 80 90 100

-20 -15 -10 -5 0 5 10 15 20

2008 2016 2017

2003 CHLORIDE 128 mg/L

DIFFERENCE BETWEEN LOGS

CONDUCTIVITY DIFFERENCE MMOHS/M

2008-16 estim. -30 mg/L chloride

2016-17

WATER LEVELS

USGS 37176807/55608001 63G 15 OY 10-4C

Depth to water level, feet below land surface

2008 2016 2017

Period of approved data Period of provisional data

Groundwater level above NGVD 1929, feet
Well 64J 11 Willis Wharf

**LOG**

<table>
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<td>2016</td>
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<tr>
<td>2017</td>
</tr>
</tbody>
</table>

**DIFFERENCE BETWEEN LOGS**

- 2016-17 estim. -50 mg/L chloride
- 2008-16 estim. +80 mg/L chloride

**WATER LEVELS**

- Depth to water levels, feet below land surface
- Period of approved data
- Period of provisional data

- 2003 CHLORIDE 1550 mg/L

- WELL SCREEN
- 2003 CHLORIDE 1550 mg/L
Well 67M 14 NASA WFF

LOG

CONDUCTIVITY MMOHS/M

WELL SCREEN

2003 CHLORIDE
144 mg/L

DIFFERENCE BETWEEN LOGS

CONDUCTIVITY DIFFERENCE MMOHS/M

2008-16

2016-17

estim.
+50 mg/L chloride

WATER LEVELS

SEA LEVEL

Depth to water level, feet below land

Period of approved data
Period of provisional data

USGS 3756170752793781 67M 14 SUW 115E


Groundwater level above NGVD 1929, feet

2008 2016 2017

8

-25

-30

-35

-40

-45

-50

-55

-60
Well 65K 23 Bayside

2003 CHLORIDE: 16 mg/L (WELL 65K 25)
1988 CHLORIDE: 800 mg/L (WELL 65K 25)
2003 CHLORIDE: 12 mg/L (WELL 65K 26)

2008-16
2016-17

WELL SCREEN

DEPTH TO WATER LEVEL, FETT BELOW LAND SURFACE

Period of approved data
Period of provisional data
Well 63F 16 Cape Center

LOG

Ddifference
BETWEEN LOGS

WATER LEVELS

2008-16
estim.
-30 mg/L
chloride

2016-17
estim.
-10 mg/L
chloride

2008
2016
2017
estim.
+10 mg/L
chloride

2003 CHLORIDE
79 mg/L

2017
2016

Depth in water levels, feet below land surface

Period of approved data
Period of provisional data
Well 66L 1 Chesser Road

LOG

DIFFERENCE BETWEEN LOGS

WATER LEVELS

CONDUCTIVITY MMOHS/M

CONDUCTIVITY DIFFERENCE MMOHS/M

2003 CHLORIDE 13 mg/L

2008-16 2016-17

WELL SCREEN

2008

2016

2017

SEA LEVEL

2008

2016

2017

Period of approved data
Period of provisional data
Well 63G 24 Cheriton

LOG

DIFFERENCE BETWEEN LOGS

WATER LEVELS

2003 CHLORIDE 625 mg/L
WELL SCREEN

2016-17 estim. -20 mg/L chloride

2008-16 estim. +30 mg/L chloride

2017

2008

2016

SEA LEVEL

Depth to water level, feet below land surface

Period of approved data
Period of provisional data
Differences Between Logs

- 2008-16
- 2016-17
- BELOW SEA LEVEL
2017 Findings

1. Analysis includes adjustment of baseline among logs run at different times

2. Six wells showing small conductivity changes in unconfined aquifer

3. Six wells showing small conductivity changes in confined aquifer

4. Uncertain baseline in four wells

5. Six wells in areas of potential inland intrusion