WATER TODAY. WATER TOMORROW.
Providing the sound science and support for managing Nebraska’s most precious resource.

WATER SCIENCE:
STREAM AND AQUIFER DEPLETION

JESSE BRADLEY, P.G., NATURAL RESOURCES PROGRAMS DIRECTOR
Nebraska Department of Natural Resources
Overview

Stream and Aquifer Depletion
- The effects of well location on stream depletion
- Review of well depletion zones
- Wells in the Republican Basin through time
- Stream depletion
- Aquifer depletion
WELL LOCATION AND
STREAM DEPLETION
Terminology:

**Cone of Depression/Hydraulic Gradient**

- As a well begins to pump water from an aquifer:
  - Groundwater levels around the well decline, creating a cone of depression in the water levels around the well.
  - A hydraulic gradient is now present between the normal water table and the aquifer around the well.

- The hydraulic gradient established within the cone of depression forces water to move from the aquifer into the well.
### Effects of Well Location on the Rate of Stream Depletion

<table>
<thead>
<tr>
<th></th>
<th>Well A</th>
<th>Well B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proximity to stream</td>
<td>Farther</td>
<td>Closer</td>
</tr>
<tr>
<td>When cone of depression reaches stream</td>
<td>Later</td>
<td>Sooner</td>
</tr>
<tr>
<td>Length of time groundwater storage is a source of water to the well</td>
<td>Longer</td>
<td>Shorter</td>
</tr>
<tr>
<td>Streamflow depletion becomes primary source of water</td>
<td>Later</td>
<td>Sooner</td>
</tr>
</tbody>
</table>

- **A**
  - When pumping starts:
  - After 10 years of pumping:
  - After 50 years of pumping:

- **B**
  - Streamflow depletion, as fraction of pumping rate
  - Time, in years

---

*Source: Department of Natural Resources*
Questions?
REVIEW OF WELL DEPLETION ZONES
Republican River Basin
Generalized Well Depletion Zones

Well Depletion Zones
- Groundwater
- Transitional
- Stream

Created by NDNR, alz
Updated December 1, 2015, emj
Digitized at a scale of 1:750,000.
Questions?
WELLS IN THE REPUBLICAN BASIN THROUGH TIME
1940 Republican River Model Area Wells
1955 Republican River Model Area Wells
1970 Republican River Model Area Wells
1985 Republican River Model Area Wells
2000 Republican River Model Area Wells
2015 Republican River Model Area Wells
Questions?
STREAM DEPLETION
Stream Depletions by Well Depletion Zone

Stream Depletion (acre-feet)

Year

1900 1920 1940 1960 1980 2000 2020

Stream Zone

Transitional Zone

Groundwater Zone
Impacts above Reservoirs Serving Frenchman Cambridge Irrigation District

Impacts 1950-1964 compared to 2000-2012

- Runoff Reduction
- Nebraska Stream Zone
- Nebraska Transitional Zone
- Nebraska Groundwater Zone, net*
- Kansas Pumping
- Colorado Pumping

*Net = Pumping impact minus imported water
Impacts to Frenchman Creek Subbasin

Impacts, 1950-1964 compared to 2000-2012

- Runoff Reduction
- Nebraska Stream Zone
- Nebraska Transitional Zone
- Nebraska Groundwater Zone, net*

*Net = Pumping impact minus imported water
Impacts to Mainstem, Swanson to Harlan

Impacts, 1950-1964 compared to 2000-2012

Stream Depletion (acre-feet)

- Runoff Reduction
- Nebraska Stream Zone
- Nebraska Transitional Zone
- Nebraska Groundwater Zone, net*
- Kansas Pumping
- Colorado Pumping

*Net = Pumping impact minus imported water
Above Harlan County Lake

Legend
- Republican Basin (NE)
- Other States
- NRD
- County
- Lake
- Stream
- Subbasins of Interest
Total Impacts above Harlan County Lake

Impacts, 1950-1964 compared to 2000-2012

<table>
<thead>
<tr>
<th>Stream Depletion (acre-feet)</th>
<th>Runoff Reduction</th>
<th>Nebraska Stream Zone</th>
<th>Nebraska Transitional Zone</th>
<th>Nebraska Groundwater Zone, net*</th>
</tr>
</thead>
<tbody>
<tr>
<td>180,000</td>
<td>160,000</td>
<td>140,000</td>
<td>120,000</td>
<td>100,000</td>
</tr>
<tr>
<td>160,000</td>
<td>140,000</td>
<td>120,000</td>
<td>100,000</td>
<td>80,000</td>
</tr>
<tr>
<td>140,000</td>
<td>120,000</td>
<td>100,000</td>
<td>80,000</td>
<td>60,000</td>
</tr>
<tr>
<td>120,000</td>
<td>100,000</td>
<td>80,000</td>
<td>60,000</td>
<td>40,000</td>
</tr>
<tr>
<td>100,000</td>
<td>80,000</td>
<td>60,000</td>
<td>40,000</td>
<td>20,000</td>
</tr>
<tr>
<td>80,000</td>
<td>60,000</td>
<td>40,000</td>
<td>20,000</td>
<td>0</td>
</tr>
<tr>
<td>60,000</td>
<td>40,000</td>
<td>20,000</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>40,000</td>
<td>20,000</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>20,000</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

*Net = Pumping impact minus imported water
Total Impacts above Harlan County Lake

Impacts, 1950-1964 compared to 2000-2012

Stream Depletion (acre-feet)

-20,000 0 20,000 40,000 60,000 80,000 100,000 120,000 140,000 160,000 180,000

Runoff Reduction
URNRD
MRNRD
LRNRD
TBNRD/Other, Net*

Kansas Pumping
Colorado Pumping

*Net = Pumping impact minus imported water

Department of Natural Resources
Questions?
AQUIFER DEPLETION
Aquifer Volume by Subbasin

- Frenchman-Cambridge Irrigation District Subbasins
- Frenchman Creek Subbasin
- Swanson to Harlan Area

Aquifer Volume (acre-feet)

Decade

1910s 1930s 1950s 1970s 1990s 2010s
Percent Change Since 1917 by Subbasin

- Frenchman-Cambridge Irrigation District Subbasins
- Frenchman Creek Subbasin
- Swanson to Harlan Area

Decade: 1910s, 1920s, 1930s, 1940s, 1950s, 1960s, 1970s, 1980s, 1990s, 2000s, 2010s

Percent change in aquifer volume since 1917

Department of Natural Resources
Percent Change Since 1917
by Subbasin

- Total above Harlan County Lake
- Frenchman-Cambridge Irrigation District Subbasins
- Frenchman Creek Subbasin
- Swanson to Harlan Area

Decade

1910s 1920s 1930s 1940s 1950s 1960s 1970s 1980s 1990s 2000s 2010s

Percent change in aquifer volume since 1917

-10 -8 -6 -4 -2 0 2 4
Actual Aquifer Storage by Depletion Zone

Total Aquifer Storage (acre-feet)

- Groundwater Zone
- Transitional Zone
- Stream Zone
Projection* of Storage Reduction by Depletion Zone

*Trends are projected 1000 years (power function) based 1970–2015 data
Questions?
WATER TODAY. WATER TOMORROW.
Providing the sound science and support for managing Nebraska’s most precious resource.

THANK YOU

JESSE BRADLEY, P.G., NATURAL RESOURCES PROGRAMS DIRECTOR
Nebraska Department of Natural Resources
402-471-2363
dnr.nebraska.gov  f  t