

Lake Barney Stormwater & Flood Mitigation Concepts



Presentation to Fitchburg Committee of the Whole

September 23, 2020

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w a t e r | e c o l o g y | c o m m u n i t y

1. Project Team
2. Area History & Project Goals
3. Background Concepts
 - Groundwater Concepts, Closed Depression Hydrology
4. Concept Solutions
5. Process for Conducting the Cost-Benefit Analysis
6. Next Steps
 1. Provide Common Council with Cost-benefit analysis
 2. Common Council to determine “go” or “no-go” on the project

Project Team



Water resources engineering consultants (Cottage Grove) with expertise in stormwater and groundwater-surface water interactions



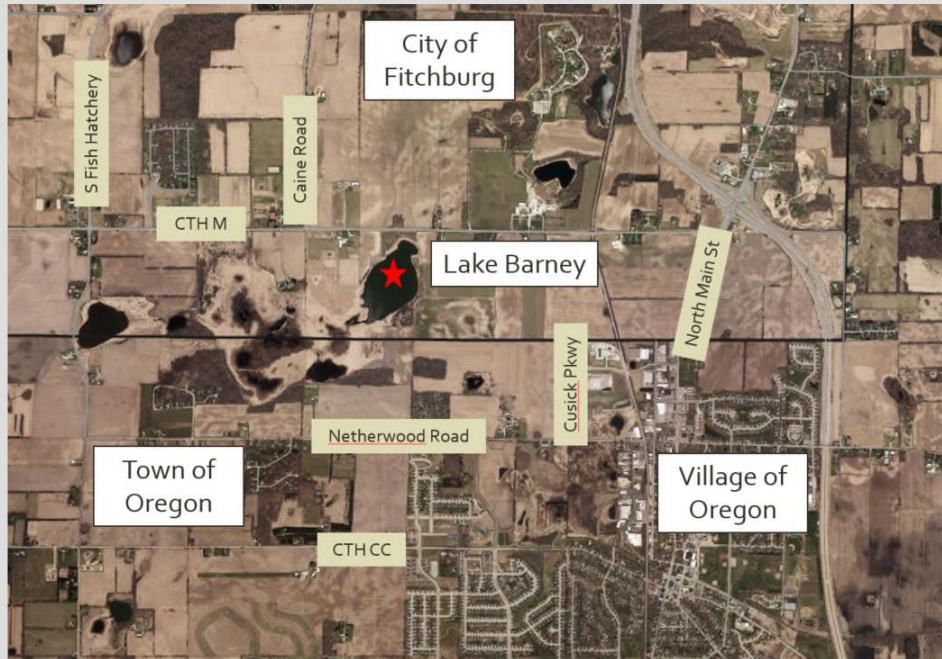
Ecological consultants (Mt. Horeb) specializing in assessing, mapping and restoring wetlands

Additional input, guidance, and support from a large stakeholder group including impacted parties, the Village of Oregon, Dane County, WDNR, and landowner representatives.

Area History and Project Goals

Area History

Lake Barney is part of a group of glacial kettles (including Swan Pond) and does not have a surface water outflow under “normal” conditions.

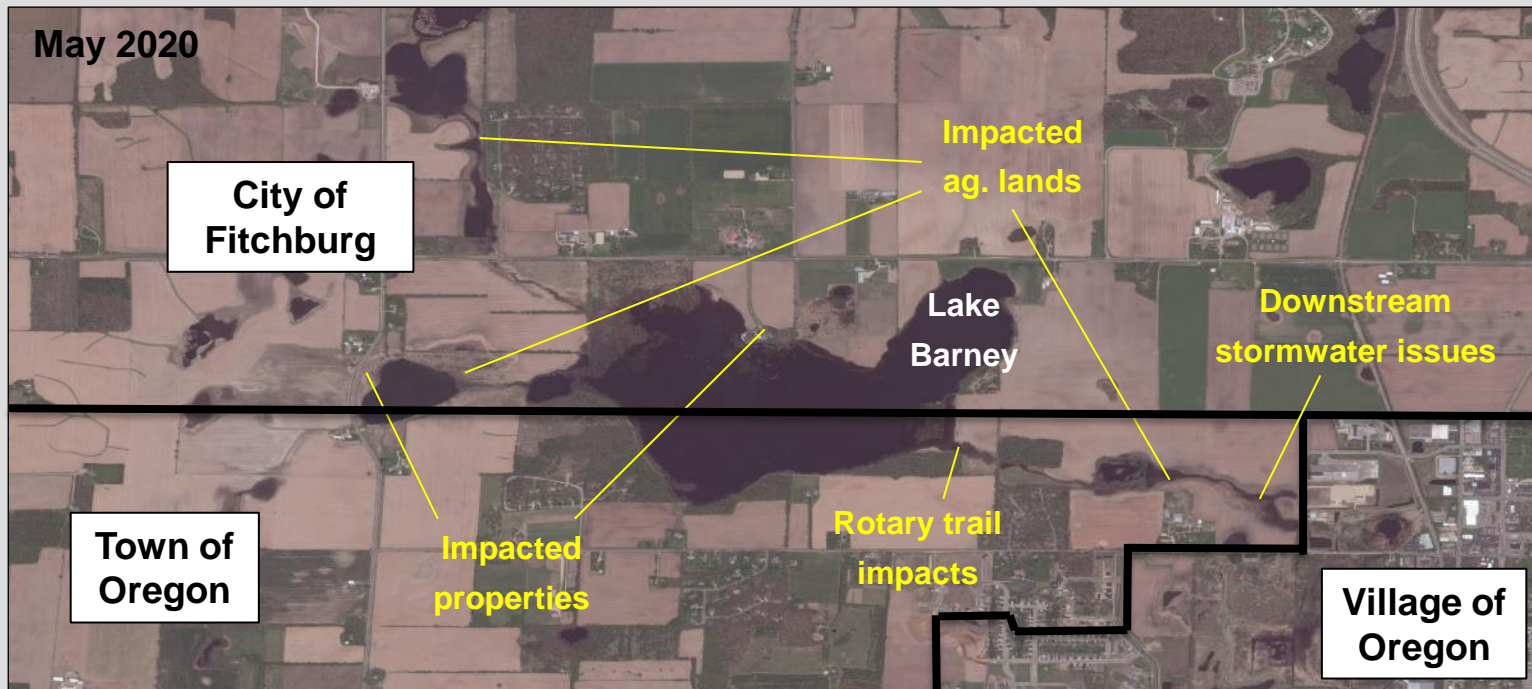


Location



Typically ~42 acres

Since 2018, runoff and high groundwater from abnormally high rainfall has raised water levels in Lake Barney, causing the lake to find a surface water outflow for the first time in over 70 years. The higher lake levels have caused local flooding, loss of agricultural lands, loss of flood storage, and stormwater flooding downstream in the Town and Village of Oregon.



Lake levels up to 7' higher than normal, and covered nearly 400 acres



Lake levels up to 7' higher than normal, and covered nearly 400 acres



Surface water impacts surrounding lake



Groundwater impacts



Downstream surface water impacts

The goal of this project is to determine what can be done to improve the negative impacts that have been seen surrounding Lake Barney.

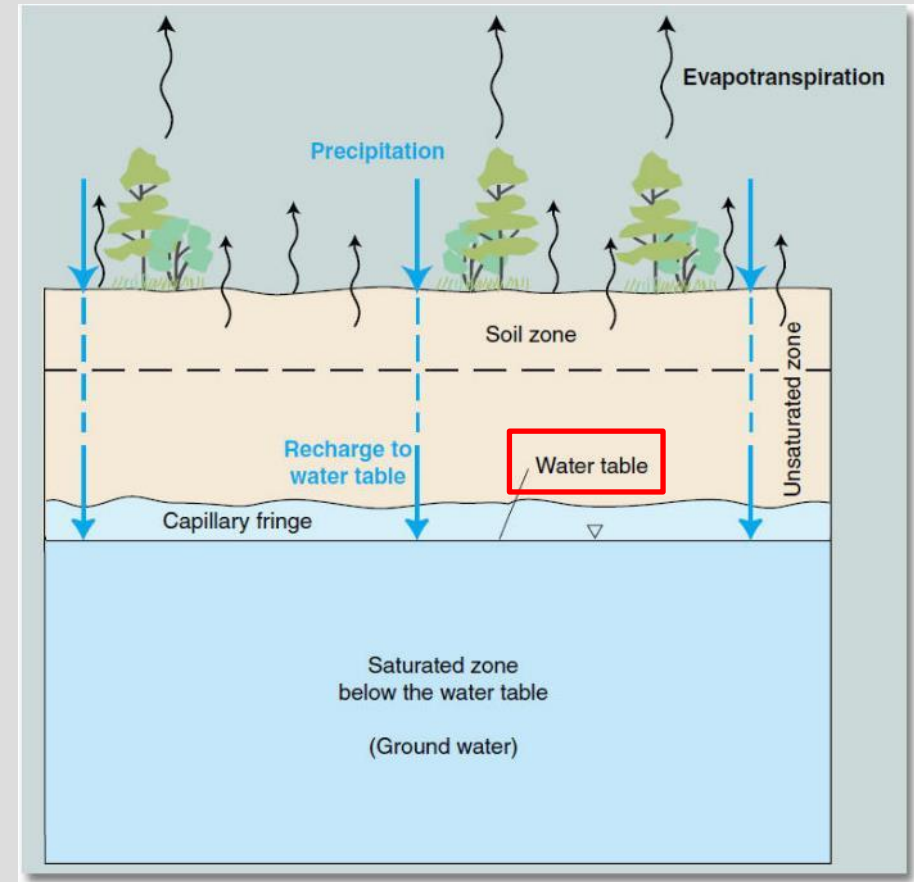
Key Project Outcomes

- Conceptual designs of flooding mitigation alternatives
- Estimate “time-to-drain” for alternatives
- Cost-benefit analysis

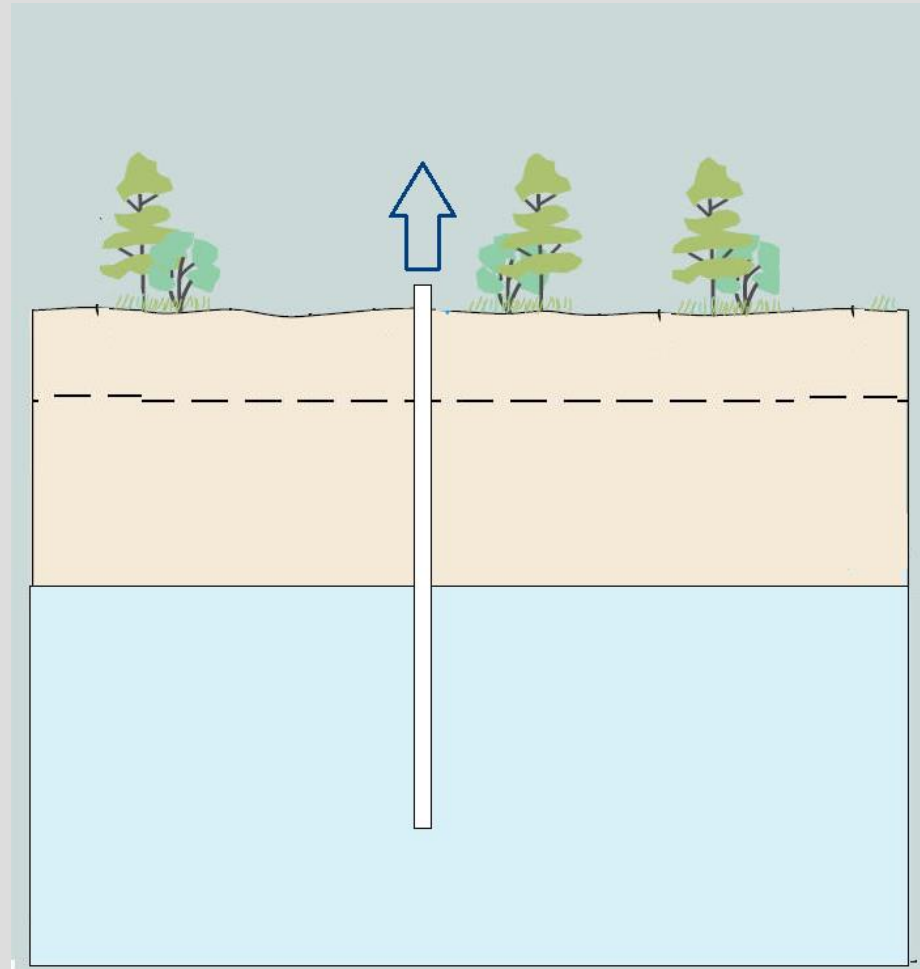
Background Concepts

Groundwater is water that exists underground in saturated zones beneath the land surface.

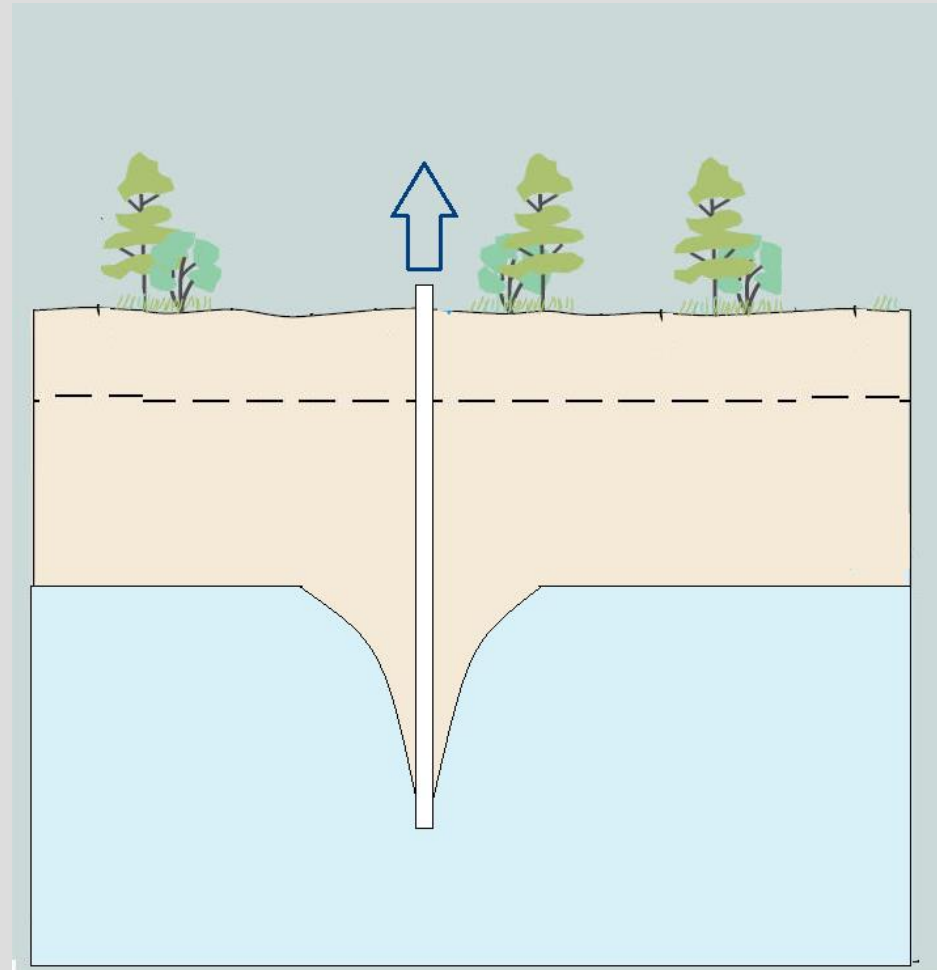
The **water table** is the level to which water would rise within a well.



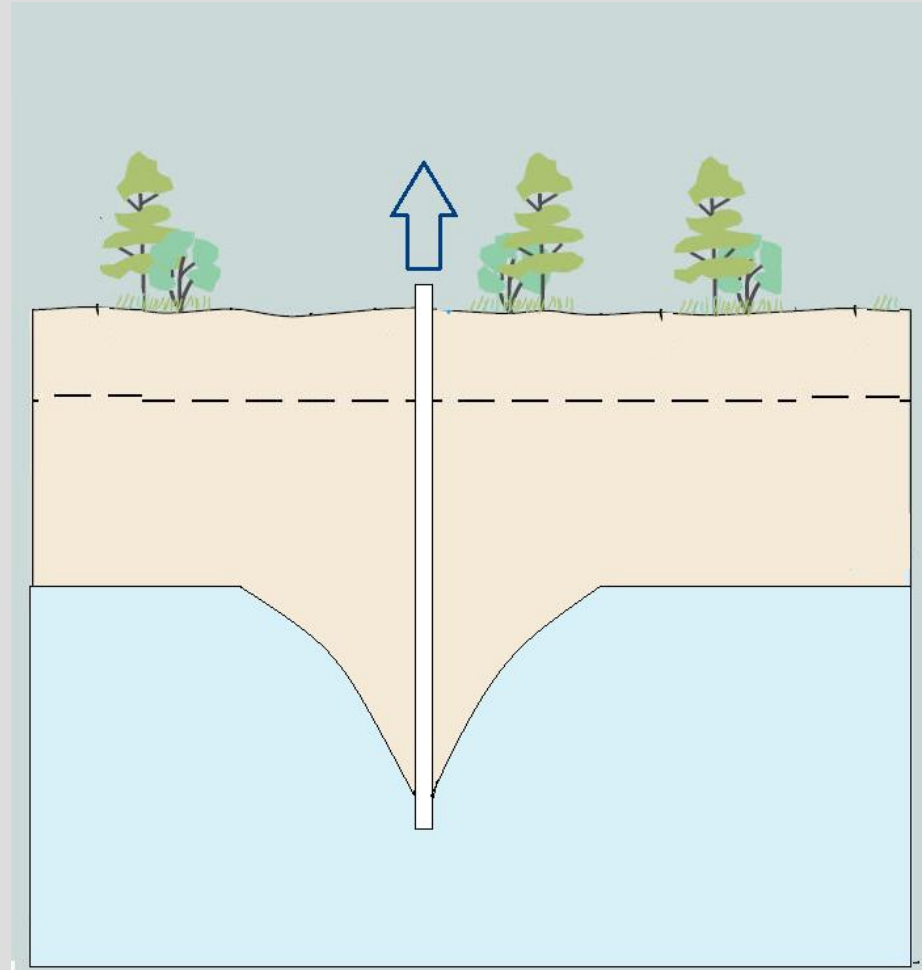
The shape of the water table can be modified by providing an artificial outlet for the water, such as pumping water from a well.



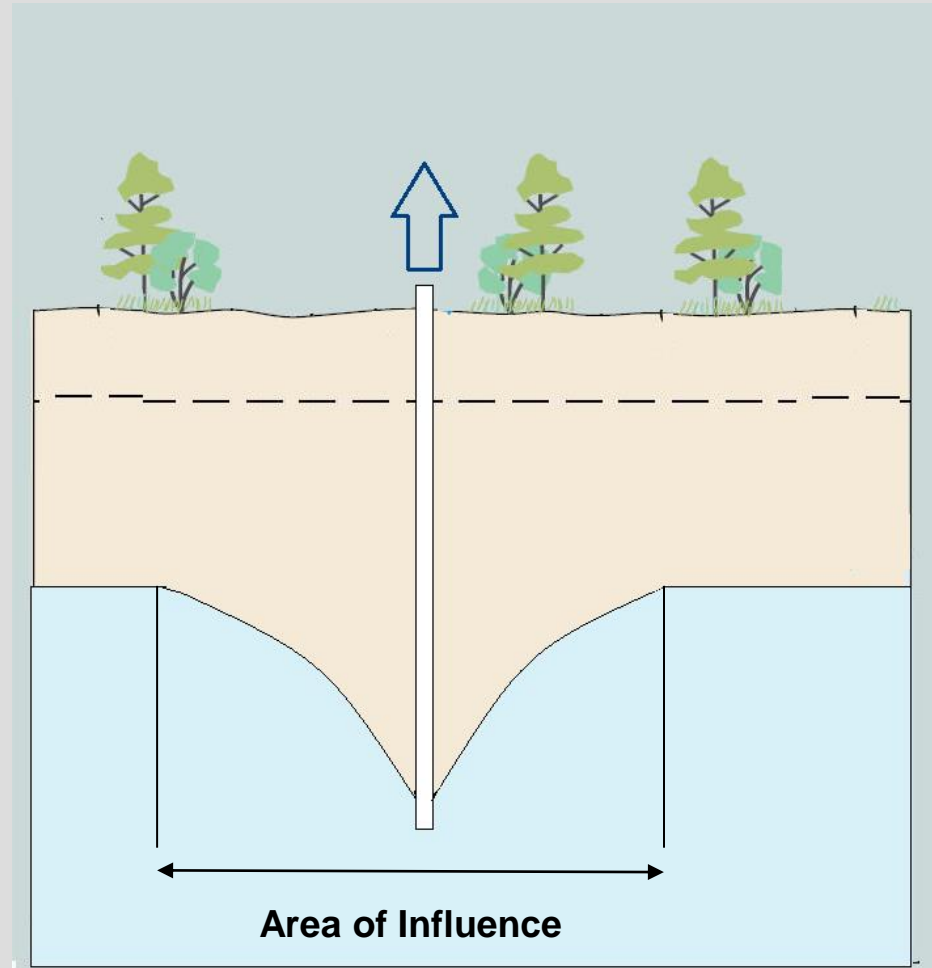
As water is pumped out of the well, the water table will lower around the well.



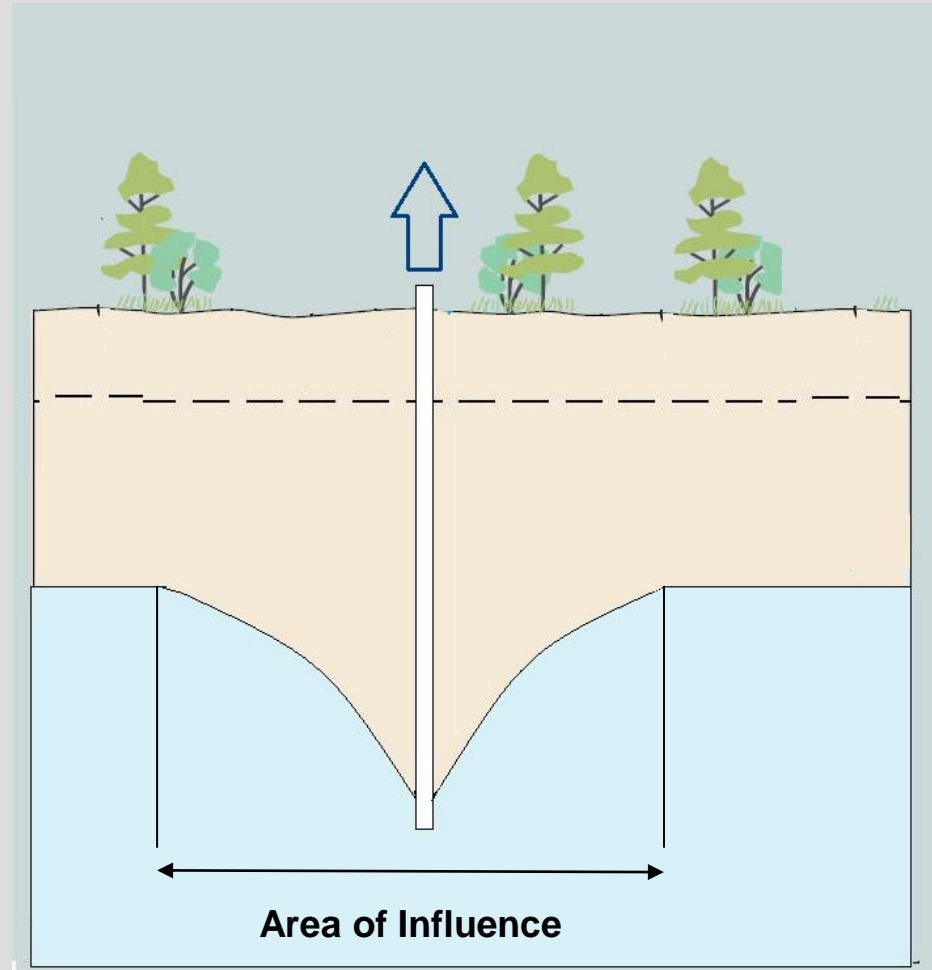
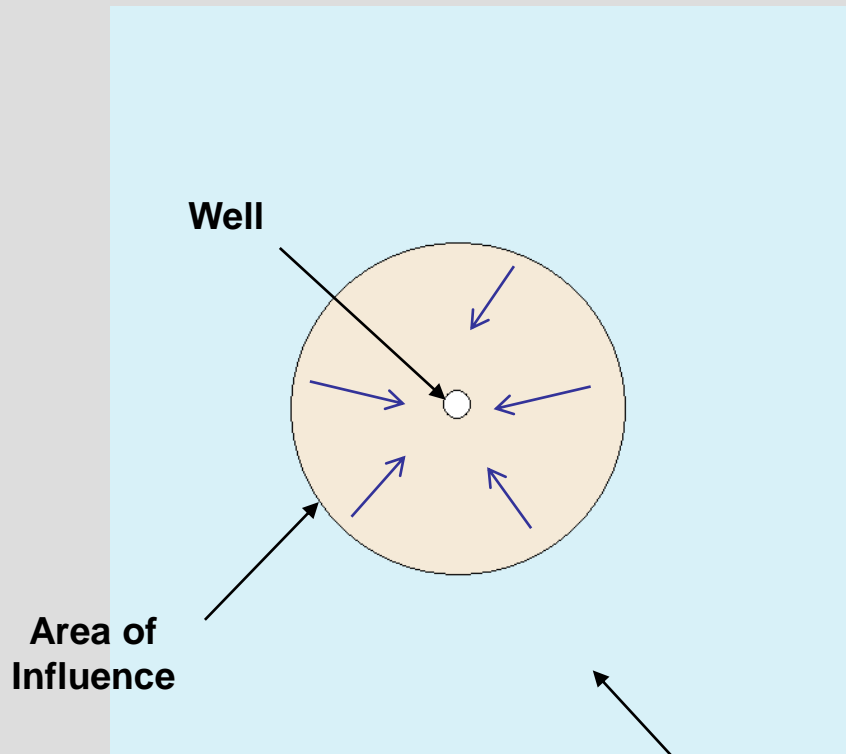
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When equilibrium is reached, the water table surrounding the well will no longer be impacted by pumping activities.

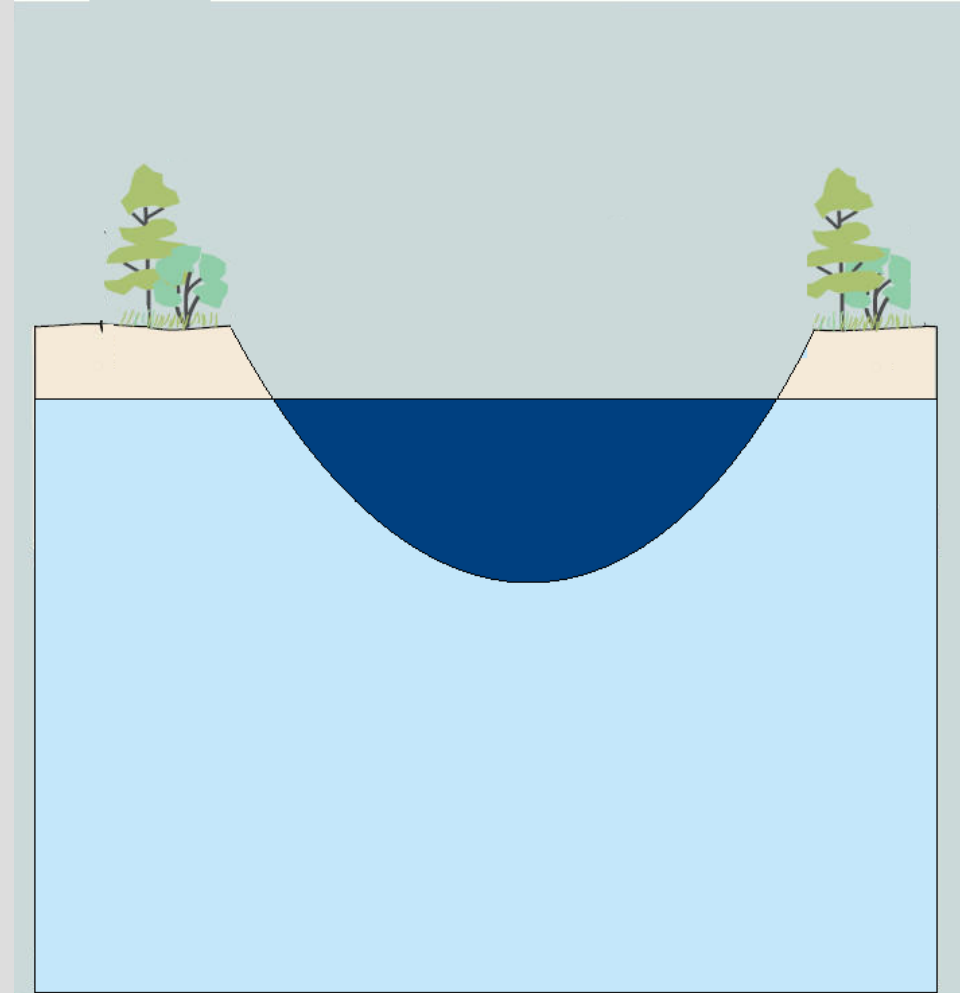


Bird's eye view

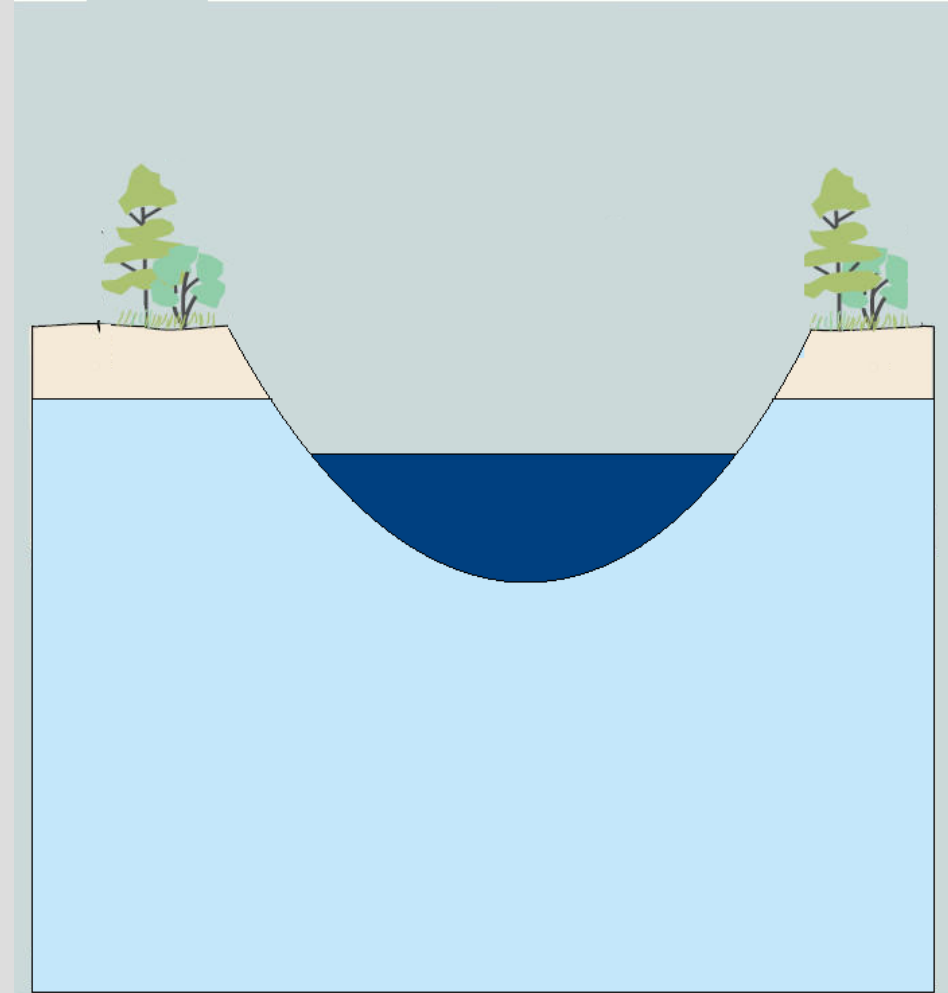


The water table outside of the area of influence is not impacted by pumping operations

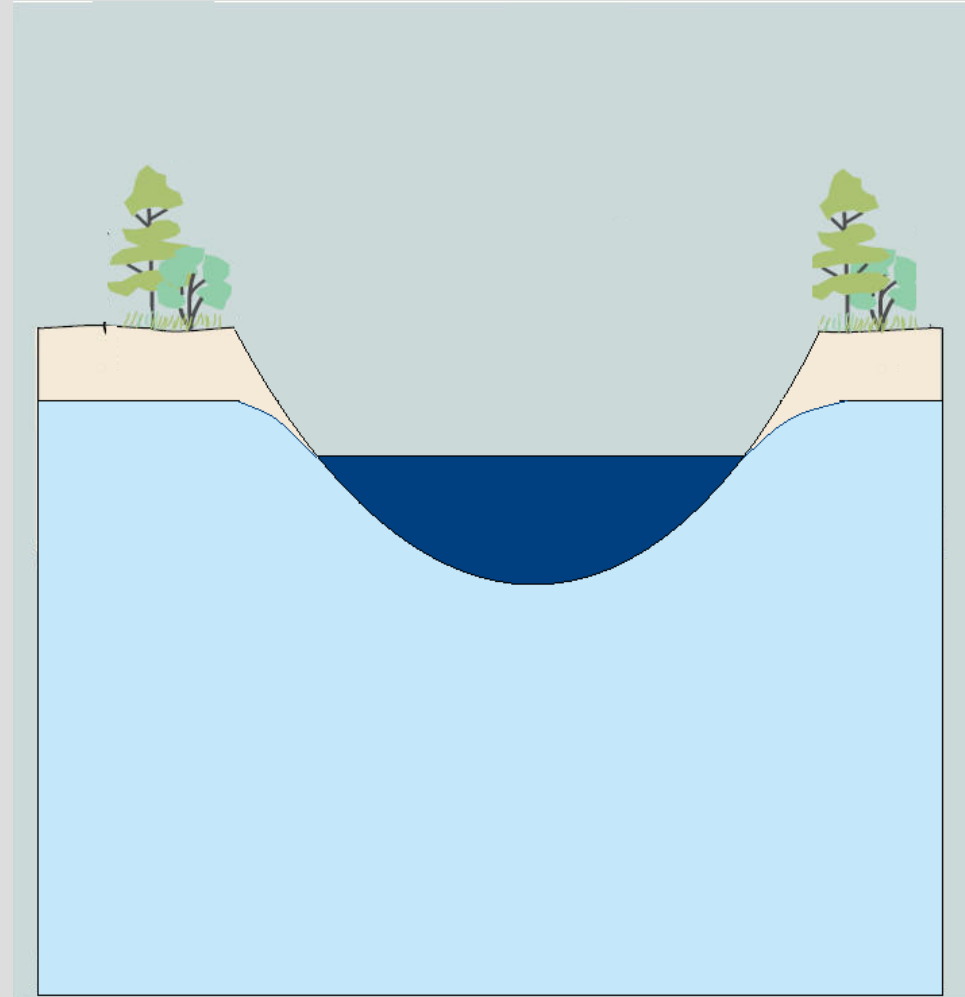
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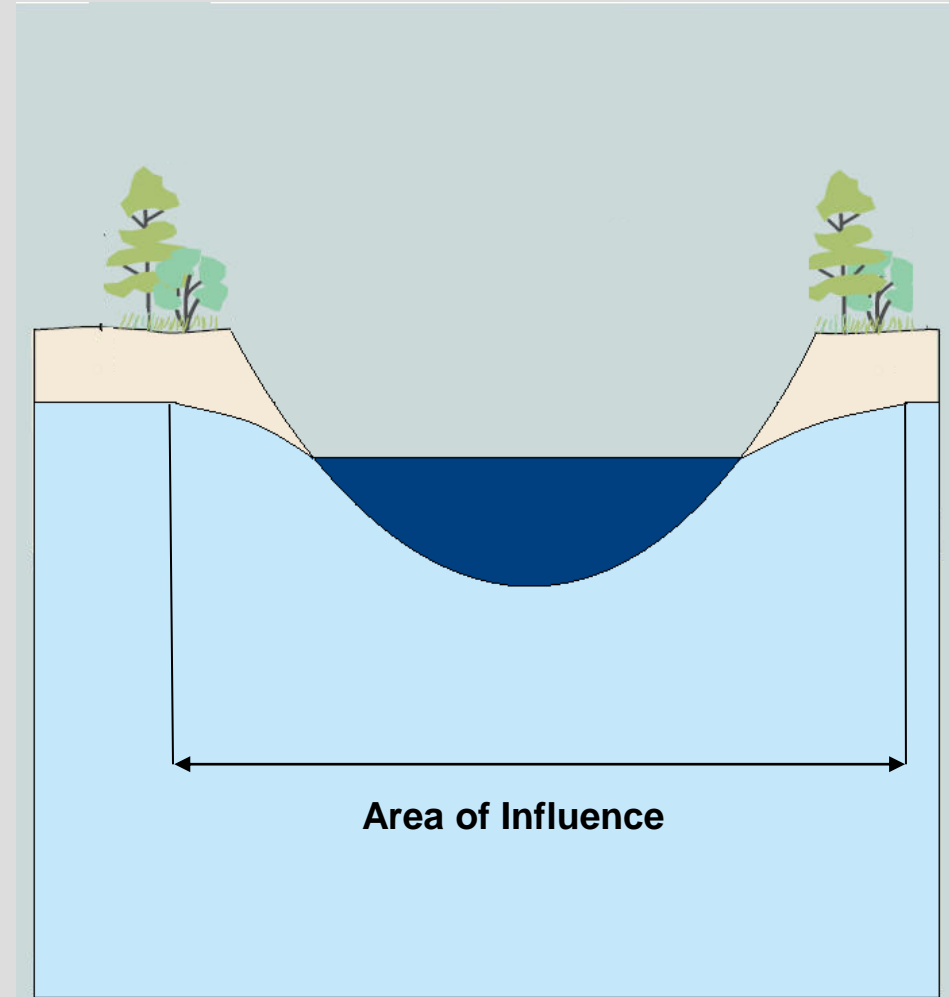
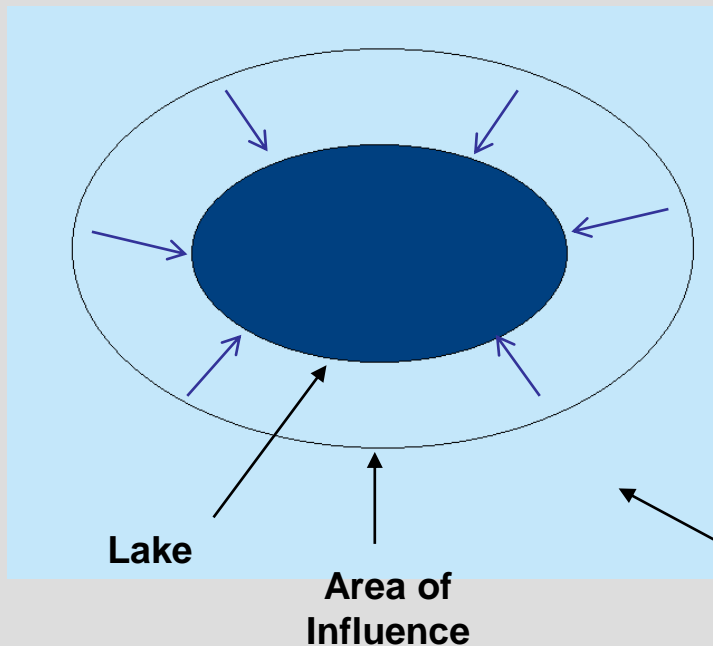
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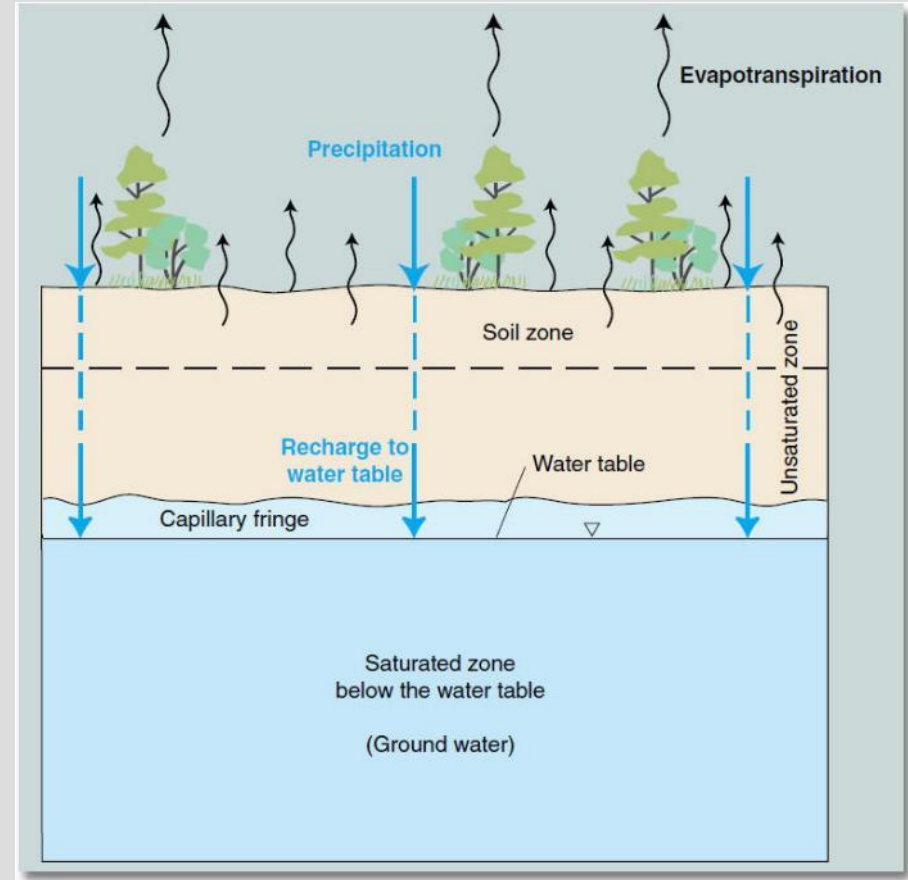
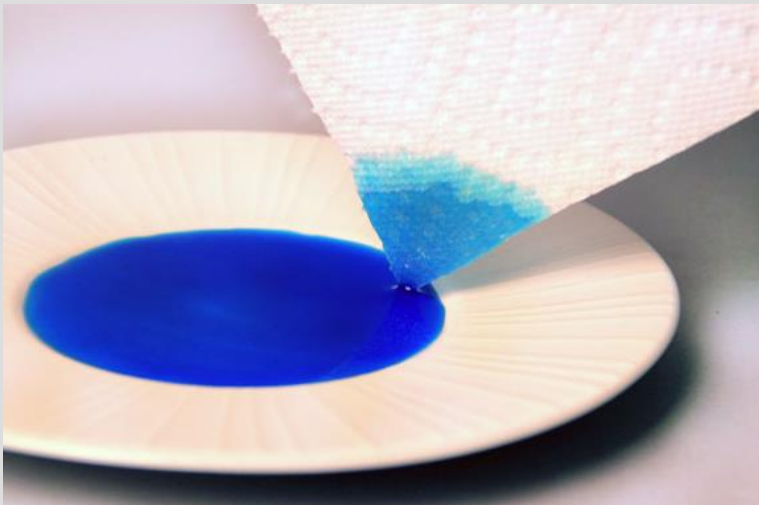
The **area of influence** is the area surrounding the lake where groundwater was lowered as a result of lowering the lake level.



The water table outside of the area of influence is not impacted by lowering the water table within the lake.

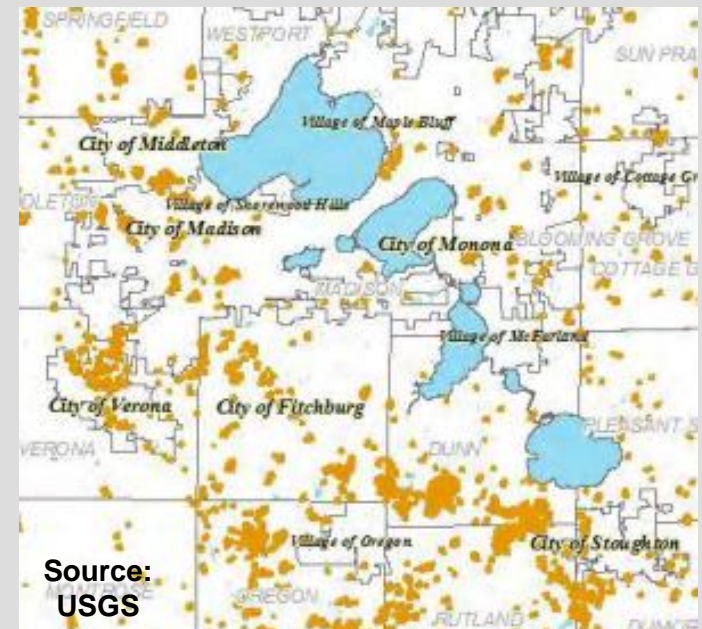
Capillary Action

Capillary action refers to the ability of water to move upward (against the force of gravity) due to surface tension properties of water molecules.



Closed Depressions (“internally drained areas” or “kettles”)

- Low areas on the landscape that do not have natural surface water drainage under typical conditions
- >2,500 in Dane County (1 – 100+ ac)
- During “normal” precipitation years, water levels in surface water features (ponds, wetlands) are relatively steady and balanced by precipitation, evapotranspiration and groundwater flow



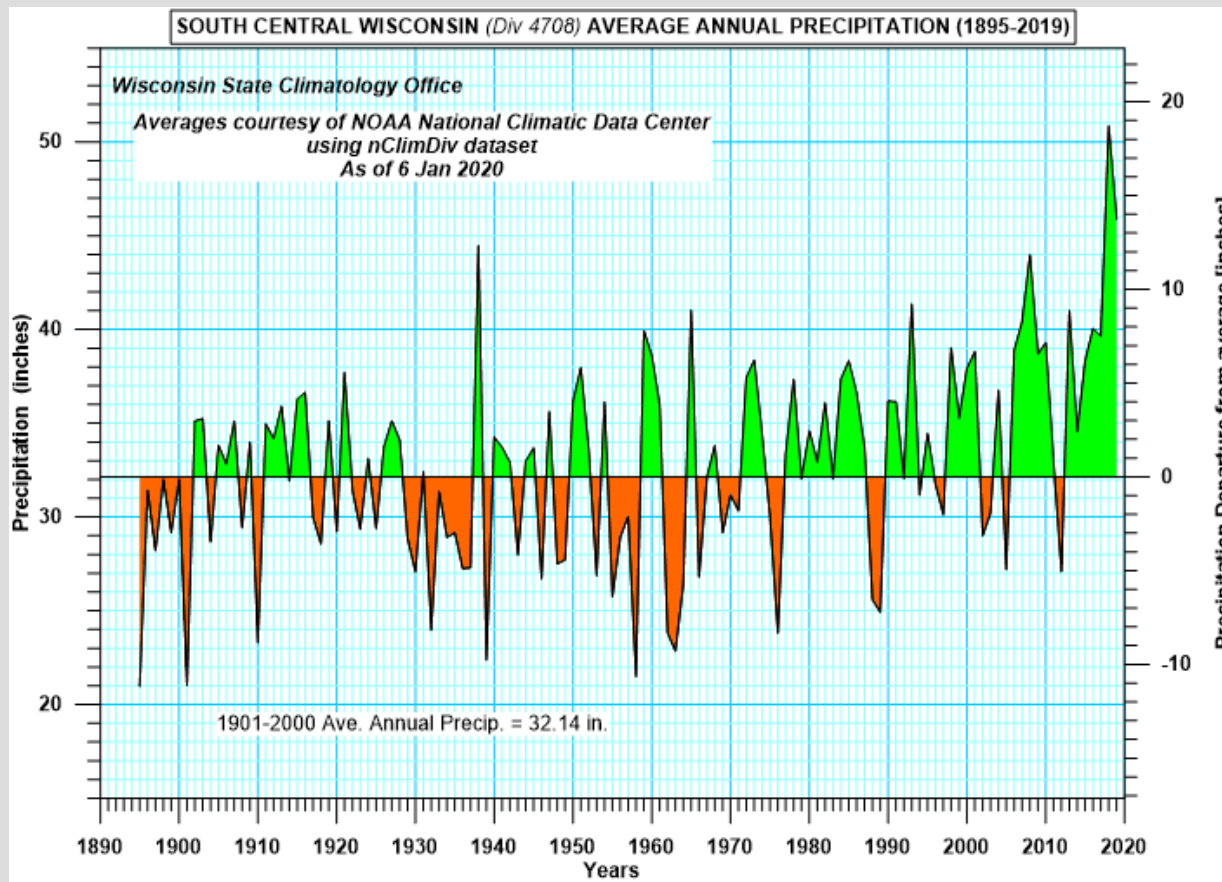
Lake Barney's elevation has typically ranged from 942' to 945', covering ~40-60 acres.

Starting in 2017, the combination of high annual precipitation, several large runoff-producing storms, and high groundwater caused the lake to grow to over 300 acres, joining with several wetlands to the west. The lake reached a peak stage of approximately 949' in 2019 and continued to overflow (no longer a closed depression) until July 2020.



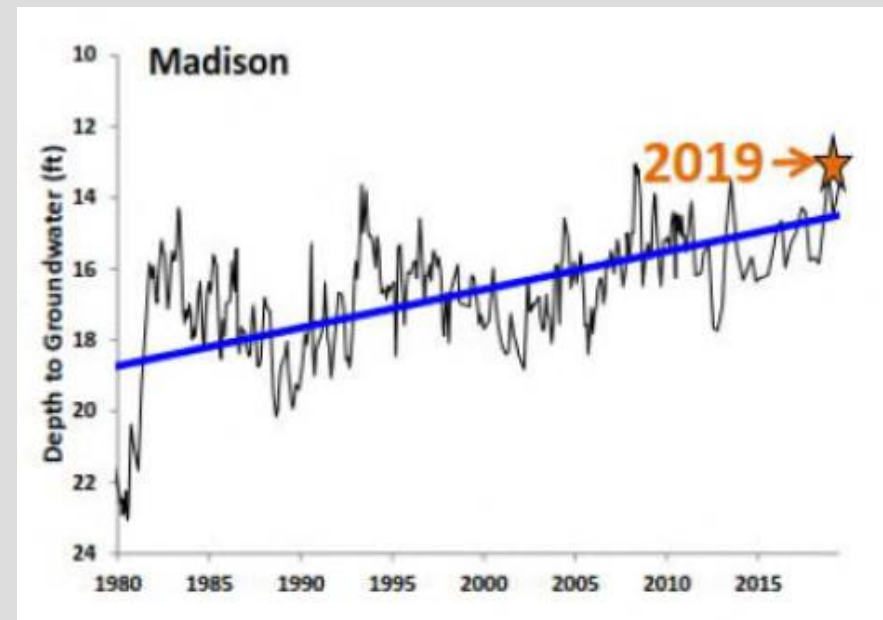
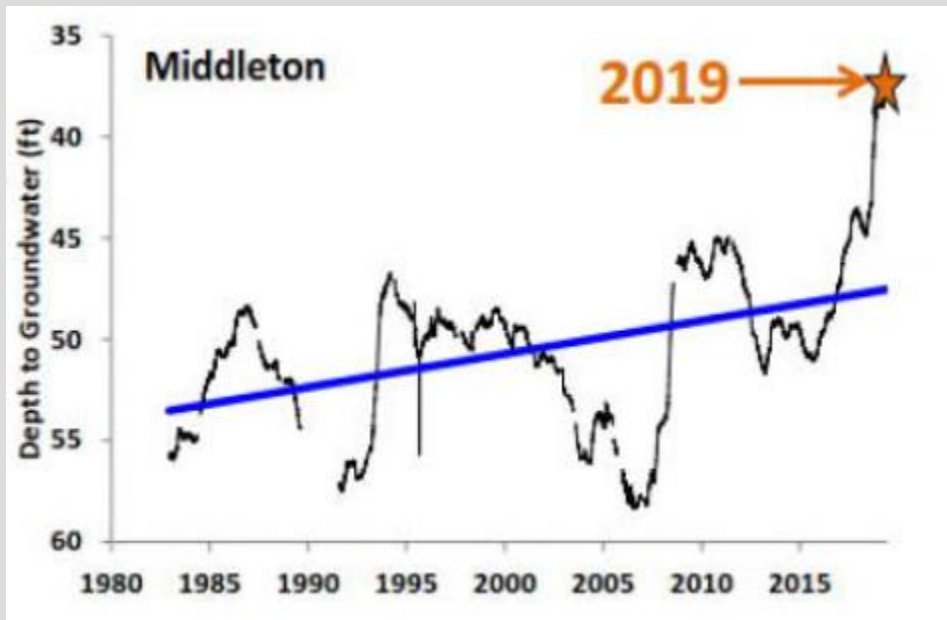
Changing Weather Conditions

South-central WI has been much wetter during recent years. In 2018, we received nearly 20" more precipitation than the 20th century average. Saturated soils + less available storage in the watershed + heavy precipitation caused more runoff into the lake than typical.



Changing Weather Conditions

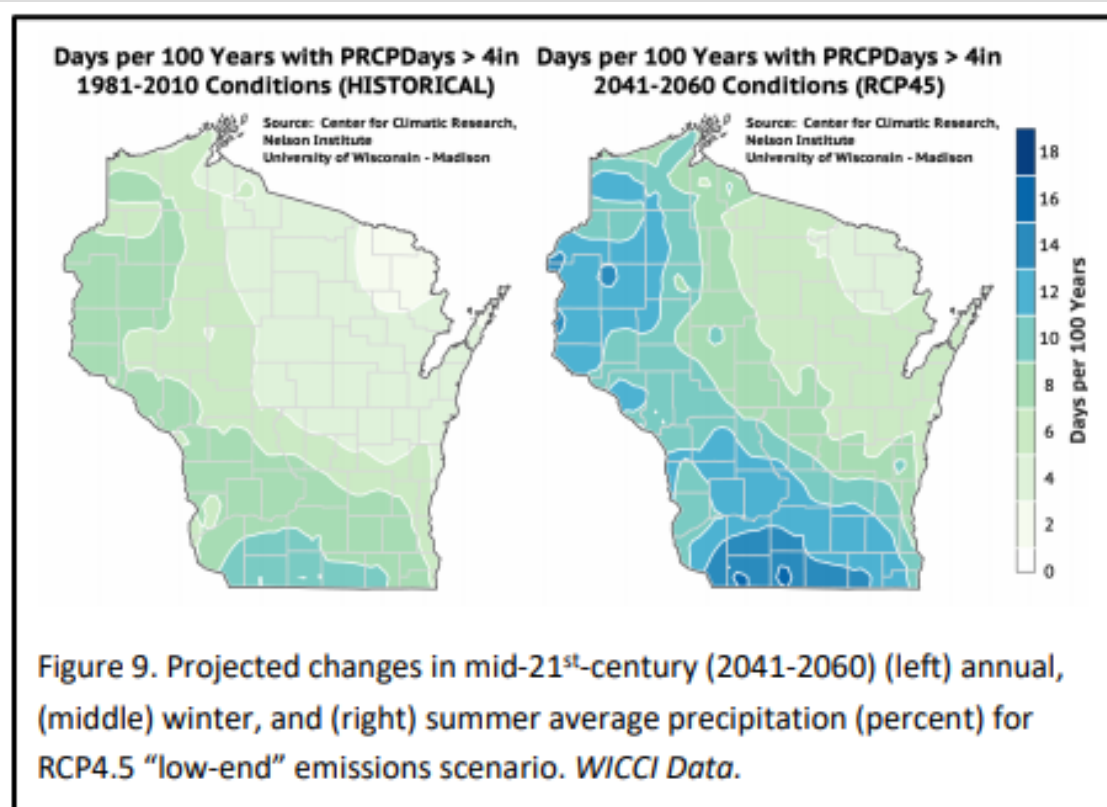
Wet weather has also raised groundwater elevations, which decreases potential groundwater drainage out of Lake Barney. Groundwater systems change slowly and have a long 'memory' – these conditions may persist for many years.



Rising groundwater elevations at 2 U.S. Geological Survey monitoring stations, 1980-2019

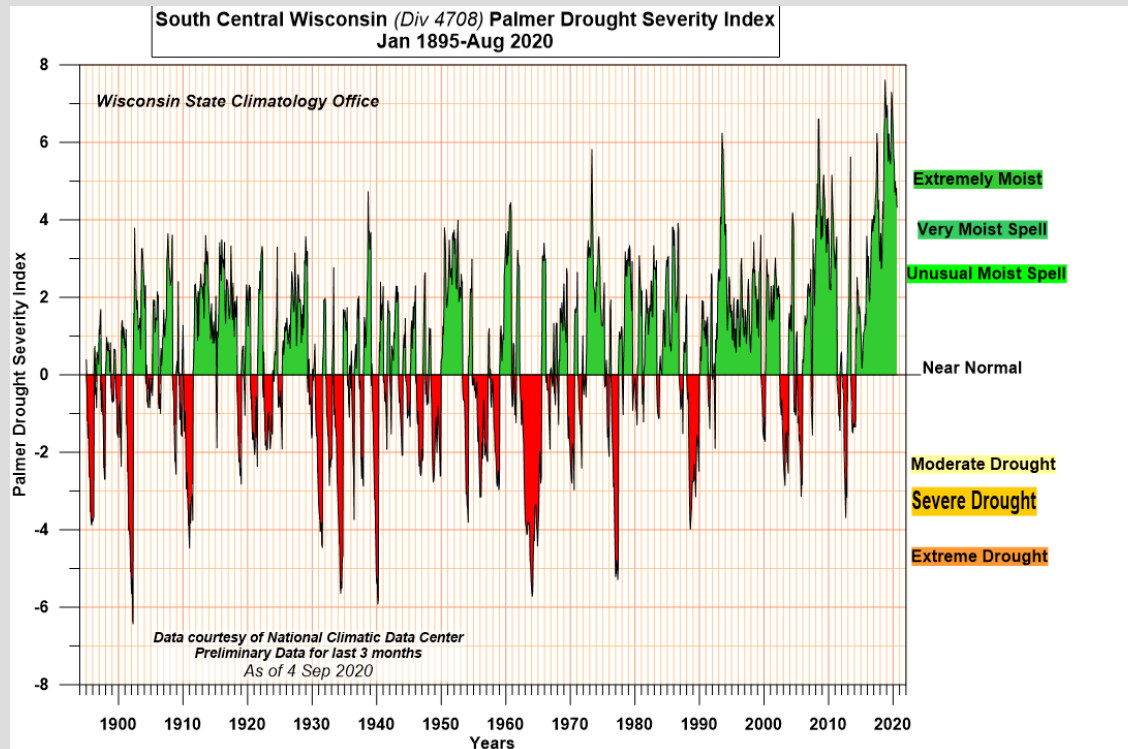
Changing Weather Conditions

Climate change models and analyses for South-central Wisconsin predict slightly higher annual average precipitation in the coming century, but a dramatic increase in heavy (>4") rainfalls. These heavy rainfalls seem to cause overflow of closed depressions in the Lake Barney watershed and trigger the prolonged increases in lake level.



Changing Weather Conditions

But there are natural wet and dry climate oscillations that can last for years to decades, and it's more difficult to predict how climate change will impact those. One prediction is that summers will be hotter and drier in between large rain events, leading to more frequent drought conditions. A Lake Barney that is kept low via an artificial outlet might provide less resilience for its groundwater-dependent wetland ecosystem during such droughts.



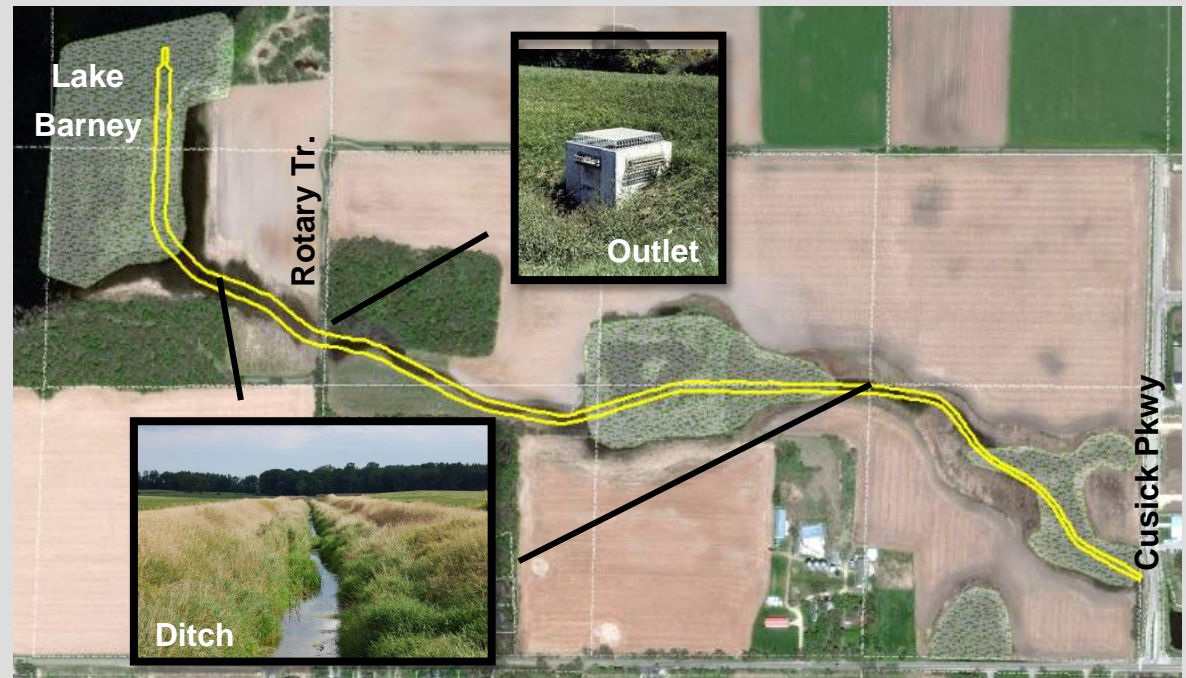
Palmer Drought Severity Index showing wet and dry periods, 1895-2020

Concept Solutions

Target Lake Level Options

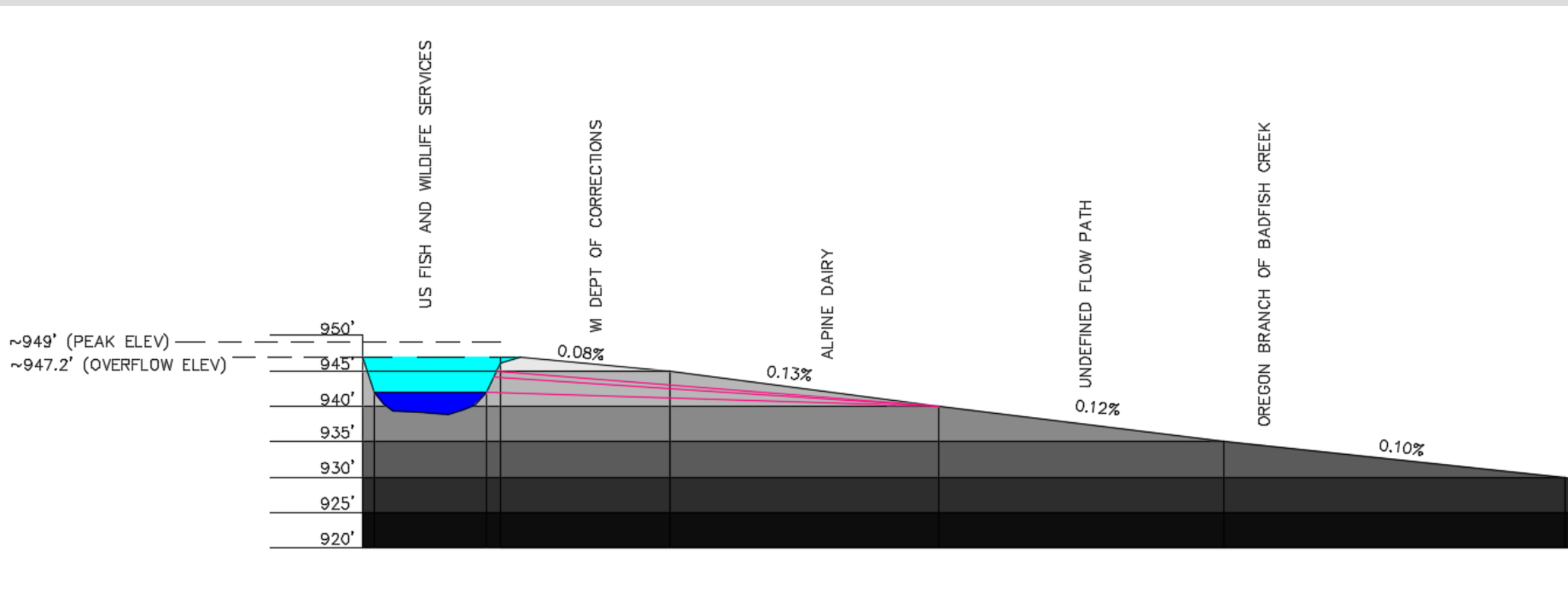
We are looking at three lake level control options, which would each include an outlet structure and drainage ditch / greenway from Lake Barney to the Village of Oregon. The options differ in the target lake stage – that is, the maximum level the lake will reach before overflowing.

All options include the same core elements – an outlet to control lake elevation and a ditch to convey water downstream.



Target Lake Level Options

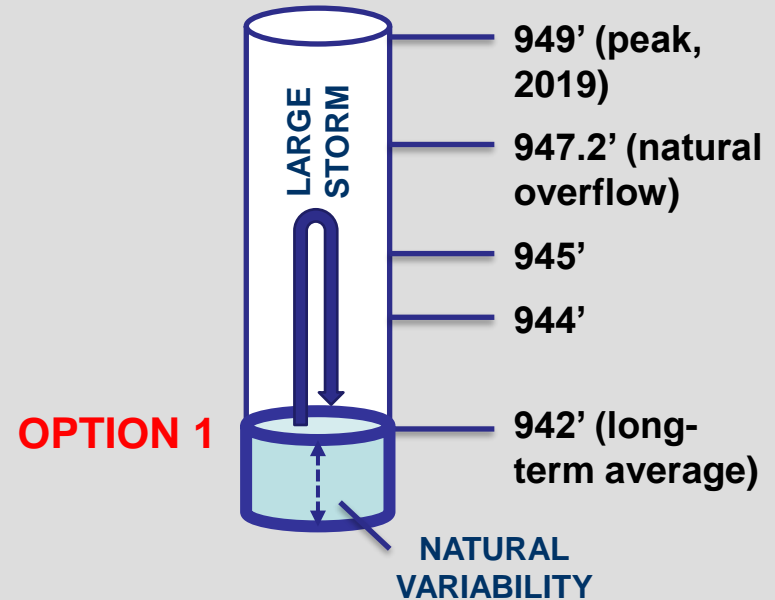
The three options will have different costs and benefits to the City of Fitchburg. The goal is to find a balance between costs, benefits, and long-term maintenance obligations.



Target Lake Level Options

- Option 1: outlet at 942'

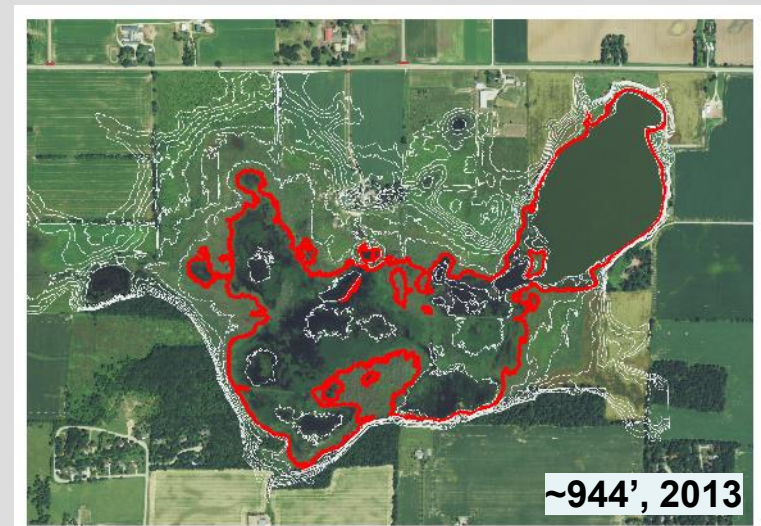
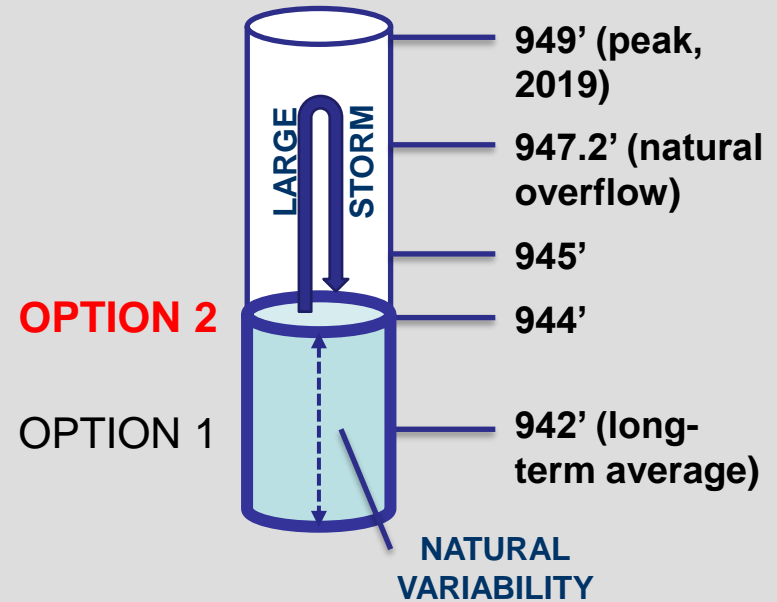
This is the lake level most frequently seen on historical aerial photography. The lake would only fluctuate above this level for short periods of time following rainfall or snowmelt and would only go below this during periods of drought.



Target Lake Level Options

- Option 2: outlet at 944'

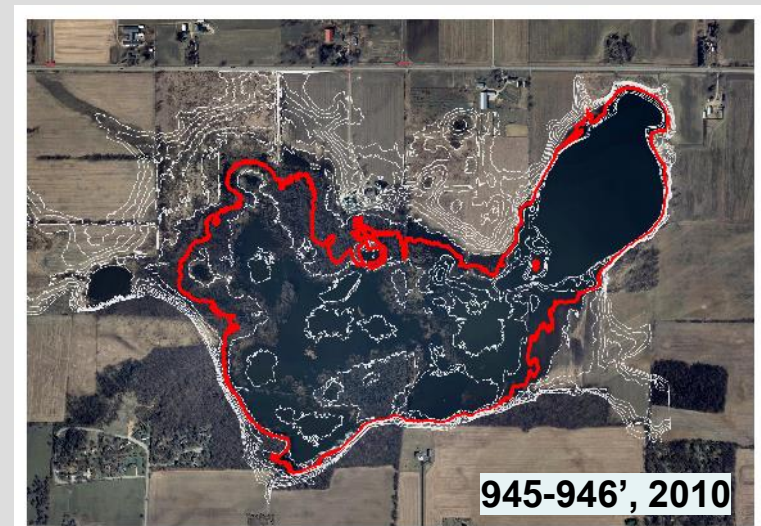
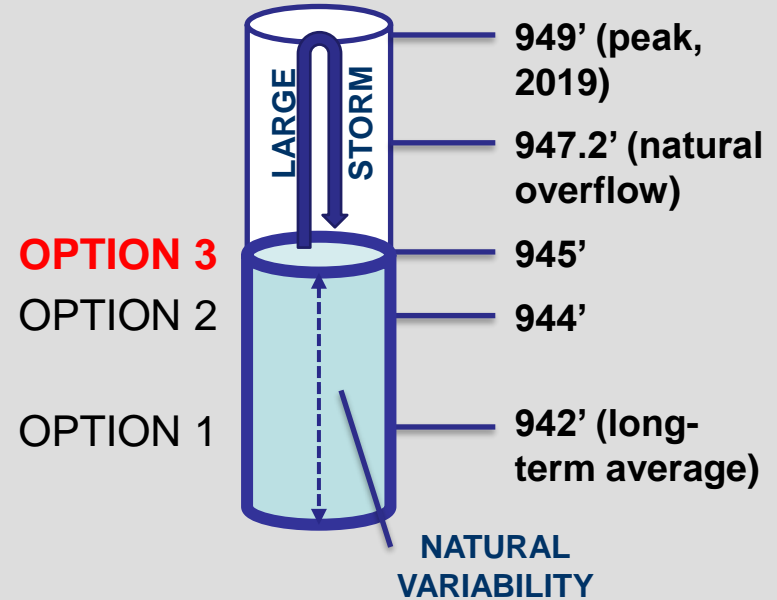
The lake would only fluctuate above this level for short periods of time following rainfall or snowmelt. The lake could naturally vary up to 944', depending on climate conditions.



Target Lake Level Options

- Option 3: outlet at 945'

The lake would only fluctuate above this level for short periods of time following rainfall or snowmelt. The lake could naturally vary up to 945', depending on climate conditions.



High groundwater near Lake Barney:

- Expands surface water features (ponds, wetlands) → threatens structures
- Limits surface water infiltration, increasing flooding and reducing workable agriculture lands

Lower lake target → higher potential groundwater benefit during very wet periods

Area of influence by target

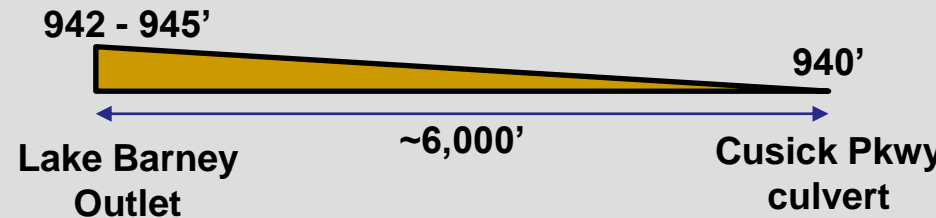


Greenway Considerations

The ditches will be very flat due to local topography, but ditch slope will differ based on the lake target.

- Sediment and vegetation build-up likely (maintenance)
- Standing water likely

Target	Ditch slope
945	0.10%
944	0.08%
942	0.04%



**Higher lake target →
steeper ditch slope → more
functional ditch**

A lower target lake means the greenway ditch needs to be dug deeper, wider, and longer to reach the lake. This will increase construction complexity and costs (earthwork, easements, etc.).

The lower target also means more ditch length to maintain, and less potential for ditches to be self-cleaning due to low slopes.



Preliminary ditch footprint – Option 1

**Higher lake target →
lower costs**

Lower Target Stage (942')

Pros:

- Greater potential drawdown benefit

- Increased flood storage

Cons:

- Channel with shallower slope

- Increased construction costs

- Increased maintenance costs

- Increased footprint on downstream properties

- Limits max water elevation to the historic “normal” water elevation

Higher Target Stage (945')

Pros:

- Channel with steeper slope

- Lower construction costs

- Lower maintenance costs

- Smaller footprint of channel on downstream properties

Cons:

- Lower potential drawdown benefit

- Lower flood storage

Process for Conduction the Cost-Benefit Analysis

Goal: assess costs, benefits and long-term maintenance of all options & recommend the option with the best balance.

■ Assumptions

- Assessed under wet conditions that persist for several years
- High groundwater and lake levels can reasonably be anticipated to happen again
- The Dane County Regional Groundwater Model (2016, WI Geological and Natural History Survey) is the best available tool to analyze the groundwater system
- We are using modeling to predict the greatest benefit that City residents would realize in a very wet year.
- The actual benefit could be anywhere from \$0 (in dry years) to this number.

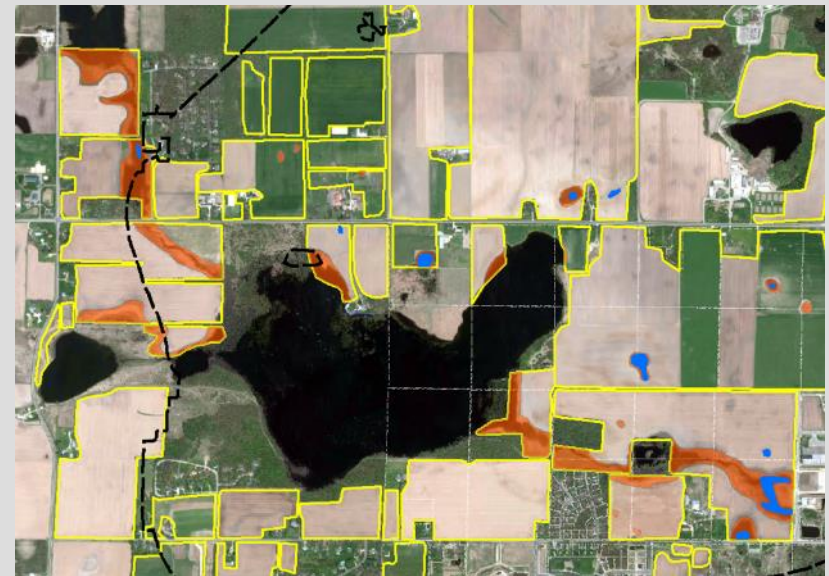
1. Determine what areas would benefit from lowering the lake level.
2. Determine the potential revenue lost from farming that acreage of land in one year.
3. Estimate the upfront cost of permitting, designing, and constructing the system.
4. Estimate the ongoing cost of maintaining the system.

Step 1. Determine what areas would benefit from lowering the lake level.

- a. Determine area impacted by high water in the last few years
 - Modeling results
 - Aerial imagery (agr. lands lost to high water 2018-2020)
 - Resident input



Impacted areas sketch (landowner)

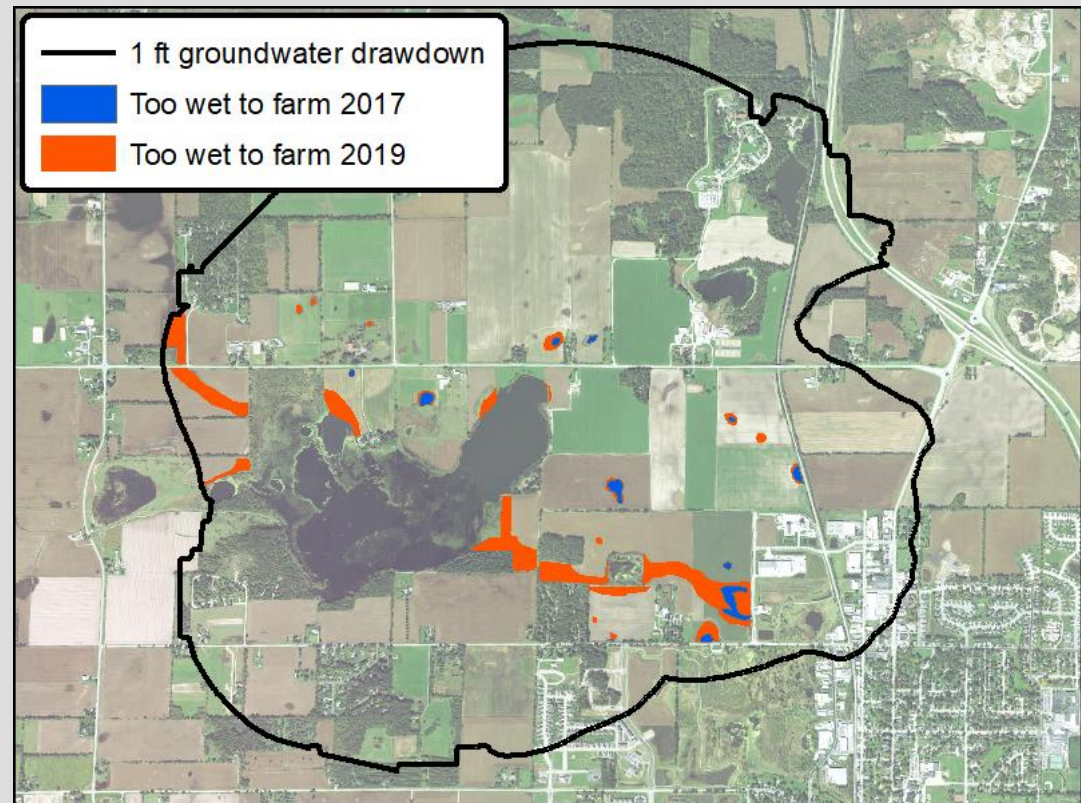


Aerial imagery analysis (orange = ag. lands lost to high water 2020 by visual inspection)

Step 1. Determine what areas would benefit from lowering the lake level.

- b. Superimpose groundwater drawdown area of influence over wet areas to identify impacted areas that would benefit from a lowered lake.

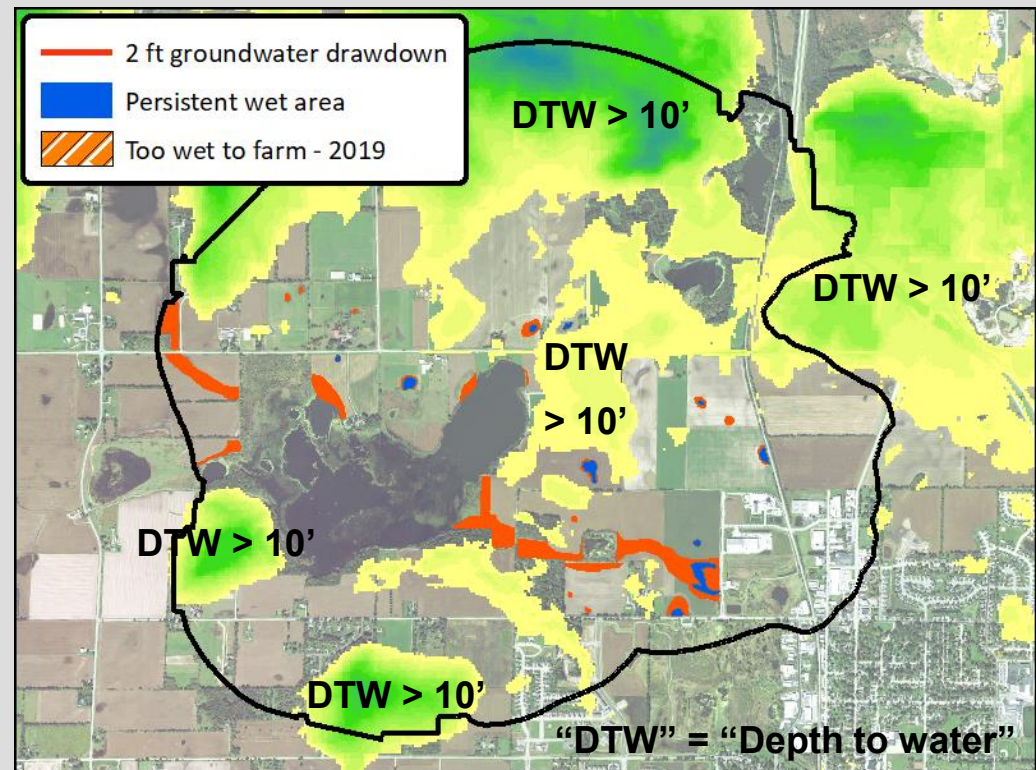
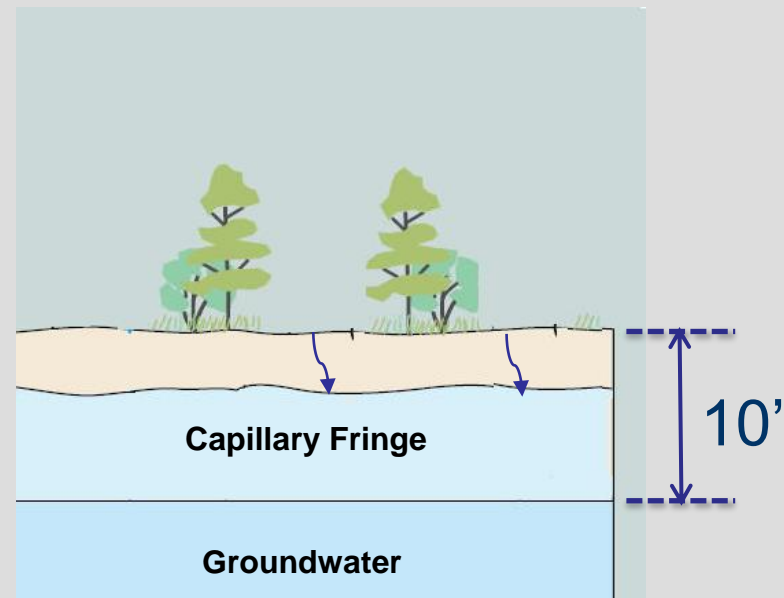
Within the area predicted to see $> 1'$ water table drop for the 942' option, there were ~71 acres of farmland lost to high water in 2019.



Maximum Benefit Calculation

Step 1. Determine what areas would benefit from lowering the lake level.

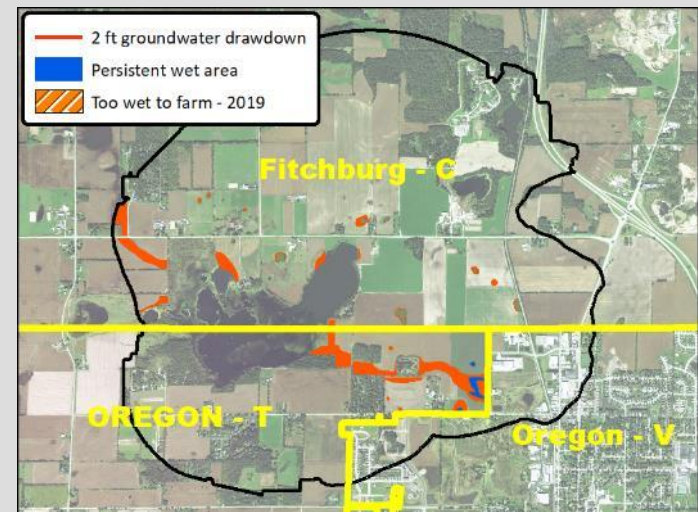
- c. Check that areas identified in previous step would actually be helped by lower groundwater and improved infiltration. Areas with land surface $> 10'$ above the wet period water table are removed.



Step 1. Determine what areas would benefit from lowering the lake level during a very wet year.

This process will complete the following table:

Option (target)	Farmable land benefit	Farmable land benefit within City of Fitchburg
1 (942')	71 acres	30 acres
2 (944')	TBD	TBD
3 (945')	TBD	TBD



Step 2. Calculate farming losses.

Determine the potential revenue lost from not farming that acreage of land.

Data source: USDA National Agricultural Statistics Service

Example calculation, for 30 acres of impacted land:

- Lost rent (low end of estimated benefit)
 - 2019 average rent for non-irrigated cropland in Dane County: \$174 per acre
 - Yearly rental loss for 30 acres: \$5,500
- Lost crop sales (high end of estimated benefit)
 - 180.9 bushels / acre corn in Dane County (2019)
 - Highest WI price received / bushel: \$3.90
 - Sale value of 30 acres of corn: \$21,200

Step 3. Project Costs

Estimate the upfront cost of permitting, designing, and constructing the system.

1. Permitting may be complicated due to altering surface water body (Lake Barney) and unavoidable wetland impacts near lake and at Cusick. Possible water quality and runoff volume concerns from WDNR, County.
2. Design is relatively straight-forward and shouldn't change much from preliminary designs completed for this feasibility study.
3. Construction will dominate costs. Some items relatively independent of lake level choice (outlet structure, easements*) but others will vary widely with target elevation, especially earthwork and restoration.

*Note: cooperation from the affected landowners (Dept. of Corrections and Alpine Dairy) will be essential to constructing this project

Ongoing O&M

Estimate the ongoing cost of maintaining the system.

- Ditch / greenway maintenance
 - Routine vegetation management (mowing)
 - Dredging of sediment buildup as needed
- Outlet
 - Clearing debris as needed, including possible animal usage.
 - Periodic inspections and possible sediment clean-out

Next Steps

The result of the analysis will look something like this.

Option (target)	Annual benefit*	Upfront cost – Design/Construction	Annual cost – O&M	Cost-benefit ratio
1 (942')				
2 (944')				
3 (945')				

- With assumed project life span and discount rate.
- * Annual benefit would vary from \$0 to the maximum benefit, depending on weather conditions.

Other factors to consider:

- Landowner peace of mind
- Yard flooding and wet ditches
- Landowner flood protection costs (pumps, etc.)
- Landowner costs to access land that is still farmable but is difficult to access due to wet areas
- Potential devaluation of property
- Ecological impacts (wetlands, trees)
- Downstream flood reduction

- ❑ Finalize the cost-benefit analysis and provide the results to Council.*
- ❑ Approach other entities for potential cost-sharing opportunities.
- ❑ Determine responsibilities for long-term maintenance of the system.
- ❑ Work on obtaining necessary easements.
- ❑ Get to work on the design and build of the proposed solution!

** The cost-benefit analysis will include a breakdown of cost-benefit for Fitchburg residents, and will also assess benefits to other surrounding entities.*

Questions?