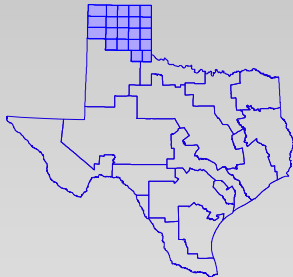


# Surface Water Study

Water Balance

Temperature Trends

**Panhandle Water  
Planning Area**



Spencer Schnier

PWPG Meeting

November 19, 2009

# Background

## Study Area

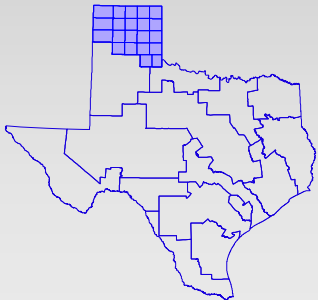


## Panhandle Water Planning Area

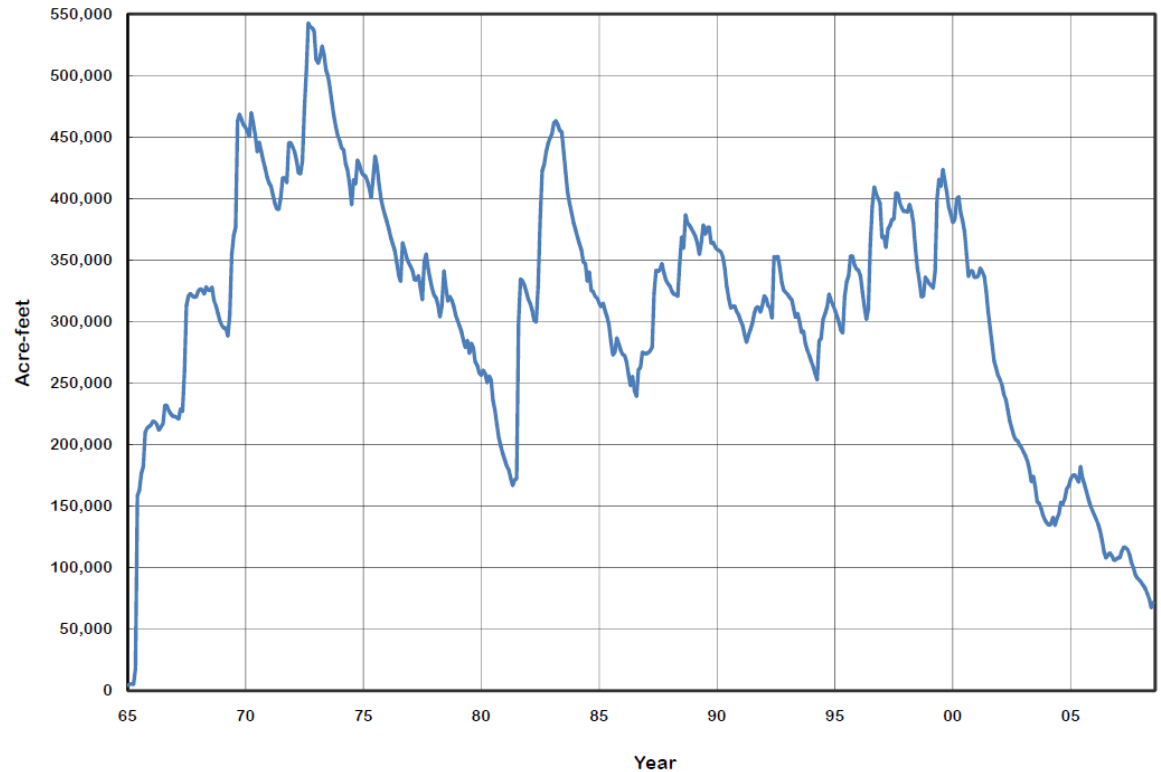


# Background

## Panhandle Water Planning Area



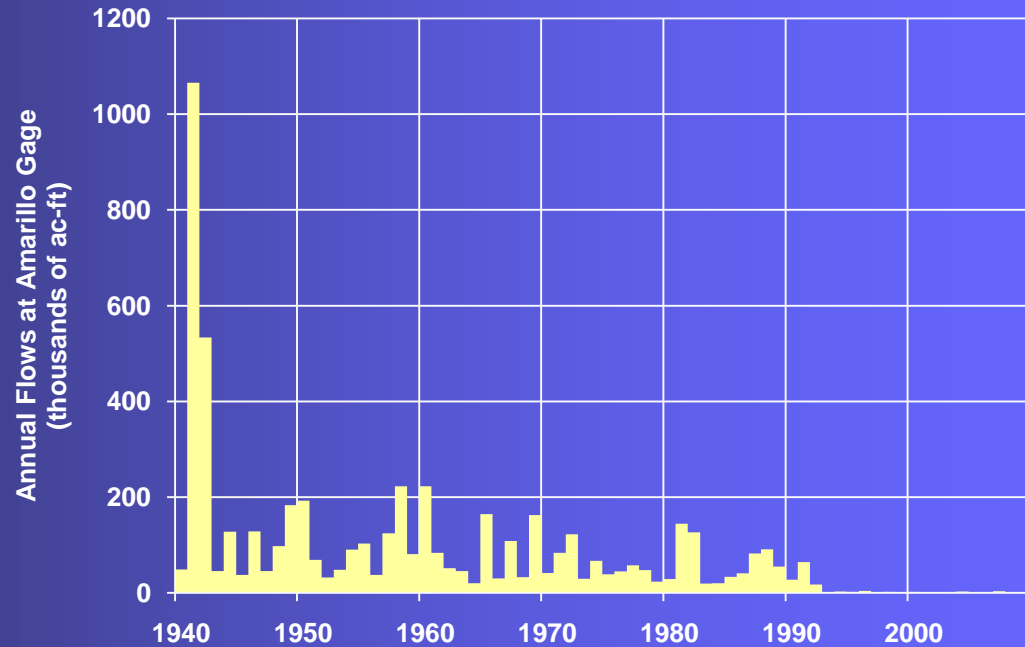
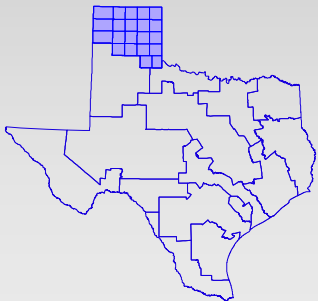
**LAKE MEREDITH**  
Total Storage



# What is reducing the level in Lake Meredith?

- Decreased stream flow

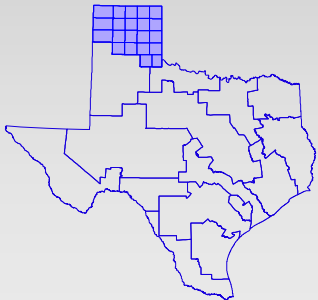
**Panhandle Water  
Planning Area**



# What is reducing the level in Lake Meredith?

- Lack of rain
- Increased evaporation
- Increase in infiltration
- Decreased spring flows
- Change in water use
- Increase in stock ponds
- Spread of salt cedar

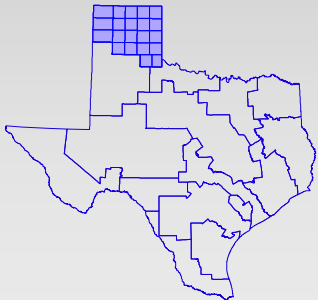
**Panhandle Water  
Planning Area**



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**Panhandle Water  
Planning Area**

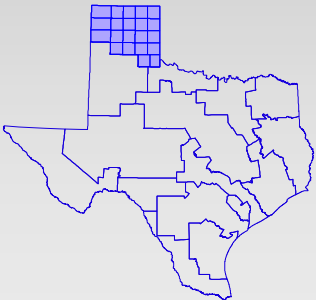


# What is reducing the level in Lake Meredith?


Water Balance

- Lack of rain
- Increased evaporation
- Increase in infiltration
- Decreased spring flows
- Change in water use
- Increase in stock ponds
- Spread of salt cedar

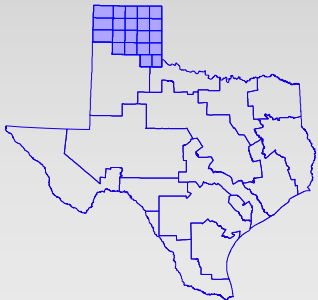
**Panhandle Water  
Planning Area**



# What is reducing the level in Lake Meredith?

- Lack of rain
  - Increased evaporation
  - Increase in infiltration
  - Decreased spring flows
  - Change in water use
  - Increase in stock ponds
  - Spread of salt cedar
- Temperature Trend
- 

**Panhandle Water  
Planning Area**



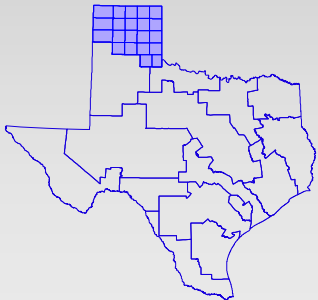
# Water Balance

Methods

Results

Conclusions

**Panhandle Water  
Planning Area**

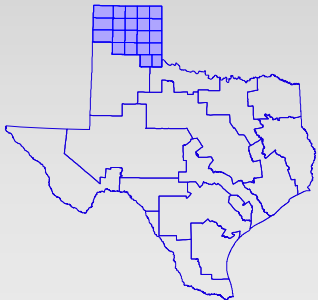


# Water Balance Methods

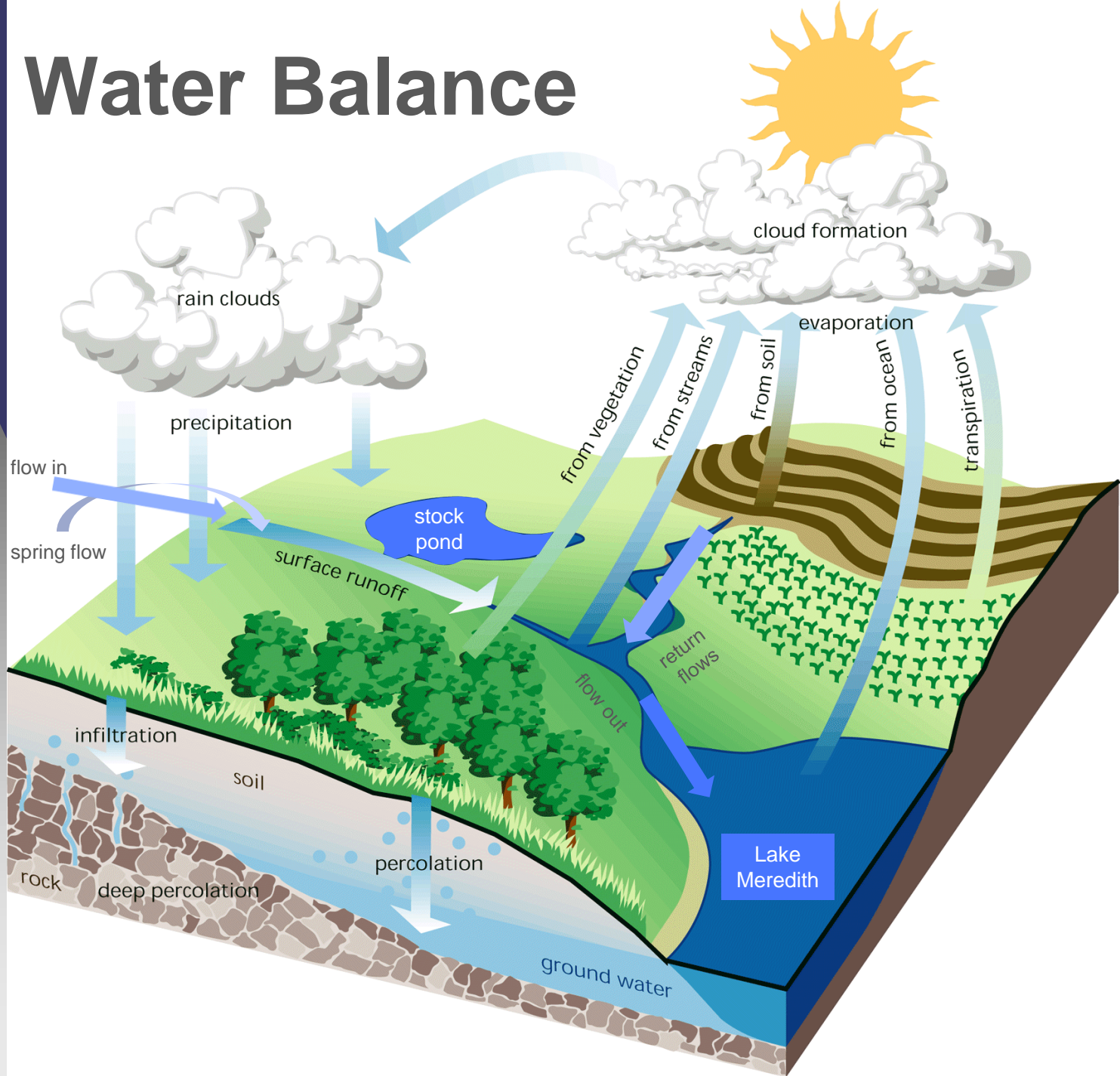
## *Hydrologic loss*

the percent of rainfall that does  
not turn into stream flow

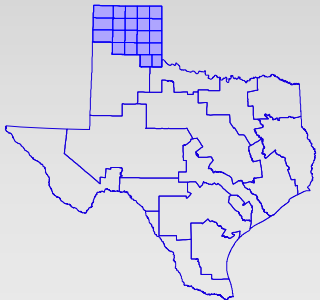
**Panhandle Water  
Planning Area**



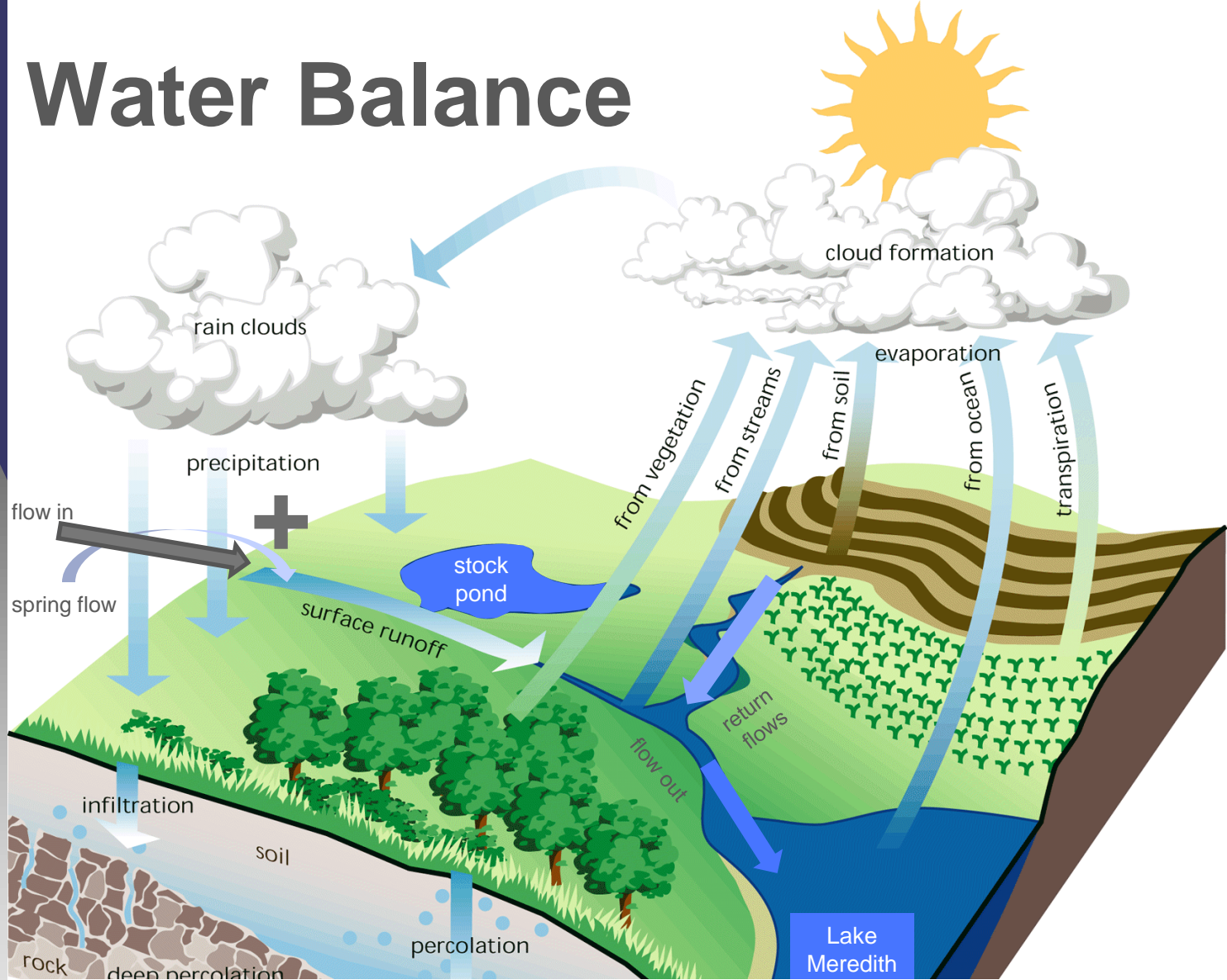
# Water Balance



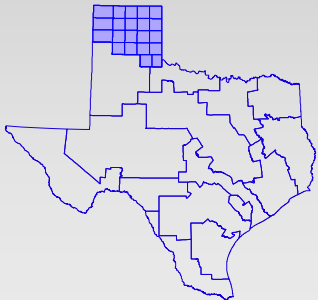
## Panhandle Water Planning Area



# Water Balance

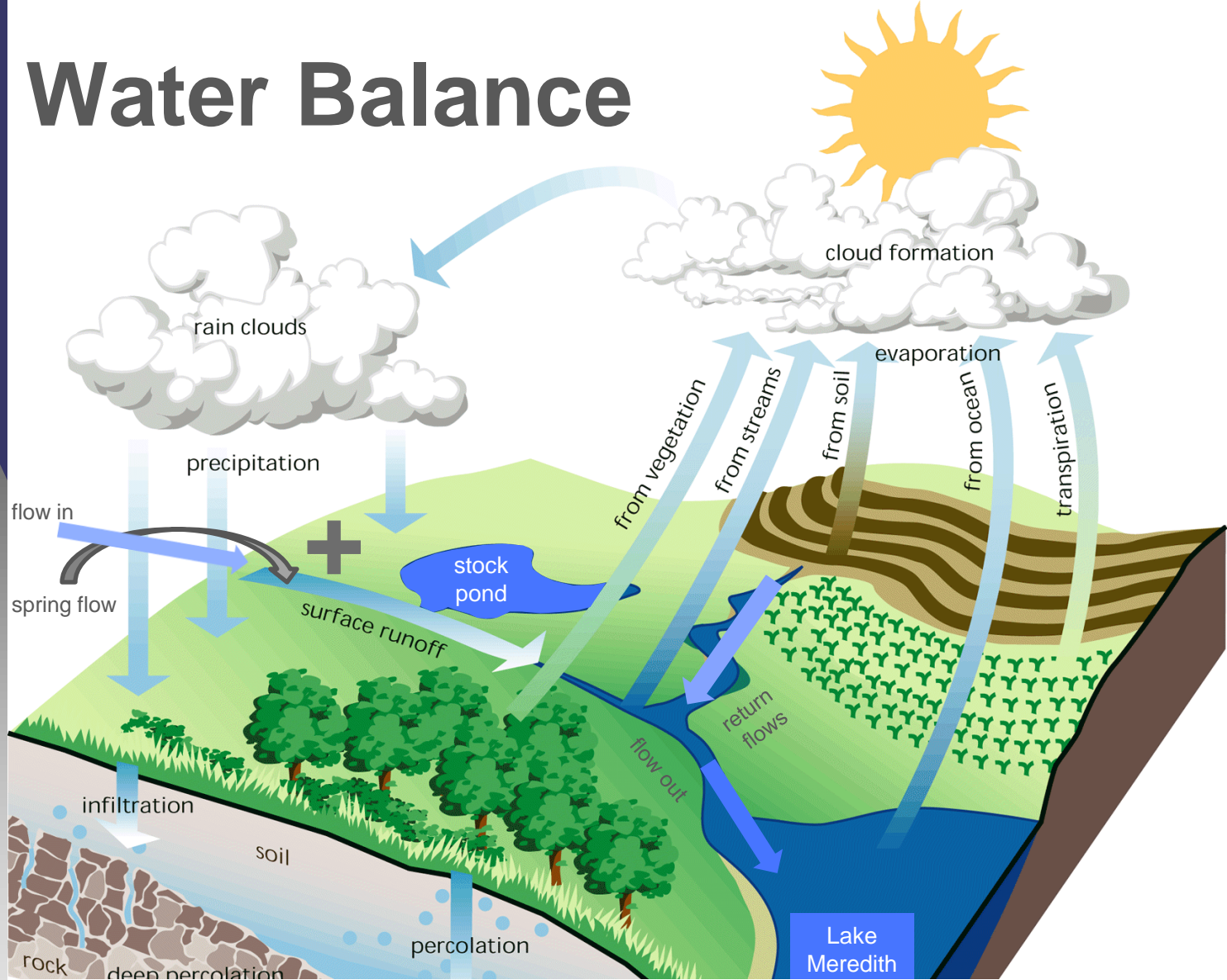


**Panhandle Water  
Planning Area**

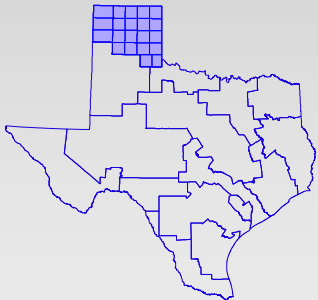


**Inflow +**

# Water Balance

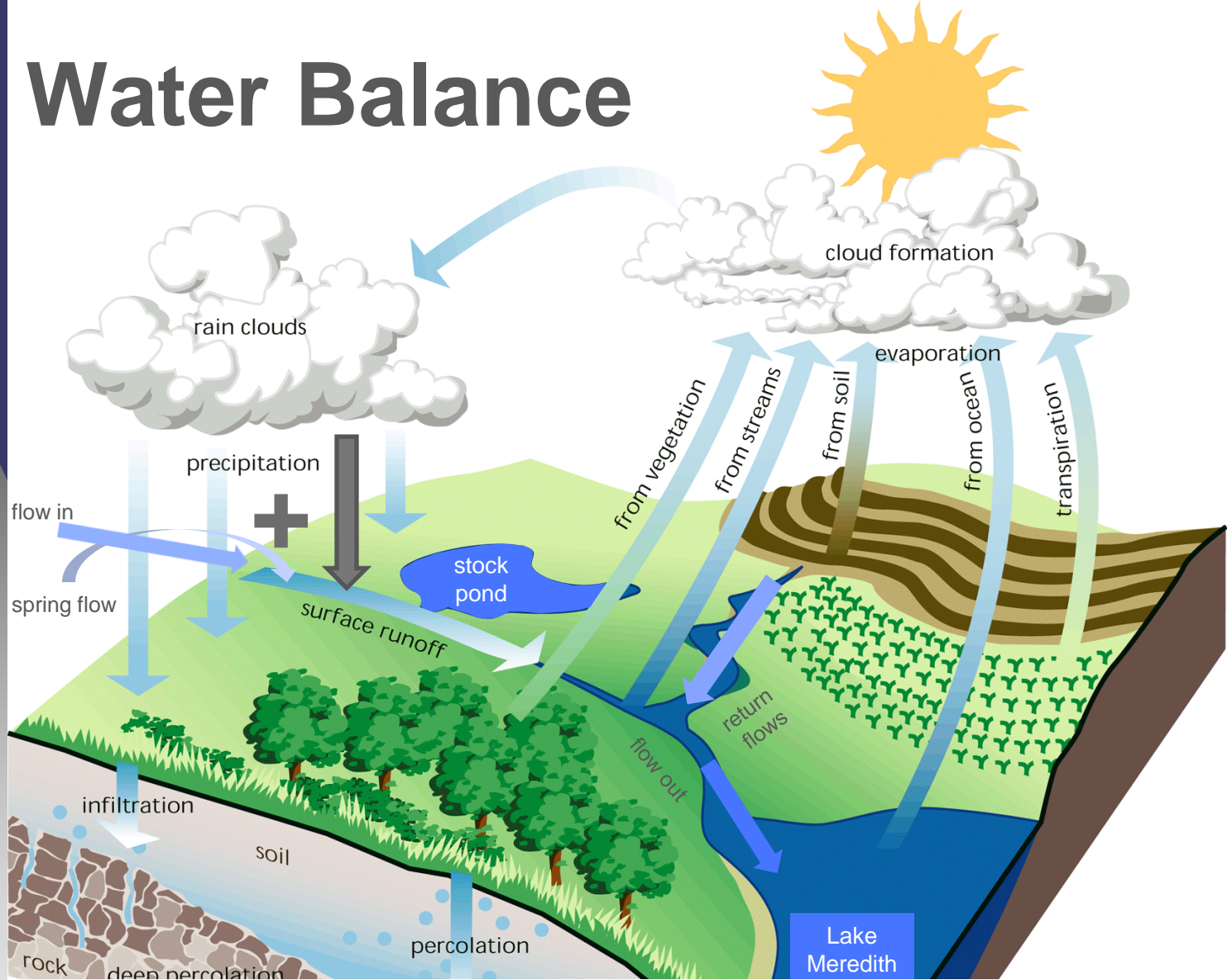


**Panhandle Water  
Planning Area**

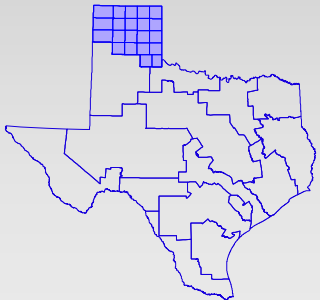


**Inflow + Spring flow**

# Water Balance

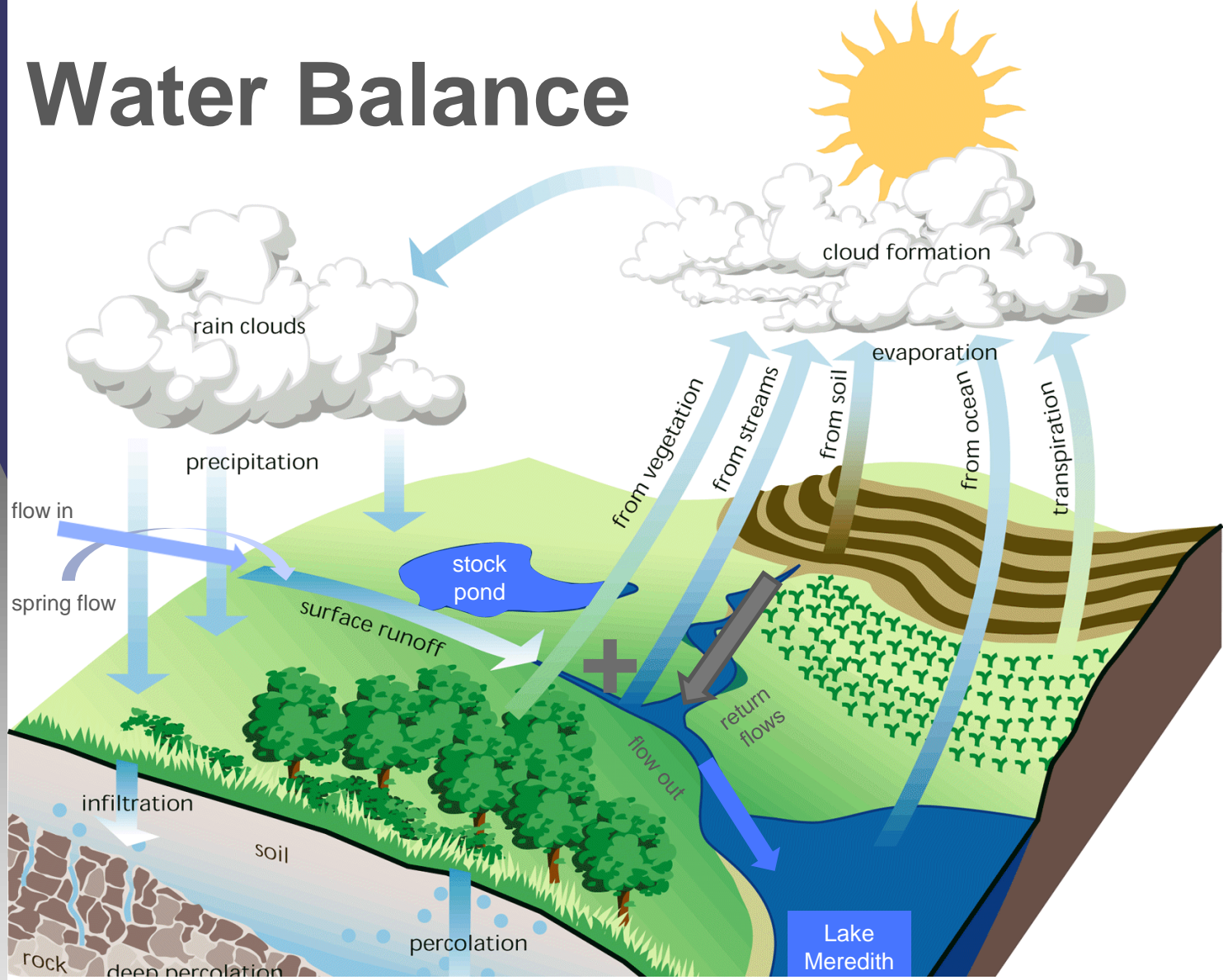


**Panhandle Water  
Planning Area**

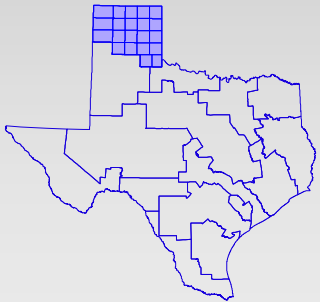


**Inflow + Spring flow + Precip**

# Water Balance

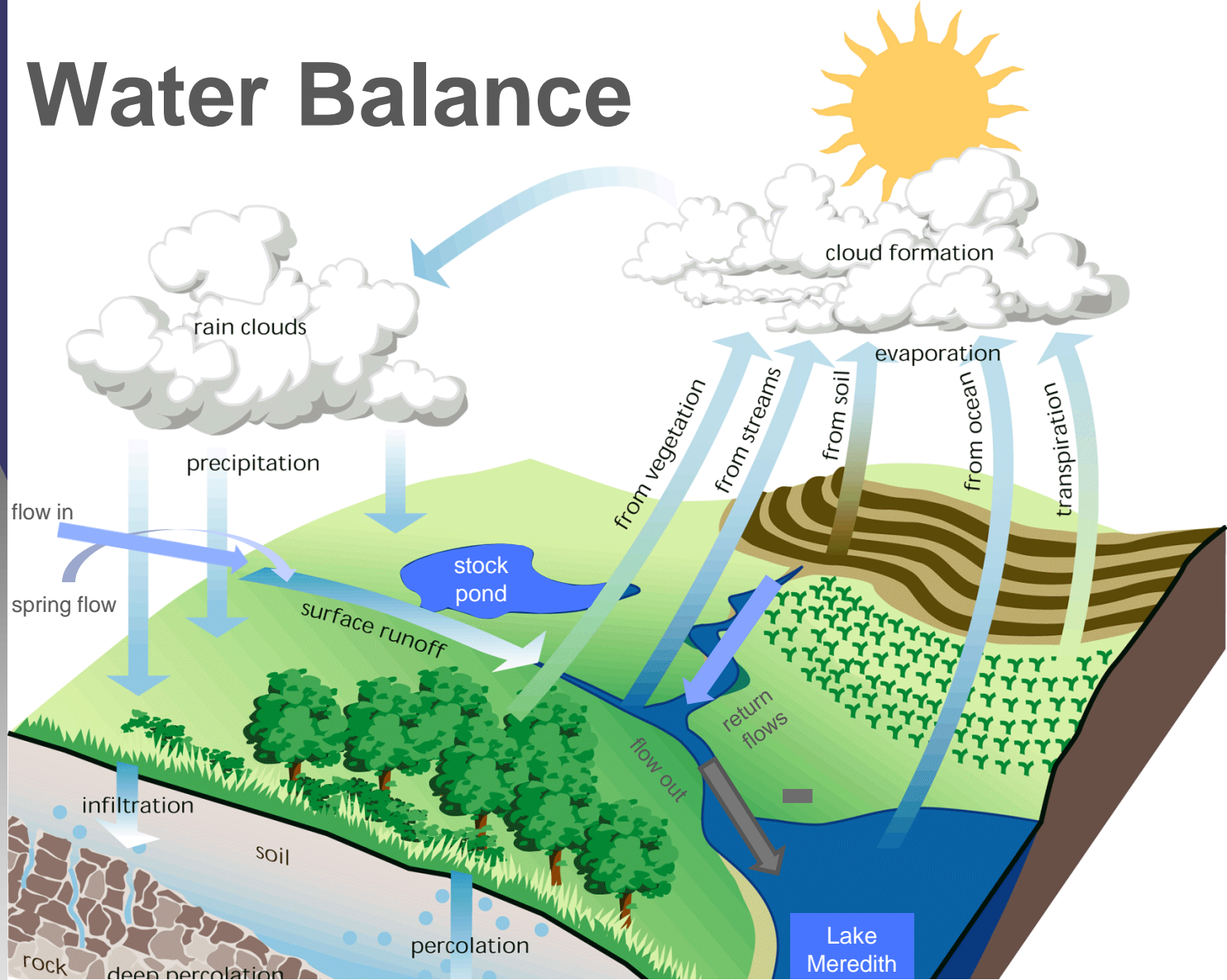


**Panhandle Water  
Planning Area**

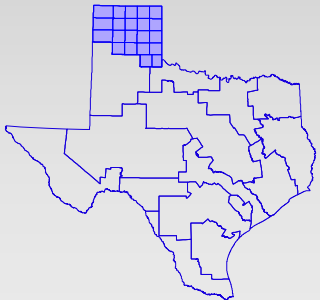


**Inflow + Spring flow + Precip + Return Flows**

# Water Balance

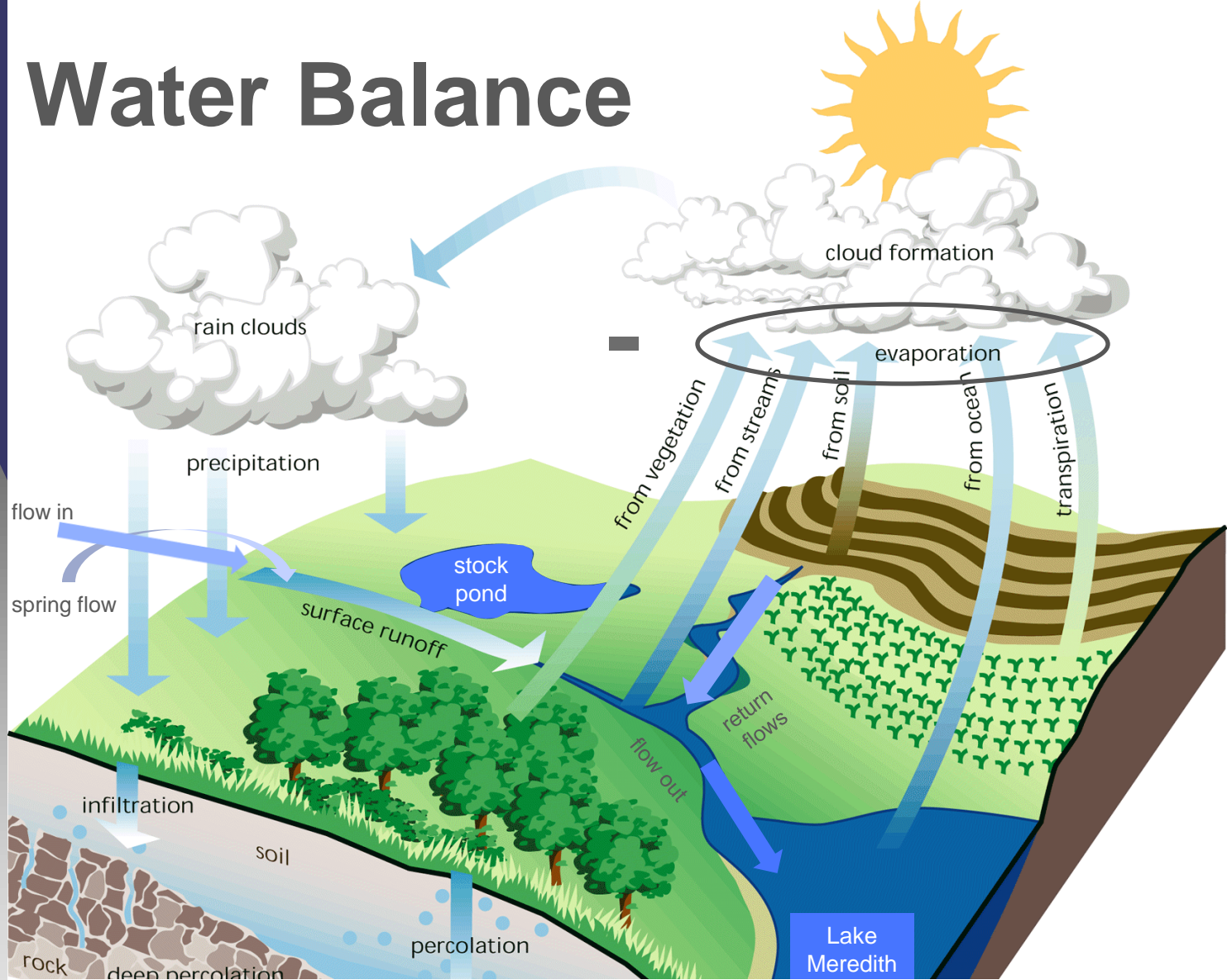


**Panhandle Water  
Planning Area**

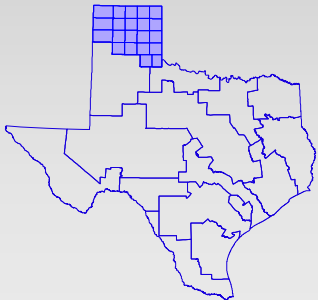


$$\text{Inflow} + \text{Spring flow} + \text{Precip} + \text{Return Flows} = \text{Outflow}$$

# Water Balance

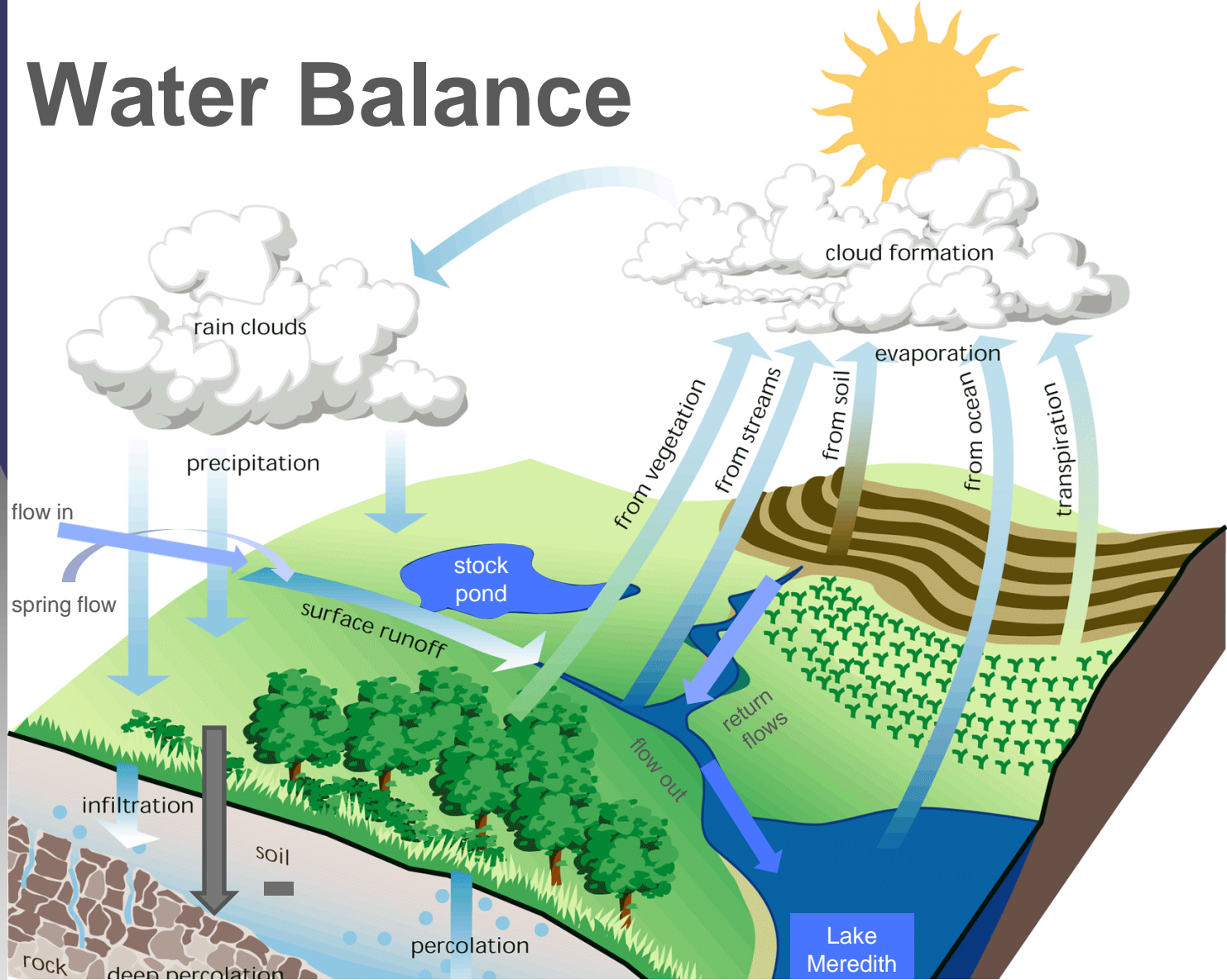


**Panhandle Water  
Planning Area**

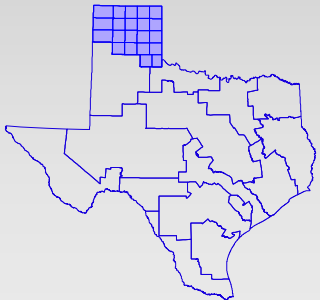


$$\text{Inflow} + \text{Spring flow} + \text{Precip} + \text{Return Flows} = \text{Outflow} + \text{Evaporation}$$

# Water Balance

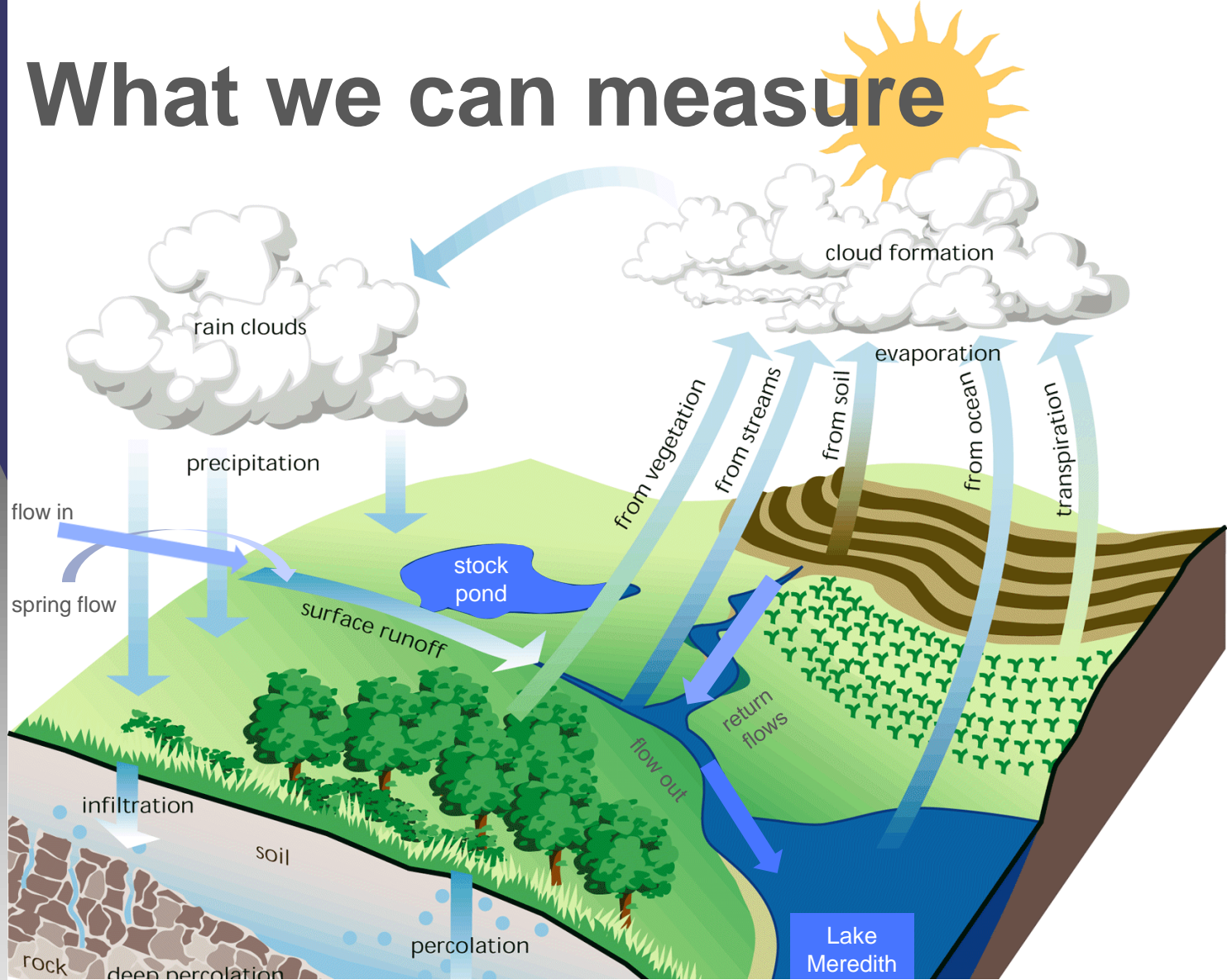


**Panhandle Water  
Planning Area**

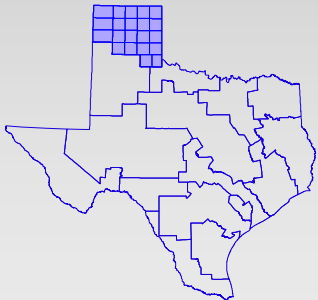


$$\text{Inflow} + \text{Spring flow} + \text{Precip} + \text{Return Flows} = \text{Outflow} + \text{Evaporation} + \text{Infiltration}$$

# What we can measure

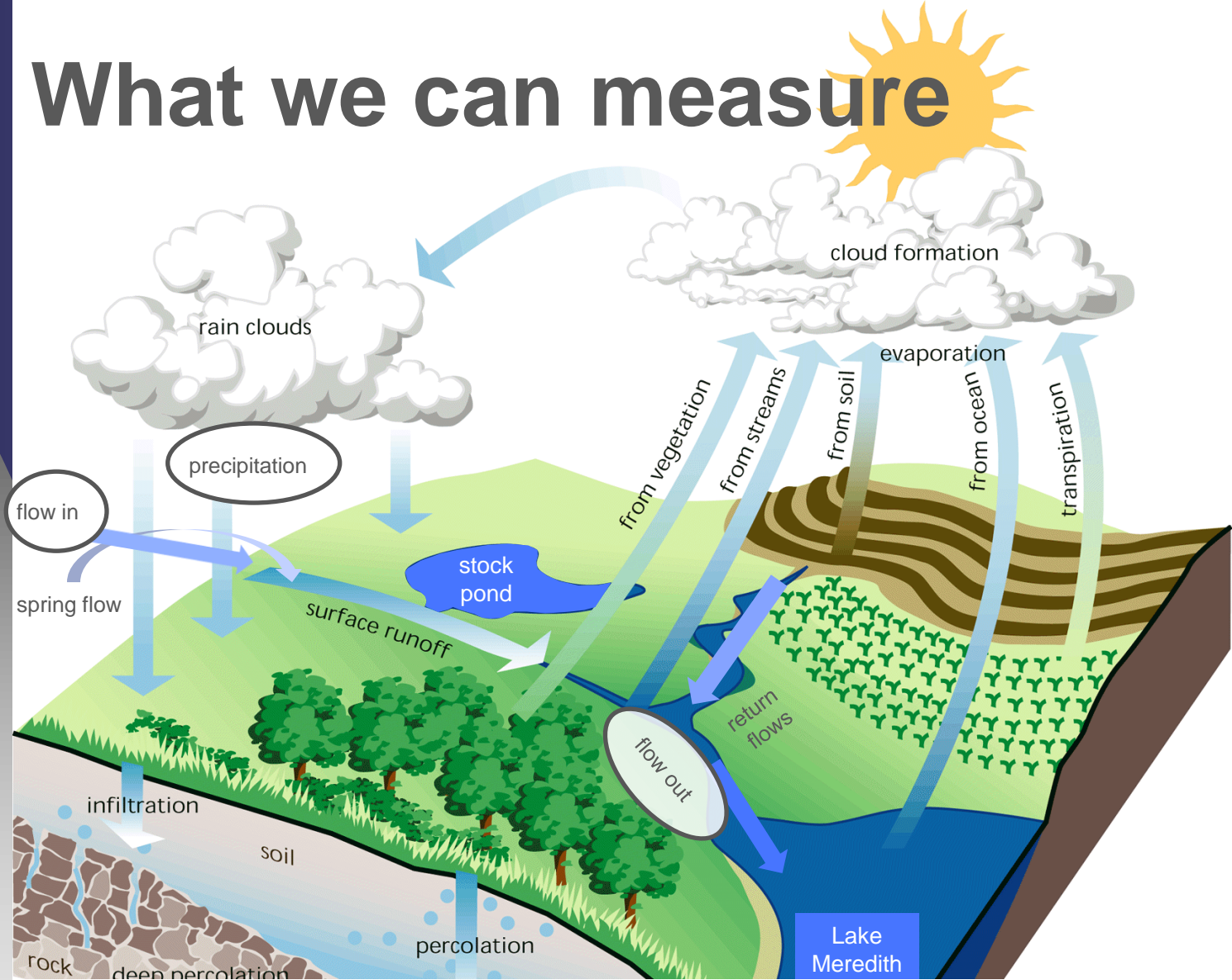


**Panhandle Water  
Planning Area**

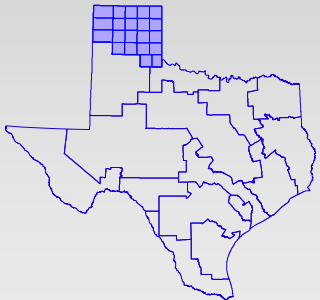


$$\text{Inflow} + \text{Spring flow} + \text{Precip} + \text{Return Flows} = \text{Outflow} + \text{Evaporation} + \text{Infiltration}$$

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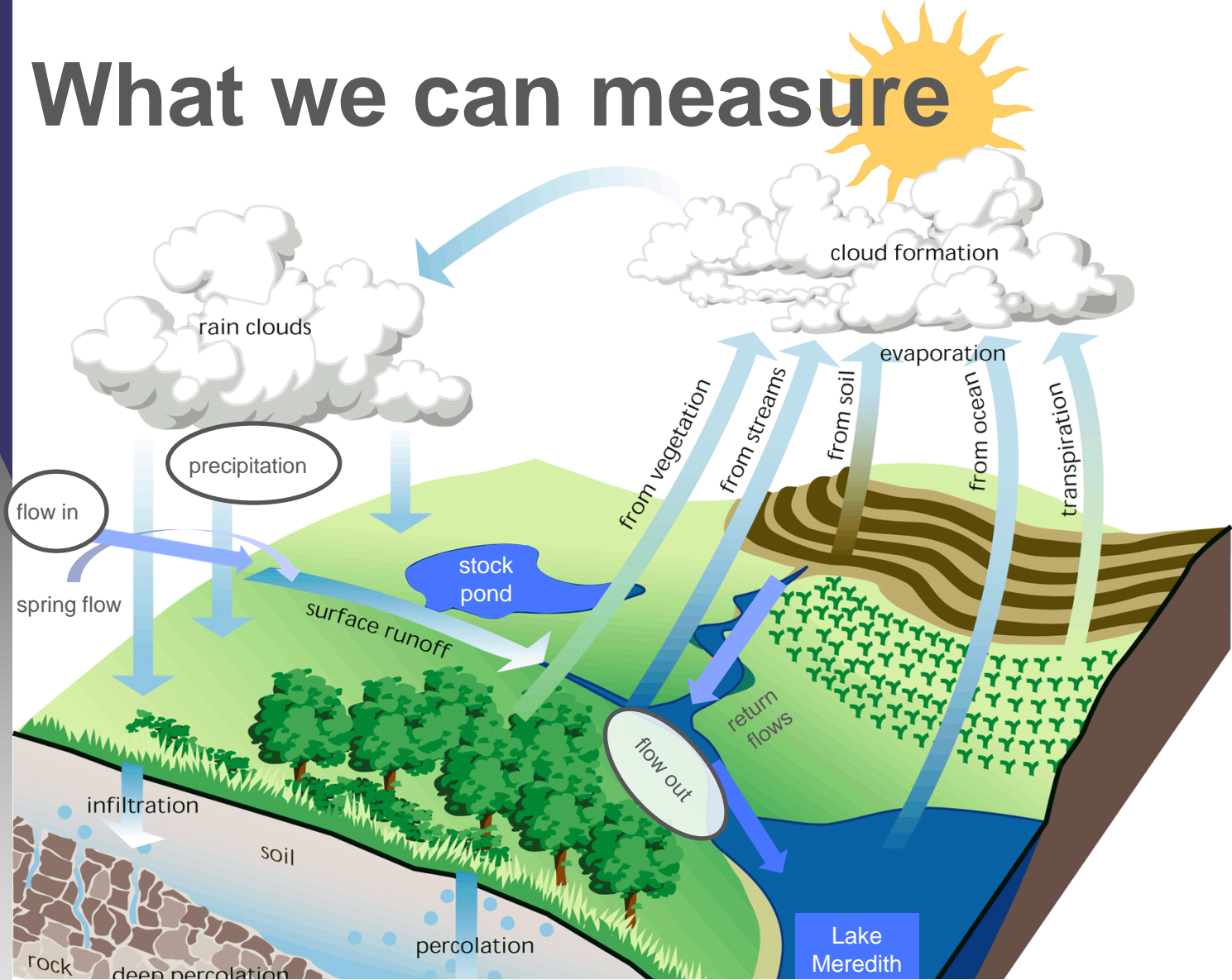


**Panhandle Water  
Planning Area**

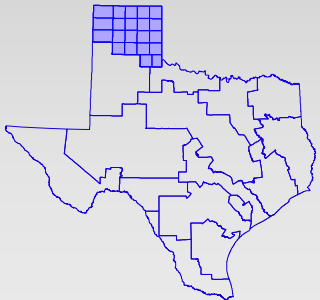


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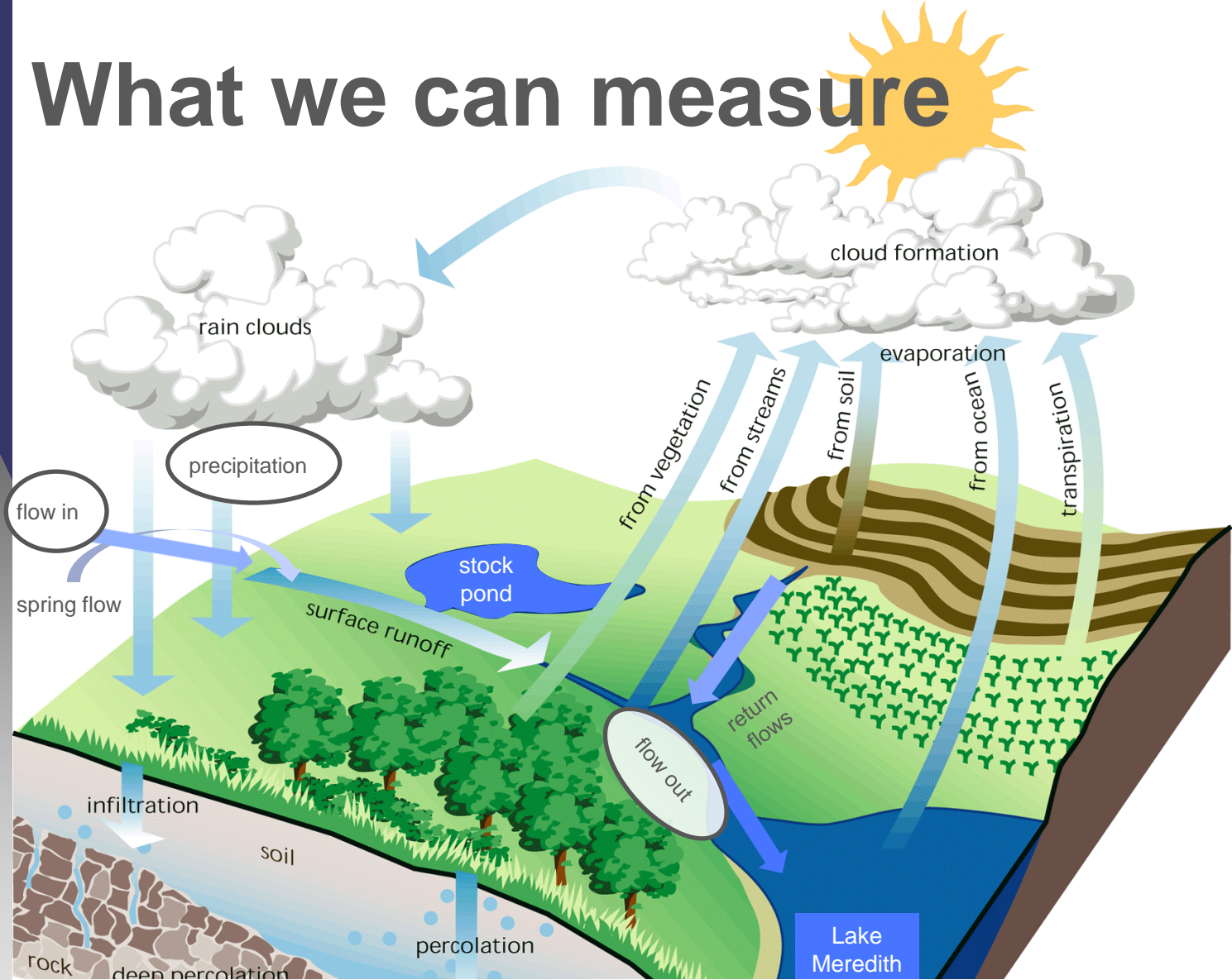


**Panhandle Water  
Planning Area**

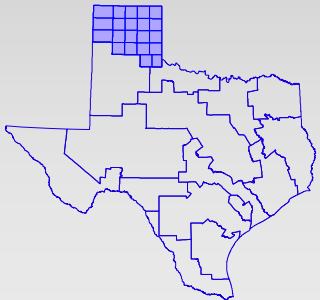


$$\text{Inflow} + \text{Spring flow} + \text{Precip} + \text{Return Flows} = \text{Outflow} + \text{Evaporation} + \text{Infiltration}$$

# What we can measure



**Panhandle Water  
Planning Area**



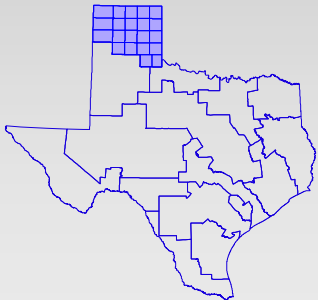
$$\text{Hydrologic Loss} = \text{Inflow} + \text{Precip} - \text{Outflow}$$

# Water Balance Methods

$$\text{Hydrologic Loss} = \text{Inflow} + \text{Precip} - \text{Outflow}$$

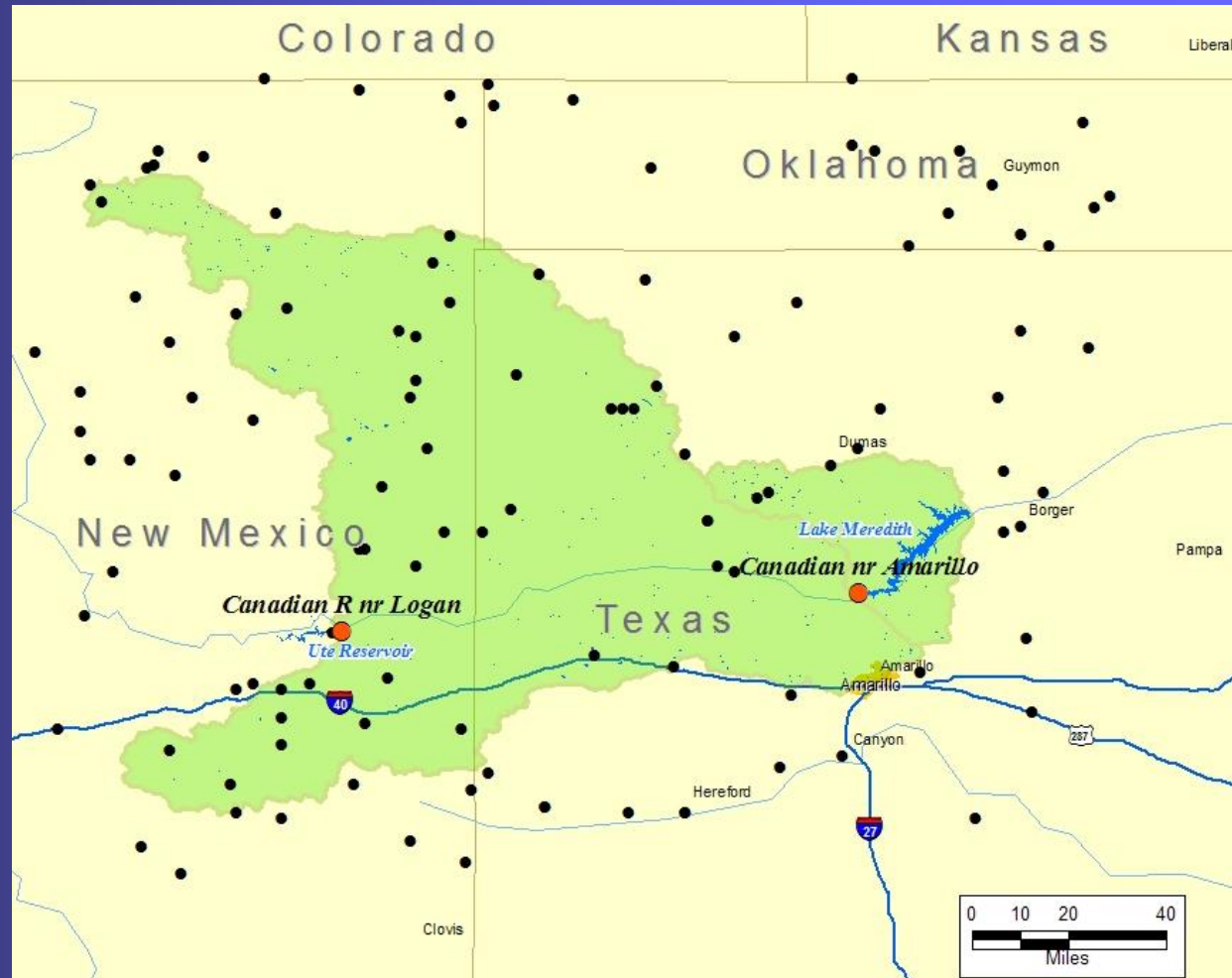
- **Time Period:** 1940 – 2006
- **Inflow:** Stream gage at Logan
- **Outflow:** Stream gage at Amarillo
- **Precip:** Interpolated from rain gages

**Panhandle Water  
Planning Area**



# Water Balance

$$\text{Hydrologic Loss} = \text{Inflow} + \text{Precip} - \text{Outflow}$$

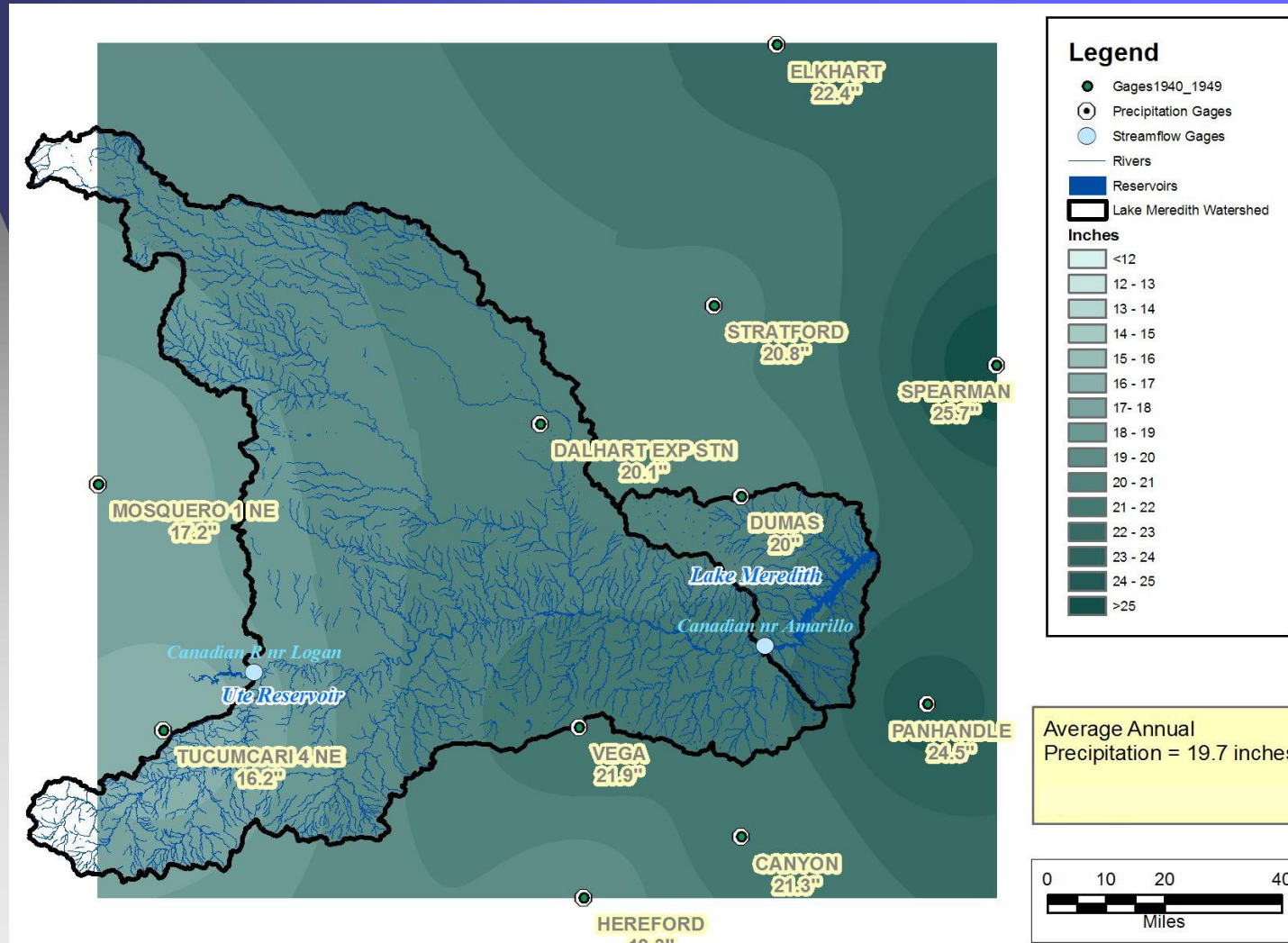


**Panhandle Water  
Planning Area**

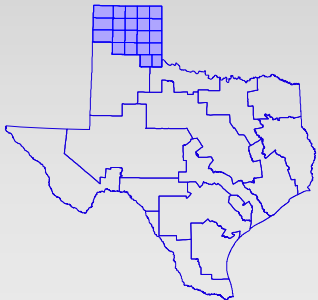


# Water Balance

## Average Annual Precipitation (1940 – 1949)

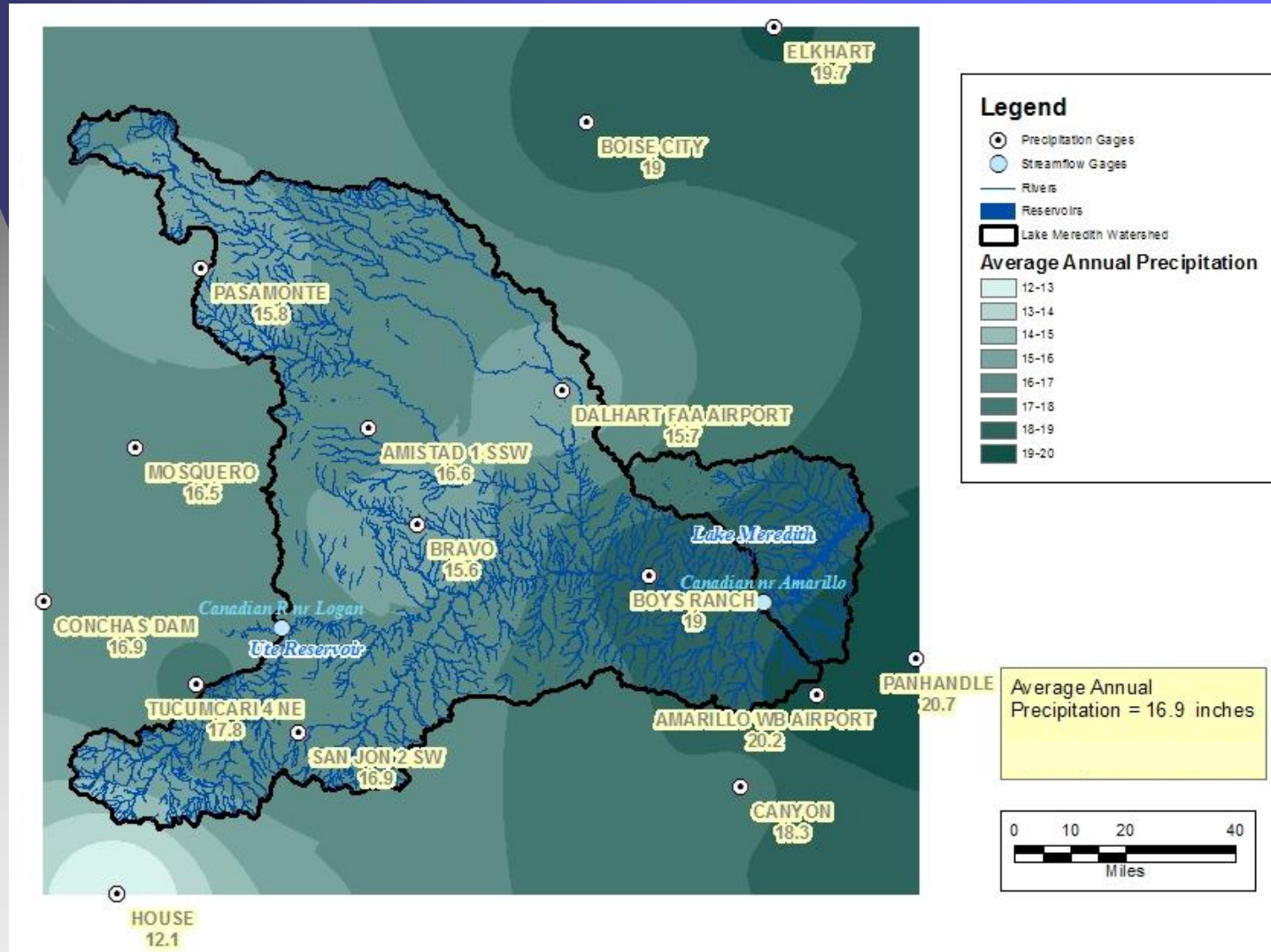


### Panhandle Water Planning Area

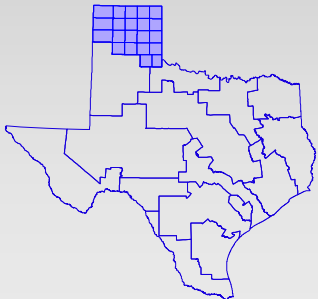


# Water Balance

## Average Annual Precipitation (1997 – 2006)



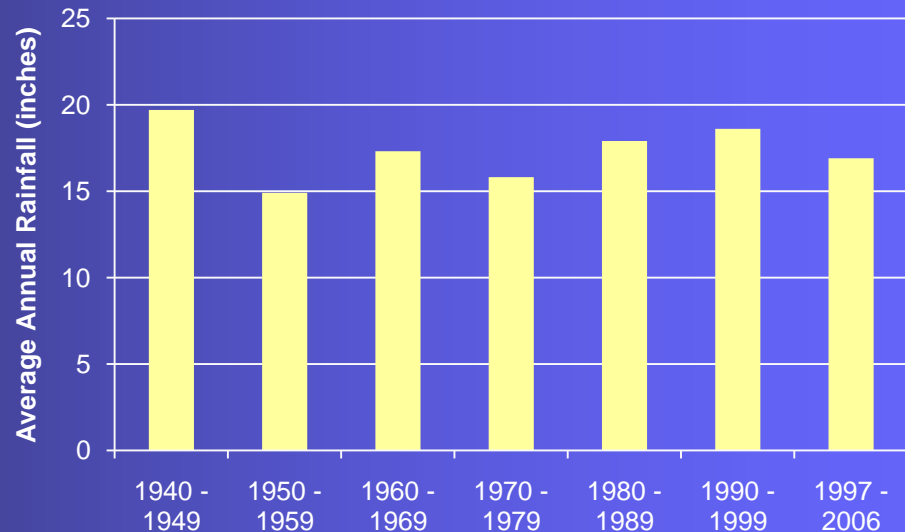
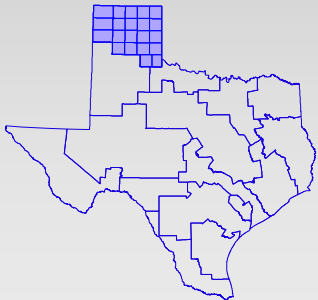
### Panhandle Water Planning Area



# Water Balance Results

## Average Annual Rainfall per Decade

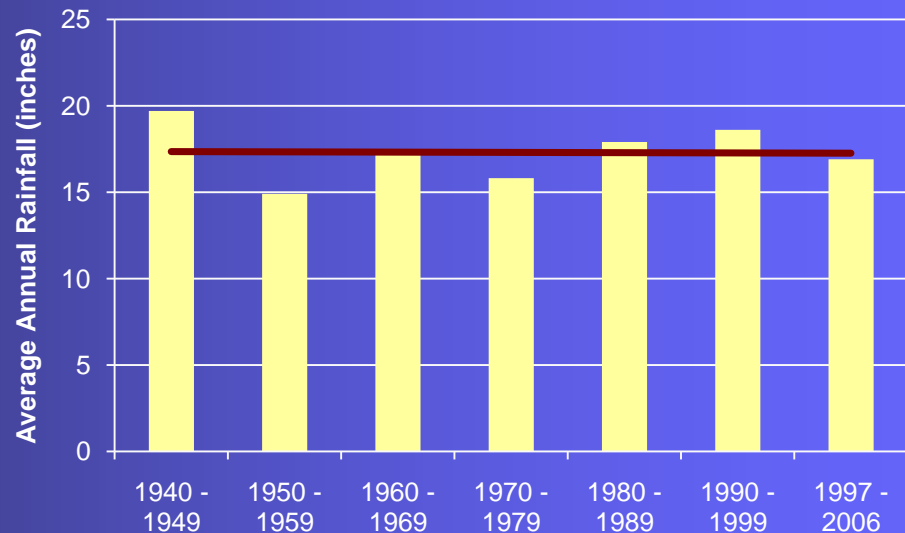
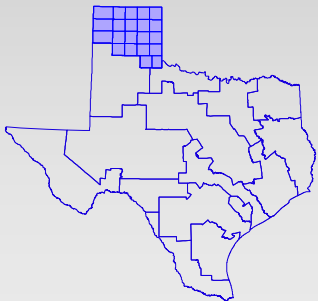
**Panhandle Water  
Planning Area**



# Water Balance Results

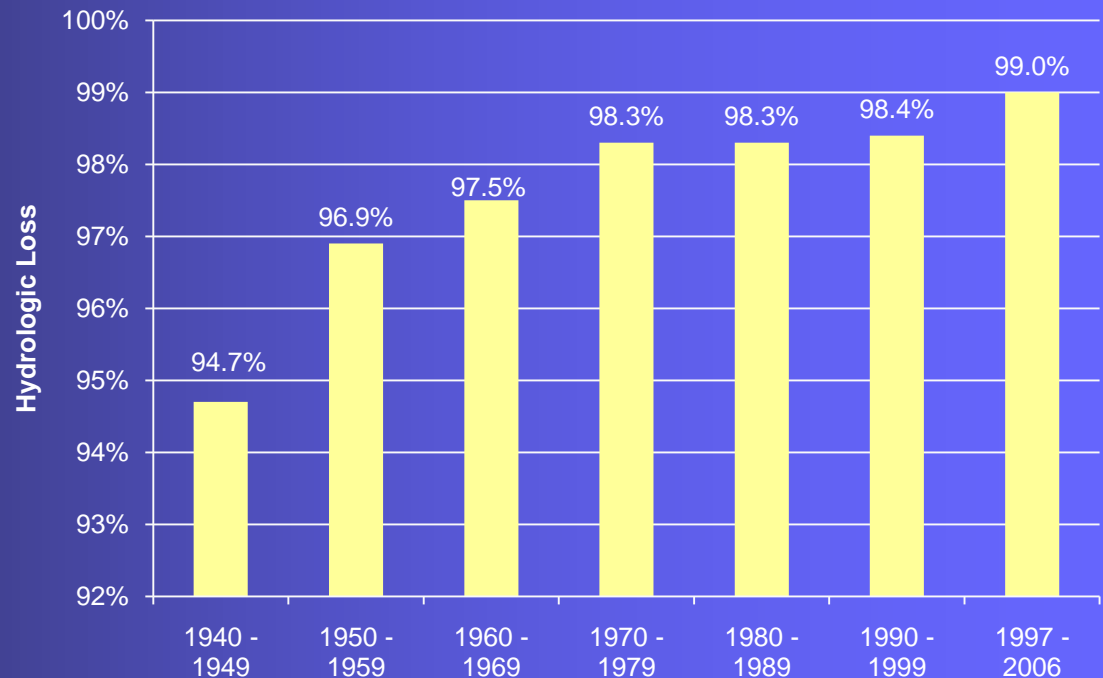
## Average Annual Rainfall per Decade

**Panhandle Water  
Planning Area**

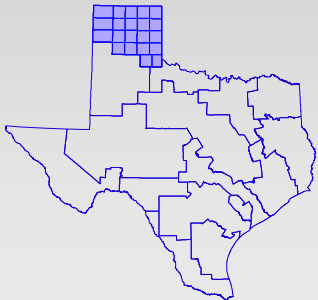


# Water Balance Results

## Hydrologic Loss per Decade



**Panhandle Water  
Planning Area**

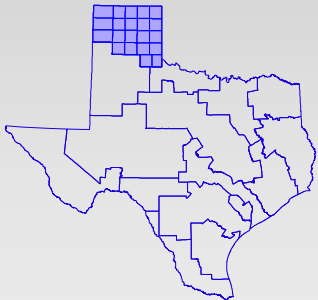


# Water Balance Conclusions

Since 1940...

- Rainfall has stayed the same
- Hydrologic loss has increased
- Less runoff is being generated

**Panhandle Water  
Planning Area**

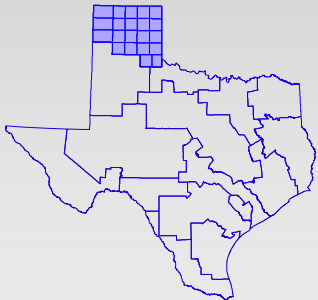


# Water Balance Conclusions

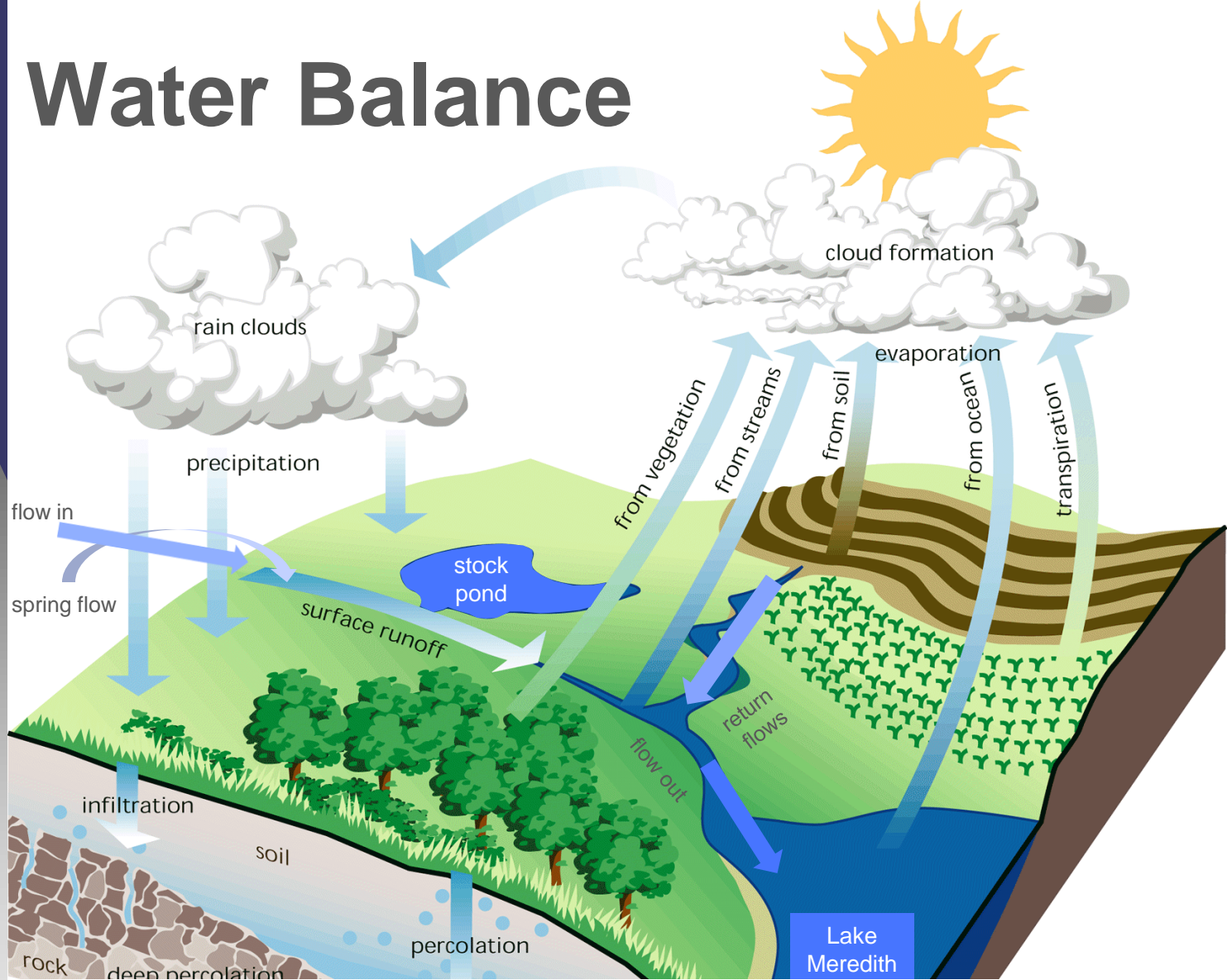
Since 1940...

- Rainfall has stayed the same
- Hydrologic loss has increased
- Less runoff is being generated
- Why?

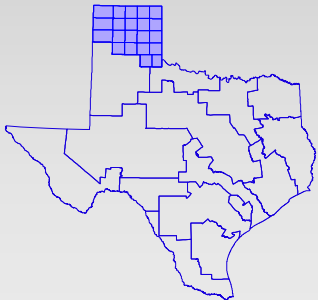
**Panhandle Water  
Planning Area**



# Water Balance

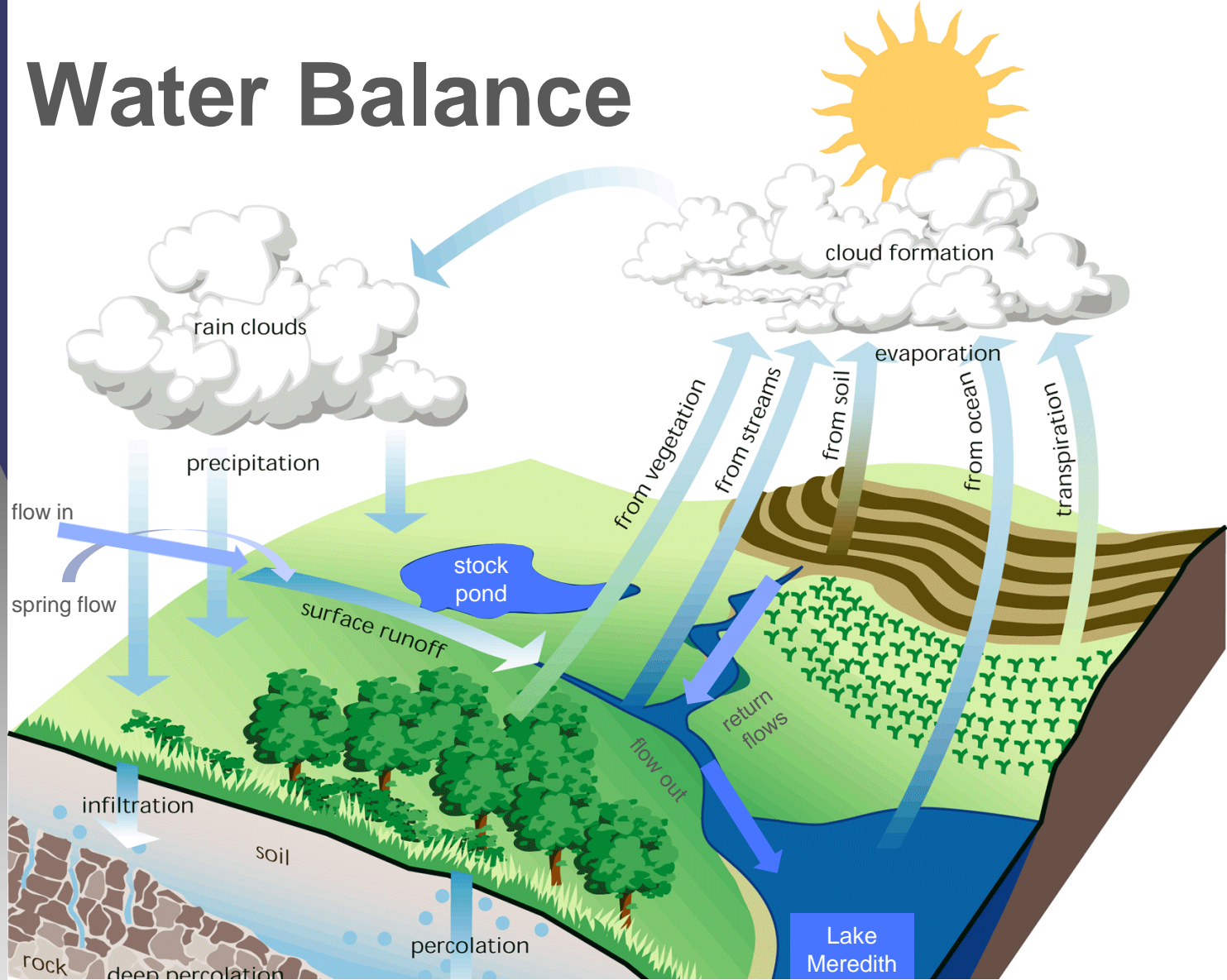


**Panhandle Water  
Planning Area**

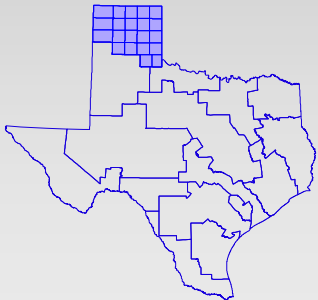


$$\text{Inflow} + \text{Spring flow} + \text{Precip} + \text{Return Flows} = \text{Outflow} + \text{Evaporation} + \text{Infiltration}$$

# Water Balance

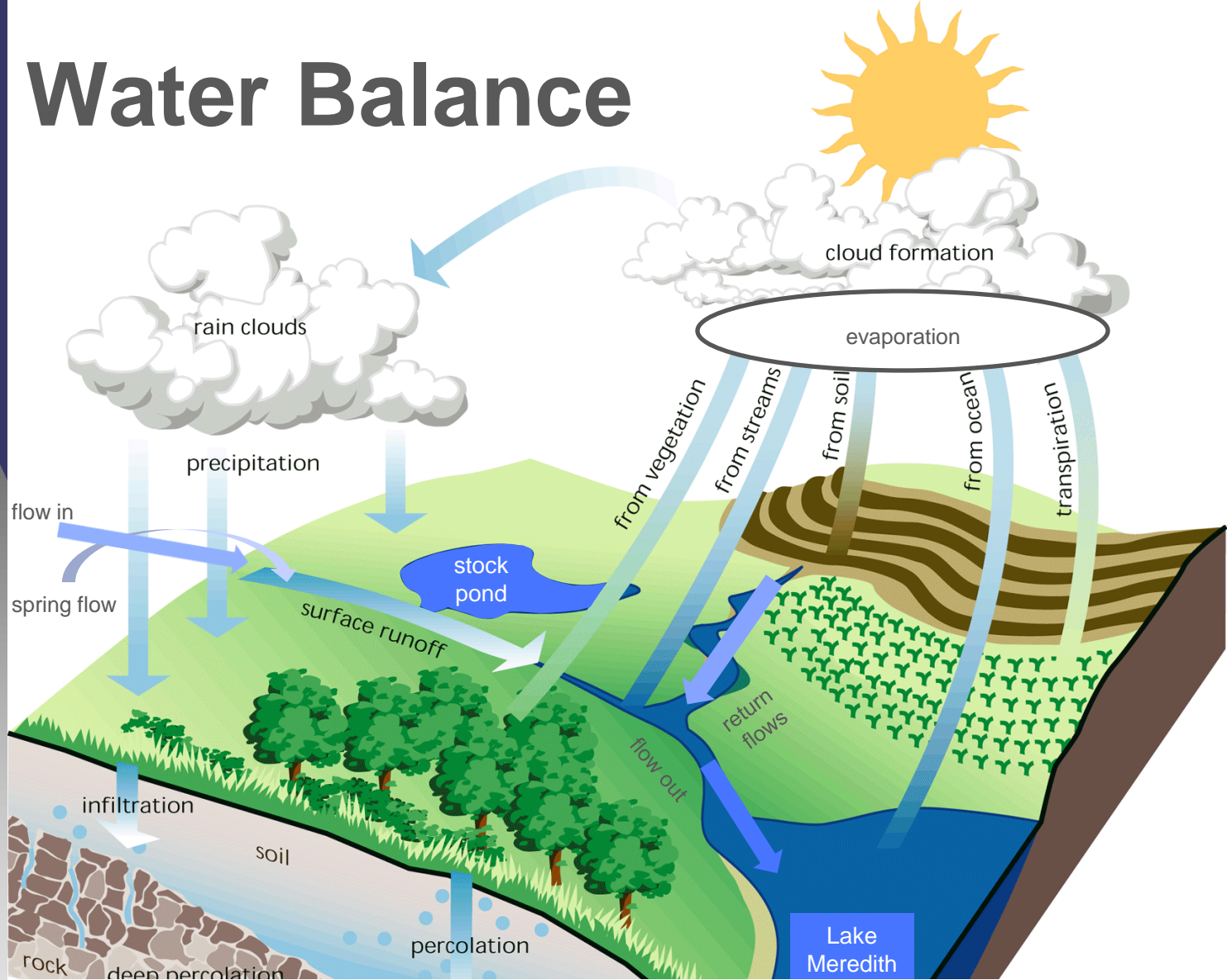


**Panhandle Water  
Planning Area**

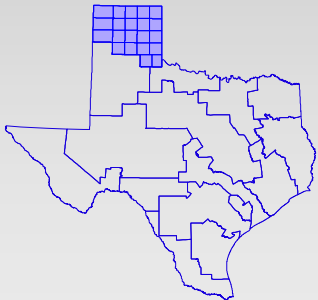


$$\text{Inflow} + \text{Spring flow} + \text{Precip} + \text{Return Flows} = \text{Outflow} + \text{Evaporation} + \text{Infiltration}$$

# Water Balance



**Panhandle Water  
Planning Area**



$$\begin{aligned}
 & \text{Inflow} + \text{Spring flow} + \text{Precip} + \text{Return Flows} \\
 & = \text{Outflow} + \text{Evaporation} + \text{Infiltration}
 \end{aligned}$$

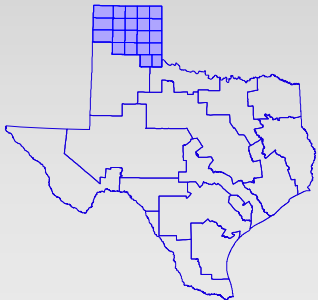
# Temperature Trends

Methods

Results

Conclusions

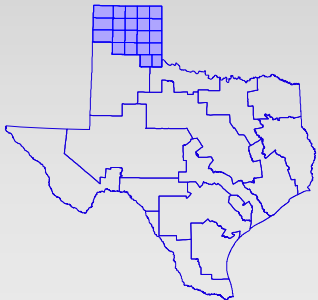
**Panhandle Water  
Planning Area**



# Temperature Trends Methods

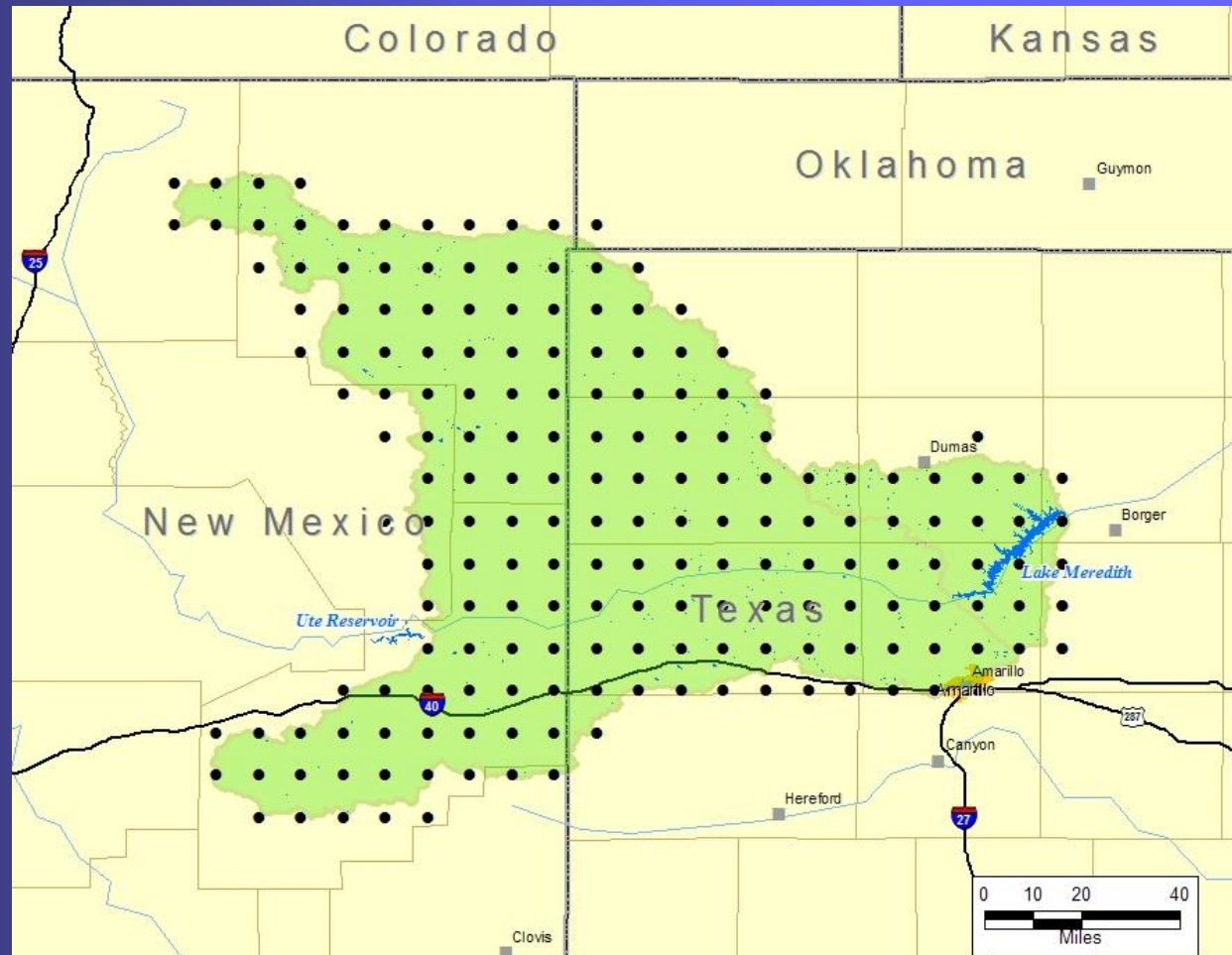
- **Objective:** Determine if trends exist in annual and seasonal temps
- **Dataset:** Maurer et al. (2002)
  - Monthly
  - Max and Min Temp
- **Procedure:** annual average max and min temps were calculated for each grid point

**Panhandle Water  
Planning Area**

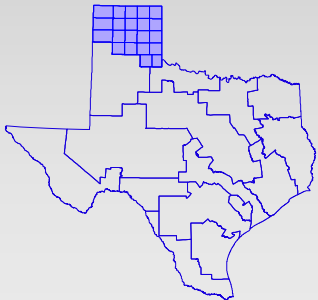


# Temperature Trends Methods

## Grid Points in Meredith Watershed

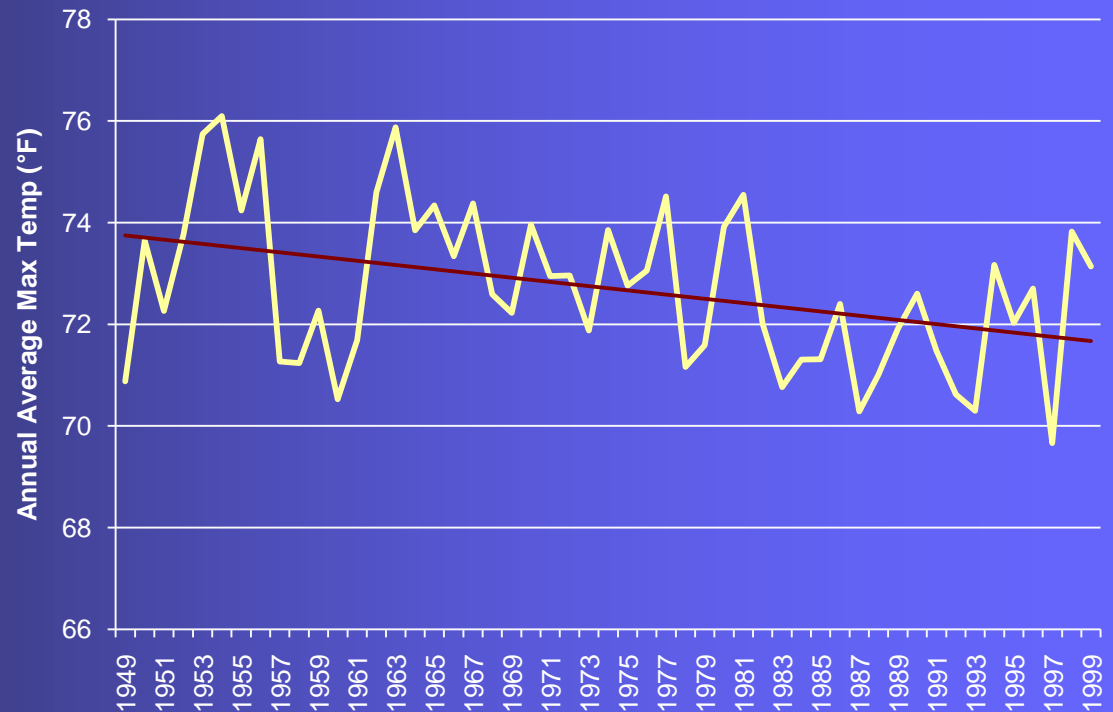


**Panhandle Water  
Planning Area**

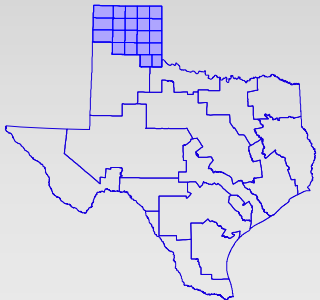


# Temperature Trends Methods

## Grid Points in Meredith Watershed

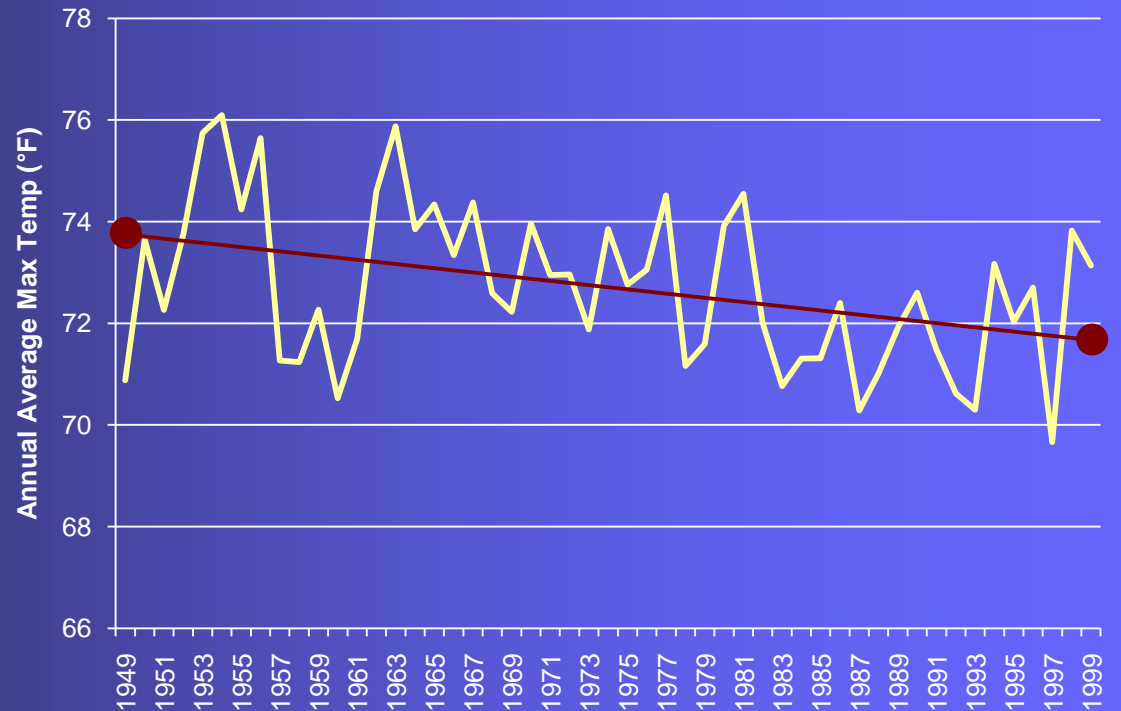


**Panhandle Water  
Planning Area**

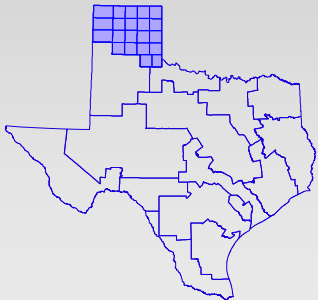


# Temperature Trends Methods

## Grid Points in Meredith Watershed

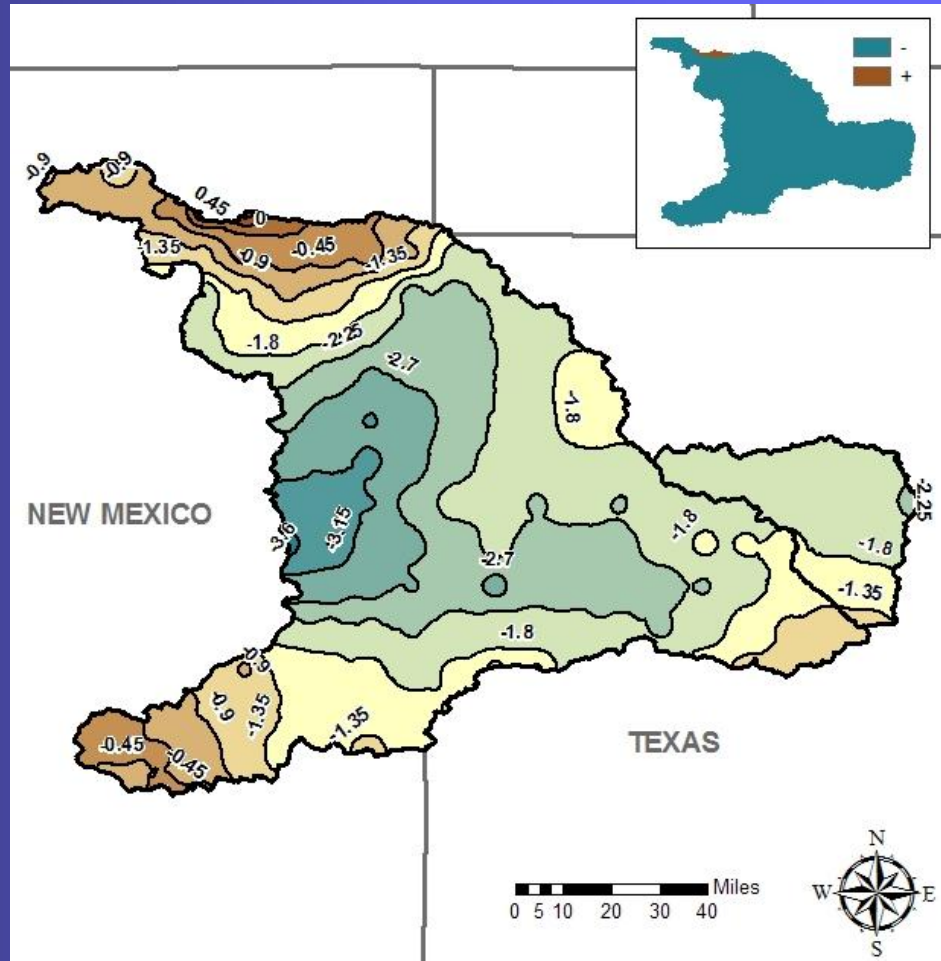


**Panhandle Water  
Planning Area**

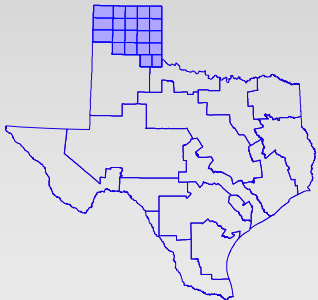


# Temperature Trends Results

## Change in Max Temperatures (1949 – 1999)

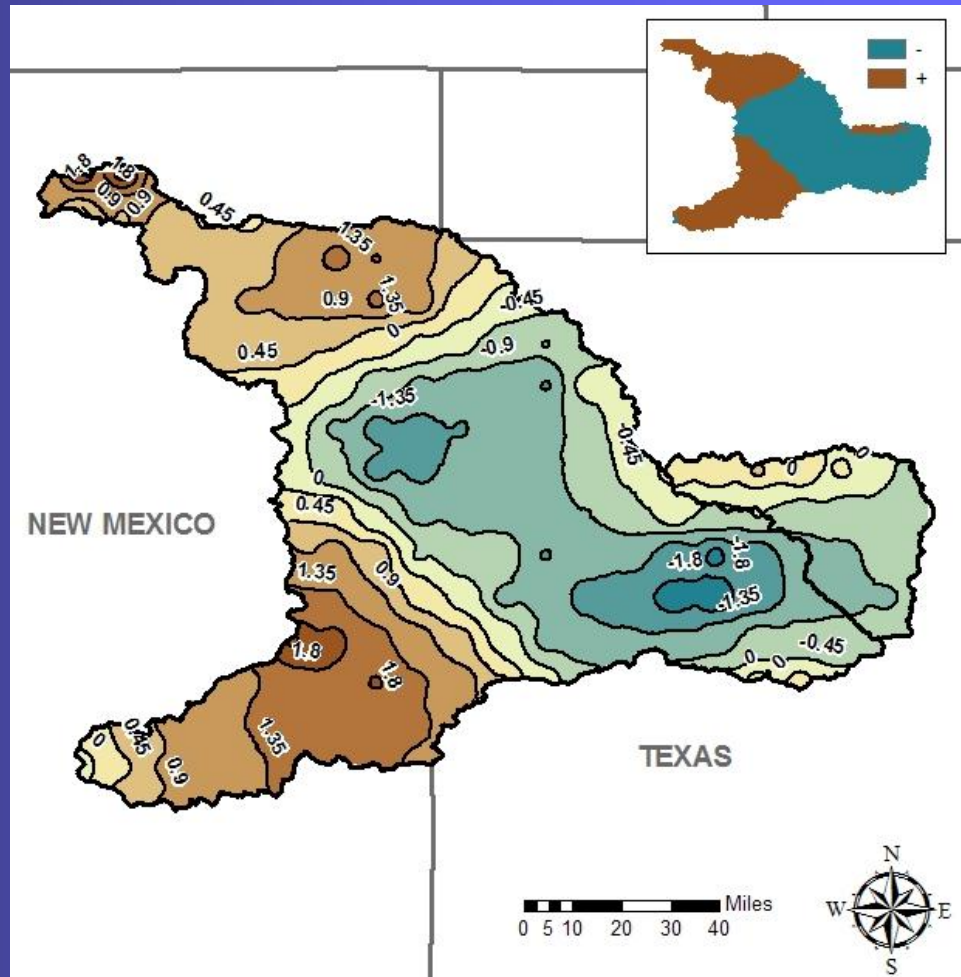


**Panhandle Water  
Planning Area**

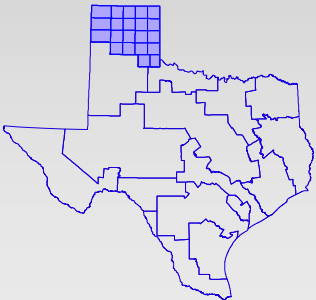


# Temperature Trends Results

## Change in Min Temperatures (1949 – 1999)

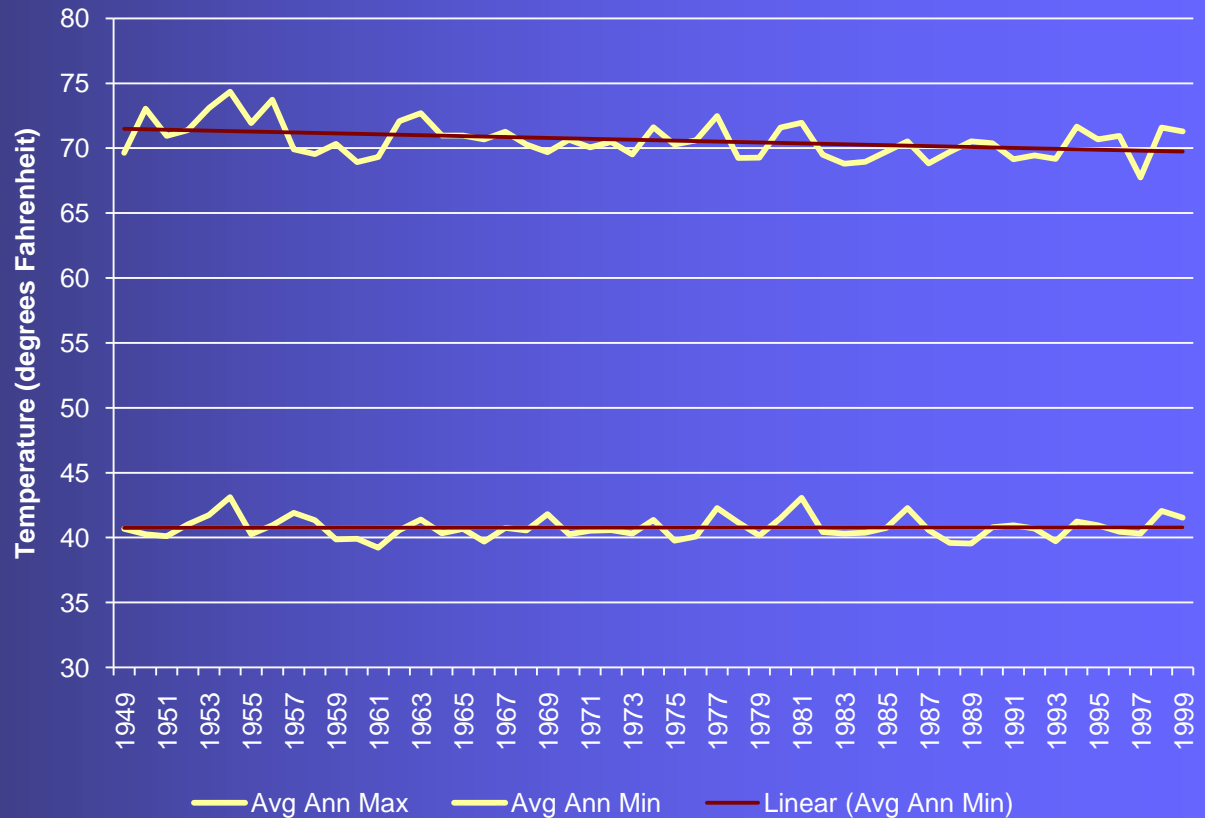


**Panhandle Water  
Planning Area**

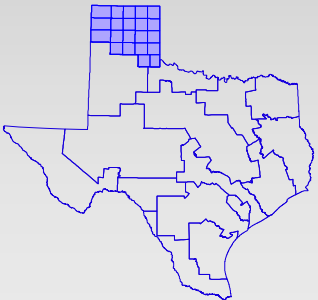


# Temperature Trends Results

## Change in Temperatures (1949 – 1999)

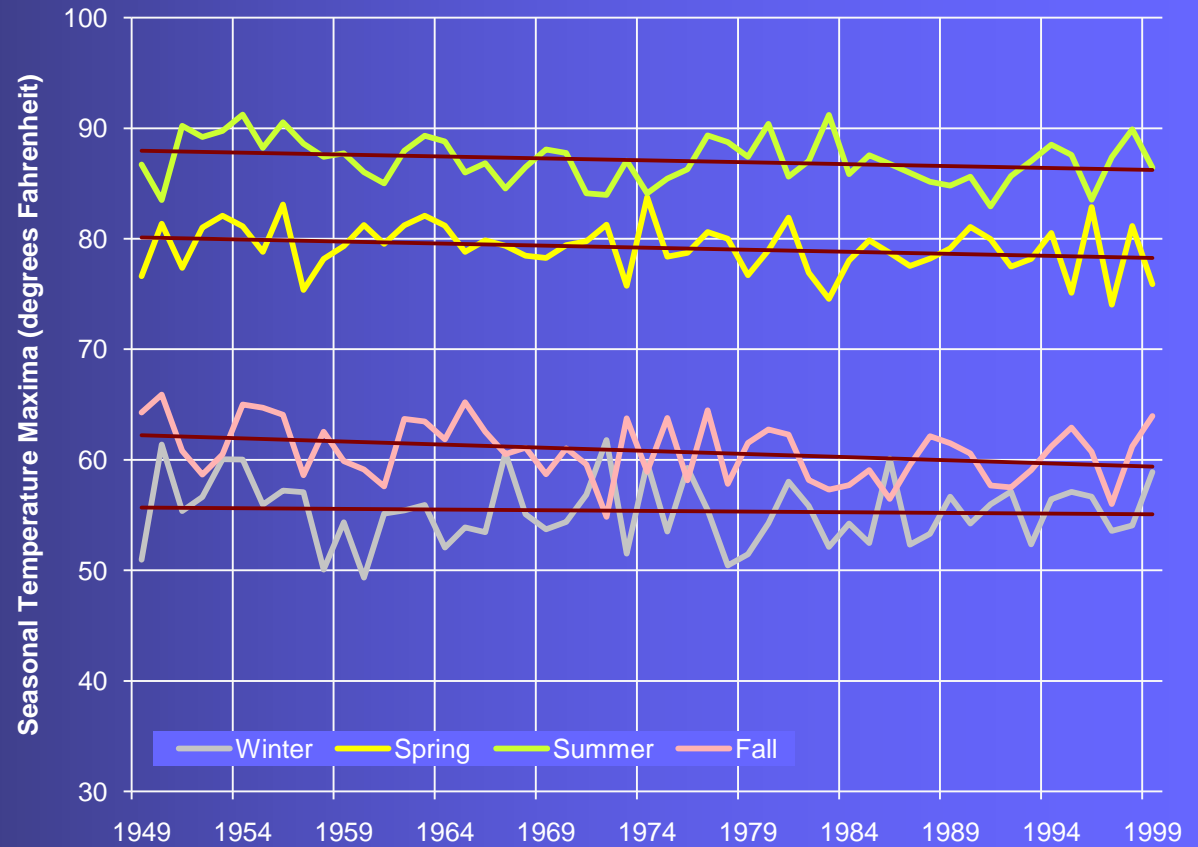


**Panhandle Water  
Planning Area**

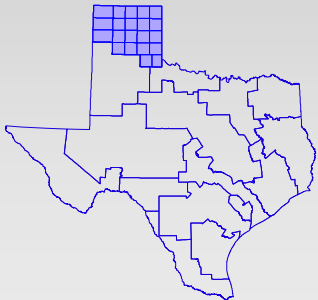


# Temperature Trends Results

## Change in Seasonal Max Temps (1949-1999)

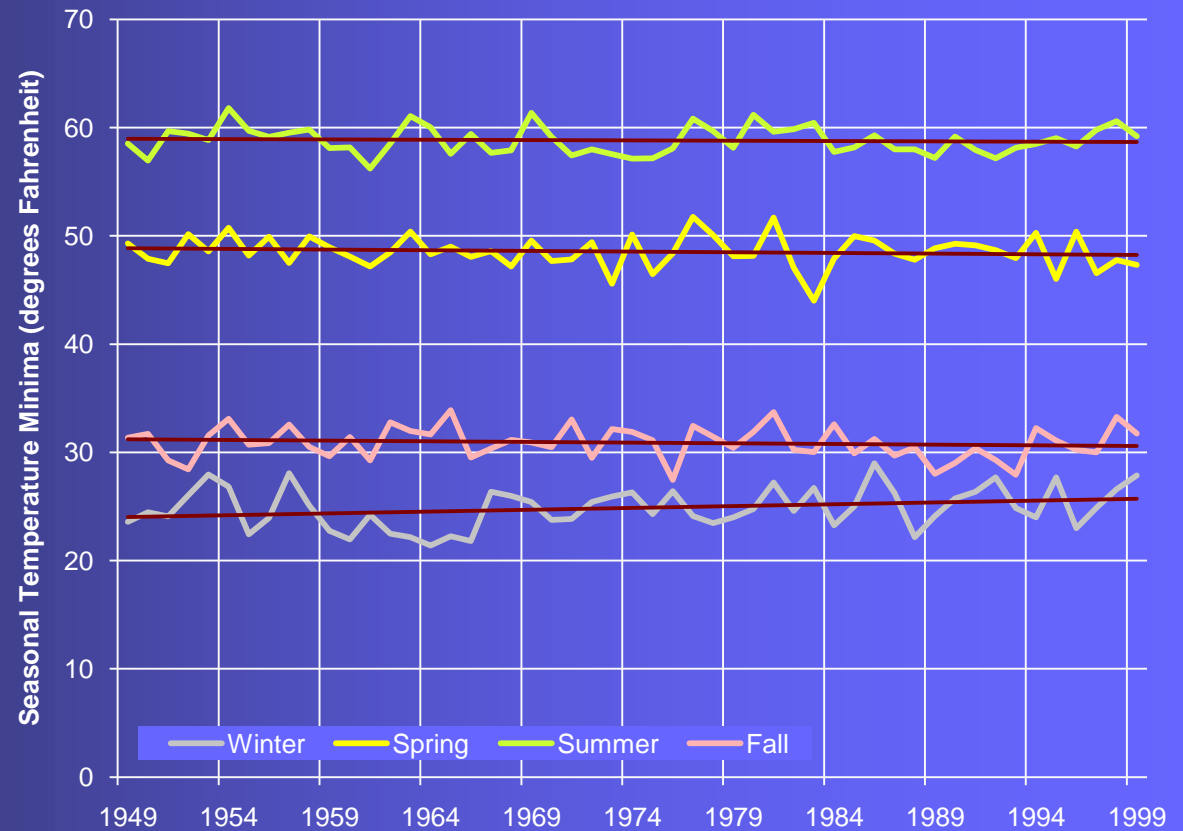


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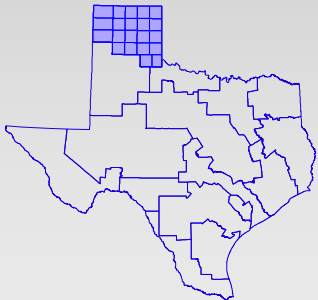


# Temperature Trends Results

## Change in Seasonal Min Temps (1949-1999)



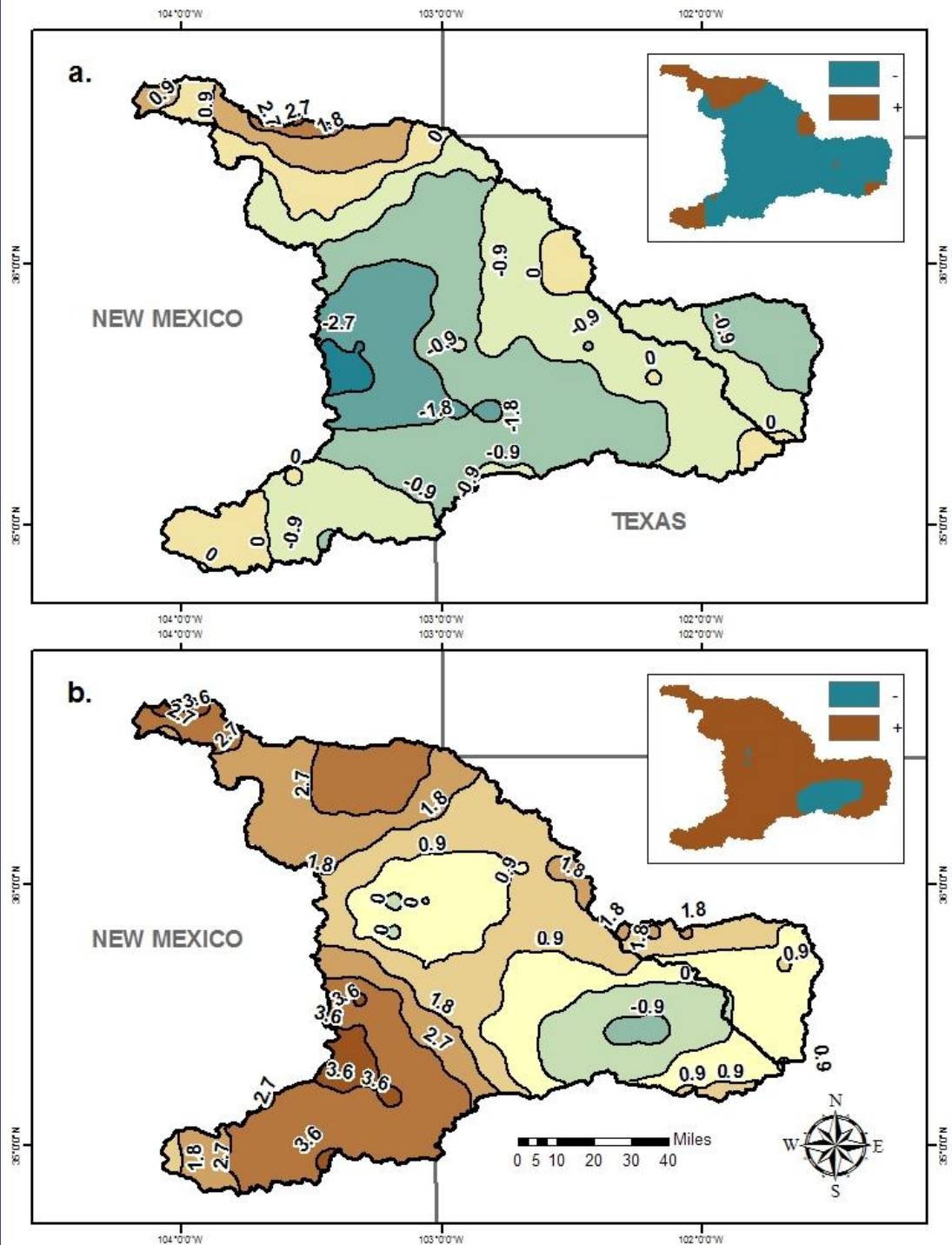
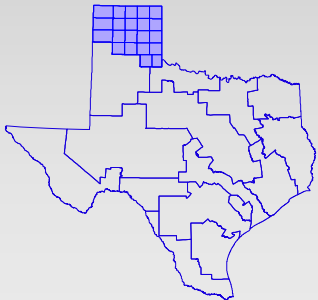
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# Temperature Trends Results

## Change in Winter Temps (1949-1999)

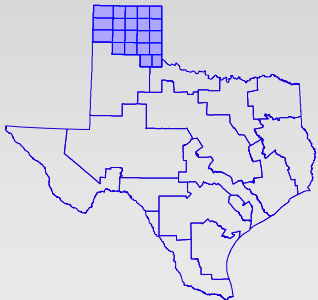
Panhandle Water Planning Area



# Temperature Trends Methods

## Change in Temperature Range (1949-1999)

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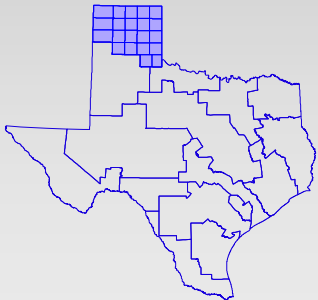


	Range (°F)
Annual	-1.8
Winter	-2.3
Spring	-1.2
Summer	-1.5
Fall	-2.2

# Temperature Trends Conclusions

- **Max temps** are decreasing across the watershed
- **Min temps** are increasing in some places and decreasing in others
- Temperature **range** is converging
- Lower temperatures mean **less potential evapotranspiration**

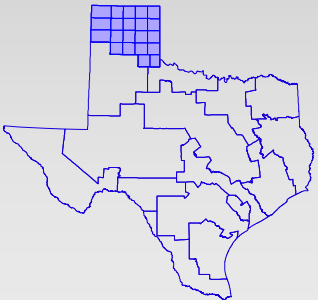
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# On-Going Work

- Lack of rain
- Increased evaporation
- Increase in infiltration
- Decreased spring flows
- Change in water use
- Increase in stock ponds
- Spread of salt cedar

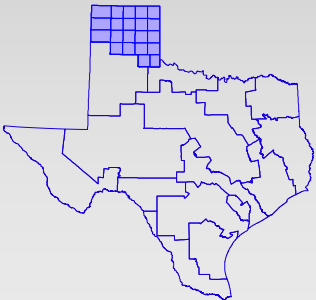
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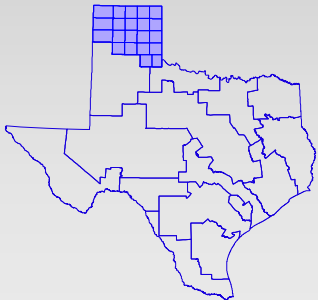
**Panhandle Water  
Planning Area**



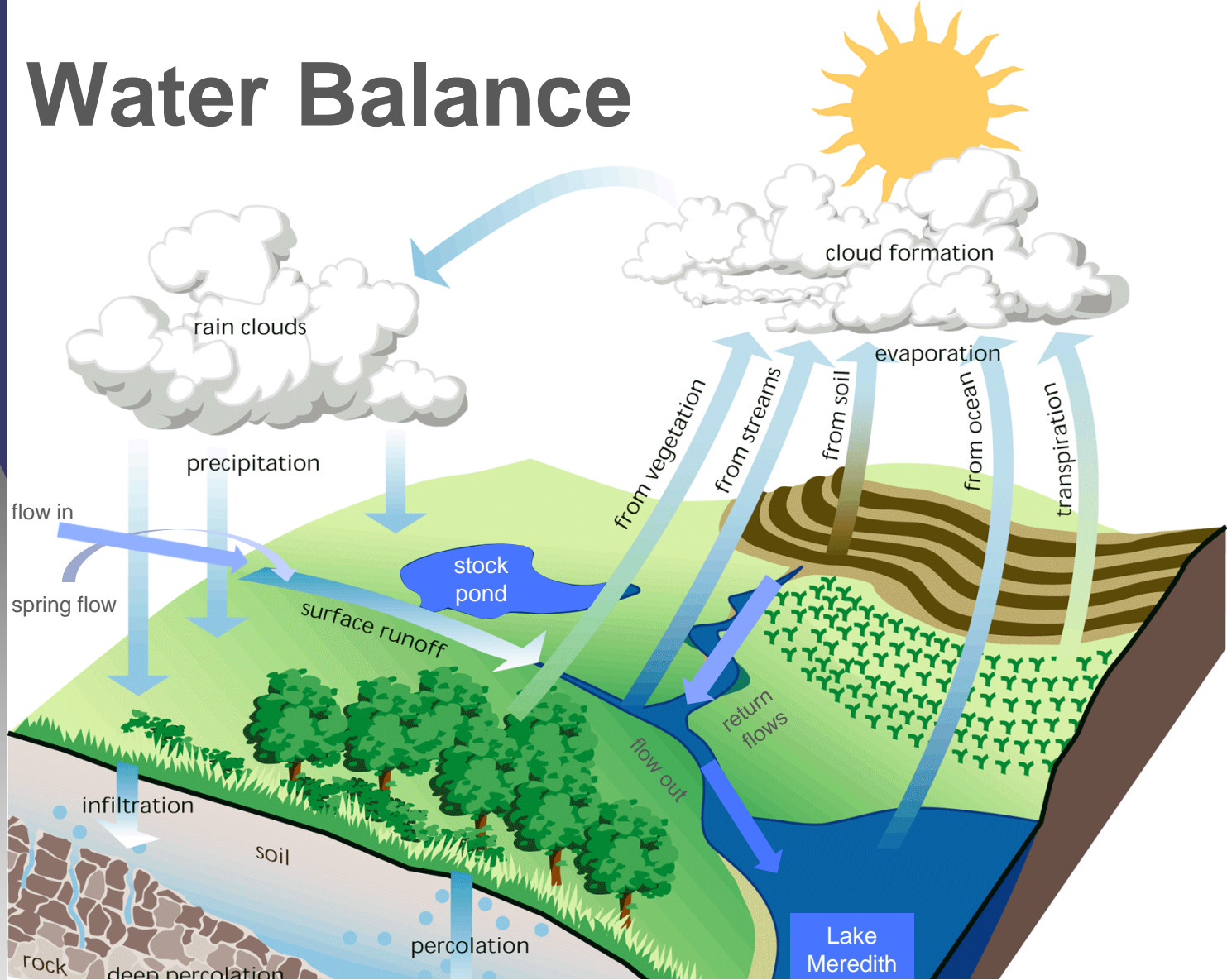
# On-Going Work

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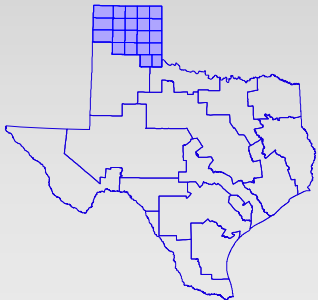
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# Water Balance

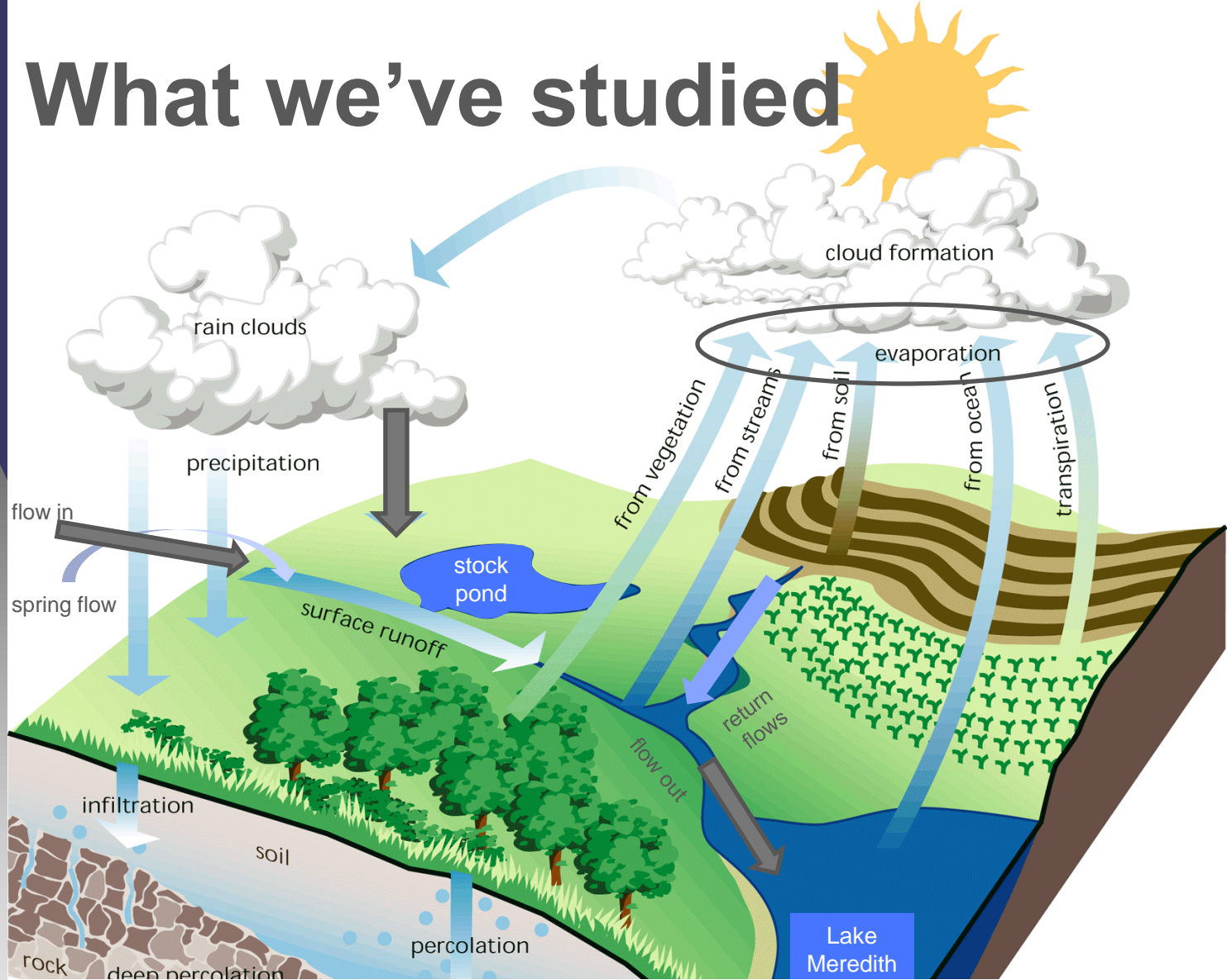


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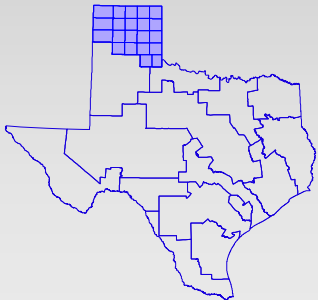


$$\text{Inflow} + \text{Spring flow} + \text{Precip} + \text{Return Flows} = \text{Outflow} + \text{Evaporation} + \text{Infiltration}$$

# What we've studied

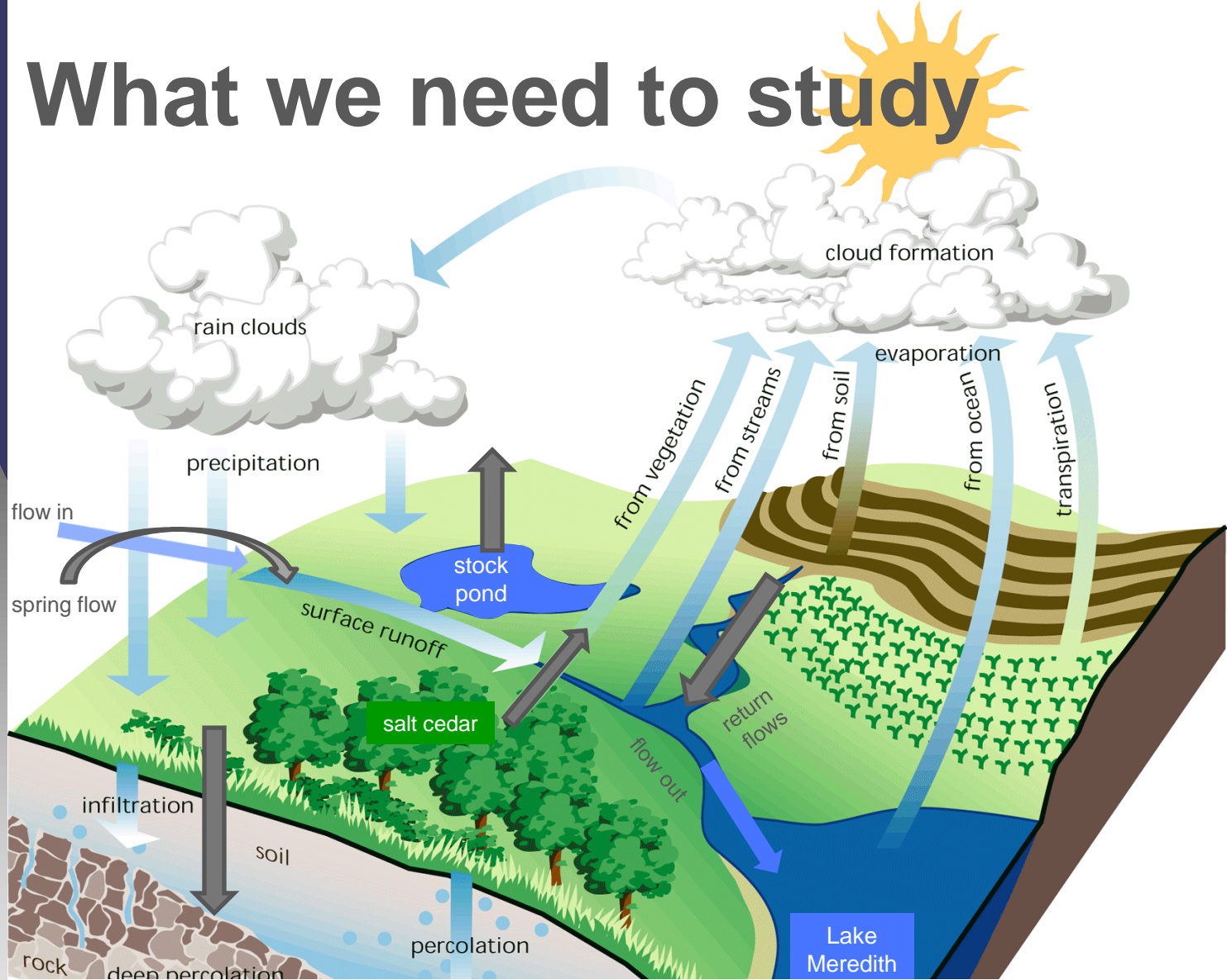


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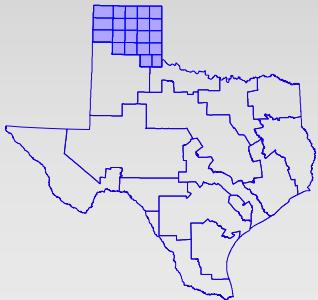


$$\text{Inflow} + \text{Spring flow} + \text{Precip} + \text{Return Flows} = \text{Outflow} + \text{Evaporation} + \text{Infiltration}$$

# What we need to study



**Panhandle Water  
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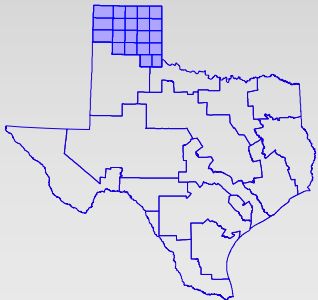


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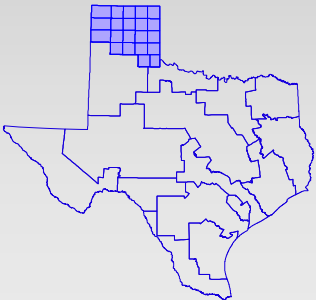
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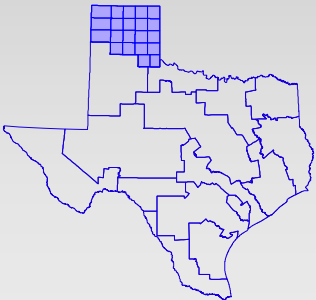
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# On-Going Work

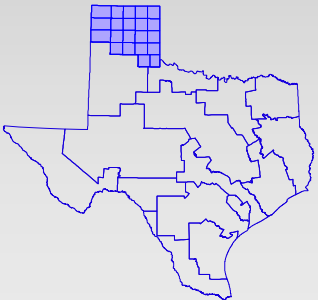
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# Thank You

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Water Resources Planning

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# References

- Maurer, E.P., A.W. Wood, J.C. Adam, D.P. Lettenmaier, and B. Nijssen, 2002, A Long-Term Hydrologically-Based Data Set of Land Surface Fluxes and States for the Conterminous United States, *J. Climate* 15(22), 3237-3251

## Panhandle Water Planning Area

