MBMG
Montana Bureau of Mines and Geology

Montana Bureau of Mines and Geology

Serving the citizens of Montana through
geologic and hydrologic research and information

Geology

- ✓ Geologic Mapping
- ✓ Geohazards/Earthquake Studies
- ✓ Economic Geology
- ✓ Energy Resources
- ✓ Data Preservation

Water Resources

- ✓ State-wide Groundwater monitoring network
- ✓ Ground Water Investigation Program
- ✓ Groundwater Characterization Program
- ✓ Environmental Studies




Ground Water Investigation Program (GWIP)

MBMG Montana Bureau of Mines and Geology

Addresses specific groundwater questions across Montana

- ✓ Designed to support science based management in Montana
- ✓ Answer locally identified questions, crucial for water management;

*Understanding impacts and **lack** of impacts, both are equally important*
Provide information so aquifers can be managed, Not just <u>used</u>

September 27, 2022
2022 Montana Association of Planners Conference

Project Areas

- ✓ Land use change from irrigated agricultural to residential
- ✓ Effects on stream flow due to increased groundwater withdrawals
- ✓ Changes in water quality due to increased subdivisions
- ✓ Impacts to groundwater and surface water from changing irrigation methods
- ✓ Effects of drought on water resources

Ground Water Steering Committee

MCA **2-15-1523**

Voting Members

- Dept. of Natural Resources and Conservation
- Dept. of Environmental Quality
- Dept. of Agriculture
- State Library

Ex-Officio Members

i. Legislative services division;

ii. Board of oil and gas conservation;

iii. Montana Bureau of Mines and Geology;

iv. Montana university system;

v. County government, appointed by an organization of Montana counties;

vi. City, town, or city-county government, appointed by an organization of Montana cities and towns;

vii. Principal federal agencies USGS, EPA, USDA, BLM, USBOR

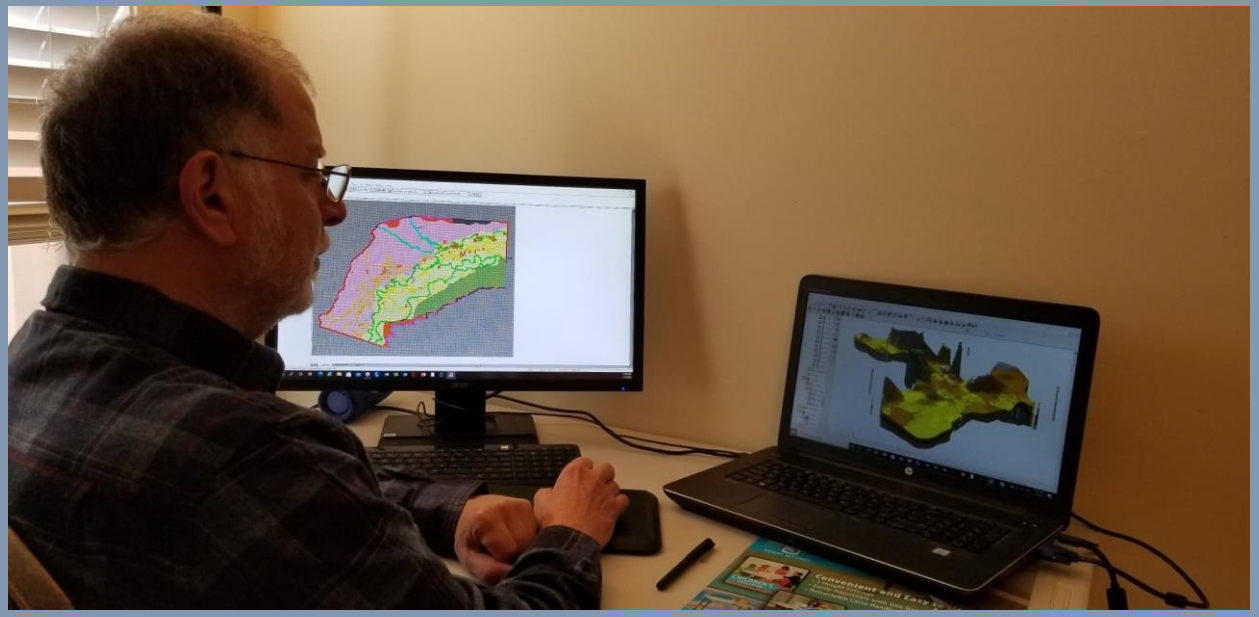
Governor Appointees:

i. Agricultural water users;

ii. Industrial water users;

iii. Conservation or ecological protection organization; and

iv. Development community.



GWIP Products

- **Interpretive Report**

- **Groundwater Modeling Report** (if appropriate)
  Used to represent natural groundwater flow
  Used to predict the affects of hydrologic changes such as stresses from pumping, climate and land use change

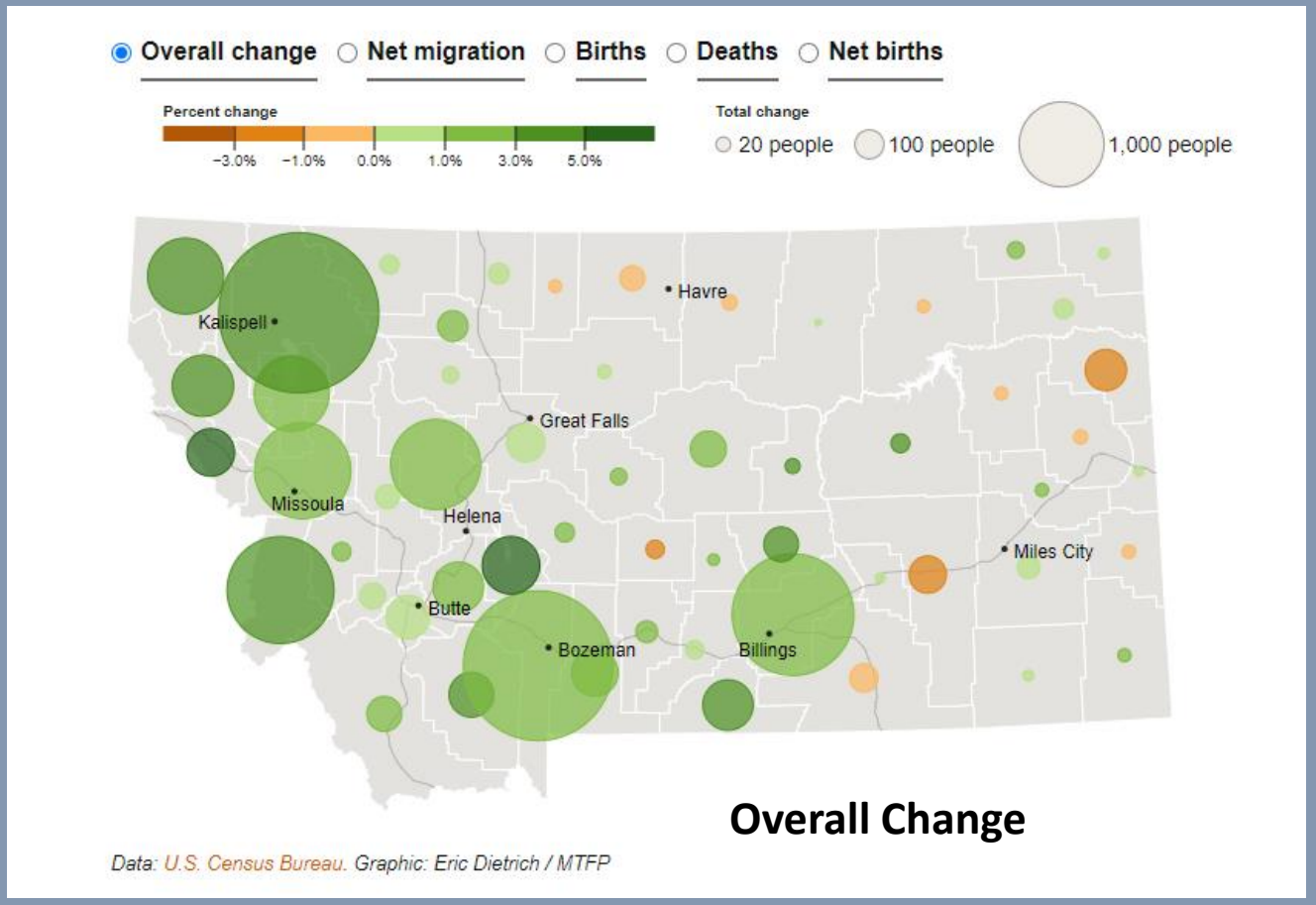
- **A Comprehensive Set of Hydrogeologic Data**
  Available through MBMG Ground-Water Information Center (GWIC), which is archived forever.

Montana's fastest-growing city last year? It wasn't Bozeman.

New Census Bureau estimates chart Montana's population shifts during the first full year of the COVID-19 pandemic. Kalispell led the pack.

Montana Free press March 30, 2022

Montana's 2020 - 2021 population shifts



Overall Change

Flathead Valley

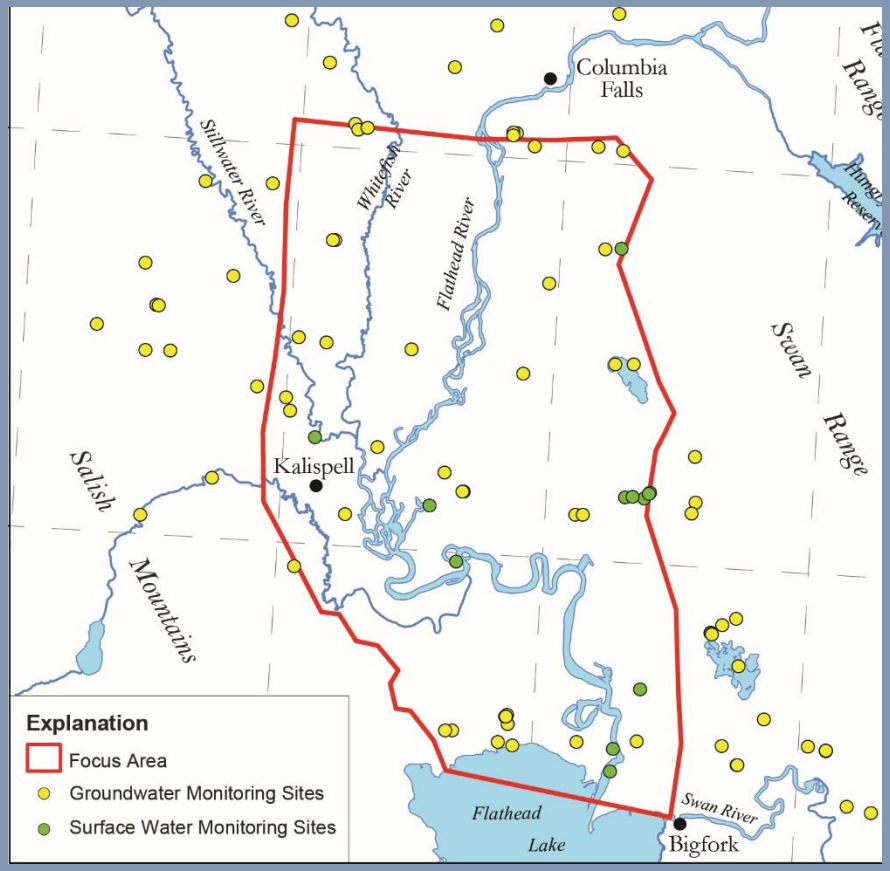
FLATHEAD BEACON

OUTLOOK-EDITION

Flathead Valley Continues to Chart Record-setting Residential Growth

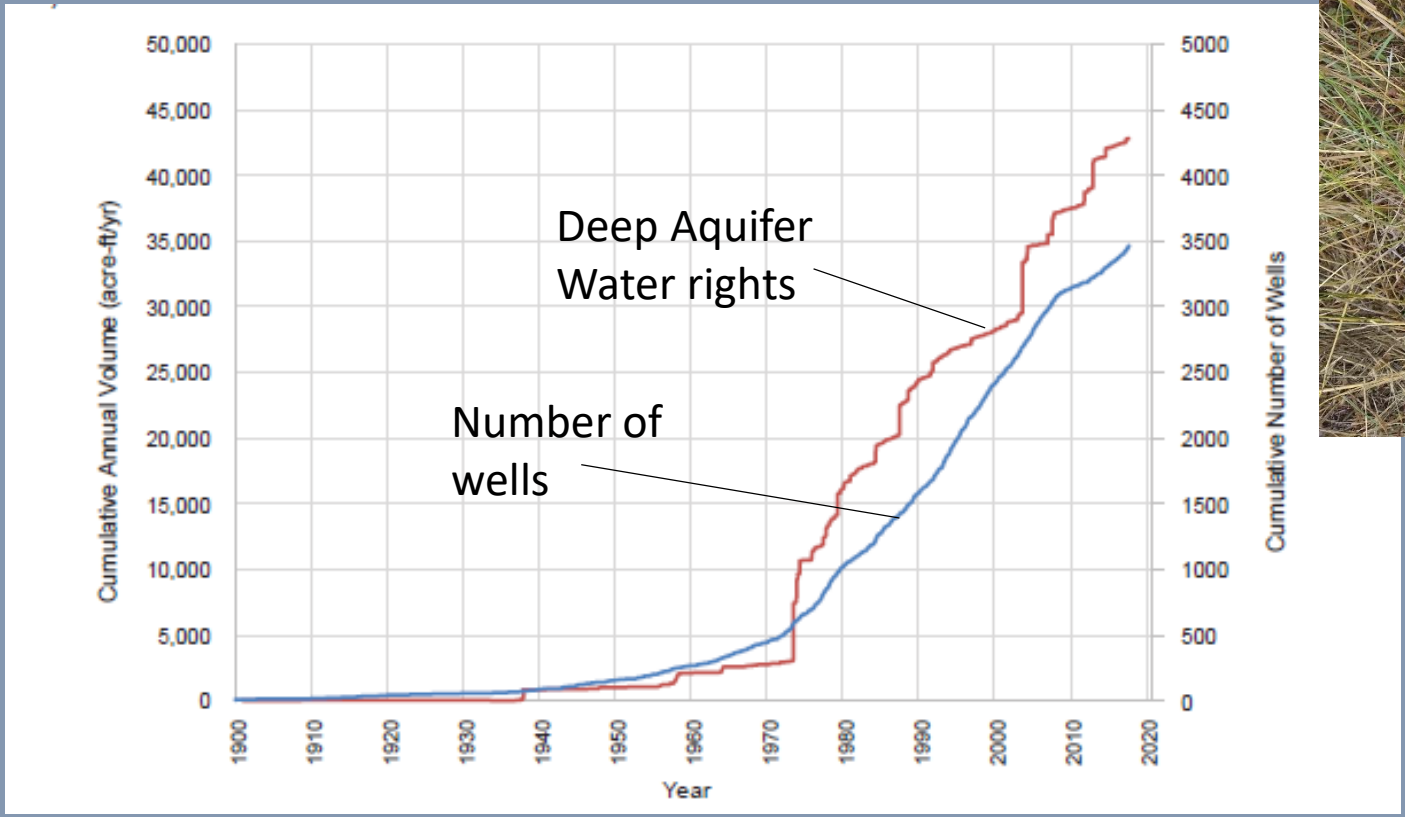
In Kalispell, permitting for residential development has set new records for three consecutive years, mirroring growth in Whitefish and Columbia Falls

BY TRISTAN SCOTT
JANUARY 5, 2022



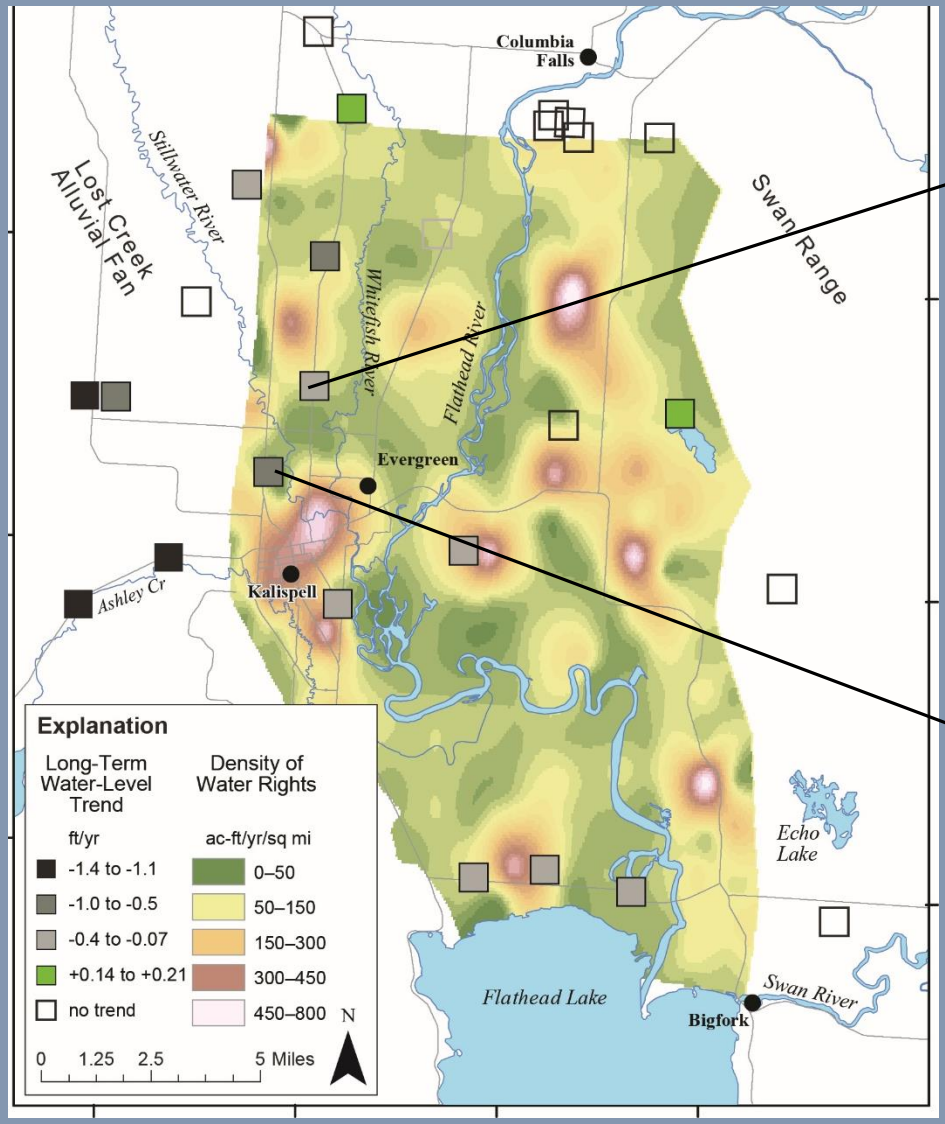
- Evaluating the interconnection between aquifers
- Identify sources of recharge and discharge to groundwater
- Analyze seasonal and long-term water-level trends in the main aquifer

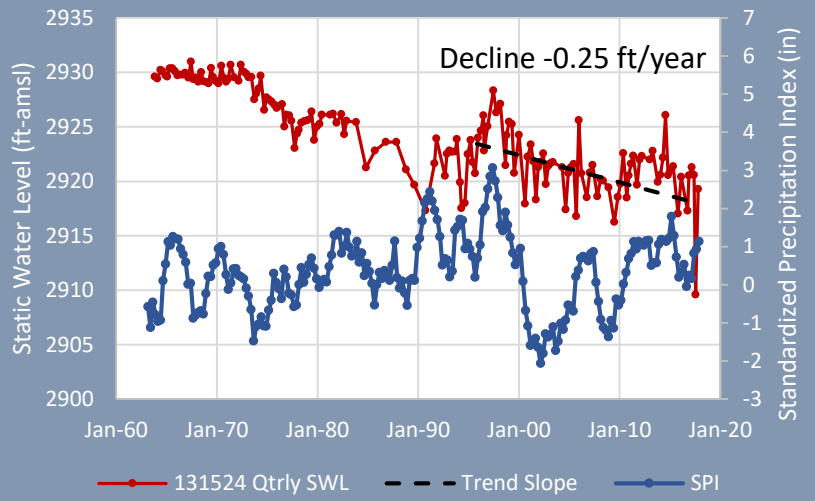
Flathead Valley

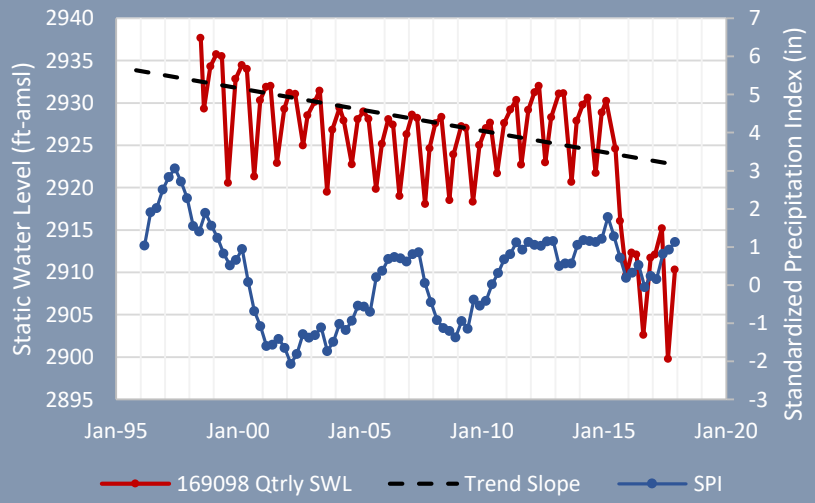


Flathead Valley

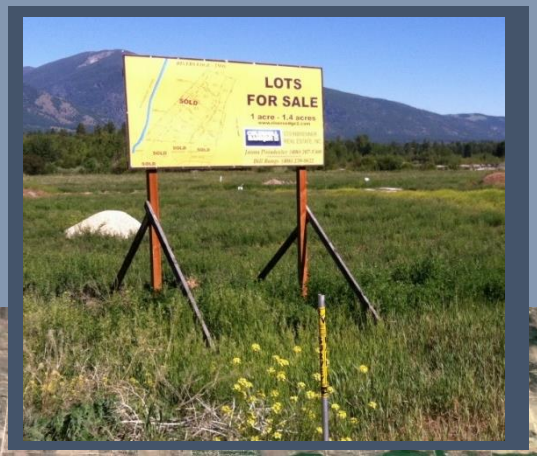
Groundwater level declines

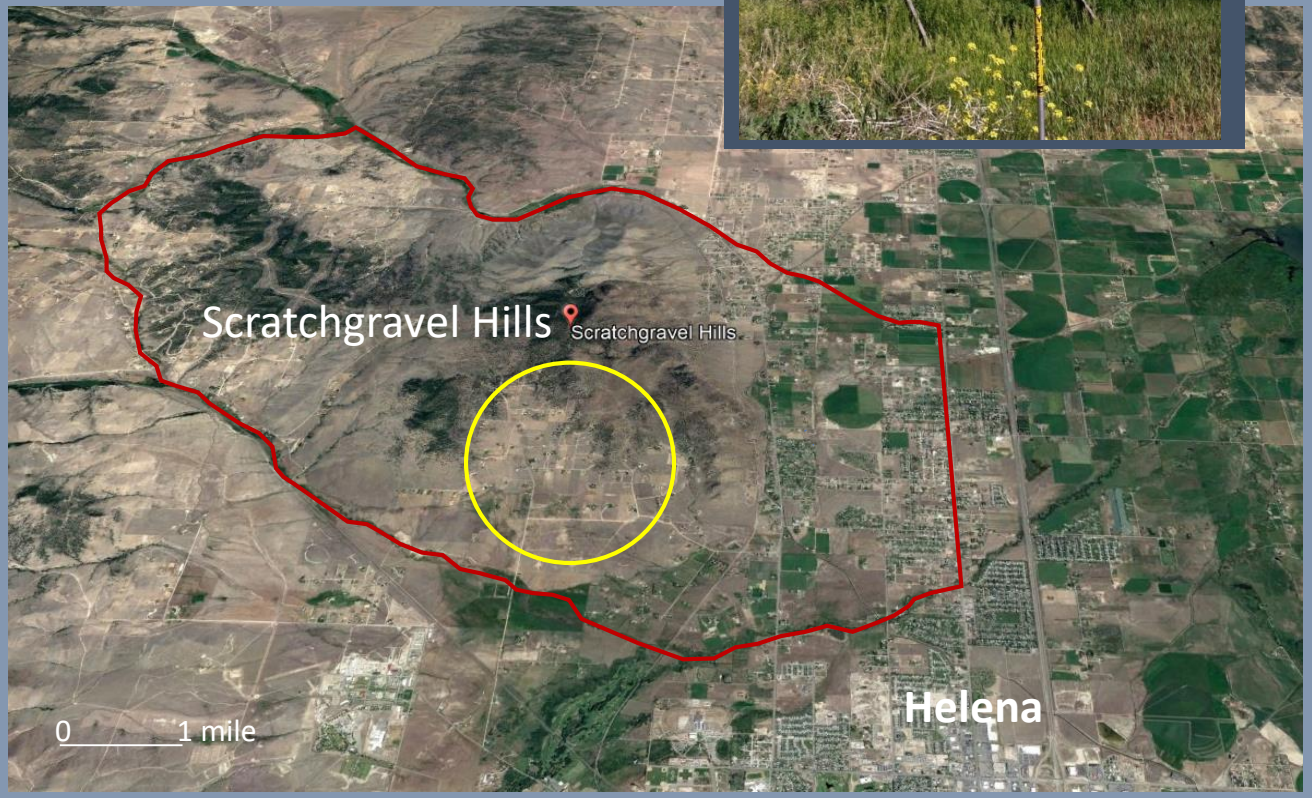






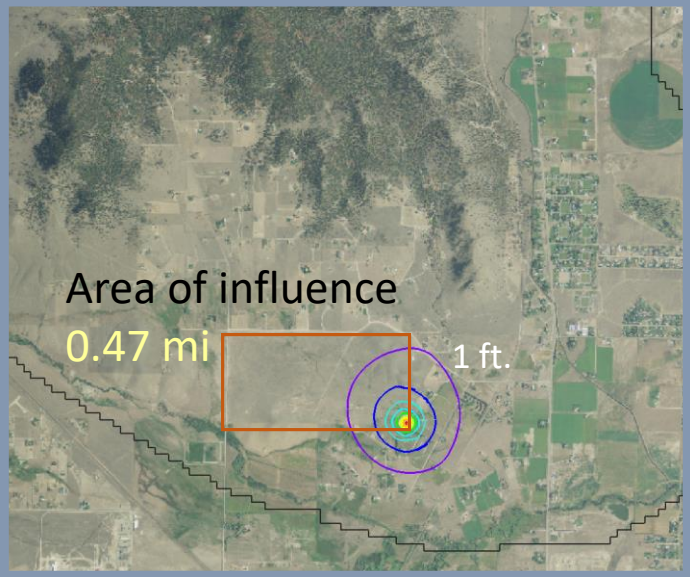
Scratchgravel Hills Helena



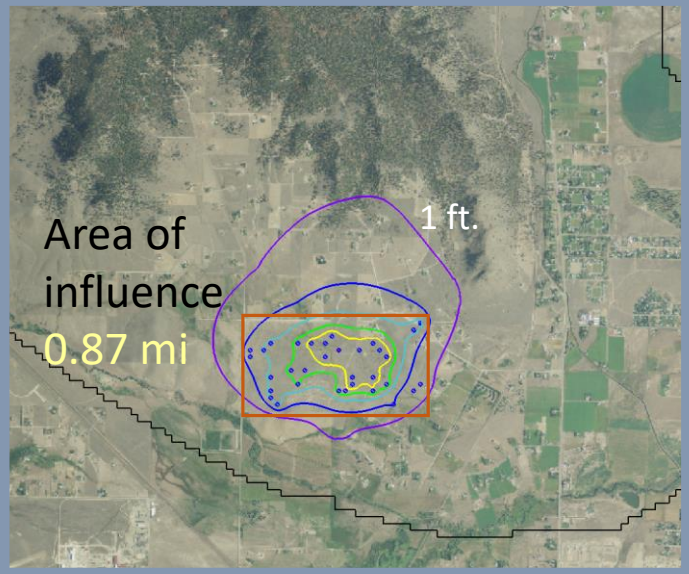


- ✓ Address concerns about the sustainability of current and future groundwater supply.
- ✓ Evaluate the potential from septic effluent to effect water quality.

1 PWS Well

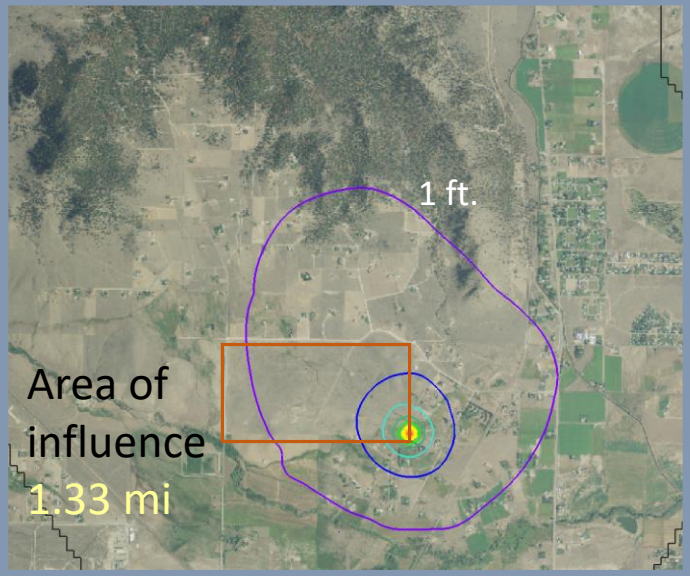


33 domestic Wells

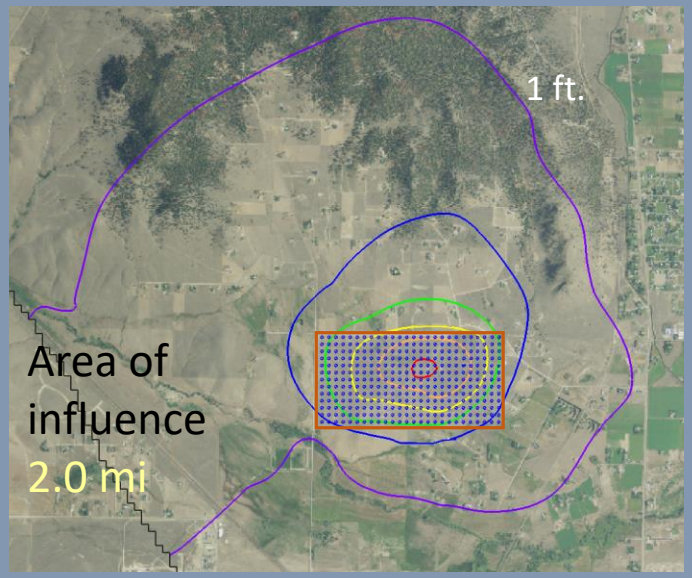


10-acre lots
10 years pumping

1 PWS Well



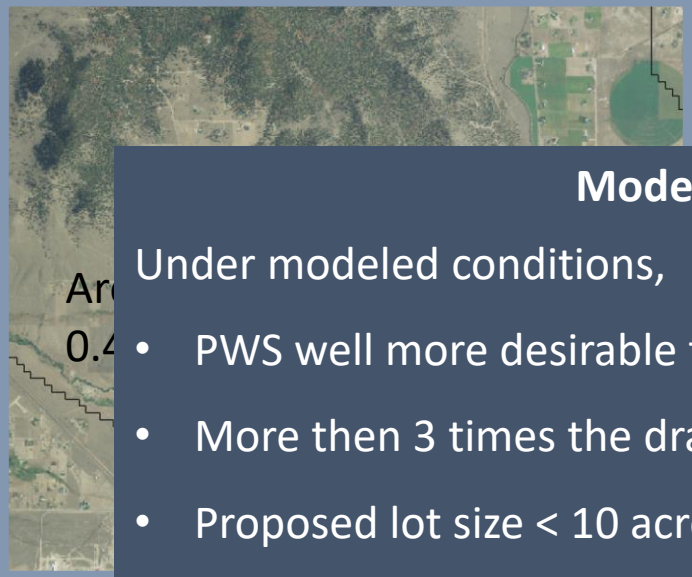
338 domestic Wells

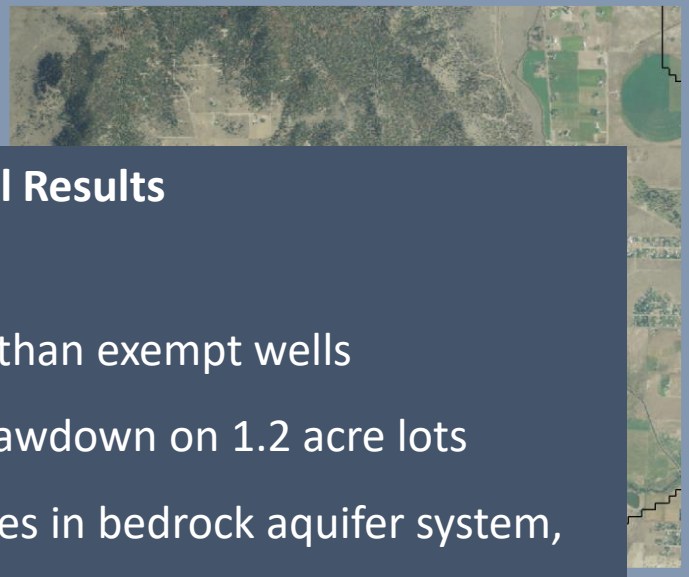


1.2-acre lots
10 years pumping

1 PWS Well

33 domestic Wells



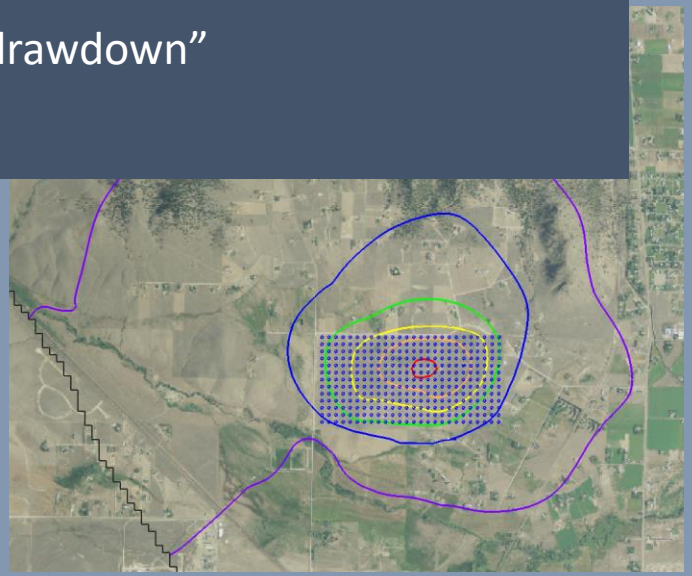


10-acre lots
10 years pumping

Model Results

Under modeled conditions,

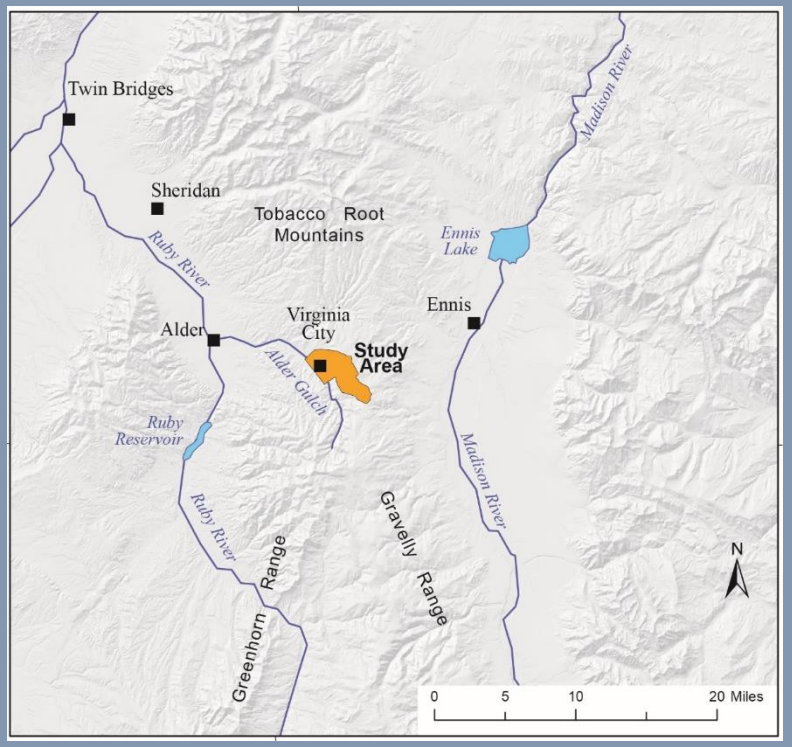
- PWS well more desirable than exempt wells
- More then 3 times the drawdown on 1.2 acre lots
- Proposed lot size < 10 acres in bedrock aquifer system, consider monitoring water levels and water use
  - Define “Acceptable drawdown”



1.2-acre lots
10 years pumping

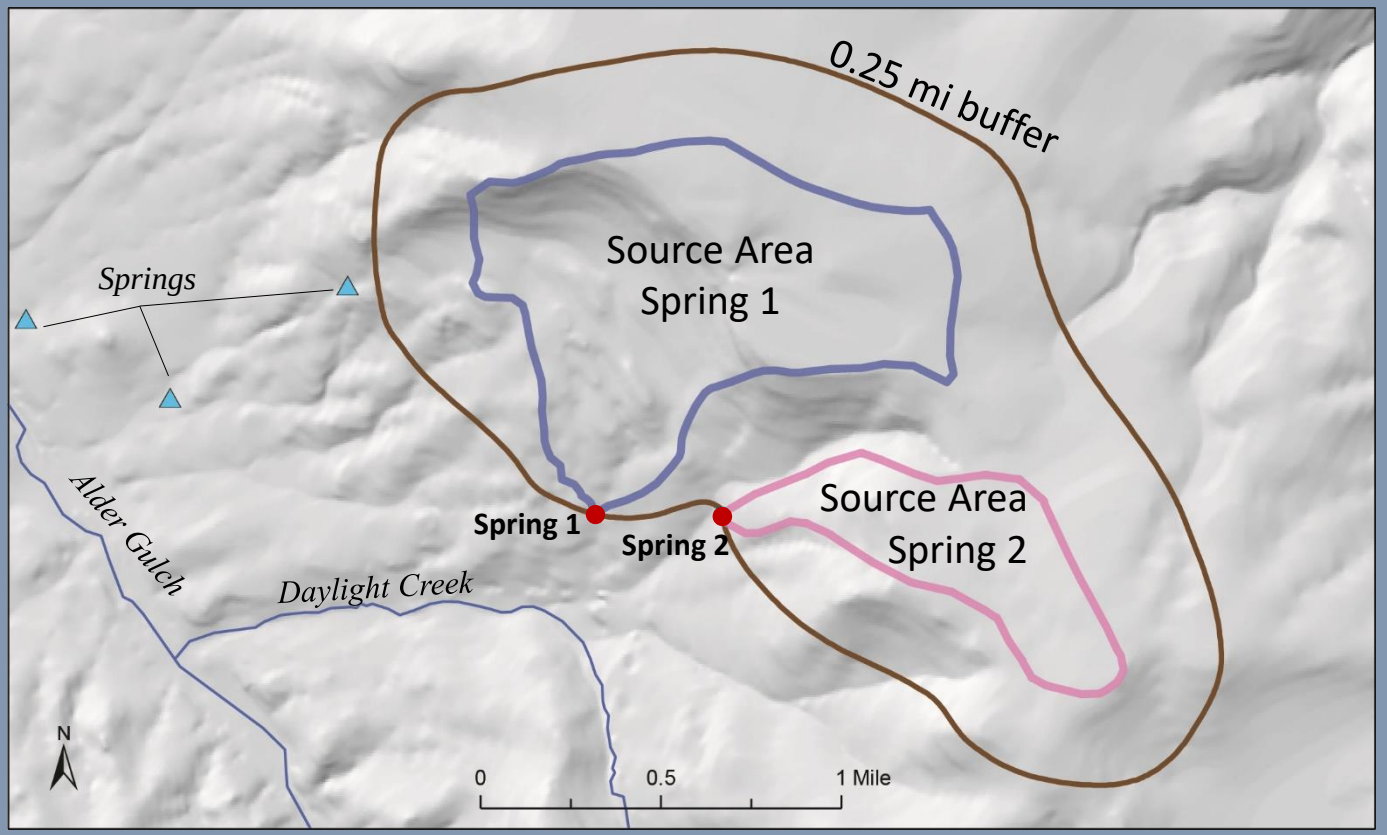
Virginia City

Proposed by the Ruby Valley Conservation District



- ✓ Understand the sources of Spring 1 and Spring 2.
- ✓ Evaluate the potential impacts of residential and commercial development on Virginia City's springs.
- ✓ Evaluate potential supplemental water sources.

Spring source areas



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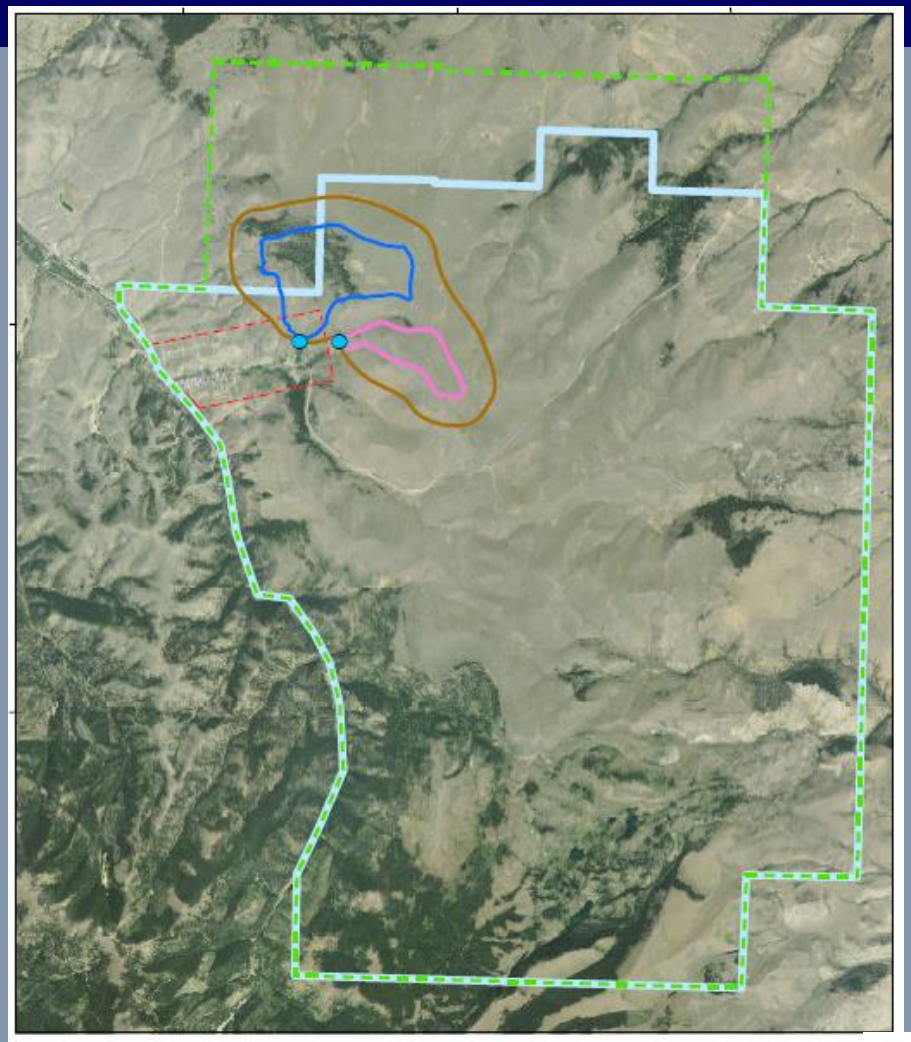


Presently providing technical information to help city and county planning efforts to protect the springs recharge areas.

Explanation

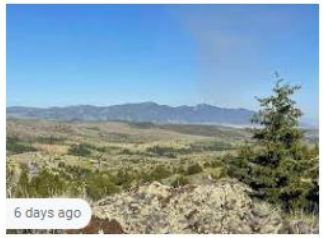
- Virginia City Springs
- Spring 1 Likley Source Area
- Spring 2 Likley Source Area
- Virgina City Springs 0.25 mi Buffer
- 2016 Source Water Protection Area
- 2000 Source Water Protection Area
- Virginia City Incorporated Area

N

0 0.5 1 2 Miles

Virginia City, MT Land for Sale - 13 ...
landsearch.com

Virginia City MT Land for Sale - 24 ...
point2homes.com



Virginia City, MT Land for Sale & Real ...
realtor.com

Identified Alternative Water Sources

(physical availability; >96 gpm)

i. Combination of two or more springs undeveloped springs

ii. Well along Alder Gulch in the alluvial sands and gravels

iii. Surface water (Daylight Creek or Alder Gulch)

Before the Well Runs Dry: Improving the Linkage Between Groundwater and Land Use Planning

Stanford University

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Montana Bureau of Mines and Geology

What are your issues? Adequate supplies? Quality?

How well is land use planning integrated with groundwater management?

Do you have the knowledge and information?

How can we help?

- ✓ Awareness
- ✓ Clear understanding of groundwater and surface water and how they interact
- ✓ Pre-analyzed information that classifies aquifers on their level of development and vulnerability to contamination
- ✓ Better clarity on your authority regarding groundwater protection and management

Incorporating groundwater issues into regional planning in the Province of Quebec, 2012
Journal of Environmental Planning

Groundwater Investigation of the Billings Aquifer

Ground Water Investigation Program

Montana Bureau of Mines and Geology

Billings and Butte

Elizabeth Meredith

MONTANA TECH

CITY OF Billings

MBMG

Montana Bureau of Mines and Geology


THE GROVE
Premier Gated Community
SOLD
Taj 406.647.2353
Ed 406.670.7236
YELLOWSTONE BANK
BANKS OF SERVICE SINCE 1907

Purpose

Evaluate the ability of the aquifer to sustain future groundwater development. Identify the extent and source of nitrates in the study area.

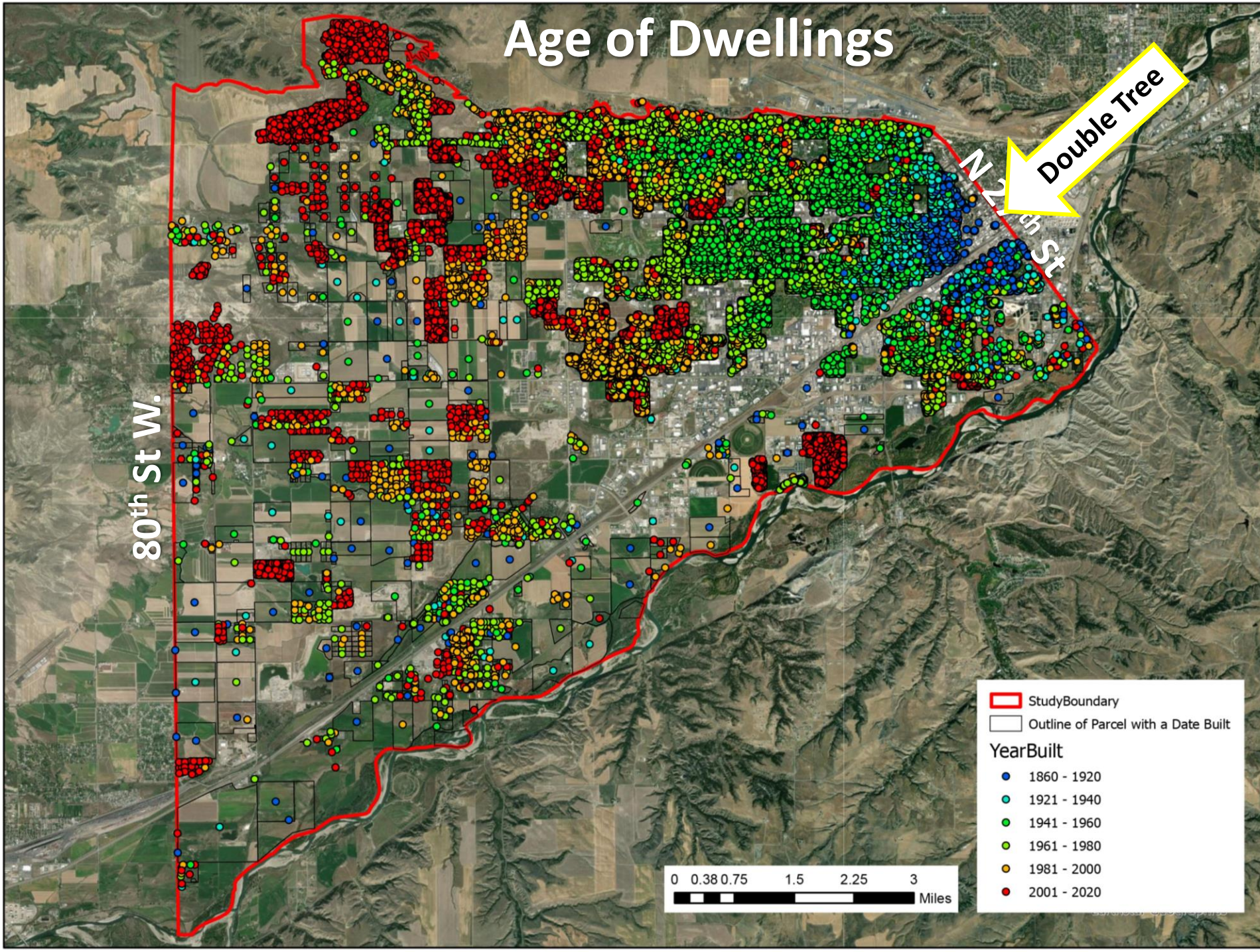
Objectives

Groundwater quantity:

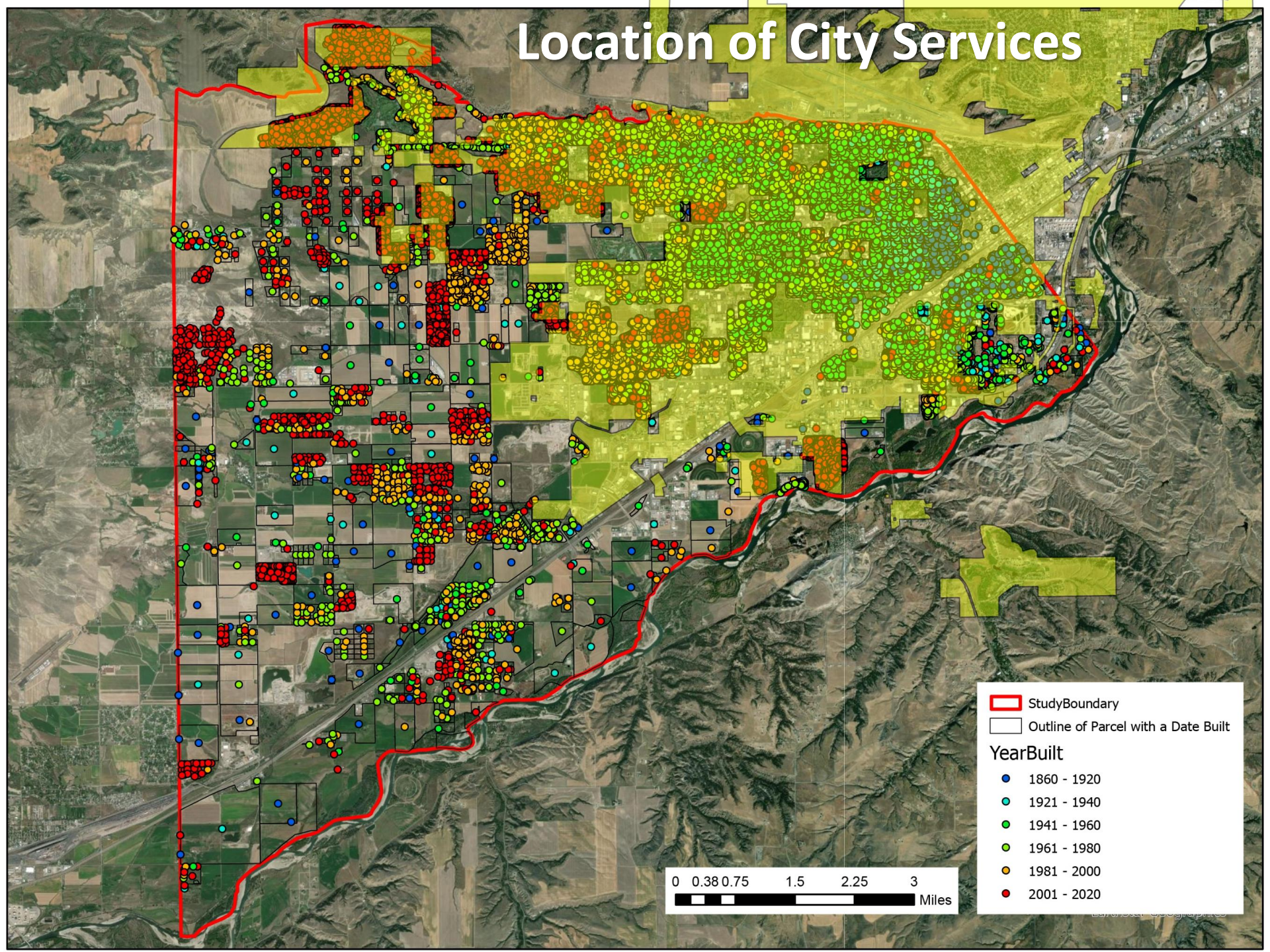
a. Identify and quantify groundwater recharge from natural sources and agricultural practices.

b. Develop conceptual and numerical groundwater models to evaluate the effect on groundwater from land use change from agriculture to residential.

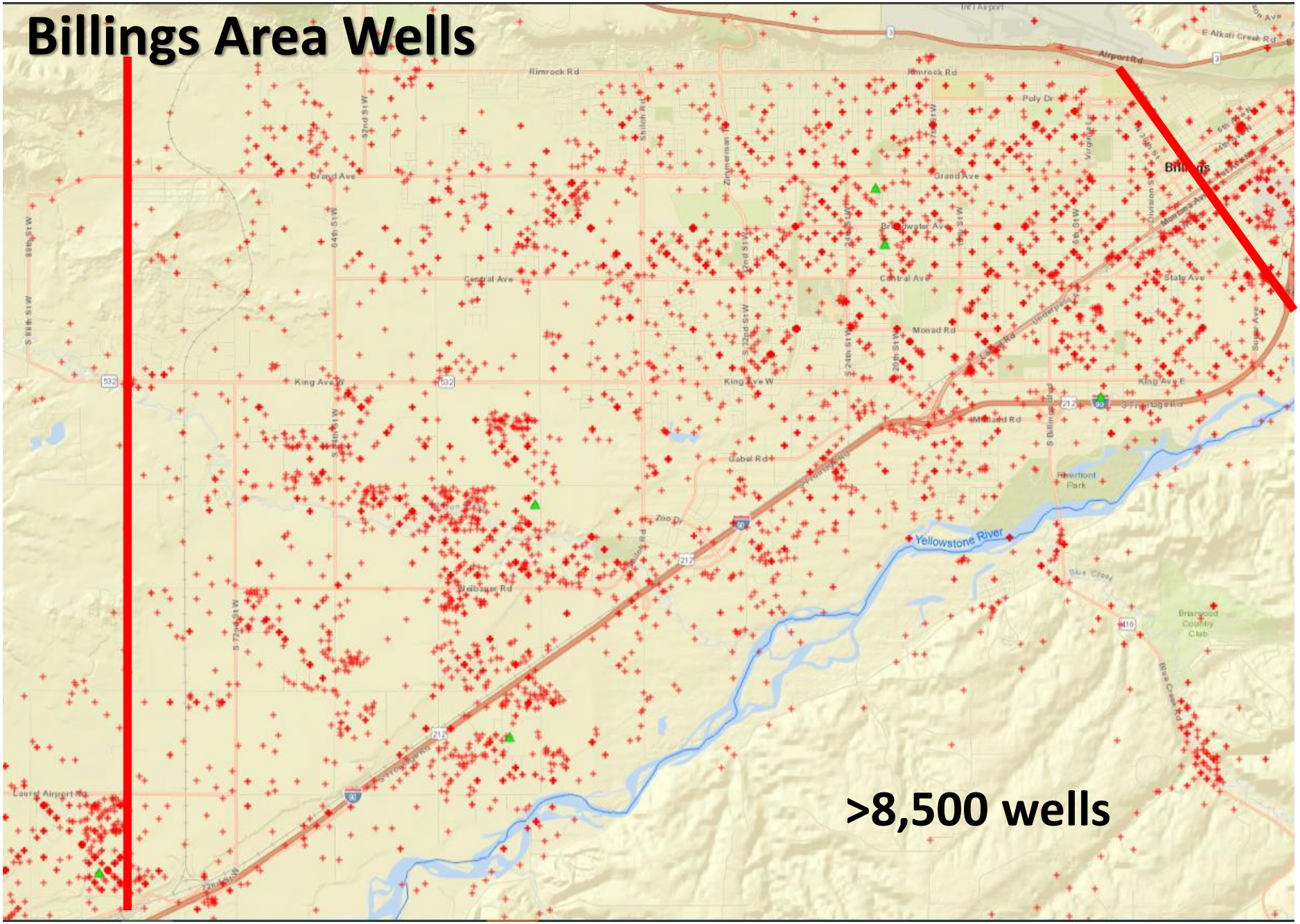
Groundwater quality: Define the role of agriculture practices and septic systems on groundwater quality. Identify nitrate distribution in groundwater and likely sources.

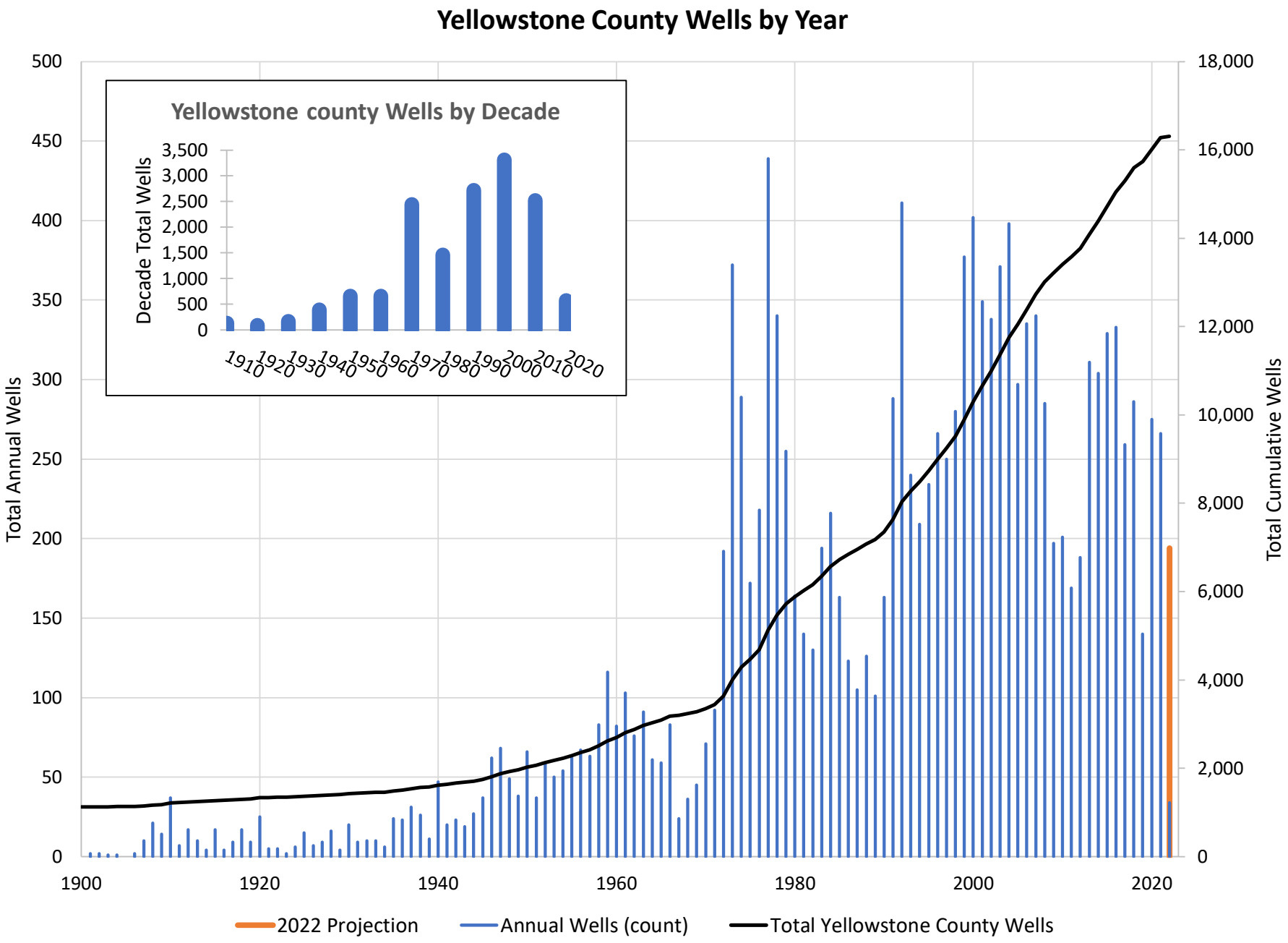

Age of Dwellings
Double Tree
N 27th St
80th St W.
StudyBoundary
Outline of Parcel with a Date Built
YearBuilt
1860 - 1920
1921 - 1940
1941 - 1960
1961 - 1980
1981 - 2000
2001 - 2020
0 0.38 0.75 1.5 2.25 3
Miles

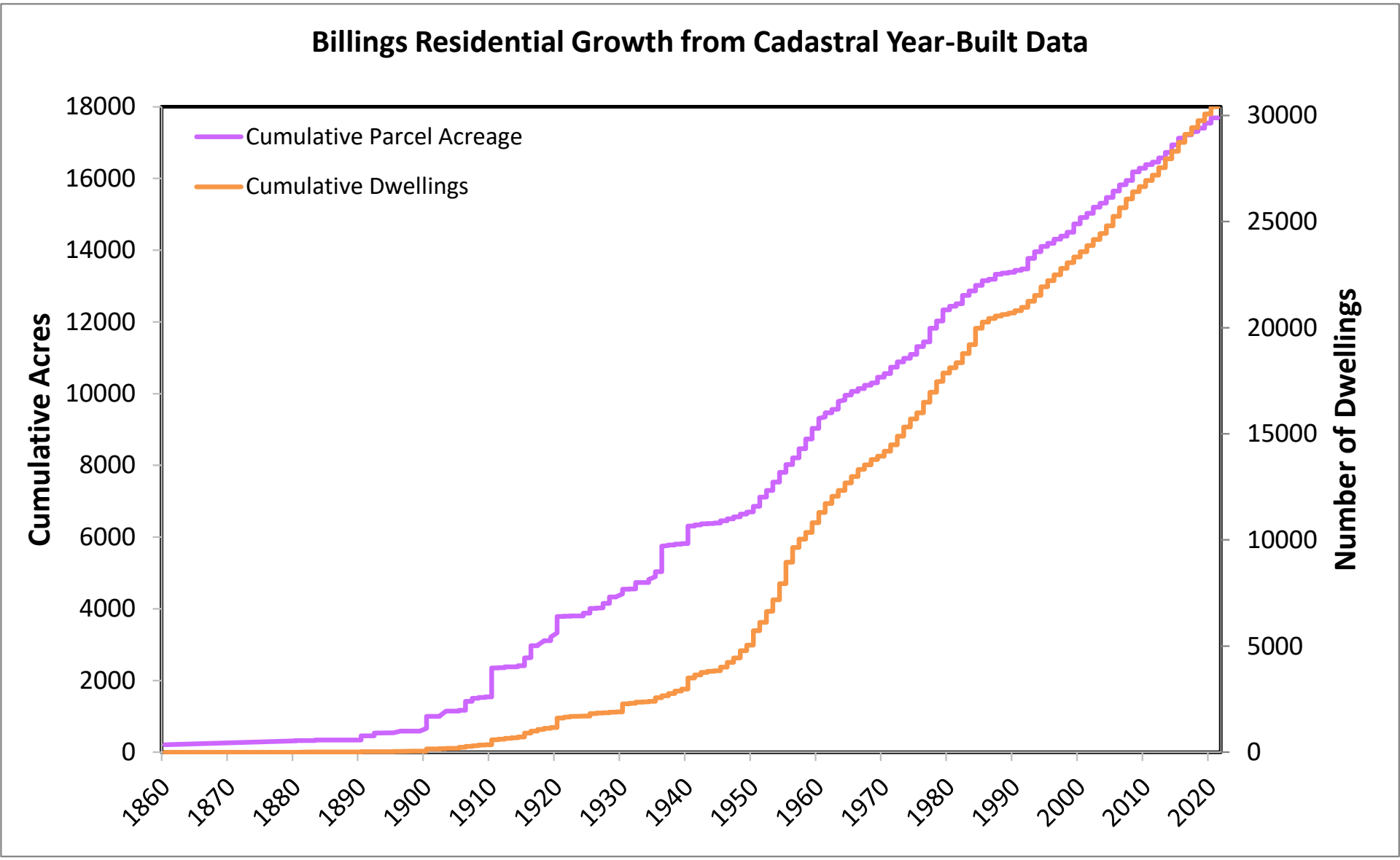
Location of City Services

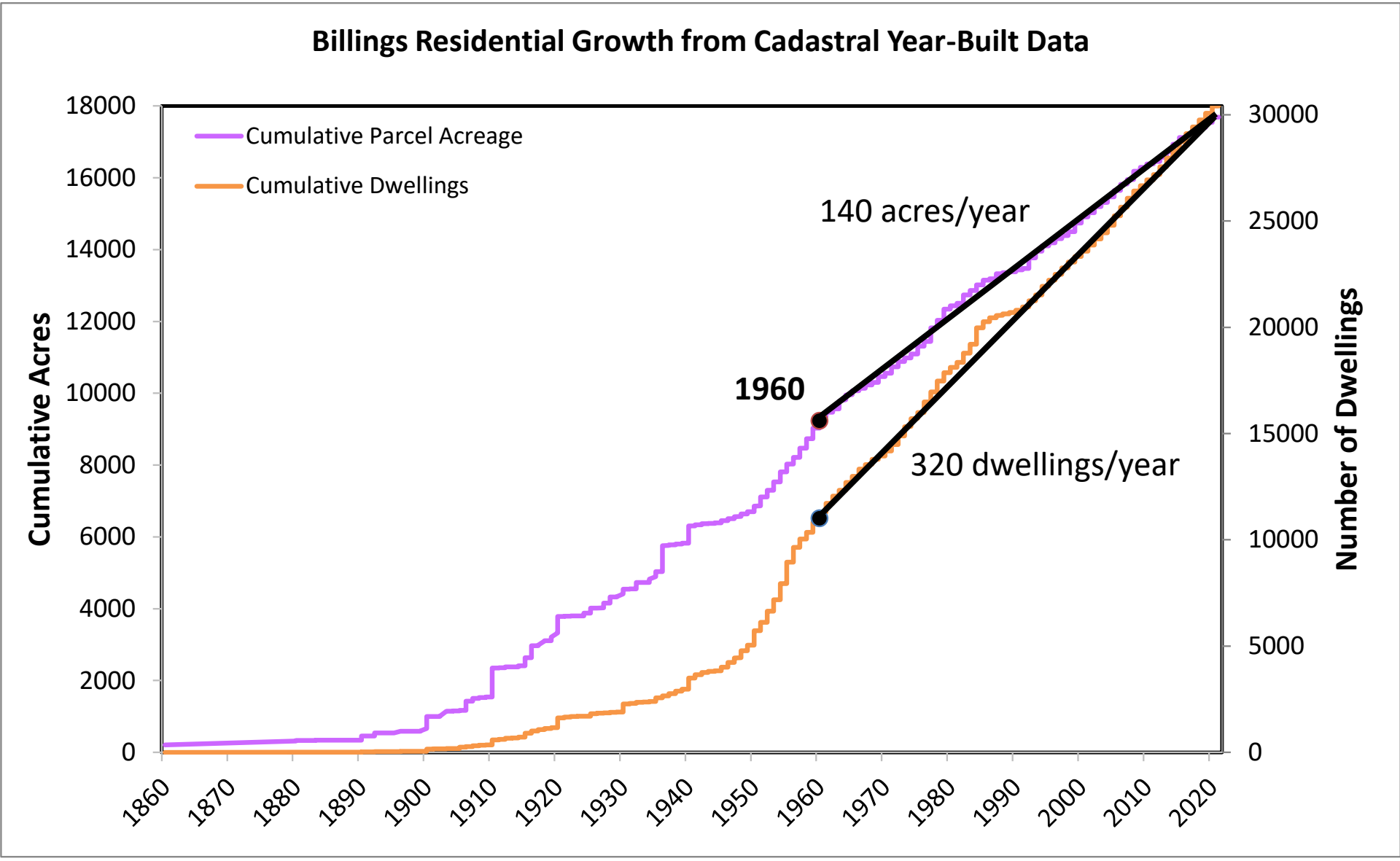


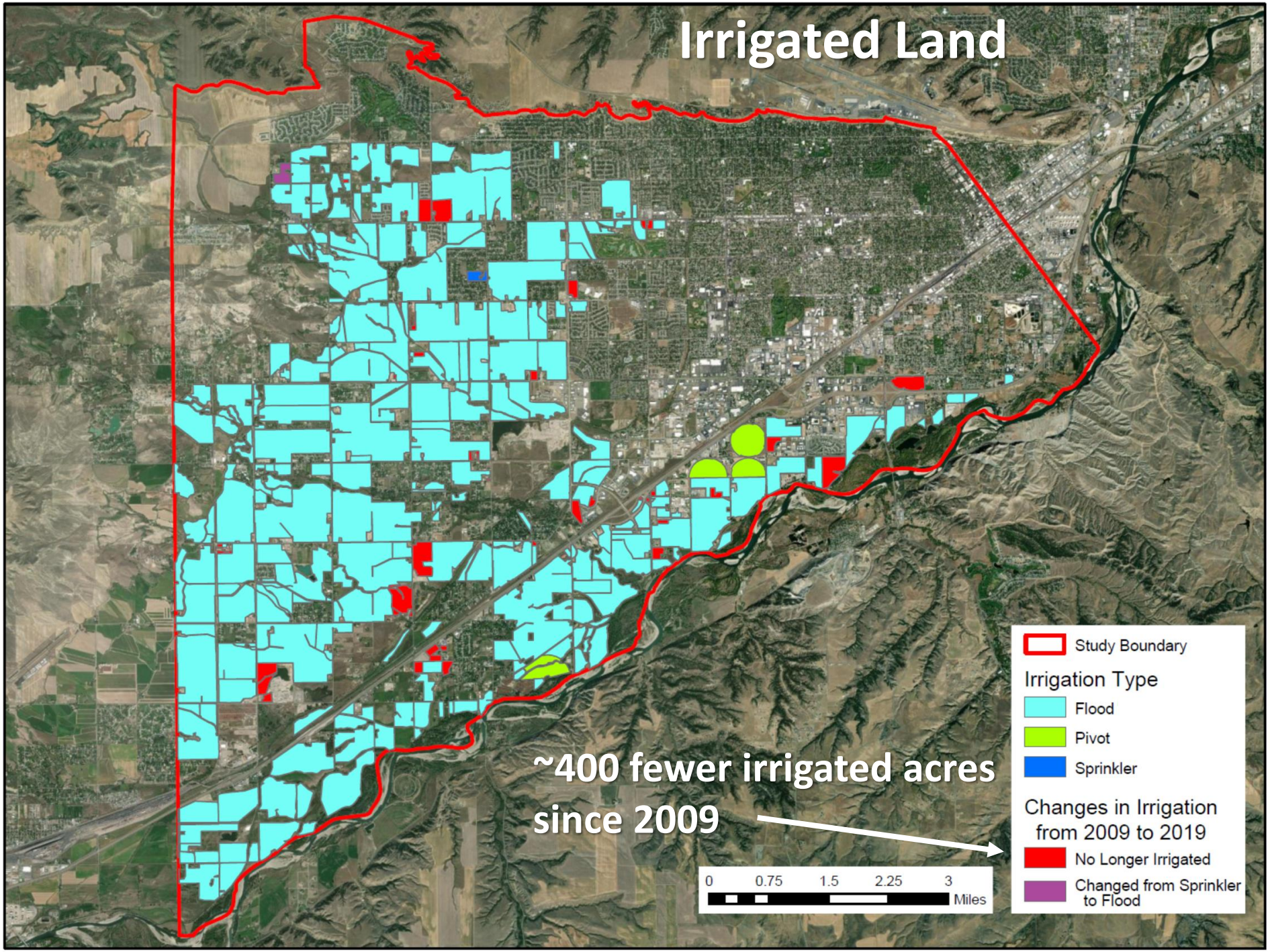
Billings Area Wells



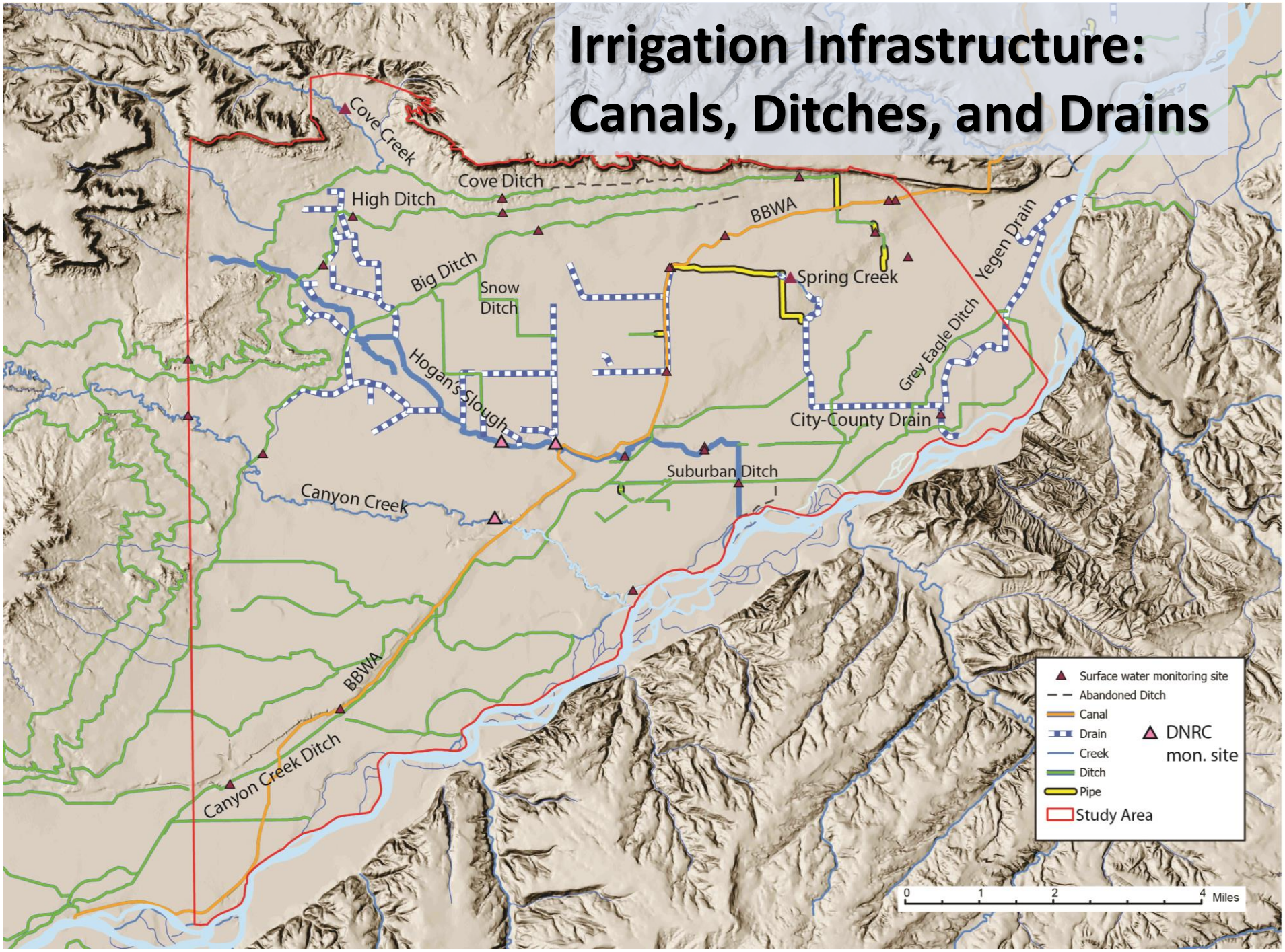

Yellowstone County Wells by Year
Yellowstone county Wells by Decade
Decade Total Wells
3,500
3,000
2,500
2,000
1,500
1,000
500
0
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020
Total Annual Wells
500
450
400
350
300
250
200
150
100
50
0
Total Cumulative Wells
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
1900
1920
1940
1960
1980
2000
2020
2022 Projection
Annual Wells (count)
Total Yellowstone County Wells

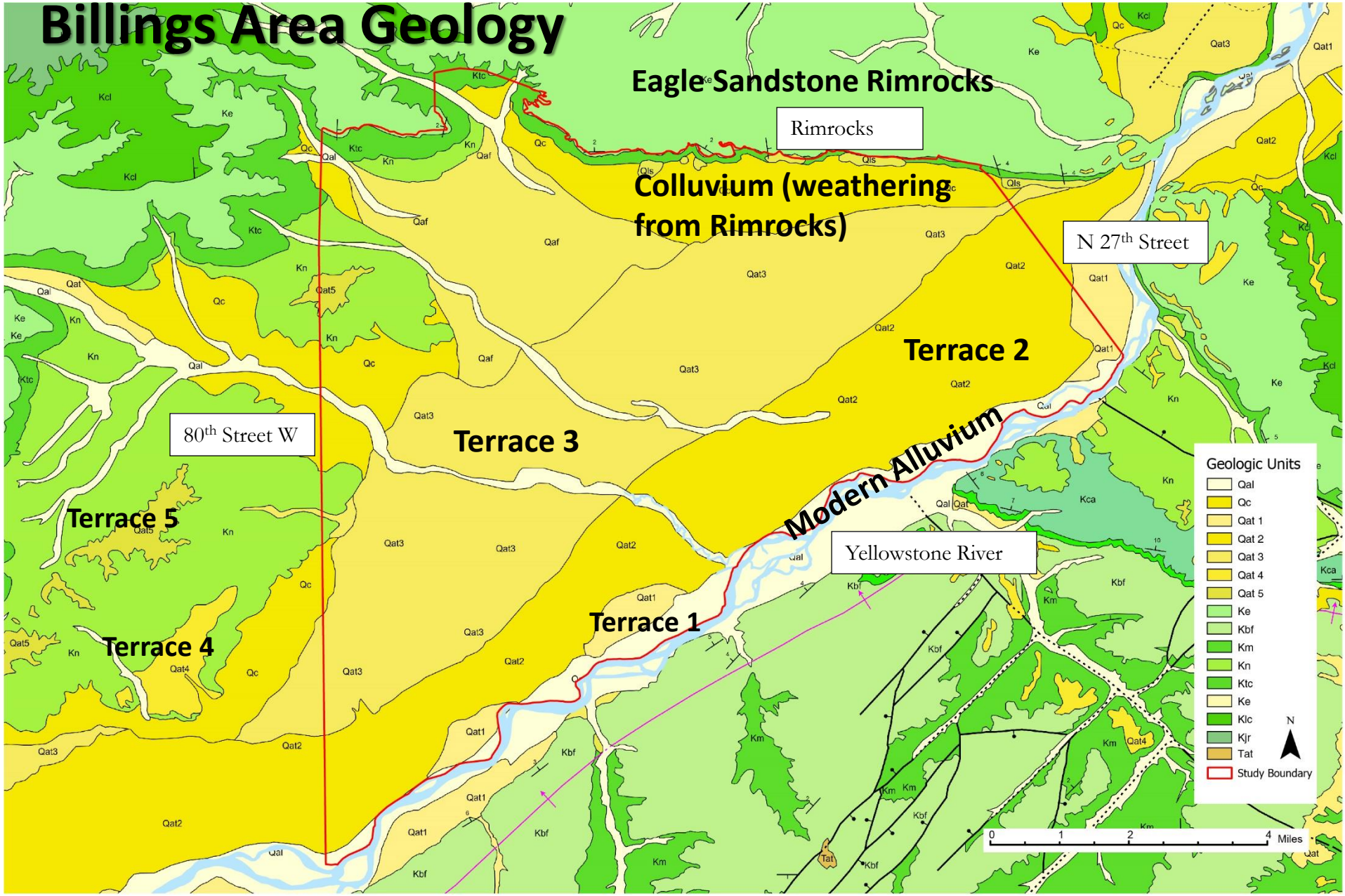

Billings Residential Growth from Cadastral Year-Built Data
Cumulative Parcel Acreage
Cumulative Dwellings
Cumulative Acres
Number of Dwellings
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
30000
25000
20000
15000
10000
5000
0
1860
1870
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020


Billings Residential Growth from Cadastral Year-Built Data
Cumulative Parcel Acreage
Cumulative Dwellings
140 acres/year
320 dwellings/year
1960
Cumulative Acres
Number of Dwellings
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
30000
25000
20000
15000
10000
5000
0
1860
1870
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020

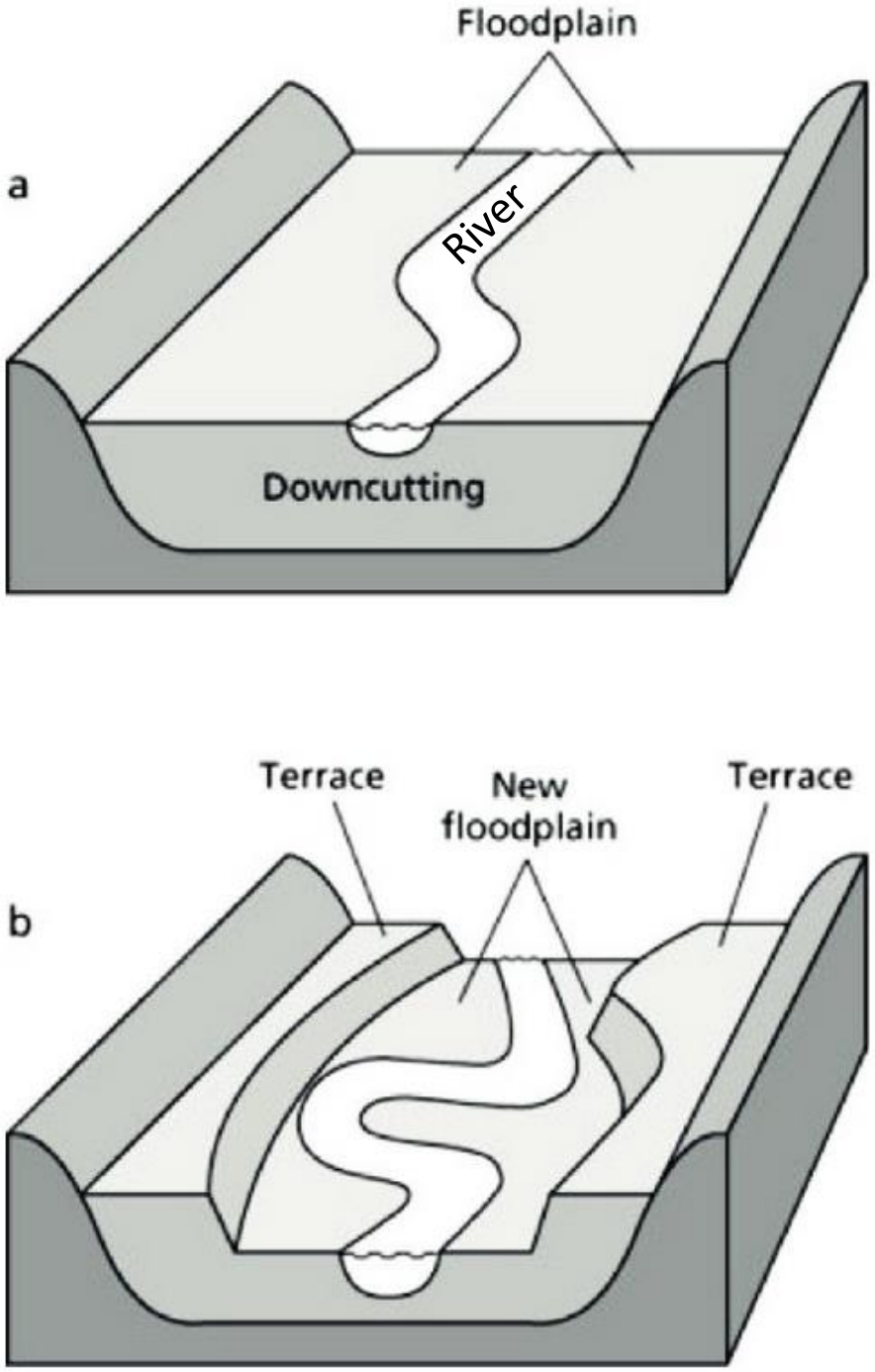

Irrigated Land
~400 fewer irrigated acres since 2009
Study Boundary
Irrigation Type
Flood
Pivot
Sprinkler
Changes in Irrigation from 2009 to 2019
No Longer Irrigated
Changed from Sprinkler to Flood
0
0.75
1.5
2.25
3
Miles

Irrigation Infrastructure: Canals, Ditches, and Drains



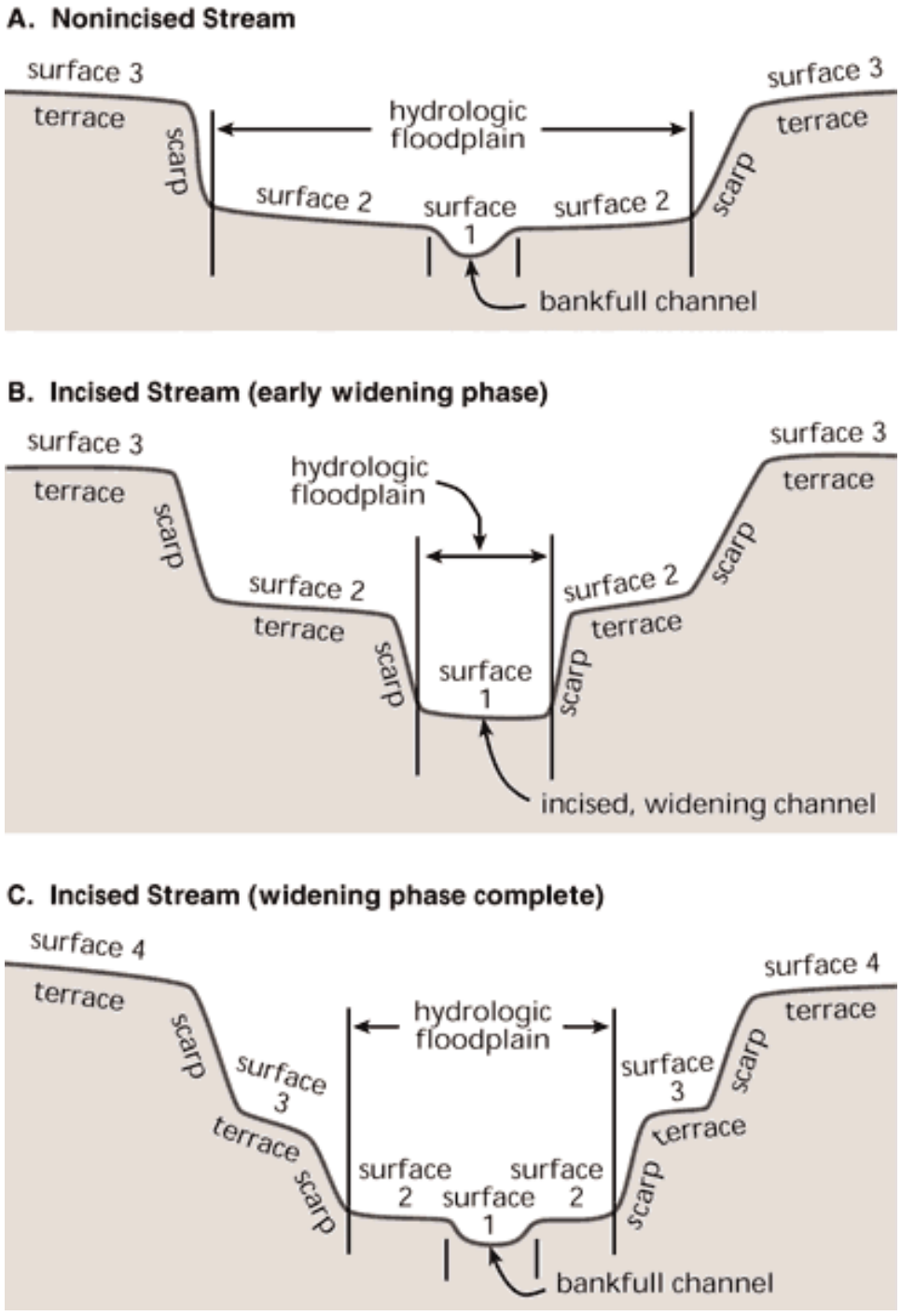

Billings Area Geology
Eagle Sandstone Rimrocks
Rimrocks
Colluvium (weathering from Rimrocks)
N 27th Street
Terrace 2
80th Street W
Terrace 3
Modern Alluvium
Terrace 5
Yellowstone River
Terrace 1
Terrace 4
Geologic Units
Qal
Qc
Qat 1
Qat 2
Qat 3
Qat 4
Qat 5
Ke
Kbf
Km
Kn
Ktc
Klc
Kjr
Tat
Study Boundary
N
0 1 2 4 Miles

Terrace Formation

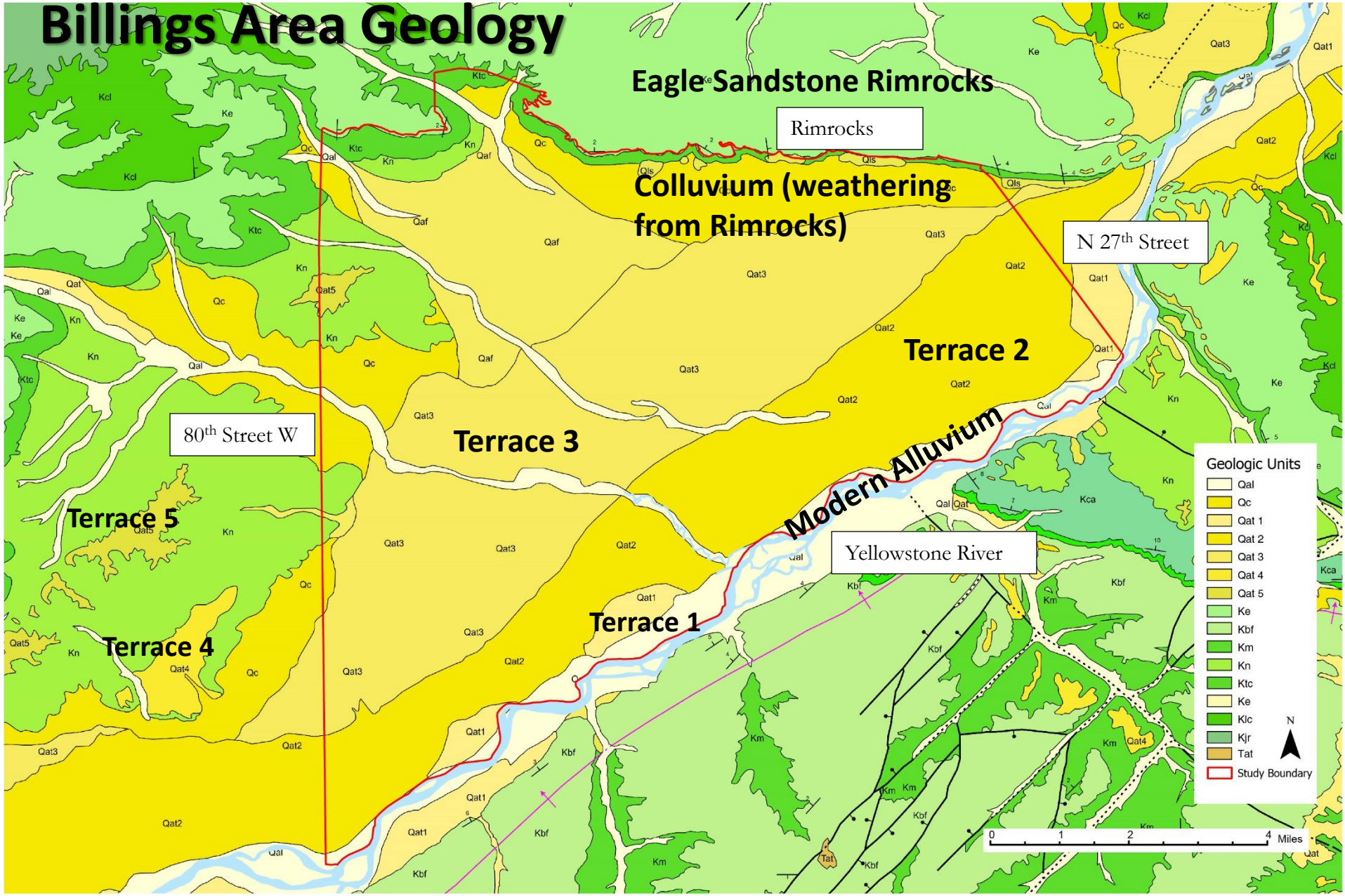


From Om N. Bhargava

Terrace Formation



EPA.gov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Geologic Units
Qal
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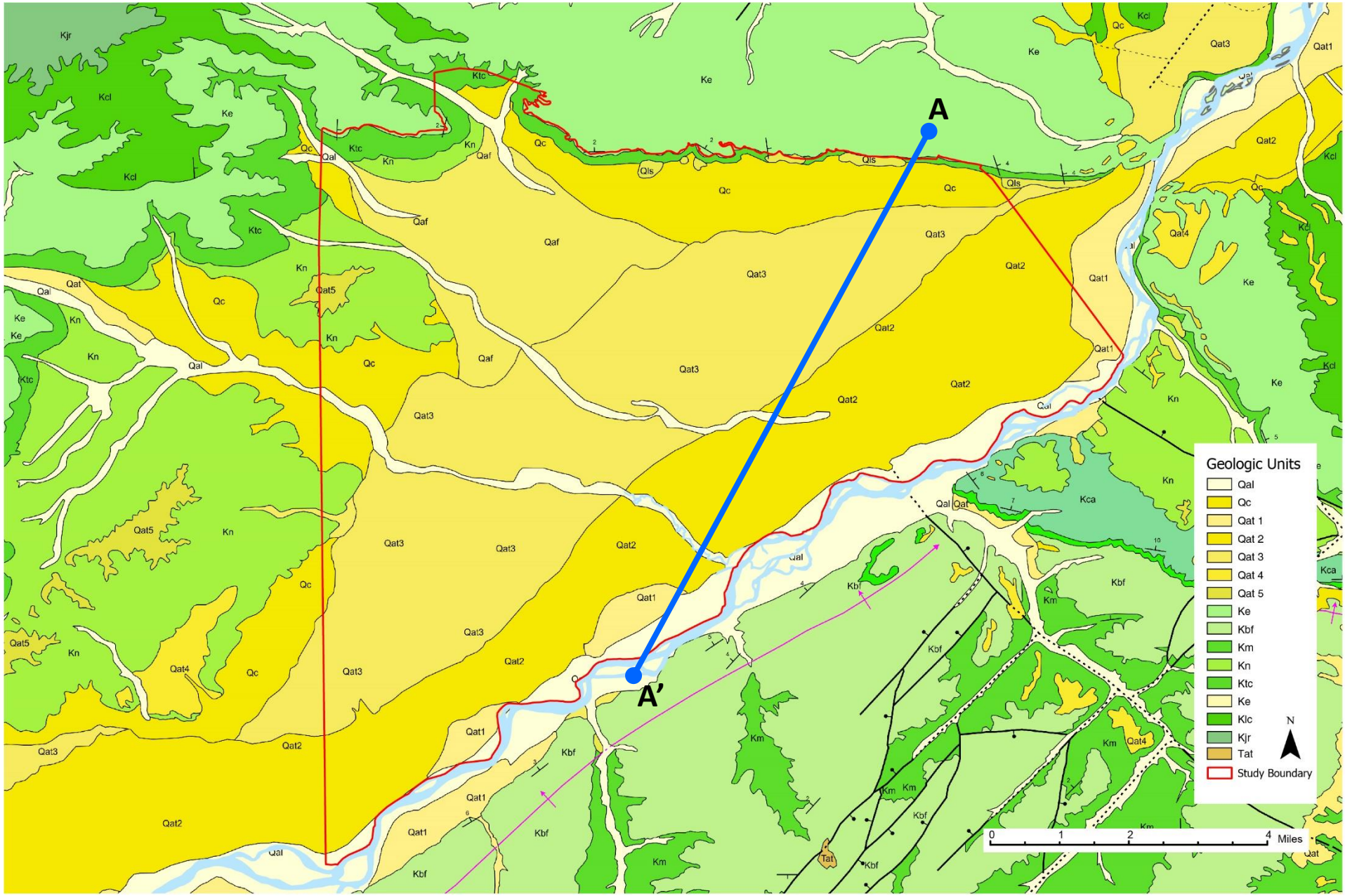
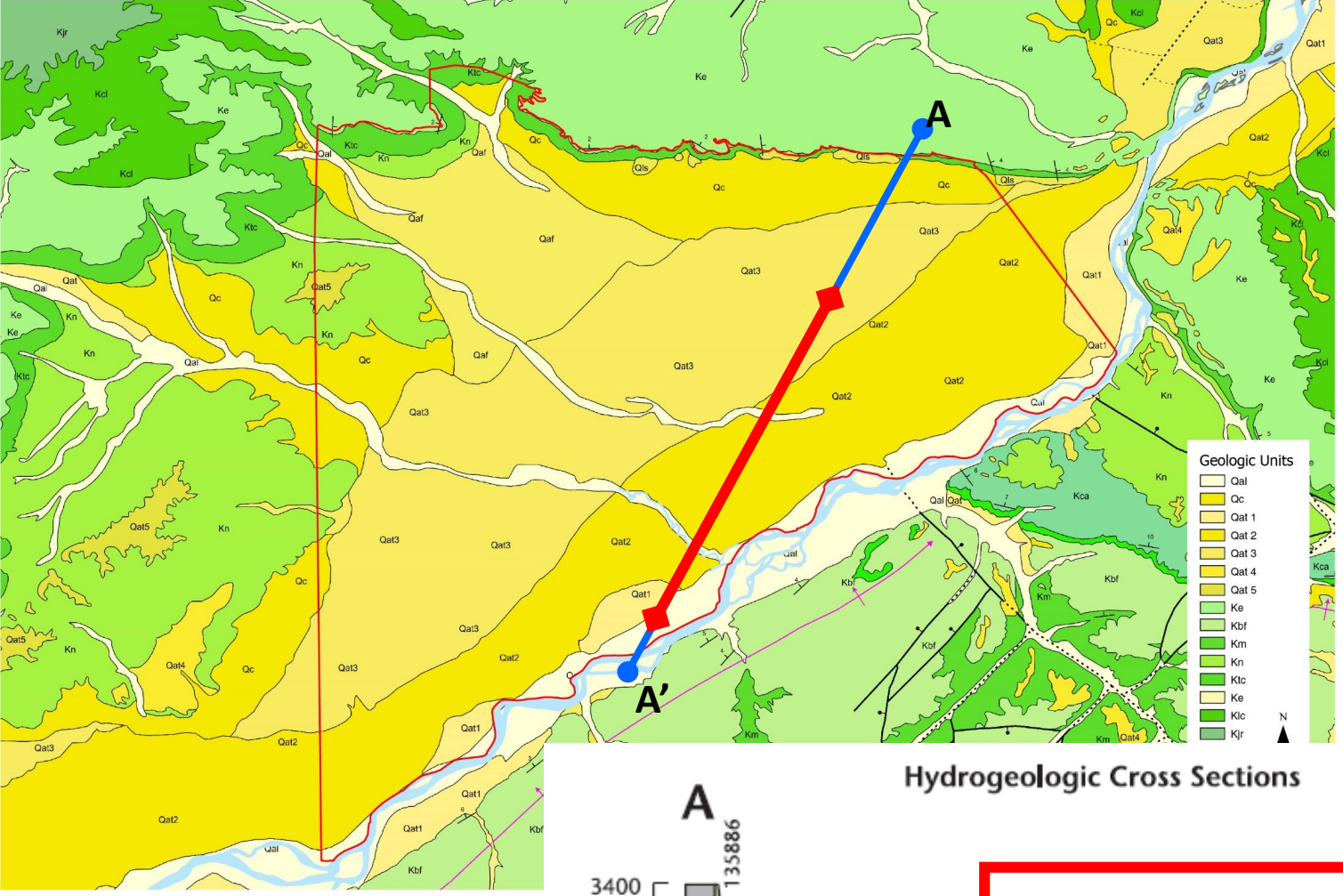
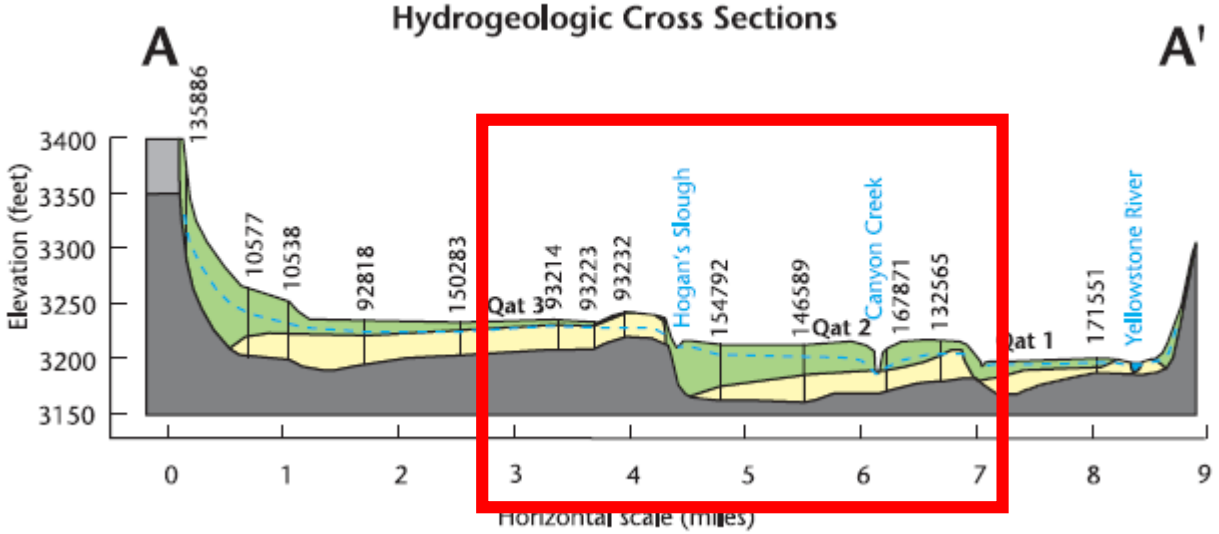
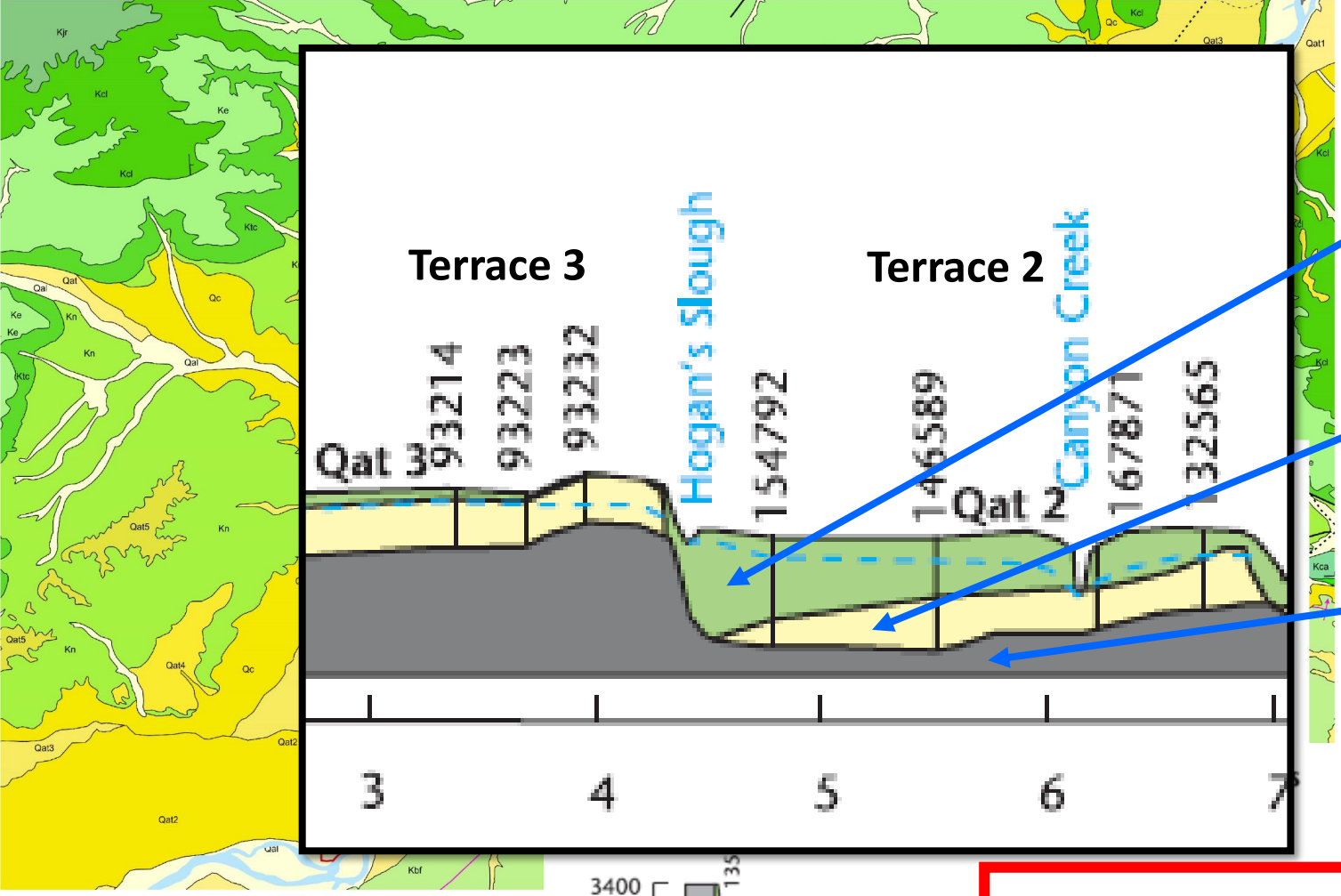
Qat 1
Qat 2
Qat 3
Qat 4
Qat 5
Ke
Kbf
Km
Kn
Ktc
Klc
Kjr
Tat
Study Boundary
N
0 1 2 4 Miles


A
A'
Geologic Units
Qal
Qc
Qat 1
Qat 2
Qat 3
Qat 4
Qat 5
Ke
Kbf
Km
Kn
Ktc
Ke
Klc
Kjr
Tat
Study Boundary
N
0
1
2
4
Miles





Olson and Reiten, 2002

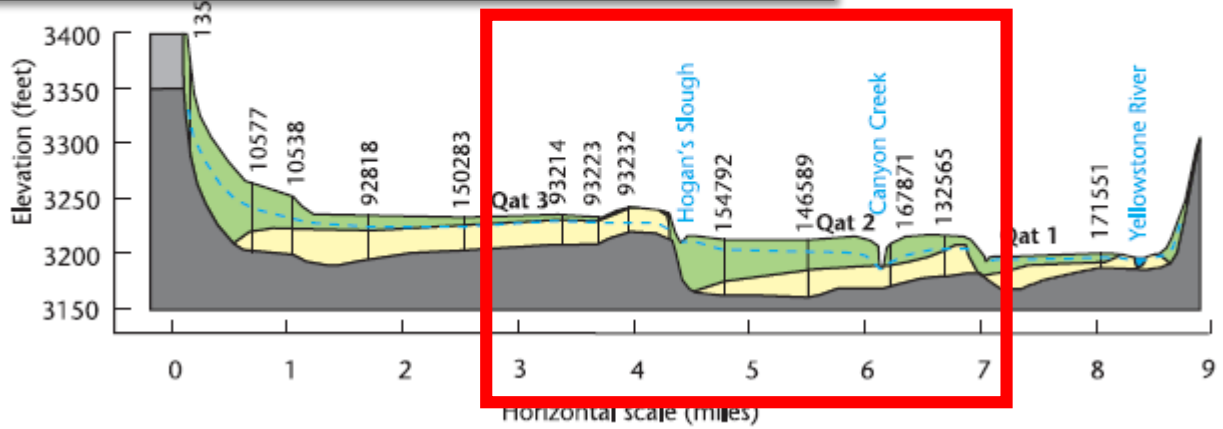


Fine-grained sediment (weathered sandstone and shale)

Sand and gravel (river deposits)

Shale bedrock (not an aquifer)

A'



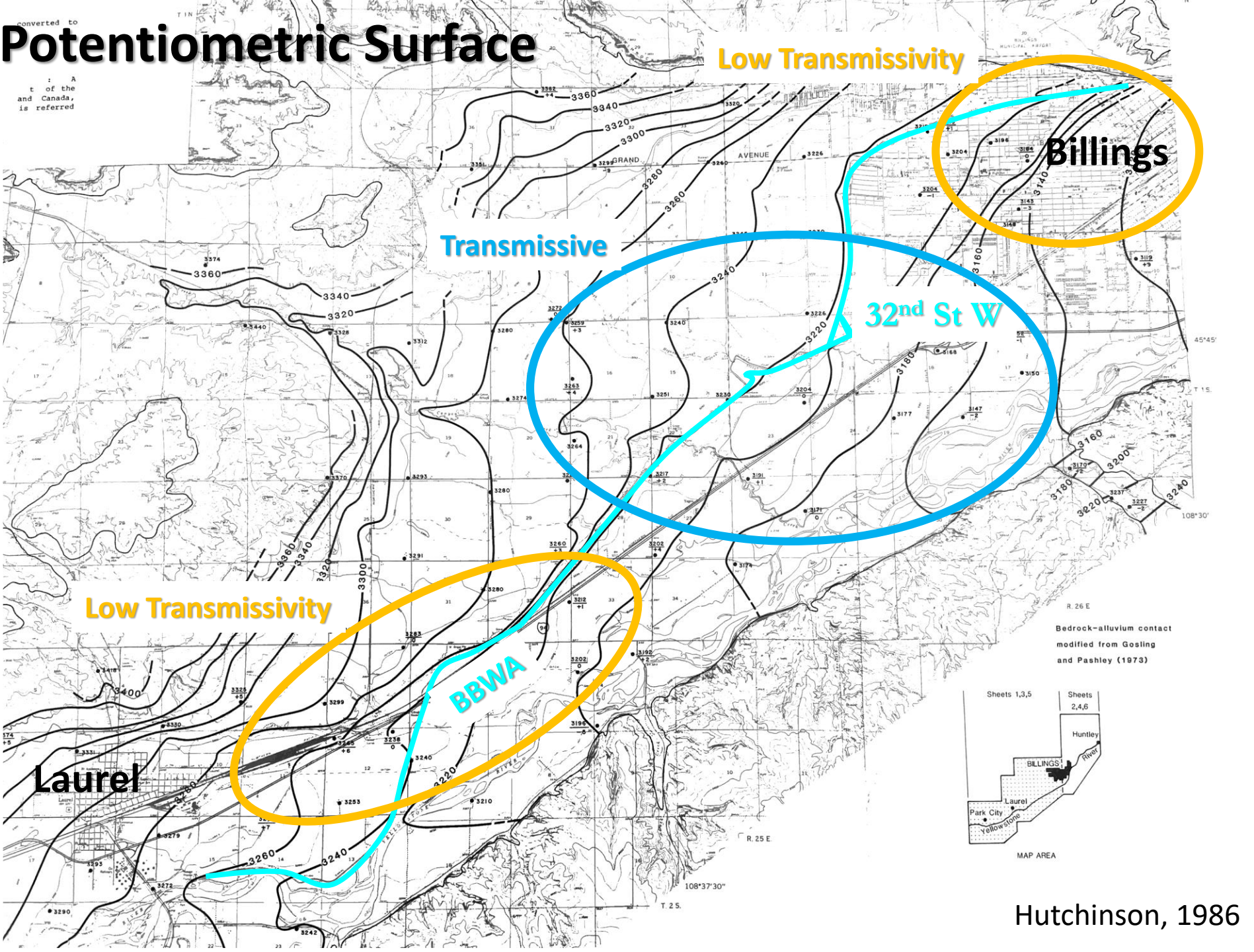
Olson and Reiten, 2002

32nd north of Gabel

8th and Lewis

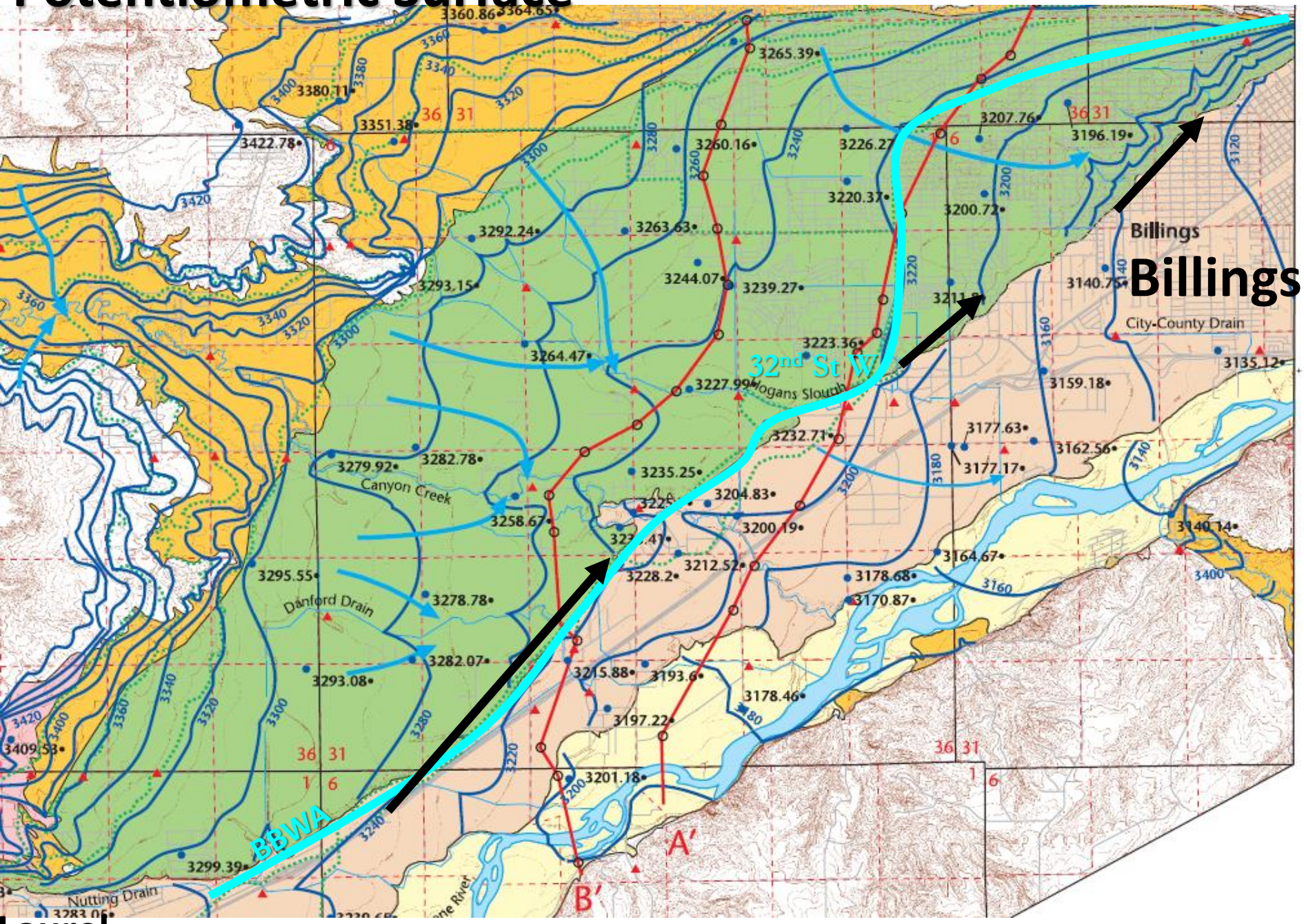
Pioneer Park

Potentiometric Surface



Hutchinson, 1986

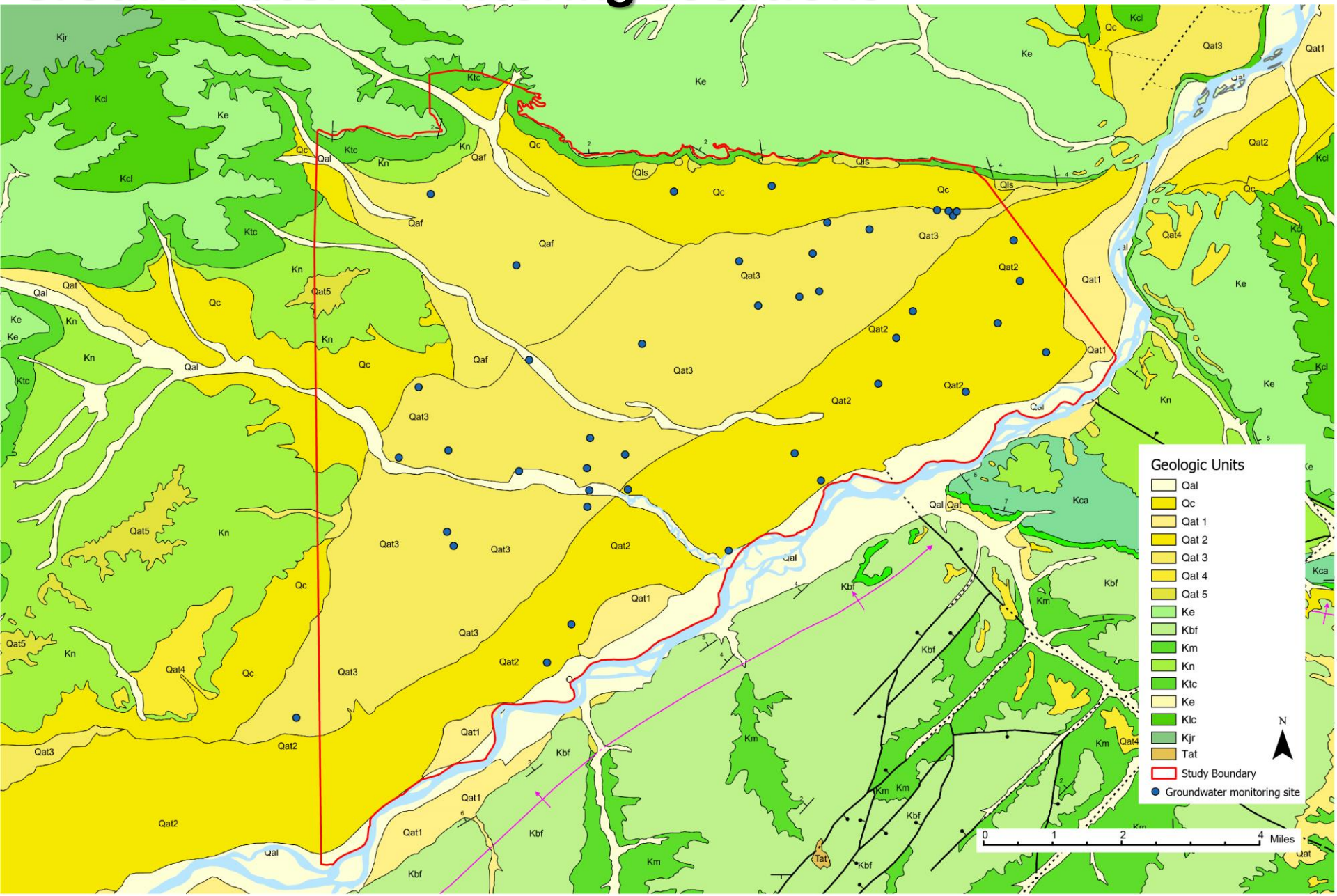
Potentiometric Surface

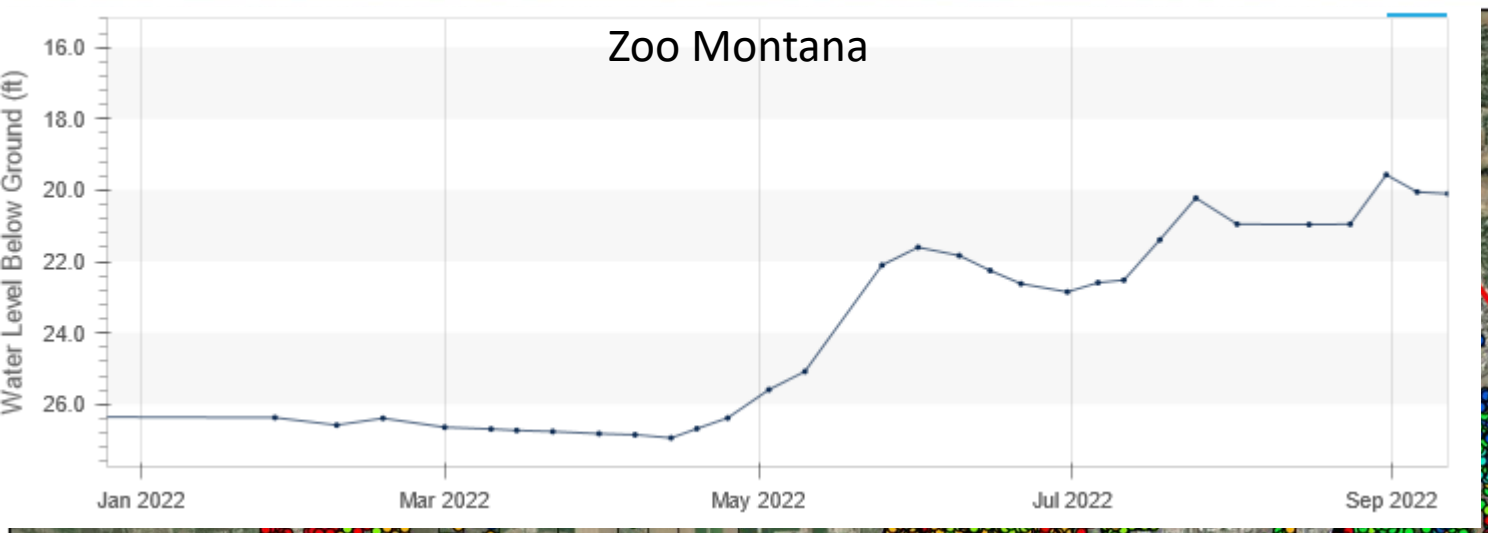


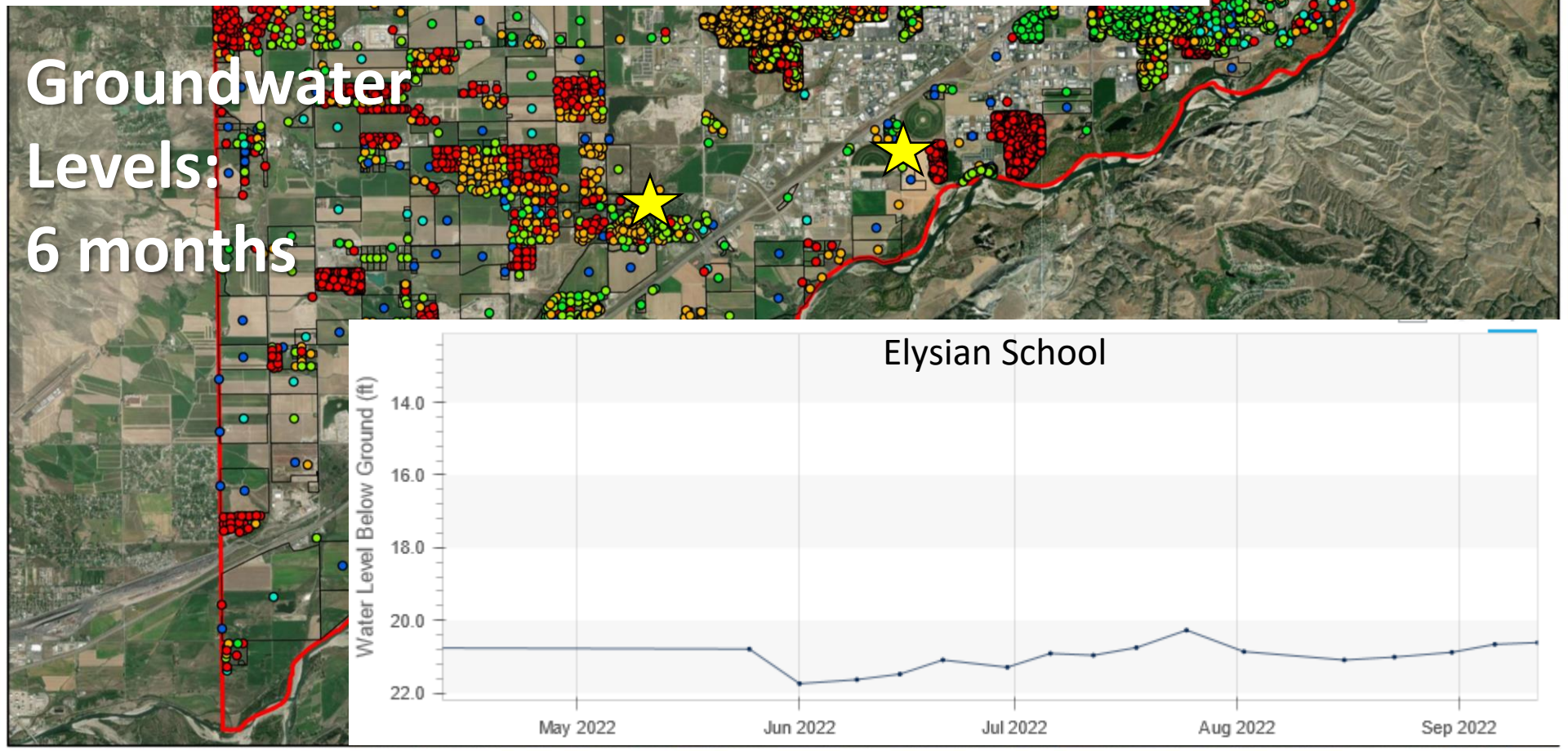
Laurel

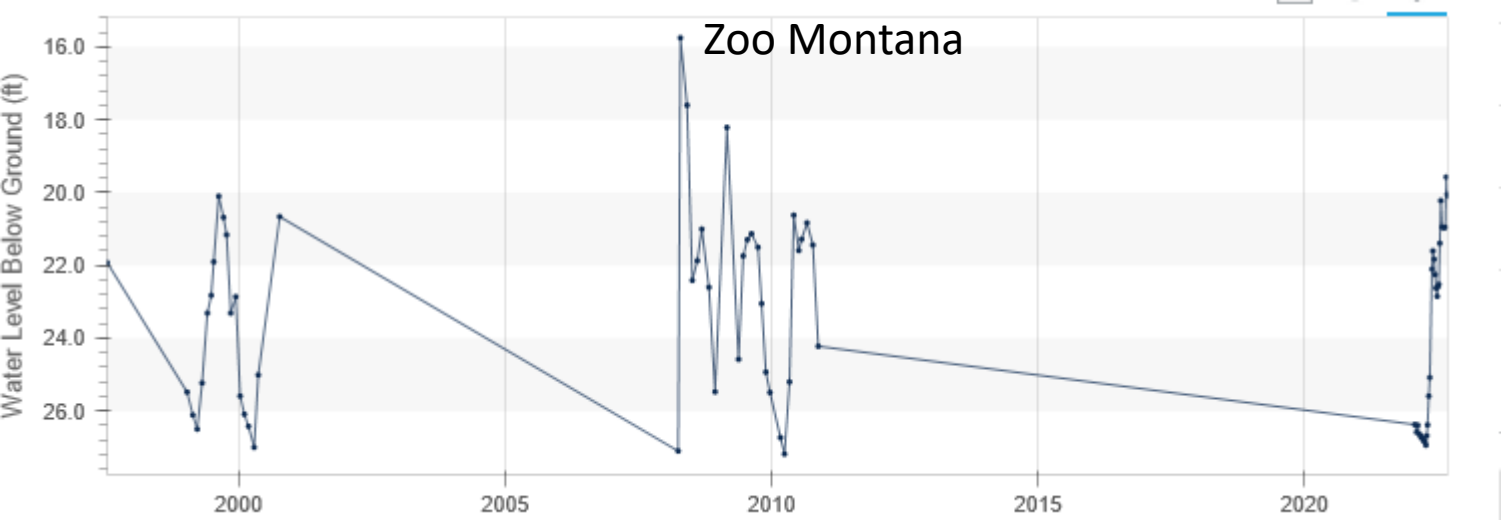
Olson and Reiten, 2002

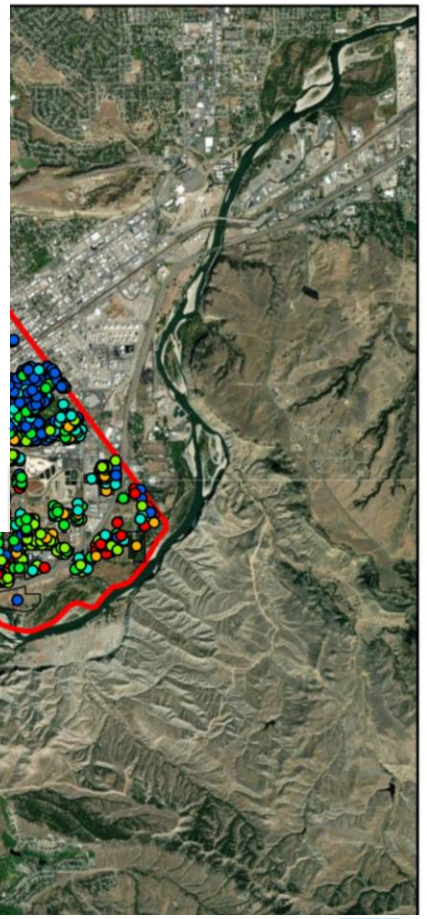
Groundwater Monitoring Locations



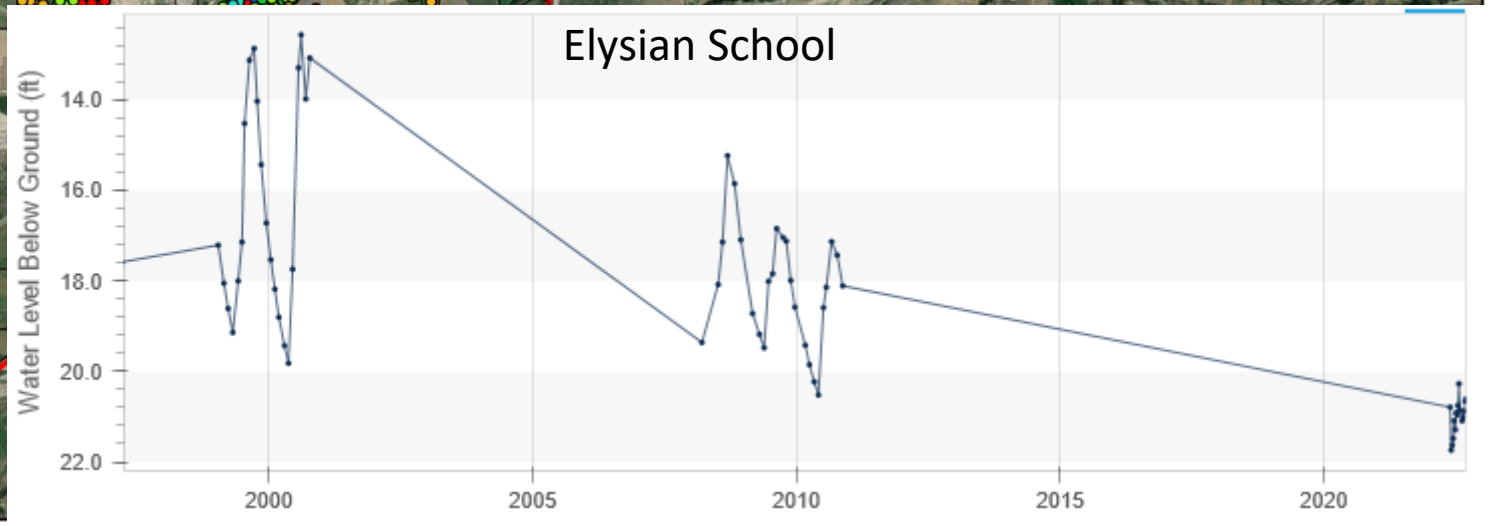

Zoo Montana
Water Level Below Ground (ft)
16.0
18.0
20.0
22.0
24.0
26.0
Jan 2022
Mar 2022
May 2022
Jul 2022
Sep 2022


Groundwater Levels: 6 months
Elysian School
Water Level Below Ground (ft)
14.0
16.0
18.0
20.0
22.0
May 2022
Jun 2022
Jul 2022
Aug 2022
Sep 2022



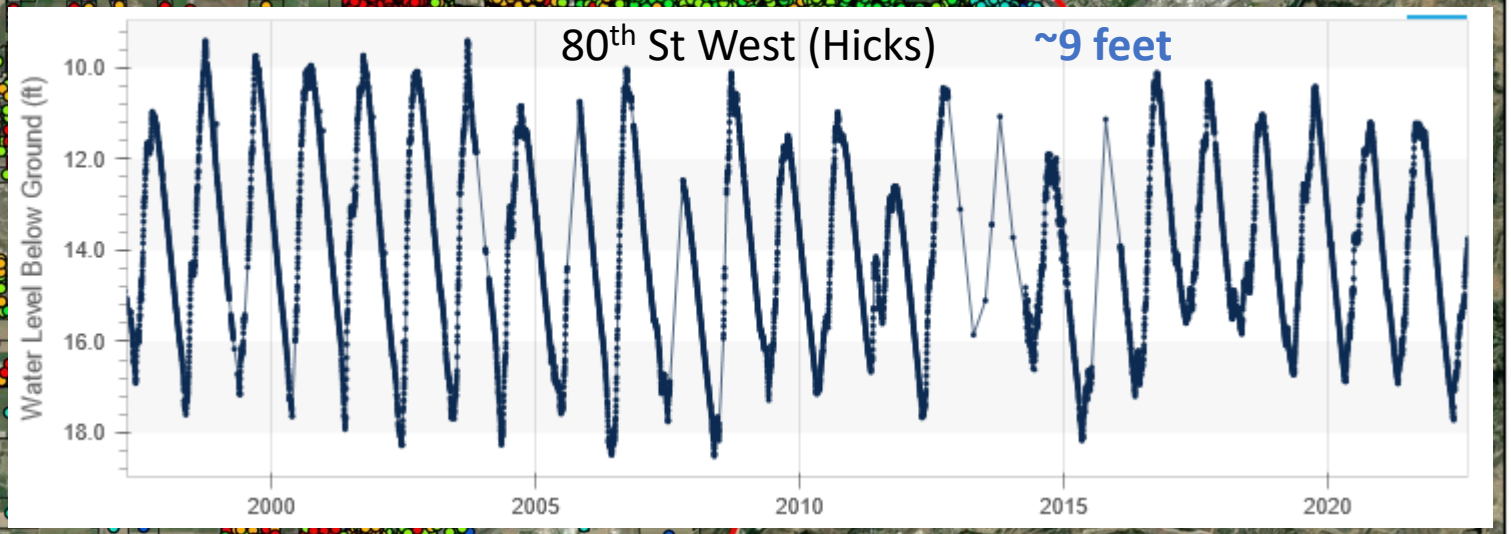


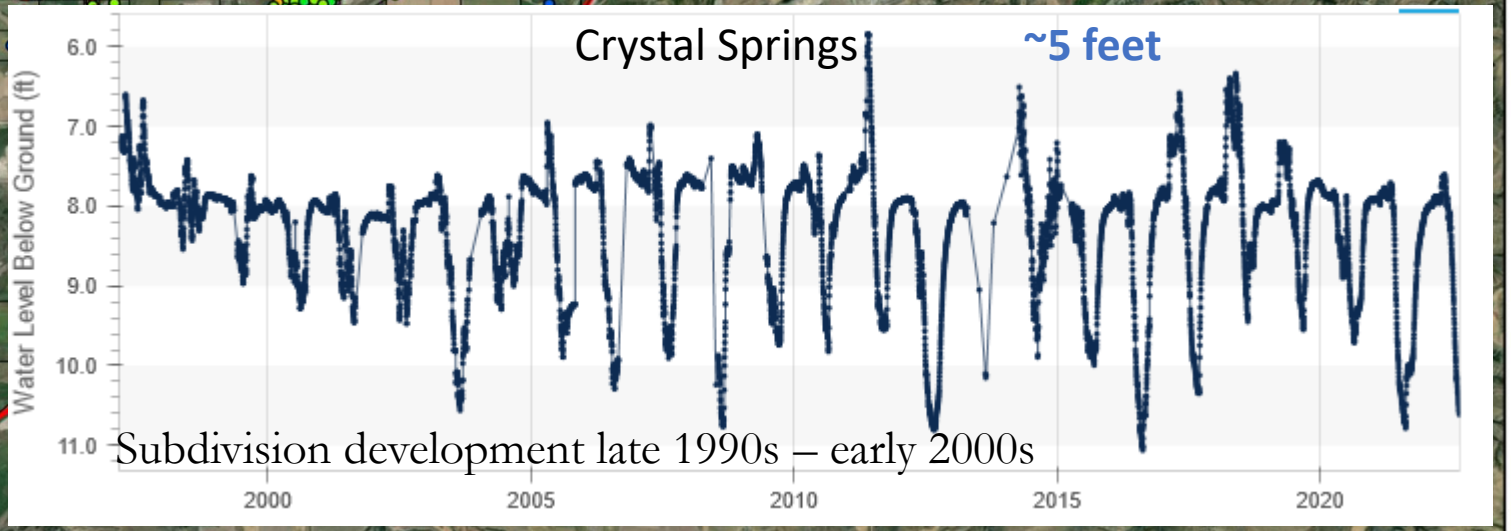
Groundwater Levels: 20 years



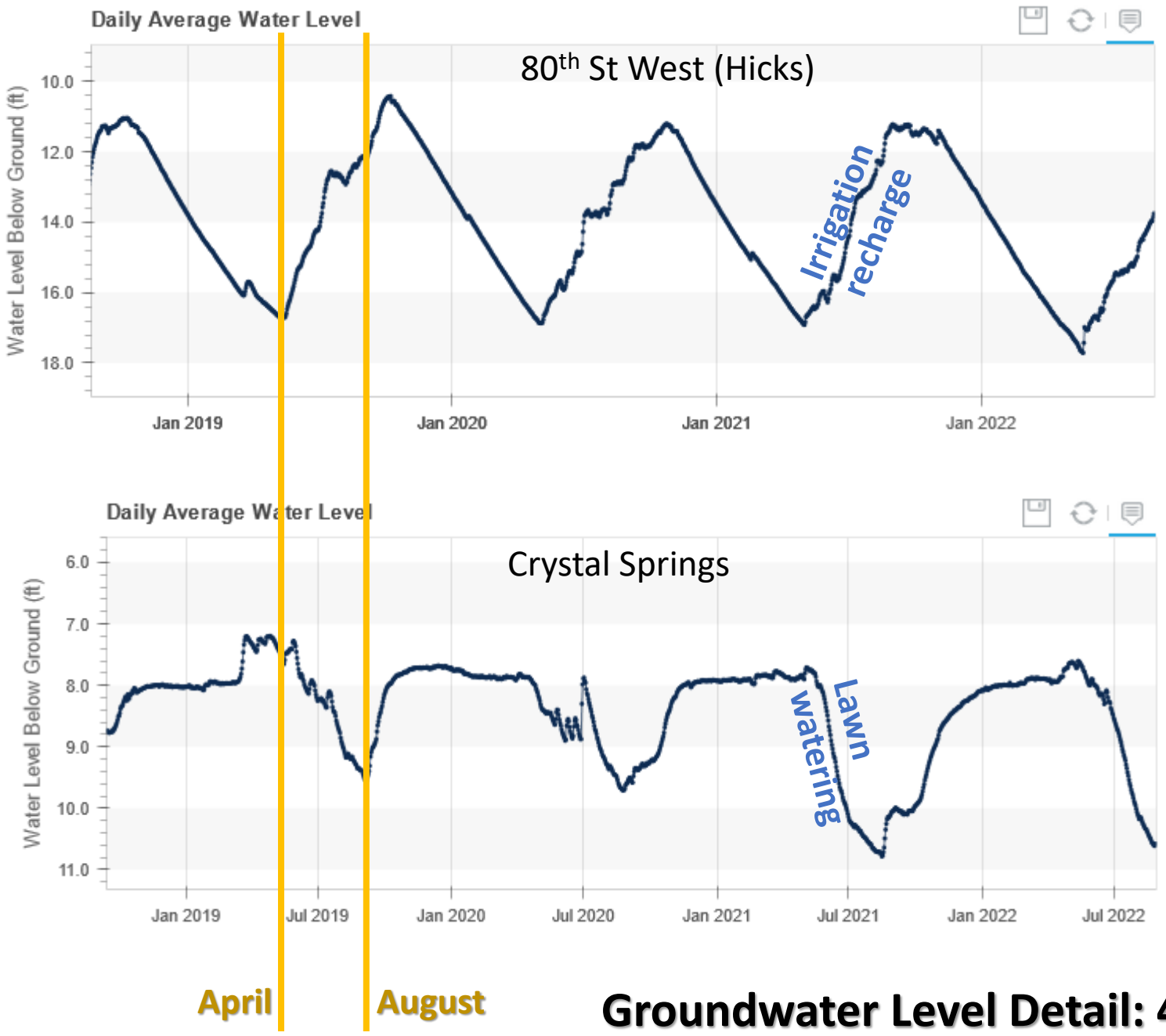
Groundwater Levels: 20 years

MBMG GWAAMON monitoring data





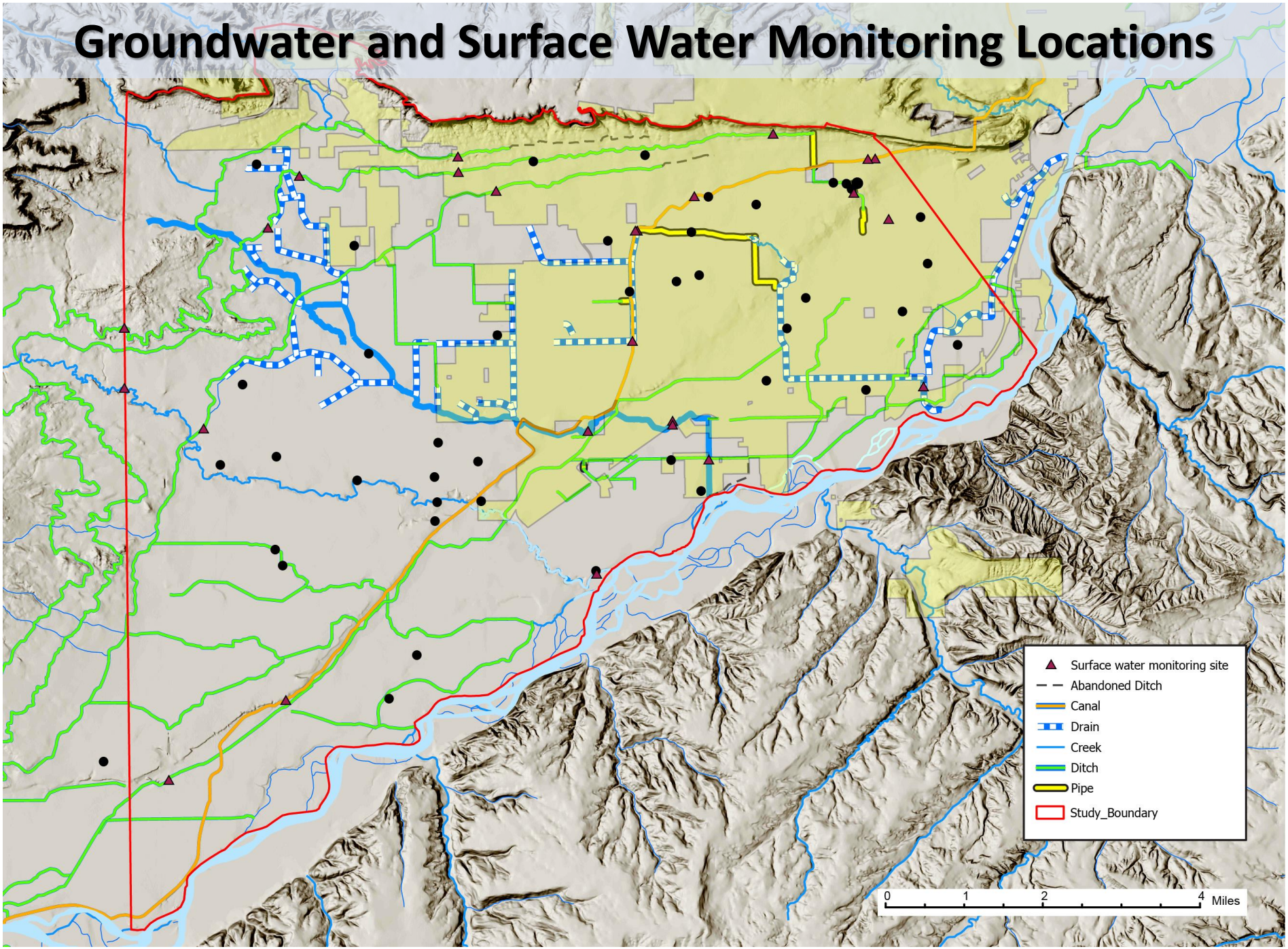
Subdivision development late 1990s – early 2000s



Groundwater Level Detail: 4 years

MBMG GWAAMON monitoring data

Groundwater and Surface Water Monitoring Locations



Alluvial Aquifer Water Budget Elements

INFLOWS	Equation Notation	Method
Groundwater inflow	GWin	modeled *(based on measured water levels)*
Bedrock in	BDin	measured (head, geochemistry)
Stream/Drain loss	STRin	measured (head, flow)
Precipitation	Precip	estimated from records
Canal loss	CNin	measured (flow)
Irrigation recharge	IR	estimated from landuse
OUTFLOWS		
Groundwater outflow	GWout	modeled *(based on measured water levels)*
Bedrock out	BDout	measured (head difference)
Stream/drain gain	STRout	measured (head, flow)
Evapotranspiration	ET	estimated from records
Wells (net out)	WELLSnet	estimated from records
change in storage	dS	measured (water levels)

Groundwater models: a new management tool
What will the model tell us?

- The groundwater budgets for terraces.
- Improve the understanding of groundwater/surface water connection.
- Show degree of connection between terraces.
- Scenarios of land use and surface water changes are of interest to the city, county and state for development purposes.

Example scenarios:

1. The extent to which major drains and streams are sensitive to increased groundwater withdrawal.
2. Effect on the shallow aquifer of removing drains and/or canals.
3. Effect on shallow aquifers of removing applied irrigation, increasing domestic withdrawals, but leaving canals in place.
4. Effect of addition of reservoir(s) on groundwater elevation and flow direction.

Thanks to our neighborhood partners:

- Irrigation Canal Companies
- Numerous private well owners and businesses

And hopefully many future partners…

Shameless plug:
Any west-end residents with a well?
We're looking for more monitoring sites.

Thank you!

Questions?

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Montana Bureau of Mines and Geology
101 Grand Avenue, Billings Montana
406-496-4599; EMeredith@mtech.edu