Exempt Wells, Water Planning, and Growth Data
Comprehensive Water Review Stakeholder Working Group
Focus Aquifers Working Document
Last update: 11.13.2023

These data are preliminary for SWG discussion purposes. The Stakeholder Working Group will further refine these data requests with input from the public. This is a working document and information compiled was with time limitations. Data from the Water Rights Information System (WRIS) is often limited by the information provided by water right holders.

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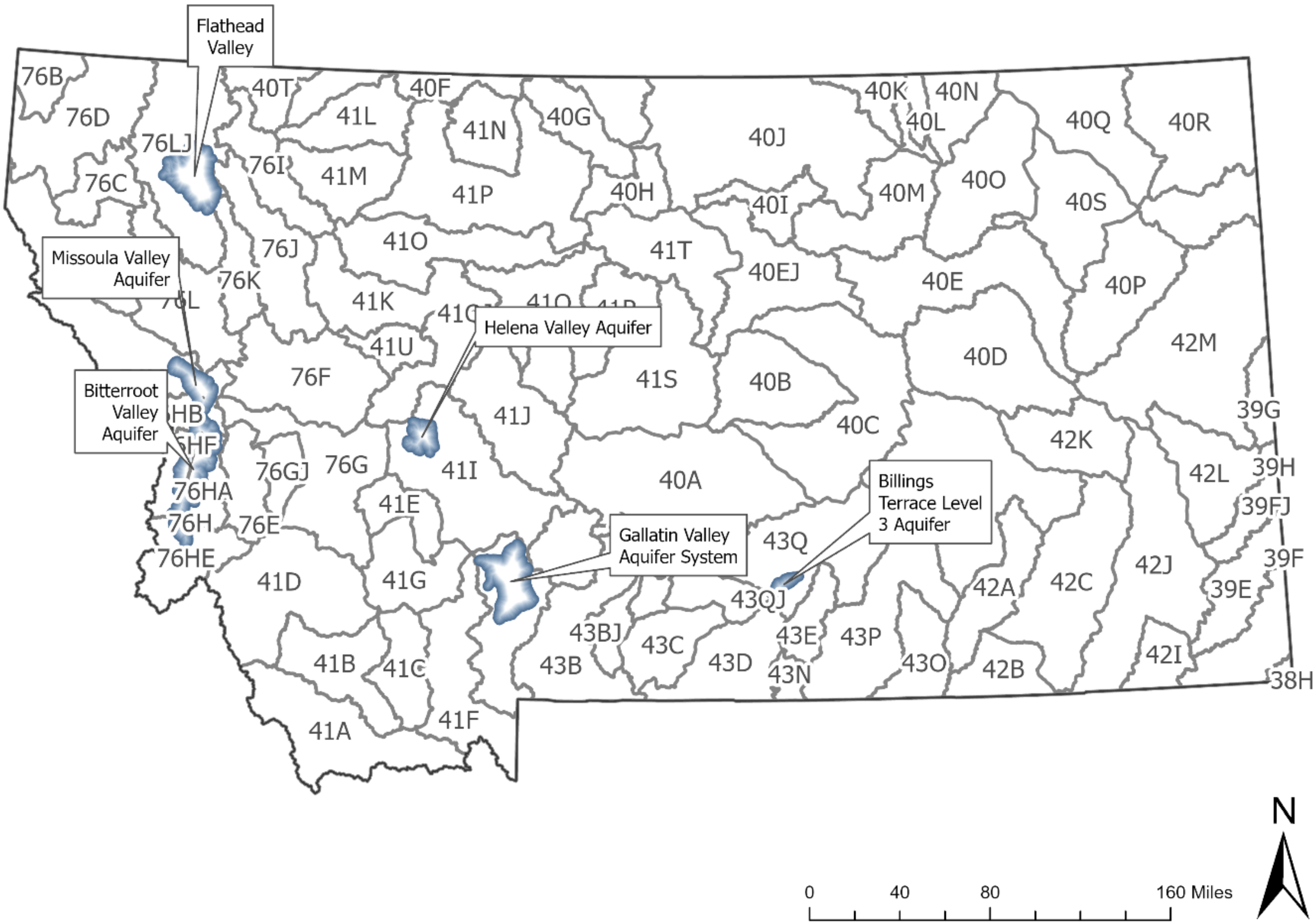
1. DNRC identified focus aquifers that warrant further discussion and investigation.



Description:

- The DNRC took previous data and identified focus aquifers that warrant further discussion and investigation. This is a preliminary analysis to spur further conversation.
- Appendix A includes an analysis of the five focus aquifers.

Rationale for focus aquifer selection:

1. Aquifers with high concentration of exempt wells, where density could have cumulative impacts.
2. Surface Water Basin Closures, or lack of SW legal availability.
3. Aquifers with known hydraulic connection to surface water.
4. New ground water permitting is likely to require mitigation, if there is SW/GW connectivity, potential to deplete surface waters resulting in adverse effect.

Summary:

	Rationale					Solution Opportunities			
	High density of wells	Basin closures	Surface water legal availability concerns	SW- GW connectivity	New GW permit likely to require mitigation	PWS Expansion	Mitigation Bank/Water Exchange	Storage	Study/policy
Helena (41I)	x	Upper Missouri	x	x	x	x-reservation	x	x	x
Gallatin (41H)	x	Upper Missouri	x	x	x	x	x	x	x
Missoula & Bitterroot (76H & M)	x	Bitterroot	Depends on source	x	Depends on location		x	x	x
Billings (43Q)	x		Depends on source	x	Depends on location	x-reservation			x
Flathead valley (76LJ)	x			x					x

Additional aquifers that may warrant additional investigation:

- Tobacco Valley Aquifer (Eureka area)
- Lower Yellowstone Buried Channel Aquifer (Sidney area)
- Ennis Area Aquifer
- Horse Creek Aquifer (Three Forks area)
- Seeley Lake Area Aquifer
- Spokane Creek Area Aquifer (East Helena Area)
- Virginia City Area Aquifer
- Dillon Area Aquifer
- Paradise Valley Aquifer
- Fox Hills-Hell Creek Aquifer
- Madison Group Aquifer

2. Overview of criteria analysis for permits and changes.

For all new permits, applicants must prove by a preponderance of the evidence the following criteria (§ 85-2-311, MCA). These criteria ensure that the Department doesn't 1) approve a permit for water that isn't actually there, 2) compound an over-appropriated condition on a source, 3) ensure the proposed use is beneficial, 4) ensure the water user can adequately respond during times of shortage. Some criteria have overlapping elements which need to be considered, but each criterion must be met independently. The statutory criteria for permits are:

- Water is physically available
- Water is legally available
- Prior appropriators will not be adversely affected
- Adequacy of diversion
- Beneficial Use
- Possessory Interest

An authorization to change is required if changing one or more of the following: Point of Diversion; Place of Use; Purpose of Use; Place of Storage. Applicants must prove criteria by a preponderance of the evidence (§ 85-2-311, MCA). The statutory criteria for changes are:

- The change will not adversely affect the use of existing water rights
- Adequacy of diversion
- Beneficial use
- Possessory interest

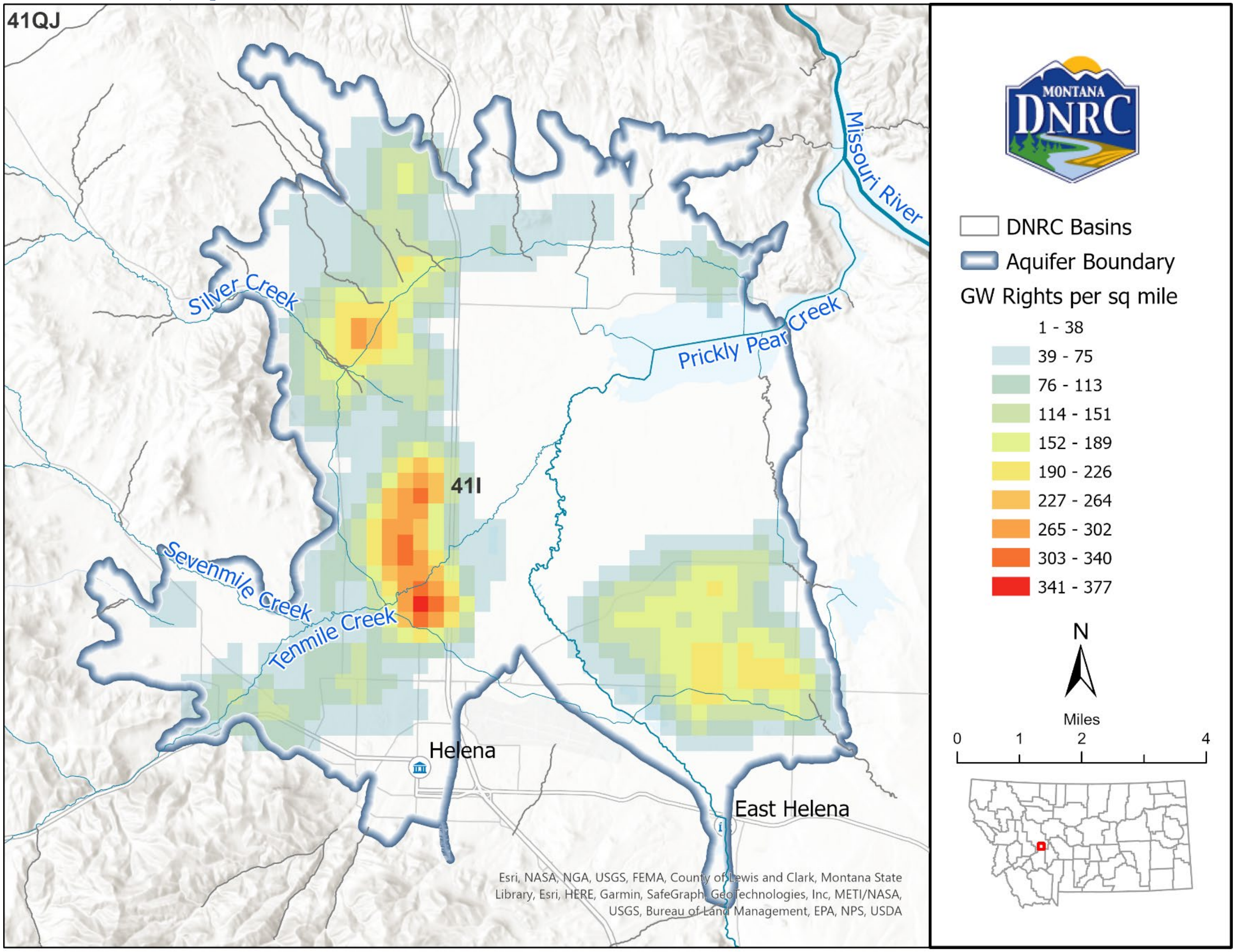
Physical Availability- To meet physical availability criteria for a new water right permit, an applicant must prove that water is physically available in the source in the amount they seek to appropriate. This applies to Surface Water, Ground Water, and the connection between (i.e., for hydraulically connected SW and GW, if SW is not physically available, then GW will not be available).

Legal Availability- To meet the legal availability criteria for a new water right permit, an applicant must prove that the amount of water they seek to appropriate can be considered legally available. This calculation is made by subtracting legal demands for the source of water from the amount of water determined to be physically available. For groundwater sources, the applicant must be able to prove water is legally available for any surface water sources that are hydraulically connected to the groundwater aquifer from which they are proposing to divert water.

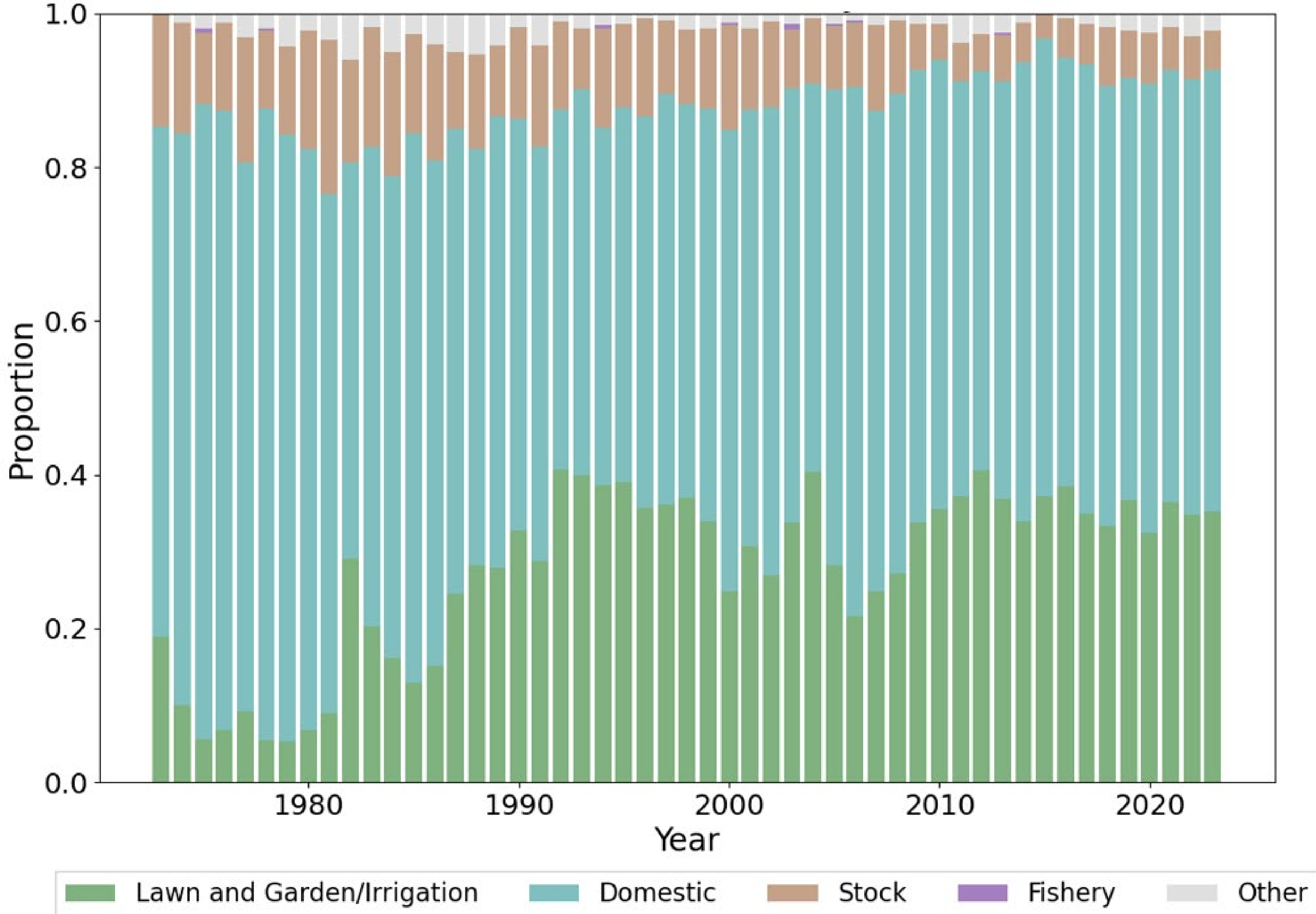
Adverse Effect- To meet the adverse effect criteria for a new water right permit, an applicant must prove that the water rights of a senior water users will not be adversely affected.

- This criterion is evaluated based on the applicant's plan to control their diversion of water if there is a shortage of water and a call is made.
- In addition, if water is not legally available in the source of supply or any depleted surface water sources, mitigation is required to offset the water use that would otherwise result in adverse effect to existing users. In these situations, the applicant is only required to mitigate for the amount of water they are proposing to use during the period(s) when water is not legally available. This mitigation also needs to be included in the applicant's plan.

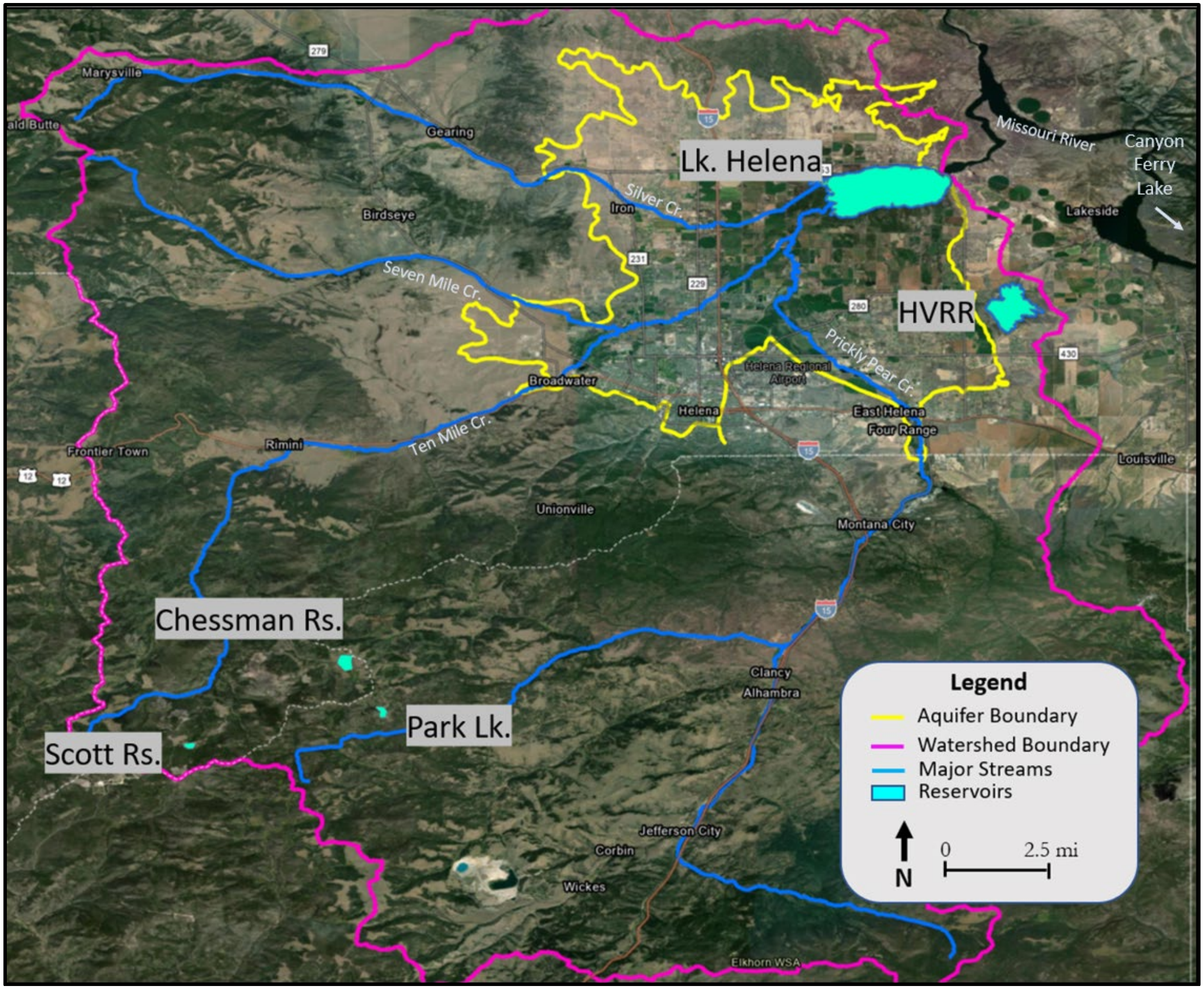
3. Helena Valley Aquifer (41I)



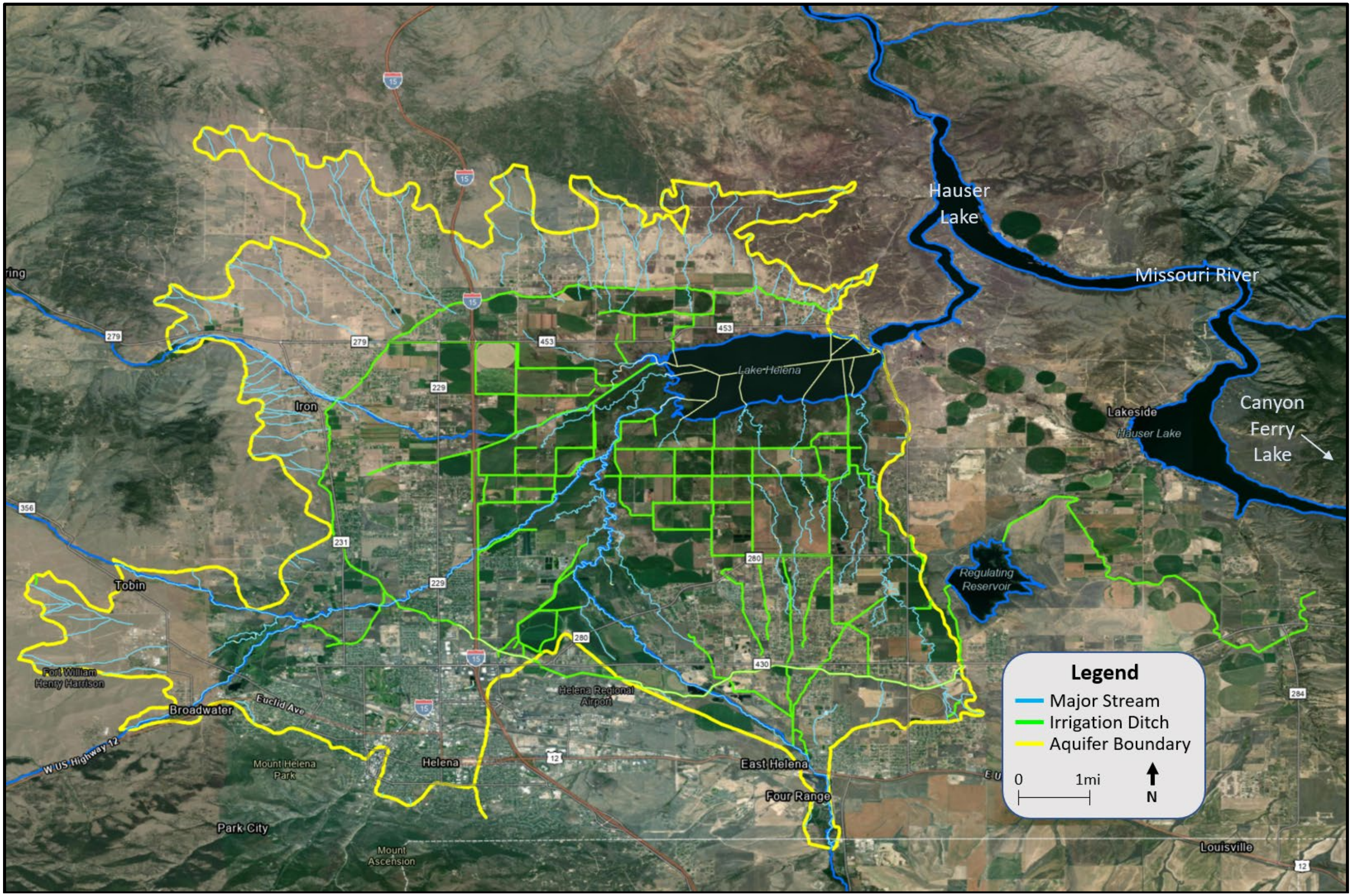
3.1. Exempt wells by purpose within Helena Valley Aquifer boundary from 1972-2023 shown as a proportion of the total per year.



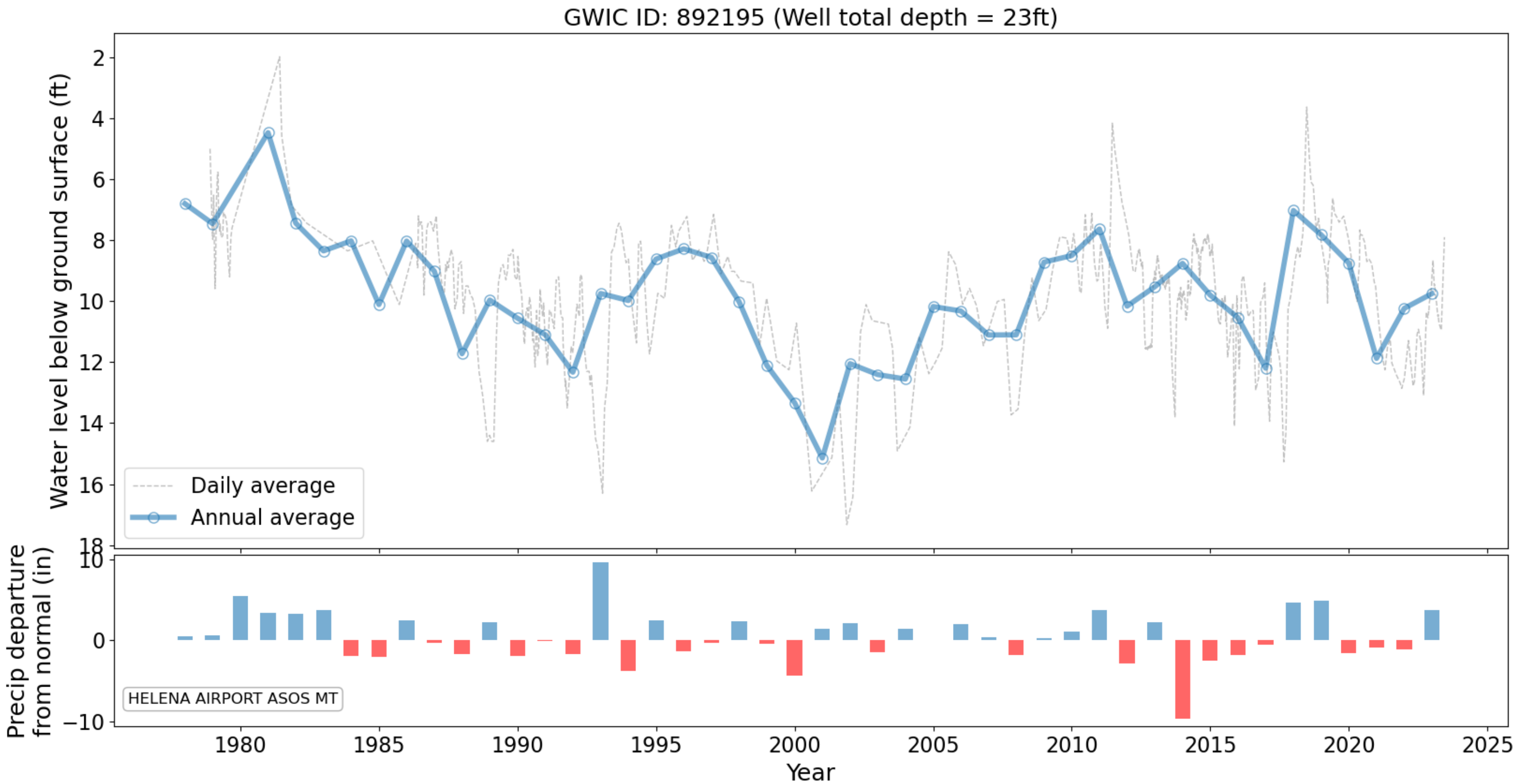
3.2. Contributing watershed (618 mi2) upstream of Helena Valley Aquifer.



3.3. Surface water in and around Helena Valley Aquifer.



3.4. Hydrograph of typical monitoring well within Helena Valley Aquifer.



Title: Helena Valley Aquifer
Type: Alluvial, unconsolidated sediments (unconfined, leaky confined)

General Description:
The depth of the unconsolidated alluvium including tertiary sediments in the Helena Valley has been estimated at 6,000 feet (i.e., this is a deep aquifer); although most wells are completed in the uppermost 200-feet. Water flows from the bedrock boundaries of the valley toward Lake Helena (from the yellow boundary line on above maps towards the northeast corner of the basin). Recharge to the aquifer is through stream (15%) and irrigation canal losses (8%), infiltration of applied irrigation water (31%), and inflow from fractures in bedrock (46%). In 1992, it was estimated that water leaving the aquifer was through groundwater recharge to streams and drains (41%), upflow to Lake Helena (57%), and through groundwater withdrawals (2%) (Briar and Madison, 1992). Considering population growth data since 1992, and increase in groundwater rights, well withdrawals are considered to be a larger component of the total amount of water leaving the aquifer.

Total Population[1]: 73,115
Area (sq miles): 87
Number of Permits: 273 (5% of groundwater rights within aquifer boundary)
Number of Exempt Wells: 4,586 (83% of groundwater rights within aquifer boundary)

Physical Availability:
- GW:
  - Briar and Madison (1992) estimate all sources of recharge into the Helena Valley Aquifer to be 86,800 acre-feet per year.
- SW:
  - DNRC has not assessed physical availability of surface water sources because of the Upper Missouri River Basin Closure (MCA 85-2-343).
- SW/GW connectivity:
  - Surface water is hydraulically connected to groundwater in this basin. Groundwater and surface water generally flows towards and discharges to the basin low point of Lake Helena, which is tributary to the Missouri River at Hauser Lake.

Legal Demand & Availability:
- GW:
  - In 1993, the Upper Missouri River Basin was closed by the legislature for any new appropriations of water. The closure is temporary until final decrees have been issued for all the subbasins. All new permits or changes that would cause an adverse effect to water users of surface water require mitigation.
  - 38,167 AF for all groundwater rights within the Helena Valley aquifer. 20% of water rights did not have a volume assigned and are not included in the total. There has been a significant increase in the percentage of withdrawal out of the aquifer due to new groundwater wells compared to the modeled data from Briar and Madison (1992), however, an updated water balance has not been calculated.

[1] Population calculated in GIS using 2020 Census Tracts that intersect aquifer boundaries. Selected census tracts extended beyond the boundaries of the aquifer and are presented for comparison only.

- SW:
  - In 1993, the Upper Missouri River Basin was closed by the legislature for any new appropriations of water. The closure is temporary until final decrees have been issued for all the subbasins. All new permits or changes that cause an adverse effect to surface water bodies, require mitigation.
  - A 1997 DNRC study of physical/legal availability of the upper Missouri River concluded that two water rights for hydropower production account for all the natural flow (physical availability) in the Upper Missouri River for most months of the year in all but the wettest years.

Concerns:

- While groundwater physical availability in the Helena Valley Aquifer is abundant, any new use of groundwater must be mitigated because that groundwater would otherwise discharge to the Missouri River where there is no remaining legal availability.
- Land development continues to be focused around the perimeter of the aquifer, where the aquifer is most vulnerable to water quantity shortages, because the aquifer is shallowest and is prone to large seasonal fluctuations in this area.
- The aquifer is likely dependent on recharge from numerous large irrigation ditches and may be vulnerable to major land use changes related to population growth. As agriculture land is converted to homes, irrigation contributions to the aquifer are lost, therefore the physical water availability of the aquifer will decline.
- City of Helena Water Master Plan (2019) identified that the demand on the city water supply would increase by approximately 1,400 acre-feet per year by 2035; a demand that can be satisfied by the current water system; and would increase by up to 9,400 acre-feet per year as the city continues to grow and incorporate existing and new homes and businesses in the Central and North Helena Valley.
- Localized water quality issues (nitrates) associated with high density of septic systems.

Solution Opportunities:

- **Public water supply:** There is a large municipal groundwater reservation for the City of Helena (6,950.64 acre-feet per year still to be perfected) and there may be opportunity to expand municipal services to tie into high growth areas.
- **Mitigation:** Additional groundwater use necessitates mitigation, and easily accessible mitigation is difficult to find. Creation of a water bank in this area would support continued groundwater development.
- **Storage:** Increasing surface water storage at existing facilities (see figure 3.2 above) that can be used for mitigation can help facilitate additional groundwater development. Several small reservoirs exist to the south of the City of Helena and are utilized for municipal water. Additionally, the City of Helena is able to purchase and utilize Missouri River water from Canyon Ferry Reservoir. Exploration of additional storage opportunities in the watershed may also provide opportunities to capture high spring flow that could provide additional water for the basin throughout dry summer months.
- **Regional Water Storage Projects:** Bureau of Reclamation is conducting a Water Availability Study for contract storage at Canyon Ferry. There is a possibility of state or private held contracts of water for future mitigation needs.
- **Study - SW**:

- The Upper Missouri Basin Closure is temporary until final decrees have been issued for all the subbasins. DNRC will be completing a revised Physical and Legal Availability analysis prior to the closure removal.
- DNRC is in the process of creating the Montana Integrated Hydrologic Model System (MIHMS) to inform surface water availability, and in the long-term legal availability. By end of 2024 MIHMS will be able to identify physical availability by stream reach throughout the state. MIHMS will be expanded in future years to include legal demand/legal availability of surface water by stream reach throughout the state.

– **Study - GW**:
  - With additional development funding and resources, MIHMS will be expanded to address a need for large scale, regional aquifer groundwater modeling. Integration of groundwater modeling into the MIHMS framework can help us understand the connection between surface water and groundwater. The groundwater modeling expansion will help establish annual aquifer recharge volumes (physical availability of groundwater) and predict impacts from changes in climate, changes in land use, and also individual changes in water rights. The groundwater modeling expansion will also help inform the science needed to make mitigation banking a reality.

DNRC Scientific Memo: No scientific memo exists for this aquifer.

Literature:

Water Quality:
Lake Helena Watershed Restoration Plan, 2016-2023., 2015, Lewis and Clark County Water Quality Protection District. Lake Helena Watershed Group. https://deq.mt.gov/files/Water/WPB/Nonpoint/Publications/WRPs/LakeHelena_WRP_Final_1212016.pdf

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Moreland, J.A. and Leonard, J.B., 1980, Evaluation of shallow aquifers in the Helena Valley, Lewis and Clark County, Montana: U.S. Geological Survey Water-Resources Investigation, Open-File Report 80-1102.

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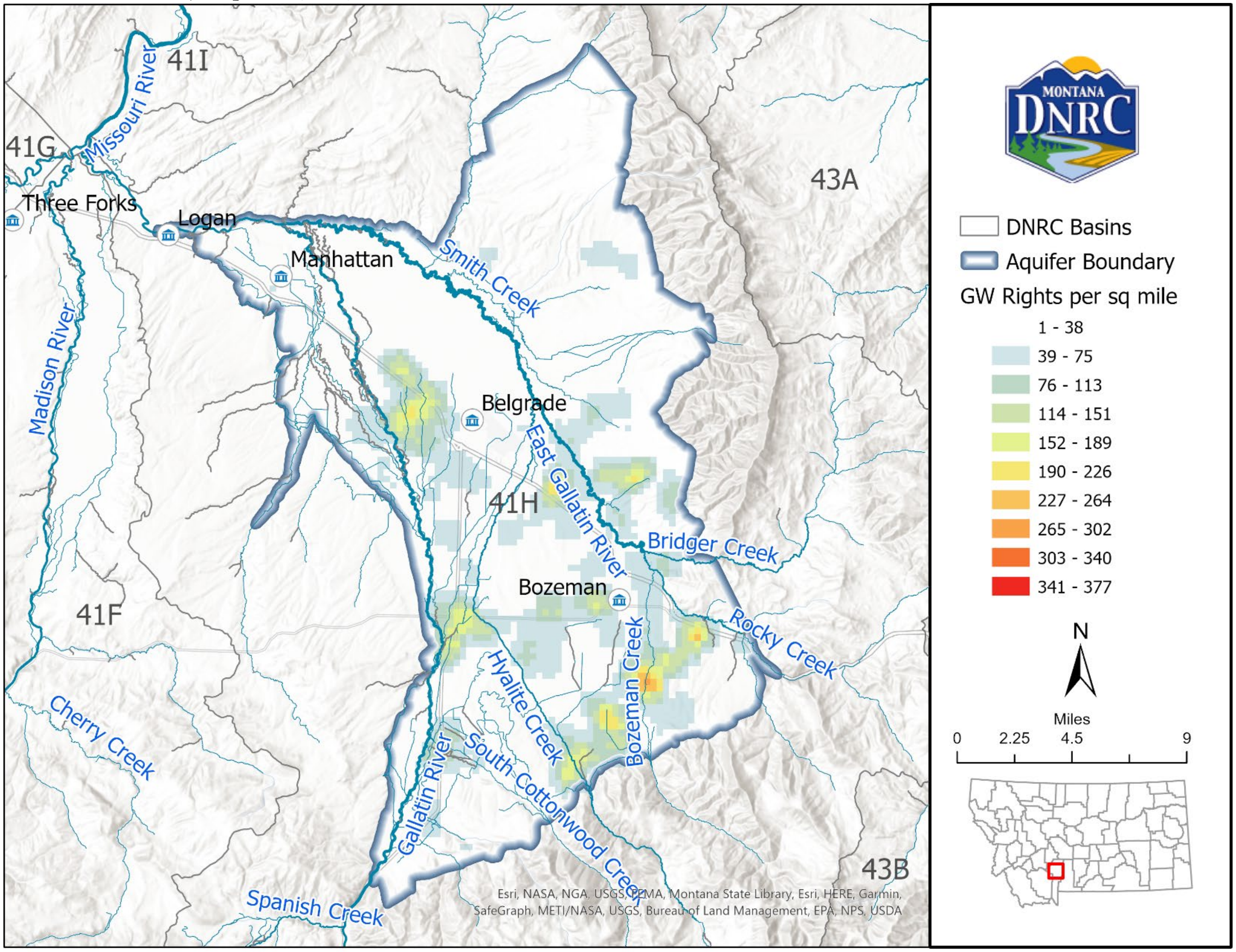
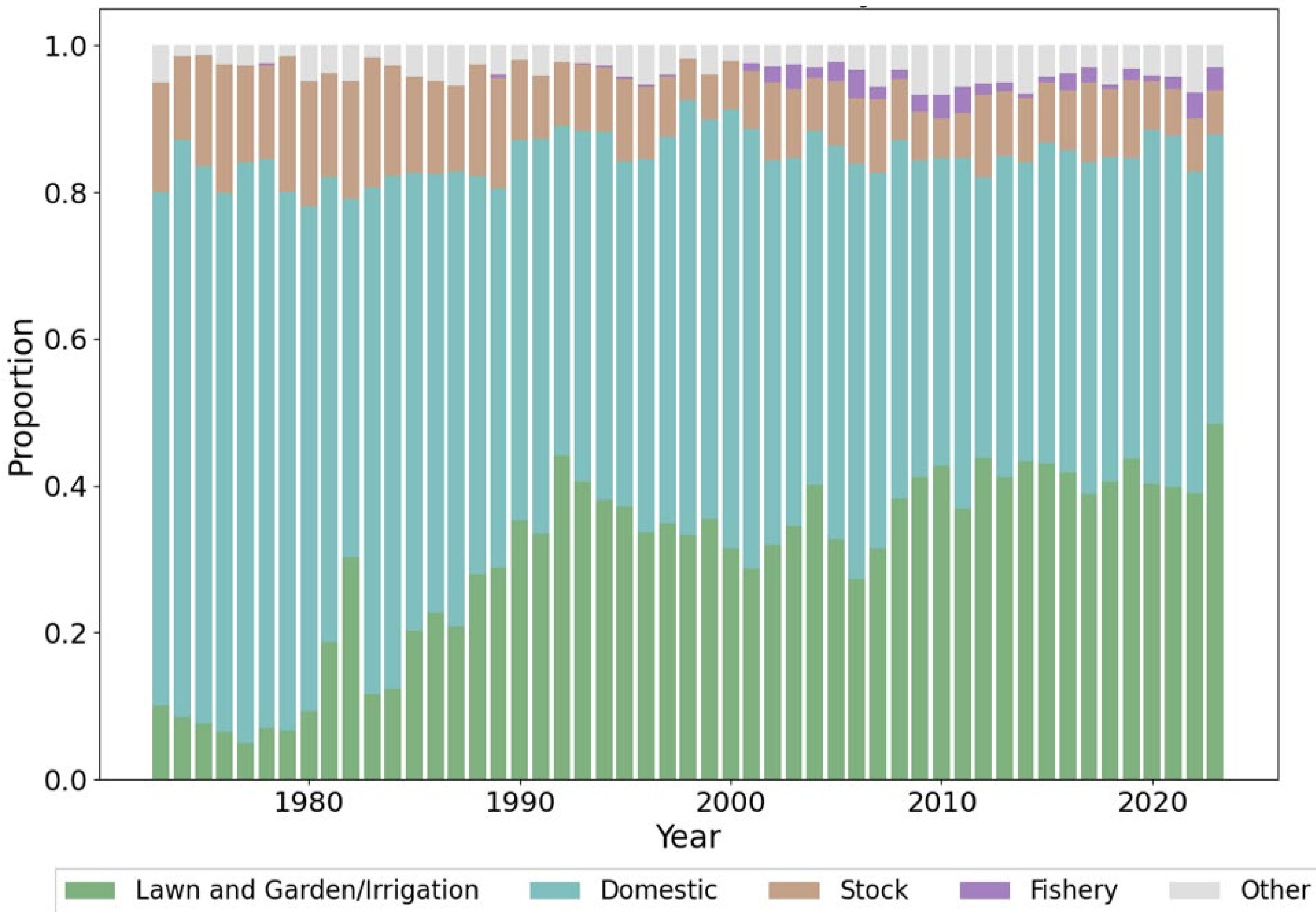
Waren, K.B., Bobst, A.L., Swierc, J.E., and Madison, J.D., 2013, Hydrologic investigation of the North Hills Study area, Lewis and Clark County, Montana, Groundwater Modeling Report: Montana Bureau of Mines and Geology Open-File Report 628, 90 p. http://mbmg.mtech.edu/mbmgcat/public/ListCitation.asp?pub_id=31597&.

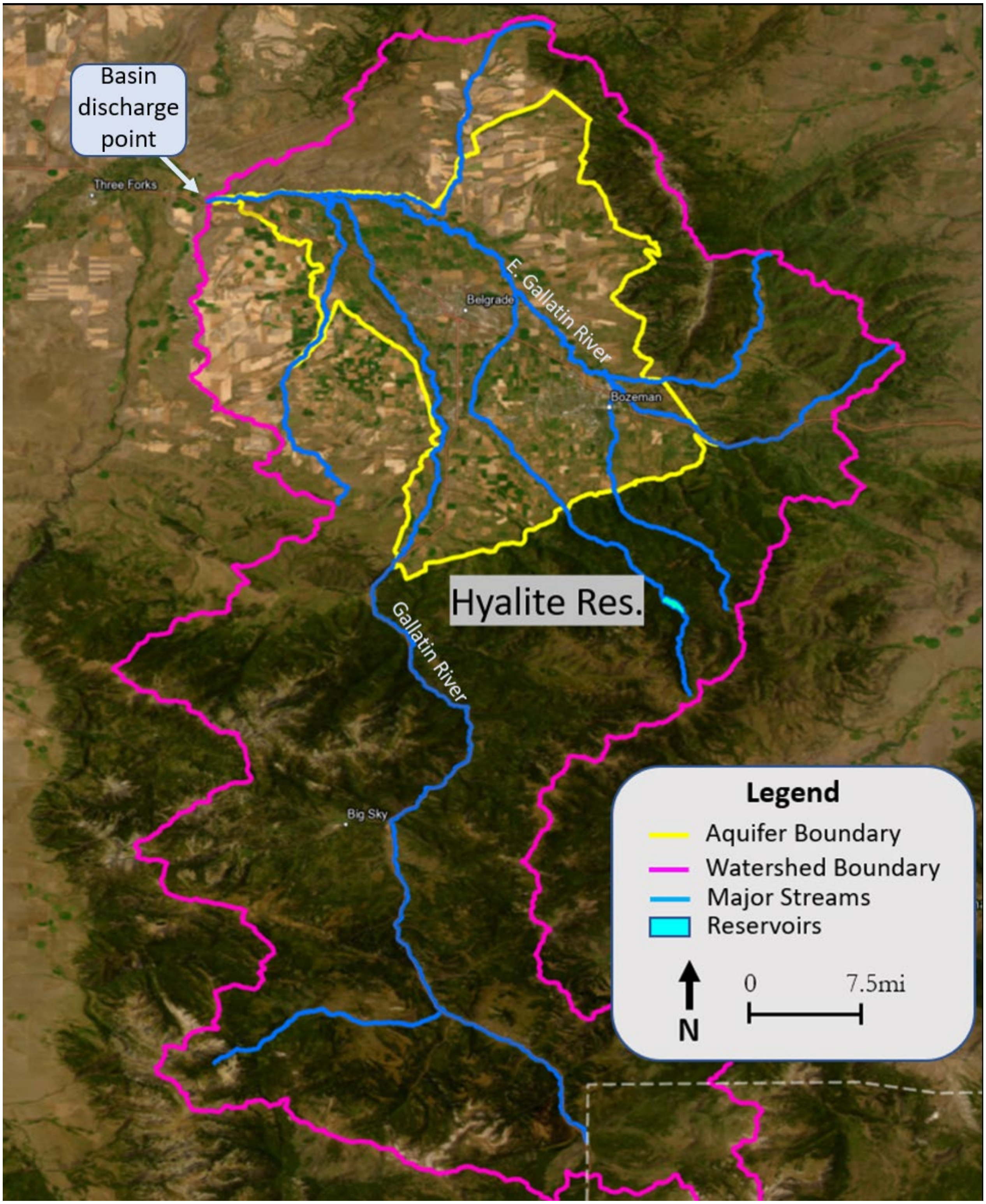
4. Gallatin Valley Aquifer (41H)



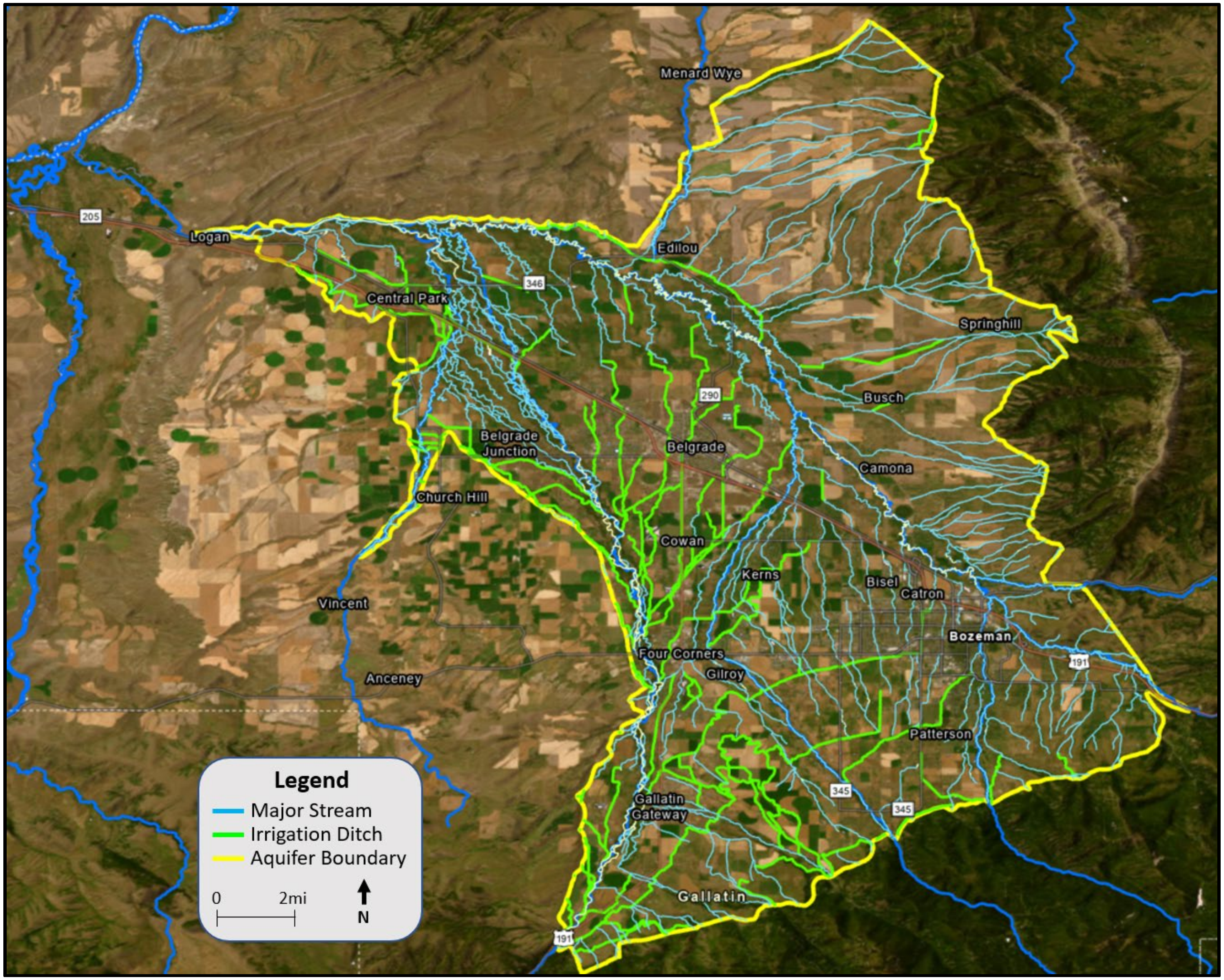
4.1. Exempt wells by purpose within Gallatin Valley Aquifer boundary from 1972-2023 shown as a proportion of the total per year.



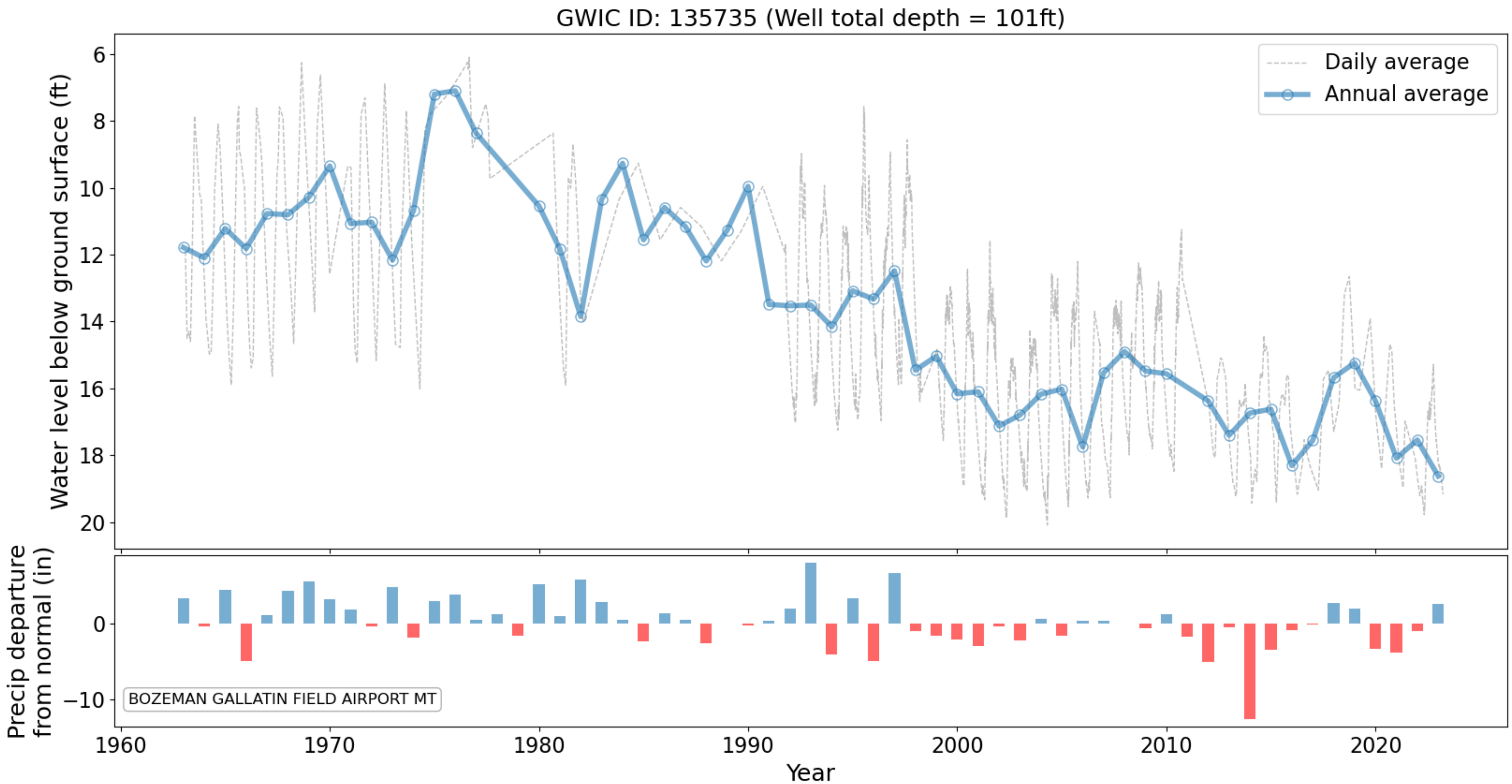
4.2. Contributing watershed (1,787 mi2) upstream of Gallatin Valley Aquifer.



4.3. Surface Water Network over Gallatin Valley Aquifer.



4.4. Hydrograph of typical monitoring well within Gallatin Valley Aquifer.



Title: Gallatin Valley Aquifer
Type: Primarily shallow alluvial/unconfined, also semi-confined, confined, and perched aquifers

General Description:
The Gallatin Valley aquifer has been described as a large regional aquifer system despite having localized unconfined, confined, and perched conditions present throughout the valley. Groundwater throughout the entire valley-fill aquifer is able to comingle and the entire valley acts as one aquifer instead of multiple smaller, distinct aquifers. The most productive zone is the shallow, coarse quaternary aged fluvial deposits underlying Gallatin Gateway, Belgrade, Central Park, Upper East Gallatin, and Manhattan. Sediments in this area are typically less than 100 ft thick. Older tertiary aged basin-fill sediments that underlie the shallow quaternary deposits may be up to 4,000 ft thick in the vicinity of the Central Park fault zone and the base of the Gallatin Range. MBMG Hydrogeologic Investigation of the Four Corners Area (2020) identified recharge from the surrounding bedrock and then canal leakage as the two largest components of groundwater recharge to the aquifer.

Total Population[2]: 113,608
Area (sq miles): 352
Number of Permits: 192 (2% of groundwater rights within aquifer boundary)
Number of Exempt Wells: 8,498 (82% of groundwater rights within aquifer boundary)

Physical Availability:

- GW:
    - Physical groundwater availability has not been quantified for the entire aquifer.
    - 2010 water budget from MBMG 4 corners study identified 169,000 acre-feet per year +/- 5,000 acre-feet recharges the aquifer (within study area) (Michalek and Sutherland, 2020).
- SW:
    - DNRC has not assessed physical availability of surface water sources because of the Upper Missouri River Basin Closure (MCA 85-2-343).
- SW/GW connectivity:
    - Numerous streams are connected to groundwater throughout the Gallatin Valley, including Bozeman Creek and Hyalite Creek draining the Gallatin Range to the south and the East Gallatin River draining the Bridger Range to the east. Near Belgrade, many spring-fed creeks originate where the Quaternary/Tertiary alluvial aquifer thickness decreases significantly to the north of the Central Park fault and shallow bedrock forces groundwater to the surface. Nearly all surface and groundwater leaves the basin at a bedrock notch just east of Three Forks (see map 4.2 above).

Legal Demand & Availability:

- GW:

[2] Population calculated in GIS using 2020 Census Tracts that intersect aquifer boundaries. Selected census tracts extended beyond the boundaries of the aquifer and are presented for comparison only.

- 74,067 acre-feet per year for all groundwater rights within the Gallatin Valley aquifer boundary. 23% of water rights did not have a volume assigned and are not included in the total.
- In 1993, the Upper Missouri River Basin was closed by the legislature for any new appropriations of water. The closure is temporary until final decrees have been issued for all the subbasins. All new permits or changes that cause an adverse effect to surface water bodies, require mitigation.

– SW:
  - In 1993, the Upper Missouri River Basin was closed by the legislature for any new appropriations of water. The closure is temporary until final decrees have been issued for all the subbasins. All new permits or changes that would cause an adverse effect to water users of surface water require mitigation.
  - A 1997 DNRC study of surface water physical/legal availability of the upper Missouri River concluded that two water rights for hydropower production account for all of the natural flow in the Upper Missouri River for most months of the year in all but the wettest years.

Concerns:

– While groundwater physical availability in the Gallatin Valley Aquifer is relatively abundant, any new use of groundwater must be mitigated because that groundwater would otherwise discharge to surface water sources that are tributary to the Missouri River where there is no remaining legal availability.

– Hydrogeologic Investigation of the Four Corners Area (MBMG, 2020) concluded that canal leakage was the second largest component of groundwater recharge after groundwater inflow. Water budget simulations were more sensitive to loss of canal leakage than to an increase in domestic water use. As agriculture land is converted to homes, irrigation contributions to the aquifer are lost, therefore the physical water availability of the aquifer will decline.

– City of Bozeman 2013 Integrated Water Resources Plan projects that the city will need to increase its water supply by 6,842-17,752 acre-feet by 2062.

– Localized water quality issues (nitrates) associated with high density of septic systems.

Solution Opportunities:

– **Public Water Supply**: Municipal water supply for the City of Bozeman is primarily surface water (Sourdough Creek, Hyalite Creek with storage in Hyalite Reservoir, Lyman Springs). The 2013 Integrated Water Resources Plan identified an existing reliable annual water supply yield of 11,500 AF and a projected water supply demand by 2062 of 28,700 AF. To fill the 17,200 AF gap, the city plans to develop groundwater. New municipal groundwater rights will require mitigation as the municipal water reservation is for surface water from Sourdough Creek. Bozeman is currently pursuing development of a well with a target annual volume of 1,600 AF, but is dependent on identifying a reliable mitigation source.

– **Mitigation:** Additional groundwater use necessitates mitigation, and easily accessible mitigation is difficult to find. Creation of a private (e.g., Gallatin Water Trust) or public water bank in this area would support continued groundwater development.

- **Storage:** Increasing surface water or groundwater storage that can be used for mitigation can help facilitate additional groundwater development. DNRC's Middle Creek/Hyalite Reservoir is the only reservoir over 20 acres in size above the Gallatin Valley Aquifer, and may provide additional water opportunity. Exploration of additional storage opportunities in the watershed may provide opportunities to capture high spring flow that could supply mitigation water to the basin.
- **Study - SW**:
  - The Upper Missouri Basin Closure is temporary until final decrees have been issued for all the subbasins. DNRC will be completing a revised Physical and Legal Availability analysis prior to the closure removal.
  - DNRC is in the process of creating the Montana Integrated Hydrologic Model System (MIHMS) to inform surface water availability, and in the long-term legal availability. By end of 2024 MIHMS will be able to identify physical availability by stream reach throughout the state. MIHMS will be expanded in future years to include legal demand/legal availability of surface water by stream reach throughout the state.
- **Study - GW**:
  - With additional development funding and resources, MIHMS will be expanded to address a need for large scale, regional aquifer groundwater modeling. Integration of groundwater modeling into the MIHMS framework can help us understand the connection between surface water and groundwater. The groundwater modeling expansion will help establish annual aquifer recharge volumes (physical availability of groundwater) and predict impacts from changes in climate, changes in land use, and also individual changes in water rights. The groundwater modeling expansion will also help inform the science needed to make mitigation banking a reality.

DNRC Scientific Memo: No scientific memo exists for this aquifer.

Literature:

Water Quality:

Lower Gallatin Planning Area TMGLs & Framework Water Quality Improvement Plan, 2013, MT Department of Environmental Quality.
https://deq.mt.gov/files/water/wqpb/CWAIC/TMDL/M05-TMDL-02a.pdf

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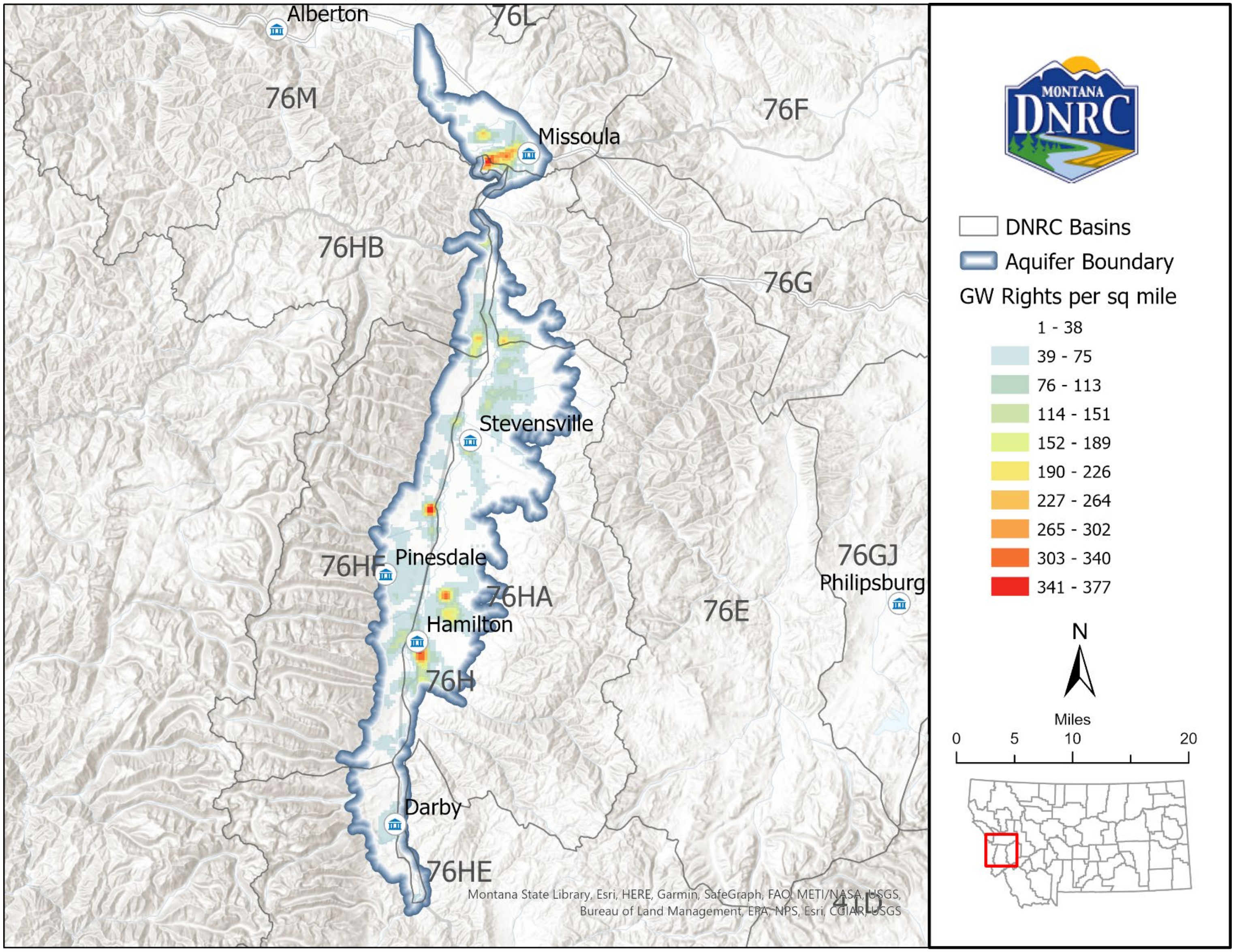
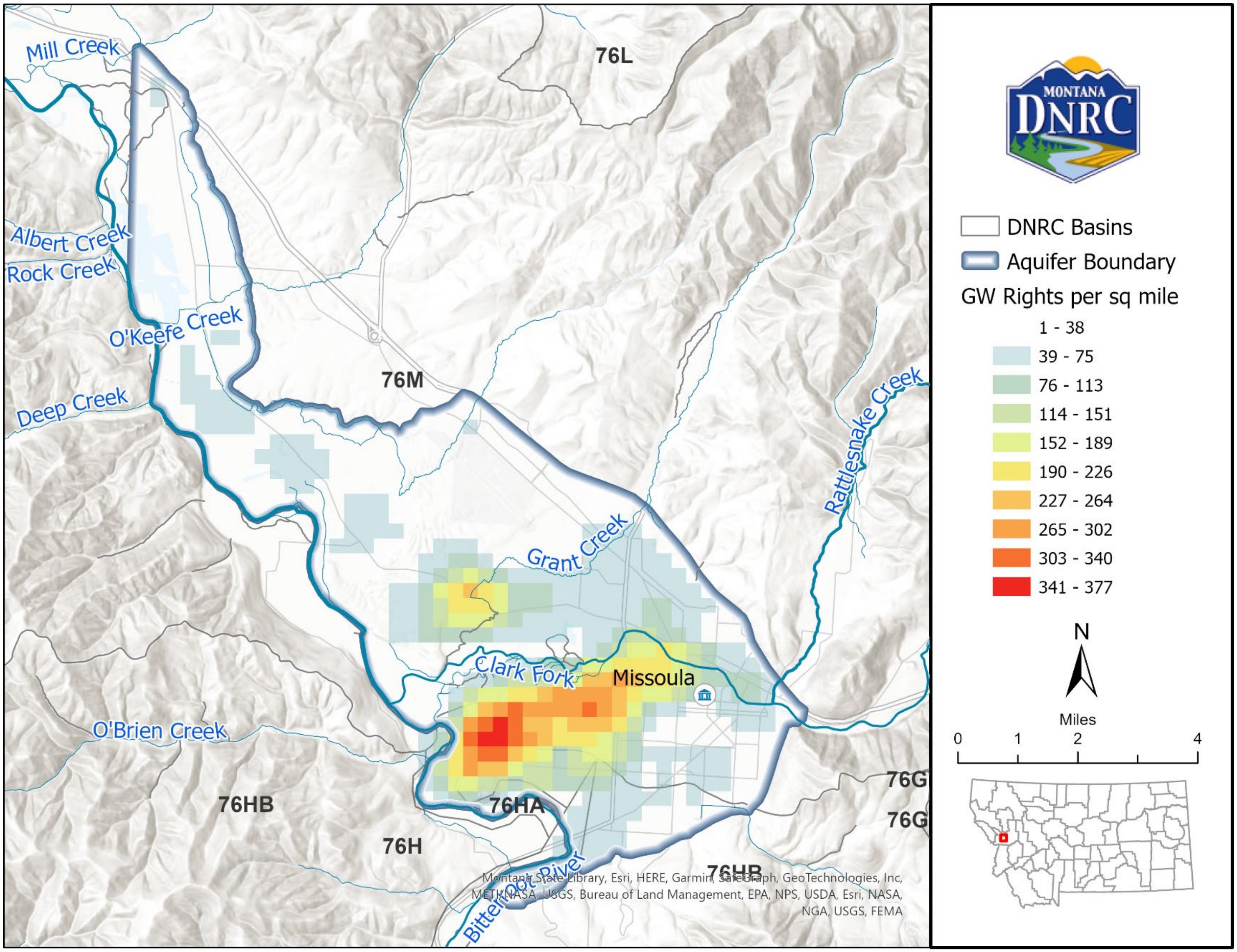
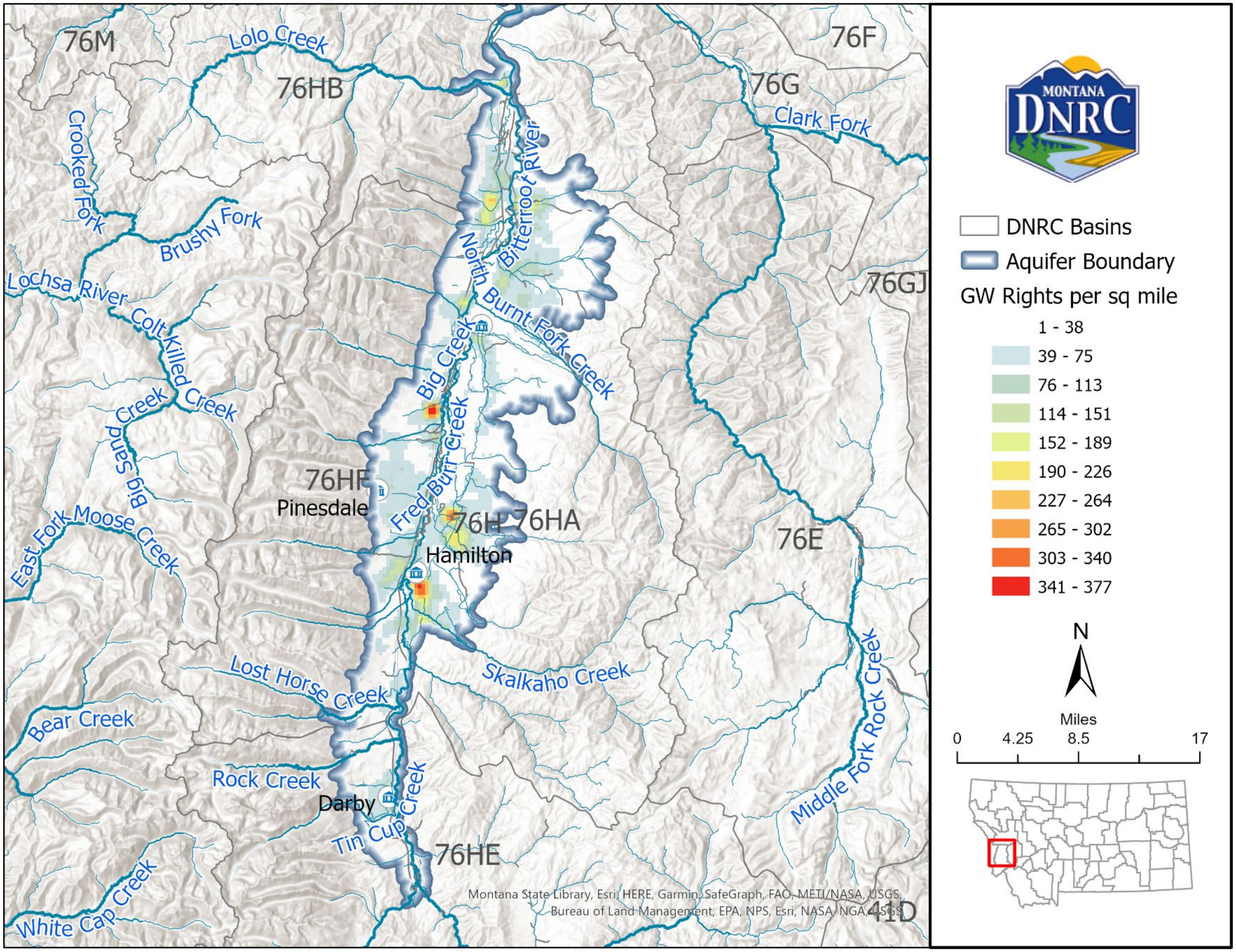
http://www.mbmg.mtech.edu/gwip/gwip_pdf/hb831book_appendix.pdf

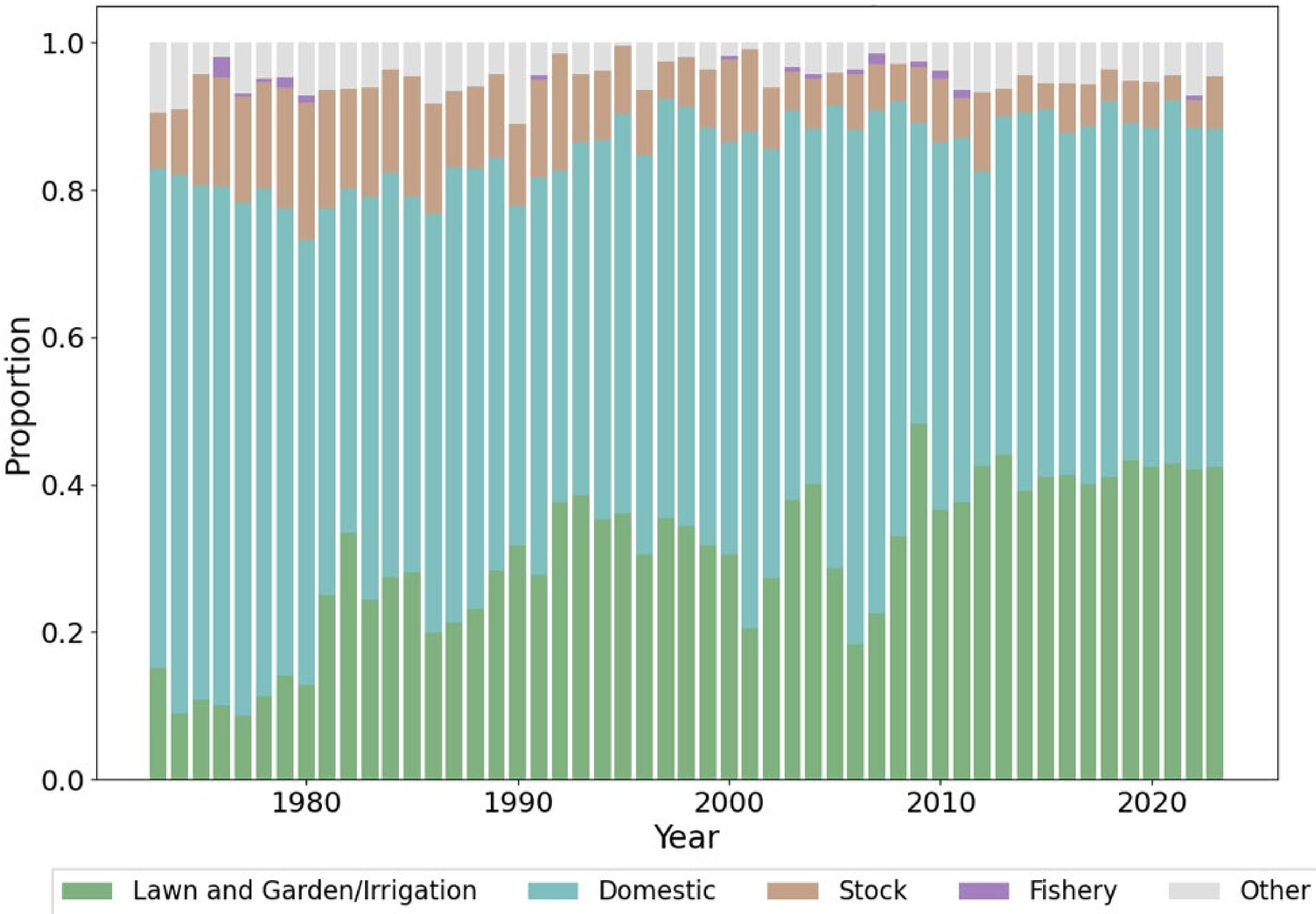
5. Missoula and Bitterroot (76H & 76M)



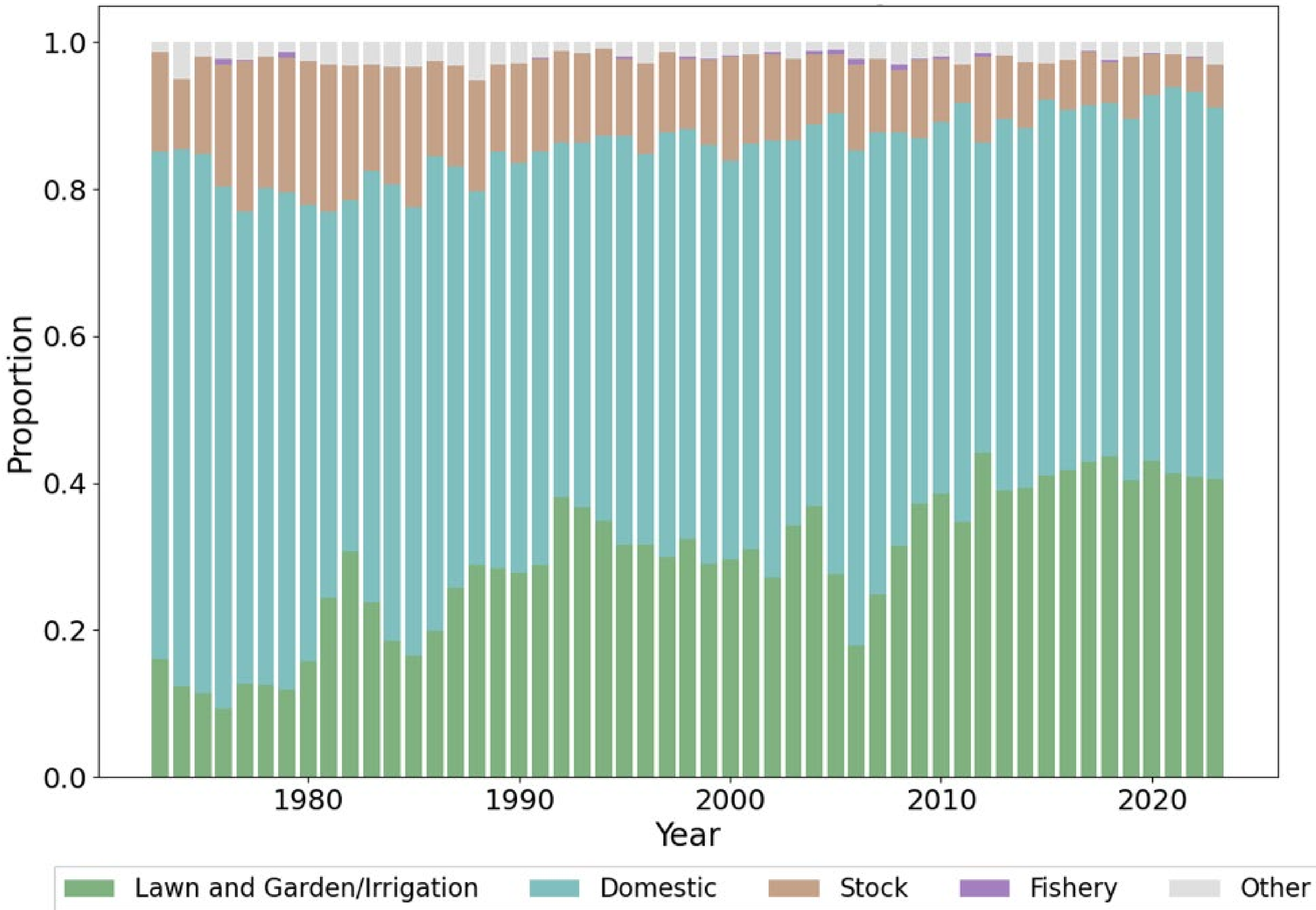

Mill Creek
76L
Albert Creek
Rock Creek
O'Keefe Creek
76M
Deep Creek
Rattlesnake Creek
Grant Creek
Clark Fork
Missoula
O'Brien Creek
76HB
76HA
76H
76G
76G
76HB
Bitterroot River
Montana State Library, Esri, HERE, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, Bureau of Land Management, EPA, NPS, USDA, Esri, NASA, NGA, USGS, FEMA
MONTANA DNRC
DNRC Basins
Aquifer Boundary
GW Rights per sq mile
1 - 38
39 - 75
76 - 113
114 - 151
152 - 189
190 - 226
227 - 264
265 - 302
303 - 340
341 - 377
N
Miles
0 1 2 4


76M
Lolo Creek
76HB
76F
76G
Clark Fork
Crooked Fork
Brushy Fork
Lochsa River
Colt Killed Creek
Bitterroot River
North Burnt Fork Creek
76GJ
Big Creek
Big Sand Creek
Fred Burr Creek
76HF
Pinesdale
East Fork Moose Creek
76H
76HA
Hamilton
76E
Lost Horse Creek
Skalkaho Creek
Bear Creek
Rock Creek
Darby
Tin Cup Creek
76HE
Middle Fork Rock Creek
White Cap Creek
41D
Montana State Library, Esri, HERE, Garmin, SafeGraph, FAO, METI/NASA, USGS, Bureau of Land Management, EPA, NPS, Esri, NASA, NGA, USGS
MONTANA DNRC
DNRC Basins
Aquifer Boundary
GW Rights per sq mile
1 - 38
39 - 75
76 - 113
114 - 151
152 - 189
190 - 226
227 - 264
265 - 302
303 - 340
341 - 377
N
Miles
0
4.25
8.5
17

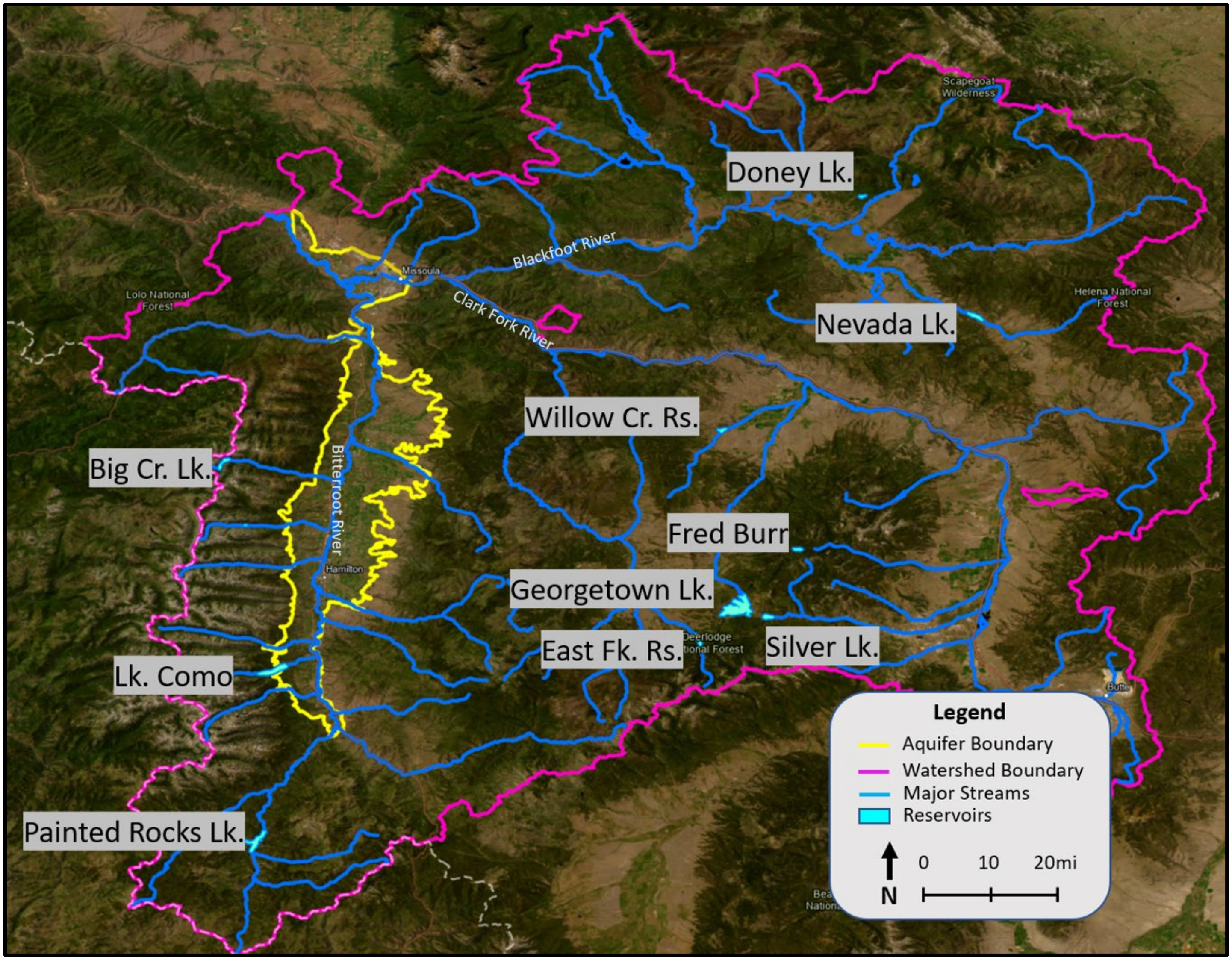
5.1. Exempt wells by purpose within Missoula aquifer boundary from 1972-2023 shown as a proportion of the total per year.



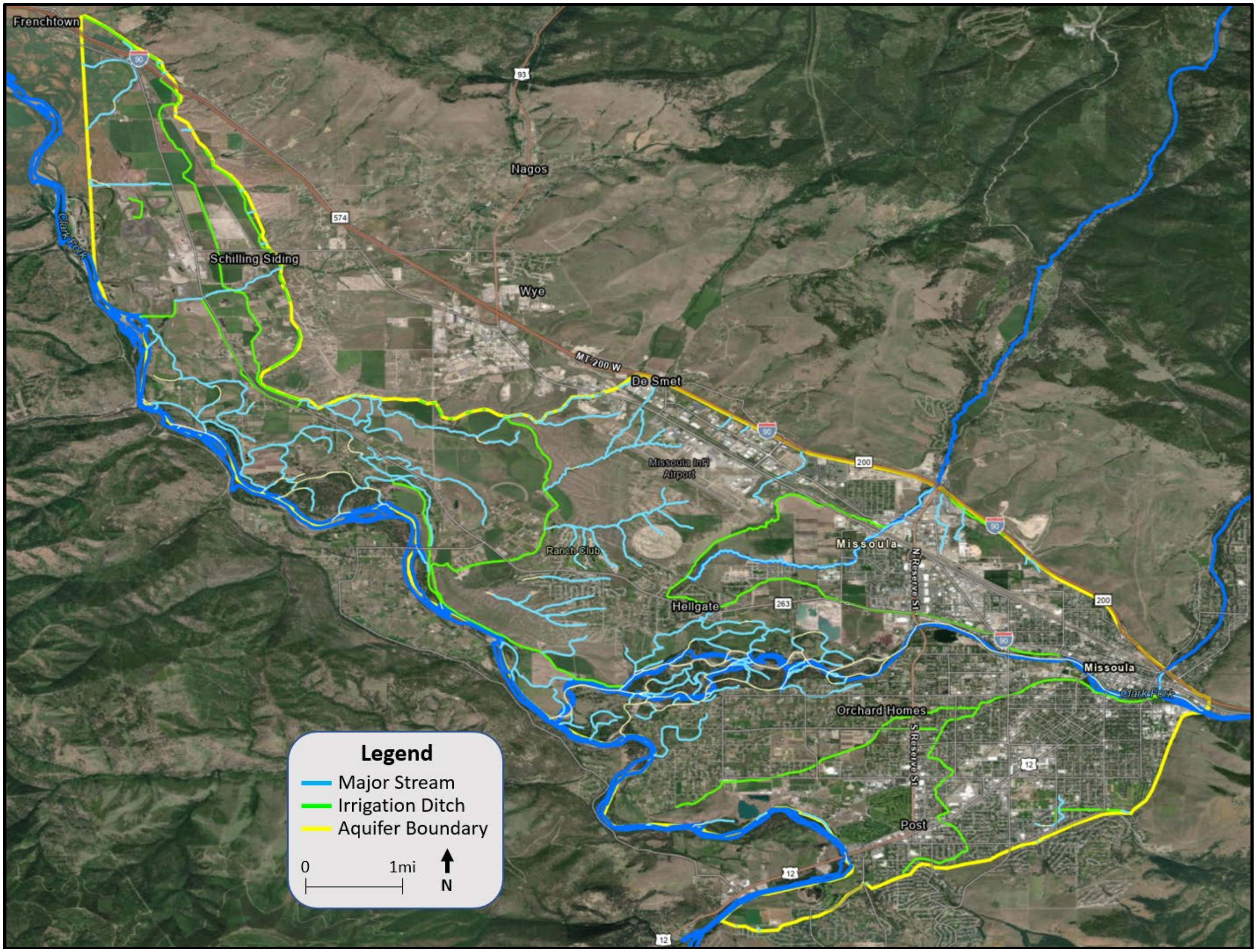
5.2. Exempt wells by purpose within Bitterroot aquifer boundary from 1972-2023 shown as a proportion of the total per year.



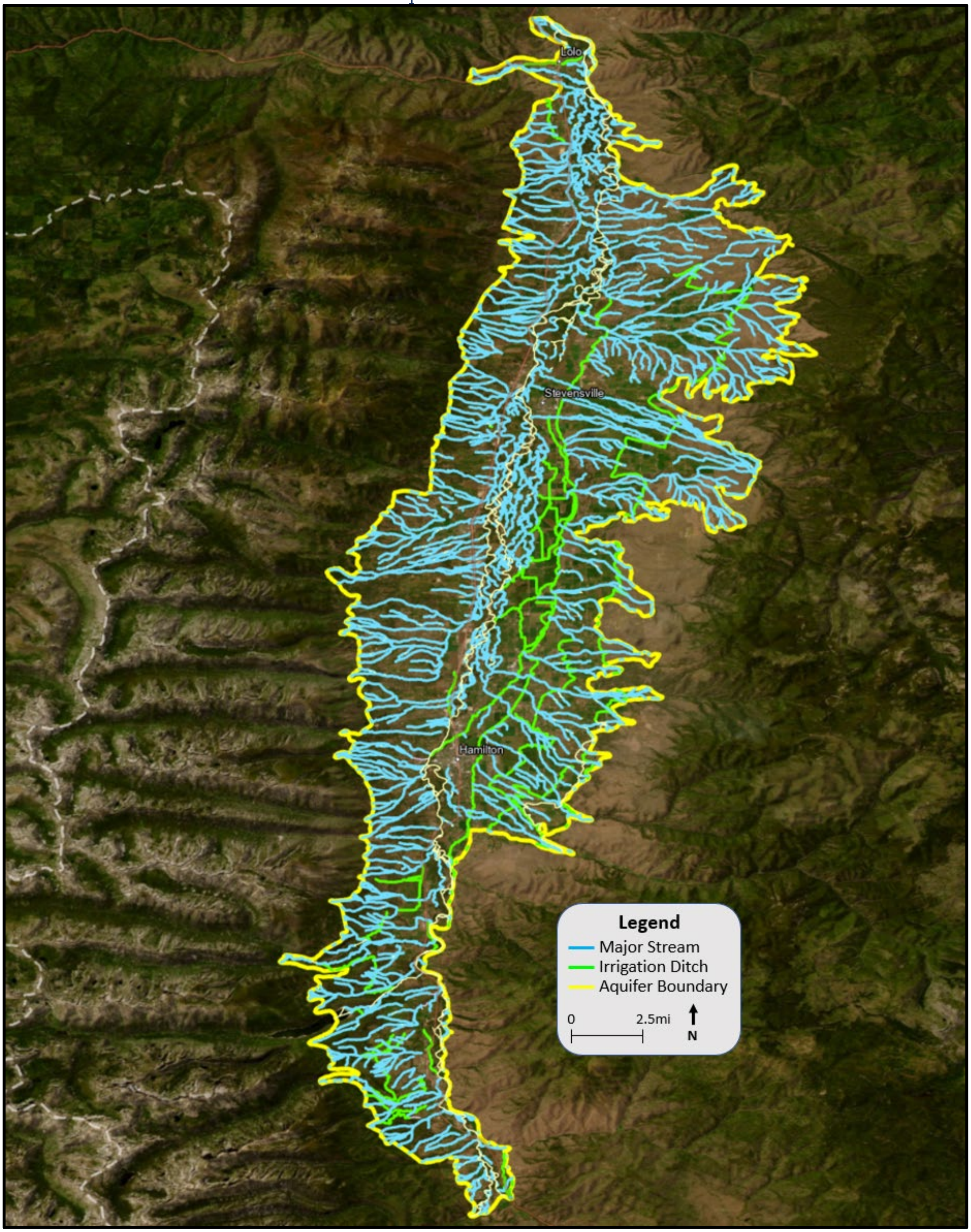
5.3. Contributing watershed (9,195 mi2) upstream of Missoula/Bitterroot aquifer.



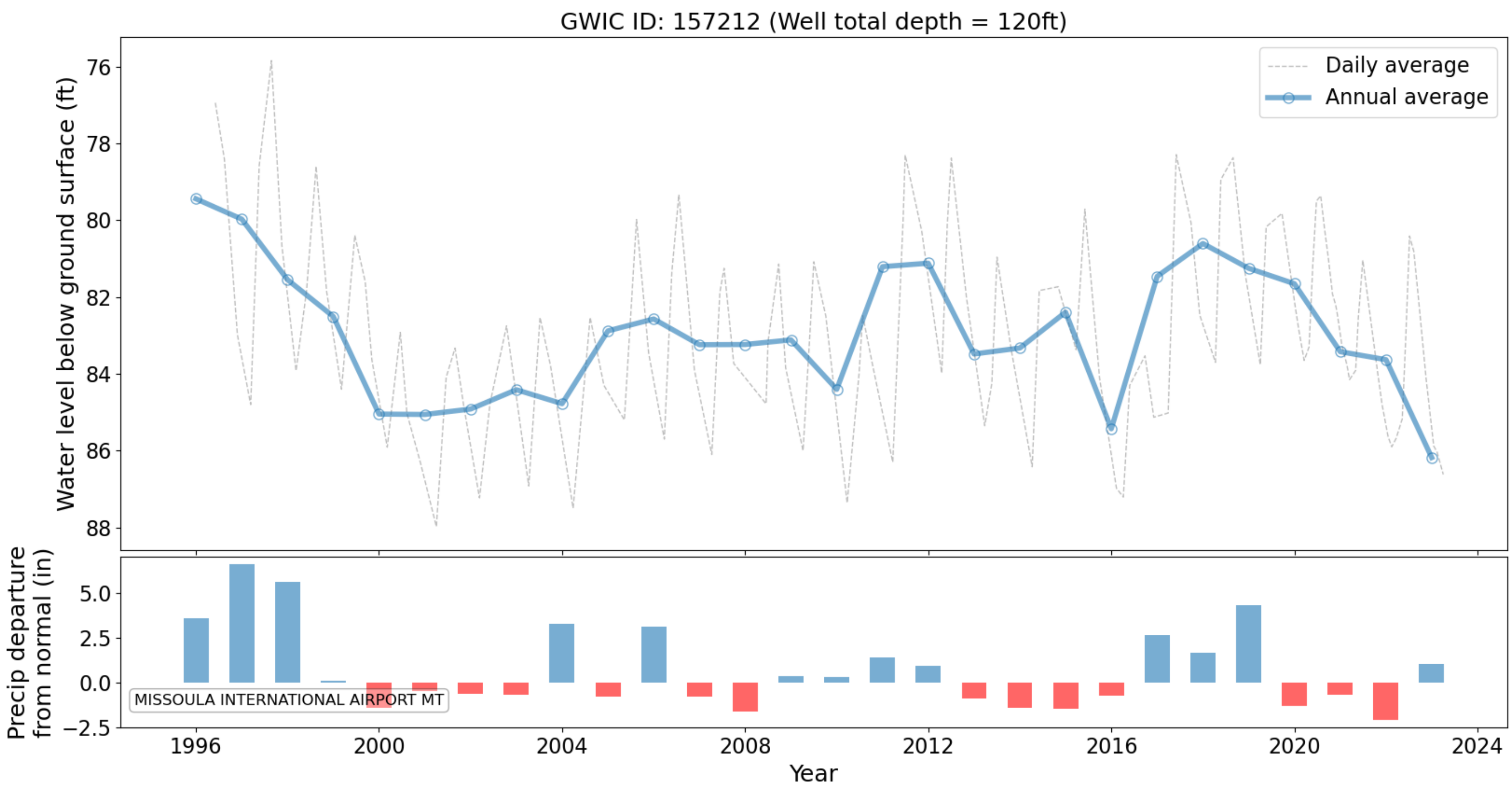
5.4. Surface water network over Missoula aquifer.



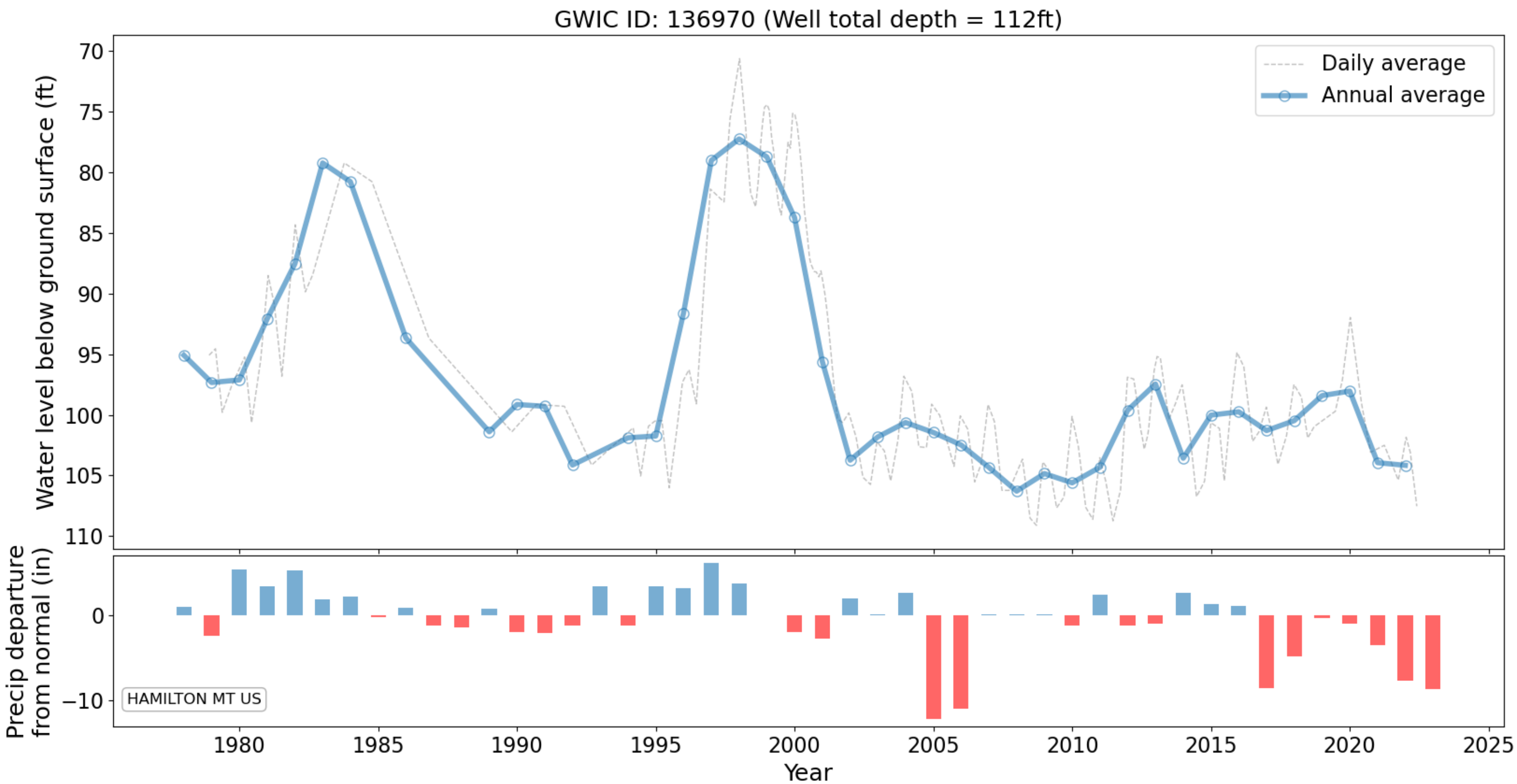
5.5. Surface water network over Bitterroot aquifer.



5.6. Hydrograph of typical monitoring well within Missoula Valley Aquifer.



5.7. Hydrograph of typical monitoring well within Bitterroot Valley Aquifer.



Title: Missoula and Bitterroot Valley Aquifers
Type:
Bitterroot: System of 3 aquifers: bedrock, deep basin-fill (confined), and shallow basin-fill (unconfined)
Missoula Valley: Unconfined, alluvial, EPA designated sole-source aquifer

General Description:
Bitterroot: The system is described as 3 regional aquifers: bedrock, deep basin-fill, and shallow basin-fill aquifers. Along the perimeter of the valley, wells are primarily completed in the bedrock aquifer. In the valley where alluvial sediments are deeper, wells are completed in either the shallow quaternary aged unconfined aquifer or the deeper and older tertiary aged semi-confined aquifer (LaFave, 2006; Smith and others, 2013; Myse and Hanson, 2023). All three aquifers are interconnected within the valley. Recharge to the bedrock aquifer occurs from infiltration. The bedrock aquifer discharges to streams and also to the shallow and deep aquifer. The deep aquifer recharge is from the bedrock aquifer and from leakage from the shallow aquifer or streams along the perimeter of the valley. The deep aquifer discharges through the upward movement of groundwater from the deep to shallow aquifer. Recharge to the shallow aquifer is from soil infiltration and from the bedrock aquifer, the deep aquifer, and leakage from streams. The shallow aquifer discharges through leakage to the deep aquifer and to streams.

Missoula Valley: The Missoula Valley aquifer is a shallow alluvial aquifer that is bounded by bedrock and designated as a sole-source aquifer by the EPA, meaning that this aquifer is the only source of water for Missoula's residents. The unconfined aquifer is comprised of three primary units: unit one (top-most unit) averages 10-30 feet thick and composed of permeable, unconsolidated course sand to boulder-size sediments; unit two (middle unit) averages a thickness of 40 feet and is composed of fine sand and silt with low permeability; unit three (bottom unit) averages 50 to 100 feet thick, composed of highly permeable sands and gravels, making this unit a highly productive aquifer. The base of the aquifer, below unit three, is not well understood but is assumed to be composed of low-permeability, older Tertiary aged sediments. The flow of the aquifer is generally from the northeast to southwest, roughly following the direction of flow of the Clark Fork and Bitterroot rivers.

Total population[3]:
Bitterroot: 62,202
Missoula Valley: 99,158
Area (sq miles):
Bitterroot: 391
Missoula Valley: 51
Number of Permits:
Bitterroot: 176 (1% of groundwater rights within aquifer boundary)
Missoula Valley: 133 (4% of groundwater rights within aquifer boundary)
Number of Exempt Wells:
Bitterroot: 13,434 (89% of groundwater rights within aquifer boundary)
Missoula Valley: 2,312 (74% of groundwater rights within aquifer boundary)
DNRC Scientific Memo:

[3] Population calculated in GIS using 2020 Census Tracts that intersect aquifer boundaries. Selected census tracts extended beyond the boundaries of the aquifer and are presented for comparison only.

Bitterroot: No scientific memo exists for this aquifer.
Missoula Valley: Variance – Missoula Valley Geothermal/Heat Exchange Wells, 2010

Physical Availability:
Bitterroot:

- GW: Physical groundwater availability has not been quantified for the entire aquifer.
- Estimated groundwater inflow into a study area near Hamilton was 84,700 acre-feet (2015 groundwater budget, Myse and Hanson 2023).
- SW: Bitterroot River Near Missoula – 1,597,421 acre-feet/ year.
- SW/GW Connection: Surface water is hydraulically connected to groundwater in this basin. Groundwater in the shallow alluvial aquifer generally flows towards and discharges to the Bitterroot River.

Missoula Valley:

- GW: Physical groundwater availability has not been quantified for the aquifer.
- Modeled hydraulic conductivity estimates range from 4,900 to 36,000 ft/d (Pracht, 2001; M.S. Thesis from University of Montana) which means water is able to move through this aquifer at a faster pace than most aquifers; however, no flux or volume estimate for the aquifer has been published. This range of conductivity makes deriving GW physical availability very difficult without a complex model.
- SW: Clark Fork River above Missoula – 1,978,216 acre-feet/ year
- SW/GW Connection: Surface water is hydraulically connected to groundwater in this basin. Groundwater in the Missoula Valley aquifer generally flows towards and discharges to either the Clark Fork River or the Bitterroot River, depending on the location within the basin.

Legal Demand & Availability:
Bitterroot:

- GW: 72,427 AF for all groundwater rights within Bitterroot Valley aquifer boundary. 19% of water rights did not have a volume assigned and are not included in the total.
- Most new groundwater permits that would deplete the Bitterroot River require mitigation because surface water is not legally available during some portions of the year and surface water and groundwater are hydraulically connected.
- SW: Legal demand is calculated on a case-by-case basis depending on the location of the application within the basin.

Missoula Valley:

- GW: 303,648 AF for all groundwater rights within Missoula Valley aquifer boundary. 14% of water rights did not have a volume assigned and are not included in the total.
- The Missoula Valley is in an open basin, however, depending on the location of a new groundwater permit, use may require mitigation if depletions in the Bitterroot River would occur during periods of the year when water is not legally available.
- SW: Legal demand is calculated on a case-by-case basis depending on the location of the application within the basin.

Concerns:

Bitterroot:

- Groundwater physical availability in the Bitterroot Valley Aquifer is generally abundant and not a limiting factor to new development; however, most new uses of groundwater from any of the three aquifers requires mitigation because that groundwater would otherwise discharge to the Bitterroot River where there are legal availability limitations.
- Groundwater budget in Myse and Hanson 2023 shows that the largest impact to groundwater physical availability is loss of irrigation contributions caused by land use changes. The study estimated that up to 75% of groundwater recharge was a result of canal leakage and irrigation contributions.
- The City of Hamilton has projected a need for at least 9,085 acre-feet of water per year in 2070; however, the city's current water rights and supply are limited to 4,398 acre-feet per year. At the anticipated growth rate of 2.5%, the City of Hamilton projects they will not have enough water to meet demand by the year 2044.
- Localized water quality issues (nitrates) associated with high density of septic systems.

Missoula Valley:

- Groundwater physical availability is generally thought to be abundant in the Missoula Valley Aquifer, however an estimate of annual recharge to the system has not been completed.
- While groundwater physical availability in the Missoula Valley Aquifer may be abundant, any use of groundwater that would otherwise discharge to the Bitterroot River generally requires mitigation due to limitations on the legal availability of water in the Bitterroot River.

Solution Opportunities:

- **Mitigation:** Additional groundwater use in areas that are connected to the Bitterroot River necessitates mitigation, and easily accessible mitigation is difficult to find. Creation of a water bank in this area would support continued groundwater development.
- **Storage:** Increasing or utilizing surface water storage at existing or new facilities (see figure above) that can be used for mitigation can help facilitate additional groundwater development. State operated reservoirs exist at the headwaters of the Bitterroot River (e.g., Painted Rocks Reservoir). Exploration of using existing storage projects for mitigation water or exploring additional storage opportunities in the watershed may provide opportunities to capture high spring flow that could provide additional water for the basin throughout dry summer months.
- **Study - SW**:
  - DNRC is in the process of creating the Montana Integrated Hydrologic Model System (MIHMS) to inform surface water availability, and in the long-term legal availability. By end of 2024 MIHMS will be able to identify physical availability by stream reach throughout the state. MIHMS will be expanded in future years to include legal demand/legal availability of surface water by stream reach throughout the state.
- **Study - GW**:
  - With additional development funding and resources, MIHMS will be expanded to address a need for large scale, regional aquifer groundwater modeling. Integration of

groundwater modeling into the MIHMS framework can help us understand the connection between surface water and groundwater. The groundwater modeling expansion will help establish annual aquifer recharge volumes (physical availability of groundwater) and predict impacts from changes in climate, changes in land use, and also individual changes in water rights. The groundwater modeling expansion will also help inform the science needed to make mitigation banking a reality.

DNRC Scientific Memo:
Bitterroot: No scientific memo exists for this aquifer.
Missoula Valley: Variance – Missoula Valley Geothermal/Heat Exchange Wells, 2010

Literature:
Bitterroot:

Bitterroot Temperature and Tributary Sediment Total Maximum Daily Loads and Framework Water Quality Improvement Plan, 2011, MT DEQ.
https://deq.mt.gov/files/water/wqpb/CWAIC/TMDL/C05-TMDL-03a.pdf

Bitterroot River Nutrient Protection Plan, 2023, MT DEQ.
https://deq.mt.gov/files/Water/WQPB/Protection%20Plans/C05-PROT-01a.pdf

Bitterroot Watershed Restoration Plan, 2020. Bitter Root Water Forum.
https://deq.mt.gov/files/Water/WPB/Nonpoint/Publications/WRPs/Bitterroot_WRP_FINAL_01132020.pdf

Bitterroot Watershed Total Maximum Daily Loads and Water Quality Improvement Plan, 2014. MT DEQ. https://deq.mt.gov/files/water/wqpb/CWAIC/TMDL/C05-TMDL-04a.pdf

Aquifer tests completed in the Bitterroot Valley, Hamilton, Montana
http://mbmg.mtech.edu/mbmgcat/public/ListCitation.asp?pub_id=32351&#gsc.tab=0

Groundwater quantity and quality near Hamilton, Montana
http://mbmg.mtech.edu/mbmgcat/public/ListCitation.asp?pub_id=32556&#gsc.tab=0

Hydrogeologic investigation of the Stevensville study area, Ravalli County, Montana: Interpretive report http://mbmg.mtech.edu/mbmgcat/public/ListCitation.asp?pub_id=32329&#gsc.tab=0

Groundwater resources of the Lolo-Bitterroot area: Mineral, Missoula, and Ravalli counties, Montana Part A * - Descriptive Overview and Water-Quality Data
http://mbmg.mtech.edu/mbmgcat/public/ListCitation.asp?pub_id=31614&#gsc.tab=0

Potentiometric surface of the shallow basin-fill, deep basin-fill, and bedrock aquifers, Bitterroot Valley, Missoula and Ravalli counties, western Montana
http://mbmg.mtech.edu/mbmgcat/public/ListCitation.asp?pub_id=16118&#gsc.tab=0

Ground-water resource development in the Lolo-Bitterroot ground-water characterization area
http://mbmg.mtech.edu/mbmgcat/public/ListCitation.asp?pub_id=30092&#gsc.tab=0

Missoula Valley:

Central Clark Fork Basin Tributaries TMDLs and Water Quality Improvement Plan, 2014, MT DEQ. https://deq.mt.gov/files/water/wqpb/CWAIC/TMDL/COL-TMDL-01a.pdf

Potentiometric Surface of the Basin-Fill and Bedrock Aquifers, Mineral and Missoula Counties, Western Montana; https://mbmg.mtech.edu/pdf-publications/GWAA04B-06.pdf

Detecting Regional Groundwater Discharge to nthe Clark Fork River, Melinda Horne, 2017; https://scholarworks.umt.edu/cgi/viewcontent.cgi?article=1193&context=utpp

The Hydrology of the Central and Northwestern Missoula Valley, C.A. Smith, 1992; https://scholarworks.umt.edu/cgi/viewcontent.cgi?article=8379&context=etd

Tracing Ground-Water Flow in the Missoula Valley Aquifer, Southwest Montana, MBMG, 2002; https://mbmg.mtech.edu/pdf/gwof17.pdf

Flow and Aquifer Parameter Evaluation Using Groundwater Age-Dating, Geochemical Tools and Numerical Modeling: Missoula Aquifer, Western Montana, K.A. Pracht, 2001; https://scholarworks.umt.edu/cgi/viewcontent.cgi?article=8380&context=etd

Clark, K.W.,1986. Interactions between the Clark Fork River and Missoula Aquifer, Missoula County, Montana, University of Montana Masters Thesis.

Miller, R.D., 1991. Numerical flow model of the Missoula Aquifer: Interpretation of aquifer properties and river interaction, 301 pp., Unpublished Masters Thesis, Department of Geology, The University of Montana.

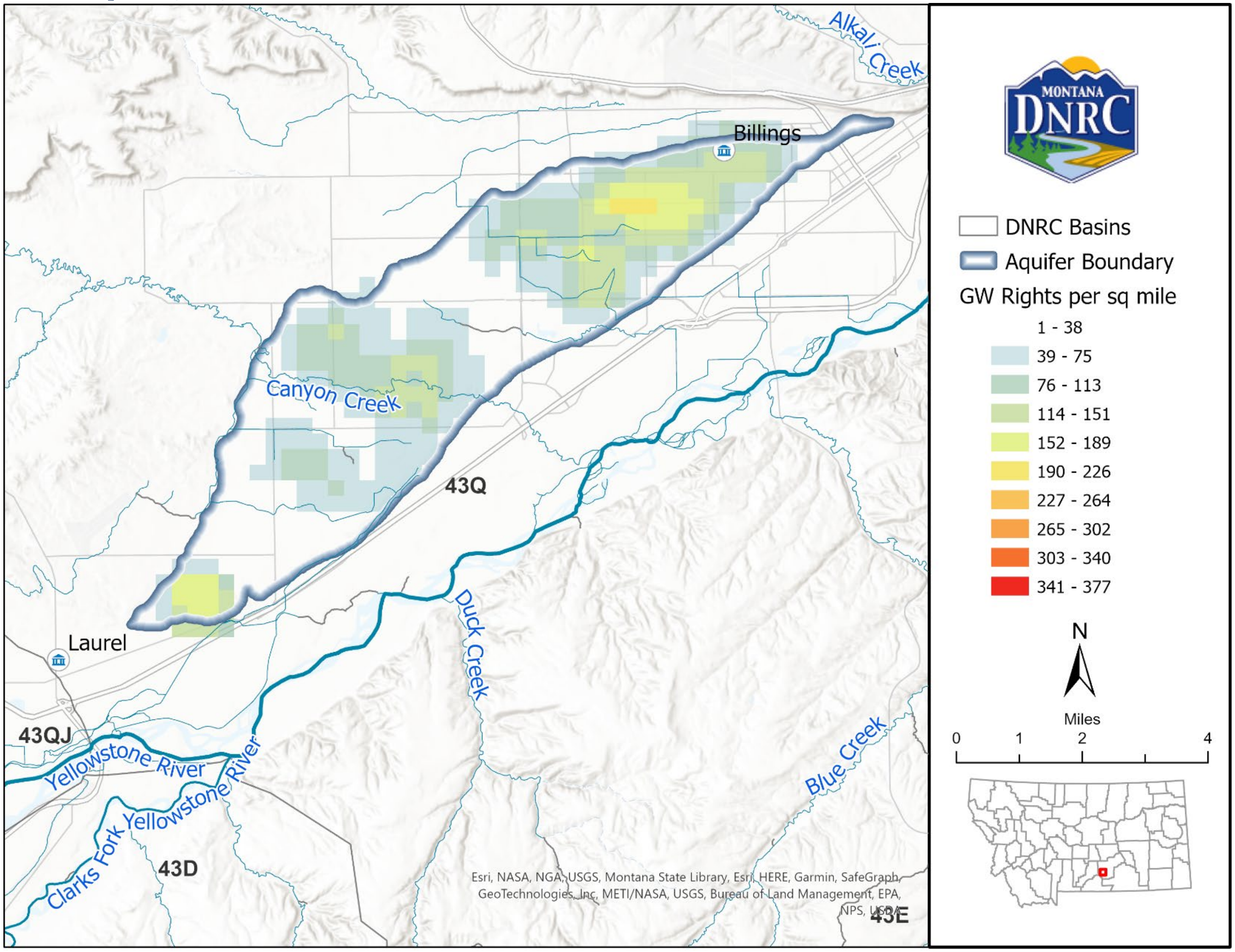
Smith, L.N., Lafave, J.I., and Patton, T.W., 2013. Groundwater resources of the Lolo-Bitterroot area: Mineral, Missoula, and Ravalli counties, Montana Part A-Descriptive Overview and Water Quality Data: Montana Bureau of Mines and Geology Montana Ground-water Assessment Atlas 4A, 96 p., http://www.mbmg.mtech.edu/mbmgcat/public/ListCitation.asp?pub_id=31614&.

Tallman, A. A., "Sources of water captured by municipal supply wells in a highly conductive aquifer western Montana" (2005). Graduate Student Theses, Dissertations, & Professional Papers. 9212. https://scholarworks.umt.edu/etd/9212

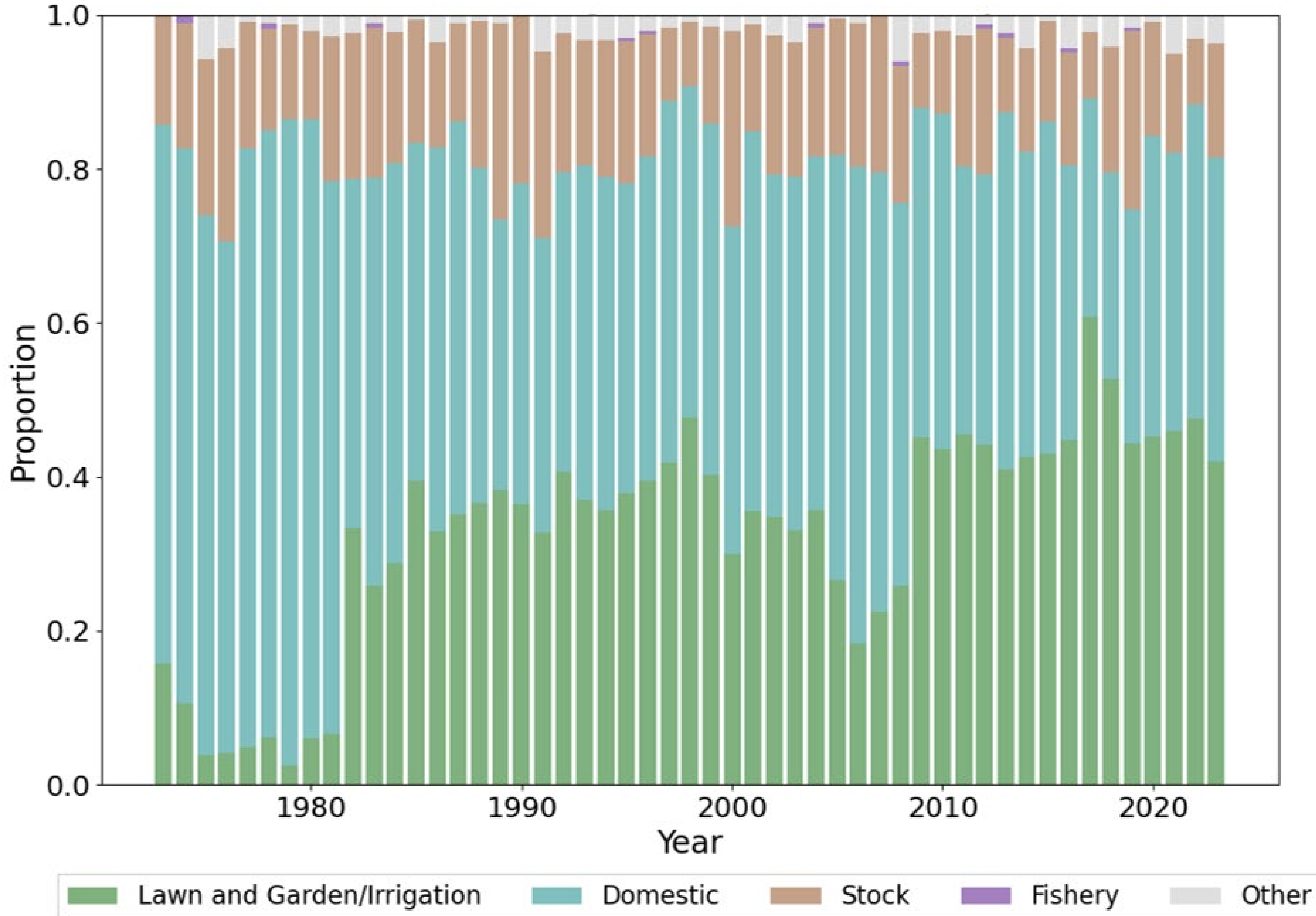
Woessner, W.W., 1988. Missoula Valley aquifer study— Hydrogeology of the eastern portion of the Missoula aquifer, Missoula County, Montana: Prepared for the Water Development Bureau, Montana Department of Natural Resources and Conservation, Helena, Montana, Volume 1, 127 p.

Miller, 1991. Numerical flow model of the Missoula Aquifer: interpretation of aquifer properties and river interaction, University of Montana Graduate Student Theses. https://scholarworks.umt.edu/cgi/viewcontent.cgi?article=8674&context=etd

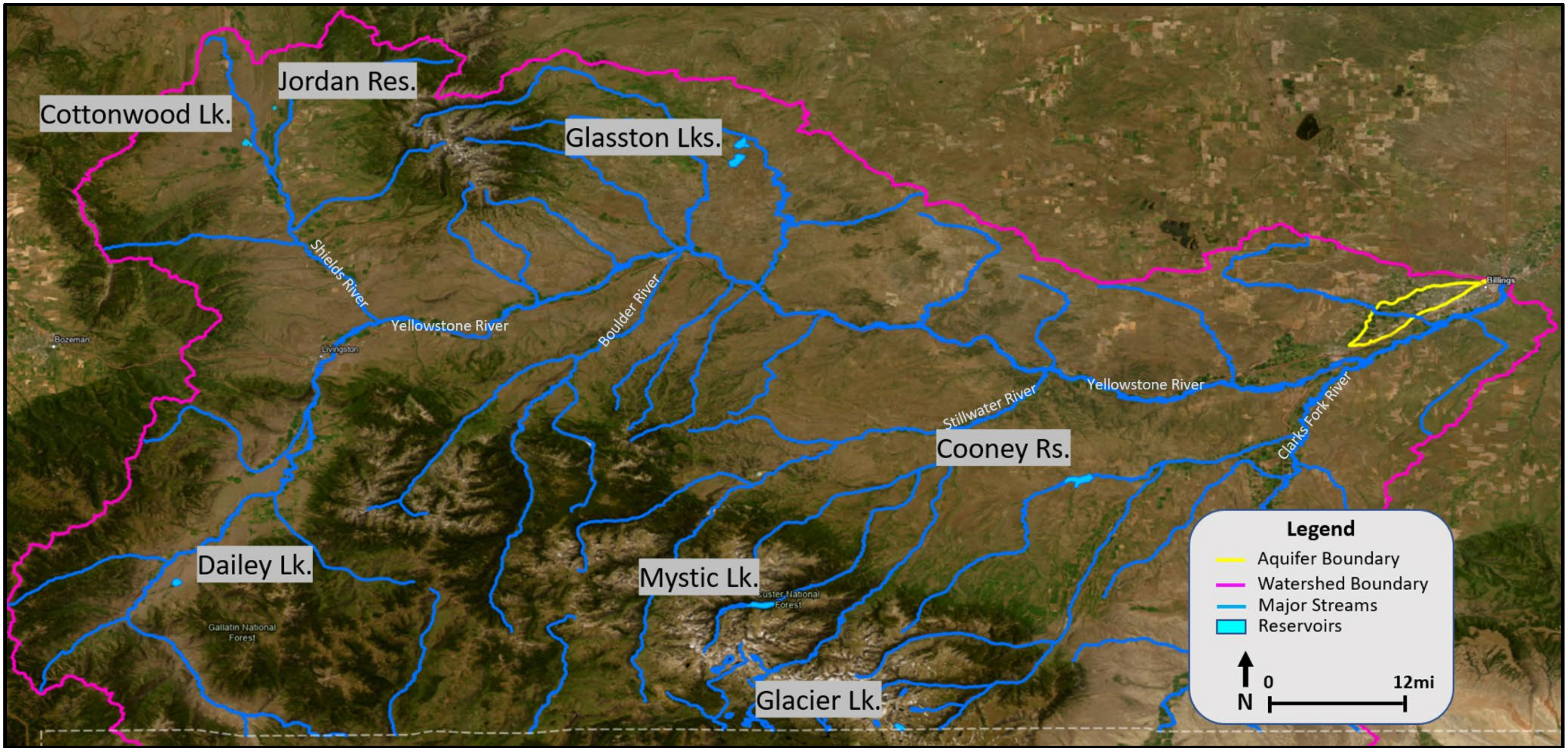
6. Billings Terrace Aquifer (43Q)



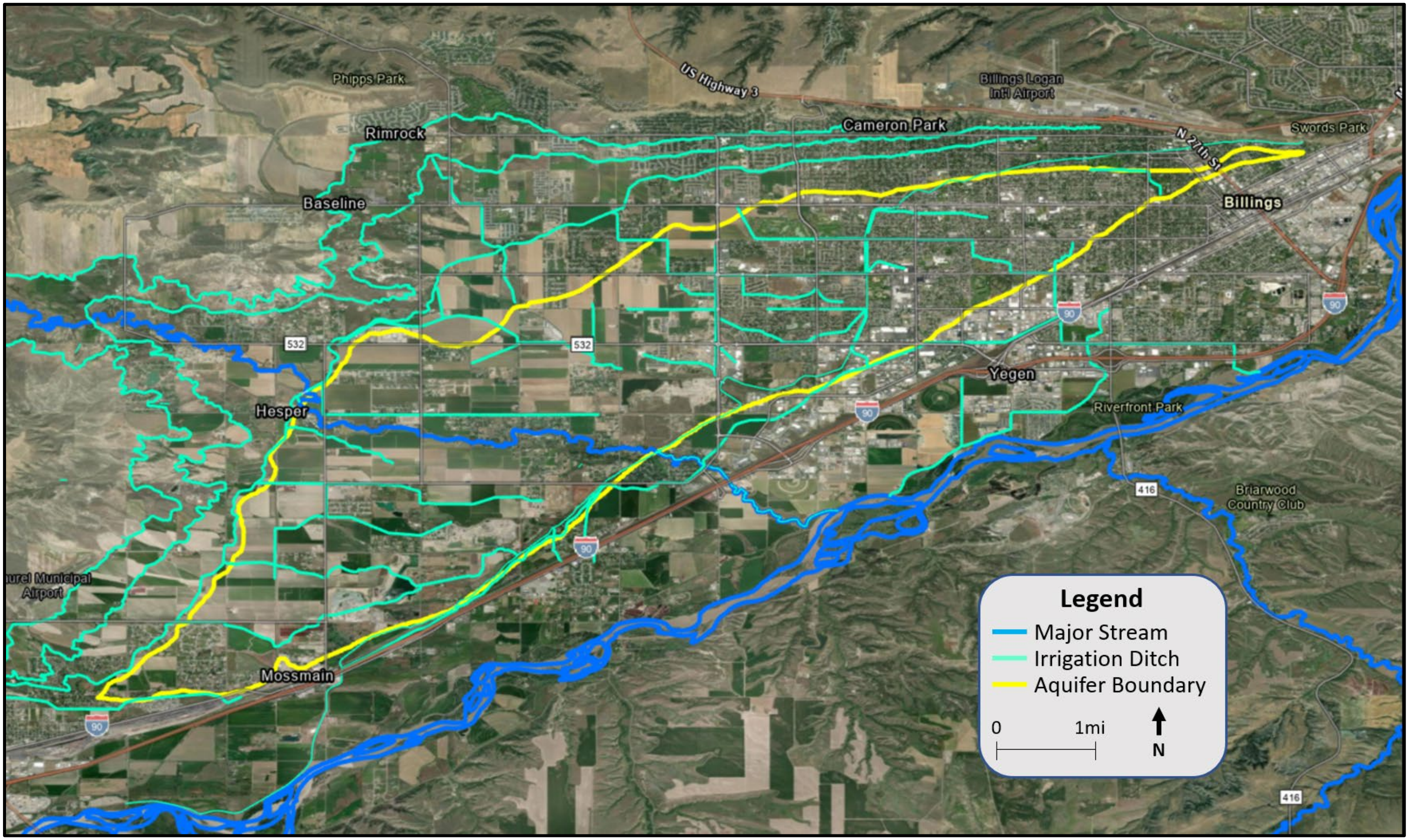
6.1. Exempt wells by purpose within Billings aquifer boundary from 1972-2023 shown as a proportion of the total per year.



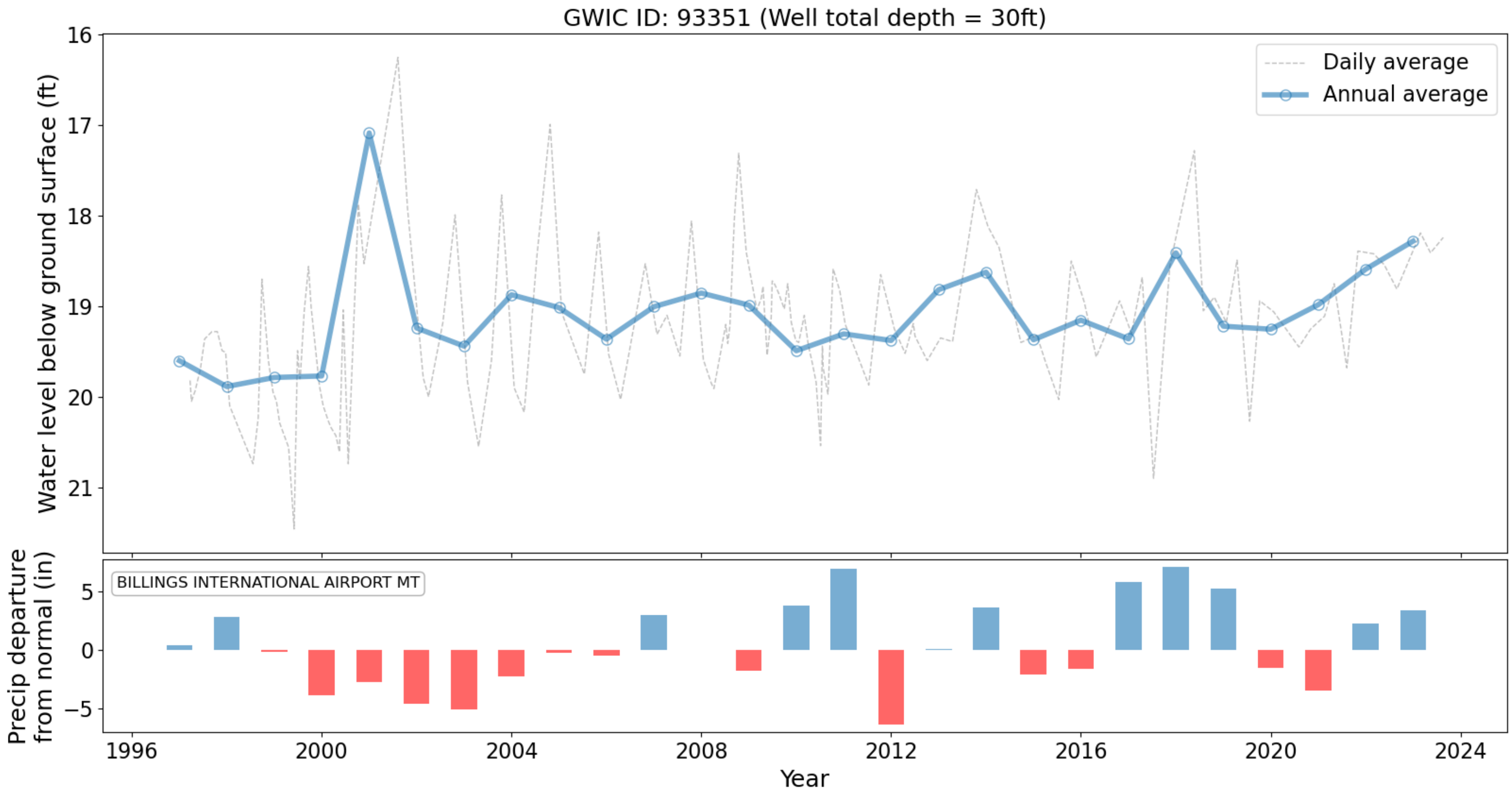
6.2. Contributing watershed (11,414 mi2) upstream of Billings aquifer.



6.3. Surface water network over Billings aquifer.



6.4. Hydrograph of typical monitoring well within Billings Terrace Aquifer.



Title: Billings Terrace Aquifer
Type: Alluvial, unconfined

General Description:
The Billings Terrace Aquifer is composed of about 50-feet of unconsolidated sediments that were deposited on an ancestral terrace of the Yellowstone River. The water table is about 20-30 feet below ground surface, leaving about 20-30 feet of aquifer thickness (Olson and Reiten, 2002). Most of the recharge to the aquifers is through agricultural irrigation and approximately a third is from precipitation (Olson and Reiten, 2002). General groundwater flow direction is from northwest to southeast at a relatively flat gradient of 0.002 ft/ft to 0.006 ft/ft (Olson and Reiten, 2002). A groundwater model by Chandler and Reiten (2019) shows that the groundwater level is most sensitive to changes in flood irrigation recharge rates, density of development, and timing of pumping for lawn irrigation. The model domain created by Chandler and Reiten (2019) shows a tipping point at which lawn irrigation pumping exceeds flood irrigation recharge and therefore creates an unsustainable aquifer yield.

Total Population[4]: 76,887
Area (sq miles): 27
Number of Permits: 27 (1% of groundwater rights within aquifer boundary)
Number of Exempt Wells: 1,767 (94% of groundwater rights within aquifer boundary)

Physical Availability:

- GW-
  - Groundwater generally flows from northwest to southeast. While some shallow groundwater recharges lower bedrock aquifers, most discharges to the lower Yellowstone bench aquifer which then discharges to the Yellowstone River (Olson and Reiten, 2002).
  - The average annual recharge and discharge to a major portion of this aquifer (between Laurel and Billings) was calculated to be approximately 35,100 acre-feet per year and 16,400 acre-feet per year, respectively (Olson and Reiten, 2002).
  - Physical availability in the entire aquifer has not been quantified.
- SW
  - Physical availability is calculated on a case-by-case basis depending on the location of the application within the basin. For groundwater applications, connected surface waters are identified, and physical availability of the source(s) is calculated.
- SW/GW connectivity
  - Surface water is hydraulically connected to groundwater in this basin. Canyon Creek, Danford Drain, Shilo Drain, Hogan's Slough, and the Yellowstone River have been identified as hydraulically connected to groundwater in previous permit applications.
  - An ongoing 2022-2023 Montana Bureau of Mines and Geology (MBMG) Groundwater Investigation Program (GWIP) study (approximately 62 mi^2) is investigating the hydraulic connections between the terrace aquifers including potential flow paths, flux between terraces, and impacts of development and land

[4] Population calculated in GIS using 2020 Census Tracts that intersect aquifer boundaries. Selected census tracts extended beyond the boundaries of the aquifer and are presented for comparison only.

use changes on the aquifer. The study will continue through the winter of 2023-2024.

Legal Demand and Availability:

- GW:
  - The total reported water right volume in the focus aquifer area is approximately 11,800 acre-feet per year.
  - Depending on where the GW permit is located, surface water may not be legally available due to the GW-SW connection and lack of legal availability in the surface water source would prohibit permitting the groundwater development without mitigation.
  - Groundwater and surface water are "open" in the basin and legal availability is determined on a case-by-case basis depending on where the new appropriation is located and what waters are determined to be connected.

- SW:
  - Legal demand is calculated on a case-by-case basis depending on the location of the application within the basin.

Concerns:

- Currently, the physical availability of groundwater throughout the aquifer is not a limiting factor for new groundwater development. Depending on the location of a new groundwater use, that groundwater may be connected to a surface water source with no remaining legal availability, and thus would require mitigation in order to be permitted.
- The aquifer is likely heavily dependent on recharge from numerous large irrigation ditches and may be vulnerable to major land use changes related to population growth. As agriculture land is converted to homes, irrigation contributions to the aquifer are lost, therefore the physical water availability of the aquifer would continue to decline.
- 2019 MBMG model suggested there is a tipping point between lawn/garden irrigation use and aquifer recharge rates, suggesting that additional use of groundwater for irrigation could outpace aquifer recharge leading to unsustainable use of the aquifer.
- Localized water quality issues (nitrates) associated with high density of septic systems.

Solution opportunities:

- **Public Water Supplies**- The City of Billings has a municipal water reservation for the Yellowstone River with 53,550 acre-feet per year of water that is unperfected and does not expire. There may be opportunities to expand municipal services to tie into high growth areas.
  Study - SW:
  - DNRC is in the process of creating the Montana Integrated Hydrologic Model System (MIHMS) to inform surface water availability, and in the long-term legal availability. By end of 2024 MIHMS will be able to identify physical availability by stream reach throughout the state. MIHMS will be expanded in future years to include legal demand/legal availability of surface water by stream reach throughout the state.
- **Study - GW**:
  - MBMG will complete the current aquifer study within the next year.

- With additional development funding and resources, MIHMS will be expanded to address a need for large scale, regional aquifer groundwater modeling. Integration of groundwater modeling into the MIHMS framework can help us understand the connection between surface water and groundwater. The groundwater modeling expansion will help establish annual aquifer recharge volumes (physical availability of groundwater) and predict impacts from changes in climate, changes in land use, and also individual changes in water rights. The groundwater modeling expansion will also help inform the science needed to make mitigation banking a reality.

DNRC Scientific Memo: Billings Level 3 Terrace Aquifer Memo (DNRC, 2022) establishes a standard transmissivity and storage coefficient for the aquifer.

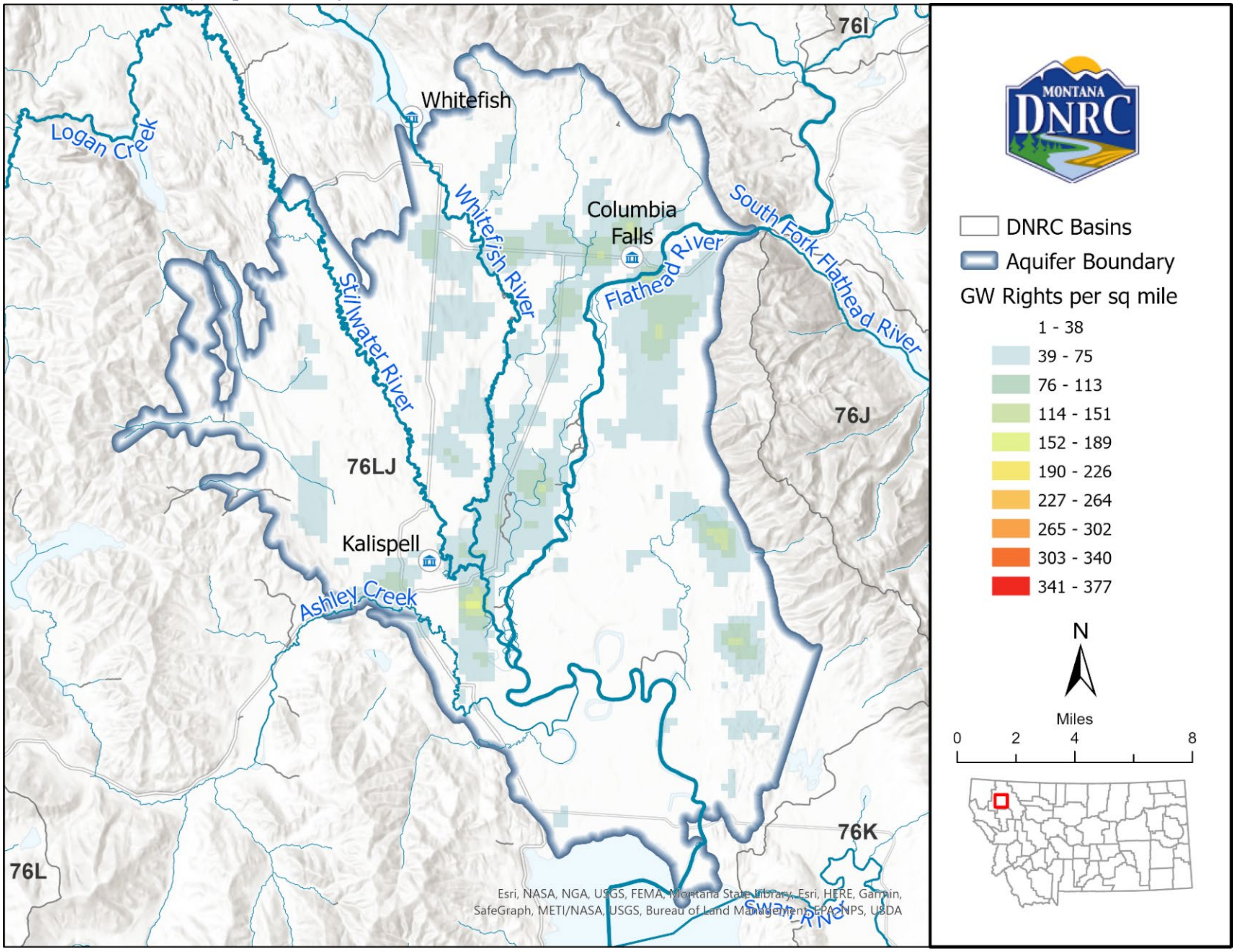
Literature:

Chandler, K., and Reiten, J., 2019, West Billings groundwater model: Aquifer response to land-use change in the West Billings area, Montana: Montana Bureau of Mines and Geology Open-File Report 716, 59 p.

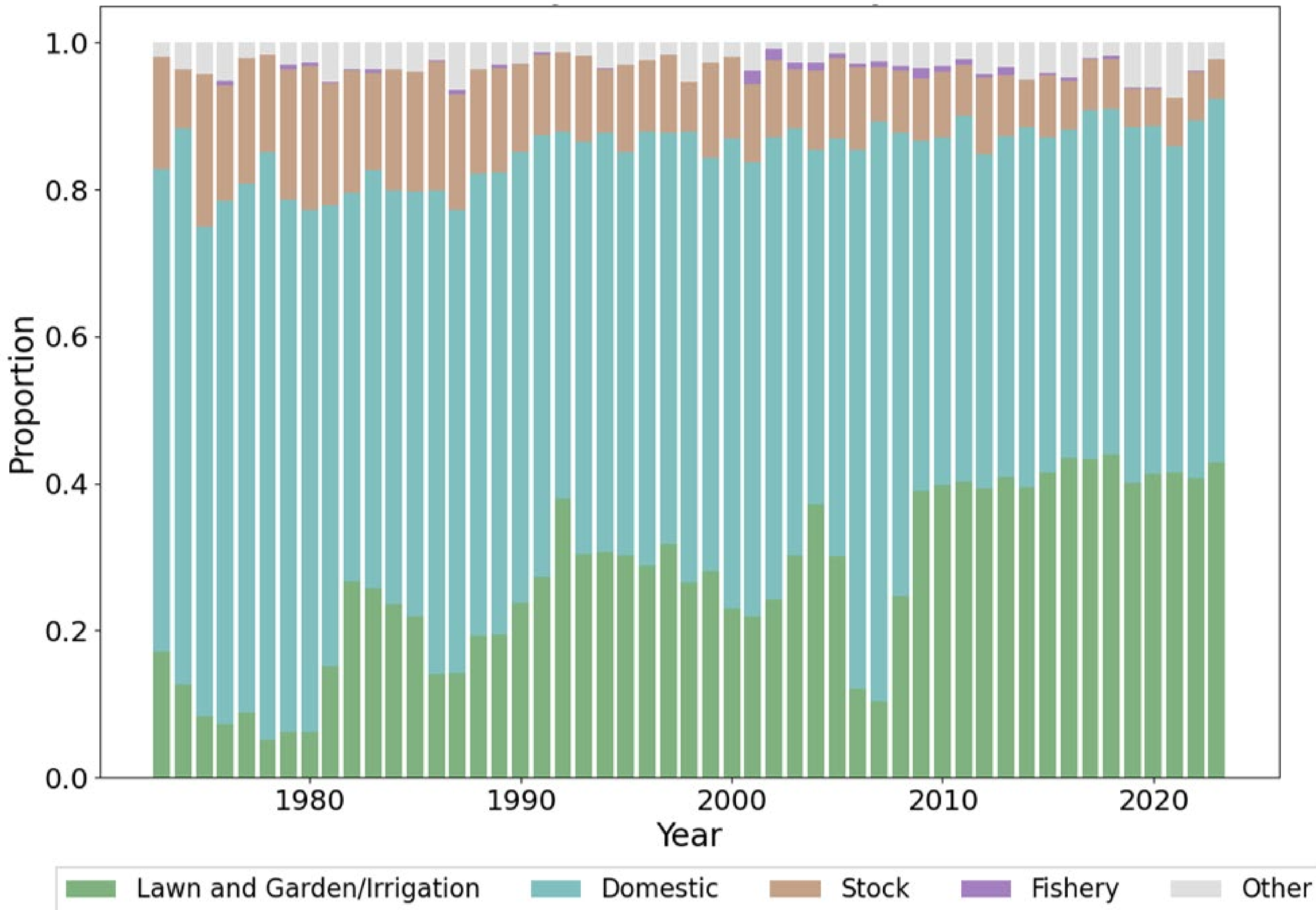
Lopez, D.A., 2000, Geologic map of the Billings 30' x 60' quadrangle, Montana: Montana Bureau of Mines and Geology Geologic Map 59, 1 sheet, scale 1:100,000.

Olson, J.L., and Reiten, J.C., 2002, Hydrogeology of the west Billings area: Impacts of land-use changes on water resources: Montana Bureau of Mines and Geology Report of Investigation 10, 32 p., 2 sheets.

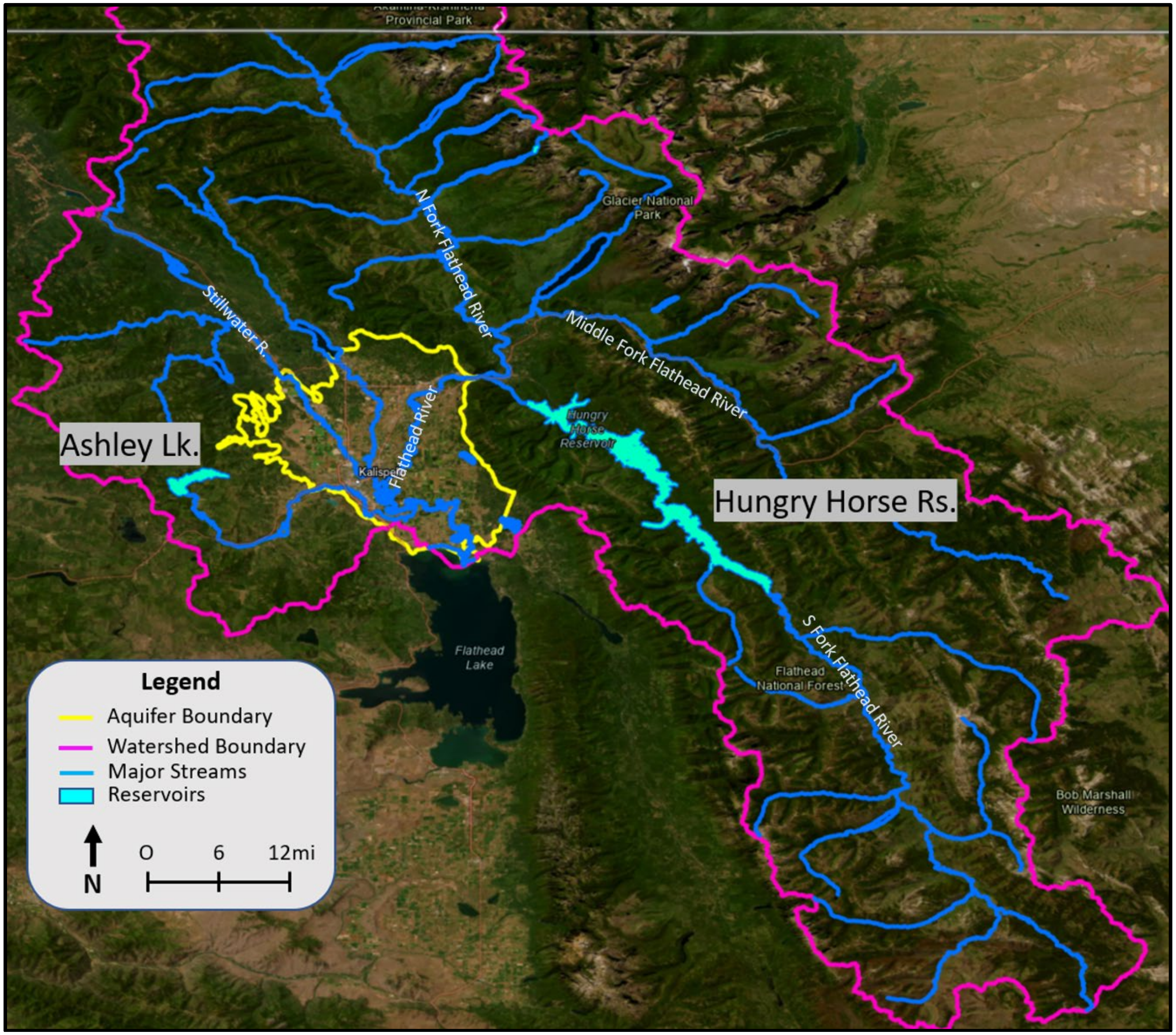
7. Flathead Valley Aquifer (76LJ)



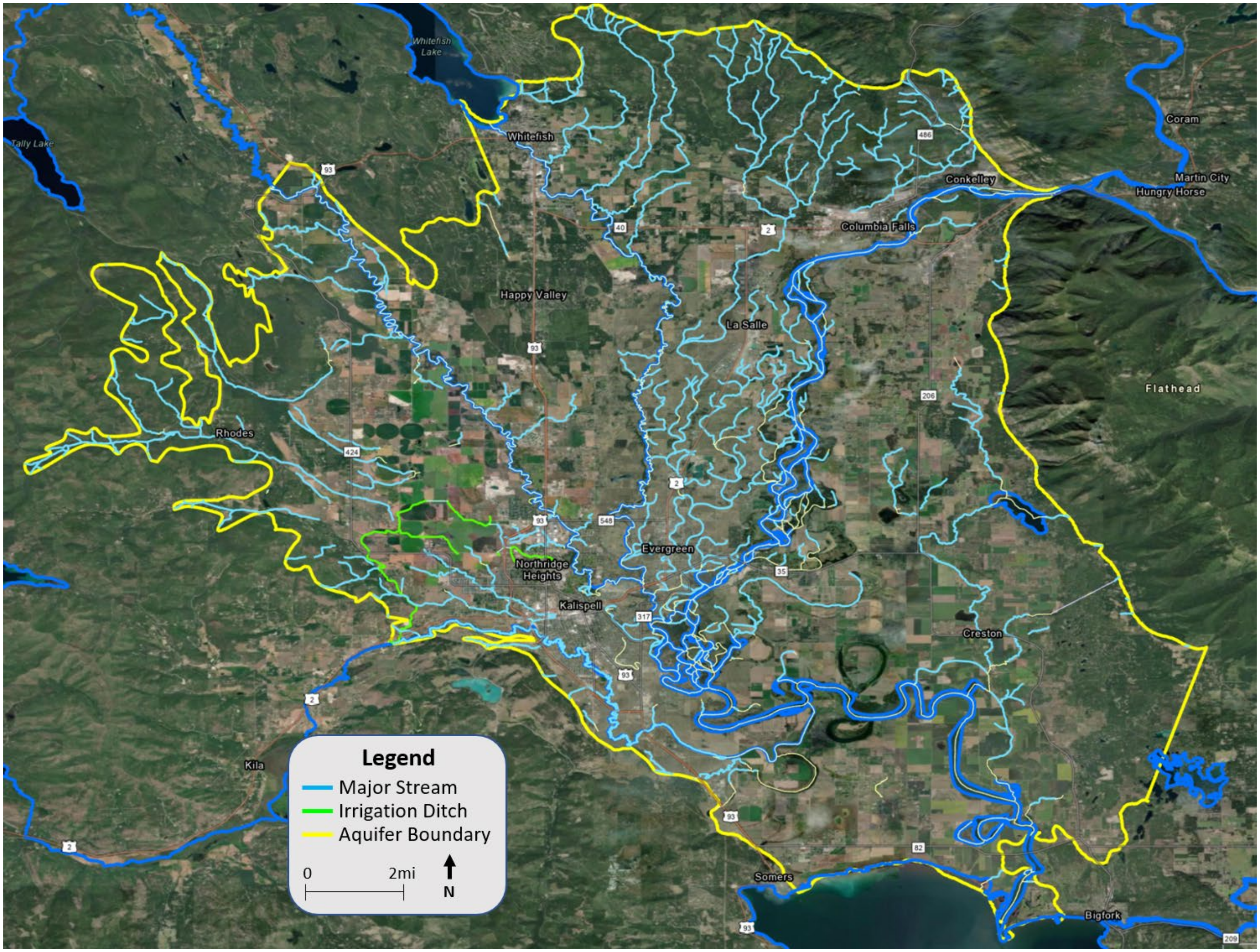
7.1. Exempt wells by purpose within Flathead aquifer boundary from 1972-2023 shown as a proportion of the total per year.



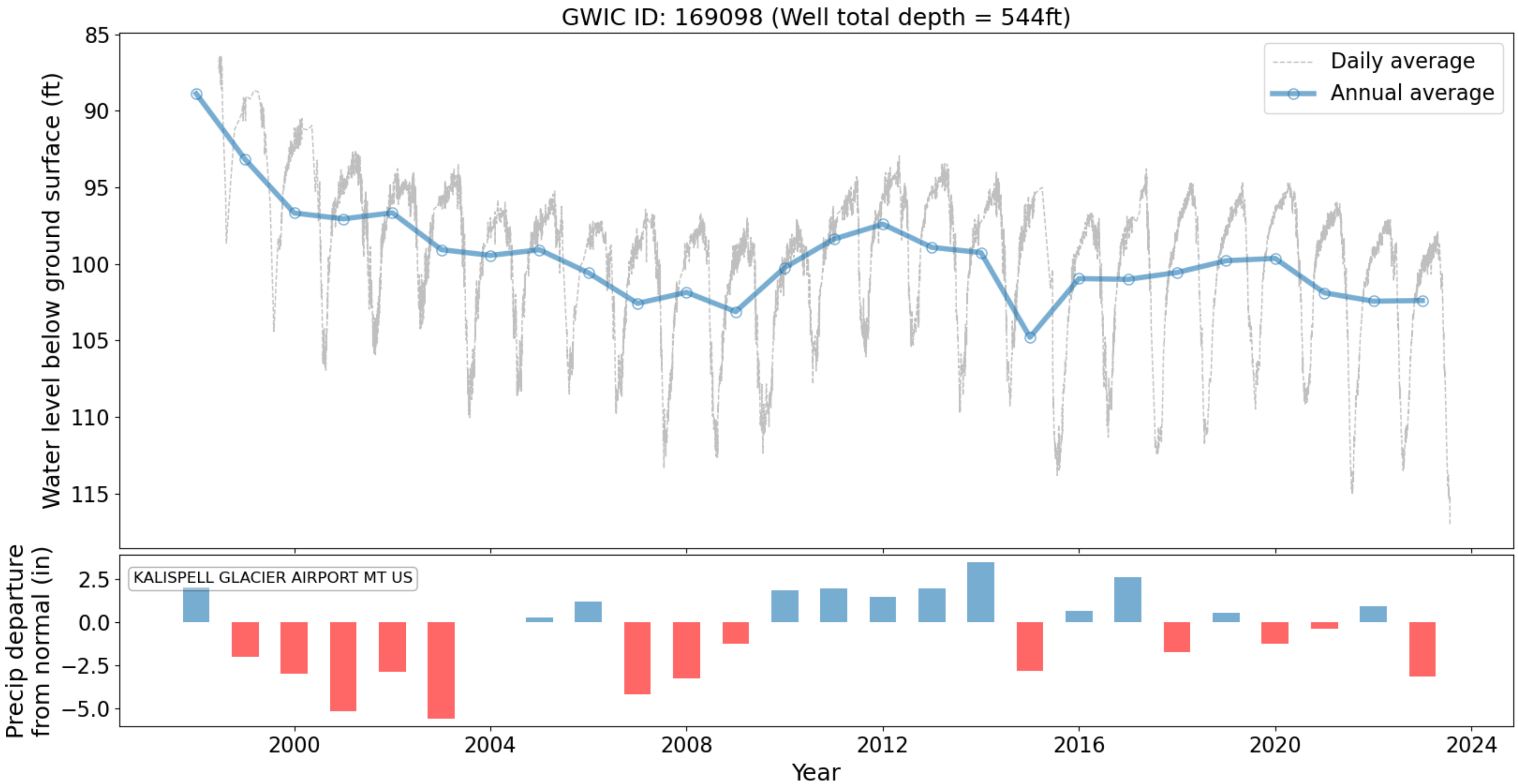
7.2. Contributing watershed (5,807 mi2) upstream of Flathead aquifer.



7.3. Surface water network over Flathead aquifer.



7.4. Hydrograph of typical monitoring well within Flathead Deep Aquifer.



Title: Flathead Valley Aquifer
Type: Primarily semi-confined deep alluvium aquifer, also unconfined shallow aquifer

General Description:
The Flathead Valley Aquifer System has been described as a complex, large regional aquifer system despite having some distinct layers that locally act as separate aquifers. The aquifer system can generally be categorized into six hydro stratigraphic units: the basement bedrock aquifer; Tertiary aged aquifer; deep alluvial aquifer; silt, clay, gravel zone of the deep alluvial aquifer; discontinuous lacustrine-till aquitard; and the shallow aquifer (Rose, J., 2018). The uppermost three layers are the primary focus of most hydrologic investigations and groundwater development in the Flathead Valley. The shallow aquifer overlies much of the Flathead Valley and sediments range in thickness from 0 to 100 feet deep. Below the shallow aquifer is a low permeability (leaky) semi-confining layer or aquitard of silt and clay where water can move vertically; although at a very slow rate (0.0007 ft/day) (Rose et al., 2022). The aquitard is discontinuous and where present, ranges in thickness between 4 to 790 feet. The deep alluvium below the aquitard is composed of coarse gravels and sand that support high production wells. The alluvium is interpreted to be in the range of 1,000-1,500 feet thick, although very few wells are completed at more than 300 feet deep (Rose, J., 2018). Groundwater throughout all layers of the aquifer system is able to comingle and the entire valley acts as one regional aquifer system. Groundwater flow in both the shallow and deep aquifer system generally is towards the center of the Flathead valley and also to the south towards Flathead Lake (Rose et al., 2022 and Smith et al., 2004).

Total population[5]: 97,750
Area (sq miles): 344
Number of Permits: 305 (3% of groundwater rights within aquifer boundary)
Number of Exempt Wells: 7,584 (83% of groundwater rights within aquifer boundary)

Physical Availability:

- GW: Approximately 2,800 acre-feet per year is recharged in a small northern portion of the deep aquifer boundary area through the aquitard (Rose et al., 2022). A recharge value has not been quantified for any other part of the aquifer system.
- SW: Physical availability in Flathead Lake was calculated at 8,117,017 AF as of August 2021. Physical availability in the Flathead River from the USGS Gage #12363000 at Columbia Falls, MT to the Flathead Lake Inlet was calculated at 6,582,569 acre-feet per year. Physical availability in the Whitefish River from Whitefish Lake Inlet to the Whitefish River Mouth was calculated at 174,933 AF as of January 2023. Physical availability in the Stillwater River from the northern boundary of Section 6, T28N R21W, to the confluence with the Flathead River was calculated at 199,172 AF as of August 2021. Physical availability in Blaine Creek from the western boundary of Section 4, T28N R20W, to the confluence with Mill Creek was calculated at 6,677 AF as of June 2020.

- SW/GW connectivity: Recharge to the shallow unconfined aquifer and semi-confined deep alluvial aquifer occurs primarily along mountain fronts surrounding the valley and is likely augmented by infiltration of surface water and vertical seepage through the

[5] Population calculated in GIS using 2020 Census Tracts that intersect aquifer boundaries. Selected census tracts extended beyond the boundaries of the aquifer and are presented for comparison only.

aquitard. Discharge generally occurs to the Flathead River or Flathead Lake. Depletion to surface water from new groundwater pumping in the Deep Aquifer generally occurs in the Flathead River and Flathead Lake. Other potentially connected surface water sources, such as the Whitefish River, Stillwater River, and Blaine Creek are evaluated on a case-by-case basis.

Legal Demand and Availability:

- GW:
  - 143,372 AF for all groundwater rights within the Flathead Valley aquifer boundary. 19% of water rights did not have a volume assigned and are not included in the total.
- SW:
  - The Flathead Valley is in an "open" basin and there have been no existing cases or issues with legal demand within the basin.
  - Legal availability in Flathead Lake was calculated at 8,010,752 AF as of August 2021. Legal availability in the Flathead River from the USGS Gage #12363000 at Columbia Falls, MT to the Flathead Lake Inlet was calculated at 3,118,655 acre-feet per year.
  - Legal availability in the Whitefish River from Whitefish Lake Inlet to the Whitefish River Mouth was calculated at 104,865 acre-feet per year.
  - Legal availability in the Stillwater River from the northern boundary of Section 6, T28N R21W, to the confluence with the Flathead River was calculated at 199,172 AF.
  - Legal availability in Blaine Creek from the western boundary of Section 4, T28N R20W, to the confluence with Mill Creek was calculated at 3,420 AF as of June 2020.

DNRC Scientific Memo: Legal Availability of Groundwater in the Flathead Deep Aquifer, 2019; Evergreen Aquifer Geothermal/Heat Exchange Wells, 2010

Concerns:

- Aquifer Recharge is predominately dependent on natural sources and not irrigation losses. Recharge has not been quantified as the aquifer system is heterogeneous, complex, and extensive. Connection between the deep aquifer and local surface water sources is unknown or poorly understood in most areas.

Opportunities:

- **Study - SW**:
  - DNRC is in the process of creating the Montana Integrated Hydrologic Model System (MIHMS) to inform surface water availability, and in the long-term legal availability. By end of 2024 MIHMS will be able to identify physical availability by stream reach throughout the state. MIHMS will be expanded in future years to include legal demand/legal availability of surface water by stream reach throughout the state.
- **Study - GW**:
  - With additional development funding and resources, MIHMS will be expanded to address a need for large scale, regional aquifer groundwater modeling. Integration of groundwater modeling into the MIHMS framework can help us understand the connection between surface water and groundwater. The groundwater modeling expansion will help establish annual aquifer recharge volumes (physical availability of

groundwater) and predict impacts from changes in climate, changes in land use, and also individual changes in water rights. The groundwater modeling expansion will also help inform the science needed to make mitigation banking a reality.

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