HIDEOUT, UTAH
PUBLIC INFORMATION PRESENTATION
May 12, 2021
Agenda

PUBLIC NOTICE IS HEREBY GIVEN that the Town Council of Hideout, Utah will hold a Public Information Presentation electronically for the purposes and at the times as described below on Wednesday, May 12, 2021

This presentation will be an electronic presentation without an anchor location pursuant to Mayor Rubin's May 7, 2021 No Anchor Site Determination Letter (attached).

Interested parties may watch the presentation via YouTube at the following address:

YouTube Live Channel: https://www.youtube.com/channel/UCKdWnJad-WwvcAK75QjRb1w/

ELECTRONIC ONLY – NO ACCOMMODATION FOR IN-PERSON ATTENDANCE

Public Information Presentation

6:30 PM

I. Call to Order
   1. No Anchor Site Determination Letter

II. Roll Call

III. Agenda Items
   1. Public Information Presentation of the Silver Meadows Annexation

IV. Meeting Adjournment

Pursuant to the Americans with Disabilities Act, individuals needing special accommodations during the meeting should notify the Mayor or Town Clerk at 435-659-4739 at least 24 hours prior to the meeting.

HIDEOUT TOWN COUNCIL
10860 N. Hideout Trail
Hideout, UT 84036
Phone: 435-659-4739
Posted 5/11/2021

The Town of Hideout will host a Public Information Presentation on the proposed Silver Meadows annexation on **May 12, 2021 starting at 6:30 pm**. The presentation will only be broadcast on the Hideout YouTube Live Channel at https://www.youtube.com/channel/UCKdWnJad-WwvcAK75QjRb1w.

The presentation will address the key questions raised during the Annexation Public Hearing held last October.

The Town will present findings from four key studies it has commissioned regarding the Annexation.

- A fiscal study
- An environmental study
- A traffic study
- A study on the impact of a recreational chair lift

Additionally, one Hideout citizen spokesperson from the Council who favors the annexation, as well as one Hideout citizen spokesperson who was a sponsor for the referendum, will utilize equal time to present their views.

Residents are encouraged to submit questions and comments regarding their reasons for supporting or opposing the annexation by email to hideoututah@hideoututah.gov. **Emails must be received no later than May 10, 2021 at 5:00 pm Mountain Standard Time.**

Please put 'Public Information Presentation' in the subject line. All submittals must be signed and include the subdivision you reside in. Priority will be given to submittals from Hideout residents and landowners. It is not guaranteed that all comments or questions will be read or addressed.

The presenters will consider the submitted questions and comments as part of their presentations.

HIDEOUT UTAH

May 7, 2021

DETERMINATION REGARDING CONDUCTING TOWN OF HIDEOUT PUBLIC MEETINGS WITHOUT AN ANCHOR LOCATION

The Mayor of the Town of Hideout hereby determines that conducting a meeting with an anchor location presents a substantial risk to the health and safety of those who may be present at the anchor location pursuant to Utah Code section 52-4-207(5) and Hideout Town Ordinance 2020-03. The facts upon which this determination is based include: The seven-day rolling percent and number of positive COVID-19 cases in Utah has been over 6.48% of those tested since May 4, 2021. The seven-day average number of positive cases has been over 342 since May 5, 2021.

This meeting will not have a physical anchor location. All participants will connect remotely. All public meetings are available via YouTube Live Stream on the Hideout, Utah YouTube channel at: https://www.youtube.com/channel/UCKdWnJad-WwvcAK75QjRb1w/

Interested parties may join by dialing in as follows:

Meeting URL: https://zoom.us/j/4356594739
To join by telephone dial: US: +1 408-638-0986
Meeting ID: 4356594739

Additionally, comments may be emailed to hideoututah@hideoututah.gov. Emailed comments received prior to the scheduled meeting will be read during the public comment portion and entered into public record.

This determination will expire in 30 days on June 6, 2021.

BY:

Phil Rubin, Mayor

ATTEST:

Alicia Fairbourne, Town Clerk

TOWN OF HIDEOUT CORPORATE Seal WASATCH COUNTY, UTAH

Annexation Referendum

Town of Hideout

May 12, 2021

Significant Opposition

- Opposition from the surrounding communities is quite intense.
  - Summit County
  - Wasatch County
  - Park City
  - Surrounding HOAs
  - JSSD
- The state legislature which originally passed the bill allowing for cross-county annexation immediately repealed this legislation once it saw what Hideout was attempting.

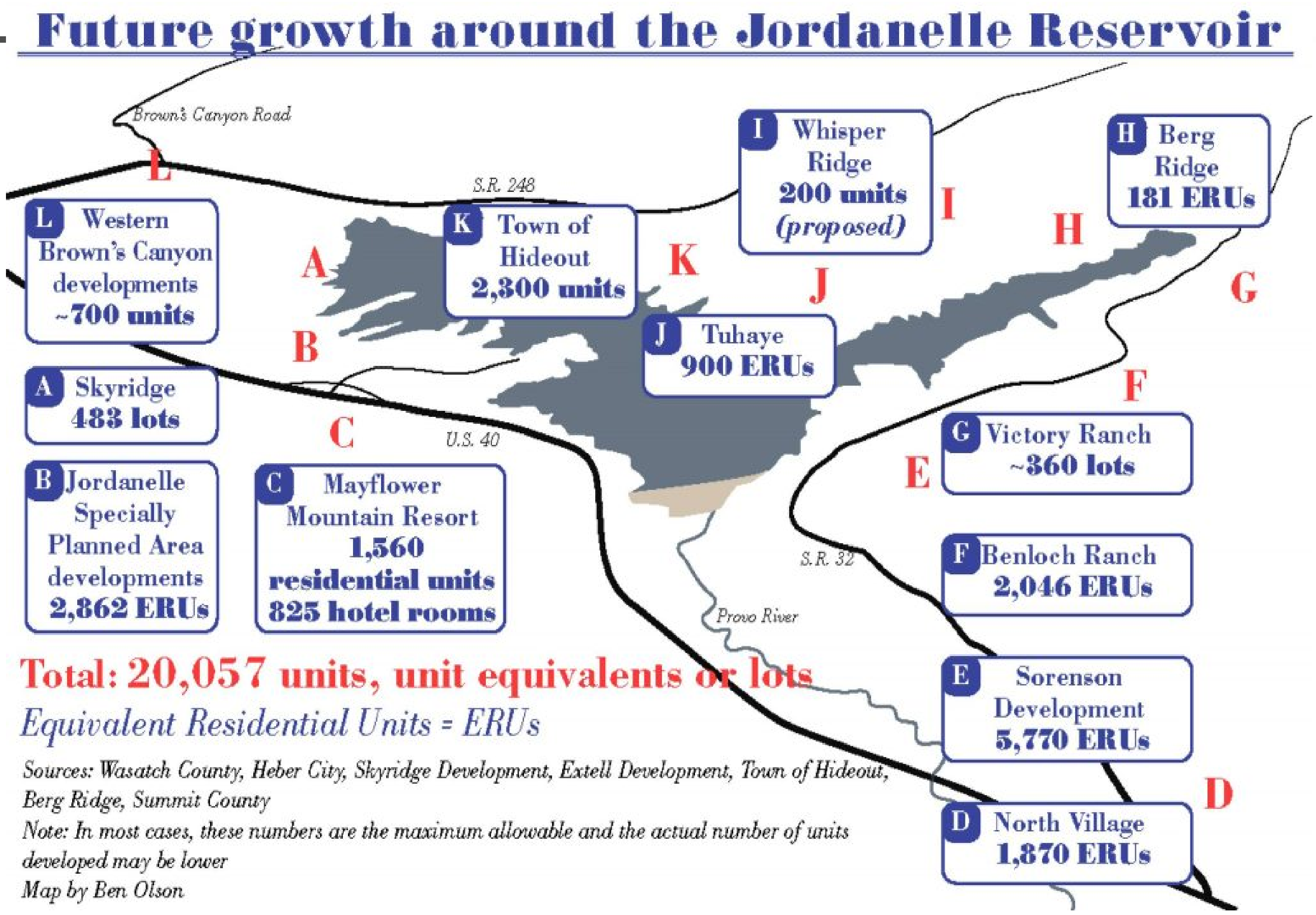
An Unnecessary Distraction

- Lawsuits will sap much of the attention of the Mayor and Town Council in the future
- Hideout is faced with significant development and developer issues
- Governance infrastructure is not in place to handle the increased demands of this project – planning, engineering and construction oversight
- Substantial uncertainty over environmental and water supply issues

Dramatic Development

- Dramatic growth has occurred over the past ten years and Covid-related explosive growth is projected over the next few years
- Traffic, critical services, water supply and infrastructure do not care about arbitrary county/town lines
- Isolated local decisions have a dramatic impact on neighbors without them having any say in outcomes

Dramatic Development



Dramatic Development

Kearns Blvd

Kimball Junction

Dramatic Development

PARKRECORD.com

New mixed-use development proposed near U.S. 40 and Silver Summit

kpcw 91.7 91.9 88.1 npr

Park City Council OKs Location For New Soils Repository

PARKRECORD.com

Summit County councilor worried about Park City's plans for contaminated soils

Inter-Government Partnership

- There needs to be a formalized Regional Planning Commission which has authority to contain and regulate this development and the negative impacts of individual community decisions on neighboring communities across counties

- All stakeholders must be included in order to make such a body effective and fair

ZIONS PUBLIC FINANCE, INC.

DRAFT - FISCAL AND ECONOMIC IMPACTS OF PROPOSED HIDEOUT ANNEXATION – RICHARDSON FLAT

BACKGROUND

This analysis considers both fiscal and economic impacts to the Town of Hideout from a proposed development at Richardson Flat. Fiscal impacts include increased property, sales, municipal energy and Class B/C road funds to the Town while economic impacts include increased jobs created and wages paid.

Proposed Development

This fiscal and economic impacts analysis is based on the following proposed development of 600 residential units and 95,000 square feet of retail development.

TABLE 1: PROPOSED DEVELOPMENT

	Units
Residential	
Affordable – Cottages	40
Affordable – Apartments	50
Affordable - Town Center	30
Single Family/Smaller Lots	65
Single-Family/Larger Lots	175
Twin Homes	40
Cottage Lots	55
Apartments	50
Town Center Condos	95
TOTAL Residential	**600**
Retail	**95,000**

EXECUTIVE SUMMARY

The proposed development results in positive net revenues to the Town's General Fund, as well as the creation of new jobs within Hideout.

Net Revenues to General Fund

Net revenues to Hideout's General Fund from the proposed development are projected to reach over $7 million over 20 years

TABLE 2: SUMMARY OF GENERAL FUND NET REVENUES OVER 20 YEARS

	20-Year Total
Revenues	$15,114,153

	20-Year Total
Expenses	($7,991,187)
Net Revenues	**$7,122,967**

In addition, an estimated 239 jobs will be created within Hideout from the proposed commercial development.

Other economic benefits include developer contributions for a town hall, school property and fire station site. The total value of these contributions is estimated at nearly $8.5 million.

TABLE 3: SUMMARY OF OTHER CONTRIBUTIONS BY DEVELOPER

Contributions	Amount
Town Hall - 12,000 sf	$3,600,000
School Property	$4,200,000
Fire Station Site	$696,960
TOTAL	**$8,496,960**

Total General Fund and other developer contributions have a net fiscal benefit to the Town of over $15.6 million over 20 Years

TABLE 4: SUMMARY OF NET BENEFITS OVER 20 YEARS

	20-Year Total
General Fund Net Benefits	$7,122,967
Developer Contribution	$8,496,960
TOTAL Net Benefit	**$15,619,927**

Other taxing entities will also receive significant economic benefit through increased property tax revenues from the proposed development. The School District will receive the major benefit through incremental tax revenues estimated at over $50 million over 20 years. Further, approximately 250 units (or 42 percent) of the total 600 residential units are anticipated to be second homes, thereby adding no school children for the School District to educate.

TABLE 5: SUMMARY OF PROPERTY TAX BENEFITS TO OTHER TAXING ENTITIES OVER 20 YEARS

Incremental Tax Revenues to Other Taxing Entities	20-Year Total
Wasatch County	$12,851,809
Wasatch County School District	$50,681,683
Hideout	$5,150,239
Wasatch County Fire Protection SSD	$4,222,482
Wasatch County SSD No 21	$1,629,521
CUWCD	$2,378,863
TOTAL – 20 Years	**$76,914,599**

This project is requesting no tax incentives or public assistance with the development. Based on the incremental revenues calculated, there appears to be no risk to the taxpayers from this project.

This project is also advantageous to Hideout because it strengthens the sustainability of the City's General Fund. If the Town were to experience no growth, it would see negative net revenues averaging $250,000 over the next 5 years. Building permits account for more than half of the Town's budget and are an important source of revenue to the Town. Further, there are economies of scale from development that build on the fixed costs (such as administrative, HR, etc.) already in place in the Town.

DEVELOPMENT ASSUMPTIONS

The proposed development includes 120 units of affordable housing.

TABLE 6: AFFORDABLE HOUSING ABSORPTION SCHEDULE

Year	Housing Type	# of Units	Sales Price	Market Value
2023	Cottages	7	$450,000	$3,150,000
2023	Apartments	50	$250,000	$12,500,000
2024	Cottage Lots	11	$450,000	$4,950,000
2024	Town Center Condos	8	$400,000	$3,200,000
2025	Town Center Condos	7	$410,000	$2,870,000
2025	Cottage Lots	5	$450,000	$2,250,000
2027	Town Center Condos	8	$425,000	$3,400,000
2027	Cottage Lots	5	$450,000	$2,250,000
2028	Cottage Lots	2	$450,000	$900,000
2028	Town Center Condos	7	$440,000	$3,080,000
2029	Cottage Lots	10	$450,000	$4,500,000
	TOTAL	**120**		**$43,050,000**

The proposed development also includes another 480 units, many of which are projected to be second homes.

TABLE 7: HOUSING ABSORPTION SCHEDULE

Year	Housing Type	# of Homes	Sales Price	% of Second Homes	Market Value Total
2022	Single Family/Smaller Lots	12	$950,000	60.00%	$11,400,000
2023	Single Family/Smaller Lots	38	$978,500	55.00%	$37,183,000
2023	Twin Homes	24	$750,000	40.00%	$18,000,000
2023	Cottage Lots	10	$650,000	60.00%	$6,500,000
2023	Apartments	50	$350,000	100.00%	$17,500,000
2024	Single Family/Larger Lots	16	$1,250,000	50.00%	$20,000,000
2024	Cottage Lots	13	$670,000	60.00%	$8,710,000
2024	Town Center Condos	24	$520,000	25.00%	$12,480,000
2025	Single Family/Larger Lots	32	$1,250,000	50.00%	$40,000,000

Year	Housing Type	# of Homes	Sales Price	% of Second Homes	Market Value Total
2025	Cottage Lots	7	$690,100	40.00%	$4,830,700
2025	Town Center Condos	24	$550,000	25.00%	$13,200,000
2026	Single Family/Larger Lots	42	$1,275,000	60.00%	$53,550,000
2027	Town Center Condos	24	$565,000	25.00%	$13,560,000
2027	Single Family/Larger Lots	9	$1,275,000	60.00%	$11,475,000
2027	Single Family/Smaller Lots	15	$1,050,000	55.00%	$15,750,000
2027	Cottage Lots	10	$785,000	40.00%	$7,850,000
2027	Twin Homes	4	$760,000	40.00%	$3,040,000
2028	Twin Homes	12	$780,000	40.00%	$9,360,000
2028	Town Center Condos	23	$575,000	25.00%	$13,225,000
2028	Cottage Lots	2	$715,000	40.00%	$1,430,000
2028	Single Family	45	$1,100,000	55.00%	$49,500,000
2029	Cottages	13	$815,000	40.00%	$10,595,000
2029	Single Family	31	$1,150,000	55.00%	$35,650,000
		480			**$414,788,700**

FISCAL IMPACTS - REVENUES

This section discusses the increased revenues generated by the proposed development that will flow to the Town of Hideout's General Fund if annexation occurs.

Property Tax Revenues

Property tax revenues are calculated based on Hideout's tax rate of 0.000866. With taxable value of over $473 million for the proposed development,[1] this results in over $5 million in property tax revenues to Hideout over a 20-year period.

TABLE 8: PROJECTED 20-YEAR PROPERTY TAX REVENUES

	20-Year Total
Property Tax Revenues	$5,150,239

Additional tax revenues will be generated for Wasatch County, Wasatch County School District, Wasatch County Fire Prevention Special Service District, Wasatch County Special Service District #21, and Central Utah Water Conservancy District by multiplying the assessed values shown previously by the tax rate of each taxing entity.

Sales Tax Revenues

[1] 2020 market values have been increased by 3% per year until the year of construction. Then, due to truth-in-taxation requirements, property values are held constant for purposes of analysis. Primary residential development is taxed at 45% of market value in order to calculate taxable value.

Sales tax revenues are based both on population distribution and point-of-sale distribution. The population distribution in Utah has recently reached about $100 per capita per year and applies only to the population associated with primary residential development. The population has been calculated based on the number of units projected and an average household size of 3.0 persons.

Point-of-sale impacts are based on average sales of $400 per square foot. The City will receive one-half of one percent of gross retail sales based on the local option sales tax.

TABLE 9: PROJECTED SALES TAX REVENUES TO HIDEOUT

	20-Year Revenues
Population Distribution	$2,831,985
Point of Sale Distribution	$4,418,569

Municipal Energy Revenues

Utah Code allows cities to collect municipal energy tax revenues of up to 6 percent on the taxable portions of electric and gas sales. Hideout has enacted the municipal energy tax at a rate of 6 percent.

Average residential monthly electric expenses in Utah are $79.00.[2] Average natural gas bills are $345.03.[3] Based on the number of households and retail square feet anticipated to be developed, revenues will reach over $1.36 million over 20 years. Average commercial expenses are $2.10 per building square foot.[4]

TABLE 10: PROJECTED MUNICIPAL ENERGY TAX REVENUES

Municipal Energy Tax Revenues	
Residential Development	$1,085,288
Commercial Development	$278,370

Class B/C Road Fund Revenues

Class B/C road funds are distributed on both population and weighted road miles.

TABLE 11: CLASS B/C ROAD FUND DISTRIBUTION

[2] https://www.electricitylocal.com/states/utah/

[3] https://www.google.com/search?q=average+residential+gas+bill+in+Utah+per+month&oq=average+residential+gas+bill+in+Utah+per+month&aqs=chrome..69i57.6761j0j7&sourceid=chrome&ie=UTF-8

[4] https://www.google.com/search?q=average+commercial+gas+bill+per+square+foot&rlz=1C1GCEB_enUS886US886&oq=average+commercial+gas+bill+per+square+foot&aqs=chrome..69i57j33l3.7275j0j7&sourceid=chrome&ie=UTF-8

Road Mile Distribution	Population	Weighted Mileage	Amount Distributed	Population Distribution	Weighted Mile Distribution	Per Capita Distribution	Per Weighted Mile Distribution
Sept-Oct 2020	3,161,105	122,143.36	$35,596,157	$17,798,078	$17,798,078	$5.63	$145.71
Nov-Dec 2020	3,161,105	121,433.26	$29,939,103	$14,969,551	$14,969,551	$4.74	$123.27
Jan-Feb 2020	3,161,105	122,580.00	$26,260,559	$13,130,280	$13,130,280	$4.15	$107.12
Mar-Apr 2020	3,161,105	122,741.35	$32,237,217	$16,118,609	$16,118,609	$5.10	$131.32
May-June 2020	3,205,958	122,841.88	$1,452,187	$15,726,094	$15,726,094	$4.91	$128.02
Jul-Aug 2021	3,205,958	122,895.96	$26,111,685	$13,055,842	$13,055,842	$4.07	$106.23
TOTAL						**$28.60**	**$741.68**
**Source: UDOT; ZPFI*							

The proposed development anticipates the addition of 4.31 road miles over 5 years of development. All of these roads will be paved, thereby equating to 21.55 weighted road miles.[5]

Hideout should receive over $1.2 million over 20 years from the additional road funds.

TABLE 12: PROJECTED CLASS B/C ROAD FUND REVENUES

Class B C Road Funds	20-Year Total
Population Distribution	$404,258
Weighted Road Mile Distribution	$809,842

Other Revenues

Other revenues will be minor and will be for fines & forfeitures and licenses (i.e., business licenses). The Town currently receives only $200 per year in business license fee revenues and $1,000 in fines & forfeitures.

Summary of Fiscal Impacts

Estimated 20-year revenues to the General Fund are projected to be over $15.1 million. A detailed, year-by-year estimate of revenues and expenses is provided in Appendix A.

TABLE 13: SUMMARY OF GENERAL FUND REVENUES

REVENUES	20-Year Total
Property Tax Revenues	$5,150,239
Sales Tax Revenues	
Population Distribution	$2,831,985
Point-of-Sale	$4,418,569
Municipal Energy	

[5] UDOT calculates weighted road miles based on the following formula: 5 weighted miles per 1 paved mile; 2 weighted miles per 1 gravel mile; and 1 weighted mile per 1 dirt mile.

REVENUES	20-Year Total
Residential	$1,085,288
Commercial	$278,370
Class B/C Road Funds	
Weighted Road Mile Distribution	$404,258
Population Distribution	$809,842
Business Licenses	$88,549
Fines & Forfeitures	$47,054
TOTAL Revenues	**$15,114,153**

FISCAL IMPACTS - EXPENSES

Although the proposed development will create additional revenues for Hideout, it will place some additional demands on services. In order to estimate the potential costs associated with these services, per capita and per employee costs for current services (based on the Town's 2020 budget) have been calculated. This cost has then been applied to future growth from the proposed development.

One further adjustment to cost projections has been made. A distinction needs to be drawn between fixed and variable costs. Fixed costs are those which do not change with growth. For example, the cost for the Town Council remains the same, whether or not annexation occurs. On the other hand, departments such as police and fire will see increased demand for patrol and responding to calls for service. Specifically, while public safety will have an estimated 10 percent of fixed costs (i.e., administration), most of its costs are variable through the need to provide additional patrol time and respond for more calls for service.

TABLE 14: GENERAL FUND BUDGET AND COST ALLOCATION

Expenses	Budget 2020	Per Capita/Employee	% Variable
Administrative	$215,800	$213.66	10%
Professional Services	$170,500	$168.81	50%
Public Safety	$70,000	$69.31	90%
Streets	$219,500	$4,038.64	0%
Parks	$5,000	$4.95	0%

Using the assumptions shown in the preceding table, the proposed annexation will cost the Town nearly $8 million for increased demand on services over the next 20 years.

TABLE 15: SUMMARY OF GENERAL FUND EXPENSES FROM PROPOSED DEVELOPMENT

	Amount
Administrative	($1,015,426)
Professional Services	($4,011,357)

Public Safety	($2,964,404)
Streets	$0
Parks	$0
TOTAL	**($7,991,187)**

SUMMARY OF GENERAL FUND FISCAL IMPACTS

Net revenues to Hideout from the proposed development are projected to reach over $7 million over 20 years.

TABLE 16: SUMMARY OF GENERAL FUND NET REVENUES

	20-Year Total
Revenues	$15,114,153
Expenses	($7,991,187)
Net Revenues	$7,122,967

ONE-TIME DEVELOPMENT-RELATED FEES

The proposed development will generate significant one-time planning and development fees, including building permits and impact fees. No revenue from these fees has been included in the analysis, nor have the related expenses been included. In theory, these revenues and expenses are considered to be offsetting.

ECONOMIC IMPACTS

Job Creation

With 95,000 retail square feet planned, and an average of 400 square feet per employee, this development will create the need for approximately 239 employees.

Wages Paid

Retail wages in Utah averaged $3,315 per month in 2019.[6] With an estimated 239 retail jobs created, an additional $9.5 million in wages annually should be paid to these retail employees in Hideout.

One-Time Construction Impacts

With total hard costs of roughly $343 million,[7] there will be additional impacts in supplies purchased locally, as well as wages paid. A general rule of thumb is 40 percent for construction supplies and 40

[6] https://jobs.utah.gov/jsp/utalmis/#/industry/list
[7] Calculated as 75% of total costs

percent for labor costs. Using this assumption, there would be one-time construction wages paid of roughly $137.2 million. In addition, there would be a one-time purchase of construction supplies of approximately $137.2 million.

General Fund Sustainability

Growth is good for Hideout's General Fund budget. With fixed costs in place, new growth does not add proportionately to costs, while still providing significant property and sales tax revenues. This is because fixed costs are already in place for several areas, such as administrative costs, professional services, etc. On the other hand, growth does add to the costs of public safety as there are more calls for service and more locations to patrol. The table below shows that while the average per capita cost in Hideout is currently $940, new growth will only add about $242 per capita. This is because there are economies of scale once fixed costs are in place.

TABLE 17: PER CAPITA COSTS ATTRIBUTABLE TO GROWTH

Expenses	Budget 2020	Per Capita	% Variable	Cost per Capita New Development
Administrative	$215,800	$247.76	10%	$24.78
Professional Services	$320,500	$367.97	50%	$183.98
Public Safety	$32,100	$36.85	90%	$33.17
Streets	$219,500	$252.01	0%	$0.00
Parks	$5,000	$5.74	0%	$0.00
Debt Service	$25,525	$29.31		$0.00
TOTAL		**$940**		**$242**

Budgeted expenses in the Town's General Fund budget have grown from $488,125 in 2019 to $818,425 in 2020 – an increase of 68 percent. However, over the same time period, sales tax revenues in the Town have not increased. This puts a burden on property tax revenues to make up the gap. Without new growth (and increased taxable value), this places pressure on the Town to raise property tax rates, add additional fees for services, or reduce current service levels. Facing just such pressure, the Town enacted a significant property tax increase in 2019 as shown in the table below.

The following table shows how the Town's costs per capita have increased from $490 per person in 2019 to $940 in 2020. As stated, this required the Town to make a significant property tax increase in 2019.

TABLE 18: GENERAL FUND ANALYSIS

Hideout Historic	Mill Rate	Taxable Value	Property Tax Revenues	General Fund Expenses	Population	Cost per Capita
2020	0.000866			$818,425	871	$940
2019	0.000867	$181,569,850	$157,421	$488,125	996	$490
2018	0.000437	$151,356,359	$66,143	$421,622	1,123	$375
2017	0.000449	$127,972,435	$57,460	$296,400	833	$356
2016	0.000497	$92,568,079	$46,006	$276,675	847	$327
2015	0.000721	$59,979,489	$43,245	$219,000	691	$317

So, the question arises, just how sustainable is Hideout Town's General Fund without new growth? The table below analyzes projected revenues assuming no new growth in the Town. In this hypothetical scenario, property taxes would remain constant.[8] Sales taxes could potentially increase a little due to inflationary factors, similar to revenues from municipal energy taxes, class C road funds and fines & forfeitures. Revenues from building permits would drop to $0. This would be especially hard on the Town as building permits currently contribute more than half of the City's revenues, yet do not account for 50 percent of Town costs.

TABLE 19: REVENUE PROJECTIONS

Revenues	Budget 2020	Year 1	Year 2	Year 3	Year 4	Year 5	AAGR*
Property Taxes	$122,525	$122,525	$122,525	$122,525	$122,525	$122,525	
Fee-in-Lieu	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	
Sales Tax	$96,000	$97,920	$99,878	$101,876	$103,913	$105,992	2%
Municipal Energy	$40,500	$41,715	$42,966	$44,255	$45,583	$46,951	3%
Building Permits	$430,200	$0	$0	$0	$0	$0	
Business Licenses	$200	$204	$208	$212	$216	$221	2%
Class C Roads	$72,500	$74,675	$76,169	$77,692	$79,246	$80,831	3%
Fines & Forfeitures	$1,000	$1,020	$1,040	$1,061	$1,082	$1,104	2%
Other	$54,500	$54,500	$54,500	$54,500	$54,500	$54,500	
TOTAL	**$818,425**	**$393,559**	**$398,287**	**$403,122**	**$408,066**	**$413,123**	

*AAGR = Average Annual Growth Rate

While revenues would decrease significantly, expenses would only decrease somewhat. Professional services could potentially cut costs by about $200,000 due to reduced building inspection costs. However, other categories would see inflationary cost increases. This would result in negative net revenues to the Town in the future, averaging about $250,000 per year over the next 5 years.

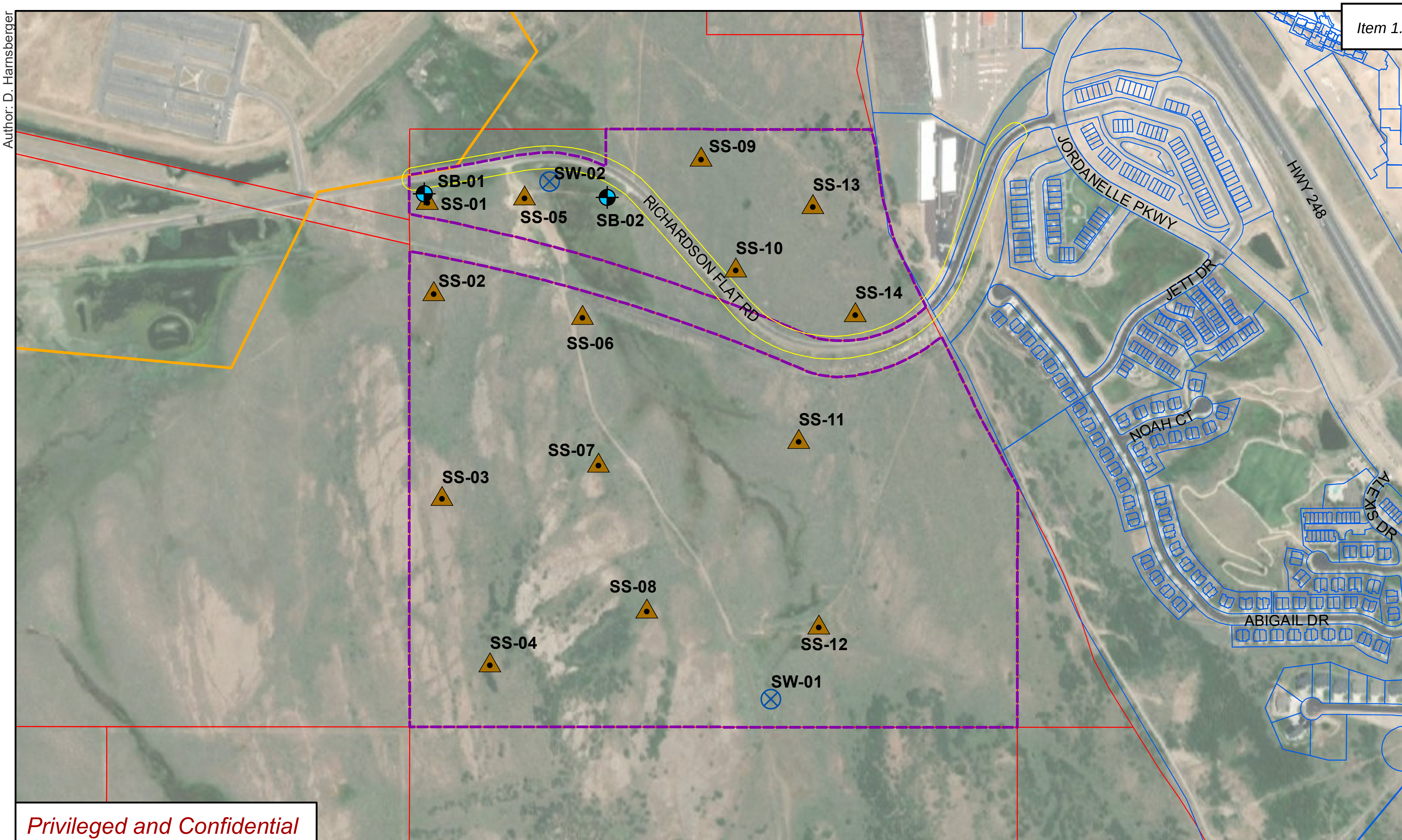
TABLE 20: EXPENSE PROJECTIONS

Expenses	Budget 2020	Year 1	Year 2	Year 3	Year 4	Year 5	AAGR
Administrative	$215,800	$220,116	$224,518	$229,009	$233,589	$238,261	2%
Professional Services	$320,500	$100,000	$103,000	$106,090	$109,273	$112,551	3%
Public Safety	$32,100	$33,705	$35,390	$37,160	$39,018	$40,969	5%
Streets	$219,500	$230,475	$241,999	$254,099	$266,804	$280,144	5%
Parks	$5,000	$5,100	$5,202	$5,306	$5,412	$5,520	2%
Debt Service	$25,525	$25,525	$25,525	$25,525	$25,525	$25,525	
TOTAL	**$818,425**	**$614,921**	**$635,634**	**$657,188**	**$679,620**	**$702,969**	
Net Revenues	**$0**	**($221,362)**	**($237,347)**	**($254,066)**	**($271,554)**	**($289,846)**	

Therefore, from a fiscal sustainability standpoint, it is to Hideout's advantage to grow.

[8] Although property values would appreciate over time, truth-in-taxation would require a lowering of the tax rate so that additional revenues are not generated unless a property tax increase is enacted and a public hearing for such is held.

Author: D. Harnsberger



Privileged and Confidential

Legend

Proposed Sampling Location Type

- Soil Boring
- Surface Water
- Surface Soil
- Site Boundary
- Wasatch County Parcel Boundaries
- Richardson Flat Tailings Superfund Site OU1
- Summit County Parcel Boundaries

Notes:

1) Sampling Locations shown here are approximate and will be finalized and recorded in the field.
2) Basemap Source: ESRI World Imagery, 2019

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0 800 Feet

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Site Sampling Plan

Parcel SS-86
Phase I ESA and Baseline Sampling
Summit County, Utah

Geosyntec consultants

Geosyntec Proj. No. XX

April 2021

Figure 2

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ECONOMIC IMPACT ANALYSIS AND SALES ANALYSIS OF RICHARDSON FLAT ANNEXATION INTO HIDEOUT, UTAH

HIDEOUT, UTAH

MAY 10, 2021

LEWIS YOUNG
ROBERTSON & BURNINGHAM, INC.
GATEWAY PLAZA BUILDING - 41 N. RIO GRANDE, STE 101 - SALT LAKE CITY, UT 84101
(P) 801-596-0700 - (TF) 800-581-1100 - (F) 801-596-2800 - WWW.LEWISYOUNG.COM

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EXECUTIVE SUMMARY

Lewis Young Robertson and Burningham, Inc. ("LYRB") was retained by the Town of Hideout (the "Town") to complete an Economic Impact and Sales Analysis related to the proposed Richardson Flat Annexation (the "Development"). LYRB, working on behalf of the Town, has prepared an analysis of the fiscal benefits to be derived from the Development, as well as the corresponding costs associated with the Town providing municipal services. The assumptions used in this analysis are based on data presented by the Developer, comparable community data, Town data, current economic and market demand factors, and public infrastructure needs.

ASSESSED VALUATION OF THE RICHARDSON FLAT DEVELOPMENT

The Development encompasses 348 acres and is intended for residential and commercial development. The Developer anticipates the construction of 100 apartments, 125 condominiums, 40 twinhomes, 95 cottages, and 240 single family homes over the next 7-8 years. The total assessed value of the Development at buildout is estimated at **$511.4 million**. This value includes consideration of a 45 percent residential exemption on 75 percent of the residential units, with the exception of the apartments where the primary residential exemption was applied to 100 percent of the units. All "for sale" residential units, with the exception of the single family homes have a portion of the units which are considered affordable. Affordable unit values were valued at approximately 60 percent of the market rate value.

TABLE E.1: DEVELOPMENT OVERVIEW AND ASSESSED VALUE

PRODUCT	ESTIMATED ASSESSED VALUE AT BUILDOUT	# OF UNITS
Apartments	5,245,320	100 units
Town Center Condos	55,780,423	125 units
Twinhomes	34,746,667	40 units
SF Cottage Lots	38,253,130	95 units
Single Family Lots	354,153,995	240 units
Assisted Living	7,417,702	72,800 SF
Retail/Commercial (NET)	15,821,416	95,000 SF
Total	**$511,418,655**	

HIDEOUT GENERAL FUND REVENUE PROJECTIONS

The revenues calculated in this analysis include property tax, sales tax, franchise taxes, and Class C road funds. A cumulative total of **$15.15 million** is projected over the 20-year planning horizon. **TABLE E.2** details the total annual revenue in years 2027, 2032, 2037, and 2042, as well as the 20-year cumulative total. Additional revenues and expenses associated with the proposed mountain lift are not included in this analysis.

TABLE E.2: HIDEOUT PROJECTED GENERAL FUND REVENUE

TOWN REVENUES	2027	2032	2037	2042	20-YEAR TOTAL
Property Tax	258,065	442,889	442,889	442,889	7,171,148
Sales Tax	193,055	289,277	308,241	328,448	5,053,863
Telecommunications Franchise Tax	1,568	2,791	3,082	3,403	47,898
Electric Franchise Tax	39,309	62,897	69,443	76,671	1,098,476
Natural Gas Franchise Tax	11,407	19,272	21,278	23,492	335,923
Class C Road Funds	39,038	82,687	97,986	116,190	1,445,707
Total Revenue	**$542,443**	**$899,812**	**$942,919**	**$991,093**	**$15,153,016**

HIDEOUT GENERAL FUND EXPENSE PROJECTIONS

The Development creates a burden on the Town's general government, parks, streets, and public safety services. In evaluating the benefits of the Development, it is critical to ensure the costs of providing municipal services does not outweigh the benefits (revenues) that are anticipated to be derived by the Town. **TABLE E.3** summarizes the total general fund expenditures related to the provision of municipal services projected in 2027, 2032, 2037, and 2042, as well as the 20-year cumulative total.

E.3: HIDEOUT PROJECTED EXPENSE

TOWN EXPENSES	2027	2032	2037	2042	20-YEAR TOTAL
Class C Road Expenditures	55,098	89,096	98,369	108,607	1,555,427
General Government (Admin & Prof. Services)	187,762	303,617	335,218	370,107	5,300,535
Public Works	52,459	99,400	109,745	121,168	1,691,152
Parks	3,726	7,060	7,794	8,606	120,110
Public Safety (Fire & Police)	114,009	216,025	238,509	263,333	3,675,374
Total Expenses	**$413,054**	**$715,197**	**$789,635**	**$871,821**	**$12,342,598**

PROPOSED INFRASTRUCTURE AND AMENITIES

The Developer will finance and construct a police and fire station, a town hall and community center, a mountain lift, trails, and 206 acres of open space that will provide benefit to the Development and the Town of Hideout. Property will also be provided for a future school. As part of the annexation, the public buildings proposed by the Developer are anticipated to bring access to local services closer to the area and offer public meeting spaces to residents of Hideout.

The trail system will provide pedestrian connections from the proposed retail to the neighborhood sections and Richardson Peak. The open space and trails are intended to be sized and programmed for general public use, and it is anticipated that they will be maintained by an HOA.

The mountain lift located in the town center and extending to Richardson Peak will provide access and viewing opportunities to guests and residents. The Town is currently reviewing whether this is an amenity they wish to own or have turned over to the HOA. Details on the expenses and revenues associated with the lift are not included this in this analysis.

The total proposed Developer funded capital infrastructure and amenities have a significant value. Additional detail on associated acreage and building sizes are required to estimate their value.

TOWN'S GENERAL FUND COST-BENEFIT SUMMARY

Based on the development assumptions utilized in this analysis, the Richardson Flat Development produces a net benefit to Hideout annually with **$2.8 million** of cumulative net revenue projected over 20 years as illustrated in **TABLE E.6**. The absorption and timing of the Development will impact the current projections. The Development may provide additional benefit to the Town through the public infrastructure and amenities considered in this analysis.

TABLE E. 6: HIDEOUT COST-BENEFIT

	2027	2032	2037	2042	20-YEAR TOTAL
Revenue					
Property Tax	258,065	442,889	442,889	442,889	7,171,148
Sales Tax	193,055	289,277	308,241	328,448	5,053,863
Telecommunications Franchise Tax	1,568	2,791	3,082	3,403	47,898
Electric Franchise Tax	39,309	62,897	69,443	76,671	1,098,476
Natural Gas Franchise Tax	11,407	19,272	21,278	23,492	335,923
Class C Road Funds	39,038	82,687	97,986	116,190	1,445,707
Total Revenue	**$542,443**	**$899,812**	**$942,919**	**$991,093**	**$15,153,016**
Expense					
Class C Road Expenditures	55,098	89,096	98,369	108,607	1,555,427
General Government (Admin & Prof. Services)	187,762	303,617	335,218	370,107	5,300,535
Public Works	52,459	99,400	109,745	121,168	1,691,152

Parks	3,726	7,060	7,794	8,606	120,110
Public Safety (Fire & Police)	114,009	216,025	238,509	263,333	3,675,374
Total Expense	**$413,054**	**$715,197**	**$789,635**	**$871,821**	**$12,342,598**
Net Operating Revenue	**$129,389**	**$184,615**	**$153,283**	**$119,271**	**$2,810,417**

ANNEXATION OF PROPOSED DEVELOPMENT OF BENEFIT TO HIDEOUT

Based on the proposed Development, including the types of development, densities, amenities and public infrastructure dedications that are envisioned to occur as part of the annexation, this Economic Impact and Sales Analysis concludes the Town's general fund will be enhanced by **$2.8 million** over the 20-year planning horizon. The Developer funded public infrastructure and amenities are of substantial benefit. Based on these calculations, LYRB is of the opinion the proposed Development, and its associated annexation, provides an overall net benefit to the Town. LYRB recommends and encourages the Town to assess the facts, circumstances and calculations presented herein throughout the proposed annexation process to ensure the Town receives the anticipated net benefits of the Development.

SECTION I: DEVELOPMENT SUMMARY

OVERVIEW OF DEVELOPMENT

The proposed Richardson Flat Development encompasses 348 acres and includes 600 residential units, 95,000 SF of retail, a 72,800 SF assisted living center, and 2016 acres of green space.

The Developer anticipates the construction of 100 apartments, 125 condominiums, 40 twinhomes, 95 cottages, and 240 single family homes over the next 7-8 years. The apartments and condominiums will be constructed within a town center retail area at the base of the mountain lift. 95,000 SF of street level commercial will provide the Town its first retail area. The 72,800 SF assisted living center will be located adjacent to the open space and trail system directly across the street from the town center. The assisted living center will provide a maximum of 520 assisted living units. The twinhomes, cottage homes, and single family homes will be clustered and connected via roadways and a trail system to the town center.

The total assessed value of the Development at buildout is estimated at **$511.42 million**. This value includes consideration of a 45 percent primary residential exemption on property taxes for 75 percent of the "for sale" residential units. With feedback from the Town, the property tax exemption was set at this level to recognize that likely 25 percent of the for sale residential units will be secondary homes and will not qualify for the exemption. The primary residential property tax exemption was applied to all 100 apartments units.

All "for sale" residential units, with the exception of the single family homes, have a portion of the units which are considered affordable. Affordable unit values were valued at approximately 60 percent of the market rate value. Per the recommendation of the Town, the number of affordable units was set to the quantities provided by the Developer in their third-party fiscal impact report. **TABLE 1.1** displays the types of units, the percent affordable, the estimated market value per unit based on comparable housing units, the estimated affordable unit value, and total number of units for each type of home.

The Developer anticipates preserving 206 acres of green space, a mountain lift, and adding a trail system to connect the neighborhoods with the town center and Richardson Peak. The mountain lift platforms will be at plazas with sitting areas.

TABLE 1.1: PROPOSED RICHARDSON FLAT DEVELOPMENT

PRODUCT	BUILDOUT ASSESSED VALUE	# OF UNITS	AFFORDABLE HOUSING (%)	MARKET UNIT VALUE OR 100K SF	AFFORDABLE UNIT VALUE
Apartments	5,245,320	100 units	50%	113,038	67,823
Town Center Condos	55,780,423	125 units	24%	714,967	428,980
Twinhomes	34,746,667	40 units	0%	1,274,228	764,537
SF Cottage Lots	38,253,130	95 units	42%	683,125	409,875
Single Family Lots	354,153,995	240 units	0%	2,166,000	
Assisted Living	7,417,702	72,800 SF		86,725	
Retail/Commercial (NET)	15,821,416	95,000 SF		148,597	
Total	**$511,418,655**				

The Developer estimates full absorption of the housing units in 7-8 years. Full absorption estimates are included in **Appendix D**. **TABLE 1.2** displays the total number of residential units in the Development and the proposed absorption.

TABLE 1.2: ABSORPTION

TOTAL UNITS	ABSORPTION TIMING
600	7-8 Years

TAXABLE (ASSESSED) VALUATION OF RESIDENTIAL DEVELOPMENT

Comparable home values from the Hideout and surrounding community were used to estimate the future assessed value of the Development. These comparables include condominiums, townhomes, twinhomes, and single family homes ranging from $589,900 to $3,200,000. **TABLE 1.3** displays the estimated assessed value at build-out of each housing unit based on the number of lots. This analysis includes consideration of a 45 percent primary residential exemption on property taxes for 75 percent of the "for sale" residential units. With feedback from the Town, the property tax exemption was set at this level to recognize that likely 25 percent of the for sale residential units will be secondary homes and will not qualify for the exemption. The primary residential property tax exemption was applied to all 100 apartments units.

TABLE 1.3: DEVELOPMENT OVERVIEW AND ASSESSED VALUE

PRODUCT	ESTIMATED ASSESSED VALUE AT BUILDOUT	# OF UNITS
Apartments	5,245,320	100 units
Town Center Condos	55,780,423	125 units
Twinhomes	34,746,667	40 units
SF Cottage Lots	38,253,130	95 units
Single Family Lots	354,153,995	240 units
Assisted Living	7,417,702	72,800 SF
Retail/Commercial (NET)	15,821,416	95,000 SF
Total	**$511,418,655**	

POPULATION PROJECTION

The current population of Hideout is 1,196. Based on the Hideout average household size of 2.40, the Development is anticipated to add 1,440 new residents at buildout. **TABLE 1.4** illustrates the current population and anticipated new growth at buildout.

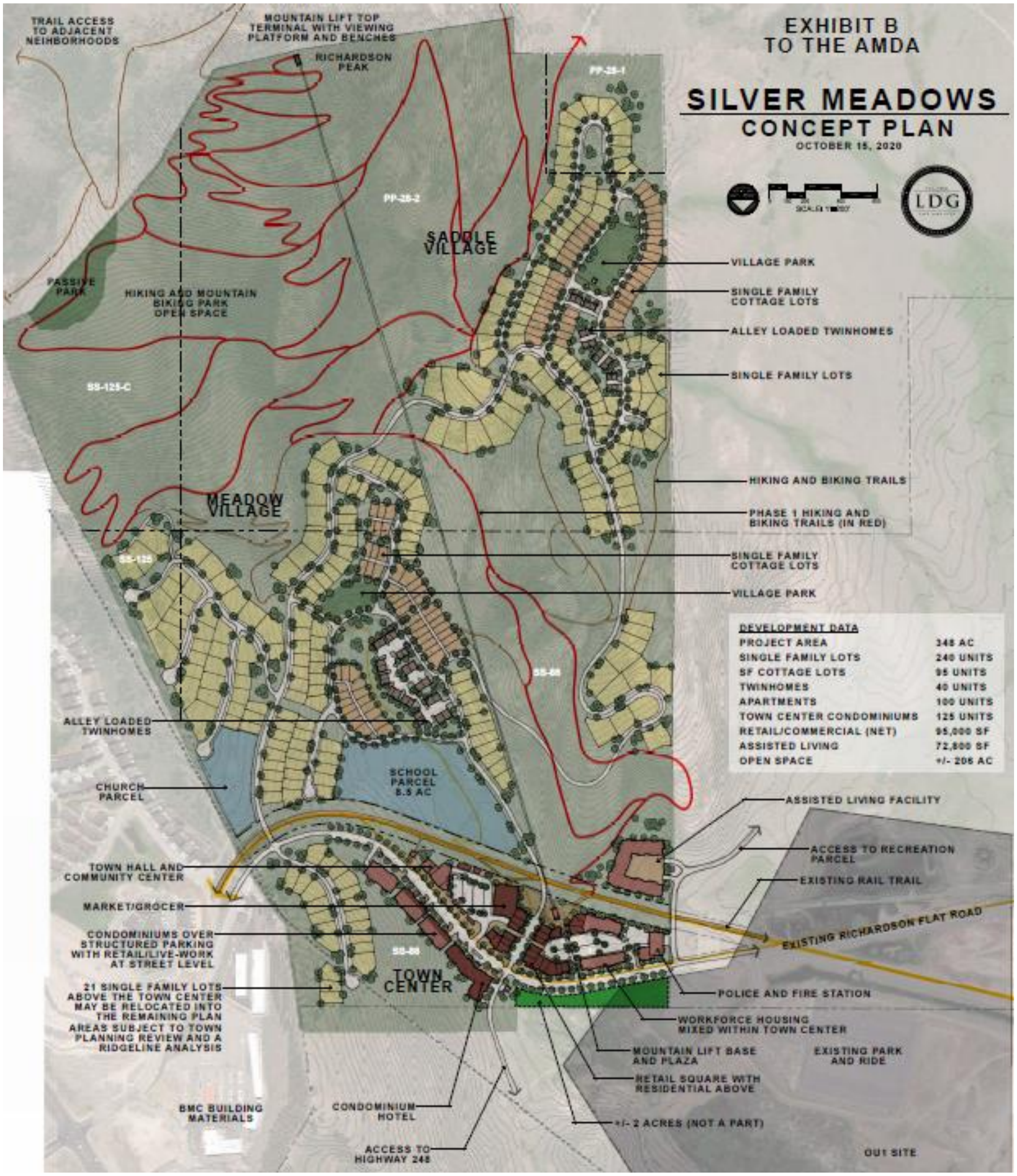
TABLE 1.4: POPULATION ESTIMATES

HIDEOUT POPULATION	HIDEOUT AVG HOUSEHOLD SIZE	PROPOSED RESIDENTIAL UNITS	ANTICIPATED POPULATION OF RICHARDSON FLAT ANNEXATION
1,196	2.40	600	1,440

SITE PLAN

IMAGE 1.1 illustrates the site plan of the proposed Development.

IMAGE 1.1: SITE PLAN



SECTION II: HIDEOUT GENERAL FUND REVENUE

Based on the development data outlined in **Section I**, LYRB developed a comprehensive financial model to forecast revenues the Development would generate for the Town. This analysis utilizes comparables from similar developments within the region and County and applies the appropriate tax rates to project property tax, sales tax, and franchise tax. Additional consideration is given for Class C road funds based on lane miles within the Development. A cumulative total of $15.15 million of general fund revenue is projected over the 20-year planning horizon. **TABLE 2.1** details the total annual revenue in years 2027, 2032, 2037, and 2042, as well as the 20-year cumulative total.

TABLE 2.1: HIDEOUT PROJECTED GENERAL FUND REVENUE

TOWN REVENUES	2027	2032	2037	2042	20-YEAR TOTAL
Property Tax	258,065	442,889	442,889	442,889	7,171,148
Sales Tax	193,055	289,277	308,241	328,448	5,053,863
Telecommunications Franchise Tax	1,568	2,791	3,082	3,403	47,898
Electric Franchise Tax	39,309	62,897	69,443	76,671	1,098,476
Natural Gas Franchise Tax	11,407	19,272	21,278	23,492	335,923
Class C Road Funds	39,038	82,687	97,986	116,190	1,445,707
Total Revenue	**$542,443**	**$899,812**	**$942,919**	**$991,093**	**$15,153,016**

PROPERTY TAX REVENUE

Property tax was calculated based on product type and absorption assumptions provided by the Developer, as well as comparable assessed values of similar developments. The tax rate used in this calculation is the Town's 2020 certified tax rate. LYRB assumed a constant tax rate and no appreciation based on the adjustments of the certified tax rate which was established to maintain budget neutrality. In the event the Town held a Truth-in-Taxation hearing, the projected property tax revenue would increase. This analysis assumes 75 percent of the "for sale" homes and all apartments are primary residences, and therefore, this percentage of units receives a 45 percent residential exemption. This calculation was estimated over the next 20 years to show the long-term property tax revenues the Development will bring to the Town. The assessed values have been calculated according to estimated absorption of the development. See the Technical Appendix for further detail related to the property tax calculations.

SALES TAX REVENUE

The sales tax distribution is calculated using historic sales tax per capita data and estimated brick and mortar sales for the retail component. The Richardson Flat annexation will include the only retail center within the town. As no historic values exist within the town to estimate sales per square foot, other communities within the region were used as comparables to develop a commercial sales per square foot value of $222 in 2023. Communities used to develop this estimate include: Salt Lake City, Morgan City, Morgan County, Kaysville, Highland, and South Jordan. As the Development includes a large commercial component, this analysis assumes a point of sales estimate which is based on the square footage of commercial space multiplied by the Time Indexed Sales per Square Foot. The sales tax revenue is conservative, and the type of retail provided may significantly increase the sales tax revenues.

Historic Hideout sales tax revenue was used to estimate the Development's per capita sales tax revenue from residents. These sales are mainly derived from online purchases. The 2015-2019 average annual growth rate (AAGR) in sales tax per capita in Hideout was 1.3% which increased sales tax revenue from $95.59 to $100.58. By applying the 1.3% AAGR to the per capita sales tax revenues, a 2023 per capita sales tax revenue of $105.82 was estimated and applied to the annexation area population. The per capita amount was grown by 1.3% each of the 20 years in the planning horizon multiplied by the estimated Development population according to the absorption schedule. The total sales tax revenue amount is the combination of the brick and mortar sales tax and the per capita component.

FRANCHISE TAX REVENUE

Cable and Telecommunication franchise taxes were calculated using an estimated usage based upon SF per year. The value was multiplied by the absorption schedule and the tax rate was then applied to determine the revenues per year. A two percent inflation factor is applied to these rates.

Electric energy tax revenues were calculated using residential energy usage per unit, per year. This value was multiplied by the number of units projected to develop each year. The total revenue is then multiplied by the local franchise tax rate of six percent to reach the total tax revenue generated by the Development annually. A two percent inflation factor is applied to these rates.

Natural gas tax revenues were calculated using residential gas usage estimates in the area per unit, per year. This value was multiplied by the number of units projected to develop each year. The total revenue is then multiplied by the local franchise tax rate of six percent to reach the total tax revenue generated by the Development annually. A two percent inflation factor is applied to these rates.

CLASS C ROAD FUND REVENUES

The Class C road funds are distributed by the Utah Department of Transportation based on a formula wherein 50 percent is distributed based on lane miles and 50 percent is distributed based on population. Lane miles are weighted depending on the road material. A weighting of five is applied to paved roads. The developer anticipates adding 4.31 mile of paved road to the Town. The resulting weighted lane mile equivalent is 21.55. The addition of paved miles is calculated incrementally following the absorption timing of the Development. The population component is estimated based on a per capita distribution applied to the new residents the development will bring. The Town's estimated people per household is 2.40. The development could produce a total of 1,440 new residents at buildout. The population component of the Class C road funds is calculated based on the incremental increase in population as the development occurs.

SECTION III: GENERAL FUND EXPENDITURES REQUIRED OF HIDEOUT

The Development will create a burden on the Town's general government, public works, parks, streets, and public safety services. In evaluating the benefits of development, it is important to ensure the costs do not outweigh the benefit. LYRB evaluated the costs associated with providing the aforementioned services through a variety of methodologies and calculations. Specifically, this section addresses the costs to provide the following services for the development:

- Public Works and Class C Roads
- General Government
- Parks
- Public Safety

The general fund expenditures of the Town related to the proposed Development are based on the current level of service provided to other developments within the Town. LYRB applied the current level of service to the proposed Development based on the number of new homes, commercial area, and the projected population of the Development to estimate the cost of servicing the Development over 20 years.

GENERAL FUND EXPENDITURES RELATED TO THE DEVELOPMENT

TABLE 3.1 below displays the annual expenditures at buildout for streets, Class C road expenditures, general government, parks, fire protection and law enforcement.

TABLE 3.1: TOWN GENERAL FUND EXPENDITURES RELATED TO MUNICIPAL SERVICES

TOWN EXPENSES	2027	2032	2037	2042	20-YEAR TOTAL
Class C Road Expenditures	55,098	89,096	98,369	108,607	1,555,427
General Government (Admin & Prof. Services)	187,762	303,617	335,218	370,107	5,300,535
Public Works	52,459	99,400	109,745	121,168	1,691,152
Parks	3,726	7,060	7,794	8,606	120,110
Public Safety (Fire & Police)	114,009	216,025	238,509	263,333	3,675,374
Total Expenses	**$413,054**	**$715,197**	**$789,635**	**$871,821**	**$12,342,598**

GENERAL GOVERNMENT (ADMINISTRATIVE & PROFESSIONAL SERVICES)

General Government costs are based on the Administrative and Professional Services costs associated with operating the Town. Professional Services which could be tied to building permit revenues were removed. These include: Building Inspection, Plan Prints, Building Plan Review, and Engineering DRC Review. The costs related to the annexation were estimated over 20 years using a per capita cost for services. The per capita amount was applied to the project Development absorption to determine the annual General Government expenses. An inflation factor of two percent is applied to the future years.

PUBLIC WORKS & CLASS C ROAD FUND EXPENDITURES

Public Works expenses were estimated over 20 years based on a historic cost per assessed value estimate. As new value is added through development absorption, the cost to provide services increases proportionally. An assumption that the new infrastructure will require less maintenance was used to apply a variable cost ratio of 30% to this amount. This assumes that increases in the Public Works budget due to the annexation will be based on $0.30 compared to the existing dollar ratio. The Class C road expenditures were left out of this calculation and were calculated separately as shown below. An inflation factor of two percent is applied to account for future year costs.

Class C road expenditures related to the Development were estimated over 20 years using incremental value and absorption from the proposed Development and applying the Class C road expenditure budget values from the previous year. The budget value, total weighted miles, and paved weighting within the Town were applied to provide an annual value for the roadway expenditures. LYRB used the existing cost per lane mile in the Town and multiplied this value by the additional weighted lane miles to be added by the Development to determine the annual Class C road expense. An inflation factor of two percent is applied to account for future year costs.

PARKS

Parks and Recreation costs related to the development were estimated over 20 years using incremental value and absorption from the proposed development and applied budget values from the previous year. A comparison between assessed value of the Town and its Parks was used to develop a cost per assessed value quantity. A variable to fixed costs ratio of 30% was applied to account for existing equipment and personnel that would not need to be duplicated for the annexation. Using the variable cost adjusted cost per assessed value, the Development's assessed value and absorption were used to estimate the Parks costs to the City. This accounts for the size of the Development in comparison with the Town. An inflation value of two percent is applied to account for future year costs.

PUBLIC SAFETY SERVICES

Public Safety services were associated with the assessed value at the recommendation of the fire chief. Per the fire chief, he anticipates that tying service costs to the assessed value will allow for level of service to be maintained for the Town and its annexation. The proposed police and fire station within the Development will be constructed by the Developer and will allow for quick response times within the entire town. An inflation value of two percent is applied to account for future year costs.

SECTION IV: PUBLIC INFRASTRUCTURE AND AMENITIES

PROPOSED INFRASTRUCTURE AND AMENITIES

The Developer will finance and construct a police and fire station, a town hall and community center, a mountain lift, trails, and 206 acres of open space that will provide benefit to the Development and the Town of Hideout. Property will also be provided for a future school. As part of the annexation, the public buildings proposed by the Developer are anticipated to bring access to local services closer to the area and offer public meeting spaces to residents of Hideout.

The trail system will provide pedestrian connections from the proposed retail to the neighborhood sections and Richardson Peak. The open space and trails are intended to be sized and programmed for general public use, and it is anticipated that they will be maintained by an HOA.

The mountain lift located in the town center and extending to Richardson Peak will provide access and viewing opportunities to guests and residents. The Town is currently reviewing whether this is an amenity they wish to own or have turned over to the HOA. Details on the expenses and revenues associated with the lift are not included this in this report. The total proposed Developer funded capital infrastructure and amenities have a significant value. Additional detail on associated acreage and building sizes are required to estimate their value.

SECTION V: HIDEOUT COST BENEFIT

TOWN'S GENERAL FUND COST-BENEFIT SUMMARY

Based on the development assumptions utilized in this analysis, the Richardson Flat Development produces a net benefit to Hideout annually with **$3.89 million** of cumulative net revenue projected over 20 years as illustrated in **TABLE 5.1**. The absorption and timing of the development will impact the current projections. The development may provide additional benefit to the Town through the public infrastructure and amenities considered in this analysis.

TABLE 5.1: HIDEOUT COST-BENEFIT

	2027	2032	2037	2042	20-YEAR TOTAL
Revenue					
Property Tax	261,191	448,465	448,465	448,465	7,262,087
Sales Tax	190,619	285,626	304,351	324,303	4,990,087
Electric Franchise Tax	38,538	61,664	68,082	75,168	1,076,937
Natural Gas Franchise Tax	11,407	19,272	21,278	23,492	335,923
Class C Road Funds	39,038	82,687	97,986	116,190	1,445,707
Total Revenue	**$540,793**	**$897,713**	**$940,162**	**$987,618**	**$15,110,741**
Expense					
Class C Road Expenditures	54,018	87,349	96,440	106,477	1,524,929
General Government (Admin & Prof. Services)	208,624	337,352	372,464	411,231	5,889,483
Parks	4,929	9,344	10,317	11,391	158,996
Public Safety (Fire & Police)	113,127	214,456	236,777	261,421	3,648,960
Total Expense	**$380,699**	**$648,501**	**$715,998**	**$790,519**	**$11,222,368**
Net Operating Revenue	**$160,095**	**$249,212**	**$224,164**	**$197,099**	**$3,888,373**

OTHER TAXING ENTITY BENEFITS

The annexation and development of Richardson Flat is anticipated to bring additional property tax revenue to all affiliated taxing entities over the 20 year planning horizon. **Table 5.2** provides details on the anticipated property taxes for each taxing entity based on 2020 property tax rates. The amounts shown in the table assume no inflation or changes in property tax rates. If tax rates remain constant, the Development will produce a combined cumulative $107 million in property tax for all taxing entities.

TABLE 5.2: PROPERTY TAX REVENUES FOR ALL TAXING ENTITIES

TOWN EXPENSES	2027	2032	2037	2042	20-YEAR TOTAL
Wasatch County	493,956	1,105,176	1,105,176	1,105,176	1,105,176
Wasatch County School District	1,947,937	4,358,310	4,358,310	4,358,310	4,358,310
Town of Hideout	197,948	442,889	442,889	442,889	442,889
Wasatch County Fire Protection SSD	162,290	363,107	363,107	363,107	363,107
Wasatch County SSD No 21	62,630	140,129	140,129	140,129	140,129
Central Utah Water Conservancy District	91,431	204,567	204,567	204,567	204,567
Total Expenses	2,956,192	6,614,177	$6,614,177	$6,614,177	107,095,217

ANNEXATION OF PROPOSED DEVELOPMENT OF BENEFIT TO HIDEOUT

Based on the proposed Development, including the type of development, densities, amenities and public infrastructure dedications that are envisioned to occur as part of the annexation, this Economic Impact and Sales Analysis concludes the Town's general fund will be enhanced by **$2.8 million** over the 20-year planning horizon. The Developer funded public infrastructure and amenities are of substantial benefit. Based on these calculations, LYRB is of the opinion the proposed Development, and its associated annexation, provides an overall net benefit to the Town. LYRB recommends and encourages the Town to assess the facts, circumstances and calculations presented herein throughout the proposed annexation process to ensure the Town receives the anticipated net benefits of the Development.

Often cities and local governments only evaluate the potential for new revenue to be derived by development or annexation. In this analysis, special attention to the costs of municipal services, demand on existing services, and personnel costs that are increased due to the Development were carefully analyzed and reviewed. Notwithstanding the additional municipal service costs, the Development does “pay for itself” and adds a “net” benefit to the Town.

In addition to the “net” fiscal benefit of the Development, the proposed annexation would provide additional benefits including: public infrastructure elements that enhance overall utilities, a retail center, trails, community buildings, and services and roof-tops that have disposable income to drive demand for goods and services.

Item 1.

APPENDIX A: GENERAL FUND REVENUE PROJECTIONS

A.1 PROPERTY TAX PROJECTIONS

Property Tax

Property Taxes		2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043
Total Apartment Property Values		-	5,245,320	5,245,320	5,245,320	5,245,320	5,245,320	5,245,320	5,245,320	5,245,320	5,245,320	5,245,320	5,245,320	5,245,320	5,245,320	5,245,320	5,245,320	5,245,320	5,245,320	5,245,320	5,245,320
Total Town Center Condo Property Values		-	-	14,007,585	27,709,400	27,709,400	42,129,758	55,780,423	55,780,423	55,780,423	55,780,423	55,780,423	55,780,423	55,780,423	55,780,423	55,780,423	55,780,423	55,780,423	55,780,423	55,780,423	55,780,423
Total Twinhome Property Values		-	20,459,088	20,459,088	20,459,088	20,459,088	24,004,857	34,746,667	34,746,667	34,746,667	34,746,667	34,746,667	34,746,667	34,746,667	34,746,667	34,746,667	34,746,667	34,746,667	34,746,667	34,746,667	34,746,667
Total SF Cottage Lot Property Values		-	6,696,042	16,223,164	21,024,038	21,024,038	27,119,815	28,758,170	38,253,130	38,253,130	38,253,130	38,253,130	38,253,130	38,253,130	38,253,130	38,253,130	38,253,130	38,253,130	38,253,130	38,253,130	38,253,130
Total Single Family Property Values		17,219,700	72,134,864	95,421,239	142,325,672	204,327,430	240,010,769	307,397,594	354,153,995	354,153,995	354,153,995	354,153,995	354,153,995	354,153,995	354,153,995	354,153,995	354,153,995	354,153,995	354,153,995	354,153,995	354,153,995
Total Assisted Living Property Values		-	-	-	-	7,417,702	7,417,702	7,417,702	7,417,702	7,417,702	7,417,702	7,417,702	7,417,702	7,417,702	7,417,702	7,417,702	7,417,702	7,417,702	7,417,702	7,417,702	7,417,702
Total Commercial Property Values		-	7,827,258	9,845,192	11,813,917	11,813,917	13,875,176	15,821,416	15,821,416	15,821,416	15,821,416	15,821,416	15,821,416	15,821,416	15,821,416	15,821,416	15,821,416	15,821,416	15,821,416	15,821,416	15,821,416
Total Net Assessed		**17,219,700**	**112,362,572**	**161,201,588**	**228,577,436**	**297,996,896**	**359,803,398**	**455,167,294**	**511,418,655**	**511,418,655**	**511,418,655**	**511,418,655**	**511,418,655**	**511,418,655**	**511,418,655**	**511,418,655**	**511,418,655**	**511,418,655**	**511,418,655**	**511,418,655**	**511,418,655**

INCREMENTAL TAX ANALYSIS:	*Payment Year*	**2024**	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043
	Tax Year	**2023**	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
Cumulative Taxable Value	Year	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20
Total Assessed Taxable Value of Project Area		17,219,700	112,362,572	161,201,588	228,577,436	297,996,896	359,803,398	455,167,294	511,418,655	511,418,655	511,418,655	511,418,655	511,418,655	511,418,655	511,418,655	511,418,655	511,418,655	511,418,655	511,418,655	511,418,655	511,418,655
Total Assessed Taxable Value of Project Area		**$17,219,700**	**$112,362,572**	**$161,201,588**	**$228,577,436**	**$297,996,896**	**$359,803,398**	**$455,167,294**	**$511,418,655**	**$511,418,655**	**$511,418,655**	**$511,418,655**	**$511,418,655**	**$511,418,655**	**$511,418,655**	**$511,418,655**	**$511,418,655**	**$511,418,655**	**$511,418,655**	**$511,418,655**	**$511,418,655**

TAX RATE & INCREMENT ANALYSIS:	2020 Rate																				
No Inflation	0.000866	14,912	97,306	139,601	197,948	258,065	311,590	394,175	442,889	442,889	442,889	442,889	442,889	442,889	442,889	442,889	442,889	442,889	442,889	442,889	442,889

Note: Property tax rates are constant, no inflation included.

Annual Property Taxes for all Taxing Entities Taxes		**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**
Wasatch County	0.002161	37,212	242,816	348,357	493,956	643,971	777,535	983,617	1,105,176	1,105,176	1,105,176	1,105,176	1,105,176	1,105,176	1,105,176	1,105,176	1,105,176	1,105,176	1,105,176	1,105,176	1,105,176
Wasatch County School District	0.008522	146,746	957,554	1,373,760	1,947,937	2,539,530	3,066,245	3,878,936	4,358,310	4,358,310	4,358,310	4,358,310	4,358,310	4,358,310	4,358,310	4,358,310	4,358,310	4,358,310	4,358,310	4,358,310	4,358,310
Town of Hideout	0.000866	14,912	97,306	139,601	197,948	258,065	311,590	394,175	442,889	442,889	442,889	442,889	442,889	442,889	442,889	442,889	442,889	442,889	442,889	442,889	442,889
Wasatch County Fire Protection Special Service District	0.000710	12,226	79,777	114,453	162,290	211,578	255,460	323,169	363,107	363,107	363,107	363,107	363,107	363,107	363,107	363,107	363,107	363,107	363,107	363,107	363,107
Wasatch County Special Service District No 21	0.000274	4,718	30,787	44,169	62,630	81,651	98,586	124,716	140,129	140,129	140,129	140,129	140,129	140,129	140,129	140,129	140,129	140,129	140,129	140,129	140,129
Central Utah Water Conservancy District	0.000400	6,888	44,945	64,481	91,431	119,199	143,921	182,067	204,567	204,567	204,567	204,567	204,567	204,567	204,567	204,567	204,567	204,567	204,567	204,567	204,567

Note: Property tax rates are constant, no inflation included.

A.2 SALES TAX PROJECTIONS

Sales Tax

ASSUMPTIONS:	Retail
Commercial Sales per SF	$ 209
Commercial	95,000
Total Commercial Square Feet	**95,000**
Additional Assumptions	
Sales Tax Growth	1.28%
Commercial Vacancy	0.00%
Discount Rate	4.00%
New Sales to City	100.00%
HOUSING ASSUMPTIONS:	
Household Size:	2.4
Housing Units	600
Current Population	1,196
Municipal Sales Tax Rate	0.50%

	2019 Sales Tax Received	2019 Total Commercial SF	Taxable Commercial Sales CY2019	2019 Commercial Sales per SF
Salt Lake City		19,423,384	$3,893,081,124	$ 200.43
Morgan City		334,188	62,581,156	$ 187.26
Morgan County		600,954	81,011,362	$ 134.80
Kaysville		980,026	261,748,105	$ 267.08
Highland				$ 200.00
South Jordan		5,192,257	1,365,074,988	$ 262.91

Source (SF): LYRB
Source (Commercial Sales): Table 8 https://tax.utah.gov/econstats/sales

Sales Tax Growth Rate

Long Term AAGR	9.6%	11.0%	1.3%
Sales Tax Revenues	**Population**	**Hideout Sales Tax Revenue**	**Per Capita**
2019	996	100,174	100.58
2018	1,123	100,994	89.93
2017	833	80,234	96.32
2016	847	68,061	80.36
2015	691	66,056	95.59
2014	536	61,391	114.54
2013	401	59,562	148.53
2012	288	55,117	191.38
2011	190	60745	319.71
2010	247	55848	226.11

SALES TAX GENERATED BY BRICK & MORTAR HIDEOUT ANNEXATION SALES

Time Indexed Sales ($)/SF	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Commercial Sales per SF	222	225	228	231	234	237	240	243	246	249
Brick & Mortar Taxable Sales Generated	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**
Commercial	-	10,700,611	13,611,738	16,507,722	16,718,700	19,814,481	22,804,229	23,095,680	23,390,856	23,689,804
Brick & Mortar Commercial Taxable Sales	-	**10,700,611**	**13,611,738**	**16,507,722**	**16,718,700**	**19,814,481**	**22,804,229**	**23,095,680**	**23,390,856**	**23,689,804**

Time Indexed Sales ($)/SF	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
Commercial Sales per SF	253	256	259	262	266	269	273	276	280	283
Brick & Mortar Taxable Sales Generated	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**
Commercial	23,992,574	24,299,213	24,609,771	24,924,298	25,242,844	25,565,463	25,892,204	26,223,121	26,558,268	26,897,698
Brick & Mortar Commercial Taxable Sales	**23,992,574**	**24,299,213**	**24,609,771**	**24,924,298**	**25,242,844**	**25,565,463**	**25,892,204**	**26,223,121**	**26,558,268**	**26,897,698**

SALES TAX GENERATED BY HIDEOUT ANNEXATION RESIDENTS (ONLINE & UTILITIES)

Growth Assumptions	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Sales Tax Growth	1.3%	1.3%	1.3%	1.3%	1.3%	1.3%	1.3%	1.3%	1.3%	1.3%
Sales Tax per Capita	105.82	107.17	108.54	109.93	111.33	112.75	114.20	115.66	117.13	118.63
Sales Tax Summary	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**
Hideout Annexation (Estimated) Population	23	447	605	768	983	1,147	1,339	1,440	1,440	1,440
Online & Utility Sales Tax from Annexation Residents	2,382	47,937	65,682	84,413	109,462	129,293	152,876	166,543	168,672	170,828
Total Sales Tax Generated by Residents	2,382	47,937	65,682	84,413	109,462	129,293	152,876	166,543	168,672	170,828

Growth Assumptions	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
Sales Tax Growth	1.3%	1.3%	1.3%	1.3%	1.3%	1.3%	1.3%	1.3%	1.3%	1.3%
Sales Tax per Capita	120.15	121.68	123.24	124.81	126.41	128.02	129.66	131.32	132.99	134.69
Sales Tax Summary	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**
Hideout Annexation (Estimated) Population	1,440	1,440	1,440	1,440	1,440	1,440	1,440	1,440	1,440	1,440
Online & Utility Sales Tax from Annexation Residents	173,011	175,222	177,461	179,729	182,027	184,353	186,709	189,095	191,512	193,960
Total Sales Tax Generated by Residents	173,011	175,222	177,461	179,729	182,027	184,353	186,709	189,095	191,512	193,960

Sales Tax Summary	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Brick & Mortar Town Sales Tax Generated	-	53,503	68,059	82,539	83,593	99,072	114,021	115,478	116,954	118,449
Online & Utility Sales Tax Generated	2,382	47,937	65,682	84,413	109,462	129,293	152,876	166,543	168,672	170,828
Total Sales Tax Generation	**2,382**	**101,441**	**133,741**	**166,951**	**193,055**	**228,365**	**266,897**	**282,022**	**285,626**	**289,277**

Sales Tax Summary	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
Brick & Mortar Town Sales Tax Generated	119,963	121,496	123,049	124,621	126,214	127,827	129,461	131,116	132,791	134,488
Online & Utility Sales Tax Generated	173,011	175,222	177,461	179,729	182,027	184,353	186,709	189,095	191,512	193,960
Total Sales Tax Generation	**292,974**	**296,718**	**300,510**	**304,351**	**308,241**	**312,180**	**316,170**	**320,211**	**324,303**	**328,448**

A.3 FRANCHISE TAX PROJECTIONS

Telecommunications	Unit	Cost per SF	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043
Apartments	Per Sq. Ft.	0.0234	$0	$1,672	$1,705	$1,739	$1,774	$1,810	$1,846	$1,883	$1,920	$1,959	$1,998	$2,038	$2,079	$2,120	$2,163	$2,206	$2,250	$2,295	$2,341	$2,388	$2,436
Town Center Condos	Per Sq. Ft.	0.0234	$0	$0	$1,005	$2,018	$2,059	$3,166	$4,250	$4,335	$4,421	$4,510	$4,600	$4,692	$4,786	$4,882	$4,979	$5,079	$5,180	$5,284	$5,390	$5,498	$5,607
Twinhomes	Per Sq. Ft.	0.0234	$0	$1,631	$1,664	$1,697	$1,731	$2,060	$3,002	$3,062	$3,123	$3,186	$3,249	$3,314	$3,381	$3,448	$3,517	$3,588	$3,659	$3,733	$3,807	$3,883	$3,961
SF Cottage Lots	Per Sq. Ft.	0.0234	$0	$538	$1,323	$1,745	$1,780	$2,329	$2,516	$3,386	$3,453	$3,522	$3,593	$3,665	$3,738	$3,813	$3,889	$3,967	$4,046	$4,127	$4,209	$4,294	$4,380
Single Family Lots	Per Sq. Ft.	0.0234	$1,199	$5,095	$6,860	$10,389	$15,138	$18,088	$23,512	$27,540	$28,091	$28,652	$29,225	$29,810	$30,406	$31,014	$31,635	$32,267	$32,913	$33,571	$34,242	$34,927	$35,626
Assisted Living	Per Sq. Ft.	0.0234	$0	$0	$0	$0	$1,845	$1,882	$1,920	$1,958	$1,997	$2,037	$2,078	$2,119	$2,162	$2,205	$2,249	$2,294	$2,340	$2,387	$2,435	$2,483	$2,533
Retail/Commercial (NET)	Per Sq. Ft.	0.0234	$0	$1,134	$1,453	$1,775	$1,811	$2,161	$2,505	$2,555	$2,606	$2,658	$2,712	$2,766	$2,821	$2,877	$2,935	$2,994	$3,054	$3,115	$3,177	$3,241	$3,305
Total Telecommunications			$1,199	$10,070	$14,011	$19,364	$26,138	$31,497	$39,550	$44,718	$45,612	$46,525	$47,455	$48,404	$49,372	$50,360	$51,367	$52,394	$53,442	$54,511	$55,601	$56,713	$57,848
Tax Revenue			**$72**	**$604**	**$841**	**$1,162**	**$1,568**	**$1,890**	**$2,373**	**$2,683**	**$2,737**	**$2,791**	**$2,847**	**$2,904**	**$2,962**	**$3,022**	**$3,082**	**$3,144**	**$3,207**	**$3,271**	**$3,336**	**$3,403**	**$3,471**

Assumptions	2020
Inflation	2.00%
Cost per SF	0.0234
Telecommunications Tax Rate	6.00%
SF Estimates	
Apartments	70,000
Town Center Condos	161,167
Twinhomes	113,847
SF Cottage Lots	125,875
Single Family Lots	1,023,936
Assisted Living	72,800
Retail/Commercial (NET)	95,000

Current Telecom Tax Revenues: **$1,955**

Electricity Tax Revenue	Unit	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043
Residential Lots	Per Unit	$13,148	$213,452	$299,794	$392,992	$450,662	$550,401	$673,691	$755,126	$770,229	$785,633	$801,346	$817,373	$833,720	$850,395	$867,403	$884,751	$902,446	$920,494	$938,904	$957,682	$976,836
Assisted Living	Per Sq. Ft.	-	-	-	-	$103,209	$105,273	$107,379	$109,526	$111,717	$113,951	$116,230	$118,555	$120,926	$123,344	$125,811	$128,328	$130,894	$133,512	$136,182	$138,906	$141,684
Commercial	Per Sq. Ft.	-	$63,457	$81,296	$99,295	$101,281	$120,891	$140,123	$142,926	$145,784	$148,700	$151,674	$154,708	$157,802	$160,958	$164,177	$167,460	$170,810	$174,226	$177,710	$181,265	$184,890
Total Revenue		**$13,148**	**$276,909**	**$381,090**	**$492,288**	**$655,153**	**$776,565**	**$921,193**	**$1,007,578**	**$1,027,730**	**$1,048,284**	**$1,069,250**	**$1,090,635**	**$1,112,448**	**$1,134,697**	**$1,157,391**	**$1,180,539**	**$1,204,149**	**$1,228,232**	**$1,252,797**	**$1,277,853**	**$976,836**
Tax Revenue		**$789**	**$16,615**	**$22,865**	**$29,537**	**$39,309**	**$46,594**	**$55,272**	**$60,455**	**$61,664**	**$62,897**	**$64,155**	**$65,438**	**$66,747**	**$68,082**	**$69,443**	**$70,832**	**$72,249**	**$73,694**	**$75,168**	**$76,671**	**$58,610**

	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043
Residential Electric Usage Per Unit Per Year	$ 1,095.64	$ 1,117.55	$ 1,139.90	$ 1,162.70	$ 1,185.95	$ 1,209.67	$ 1,233.87	$ 1,258.54	$ 1,283.71	$ 1,309.39	$ 1,335.58	$ 1,362.29	$ 1,389.53	$ 1,417.32	$ 1,445.67	$ 1,474.58	$ 1,504.08	$ 1,534.16	$ 1,564.84	$ 1,596.14	$ 1,628.06
Non-Residential Electric Energy Usage per SF per Year	$ 1.31	$ 1.34	$ 1.36	$ 1.39	$ 1.42	$ 1.45	$ 1.47	$ 1.50	$ 1.53	$ 1.57	$ 1.60	$ 1.63	$ 1.66	$ 1.69	$ 1.73	$ 1.76	$ 1.80	$ 1.83	$ 1.87	$ 1.91	$ 1.95

ASSUMPTIONS:	2019
Inflation (CPI)	2.00%
Franchise Tax Rate	6.00%
Discount Rate	4.00%

Natural Gas Tax Revenue	Unit	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043
Residential Lots	Per Unit	$4,896	$79,487	$111,639	$146,345	$167,820	$204,962	$250,873	$281,198	$286,822	$292,559	$298,410	$304,378	$310,466	$316,675	$323,008	$329,469	$336,058	$342,779	$349,635	$356,627	$363,760
Assisted Living		-	-	-	-	$11,253	$11,478	$11,707	$11,942	$12,180	$12,424	$12,672	$12,926	$13,184	$13,448	$13,717	$13,991	$14,271	$14,557	$14,848	$15,145	$15,448
Non-Residential		-	$6,919	$8,864	$10,826	$11,043	$13,181	$15,278	$15,583	$15,895	$16,213	$16,537	$16,868	$17,205	$17,549	$17,900	$18,258	$18,623	$18,996	$19,376	$19,763	$20,158
Total		**$4,896**	**$86,405**	**$120,503**	**$157,171**	**$190,116**	**$229,620**	**$277,858**	**$308,723**	**$314,897**	**$321,195**	**$327,619**	**$334,172**	**$340,855**	**$347,672**	**$354,626**	**$361,718**	**$368,952**	**$376,331**	**$383,858**	**$391,535**	**$399,366**
Tax Revenue		**$294**	**$5,184**	**$7,230**	**$9,430**	**$11,407**	**$13,777**	**$16,671**	**$18,523**	**$18,894**	**$19,272**	**$19,657**	**$20,050**	**$20,451**	**$20,860**	**$21,278**	**$21,703**	**$22,137**	**$22,580**	**$23,031**	**$23,492**	**$23,962**

	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043
Residential NG Per Unit Per Year	$ 408.00	$ 416.16	$ 424.48	$ 432.97	$ 441.63	$ 450.46	$ 459.47	$ 468.66	$ 478.04	$ 487.60	$ 497.35	$ 507.30	$ 517.44	$ 527.79	$ 538.35	$ 549.11	$ 560.10	$ 571.30	$ 582.72	$ 594.38	$ 606.27
Non-Residential NG per SF per Year	$ 0.14	$ 0.15	$ 0.15	$ 0.15	$ 0.15	$ 0.16	$ 0.16	$ 0.16	$ 0.17	$ 0.17	$ 0.17	$ 0.18	$ 0.18	$ 0.18	$ 0.19	$ 0.19	$ 0.20	$ 0.20	$ 0.20	$ 0.21	$ 0.21

ASSUMPTIONS:	2019
Inflation (CPI)	2.00%
Franchise Tax Rate	6.00%
Discount Rate	4.00%

Residential Average Electricity per/SF per Year
$ 1.21

Source: Rocky Mountain Power: Energy Usage Calculator - Conservative assumptions used to calculate

Average Yearly Gas Use per/SF
$ 0.14

An average from multiple sources, rounded down

Item 1.

A.4 CLASS C ROAD REVENUE

Class B & C Roads

Total Weighted Lane Miles 21.55

Based on Statewide Distribution

	2015	2016	2017	2018	2019	2020	AAGR	Projected 2023	2024	2025	2026	2027	2028
Total Distribution Pool	131,136,765	146,685,044	171,689,820	169,543,658	179,188,729	177,562,815	6.25%	188,659,002	200,448,608	212,974,965	226,284,115	240,424,974	255,449,519
Lane Miles Pool	65,568,382	73,342,522	85,844,910	84,771,829	89,594,365	88,781,407	6.25%	94,329,501	100,224,304	106,487,483	113,142,057	120,212,487	127,724,760
Statewide Weighted Miles	111,760	121,109	121,540	122,540	121,813	122,842	1.91%	125,187	127,576	130,012	132,494	135,023	137,600
Distribution Per Weighted Mile	587	606	706	692	736	723		754	786	819	854	890	928
Estimated Annexed Area Weighted Miles								0	7	9	11	15	17
Lane Mile Distribution	-	-	-	-	-	-		254	5,259	7,418	9,813	13,100	15,929
Lane Miles Pool	65,568,382	73,342,522	85,844,910	84,771,829	89,594,365	88,781,407		94,329,501	100,224,304	106,487,483	113,142,057	120,212,487	127,724,760
State Population	2,817,222					3,270,729	3.03%	3,326,920	3,384,056	3,441,769	3,500,064	3,558,948	3,618,426
Distribution Per Capita	23					27		28	30	31	32	34	35
Hideout Annexation (Estimated) Population								-	23	447	605	768	983
Land * per Capita	-					-		-	667	13,839	19,562	25,938	34,706
Total Distribution	-	-	-	-	-	-		254	5,925	21,257	29,375	39,038	50,634

	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
Total Distribution Pool	271,412,972	288,374,008	306,394,965	325,542,081	345,885,732	367,500,690	390,466,401	414,867,278	440,793,004	468,338,871	497,606,123	528,702,333	561,741,796	596,845,948
Lane Miles Pool	135,706,486	144,187,004	153,197,483	162,771,041	172,942,866	183,750,345	195,233,201	207,433,639	220,396,502	234,169,435	248,803,062	264,351,167	280,870,898	298,422,974
Statewide Weighted Miles	140,227	142,904	145,632	148,412	151,245	154,132	157,074	160,072	163,128	166,242	169,415	172,649	175,945	179,304
Distribution Per Weighted Mile	968	1,009	1,052	1,097	1,143	1,192	1,243	1,296	1,351	1,409	1,469	1,531	1,596	1,664
Estimated Annexed Area Weighted Miles	20	22	22	22	22	22	22	22	22	22	22	22	22	22
Lane Mile Distribution	19,389	21,744	22,670	23,635	24,642	25,691	26,785	27,926	29,115	30,355	31,648	32,996	34,401	35,867
Lane Miles Pool	135,706,486	144,187,004	153,197,483	162,771,041	172,942,866	183,750,345	195,233,201	207,433,639	220,396,502	234,169,435	248,803,062	264,351,167	280,870,898	298,422,974
State Population	3,678,506	3,739,193	3,852,499	3,969,239	4,089,517	4,213,439	4,341,116	4,472,662	4,608,194	4,747,833	4,891,704	5,039,934	5,192,656	5,350,006
Distribution Per Capita	37	39	40	41	42	44	45	46	48	49	51	52	54	56
Hideout Annexation (Estimated) Population	1,147	1,339	1,440	1,440	1,440	1,440	1,440	1,440	1,440	1,440	1,440	1,440	1,440	1,440
Land * per Capita	42,303	51,623	57,263	59,052	60,897	62,799	64,761	66,784	68,871	71,023	73,242	75,530	77,890	80,323
Total Distribution	61,691	73,366	79,932	82,687	85,538	88,490	91,547	94,711	97,986	101,378	104,890	108,526	112,291	116,190

APPENDIX B: GENERAL FUND EXPENDITURES

B.1: GENERAL GOVERNMENT EXPENSE PROJECTIONS

Hideout Annexation
Increment and Budget Analysis
Appendix: Town Expenditures

	General Government	Total Assessed Value	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Method 2	Annexation Population		23	447	605	768	983	1,147	1,339	1,440	1,440	1,440
	Per Capita Cost	$170	$176	$180	$184	$187	$191	$195	$199	$203	$207	$211
per capita	**Total**		**$3,971**	**$80,494**	**$111,076**	**$143,770**	**$187,762**	**$223,359**	**$265,983**	**$291,827**	**$297,664**	**$303,617**

	General Government	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043
Method 2	Annexation Population	1,440	1,440	1,440	1,440	1,440	1,440	1,440	1,440	1,440	1,440	1,440
	Per Capita Cost	$215	$219	$224	$228	$233	$237	$242	$247	$252	$257	$262
per capita	**Total**	**$309,689**	**$315,883**	**$322,201**	**$328,645**	**$335,218**	**$341,922**	**$348,761**	**$355,736**	**$362,850**	**$370,107**	**$377,510**

ASSUMPTIONS:		2021
Cost per $ Assessed (2020)	$	0.00200
Inflation (CCI)		2.0%
Assessed Value (2020) [1]		135,109,852
General Government Budget Expenditures (2020) [2]		270,365
Variable to Fixed Cost Ratio		**75%**
Discount Rate		4.00%

<Removed development/building permit categories (Plan Prints & Building Review, Building Inspections)

	Population	Gen. Gov't	Per Capita
Hideout	1,196	270,365.00	226.10
Annexation Area Fixed to Variable Adjusted per Cap			169.57

Note 1: Source, Utah State Tax Commission , 2020 Certified Tax Rate, (https://taxrates.utah.gov/RateDetail2017.aspx)
Note 2: Source, Utah State Auditors Office - Town of Hideout 2021 Budget

B.2 PUBLIC SAFETY EXPENSE PROJECTIONS

	Public Safety	Total Assessed Value	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Per Assessed Value	Total New Taxable Value		$17,219,700	$112,362,572	$161,201,588	$228,577,436	$297,996,896	$359,803,398	$455,167,294	$511,418,655	$511,418,655	$511,418,655
	Fire		1,312.73	8,737.16	12,785.51	18,491.94	24,590.14	30,284.10	39,076.94	44,784.35	45,680.04	46,593.64
	Police		4,773.55	31,771.50	46,492.78	67,243.41	89,418.68	110,123.99	142,097.98	162,852.19	166,109	169,431
	Total		**$6,086**	**$40,509**	**$59,278**	**$85,735**	**$114,009**	**$140,408**	**$181,175**	**$207,637**	**$211,789**	**$216,025**

	Public Safety	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043
Per Assessed Value	Total New Taxable Value	$511,418,655	$511,418,655	$511,418,655	$511,418,655	$511,418,655	$511,418,655	$511,418,655	$511,418,655	$511,418,655	$511,418,655	$511,418,655
	Fire	47,525.51	48,476.02	49,445.54	50,434.45	51,443.14	52,472.01	53,521.45	54,591.87	55,683.71	56,797.39	57,933.33
	Police	172,820	176,276	179,802	183,398	187,066	190,807	194,623	198,516	202,486	206,536	210,667
	Total	**$220,346**	**$224,752**	**$229,248**	**$233,832**	**$238,509**	**$243,279**	**$248,145**	**$253,108**	**$258,170**	**$263,333**	**$268,600**

ASSUMPTIONS:		2021
Police Cost per $ Assessed (2021)	$	0.00030
Fire Cost per $ Assessed (2021)	$	0.00008
Inflation (CCI)		2.0%
Assessed Value (2020) 1		135,109,852
Fire Budget Expenditures (2021) [2]		11,000
Police Budget Expenditures		40,000
Total Public Safety Expenditures		11,000
Variable to Fixed Cost Ratio		**90%**
Discount Rate		4.00%

Note 1: Source, Utah State Tax Commission , 2020 Certified Tax Rate, (https://taxrates.utah.gov/RateDetail2017.aspx)
Note 2: Source, Utah State Auditors Office - Town of Hideout 2021 Budget
Note 3: Method recommendation from Chief Giles, Fire Department

B.3 FIRE PROTECTION EXPENSE SERVICES

Method 1	Streets/Public Works	Total Assessed Value	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
	Annexation Area		$2,800	$18,639	$27,276	$39,449	$52,459	$64,606	$83,364	$95,540	$97,451	$99,400
Assessed Value Method	**Total**		**$2,800**	**$18,639**	**$27,276**	**$39,449**	**$52,459**	**$64,606**	**$83,364**	**$95,540**	**$97,451**	**$99,400**

Method 1	Streets/Public Works	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043
	Annexation Area	$101,388	$103,416	$105,484	$107,594	$109,745	$111,940	$114,179	$116,463	$118,792	$121,168	$123,591
Assessed Value Method	**Total**	**$101,388**	**$103,416**	**$105,484**	**$107,594**	**$109,745**	**$111,940**	**$114,179**	**$116,463**	**$118,792**	**$121,168**	**$123,591**

ASSUMPTIONS:		2021
Cost per $ Assessed (2021)	$	0.00052
Inflation (CCI)		2.0%
Assessed Value (2020) 1		135,109,852
Streets Budget Expenditures (2021) [2]		70,400
Variable to Fixed Cost Ratio		**30%**
Discount Rate		4.00%

Streets lass C Revenue		Public Works Portion
148400	78,000	70,400

	2021	Buildout	Difference
Hideout Population:	1,196	5,520	4,324
Buildout Annexation Pop.		1,440	
Public Works $ per capita	17.66		
Annexation PpC		25,434	

Note 1: Source, Utah State Tax Commission , 2020 Certified Tax Rate, (https://taxrates.utah.gov/RateDetail2017.aspx)
Note 2: Source, Utah State Auditors Office - Town of Hideout 2021 Budget

B.4 PARKS EXPENSES

Method 1	Parks	Total Assessed Value	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
	Annexation Area		$17,219,700	$112,362,572	$161,201,588	$228,577,436	$297,996,896	$359,803,398	$455,167,294	$511,418,655	$511,418,655	$511,418,655
	Total		$199	$1,324	$1,937	$2,802	$3,726	$4,588	$5,921	$6,786	$6,921	$7,060
Assessed Value Method	**Total**		**$199**	**$1,324**	**$1,937**	**$2,802**	**$3,726**	**$4,588**	**$5,921**	**$6,786**	**$6,921**	**$7,060**

Method 1	Parks	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043
	Annexation Area	$511,418,655	$511,418,655	$511,418,655	$511,418,655	$511,418,655	$511,418,655	$511,418,655	$511,418,655	$511,418,655	$511,418,655	$511,418,655
	Total	$7,201	$7,345	$7,492	$7,642	$7,794	$7,950	$8,109	$8,271	$8,437	$8,606	$8,778
Assessed Value Method	**Total**	**$7,201**	**$7,345**	**$7,492**	**$7,642**	**$7,794**	**$7,950**	**$8,109**	**$8,271**	**$8,437**	**$8,606**	**$8,778**

ASSUMPTIONS:	2021
Cost per $ Assessed (2021)	$ 0.00004
Inflation (CCI)	2.0%
Assessed Value (2020) 1	135,109,852
Parks & Rec Expenditure	5,000
Variable to Fixed Cost Ratio	**30%**
Discount Rate	4.00%

	2021	Buildout	Difference
Hideout Population:	1,196	5,520	4,324
Buildout Annexation Pop.		1,440	
Park $ per capita	1.25		
Annexation PpC		1,806	

Note 2: Source, Utah State Auditors Office - Town of Hideout 2021 Budget

B.5 CLASS C ROAD EXPENSES

Hideout Road Expense

Annual

2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
	1,165	23,621	32,595	42,189	55,098	65,544	78,052	85,636	87,349	89,096	90,877	92,695	94,549	96,440	98,369	100,336	102,343	104,390	106,477	108,607

Year	2021	
Streets Expenditure in budget	148,400	
Total Weighted Miles	44.63	
Cost per Existing Lane Mile	3,325	
Additional Weighted Lane Miles	21.55	TRUE
Road Expense	71,656	
Inflation	2.00%	

Hideout Total Acres	2,230
Total Weighted Miles per A	0.02
Annexed Area	
Weighted Miles	**21.55**

County	City/Town	Last Update	Paved Surface	Gravel Surface	Dirt Surface	Total Actual Miles	Total Weighted Miles	
Wasatch	Hideout	Mar-21	8.31	1.33	0.21	9.85	**44.63**	**EXISTING**
Wasatch	Hideout		4.31	0.00	0.00	4.31	**21.55**	**ANNEXATION**

USPS	GEOID	ANSICODE	NAME	LSAD	FUNCSTAT	ALAND	AWATER	ALAND_SQM	AWATER_SQM	INTPTLAT	INTPTLONG	Land Acres
UT	4935120	2519168	Hideout Town	43	A	9022907	1497777	**3.484**	0.578	40.643904	-111.401396	**2,230**

Source: 2020 Hideout Acres: https://www2.census.gov/geo/docs/maps-data/data/gazetteer/2020_Gazetteer/

APPENDIX C: SUMMARY OF NET FISCAL BENEFIT/COST ANALYSIS

C.1 SUMMARY OF NET FISCAL BENEFIT/COST ANALYSIS

Hideout Annexation

Net Benefit

Key Assumptions	
Sales Tax Growth	1.3%
Inflation	2.0%
Discount Rate	4.0%
2021 Hideout Population	1,196
Average Household Size	2.40

City Services

TY	Projected																					
General Fund Revenue	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**Totals**	**NPV**
Property Tax (Hideout)	14,912	97,306	139,601	197,948	258,065	311,590	394,175	442,889	442,889	442,889	442,889	442,889	442,889	442,889	442,889	442,889	442,889	442,889	442,889	442,889	7,171,148	4,516,279
Sales & Use	2,382	101,441	133,741	166,951	193,055	228,365	266,897	282,022	285,626	289,277	292,974	296,718	300,510	304,351	308,241	312,180	316,170	320,211	324,303	328,448	5,053,863	3,195,743
Telecommunications & Cable (Franchise)	72	604	841	1,162	1,568	1,890	2,373	2,683	2,737	2,791	2,847	2,904	2,962	3,022	3,082	3,144	3,207	3,271	3,336	3,403	47,898	29,698
Electric (Franchise)	789	16,615	22,865	29,537	39,309	46,594	55,272	60,455	61,664	62,897	64,155	65,438	66,747	68,082	69,443	70,832	72,249	73,694	75,168	76,671	1,098,476	685,283
Natural Gas (Franchise)	294	5,184	7,230	9,430	11,407	13,777	16,671	18,523	18,894	19,272	19,657	20,050	20,451	20,860	21,278	21,703	22,137	22,580	23,031	23,492	335,923	209,513
Class C Road Revenues	254	5,925	21,257	29,375	39,038	50,634	61,691	73,366	79,932	82,687	85,538	88,490	91,547	94,711	97,986	101,378	104,890	108,526	112,291	116,190	1,445,707	877,129
Total Revenue	**18,702**	**227,075**	**325,535**	**434,404**	**542,443**	**652,850**	**797,080**	**879,937**	**891,741**	**899,812**	**908,060**	**916,490**	**925,106**	**933,914**	**942,919**	**952,126**	**961,541**	**971,170**	**981,018**	**991,093**	**15,153,016**	**9,513,644**
General Fund Expense	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**Totals**	**NPV**
Class C Road Expenditures	1,165	23,621	32,595	42,189	55,098	65,544	78,052	85,636	87,349	89,096	90,877	92,695	94,549	96,440	98,369	100,336	102,343	104,390	106,477	108,607	1,555,427	970,303
General Government (Admin & Prof. Services)	3,971	80,494	111,076	143,770	187,762	223,359	265,983	291,827	297,664	303,617	309,689	315,883	322,201	328,645	335,218	341,922	348,761	355,736	362,850	370,107	5,300,535	3,306,568
Public Works	2,800	18,639	27,276	39,449	52,459	64,606	83,364	95,540	97,451	99,400	101,388	103,416	105,484	107,594	109,745	111,940	114,179	116,463	118,792	121,168	1,691,152	1,045,279
Parks	199	1,324	1,937	2,802	3,726	4,588	5,921	6,786	6,921	7,060	7,201	7,345	7,492	7,642	7,794	7,950	8,109	8,271	8,437	8,606	120,110	74,239
Public Safety (Fire & Police)	6,086	40,509	59,278	85,735	114,009	140,408	181,175	207,637	211,789	216,025	220,346	224,752	229,248	233,832	238,509	243,279	248,145	253,108	258,170	263,333	3,675,374	2,271,700
Total Expense	**14,221**	**164,587**	**232,163**	**313,945**	**413,054**	**498,505**	**614,495**	**687,425**	**701,174**	**715,197**	**729,501**	**744,091**	**758,973**	**774,152**	**789,635**	**805,428**	**821,537**	**837,967**	**854,727**	**871,821**	**12,342,598**	**7,668,089**
Revenues minus Expenditures	**4,481**	**62,488**	**93,372**	**120,459**	**129,389**	**154,345**	**182,585**	**192,512**	**190,568**	**184,615**	**178,559**	**172,399**	**166,133**	**159,762**	**153,283**	**146,698**	**140,005**	**133,203**	**126,292**	**119,271**	**2,810,417**	**1,845,556**
Net Benefit	4,481	62,488	93,372	120,459	129,389	154,345	182,585	192,512	190,568	184,615	178,559	172,399	166,133	159,762	153,283	146,698	140,005	133,203	126,292	119,271	2,810,417	1,845,556

APPENDIX D: ESTIMATED ABSORPTION OF DEVELOPMENT

D.1 ANNUAL PERCENTAGE, CUMULATIVE, AND ANNUAL SF ABSORPTION

Absorption																				
TY	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20
Annual Absorption %	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
Apartments	0%	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Town Center Condos	0%	0%	26%	25%	0%	26%	24%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Twinhomes	0%	60%	0%	0%	0%	10%	30%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
SF Cottage Lots	0%	18%	25%	13%	0%	16%	4%	24%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Single Family Lots	5%	16%	7%	13%	18%	10%	19%	13%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Assisted Living	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Retail/Commercial (NET)	0%	50%	13%	12%	0%	13%	12%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Absorption																				
	TY																			
Cumulative Absorption %	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
Apartments	0%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Town Center Condos	0%	0%	26%	50%	50%	76%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Twinhomes	0%	60%	60%	60%	60%	70%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
SF Cottage Lots	0%	18%	43%	56%	56%	72%	76%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Single Family Lots	5%	21%	28%	41%	58%	68%	87%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Assisted Living	0%	0%	0%	0%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Retail/Commercial (NET)	0%	50%	63%	75%	75%	88%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Absorption																				
	TY																			
Annual Absorption SF	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
Apartments	-	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Town Center Condos	-	-	32	31	-	32	30	-	-	-	-	-	-	-	-	-	-	-	-	-
Twinhomes	-	24	-	-	-	4	12	-	-	-	-	-	-	-	-	-	-	-	-	-
SF Cottage Lots	-	17	24	12	-	15	4	23	-	-	-	-	-	-	-	-	-	-	-	-
Single Family Lots	12	38	16	32	42	24	45	31	-	-	-	-	-	-	-	-	-	-	-	-
Assisted Living	-	-	-	-	73	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Retail/Commercial (NET)	-	48	12	12	-	12	11	-	-	-	-	-	-	-	-	-	-	-	-	-
Annual Total	12	227	84	87	115	87	102	54	-	-	-	-	-	-	-	-	-	-	-	-
Cumulative Total	12	239	323	409	524	611	714	768	768	768	768	768	768	768	768	768	768	768	768	768
Percentage Total	2%	31%	42%	53%	68%	80%	93%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Table 1
Draft Soil Sample Analytical Summary
Parcel SS-86
Summit County, Utah
Priviledged and Confidential

Lab Sample ID		L1339512-01		L1339512-15		L1339512-02		L1339512-03		L1339512-04		L1339512-05		L1339512-06		L1339512-16		USEPA Residential RSL for Soil[1]
Client Sample ID		SS-01		SS-01 (Duplicate)		SS-02		SS-03		SS-04		SS-05		SS-06		SS-06 (Duplicate)[b]		
Date Collected		04/13/2021		04/13/2021		04/13/2021		04/13/2021		04/13/2021		04/13/2021		04/13/2021		04/13/2021		
Analyte	Units	Result	Qualifier	Result	Qualifier	Result	Qualifier	Result	Qualifier	Result	Qualifier	Result	Qualifier	Result	Qualifier	Result	Qualifier	
ALUMINUM	mg/kg	18700		20600		23500		24100		17900		23700		26300	O1 V	27200		77000
ANTIMONY	mg/kg	<2.41		0.941	J	2.06	J	<2.52		0.956	J	3.07		<2.43	J6	<2.46		31
ARSENIC	mg/kg	7.87		7.85		13.1		5.78		7.78		14.0		8.38		8.02		0.68
BARIUM	mg/kg	188		195		257		256		289		234		311		293		15000
CADMIUM	mg/kg	0.612		0.588	J	2.17		0.312	J	0.930		3.05		0.910		0.876		71
CHROMIUM	mg/kg	31.9		32.8		22.3		20.9		16.9		24.5		30.6		31.0		NS
COPPER	mg/kg	22.6		24.5		43.6		25.5		31.9		40.0		37.3		36.4		3100
LEAD	mg/kg	80.0		76.2		237		40.9		90.6		301		184	J5	161		400
NICKEL	mg/kg	13.3		13.9		14.7		15.4		14.9		18.0		20.8		21		1500
SELENIUM	mg/kg	1.24	J	<2.42		<2.83		<2.52		1.41	J	<2.35		<2.43		<2.46		390
SILVER	mg/kg	0.273	J	0.302	J	0.933	J	<1.26		0.406	J	1.60		0.421	J	0.398	J	390
ZINC	mg/kg	132		140		330		80.3		126		475		168		170		23000
MERCURY	mg/kg	0.0488		0.057		0.142		0.0494	J	0.085		0.255		0.0695		0.0727		11

Lab Sample ID		L1339512-07		L1339512-08		L1339512-09		L1339512-10		L1339512-11		L1339512-12		L1339512-13		L1339512-14		USEPA Residential RSL for Soil[1]
Client Sample ID		SS-07		SS-08		SS-09		SS-10		SS-11		SS-12		SS-13		SS-14		
Date Collected		04/13/2021		04/13/2021		04/13/2021		04/13/2021		04/13/2021		04/13/2021		04/13/2021		04/13/2021		
Analyte	Units	Result	Qualifier	Result	Qualifier	Result	Qualifier	Result	Qualifier	Result	Qualifier	Result	Qualifier	Result	Qualifier	Result	Qualifier	
ALUMINUM	mg/kg	21700		24300		21100		23100		24400		30000		27400		21600		77000
ANTIMONY	mg/kg	1.26	J	<3.06		<2.26		0.676	J	<2.64		<2.44		<2.36		0.891	J	31
ARSENIC	mg/kg	9.32		9.74		5.50		8.87		9.25		6.05		5.91		9.71		0.68
BARIUM	mg/kg	296		357		213		248		290		268		271		285		15000
CADMIUM	mg/kg	1.42		1.55		0.488	J	0.844		1.35		0.307	J	0.345	J	1.71		71
CHROMIUM	mg/kg	20.4		18.8		20.0		17.5		19.5		21.6		21.0		18.2		NS
COPPER	mg/kg	42.0		40.2		29.4		37.3		44.7		26.4		33.3		50.9		3100
LEAD	mg/kg	153		139		42.6		98.7		125		24.4		28.1		211		400
NICKEL	mg/kg	15.4		14.8		19.0		17.7		17		19.8		20.6		18.6		1500
SELENIUM	mg/kg	<3.00		<3.06		<2.26		0.96	J	<2.64		1.05	J	<2.36		<2.11		390
SILVER	mg/kg	0.725	J	0.676	J	<1.13		0.664	J	0.442	J	<1.22		<1.18		1.50		390
ZINC	mg/kg	208		193		96.2		133		193		74.1		76.8		221		23000
MERCURY	mg/kg	0.122		0.11		0.166		0.0966		0.092		<0.0488		0.0283	J	0.146		11

Notes:
[1]USEPA RSL for residential soil dated, November 2020
[a]Duplicate collected from location SS-01. Sample labled SS-44
[b]Duplicate collected from location SS-06. Sample labled SS-66
Concentrations in red exceed RSL
NS = No Standard
RSL = Regional Screening Level

Qualifiers:
J :The identification of the analyte is acceptable; the reported value is an estimate.
O1 :The analyte failed the method required serial dilution test and/or subsequent post-spike criteria. These failures indicate matrix interference.
V :The sample concentration is too high to evaluate accurate spike recoveries.
J6 :The sample matrix interfered with the ability to make any accurate determination; spike value is low.
J5 :The sample matrix interfered with the ability to make any accurate determination; spike value is high.

Item 1.

Table 2
Draft Surface Water Analytical Summary
Parcel SS-86
Summit County, Utah
Priviledged and Confidential

Lab Sample ID		L1339512-17		L1339512-19		L1339512-18		Utah Numeric Surface Water Criteria[1]	Utah Human Health Surface Water Consumption Criteria[2]
Client Sample ID		SW-01		SW-01 (Duplicate)[a]		SW-02			
Date Collected		04/13/2021		04/13/2021		04/13/2021			
Analyte	Units	Result	Qualifier	Result	Qualifier	Result	Qualifier		
ALUMINUM	mg/l	0.0593	J	0.0562	J	0.0690	J	NS	NS
ANTIMONY	mg/l	<0.0100		<0.0100		0.00762	J	NS	0.0056
ARSENIC	mg/l	<0.0100		<0.0100		0.0178		0.01	0.01
BARIUM	mg/l	0.101		0.109		0.124	O1	1.0	NS
CADMIUM	mg/l	<0.00200		<0.00200		<0.00200		0.01	NS
CHROMIUM	mg/l	<0.0100		<0.0100		<0.0100		0.05	NS
COPPER	mg/l	0.00395	J	0.00790	J	<0.0100		NS	1.3
LEAD	mg/l	<0.00600		<0.00600		<0.00600		0.015	NS
NICKEL	mg/l	<0.0100		0.00186	J	<0.0100		NS	0.61
SELENIUM	mg/l	<0.0100		<0.0100		<0.0100		0.05	0.17
SILVER	mg/l	<0.00500		<0.00500		<0.00500		0.05	NS
ZINC	mg/l	<0.0500		<0.0500		0.0188	J	NS	7.4
MERCURY	mg/l	<0.000200		<0.000200		<0.000200		0.002	0.002

Notes:
[1]Numeric Surface Water Criteria for Domestic, Recreation and Agricultural Uses, R317-2-14, Table 2.14.1. Criteria based on Class 1C water
[2]Numeric Human Health Criteria for Consumption, R317-2-14, Table 2.14.6. Criteria based on Class 1C water.
[a]Duplicate sample collected from location SW-01. Sample labled SW-11
All concentrations are dissolved metals
Concentrations in red exceed relevant water quality criteria
NS = No Standard

Qualifiers:
J :The identification of the analyte is acceptable; the reported value is an estimate.
O1 :The analyte failed the method required serial dilution test and/or subsequent post-spike criteria. These failures indicate matrix interference.

Table 3
Draft Groundwater Analytical Summary
Parcel SS-86
Summit County, Utah
Priviledged and Confidential

Lab Sample ID		L1339512-20		L1339512-21		L1339512-22		Utah Groundwater Quality Standard[1]	USEPA RSL for Tapwater[2]
Client Sample ID		SB-01		SB-02		SB-02 (Duplicate)[a]			
Date Collected		04/13/2021		04/13/2021		04/13/2021			
Analyte	Units	Result	Qualifier	Result	Qualifier	Result	Qualifier		
ALUMINUM	mg/l	<0.200		<0.200		<0.200		NS	20
ANTIMONY	mg/l	<0.0100		<0.0100		<0.0100		0.006	-
ARSENIC	mg/l	<0.0100		0.00583	B J	0.00742	B J	0.05	-
BARIUM	mg/l	0.127		0.144		0.151		2.0	-
CADMIUM	mg/l	<0.00200		<0.00200		<0.00200		0.005	-
CHROMIUM	mg/l	0.00195	J	<0.0100		<0.0100		0.1	-
COPPER	mg/l	<0.0100		<0.0100		<0.0100		1.3	-
LEAD	mg/l	<0.00600		<0.00600		<0.00600		0.015	-
NICKEL	mg/l	0.00261	J	<0.0100		<0.0100		NS	NS
SELENIUM	mg/l	<0.0100		0.0121		<0.0100		0.05	-
SILVER	mg/l	<0.00500		<0.00500		<0.00500		0.1	-
ZINC	mg/l	<0.0500		<0.0500		<0.0500		5.0	-
MERCURY	mg/l	<0.000200		<0.000200		<0.000200		0.002	-

Notes:
[1]Utah Groundwater Quality Standard, R317-6-2, Table 1
[2]USEPA RSL for tapwater ingestion. For metals that do not have established Utah Groundwater Qaulity Standard, USEPA RSL for tapwater applied.
[a]Duplicate sample collected from location SB-02. Sample labled SB-12
All concentrations are dissolved metals
NS = No Standard
RSL = Regional Screening Level

Qualifiers:
J :The identification of the analyte is acceptable; the reported value is an estimate.
O1 :The analyte failed the method required serial dilution test and/or subsequent post-spike criteria. These failures indicate matrix interference.
B :The same analyte is found in the associated blank.

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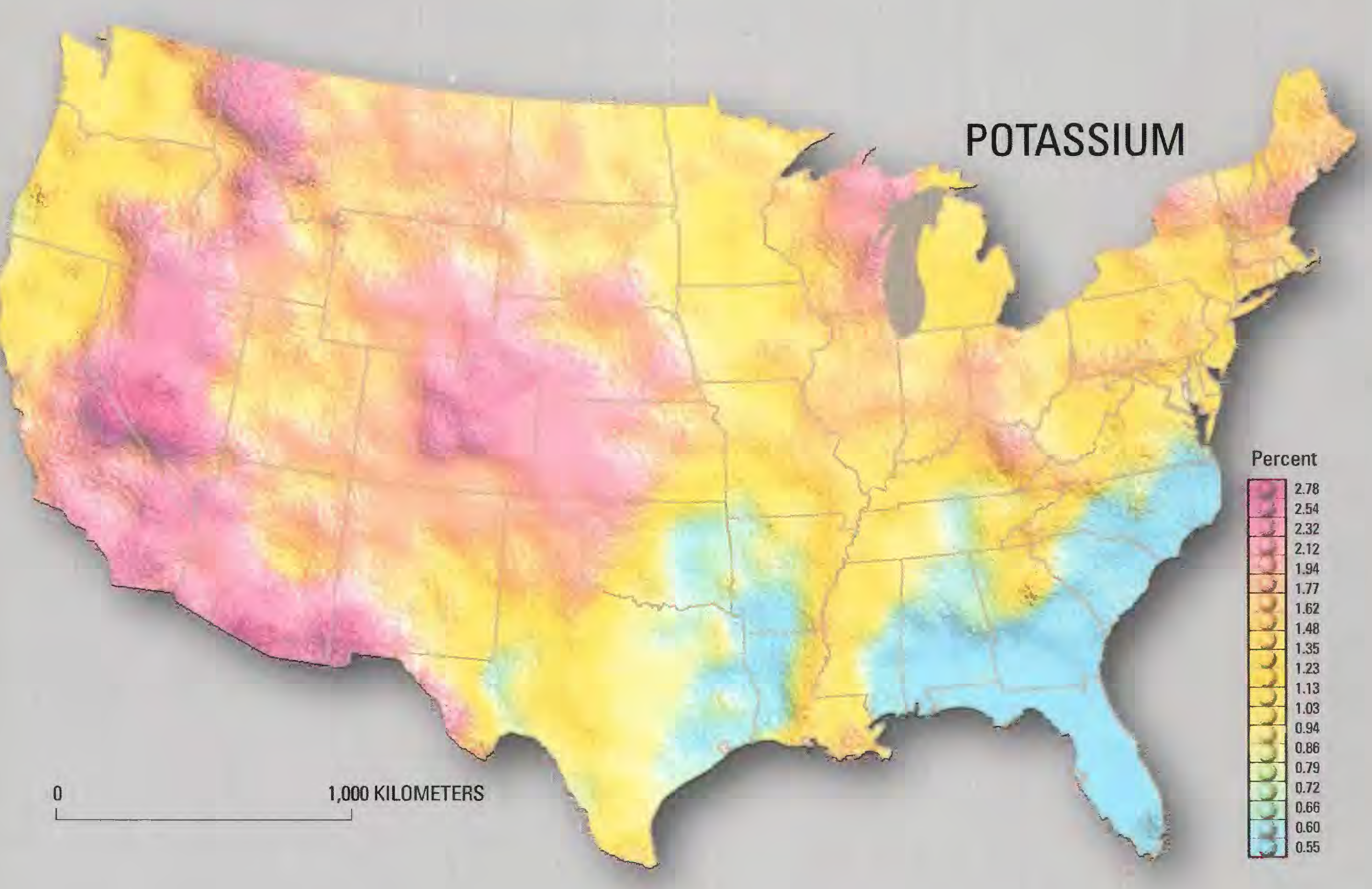
Item 1.

Geochemical Landscapes of the Conterminous United States—New Map Presentations for 22 Elements

U.S. Geological Survey Professional Paper 1648



U.S. Department of the Interior
U.S. Geological Survey

Cover.—Geochemical map showing the distribution of potassium in the conterminous United States. The map is based on chemical analyses of 1,323 samples of soils and other surficial materials as reported in Boerngen and Shacklette (1981).

Geochemical Landscapes of the Conterminous United States— New Map Presentations for 22 Elements

By N. Gustavsson, B. Bølviken, D.B. Smith, *and* R.C. Severson

U.S. Geological Survey Professional Paper 1648

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Geochemical Landscapes of the Conterminous United States—New Map Presentations for 22 Elements

By N. Gustavsson,[1] B. Bølviken,[2] D.B. Smith,[3] *and* R.C. Severson[3]

Abstract

Shacklette and Boerngen (1984) collected soil and other regolith samples from 1,323 sites in the conterminous United States (7,840,000 km^2) and prepared single-element point-symbol geochemical maps in black and white for 7 major and 39 trace elements. We have reprocessed these data, using weighted-median and Bootstrap procedures for interpolation and smoothing, and produced full-color maps for seven major elements (Al, Ca, Fe, K, Mg, Na, and Ti) and 15 trace elements (As, Ba, Cr, Cu, Hg, Li, Mn, Ni, Pb, Se, Sr, V, Y, Zn, and Zr). Comparison of the K map produced in this manner with a corresponding map obtained from airborne radiometric measurements of ^{40}K indicates that the reliability of the soil maps is good even with this ultra low sample density.

Many broad geochemical dispersion patterns for both major and trace elements have been delineated. Some of these agree with known geologic and physiographic features, whereas others seem to reflect variations in natural parameters such as soil type and climate. Certain patterns may be due to pollution, and others are difficult to interpret in view of the present knowledge.

It is concluded that geochemical maps based on ultra low density sample distributions, such as those presented in this publication, should have potential use in various fields. This type of map may be used to (1) establish general baselines against which more specific natural geochemical variations and human-induced perturbations can be appraised, (2) reflect large underlying geologic features and therefore delineate geochemical provinces of interest in exploration for mineral resources, (3) show how geochemical patterns in the regolith are influenced by natural features such as soil type, climate, and vegetation, (4) provide a basis for research within the field of geomedicine (environmental geochemistry and health), and (5) show large geochemical contrasts between continents.

[1] Geological Survey of Finland.

[2] Geological Survey of Norway.

[3] U.S. Geological Survey.

Introduction

In their paper "Element concentrations in soils and other surficial materials of the conterminous United States," Shacklette and Boerngen (1984) published a number of geochemical point-symbol maps (Howarth, 1983) covering the conterminous United States. The maps were based on chemical analyses of 1,323 samples of soils or other regolith materials collected, primarily, along the network of existing roads. At that time, such a low sampling density was not considered adequate to generate reproducible results. Furthermore, the maps produced by Shacklette and Boerngen were not very illustrative. These are probably the two main reasons why the maps did not receive proper attention during the 1980's. Recent geochemical mapping has, however, shown that significant broad geochemical distribution patterns with distinct contrasts between subareas exist in many places, even at continental scale (Duval, 1990; Xie and Ren, 1993), and that these patterns may be recognized based on one sample per 1/1000 of the area studied (e.g., Bølviken and others, 1992; Eden and Björklund, 1994). It was in this context that the importance of the Shacklette and Boerngen data set was recognized during the early stages of the International Geological Correlation Program's Project 259/360 (International Geochemical Mapping) (Darnley and others, 1995). The data set was, at that time, and still is at the time of this publication, the only national geochemical data set for the conterminous United States that was generated according to consistent and standardized sampling and analytical protocols. As such, it presents an opportunity to obtain a first approximation of the geochemical landscape for this large area of the Earth's surface. We have, therefore, drawn new maps of Shacklette and Boerngen's data using modern computerized techniques and find the disclosed geochemical patterns so interesting that a republication of the maps is justified.

Sample Collection

This summary of sampling and chemical analysis is based on the papers by Shacklette and others (1971), Boerngen and Shacklette (1981), and Shacklette and Boerngen (1984).

The sampling was done by U.S. Geological Survey (USGS) personnel at sampling stations located along their routes of travel to project areas and within project areas in various parts of the United States. The location of the stations, therefore, depended on both the road network and the destination of the samplers. The sample stations were selected approximately every 80 km along the roads, which resulted in a total of 1,323 stations, corresponding to an average of one sample station per 6,000 km^2 for the conterminous United States. (It should be noted that there is some discrepancy in the number of samples in the above references. Although Shacklette and Boerngen (1984) state 1,318 samples were collected, seven of the geochemical maps (Ba, B, Cr, Pb, V, Y, and Zr) in that publication show 1,319 samples were plotted. In addition, Boerngen and Shacklette (1981), in their tabulation of all the data generated in the study, show 1,323 samples. The current study used this data set of 1,323 samples as the basis for all the new maps shown in figures 3–24.) In most cases the stations were located at least 100 m from the road and at sites that had natural surficial materials supporting native plant growth. Occasionally, the distance to the road had to be reduced for practical reasons, and, in some areas, only cultivated fields were available for sampling.

The samples were collected in two phases during 1961–71 and 1971–75 resulting in 962 and 356 samples, respectively (fig. 1). (Based on the above-referenced publications, we found it impossible to fully reconcile the samples between the two phases of sample collection. Therefore, figure 1 distinguishes those samples we could unambiguously identify as phase-1 and phase-2 samples from those whose placement was uncertain.) One sample was collected at each selected station. The materials sampled included that part of the regolith that normally is defined as "soil" by soil scientists. About 0.25 L of soil was taken at a depth of 20 cm below the surface, which is normally in the B horizon of podzols or just below the plow zone in cultivated soils. The samples were packed in metal-free paper envelopes and shipped to the USGS laboratories in Denver, Colo., where they were oven-dried, pulverized if necessary, and sieved to a minus-2-mm fraction. This fraction was further milled to minus 200 mesh (<75 µm) before analysis.

Chemical Analysis

Boerngen and Shacklette (1981) report analytical values for 46 elements analyzed by a variety of methods. Table 1 shows the analytical methods used to analyze the 22 elements discussed in this study. For some elements, the methods of chemical analysis were consistent throughout the duration of the project, whereas, for others, the methods were different in phase 1 and phase 2 (table 1). The use of different methods in phases 1 and 2 may complicate the interpretation of the data generated because the accuracy and precision may vary between phases. This type of problem will be discussed in more detail in the section on reliability of the maps.

Each of the analytical methods described in Boerngen and Shacklette (1981) and Shacklette and Boerngen (1984) gives the total contents of the element determined. Therefore, reported values from the different methods can be directly compared for each element. Similar analytical methods were used for a reconnaissance geochemical survey of the State of Missouri conducted by the USGS during 1969–73 (Conner and others, 1972; Tidball, 1974, 1976; Miesch, 1976). After testing the sampling and analytical reproducibility in this survey, Miesch (1976) concluded that the sampling errors were more significant than the analytical errors and that the application of more precise analytical methods would have been a waste of money. The Missouri geochemical survey included 7,000 samples taken within 180,000 km^2 as opposed to 1,300 samples from 8,000,000 km^2 in the survey reported here. This much lower sampling density, with a corresponding greater sampling error, indicates that the reproducibility of the analytical results reported by Shacklette and Boerngen (1984) is adequate even between sample-collection phases.

The data were censored by both lower and upper limits of determination (Shacklette and Boerngen, 1984). Fortunately, even though the analytical techniques changed for a few elements during the project (table 1), the determination limits remained constant. Table 2 summarizes the determination limits, the number of samples with censored values, the number of samples not analyzed for a given element, and the number of analyses plotted to generate the geochemical maps (figs. 3–24).

Data Treatment and Map Presentation

The Geological Survey of Finland produced the maps from data obtained from the USGS National Geochemical Database. The software employed has also been used for generating maps in national and international geochemical atlases (Koljonen and others, 1992; Lahermo and others, 1990; Gustavsson and others, 1994, 1995; Lahermo and others, 1996).

Among available presentation techniques, we chose color surface maps (Gustavsson and others, 1997) to show regional-scale trends in element content. Color surface maps are generated from gridded data. Each grid node corresponds to a pixel, which is assigned a color depending on the local interpolated and smoothed concentration level. A basic problem in producing color surface maps is that the measurements tend to be irregularly located in the mapped area, whereas the pixels

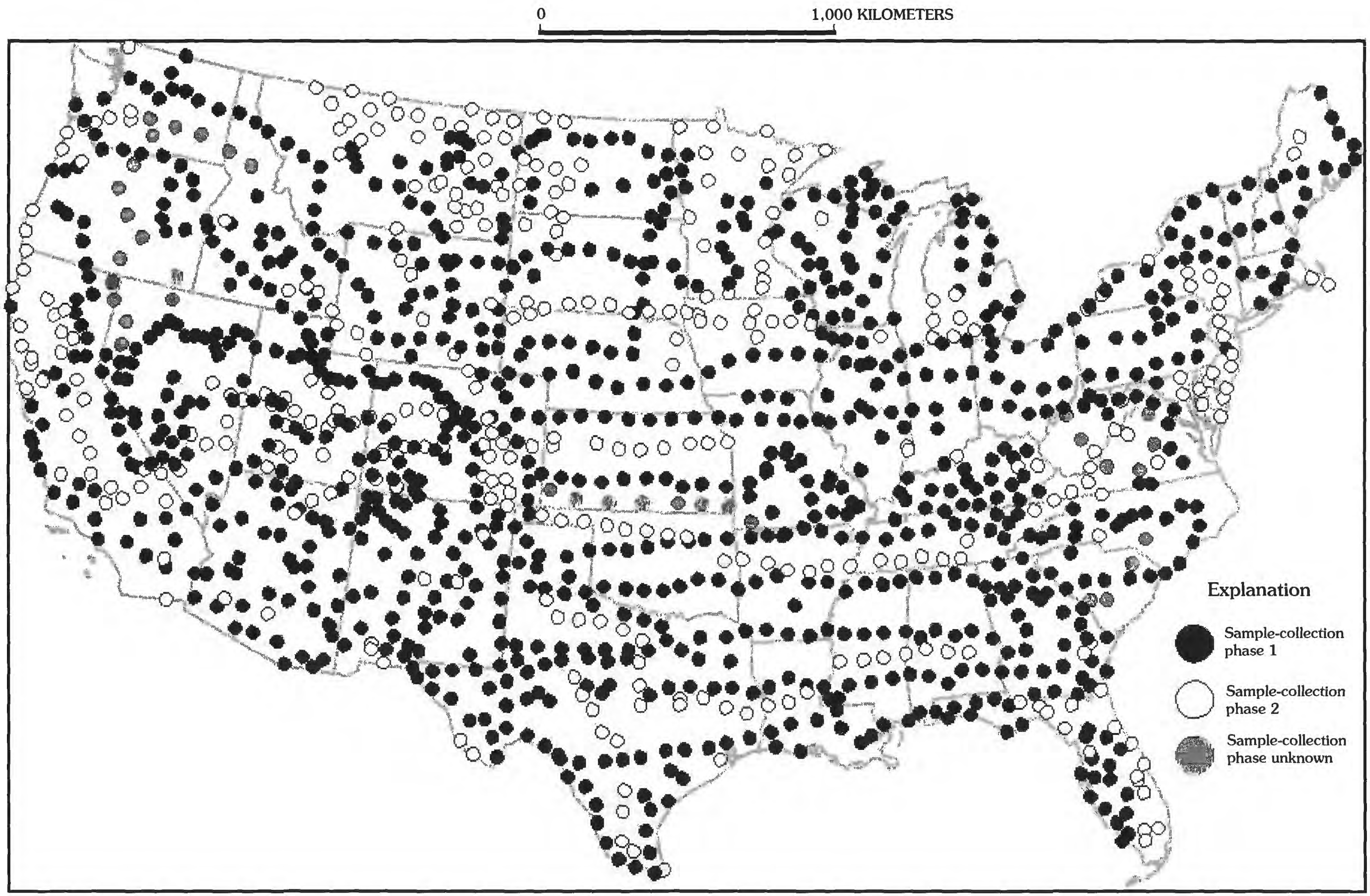

Figure 1. Map showing geochemical sample stations. Black dots indicate samples from sample-collection phase 1, white dots indicate samples from sample-collection phase 2, gray dots indicate samples whose placement into phase 1 or phase 2 is uncertain.

Table 1. Methods of chemical analysis for selected elements in soil samples.

[References are in footnotes]

Element		Method of analysis	
		Sample-collection phase 1 (962 samples)	Sample-collection phase 2 (356 samples)
1	Al	Emission spectrography[1]	Emission spectrography
2	As	Arsine evolution-spectrophotometric-isotope dilution[2]	Arsine evolution-spectrophotometric-isotope dilution
3	Ba	Emission spectrography	Emission spectrography
4	Ca	EDTA titration	X-ray fluorescence spectrometry[3]
5	Cr	Emission spectrography	Emission spectrography
6	Cu	Emission spectrography	Emission spectrography
7	Fe	Emission spectrography	X-ray fluorescence spectrometry
8	Hg	Flame and flameless atomic absorption[4]	Flame and flameless atomic absorption[4]
9	K	Flame photometry[5]	X-ray fluorescence spectrometry
10	Li	Emission spectrography	Flame atomic absorption
11	Mg	Emission spectrography	Flame atomic absorption
12	Mn	Emission spectrography	Emission spectrography
13	Na	Emission spectrography	Flame atomic absorption
14	Ni	Emission spectrography	Emission spectrography
15	Pb	Emission spectrography	Emission spectrography
16	Se	X-ray fluorescence spectrometry	X-ray fluorescence spectrometry
17	Sr	Emission spectrography	Emission spectrography
18	Ti	Emission spectrography	X-ray fluorescence spectrometry
19	V	Emission spectrography	Emission spectrography
20	Y	Emission spectrography	Emission spectrography
21	Zn	Colorimetry[5]	Flame atomic absorption
22	Zr	Emission spectrography	Emission spectrography

[1] Myers and others (1961); Neiman (1976).
[2] Huffman and Dinnin (1979).
[3] Wahlberg (1976).
[4] Huffman and Dinnin (1976).
[5] Ward and others (1963).

form a regular grid. For decades, interpolation and smoothing techniques have been employed to compute "best" and least misleading surfaces from values on an irregular grid. Many of these techniques work well for evenly distributed data points, but difficulties may arise when the data set is sparse. Stable results for sparse data sets typically require more smoothing, which leads to fewer details. We chose Bootstrap estimates (Efron and Tibshirani, 1991; Stuart and Ord, 1987) of the moving weighted median (Björklund and Lummaa, 1983) to achieve robustness against local outliers.

Moving Weighted Median

Calculation of the moving weighted median to interpolate a continuous "surface" from scattered point data involves computing, for each grid cell, the median of distance-weighted observation values found within a circle of radius R from the center of the cell. Assume a circular window centered at a pixel and containing n observed sampling points with measured values x_i. The values are sorted in ascending order. For odd n, the ordinary *unweighted moving median* is then $x_{(n+1)/2}$, and, for even n, a value between $x_{n/2}$ and $x_{n/2+1}$ is computed by linear interpolation (Stuart and Ord, 1987). The unweighted moving median does not depend on the spatial position of the sampling points. Every sampling point carrying a value is at a distance d_i from the window center. Given a weight function W, the corresponding weight of value x_i at distance d_i is $w_i = W(d_i)$. Now, the frequencies f_i (equal to $1/n$) of x_i are adjusted by the weights yielding new weighted frequencies g_i by

Table 2. Summary information on chemical analysis of the 22 elements plotted as geochemical maps in figures 3–24.

Element	Concentration units	Detection limit	Upper determination limit	Number of samples missing analysis	Number of samples with analysis below detection limit	Number of samples with analysis above upper determination limit	Number of samples plotted
Al	%	0.07	10	76	0	136	1,247
As	ppm	0.01		66	8		1,257
Ba	ppm	10		4	0		1,319
Ca	%	0.01		32	0		1,291
Cr	ppm	1.0		4	0		1,319
Cu	ppm	1.0		12	10		1,311
Fe	%	0.01	10	6	0	2	1,317
Hg	ppm	0.01		56	4		1,267
K	%	0.01		9	0		1,314
Li	ppm	5.0		65	48		1,258
Mg	%	0.005	10	17	0	1	1,306
Mn	ppm	2.0		6	3		1,317
Na	%	0.05		130	86		1,193
Ni	ppm	5.0		5	128		1,318
Pb	ppm	10		4	185		1,319
Se	ppm	0.1		56	228		1,267
Sr	ppm	5.0		5	39		1,318
Ti	%	0.007		6	0		1,317
V	ppm	7.0		4	25		1,319
Y	ppm	10		4	83		1,319
Zn	ppm	5.0		75	9		1,248
Zr	ppm	20		4	3		1,319

$$g_i = f_i w_i \ / \sum_{i=1}^{n} w_i \qquad (1)$$

where,

the distance weights are rescaled to sum up to unity. The corresponding cumulative frequencies, $G(x_k)$, are expressed by

$$G(x_k) = \sum_{i=1}^{k} g_i \quad , k = 1,..., n \qquad (2)$$

The *moving weighted median* is finally obtained by linear interpolation between x_k and x_{k+1} where x_k is the greatest observed value with $G(x_k) \leq 0.5$. A bell-shaped function known as the Butterworth's function was here used for the distance-dependent weights

$$w = \frac{1}{1 \ (d/d_0)^{2m}} \qquad (3)$$

where,

d ($0 \leq d \leq R$) is the distance to the window center,

d_0 (> 0) is a value indicating the distance at which the weight is halved, and

m is the order effecting the steepness of the curve (Gonzales and Winz, 1987).

Finally w is adjusted by a term depending on R to achieve 0 at the window periphery. A large d_0 smears out details, whereas a small d_0 preserves them. A minimum number of samples in the window was also used.

The particular Butterworth function used for the maps is shown in figure 2 and the corresponding parameter values are given in table 3. The parameter values are chosen by experience according to the scale of the map and the sampling density. The pixel size was chosen as 5×5 km to yield a sufficiently smooth surface.

Bootstrap Estimate

A procedure termed "Bootstrap" (Efron and Tibshirani, 1991; Stuart and Ord, 1987) was used to estimate the average of repeated moving weighed medians within the window. A statistical sample of n items was repeatedly drawn from the values within the window one value at a time with replacement (i.e., the same geochemical value may appear several times in the statistical sample). For the statistical sample drawn, the weighted median based on n values was computed. This was repeated a number of times (k), and the arithmetic mean of the k weighted medians was computed. When drawing the

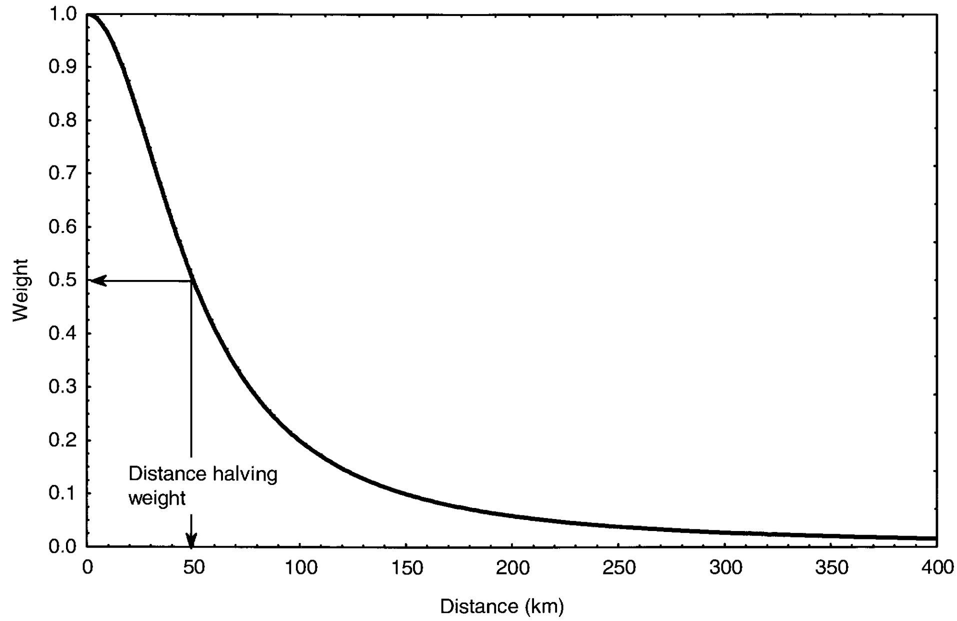

Figure 2. Curve representing the local weight function (Butterworth's) depending on the distance of the sampling station to the center of a circular window.

k statistical samples at random, every geochemical sampling point has the same probability to be included. Because of the replacement, the most common values (several geochemical sampling points may have the same value) occur very often, whereas outliers are rarely included. Bootstrap estimates in overlapping interpolation windows yield less uncertainty than ordinary methods without repeated sampling. Furthermore, the sampling variance (variance between the statistical samples) can be estimated and shown on a map.

The sampling variance of the estimate can also be emphasized by "illuminating" the color surface to create the effect of shaded relief. Then the variation between neighboring pixels is shown as a grainy texture. The more uneven the surface, the more local variation is present in the data. The illuminated map shows not only the concentration level but also the local variation, which may reveal important regional geochemical features in the data (Gustavsson, 1995).

Color Scheme

The interpolated grid values (pixel values) are presented on a scale with 20 colors ranging from cyan (lowest 10 percent of values) to magenta (highest 1 percent of values). The color scale is tied at two percentiles of the empirical cumulative frequency curve of gridded values. The color-class intervals were derived by slicing the interval between these percentiles into equal-length slices on a logarithmic scale. When the analytical detection limit exceeded the lower percentile, the percentile was replaced by the detection limit.

The surface was illuminated by directed and ambient light in a lighting model presented by Strauss (1990). The resulting shaded-relief maps highlight subtle features, which may not be revealed on ordinary color maps. Shaded-relief maps are commonly produced by image-processing systems and by custom-written programs for geochemistry (Björklund and Gustavsson, 1987; Davenport and others, 1991).

To comprehensively show all possible effects due to relief shading of colors in the legend, each class is portrayed on an illuminated horizontal rectangle with a bubble (or hemisphere). All possible slopes on the map are represented on the surface of the bubble, and the reflection pattern shows where the directed light comes from.

The ambient light and a directed light source were located in the northeast and 30 degrees from the zenith. The maps were plotted in Albers Equal Area projection with standard parallels at lat 29°30′N. and 45°30′N. and the origin at lat 23°N. and long 96°W. (Snyder, 1987). The software for interpolation and plotting was written at the Geological Survey of Finland except for basic graphical and statistical procedures, which were invoked from the UNIRAS FGL/GRAPHICS™ library and the IMSL STAT/LIBRARY™, respectively.

Table 3. Parameter settings for computing regular grid using Bootstrap estimates of the moving weighted median.

Subject	Parameter	Used value	Remarks
Grid	Pixel size (km × km)	5 × 5	
	Number of pixels	580 × 920	total pixels 533,600
Weighted median	R, window radius (km)	400	Average number of points in window is 63
	N_{min}, the minimum number of points in the window	3	
	d_0, halving distance of weights (km)	50	Average number of points in window within d_0 is 2
	m, order of weight function affecting steepness	1	
Bootstrap	Sample size at resampling	average 63	Same as the number of values in window
	Number of repeated samples in window	30	Constant

Table 4. Quartiles and relative quartile deviations of interpolated and smoothed data for each element.

	Element (unit)	First quartile Q_1 (25 %)	Second quartile Q_2 (50 %)	Third quartile Q_3 (75 %)	Relative quartile deviation $(Q_3–Q_1)/(2Q_2)$
1	Al (%)	3.47	5.14	6.83	0.33
2	As (ppm)	4.21	5.57	7.06	0.26
3	Ba (ppm)	307	502	680	0.37
4	Ca (%)	0.392	0.992	1.93	0.78
5	Cr (ppm)	28.6	40	53.2	0.31
6	Cu (ppm)	11.8	18.2	23.4	0.32
7	Fe (%)	1.48	1.95	2.59	0.28
8	Hg (ppm)	0.0385	0.0518	0.0739	0.34
9	K (%)	1.06	1.51	1.86	0.26
10	Li (ppm)	16.4	21.5	24.9	0.2
11	Mg (%)	0.283	0.599	0.906	0.52
12	Mn (ppm)	257	398	533	0.35
13	Na (%)	0.52	0.815	1.1	0.36
14	Ni (ppm)	11.8	15	18.7	0.23
15	Pb (ppm)	14.5	16.5	19.8	0.16
16	Se (ppm)	0.205	0.293	0.393	0.32
17	Sr (ppm)	77.3	148	207	0.44
18	Ti (%)	0.192	0.253	0.317	0.25
19	V (ppm)	45.9	67.3	80.3	0.26
20	Y (ppm)	18.1	22.7	28.6	0.23
21	Zn (ppm)	36.8	51.7	65.7	0.28
22	Zr (ppm)	150	188.2	247	0.26

Results and Interpretation

Features of the Geochemical Landscape and Correlations with Known Geology, Climate, and Human Activity

Table 4 shows the quartiles and the relative quartile deviations of smoothed data for each element from the whole area. The geochemical maps are presented in figures 3–24.

Text continues on page 31

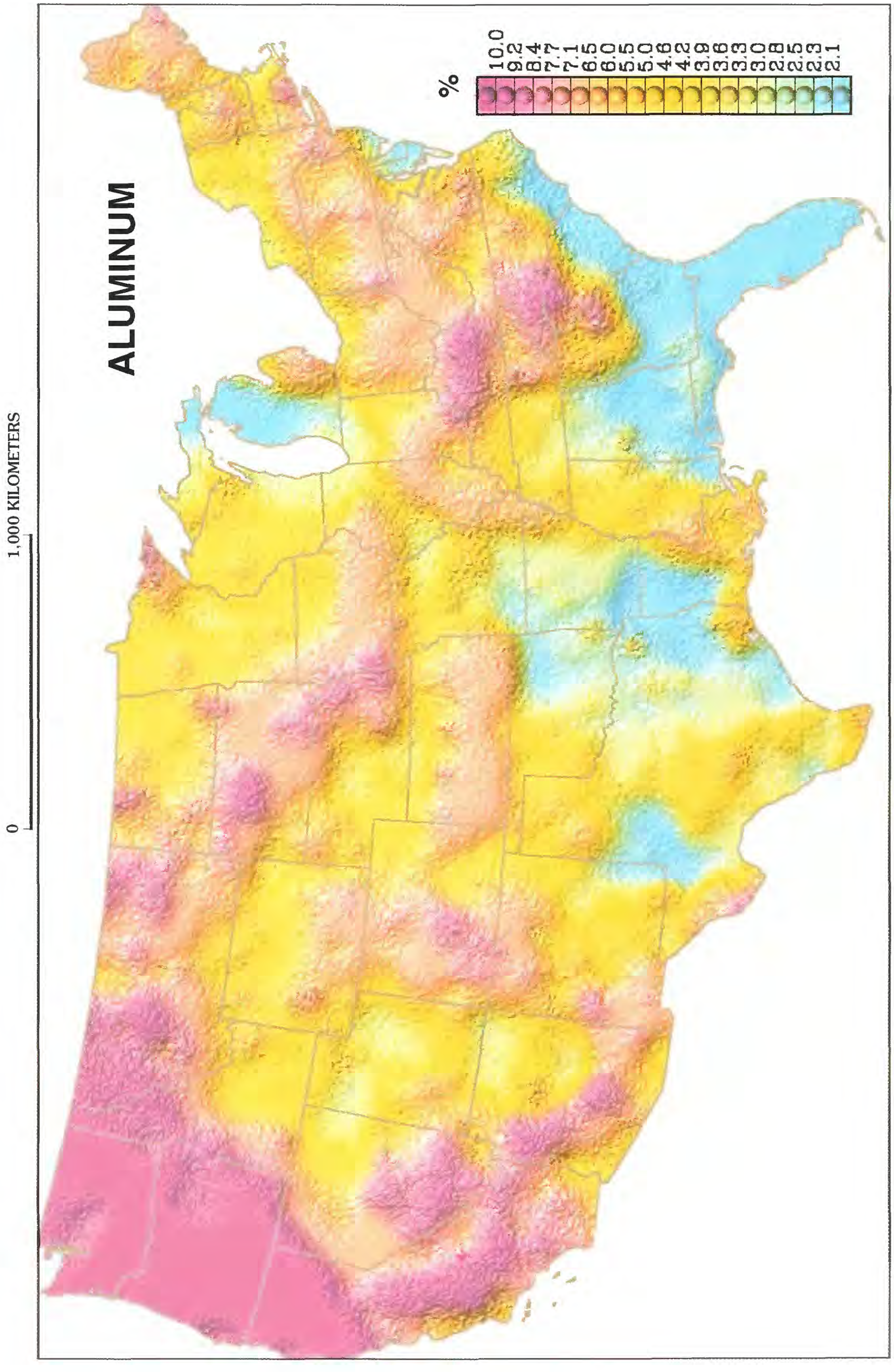

Figure 3. Colored surface map of Al distribution in soils and other surficial materials of the conterminous United States.

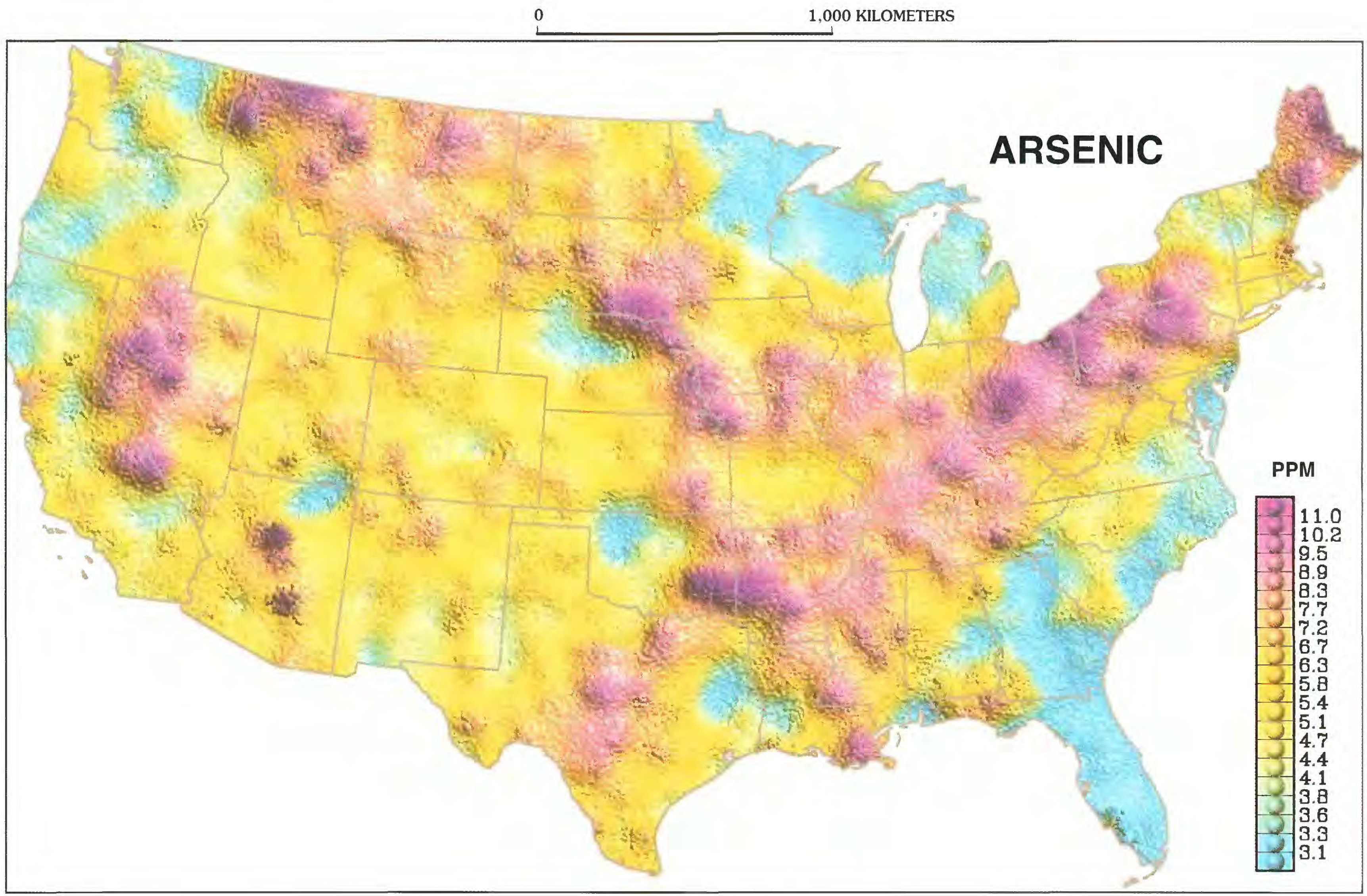

Figure 4. Colored surface map of As distribution in soils and other surficial materials of the conterminous United States.

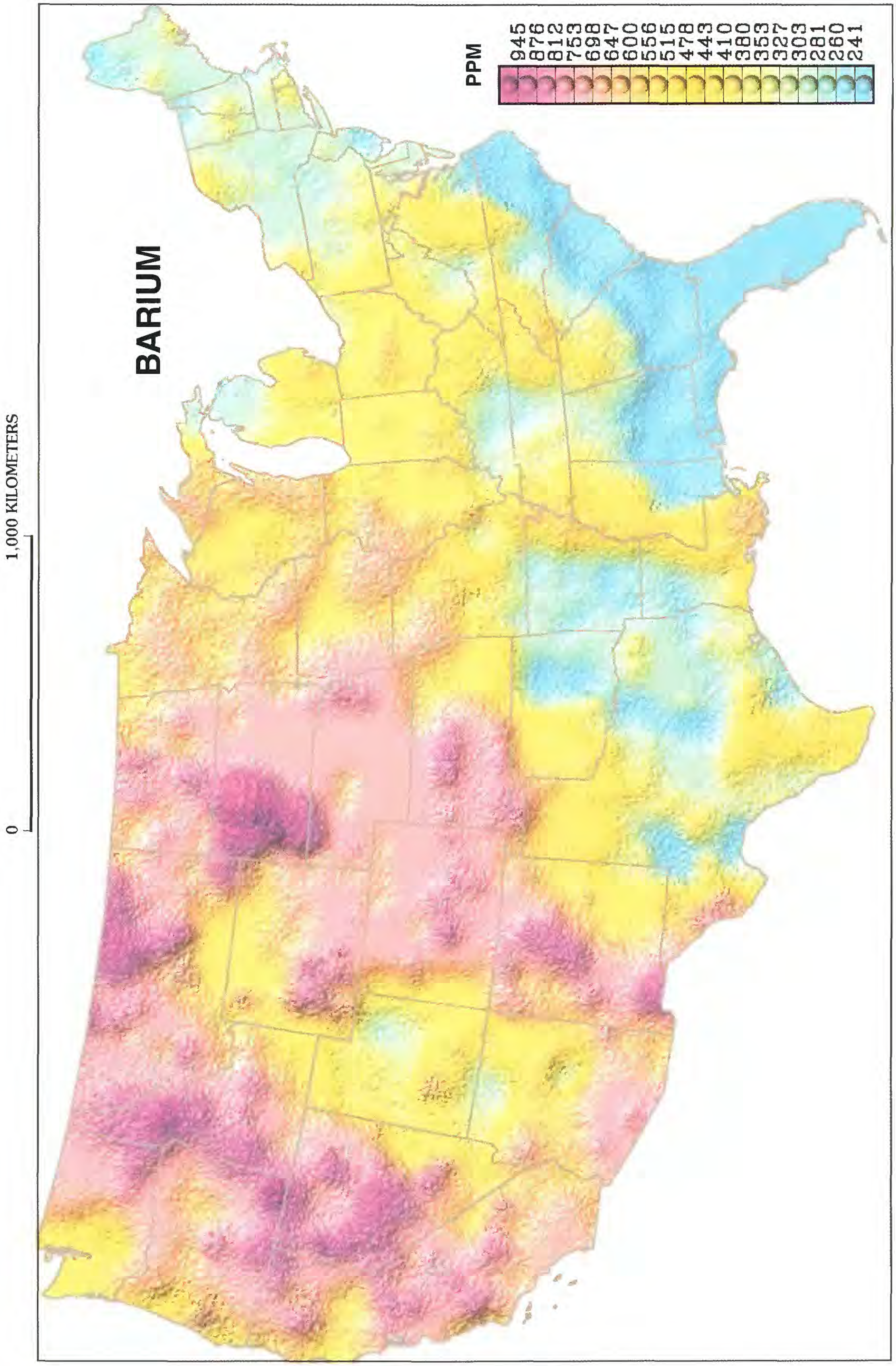

Figure 5. Colored surface map of Ba distribution in soils and other surficial materials of the conterminous United States.

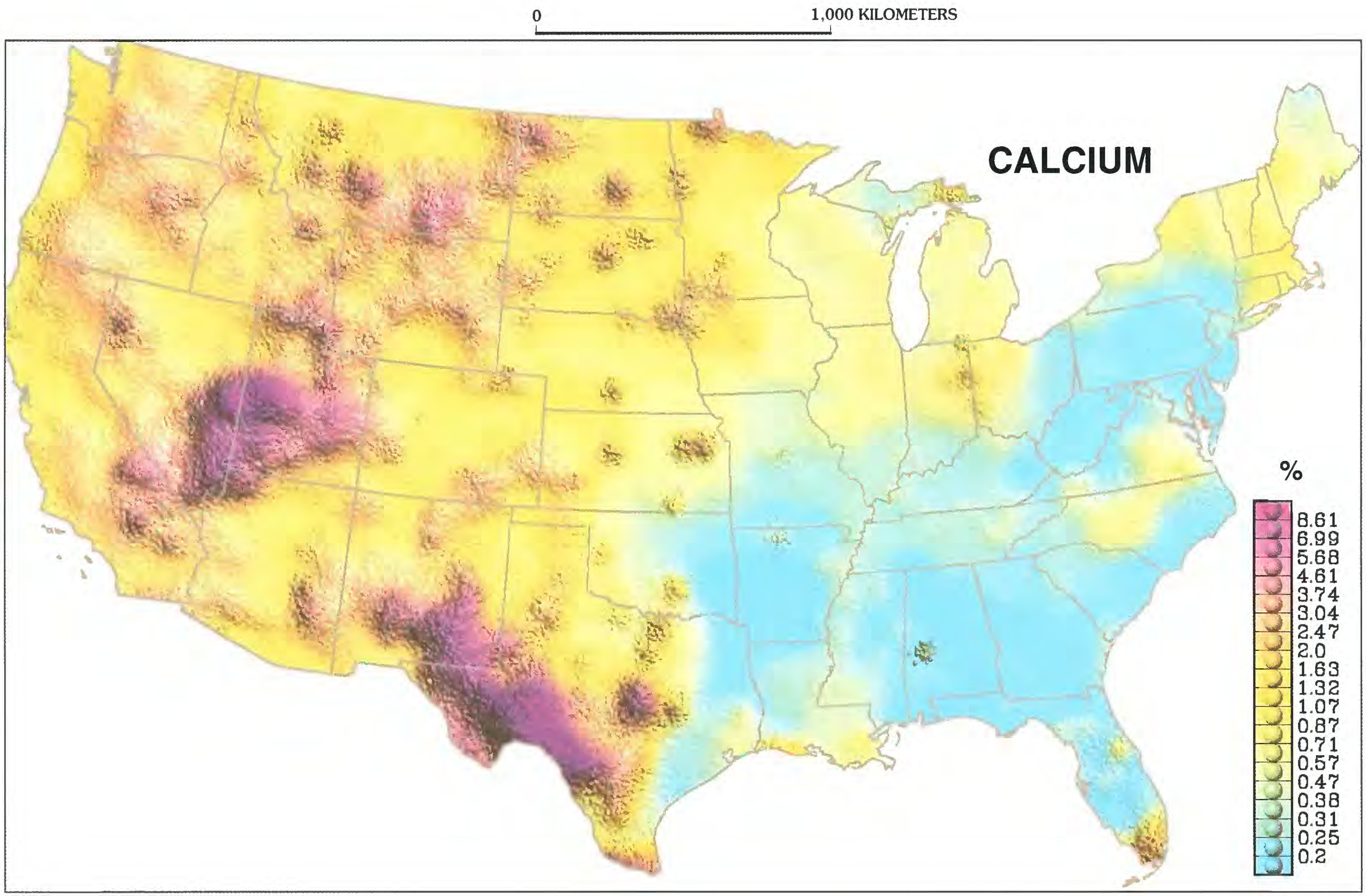

Figure 6. Colored surface map of Ca distribution in soils and other surficial materials of the conterminous United States.

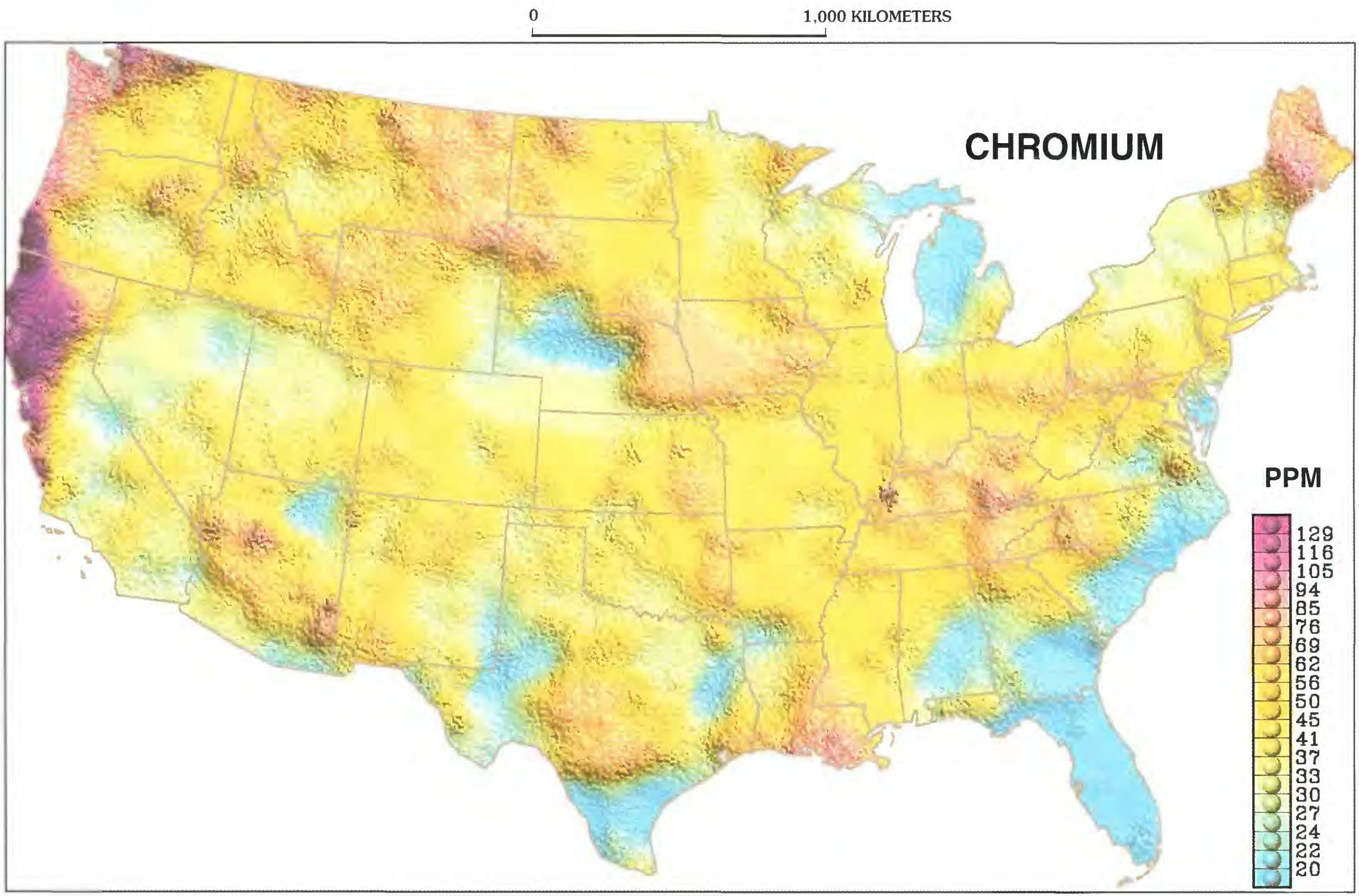

Figure 7. Colored surface map of Cr distribution in soils and other surficial materials of the conterminous United States.

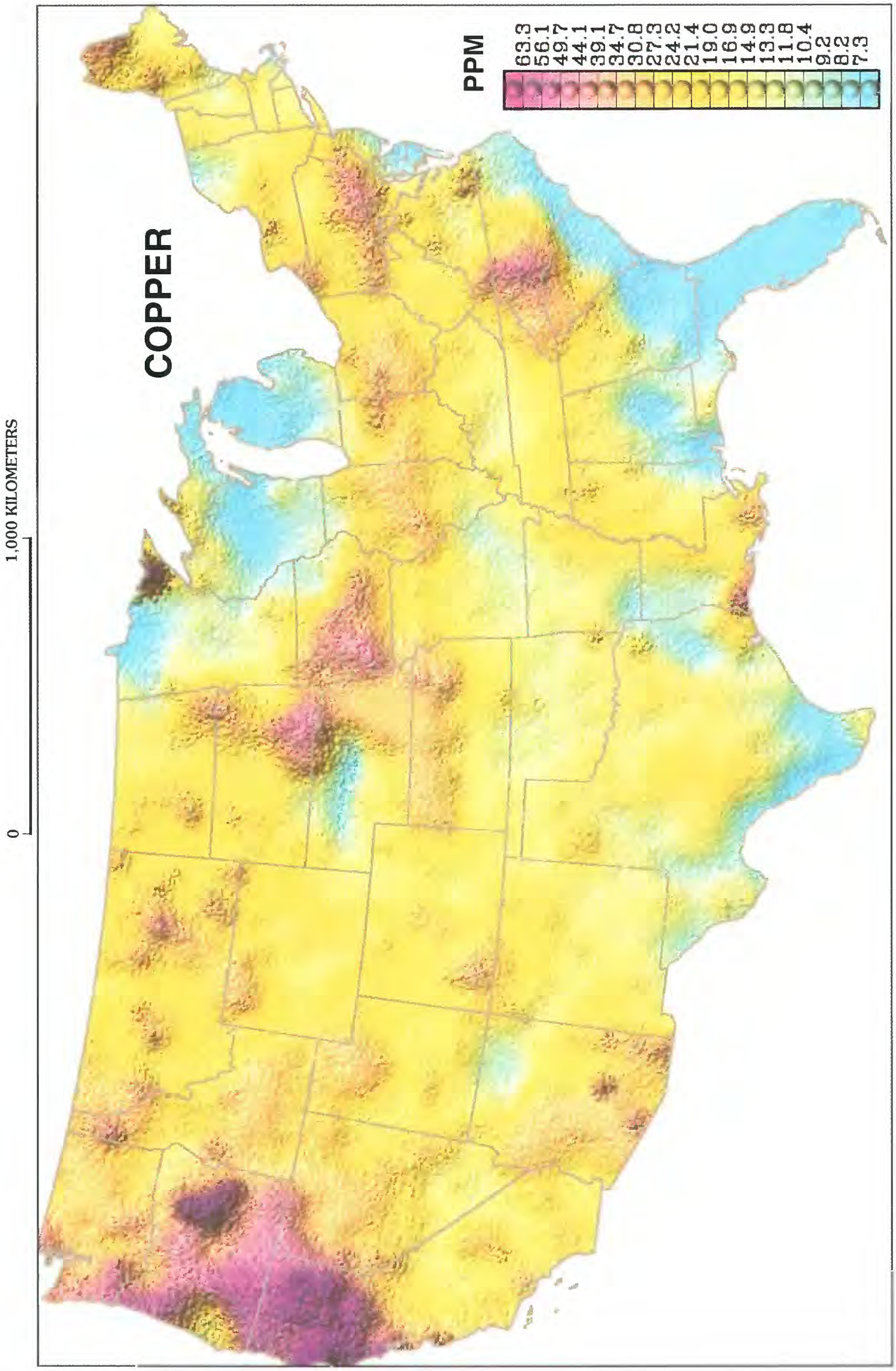

Figure 8. Colored surface map of Cu distribution in soils and other surficial materials of the conterminous United States.

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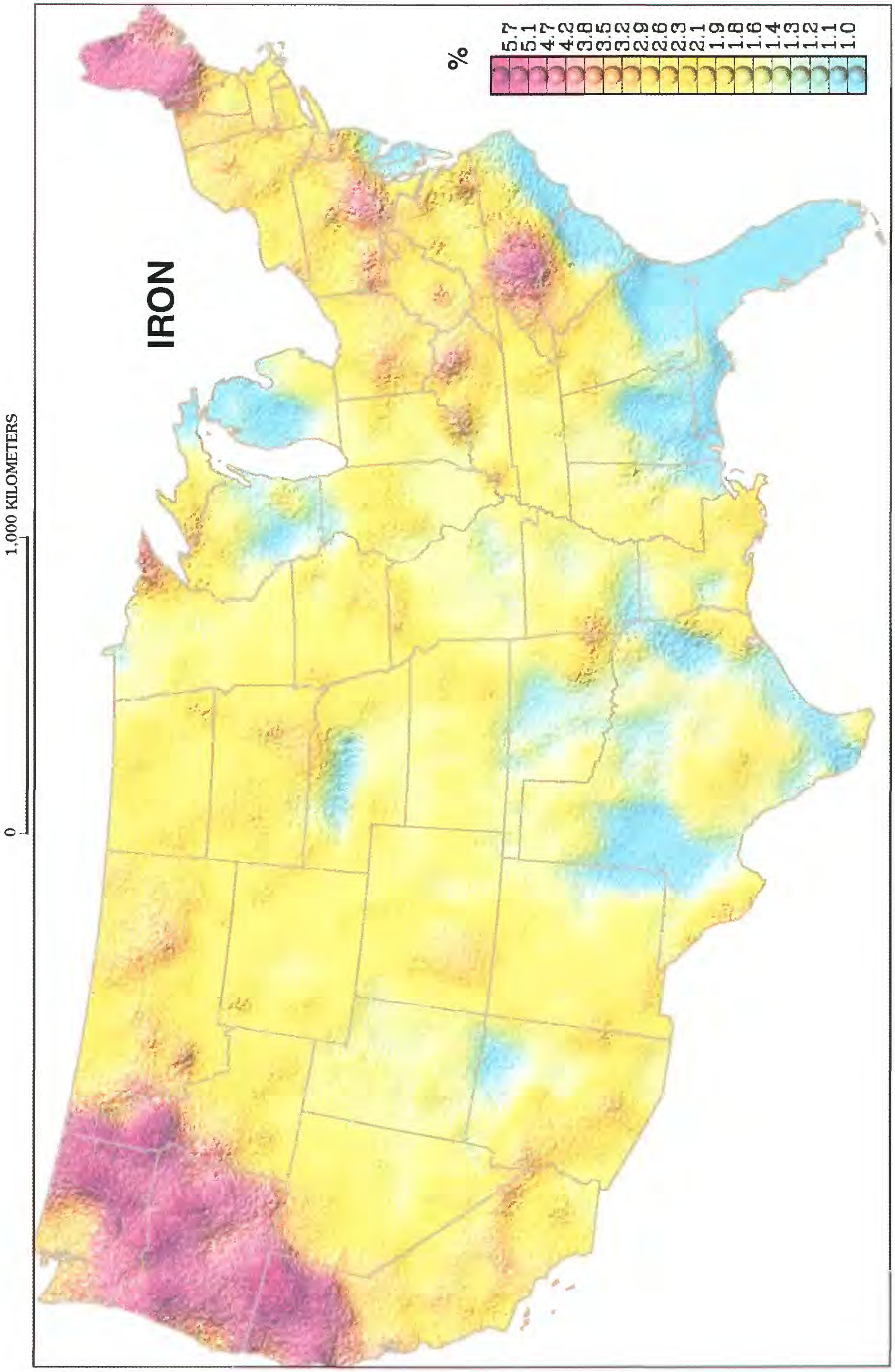

Figure 9. Colored surface map of Fe distribution in soils and other surficial materials of the conterminous United States.

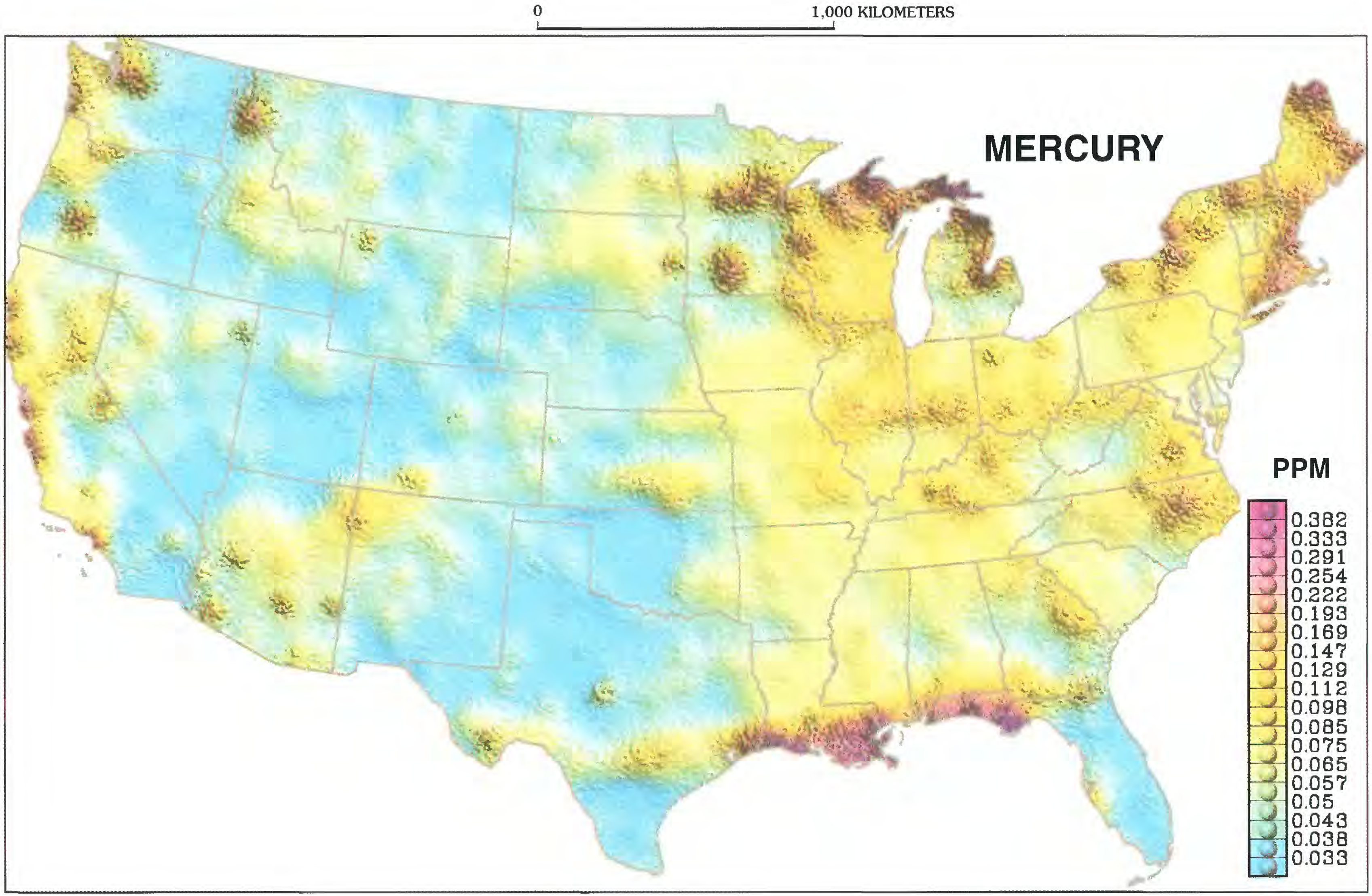

Figure 10. Colored surface map of Hg distribution in soils and other surficial materials of the conterminous United States.

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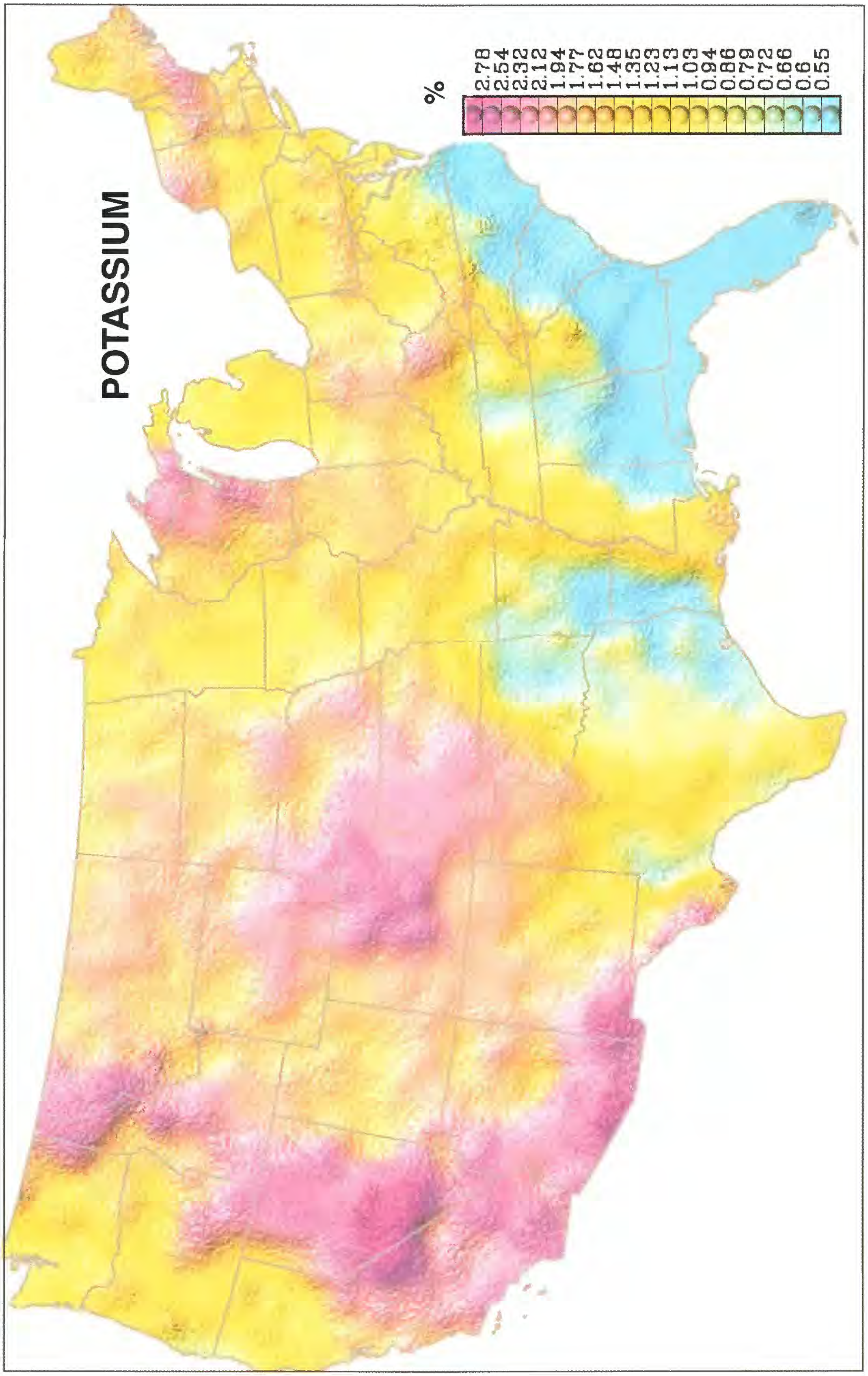

Figure 11. Colored surface map of K distribution in soils and other surficial materials of the conterminous United States.

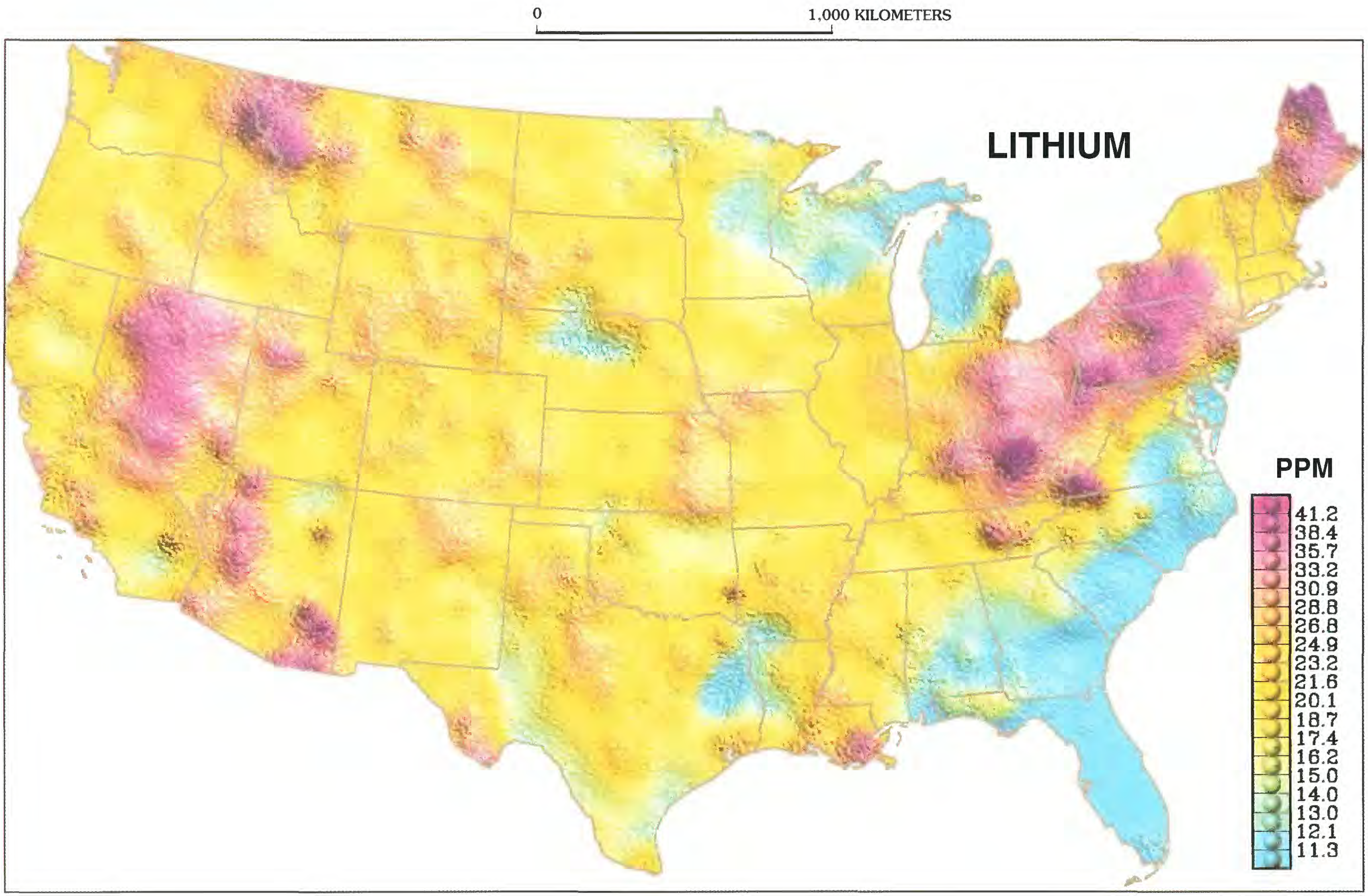

Figure 12. Colored surface map of Li distribution in soils and other surficial materials of the conterminous United States.

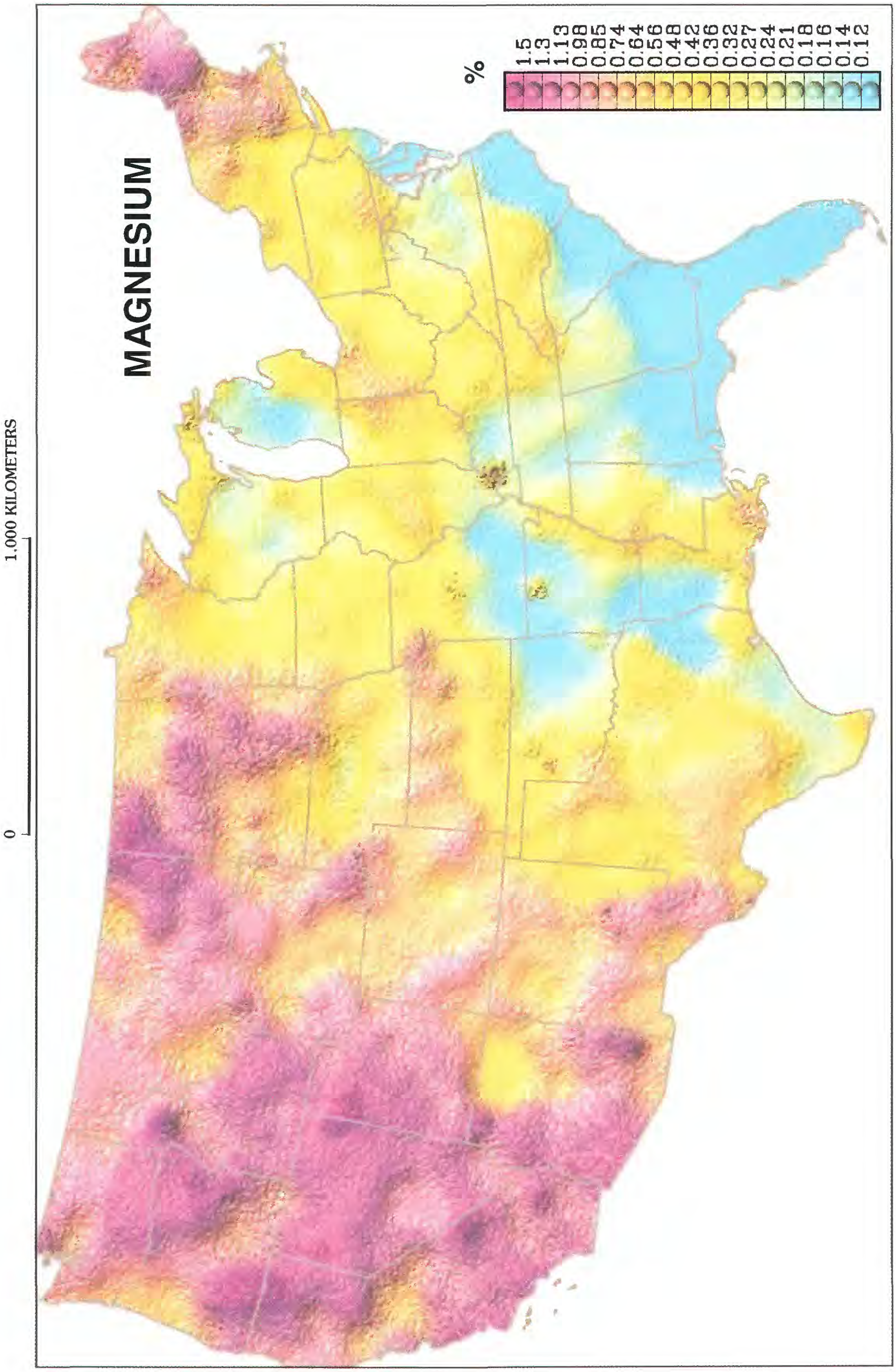

Figure 13. Colored surface map of Mg distribution in soils and other surficial materials of the conterminous United States.

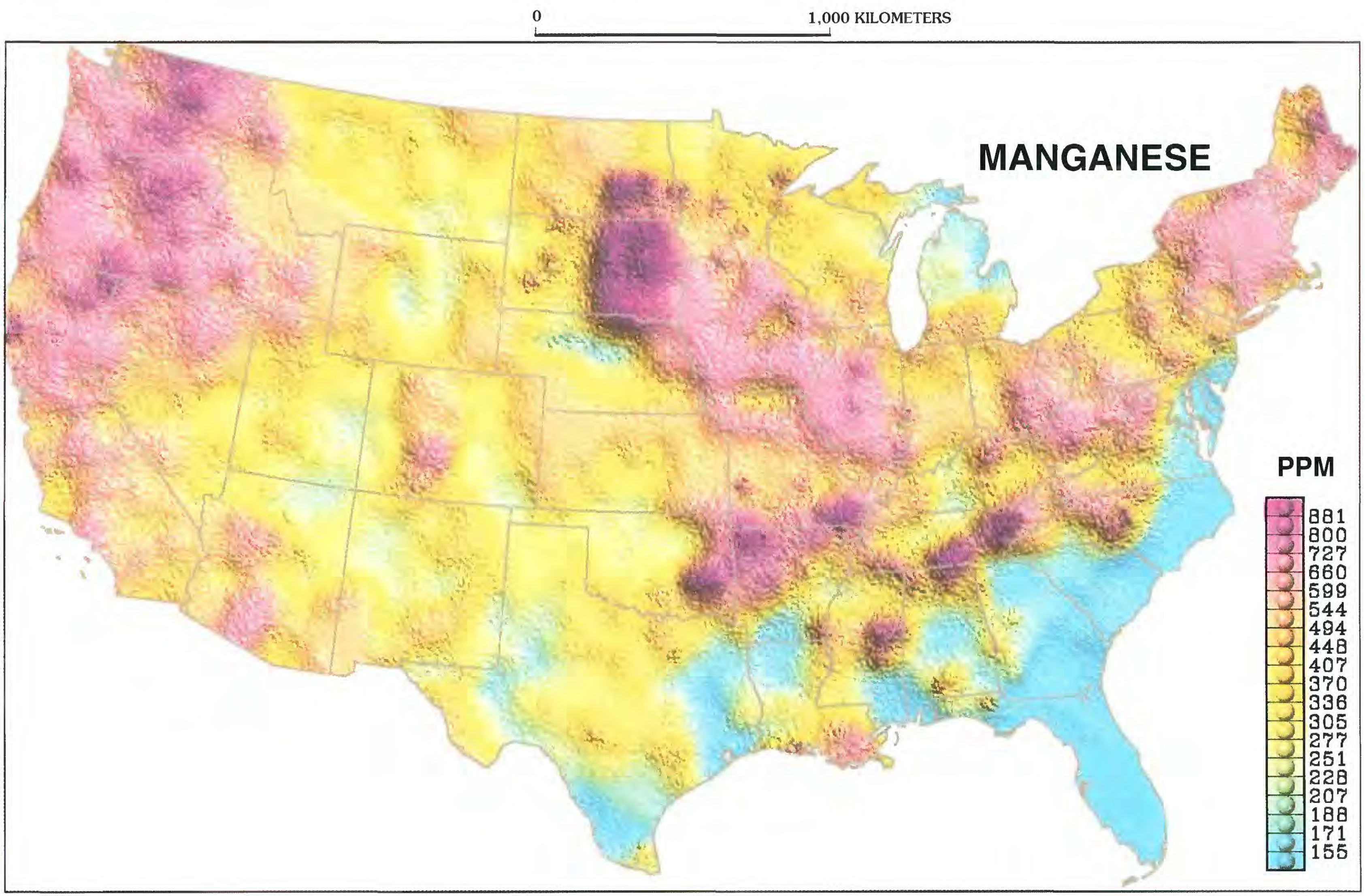

Figure 14. Colored surface map of Mn distribution in soils and other surficial materials of the conterminous United States.

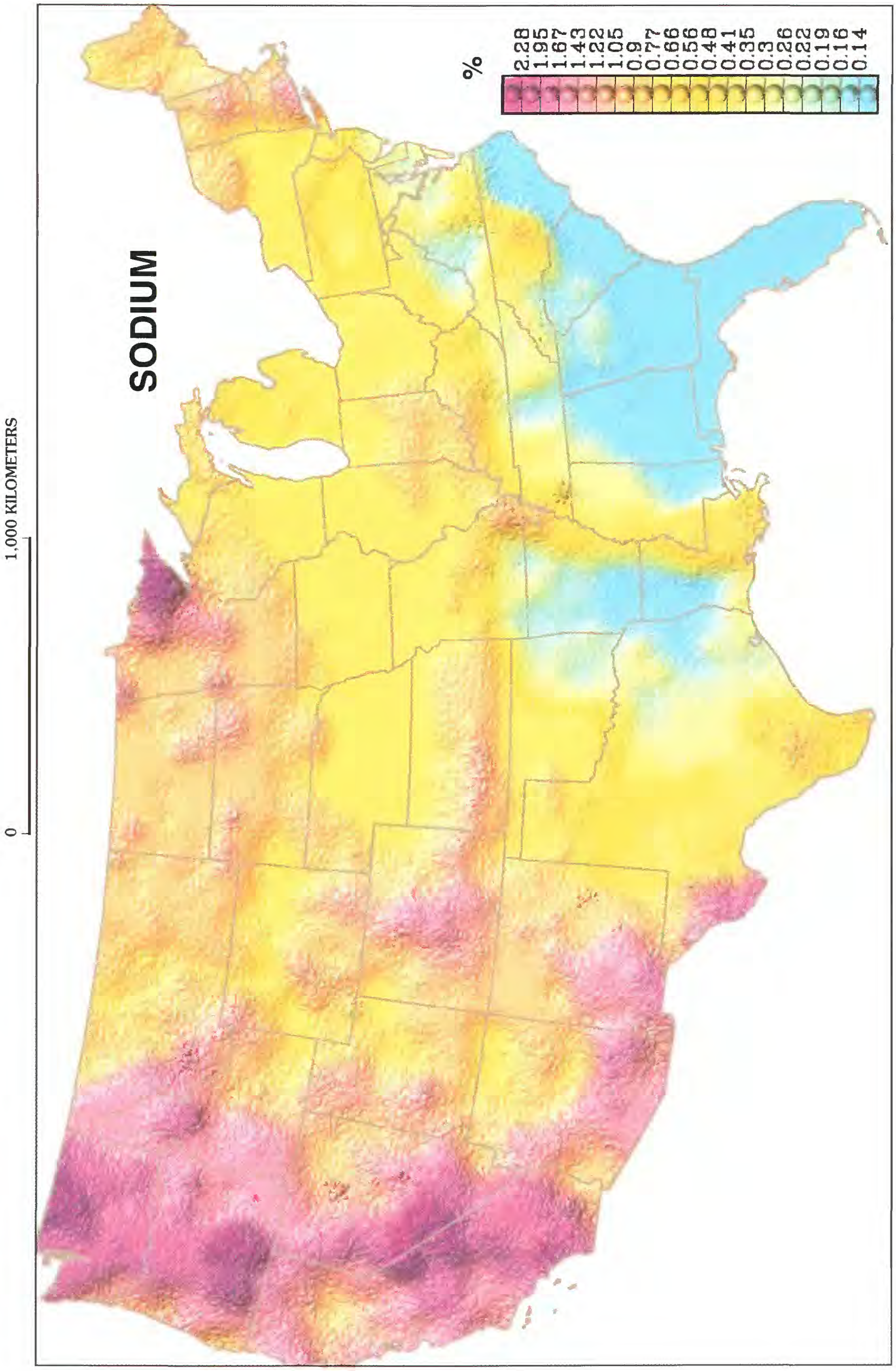

Figure 15. Colored surface map of Na distribution in soils and other surficial materials of the conterminous United States.

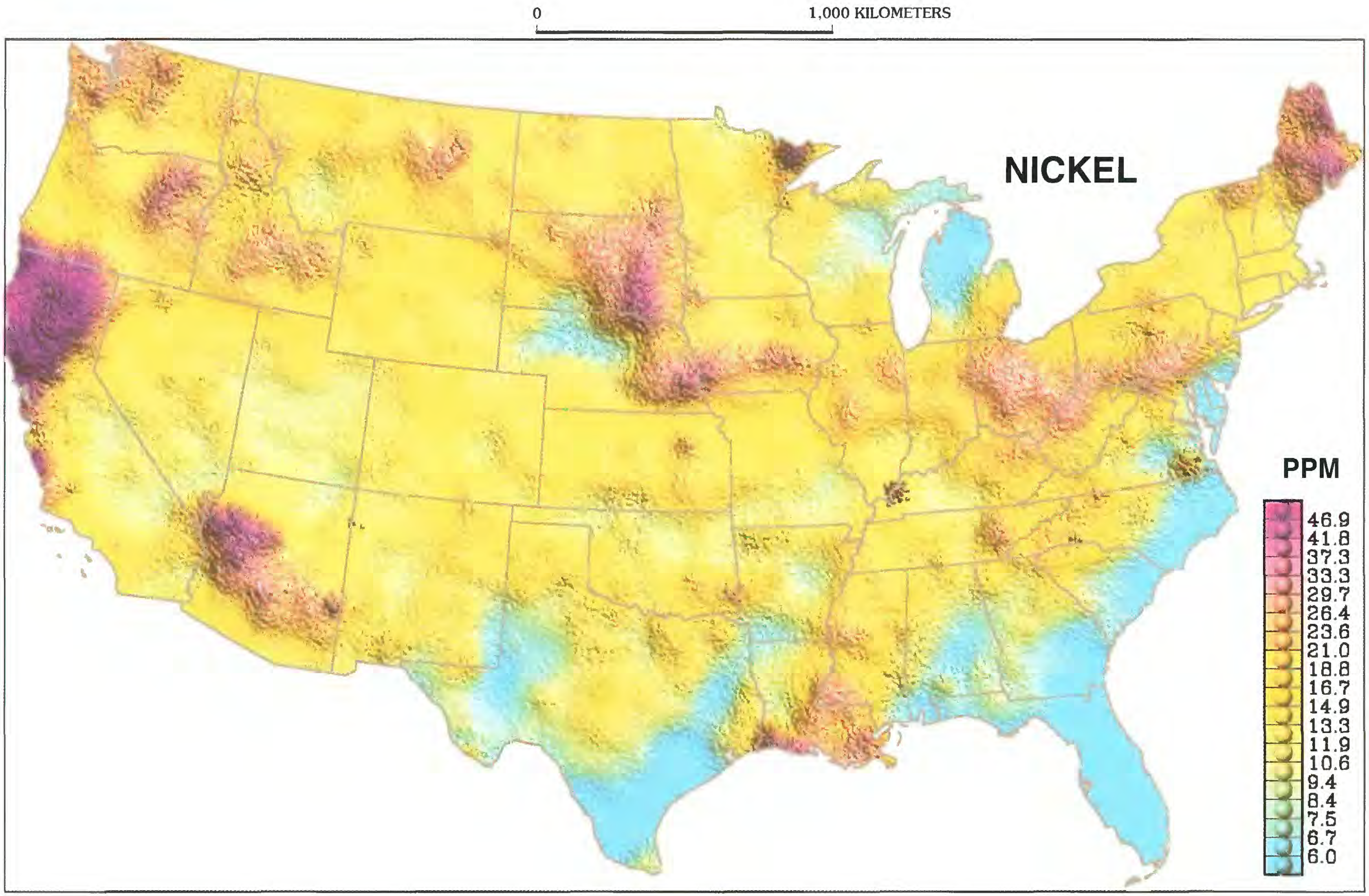

Figure 16. Colored surface map of Ni distribution in soils and other surficial materials of the conterminous United States.

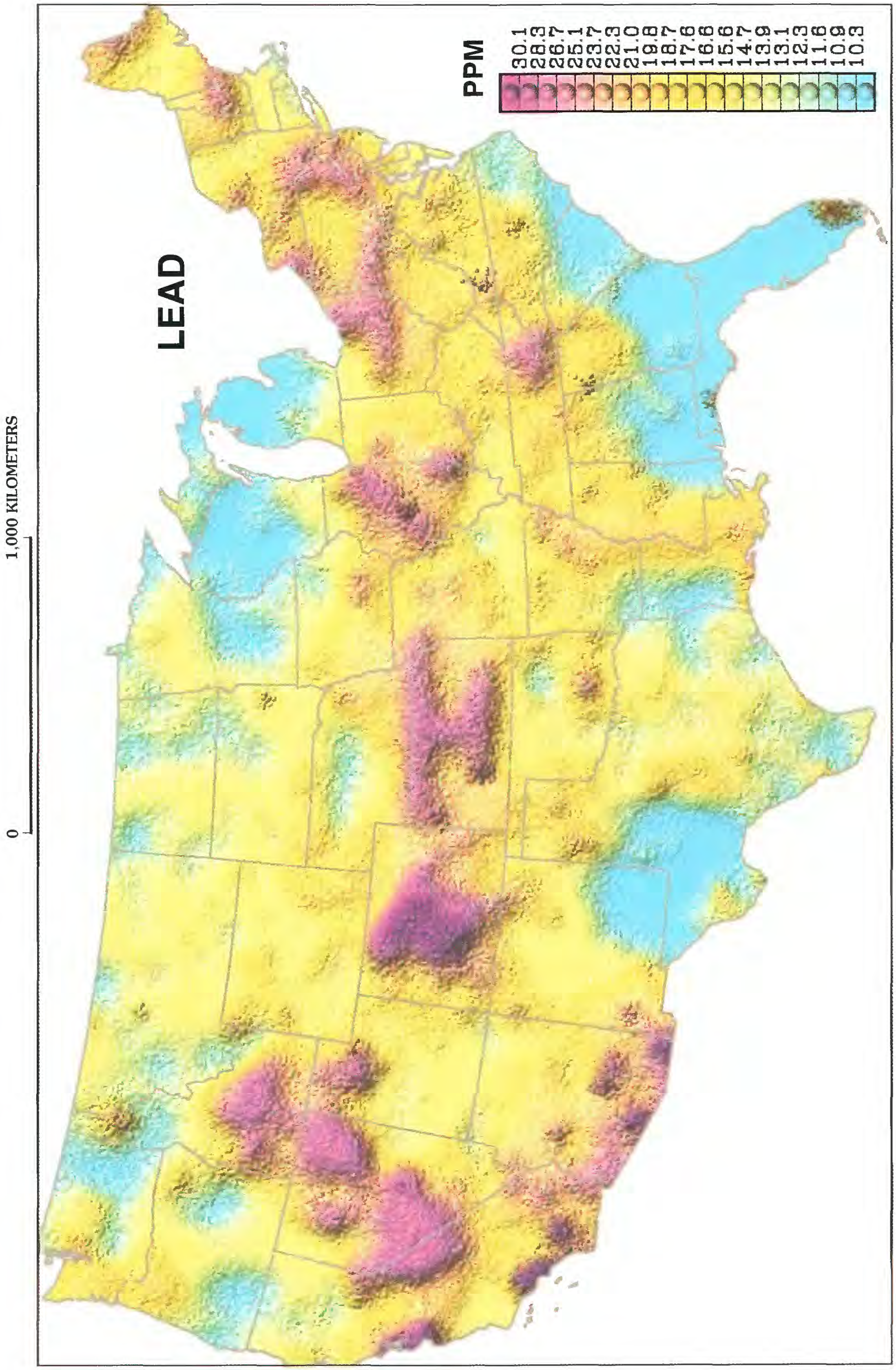

Figure 17. Colored surface map of Pb distribution in soils and other surficial materials of the conterminous United States.

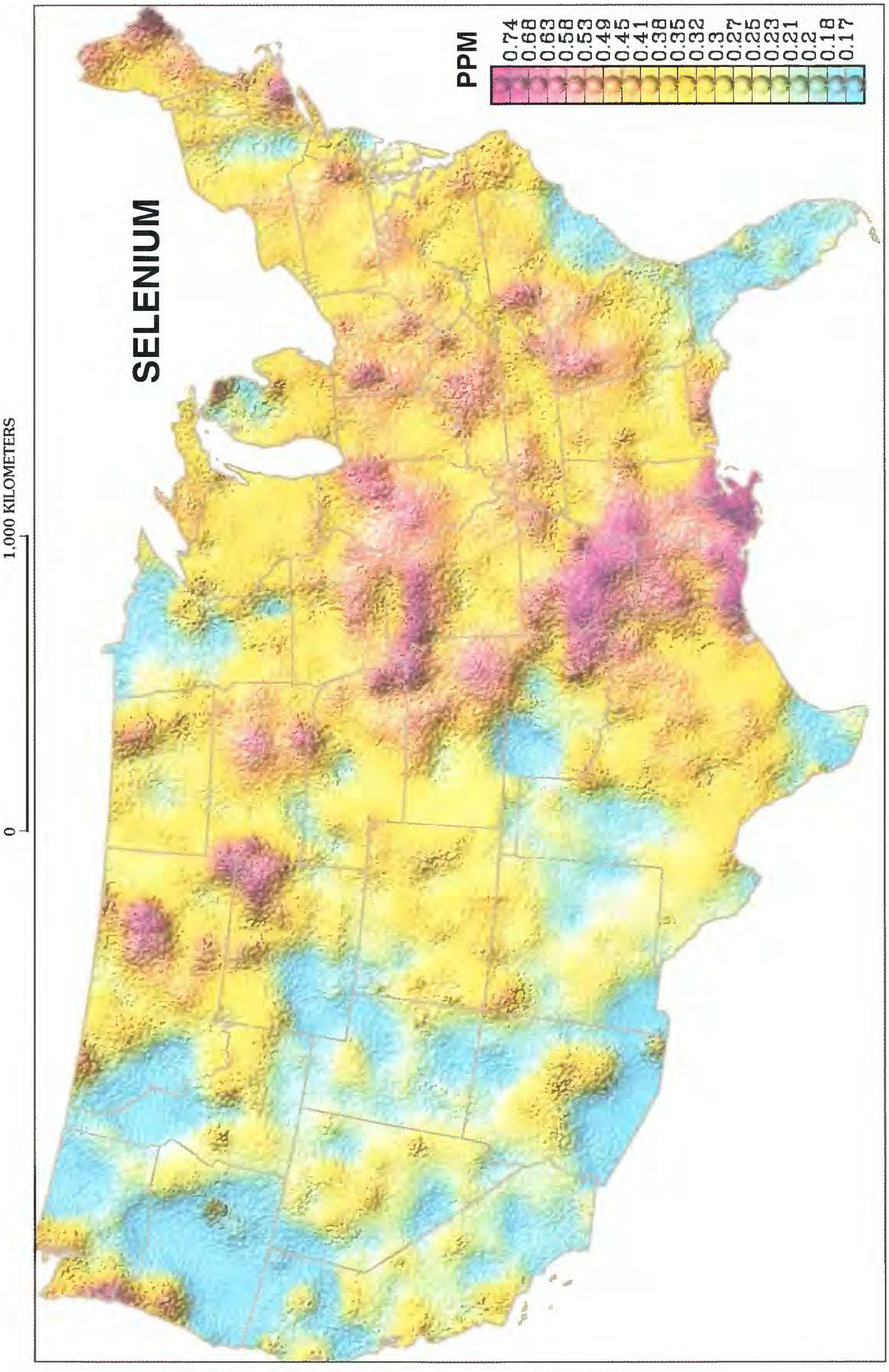

Figure 18. Colored surface map of Se distribution in soils and other surficial materials of the conterminous United States.

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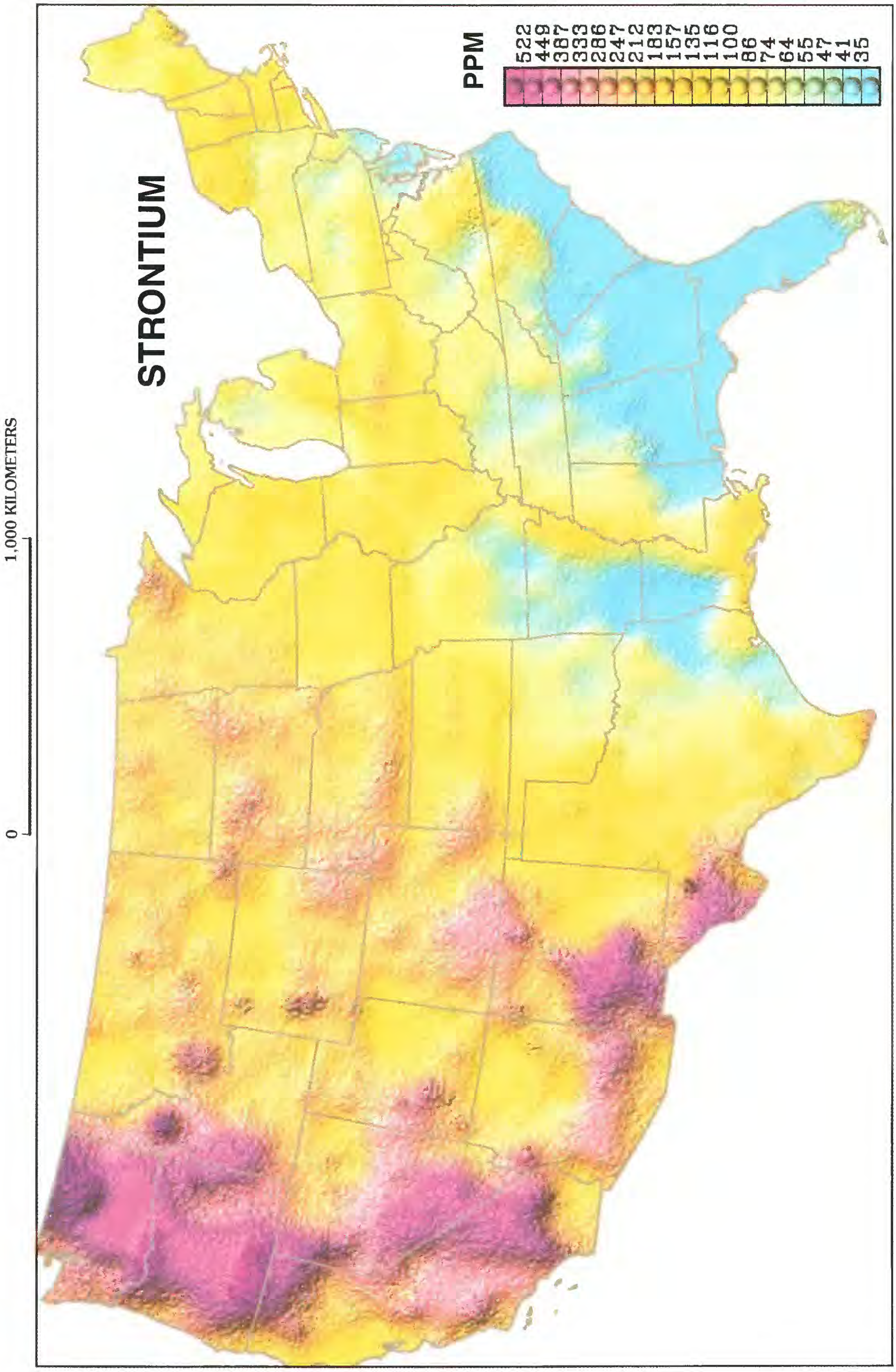

Figure 19. Colored surface map of Sr distribution in soils and other surficial materials of the conterminous United States.

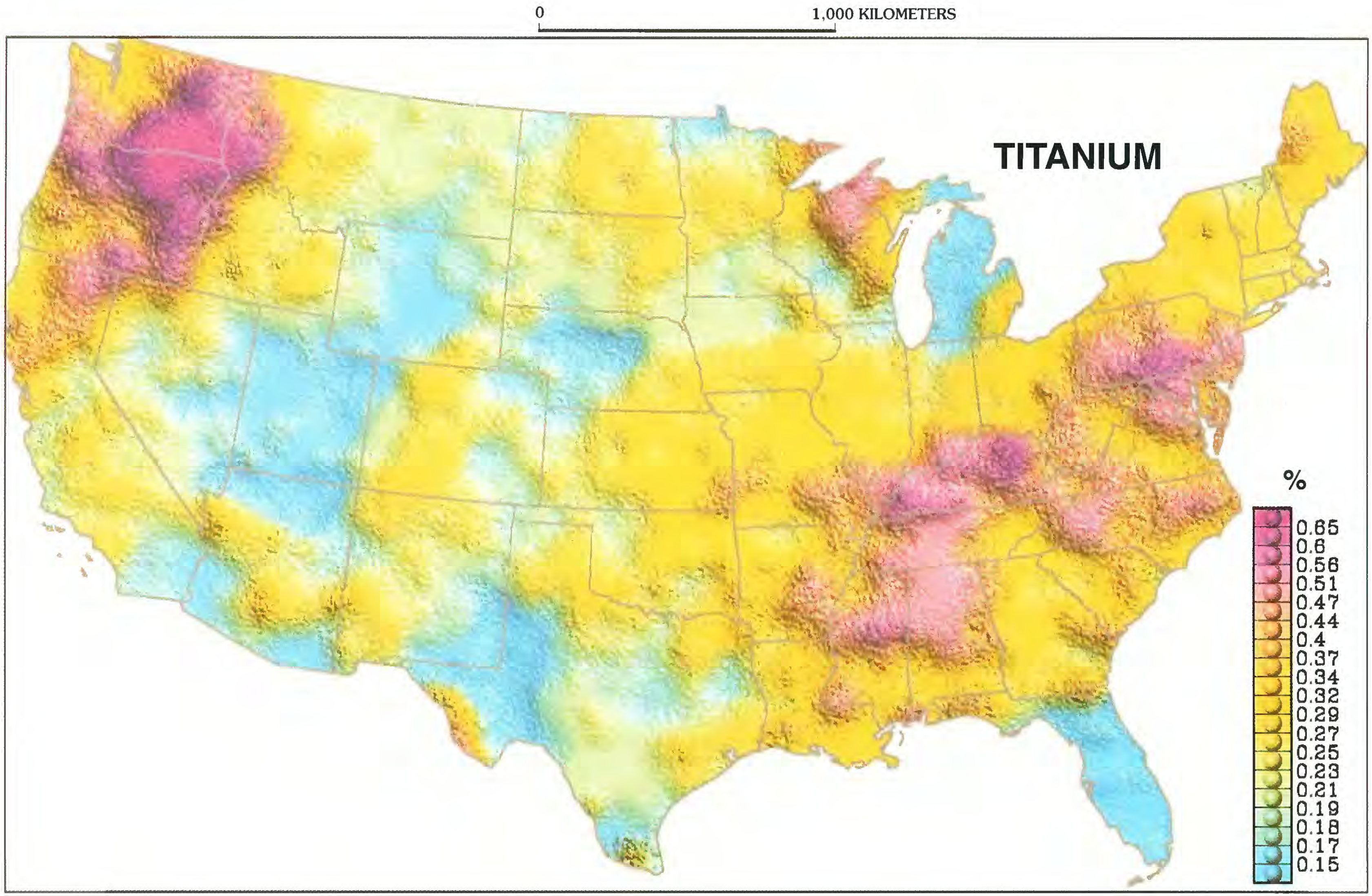

Figure 20. Colored surface map of Ti distribution in soils and other surficial materials of the conterminous United States.

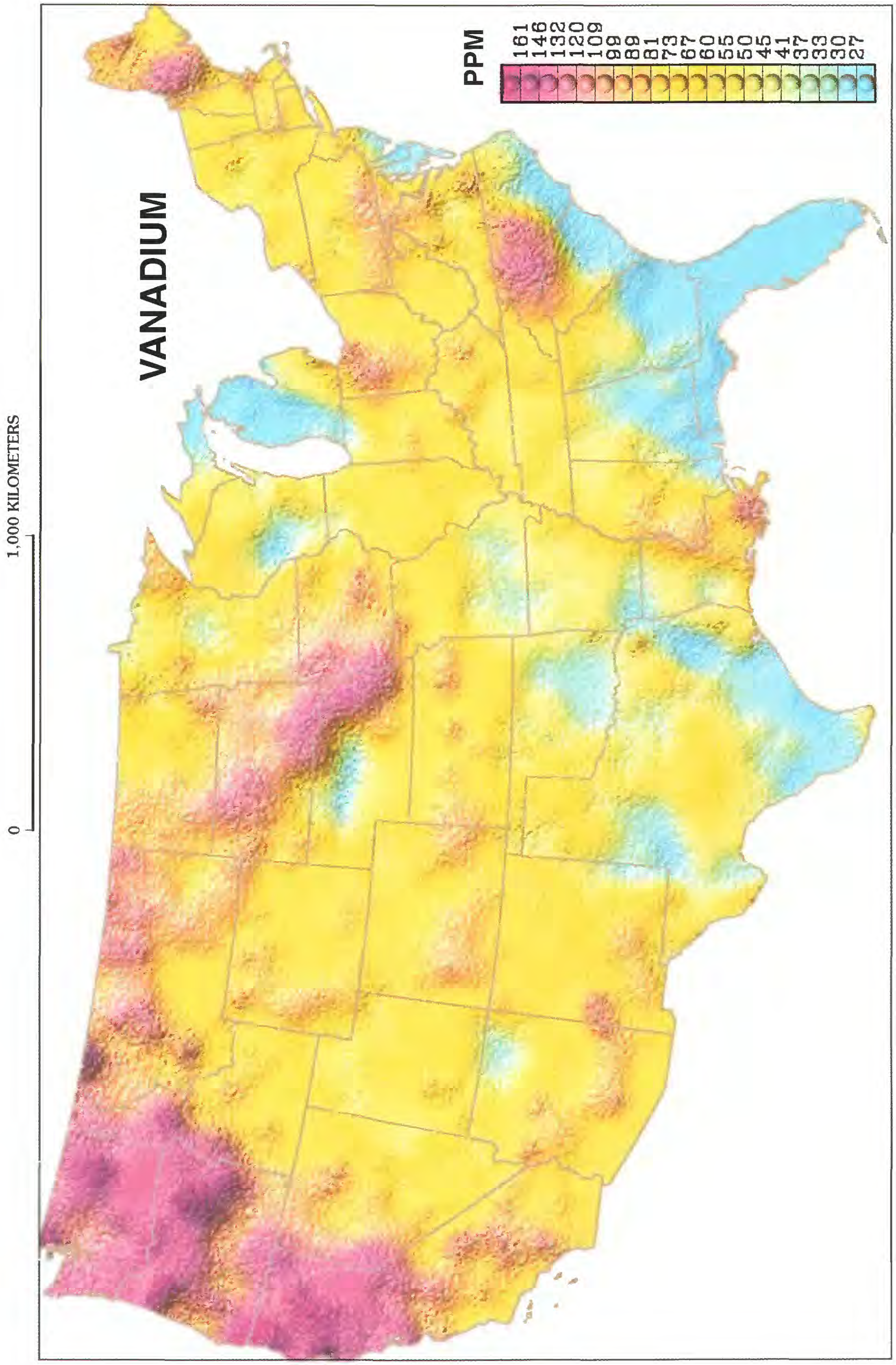

Figure 21. Colored surface map of V distribution in soils and other surficial materials of the conterminous United States.

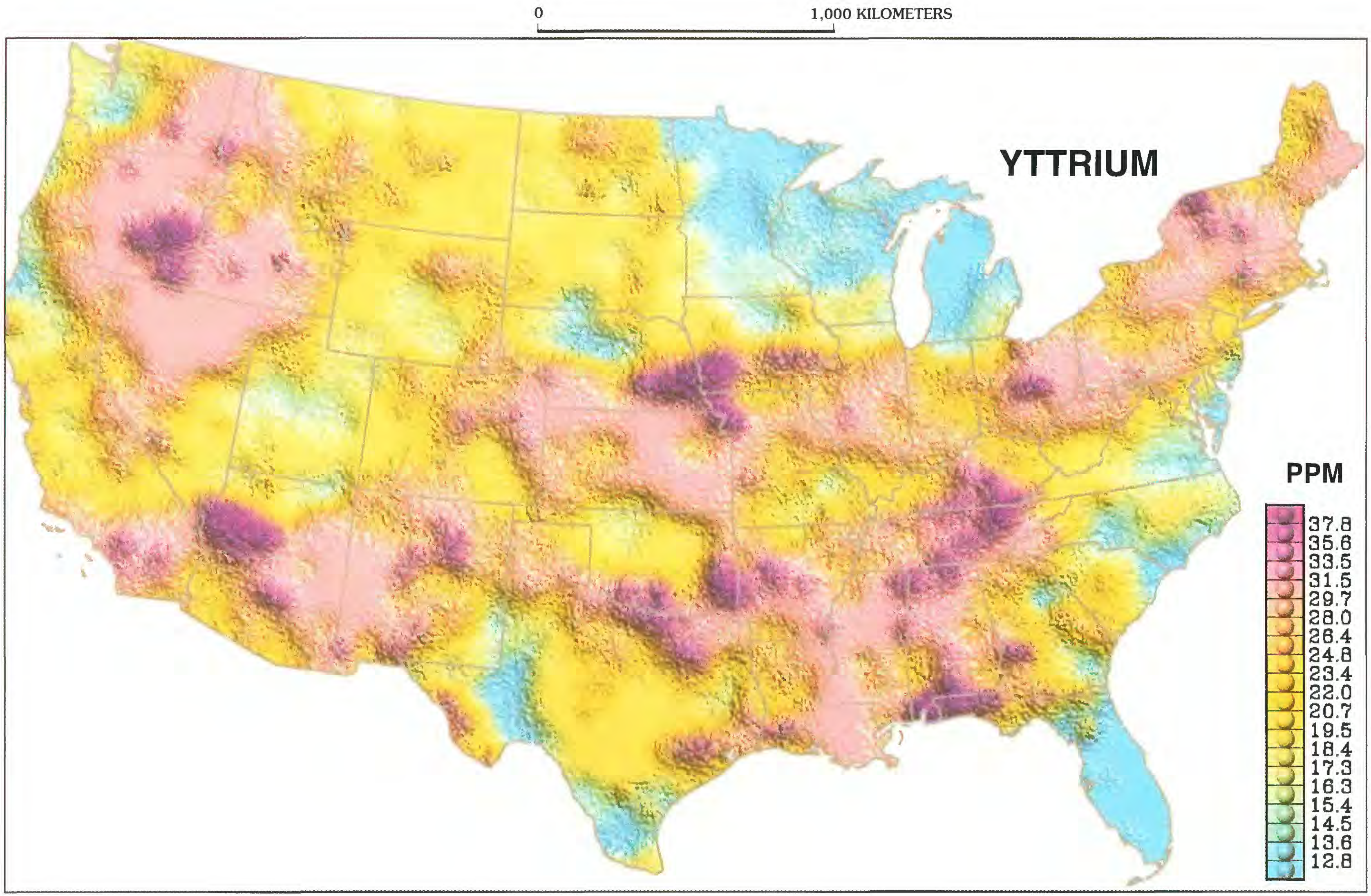

Figure 22. Colored surface map of Y distribution in soils and other surficial materials of the conterminous United States.

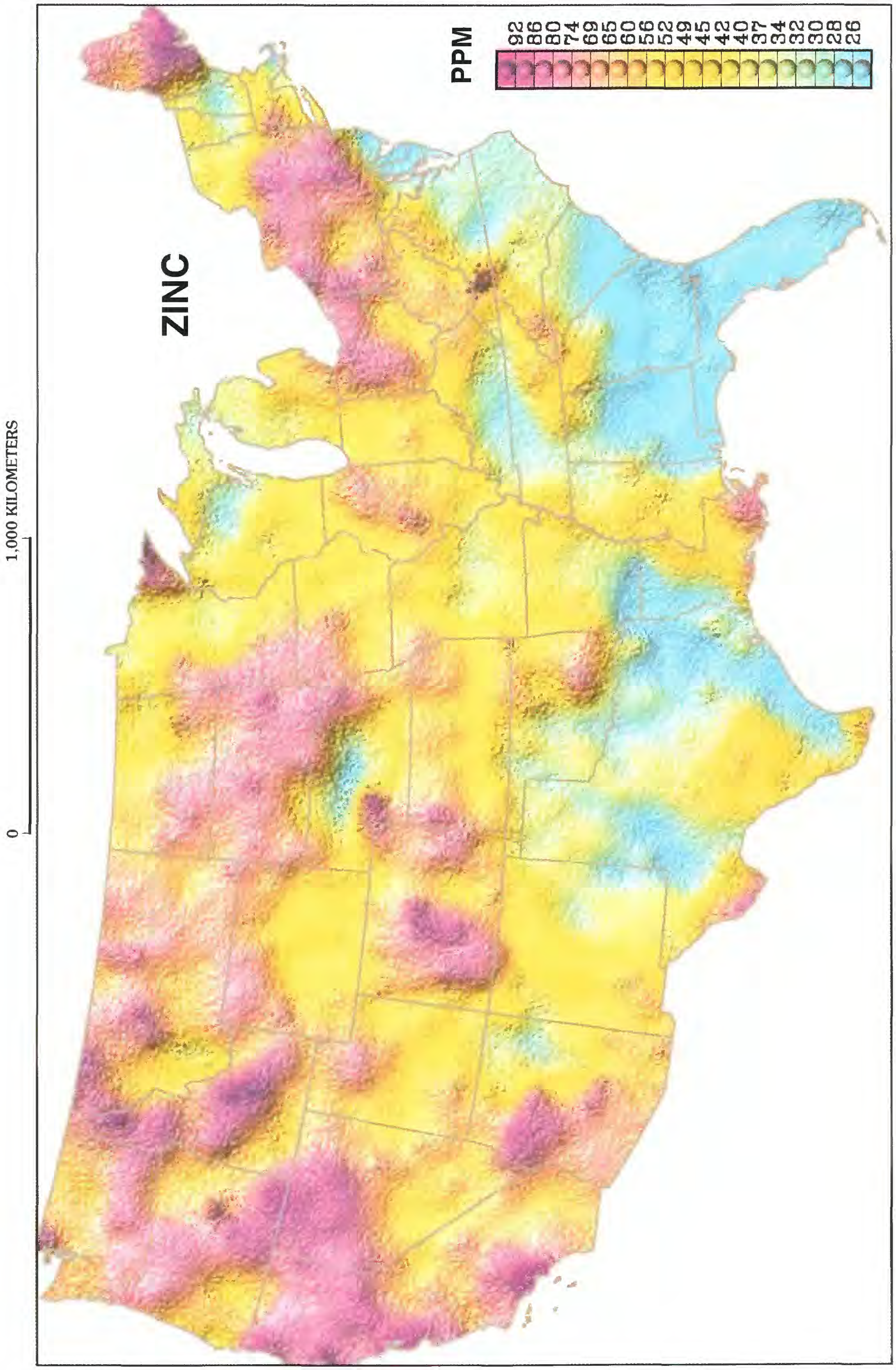

Figure 23. Colored surface map of Zn distribution in soils and other surficial materials of the conterminous United States.

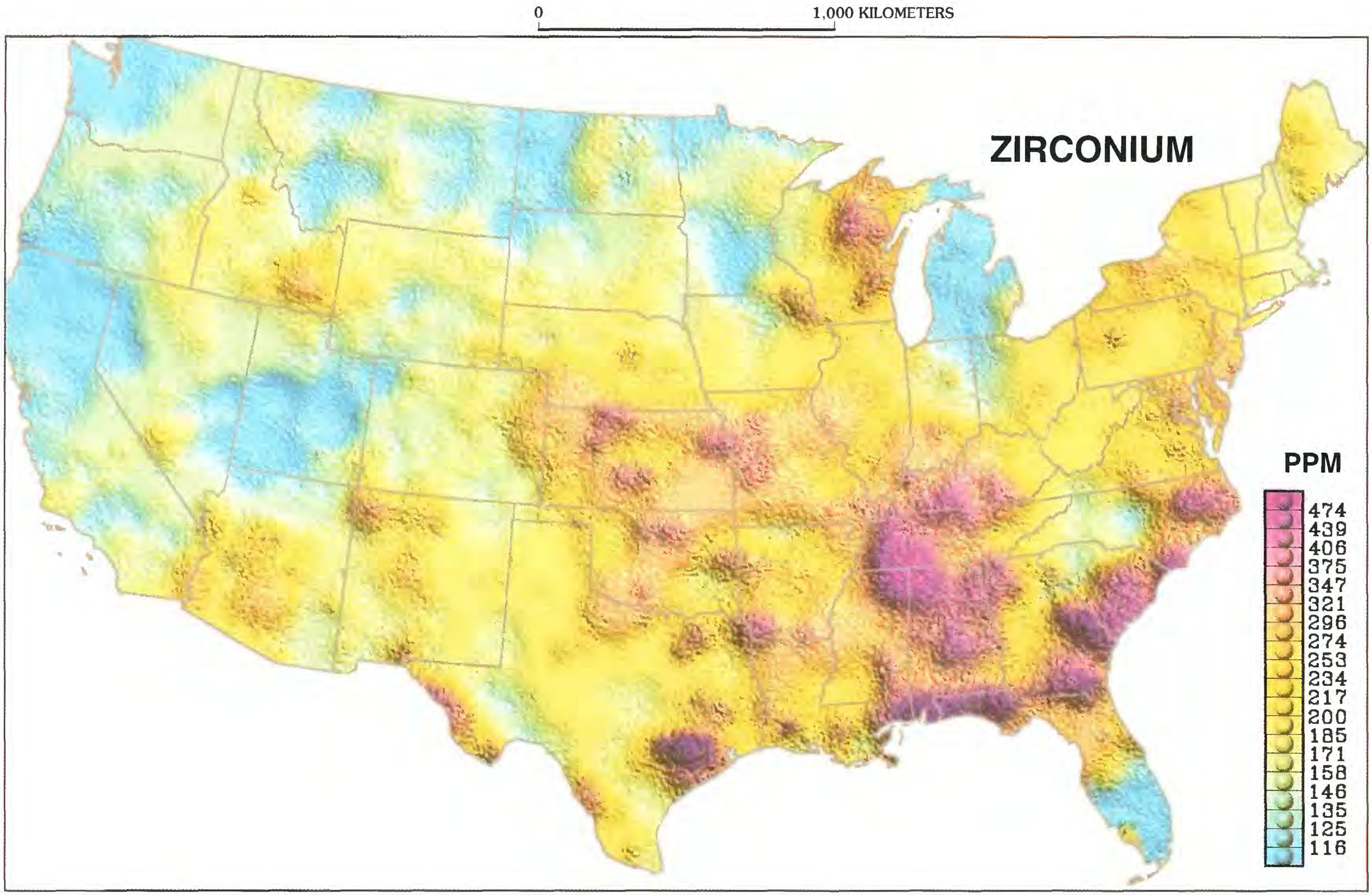

Figure 24. Colored surface map of Zr distribution in soils and other surficial materials of the conterminous United States.

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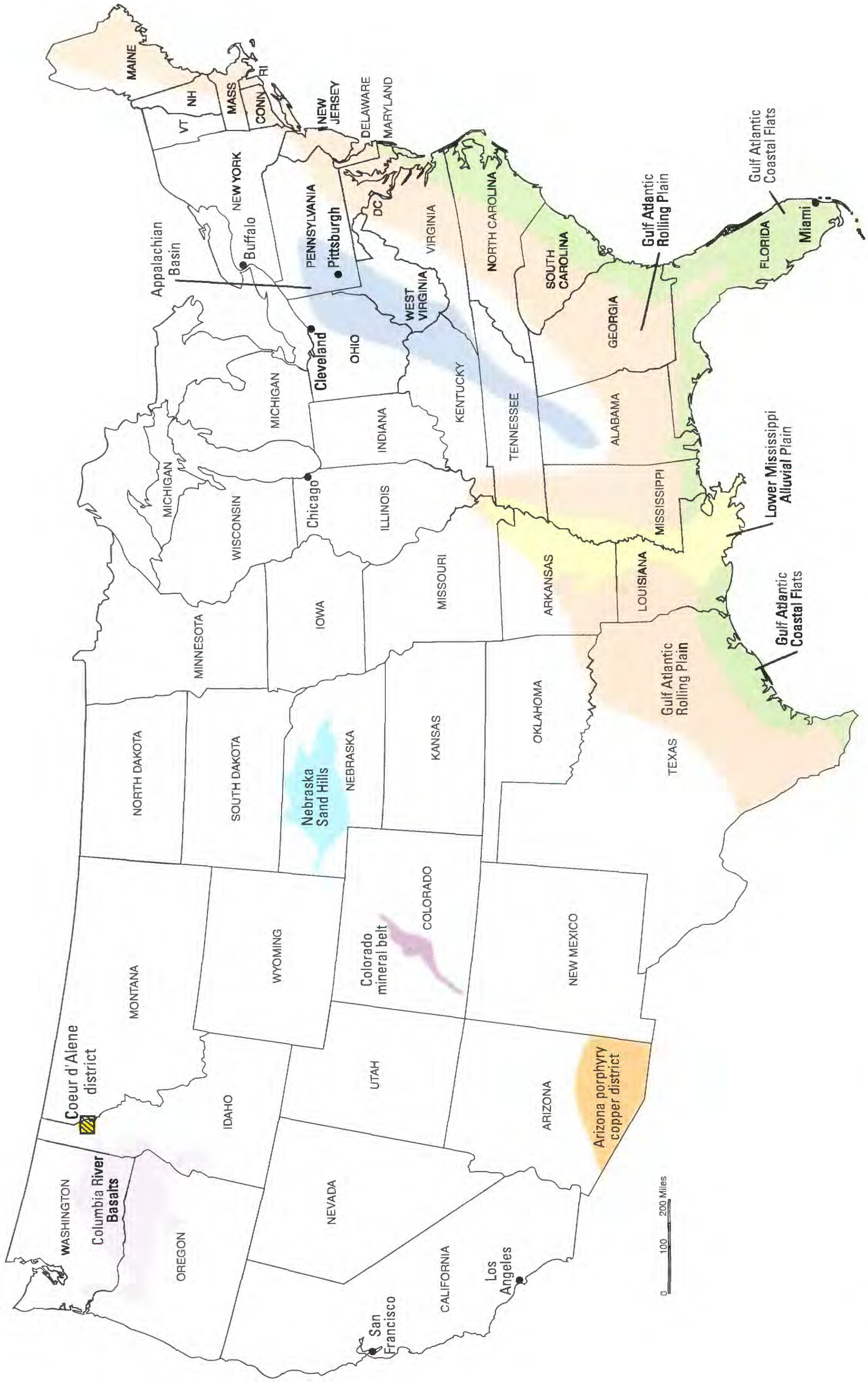

Figure 25. Map of conterminous United States showing approximate location of selected physiographic and geologic features.

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A number of broad geochemical dispersion patterns are obtained for both major and trace elements (figs. 3–24). Some of these patterns were previously described by Shacklette and Boerngen (1984), and further comments are found in the following discussion. The discussion and interpretation of the geochemical patterns frequently necessitates reference to physiographic and geologic features of the conterminous United States. Figure 25 shows the approximate location of these features.

1. The largest scale regional pattern observed on the maps is formed by elements such as Ba, Ca, K, Mg, Na, and Sr. All these elements show significantly higher concentrations in the western part of United States than in the eastern part. This main pattern likely represents a complex interaction of factors such as bedrock composition, topography, climate, soil development, and vegetation. It is difficult to judge the contribution for each factor.
   Shacklette and Boerngen (1984) point out that the abundances of Ba, Ca, Mg, K, Na, and Sr are markedly different on either side of a line extending from western Minnesota southward through east-central Texas, which marks the approximate boundary between classes of moist-to-wet soils in the Eastern United States and dry soils of the West as mapped by the U.S. Soil Conservation Service (1969). Thus, the effect of climate on soil formation is probably a major factor in the development of these regional geochemical patterns.
2. Another striking feature is the low concentration of many elements in portions of the Gulf-Atlantic Coastal Flats and the Gulf-Atlantic Rolling Plain as defined by Hammond (1964). This area includes the State of Florida and portions of North Carolina, South Carolina, Georgia, Alabama, Mississippi, and Texas. This feature is likely due to a combination of the abundance of quartz sand in surficial material and the wet climate, which causes leaching of many elements from the upper soil horizons. The only exceptions among the mapped elements to this trend of low concentration are Zr and Y. These elements show relatively high concentrations along the Gulf-Atlantic Coastal Flats of northern Florida, southern Alabama and Mississippi, and eastern South and North Carolina. This trend is believed to reflect the placer accumulation of heavy minerals, such as zircon and xenotime, within sandy soils and their resistance to weathering.
3. The feature described in no. 2 above is interrupted by the alluvial plain of the Mississippi River. This is best seen in the distribution of Al, Ba, K, Mg, Na, Sr, and Zn. It appears that the flood plains of the Mississippi River system contain long-transported sediments with a composition more typical for the West (no. 1 above) than for the Southeast (no. 2 above).
4. Northern California and southern Oregon show high levels of Cu, Cr, and Ni. This is consistent with the presence of ultramafic rocks in this area (Jennings, 1977; Walker and MacLeod, 1991).
5. The area in north-central Nebraska with low concentrations of As, Cu, Cr, Fe, Li, Mg, Mn, Ni, Pb, Ti, V, Y, and Zn corresponds to the Nebraska Sand Hills, the largest dune field in the Western Hemisphere (Ahlbrandt and Fryberger, 1980).
6. The area of central Colorado containing elevated concentrations of Pb and Zn corresponds to the Colorado mineral belt, a region of historic precious- and base-metal mining (Tweto and Sims, 1963). This zone of increased Pb and Zn concentration also shows up on a geochemical map of Colorado based on data from stream sediments collected during the National Uranium Resource Evaluation (NURE) program (Plumlee and others, 1993; Grossman, 1998).
7. High concentrations of As, Cu, Hg, Pb, and Zn in northern Idaho corresponds to the Coeur d'Alene mining district, a region of historic base- and precious-metal mining (Ransome, 1908).
8. The southern Arizona porphyry copper province (Titley, 1982) is shown by increased abundance of Cu and Pb.
9. Immediately to the north of the Arizona copper province is a region of increased abundance of Cr, Ni, and V. This area seems to correspond to a belt of Precambrian rocks that include diabase, diorite, gabbro, pyroxenite, and basalt as shown by Wilson and others (1969).
10. The area of eastern Oregon and Washington showing high Fe, Mg, V, and Ti coincides with exposures of the Columbia River Basalt Group (Huntting and others, 1961; Swanson and others, 1979; Walker and MacLeod, 1991).
11. The Ca map shows two prominent highs—one extending from southern Texas, just east of the Big Bend area, into southeastern New Mexico and the other in western Utah and eastern Nevada. The area of high Ca in southern Texas and southeastern New Mexico shows close correspondence to outcrops of Lower Cretaceous and Permian limestones and Quaternary deposits derived from these limestones (Geologic Atlas of Texas, 1977, 1981, 1982; Dane and Bachman, 1965). The area in western Utah and eastern Nevada contains numerous exposures of Paleozoic limestones exposed by basin-and-range faulting (Stewart and Carlson, 1978; Hintze, 1980).
12. A slight increase in Pb abundance is noted in the vicinity of the cities of Cleveland, Ohio; Miami, Fla.; Buffalo, N.Y.; Pittsburgh, Pa.; Chicago, Ill.; San Francisco, Calif.; and Los Angeles, Calif. This may reflect an anthropogenic component of the geochemical landscape from industrial pollution and automobile exhaust.
13. The distribution of Hg shows generally higher concentrations in the Eastern than in the Western Unite

States. Specific areas with relatively high Hg concentrations are seen in the South along the coast of Louisiana, Mississippi, Alabama, and the Florida panhandle, and in the North along the coasts of Lake Michigan, Lake Superior, and Lake Huron. These features may be attributed to high contents of organic matter in samples from these coastal areas.

14. The pattern of elevated As concentration from western Pennsylvania through West Virginia, Kentucky, and Tennessee coincides, at least in part, with the Appalachian Basin, which produces high-arsenic coal, and with the distribution of power plants that burn the coal (Goldhaber and others, 2000).

These 14 examples are only a selection of geochemical patterns that can be related to known natural features or associated with anthropogenic pollution. Other observed patterns have no obvious explanation; for example, the higher abundance of Se in the Eastern United States as compared to the Western United States.

Reliability of the Geochemical Maps

A visual comparison of the sample-locality map (fig. 1) with each of the geochemical maps (figs. 3–24) shows no obvious geochemical patterns unique to either of the two sampling phases. For K, we have also estimated the correlation between pairs of neighboring samples, one originating in phase 1 and the other in phase 2 (fig. 26). The correlation coefficient for 31 such pairs is 0.65, which is significant at $p<0.01$. These results and the discussion in the Chemical Analysis section indicate that differences in analytical methods in the two phases of the project do not cause errors that overshadow the sampling errors.

The reliability of the obtained geochemical patterns can be judged by other comparisons. As pointed out by Darnley (1993), surface K abundance obtained by airborne gamma-ray spectrometry can provide an independent reference against which K distribution derived from sampling of surficial materials may be evaluated. Figure 27 shows the K map of the conterminous United States derived from aerial gamma-ray surveys (Duval and others, 1990; Duval and Riggle, 1999). A visual comparison of this map with the K map based on the ultra low density data of Shacklette and Boerngen (1984) (fig. 11) shows many similarities.

On both maps there is higher K abundance in the Western than in the Eastern United States, prominent K lows in the Gulf-Atlantic Coastal Flats, and prominent highs in the western United States from the Big Bend area of Texas across southern New Mexico and Arizona through southeastern California and Nevada. Both maps show what is evidently a redistribution of K from the upper regions of the Mississippi River system, where the source material is relatively K-rich, to the flood plains of the lower Mississippi, where the local surficial materials are relatively K-poor. In addition, features such as relative K-low areas are seen on both maps in (1) the Pacific

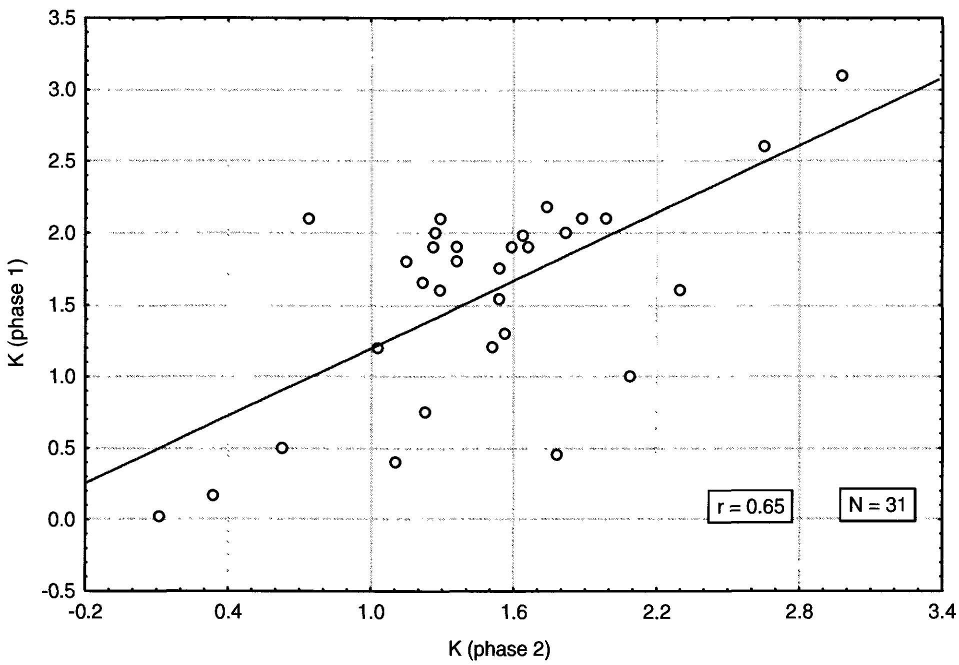

Figure 26. Plot of K in regolith from sample-collection phase 1 versus sample-collection phase 2. Only pairs separated by less than 25 km were included.

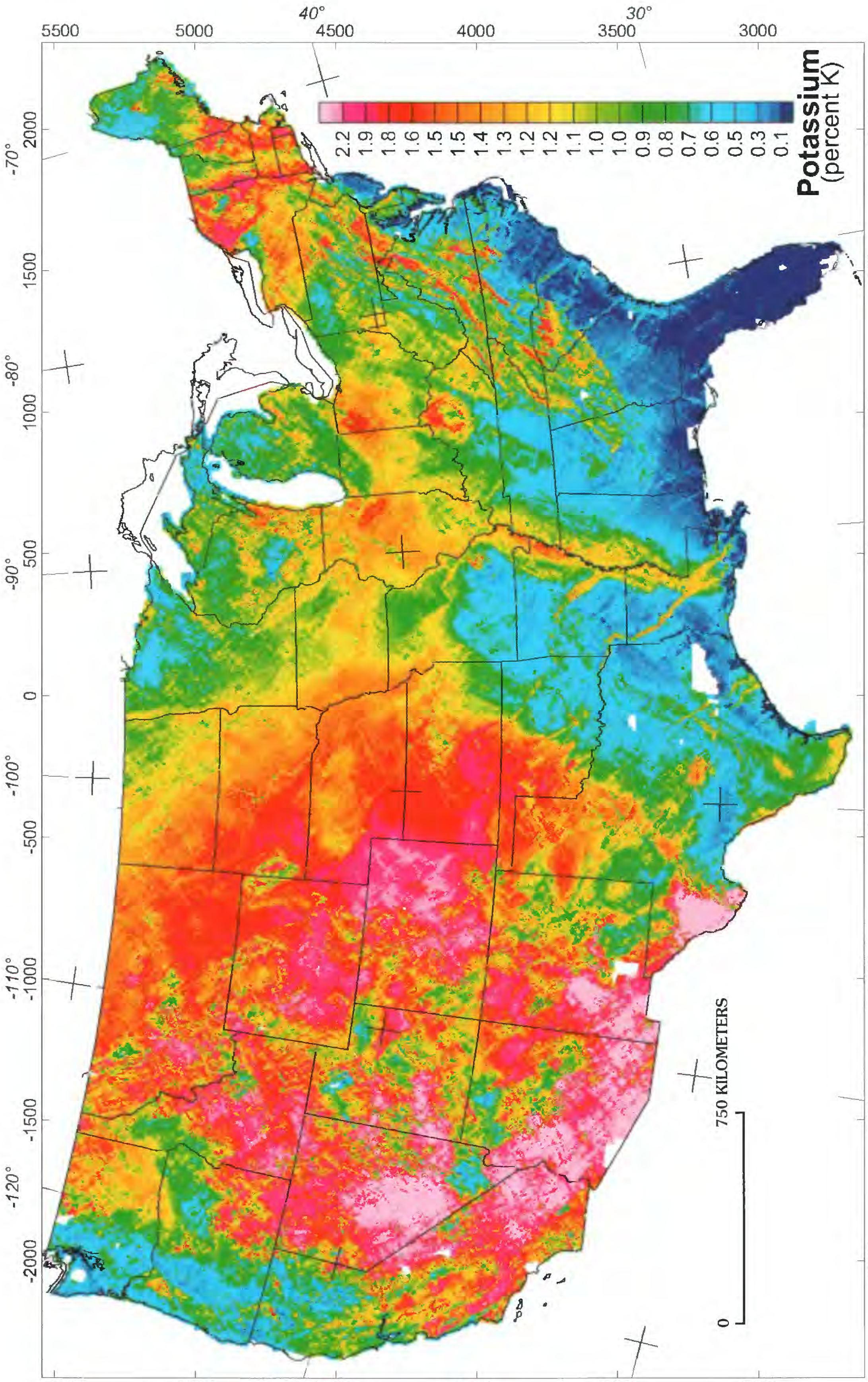

Figure 27. Potassium map of conterminous United States derived from aerial gamma-ray surveys (Duval and others, 1990; Duval and Riggle, 1999).

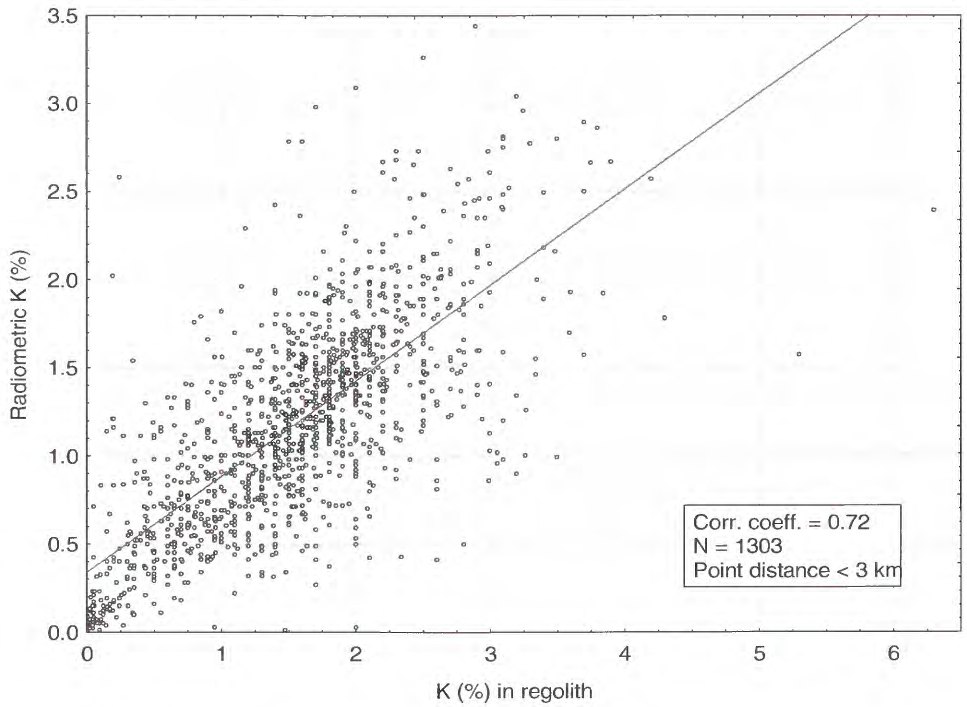

Figure 28. Plot of K in regolith versus radiometric K at the corresponding nearest point.

northwest, (2) the area through southern Missouri, eastern Oklahoma, western Arkansas, eastern Texas, and western Louisiana, and (3) the area through southern Kentucky, central Tennessee, eastern Mississippi, and Alabama.

The two data sets of K (regolith chemical analysis and airborne radiometry) were also compared statistically by (1) plotting a scattergram and estimating the correlation coefficient (Pearson's) for the overall covariation (fig. 28) and (2) by mapping a spatially moving correlation coefficient (Spearman-rank) for the survey area (fig. 29). The data pairs needed for these computations were generated by using the raw geochemical data and the radiometric values at the nearest grid point (Phillips and others, 1993) for each regolith sample. The scattergram and the overall coefficient of correlation (N = 1,323) were computed using standard methods. The scattergram (fig. 28) and the significant overall correlation coefficient (0.72) indicate that the two independent data sets reflect the same phenomena.

A moving correlation coefficient was estimated using a method introduced by Bølviken and others (1997). A circle was drawn around each sample site on the geochemical map in such a way that it included the 29 closest neighboring samples. The Spearman-rank correlation coefficient between the chemical and radiometric K values within the circle was calculated (29+1 = 30 pairs of values, 28 degrees of freedom) and assigned to the site. This procedure was repeated for all 1,323 sample sites. The resulting map shows the regional variation of the correlation coefficient between the two K data sets for mutually overlapping sets of 30 neighboring samples (fig. 29).

There may be effects of biases in the data. Shacklette and Boerngen (1984) point out apparent differences in values between certain sampling routes. Specifically, they mention high values for Ce, Co, Ga, and Pb predominate on the routes across the Great Plains and the North-Central States, suggesting the possibility of systematic errors in sampling or laboratory analysis. It seems, however, that the smoothing technique to some extent compensates for such errors because they are not easily detected on the colored maps.

Conclusions

The feasibility of ultra low density geochemical maps may be appraised by their ability to show regional geochemical patterns that (1) indicate large underlying geologic features, (2) reflect the influence of human activity, (3) agree with major features of the geochemical landscape obtained with higher sample density, and (4) correlate with other features such as soil types, climate, vegetation, etc. The examples given in the previous section indicate that many of the variations observed on the accompanying maps meet one or more of these criteria.

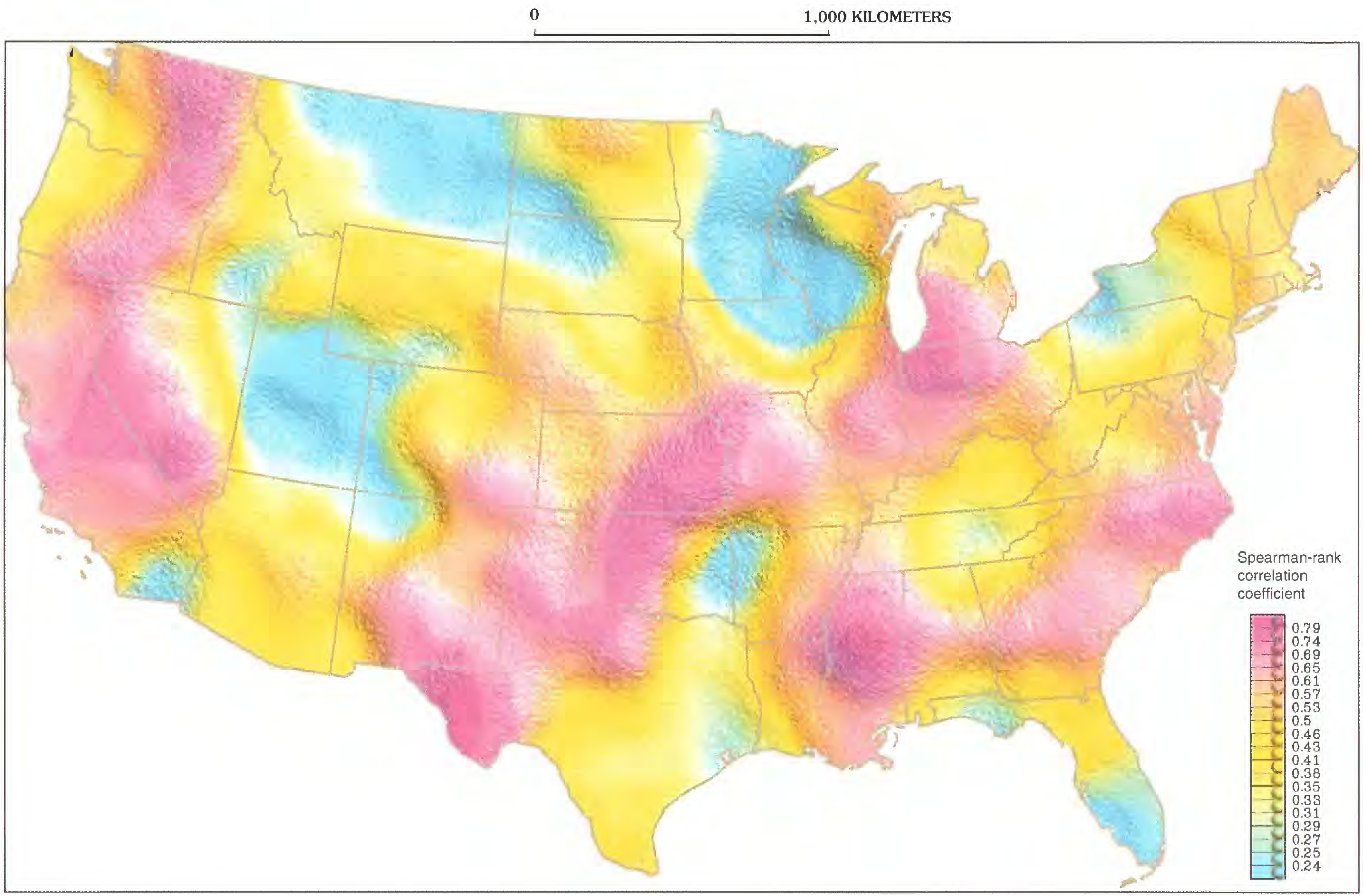

Figure 29. Map of conterminous United States showing the moving correlation (Spearman-rank correlation coefficient) between K in regolith samples (Boerngen and Shacklette, 1981) and K determined by airborne gamma-ray surveys (Phillips and others, 1993).

It is concluded that ultra low density geochemical maps such as those presented in this publication should have potential use in various fields since they may (1) establish general baselines against which more specific natural geochemical variations and human-induced perturbations can be recognized, (2) reflect large underlying geologic features and can therefore be used to delineate geochemical provinces of interest in exploration for mineral resources, (3) show how geochemical patterns in the regolith are influenced by natural features such as soil type, climate, and vegetation, (4) provide a basis for research within the field of geomedicine (environmental geochemistry and health), and (5) show large geochemical contrasts between continents, perhaps indicating that even sparser sampling than that used here could be adequate for global geochemical mapping.

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Scientific Investigations Report 2020–5047

U.S. Department of the Interior
U.S. Geological Survey

Cover images: Left, Utah Valley, 1986, Google Earth
Right, Utah Valley, 2016, Google Earth.

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Tables

Conversion Factors

U.S. customary units to International System of Units

Multiply	By	To obtain
acre-foot (acre-ft)	1,233	cubic meter (m^3)

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:
°F = (1.8 × °C) + 32.

Datum

Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83).

Supplemental Information

Concentrations of chemical constituents in water are given in either milligrams per liter (mg/L) or micrograms per liter (µg/L).

Abbreviations

EPA	U.S. Environmental Protection Agency
IQR	interquartile range
MCL	maximum contaminant levels
NTU	Nephelometric Turbidity Units
NWIS	National Water Information System
SDWA	Safe Drinking Water Act
SDWIS	Safe Drinking Water Information System
SMCL	secondary maximum contaminant level
USGS	U.S. Geological Survey

Quantifying Trends in Arsenic, Nitrate, and Dissolved Solids from Selected Wells in Utah

By Olivia L. Miller

Abstract

Groundwater makes up a primary portion of the water supply in many parts of Utah, with annual withdrawals estimated at more than 1,000,000 acre-feet per year. Increases to groundwater withdrawal and land use may negatively impact water availability. Ensuring availability of clean water requires understanding how water quality has changed over time and how natural and human activities and processes influence water quality. Changes in arsenic, nitrate, and dissolved-solids concentrations in the groundwater in basins with high groundwater withdrawals were evaluated between 1975 and 2015 as indicators of basinwide water quality and the suitability of water for drinking. Data were used from the U.S. Geological Survey's National Water Information System (NWIS) database and the Safe Drinking Water Information System (SDWIS) maintained by the Utah Department of Environmental Quality, Division of Drinking Water. Mann-Kendall trend tests were used to assess temporal trends in decadal and 5-year (sub-decadal) median analyte concentrations in basins. Trends also were assessed in smaller parts of larger basins to focus on changes occurring at a smaller spatial scale. To evaluate the relationship between land-use change and water-quality changes, trends also were evaluated for wells where land use has changed. Trends in decadal and sub-decadal median arsenic, nitrate, and dissolved-solids concentrations over time were identified throughout the basins and sub-basins in this study. For combined NWIS and SDWIS data, rates of median arsenic concentration change in basins and sub-basins ranged between decreases of –0.24 microgram per liter (ug/L) per year and increases of 0.48 ug/L per year. Rates of median nitrate-concentration change ranged between decreases of –0.08 milligram per liter (mg/L) per year and increases of 0.02 mg/L per year. Rates of median dissolved solids concentration change ranged between decreases of –5 mg/L per year and increases of 7 mg/L per year. The rates of change for nitrate and dissolved solids were similar to or less than rates of change observed in other parts of the country. Trends were not directly related to land-use change approximal to a well, although more data from wells where land use has changed would improve this evaluation. These findings highlight that water quality at a well is related to a range of factors including land, demographics, and water use over a larger area surrounding and up-gradient from the well; rates and direction of groundwater movement; and geologic and hydrologic conditions.

Introduction

Groundwater withdrawals in Utah have increased over time, mostly due to increased irrigation and industrial use (Burden, 2015). Groundwater also is used for public supply and serves as buffer for water suppliers when surface-water supplies decrease (for example, during summer months or drier years). Groundwater use is expected to play an even bigger role in meeting growing water demand as the population of Utah grows. The Utah Governor's Office of Planning and Budget estimates indicate that the population in Salt Lake County will nearly double from approximately 1 million people in 2010 to 1.8 million people by 2050 (Utah Governor's Office of Planning and Budget, 2012). Groundwater quality becomes increasingly important for supplying clean water to a growing population. Degradation of groundwater quality can have long-term negative implications for the viability of groundwater as a source of drinking water.

Groundwater has several advantages as a source for public water supply. Although surface-water supplies may be sensitive to precipitation and temperature variability on weekly to monthly timescales, groundwater integrates climatic conditions over multi-year timescales, making it a more constant supply. Groundwater also can be harder to contaminate than surface-water bodies because contaminants introduced at the land surface must travel through the subsurface to reach aquifers. Finally, groundwater withdrawal often occurs proximal to areas of demand, whereas surface water often requires conveyance over long distances (Price, 1985). These advantages, in addition to the relatively large volumes of groundwater relative to surface water, make groundwater an important source of water for future water use and management plans. However, for groundwater to continue to be a viable supply into the future, groundwater resources must be carefully managed by using knowledge of the groundwater conditions. Excessive withdrawals can result in declines in water levels leading to increased costs to drill wells, land-surface subsidence, water-quality deterioration, and conflicts over water rights.

This report investigates spatial and temporal trends in arsenic, nitrate, and dissolved-solids concentrations in basins that have experienced significant groundwater development in Utah. These analytes were selected for several reasons. Each analyte is regulated by the U.S. Environmental Protection Agency (EPA) and reflects different natural and anthropogenic processes. Increased concentrations of nitrate and dissolved solids, resulting from human activities, also are a common water-quality issues in the southwestern United States (U.S.; Thiros and others, 2010). Characterizing temporal and spatial patterns and trends in these analytes is important for regulatory compliance and for understanding impacts of different natural and anthropogenic influences.

Arsenic, a toxic element of concern for human and animal health, has been predicted to exceed drinking water standards in 43 percent of the area of basin-fill aquifers in the southwestern U.S. (Anning and others, 2012; Beisner and others, 2012). Arsenic often occurs naturally in aquifers from interactions between water and arsenic-bearing minerals in rocks. Generally, at local scales, human alteration of aquifer geochemical conditions such as pH or oxidation-reduction conditions can mediate arsenic concentrations in groundwater; this could occur through groundwater pumping or artificial recharge, or the addition or removal of an acid or base to the groundwater system. Increased loading of arsenic, through leaching of mining tailings, for example, also can impact groundwater arsenic concentrations.

Nitrate can occur naturally in groundwater through dissolution of geologic deposits or from desert legume soil processes; or it can be introduced to water by human activity through fertilizer use, manure production, and agricultural and urban land development (Anning and others, 2012). Nitrate can cause a range of negative human and animal health impacts.

Dissolved solids occur naturally in water through dissolution of geologic deposits, or through anthropogenic processes including land development, wastewater treatment plant discharge, and irrigation and other agricultural practices. Dissolved-solids concentrations can increase through water consumption (for example, diversion of clean water out of a basin or evapotranspiration), which reduces the amount of water available for dilution. High concentrations of dissolved solids can impact aquatic ecosystems, and agricultural, municipal, industrial, and domestic water users who require or prefer water with low dissolved solids.

Factors that Affect Water Quality

Natural and human factors can influence groundwater quality. In the southwestern U.S., several natural and human factors have been identified as important controls on groundwater quality including the quality of recharge water, the composition of geologic material in contact with water, land and water use, and chemical spills or leaks (Thiros and others, 2010). Bexfield and others (2011) described in detail common natural and human contamination sources to basin-fill aquifers in the southwestern U.S. Because these processes vary in time and space, and can work constructively or destructively, disentangling the effects of specific processes on water quality poses a unique challenge. In addition, assessment and process attribution of changing groundwater quality over time is further complicated by the multiyear to millennial timeframes of groundwater movement. The following paragraphs broadly describe natural and human factors, including changes to the hydrologic flow system and changes to constituent sources, that can influence arsenic, nitrate, and dissolved-solids concentrations in groundwater.

Natural factors can influence groundwater quality. The chemical composition and amount of recharge water can influence groundwater quality. The geologic composition of porous media through which water passes, the contact time, and geochemical conditions can greatly influence concentrations of dissolved solids and metals (for example, arsenic and uranium; Anning and others, 2007; Bexfield and others, 2011). In the Southwest, volcanic bedrock surrounding basin-fill aquifers, low rates of natural recharge from precipitation, high potential evapotranspiration, minimal basin outflow, and geochemical conditions all contribute to increased vulnerability of an aquifer to high arsenic concentrations (Anning and others, 2012). Recharge from mountain streams to basin-fill aquifers typically originates as snowmelt runoff and is generally of high quality (low dissolved solids). Dissolved-solids concentrations typically increase along flow paths through interactions with basin-fill sediments and evapotranspiration (Anning and others, 2007). Evapotranspiration and nitrate fixation by vegetation also can concentrate nitrate in soils, which can subsequently dissolve in recharge passing through soil and moving downward to aquifers.

Humans have influenced groundwater quality through alteration of the hydrologic flow system in Utah (Thiros and others, 2010). As groundwater pumping and use have increased, human-mediated recharge (for example, through infiltration of excess irrigation water and seepage from leaky canals, pipes, or ponds) has become an important component of the hydrologic system with potentially important impacts on groundwater quality. Increased pumping can alter flow patterns within an aquifer, leading to higher flows and thus higher connectivity, particularly from the land surface to shallow aquifers, thereby increasing the risk of contamination from the surface (Thiros and others, 2010). Recharge of water exposed to surface contamination can transport contaminants to aquifers. Historically, recharge has occurred through mountain block recharge or as infiltration through streams and alluvial fans at the base of mountains. However, as irrigation and development has increased, excess water from fields and yards and leaking canals and pipes has become a source of recharge to aquifers (Lambert, 1995). Excess irrigation and artificial recharge (for example, seepage from unlined canals, leaky pipes, or septic systems; or engineered recharge facilities including percolation ponds) can contribute substantially to increased concentrations of nitrate and dissolved solids in groundwater (Bexfield and others, 2011). Recharge of this kind poses a risk for degrading water quality in underlying aquifers because the water quality can be poor at the surface and this water is more susceptible to surface contamination. Recharge and flow rates, which also depend on sediment type and the presence of large fractures, control how quickly contaminated surface water moves into and through an aquifer. Coarser sediments with well-connected pore space allow for higher flows, whereas finer sediments with poorly connected pore space impede or even prevent flow. Flow rates determine the duration of contact between groundwater and aquifer material, and longer contact times can result in greater interaction between water and porous media, which controls constituent concentration.

Humans have also influenced groundwater quality through activities related to constituent source. Mining and mineral processing waste and leachate from landfills can contribute to increases in concentration of metals and dissolved solids in groundwater (Waddell and others, 1987). Commercial fertilizer application is the dominant source of nitrogen in agricultural areas of the western U.S. (Puckett, 1994) and in some urban areas (Hamlin and others, 2002). In agricultural areas, nitrate can be added to groundwater through infiltration of irrigation drainage containing nitrate (Edmonds and Gellenbeck, 2002), whereas in urban areas this can occur through recharge from leaky septic systems, water lines, septic systems, or lawn irrigation (Thiros, 2003). Regions with cropland and well drained soils are at greater risk for high nitrate levels in groundwater, particularly where irrigation is necessary (Spalding and Exner, 1993). Older or poorly constructed wells can exhibit increased nitrate in well water (Spalding and Exner, 1993). These processes also would contribute dissolved solids to groundwater.

Recharge of urban runoff and leaky infrastructure to aquifers can affect groundwater quality (Carlson and others, 2011). Road salt application has been proposed as a source of chloride in groundwater (Waddell and others, 1987). Broadly, numerous factors associated with urbanization could contribute to water-quality degradation, including changes in amount and type of water use, which could impact infiltrations patterns, irrigation with reclaimed wastewater, fertilizer and pesticide application, mining activities, septic system use, and water system infrastructure. Aging of urban water infrastructure such as sewage system pipes also makes it more susceptible to leaks, which can affect groundwater.

Effects and Regulation of Groundwater Contamination

Degradation of groundwater quality can result in human and animal health problems. Arsenic exposure can result in skin lesions, circulatory system problems, neuropathy, and increased risks of cancer and diabetes (Yu and others, 2003; Ahamed and others, 2006). Ingestion of nitrate in drinking water can cause methemoglobinemia (blue baby syndrome), which can be fatal for infants and livestock (Campbell and others, 1954; Ward and others, 2005). Nationally, nitrate is one of the most frequent anthropogenic contaminants to exceed human health standards in water from public-supply wells (Toccalino and others, 2010). High levels of dissolved solids in water can affect the taste and color of water, lead to mineral deposits on pipes and other infrastructures, and impact plants and animals that cannot tolerate saline water. Although dissolved solids can have limited impact on health, their presence can result in an aversion to the public water supply and be costly to treat.

To reduce the risks to human health arising from poor public-supply water quality, the EPA has defined Maximum Contaminant Levels (MCL) for a range of constituents in the National Primary Drinking Water Regulations, pursuant to the Safe Drinking Water Act (SDWA; U.S. Environmental Protection Agency, 2009). Primary drinking water regulations apply to a range of microorganisms, disinfectants and their byproducts, inorganic and organic chemicals, and radionuclides. Non-enforceable secondary maximum contaminant levels (SMCL), established in the National Secondary Drinking Water Regulations, have been developed to assist public water suppliers in managing water for color, taste, and odor qualities (U.S. Environmental Protection Agency, 2009). Secondary standards apply to dissolved solids, some metals and foaming agents, and pH. The State of Utah has primary and secondary standards consistent with federal regulations and has additional standards for dissolved solids (Utah Administrative Code, 2019; table 1).

Table 1. Primary and secondary drinking water standards.

[*Maximum total dissolveds solids levels are given in the Utah Primary Drinking Water Standards. Adapted from R309-200 (Monitoring and water quality: Drinking water standards, Utah Administrative Code) and U.S. Environmental Protection Agency (2009). **Abbreviations**: mg/L, milligrams per liter; >, greater than]

Contaminant	Maximum contaminant level (mg/L)	Secondary maximum contaminant level (mg/L)
Arsenic	0.010 (0.05 mg/L prior to 1/23/2006)	None
Nitrate	10 (as nitrogen)	None
Nitrite	1 (as nitrogen)	None
Total nitrate and nitrite	10 (as nitrogen)	None
Total dissolved solids*	2,000 (if concentration >1,000 mg/L, supplier must meet additional requirements)	500

Prior work has been completed to analyze conditions and trends of arsenic, nitrate, and dissolved solids in groundwater at regional, well, or basin-specific scales in Utah. Since 1964, the U.S. Geological Survey (USGS) has published yearly reports describing annual groundwater conditions, including annual water levels and water-quality measurements, although temporal changes in water quality are not generally addressed (Burden, 2017). A few examples of prior work that focused on arsenic, nitrate, or dissolved solids conditions, conducted at either the regional or local scale, are described below. These studies tended to examine shorter periods (years to decades) than the analysis presented in this report.

In a regional study of arsenic, Anning and others (2012) used statistical models to predict arsenic concentrations throughout basin-fill aquifers in the southwestern U.S. Of the total area of basin-fill aquifers in Utah, approximately 53 percent were predicted to have low arsenic concentrations (less than 10 micrograms per liter, µg/L), 24 percent were predicted to have concentrations between 10 and 24 µg/L, and 23 percent were predicted to have concentrations greater than or equal to 25 µg/L (Anning and others, 2012). Many of the high concentration areas were in western Utah.

A few studies have been conducted on arsenic conditions at the basin or well scale in Utah. For example, sources of arsenic have been investigated in Goshen Valley (in the Utah Valley basin in this study); geothermal springs had the highest arsenic concentrations, and groundwater interactions between alluvial or carbonate rocks also were associated with moderate arsenic concentrations (Selck and others, 2018). Arsenic in areas of residential development in the Salt Lake Valley was characterized, and no correlation between percentage of residential land use surrounding a well and arsenic concentration in well water was determined (Thiros, 2003). This study also reported higher arsenic concentration on the western and northwestern sides of the Salt Lake Valley than the eastern side, which were possibly related to sedimentology, redox conditions and reactions, proximity to faults and geothermal water, high concentrations of arsenic in canals, and the presence of volcanic rocks. Arsenic trends in the Great Salt Lake have been assessed and although mean concentrations were greater than 100 ug/L, consistent evidence for temporal trends was not identified (Adams and others, 2015).

In a regional study of nitrate concentrations in the Southwest, Anning and others (2012) used statistical models to predict nitrate concentrations throughout basin-fill aquifers. Nitrate concentrations were generally predicted to be less than 5 milligrams per liter (mg/L; Anning and others, 2012). Approximately 65 percent of the total area of basin-fill aquifers in Utah were predicted to have nitrate concentrations less than 0.5 mg/L, 10 percent were predicted to have concentrations between 0.5 and 0.99 mg/L, and 20 percent were predicted to have concentrations between 1.0 and 1.9 mg/L (Anning and others, 2012). Higher concentrations were predicted for shallower wells (Anning and others, 2012). A mapper also was developed to display spatio-temporal trends in nitrate in public-supply systems across the state (Wallace and Inkenbrandt, 2013).

Many studies have been conducted on nitrate conditions at the basin or well scale in Utah (fig. 1 shows a map of Utah). For example, geologic sources, septic-tank systems, and agricultural activities have been identified as potential sources of nitrate in groundwater in Cedar City Valley (Lowe and Wallace, 2001). Sources also were evaluated in Goshen Valley (part of Utah Valley in this study) where the highest nitrate concentrations occurred in agricultural areas, with manure being the major source (Selck and others, 2018). Nitrate conditions and sources in the Salt Lake Valley public-supply wells were characterized, and human influence (for example, from fertilizer application, or leaky septic systems or sewer pipes) was implicated in areas where nitrate concentrations were greater than 2–3 mg/L (39 percent of sampled public-supply wells; Thiros and Manning, 2004).

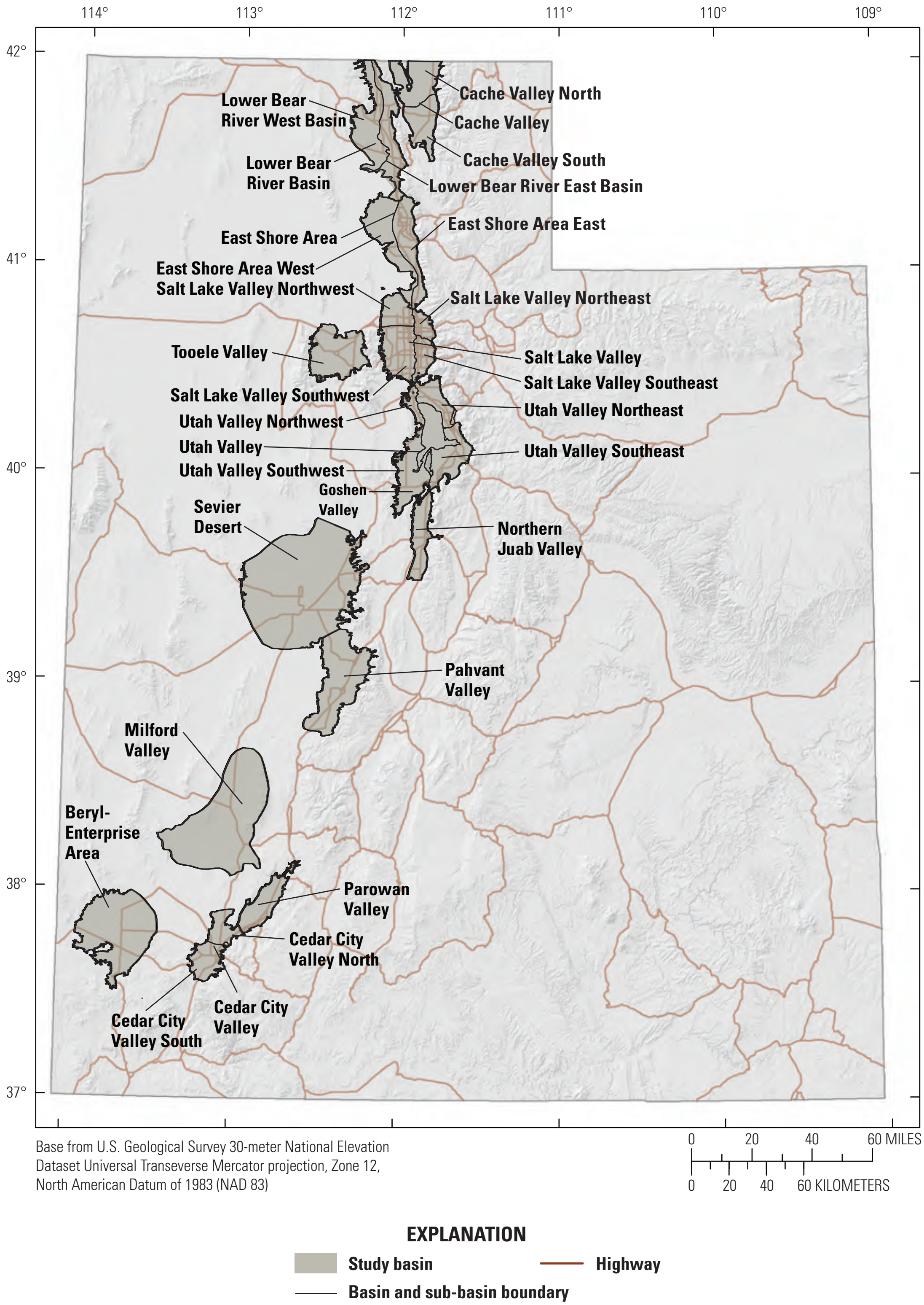


Figure 1. Study basins in Utah.

Nitrate occurrence and distribution in the Great Salt Lake Basins and Tooele Valley was described in Thiros (2000) and Susong (2005). Throughout the Great Salt Lake Basins, water from wells in agricultural or urban areas had higher nitrate concentrations than water from wells in rangeland areas, and in urban areas shallower wells had higher median nitrate concentrations than deeper wells. Groundwater quality in Cache Valley has been classified by nitrate concentration and shallower wells, and wells in discharge zones tended to have higher nitrate concentrations (Lowe and others, 2003). Nitrate concentrations and trends at several wells in Milford Valley were evaluated, and trends varied by well (Susong, 1996).

Anning and others (2007) conducted a regional study of dissolved-solids concentrations and trends in basin-fill aquifers and streams across the Southwest. Nearly 40 percent of the area of basin-fill aquifers in the southwestern U.S., including Utah, exceeded the SMCL for dissolved solids of 500 mg/L from the 1960s through the 1980s (Anning and others, 2007). Anning and others (2007) assessed dissolved solids trends in select wells in basin-fill aquifers across the Southwest for 1974–88, 1989–2003, and 1974–2003 and reported that concentrations of dissolved solids did not increase over time in most groundwater-quality monitoring wells. Of wells with trends, more showed increasing trends than decreasing trends (Anning and others, 2007).

Several studies have been conducted on dissolved solids conditions at the basin or well scale in Utah. For example, changes in dissolved-solids concentrations in wells in the Salt Lake Valley were determined (Waddell and others, 1987; Thiros and Manning, 2004; Thiros and Spangler, 2010). Among public-supply wells, dissolved-solids concentrations were generally lower on the eastern side of the valley than the western side, and the southeastern side of the valley had the lowest concentrations, although concentrations were increasing in some areas (Thiros and Manning, 2004; Thiros and Spangler, 2010). Increasing trends were identified in wells completed in the principal aquifer in the Salt Lake Valley between 1962 and 1984; seepage from reservoirs, evaporation ponds, and tailings piles contributed to increased dissolved-solids concentrations (Waddell and others, 1987). Dissolved solids have been used to classify groundwater in Cedar Valley, where 80 percent of the basin, primarily in the central and western parts, had concentrations less the 500 mg/L (Lowe and others, 2010). Although year-to-year fluctuations have occurred, few substantial changes in dissolved-solids concentrations over time were observed in the East Shore Area wells between 1960 and 1969 (Bolke and Waddell, 1972).

Purpose and Scope

This report presents the result of an analysis of trends in groundwater arsenic, nitrate, and dissolved-solids concentrations between 1975 and 2015 in selected basins characterized by high groundwater development. This analysis was conducted with support from the Utah Department of Environmental Quality, Division of Water Quality. The objectives of the analysis were to (1) compare data from two different databases and their combination to determine if samples from each database are comparable, and (2) identify and interpret trends in groundwater quality in select basins across Utah. Water-quality data come from the National Water Information System (NWIS) and Safe Drinking Water Information System (SDWIS) databases. This analysis provided a more temporally and spatially comprehensive assessment of the state of water quality in the selected basins throughout Utah.

Methods

A description of the study area, datasets used, data preparation, and statistical methods applied to the data are included in the following sections.

Study Area

Selected basins analyzed for this study included Cache Valley, Cedar City Valley, East Shore Area, Lower Bear River Basin, Milford Valley, Northern Juab Valley, Pahvant Valley, Parowan Valley, Salt Lake Valley, Sevier Desert, Tooele Valley, and Utah Valley (fig. 1). Milford Valley is similar to the area called the Milford area of Escalante Valley in the annual "Groundwater Conditions in Utah" reports (for example, Burden and others, 2017).

Data Sets Used

Water-quality data from two sources were used in this study: the USGS NWIS database and the EPA SDWIS database maintained by the Utah Department of Environmental Quality, Division of Drinking Water (Utah Division of Drinking Water, 2017). NWIS data were obtained from the USGS NWIS database (U.S. Geological Survey, 2017, https://waterdata.usgs.gov), and the SDWIS data were obtained from the SDWIS database (http://www.drinkingwater.utah.gov/).

The NWIS database contains water-quality data, beginning in 1911 through the time of this study from more than 6,000 wells in Utah, collected for local and regional studies or as part of an annual groundwater monitoring program in cooperation with the Utah Department of Natural Resources, Division of Water Rights, and Utah Department of Environmental Quality, Division of Water Quality. Wells were not necessarily sampled at regular time intervals. Data in NWIS represent samples taken at individual wells. Wells included had a wide range of depths and uses, from irrigation to monitoring to public supply; therefore, the source of water may have varied substantially.

The SDWIS database contains water-quality data from regular sampling of nearly 700 public-supply wells in accordance with the SDWA. Public-supply wells must be sampled every 3 years for inorganic and metal contaminants and sampled annually for nitrate unless a waiver is obtained. Samples for arsenic, total dissolved solids, nitrate, and nitrite are taken at the source. This study used SDWIS data from samples that were taken at single source wells before treatment or distribution. Data within the SDWIS database come from public-supply wells, which may bias the results toward cleaner water from potentially deeper wells, although exceptions may occur.

Data Preparation

Water-quality data from the NWIS and SDWIS databases were compiled (hereinafter referred to as NWIS samples and SDWIS samples). Data from the SDWIS database were limited to single source wells before treatment or distribution. Delineations of basin-fill aquifers (McKinney and Anning, 2009) were modified to focus on areas of substantial groundwater and agricultural development. Basins were further subdivided into sub-basins to evaluate trends on a smaller spatial scale. Subdivision was based on hydrologic unit code eight boundaries, and river and municipality locations.

For the trend analysis, datasets were limited to the years 1975–2015 for two reasons: (1) much of the SDWIS data were collected after the Safe Drinking Water Act of 1974 was enacted, and (2) to divide data into sub-decades of equal length. Arsenic data from 1,337 wells (598 NWIS wells and 739 SDWIS wells) were used. Nitrate data from 1,857 wells (1,051 NWIS wells and 806 SDWIS wells) were used. Dissolved solids data from 1,955 wells (1,173 NWIS wells and 782 SDWIS wells) were used.

Duplicate sample entries within datasets were excluded from the analysis. Additionally, some samples had multiple results reported for the same analyte (for example, dissolved solids reported as the sum of constituents and the residual on evaporation at 180 degrees Celsius; °C). For nitrate data, the order of preference was filtered nitrate, unfiltered nitrate, filtered nitrate plus nitrite, and finally unfiltered nitrate plus nitrite following Oelsner and others (2017). For dissolved solids data, values obtained from both methods were used, although the sum of a constituent’s value was preferentially selected over the residual on evaporation value (Liebermann and others, 1989).

Data were manually and visually inspected for unlikely measurement values such as concentrations in multiple orders of magnitude above other values from the same well, samples collected during drilling operations, or probable typographical errors. Suspect data were compared to original lab reports and other concentration data for a given site and were eliminated if obvious errors were identified. In the SDWIS database, data from one site were sometimes assigned to multiple wells in a basin. Such group assignments are coded into the SDWIS dataset during data reporting. However, for older data (1980s and older), group assignment of measurements was not coded. To eliminate replication, and thus artificial weighting of data that were sampled at one site but assigned to multiple sites, identical concentrations taken on the same date in the same basin and stored in the same database were filtered out and only one value was retained.

Comparison Between Data Collection and Analysis Methods for Data from National Water Information System and Safe Drinking Water Information System Databases

The water data in the NWIS and SDWIS databases differ in several ways. In addition to the challenges of combining water-quality data described by Sprague and others (2017), including missing or ambiguous sample fraction, chemical form, parameter name, units of measurement, precise numerical value, or remark codes, several differences between NWIS and SDWIS data were identified. Sample collection and analysis methods differ for sample filtration and well purging and pumping practices for NWIS and SDWIS data. NWIS samples are collected in accordance with the sampling procedures described in the USGS National Field Manual (U.S. Geological Survey, 2006) and analyzed according to a range of standardized methods. The SDWIS samples are collected according to 40 CFR 141.23 (U.S. Environmental Protection Agency, 1996). Some sampling and laboratory methods have changed over time because of technology advances and improved method development.

NWIS and SDWIS samples have different practices for sample filtration, well purging and pumping, and potentially different depths of sample collection. NWIS samples are generally collected after well purging and then are filtered in the field. Some NWIS groundwater samples for smaller studies are collected with low-flow pumps following well purging. Purging is meant to ensure samples are representative of ambient formation water and filtering is done for analysis of dissolved ions in water. Explicit purging of wells may not occur before collection of SDWIS samples, although wells used for public supply are generally pumped more frequently and for longer duration, and samples are not field filtered, although some lab filtering may occur. NWIS samples come from wells with a wide range of uses, from irrigation to monitoring to public supply, and can therefore come from shallow or deep wells. The SDWIS samples come from public-supply wells, which can bias the results toward cleaner water, and in many cases, deeper wells. The main sampling differences (filtration, pumping rate, purging, and well depth) influence particulate matter or turbidity in water, which can alter constituent measurements. Specifically, constituents can interact with particulate matter, thereby altering measured concentrations.

Although variation in sample collection and laboratory analysis procedures between NWIS and SDWIS samples exists, comparing data from the NWIS and SDWIS databases is justified because the sampling differences generally result in lower-turbidity samples that are more comparable. According to R309-200 (Monitoring and Water Quality: Drinking Water Standards) of the Utah Administrative Code, turbidity in samples of groundwater for public supply must be below 5 Nephelometric Turbidity Units (NTU). This is lower than the 100 NTU that Puls and Powell (1992) observed contribute to significant metal concentration differences between filtered and unfiltered water samples. Therefore, samples in SDWIS are biased toward low turbidity (unless they are in violation of that standard) so they should be comparable to filtered NWIS samples even if the lab does not filter samples (Puls and Powell, 1992). For samples with low turbidity, difference in filtration should not bias contaminant measurements between the two databases. In a nationwide study of trends in rivers and streams, concentrations of nitrate and nitrate plus nitrite from filtered samples were indistinguishable from unfiltered samples (Oelsner and others, 2017).

Because the data from the two databases were determined to be comparable (in other words, an analyte from one database is comparable to the same analyte in the other database), combining the datasets was therefore justified. Data stored in the NWIS and SDWIS databases were combined to increase the number of samples available for analysis and expand the temporal and spatial data coverage. Using information about groundwater conditions from multiple sources improves the robustness of the analysis against biases arising from different sampling strategies and protocols and provides a more comprehensive analysis of water quality. Accounting for all the variation and temporal changes in sampling and analysis is beyond the scope of this report, but it should be acknowledged to potentially induce variability and bias into datasets, which can make trend determination more difficult.

Data Analysis

Before trend analysis, the data from each database, and the combination of datasets, were compared to understand differences between datasets and how that may influence trend results. The Mann-Kendall trend test was used to identify and quantify monotonic trends in decadal and sub-decadal median concentrations of arsenic, nitrate, and dissolved solids in groundwater over time. Monotonic trends were of interest because they identify overarching, consistent changes in water quality over time. Trends were identified in decadal and sub-decadal median concentrations within each basin and smaller portions of some basins (sub-basins). To evaluate the effect of land-use change on water quality, trends were identified among wells in each basin that had experienced different kinds of land-use change.

Water-quality data are often censored (reported as less than a certain value). Data can be reported at multiple censoring limits because labs and analysis techniques change. The purpose of sample collection can even determine censoring limit; some concentrations in the SDWIS database are reported as less than the MCL instead of reported as the measured value. Although censored values contain information about water quality, they complicate common statistical calculations. A range of statistical techniques have been employed by various researchers to deal with censored data including substitution, maximum likelihood, regression on order statistics, and nonparametric treatments.

Trends were evaluated using the Mann-Kendall trend test, which uses Kendall's tau, a nonparametric correlation coefficient statistic that indicates the monotonic association between two variables (in this study, time and analyte concentration). Water-quality data rarely follow a normal distribution, which is required for parametric trend tests (for example, linear regression). The nonparametric Mann-Kendall trend test can determine a trend regardless of whether or not the data follow a normal distribution. Kendall's Tau, which ranges from 1 to –1, depends on the number of increases and decreases in concentration over time. If all median concentrations increased over time, tau would equal +1 and if all median concentrations decreased over time, tau would be –1. Consequently, noise in the concentration data reduces tau toward zero (similar number of increase and decreases over time). The Theil-Sen slope estimate of the trend line, a nonparametric analog to linear regression commonly used in environmental analysis, also was used and can be interpreted in this study as the rate of median-concentration changes over time. Trends were considered significant at the 90-percent confidence level if the two-sided p-value was less than 0.1.

To identify basin-wide trends in groundwater quality, decadal and sub-decadal nonparametric Kaplan-Meier estimates of summary statistics for each basin were calculated using a single concentration per well per year (Helsel, 2012). At least three concentrations per basin per decade or sub-decade were required to calculate a median concentration. Calculation of summary statistics and trend tests all account for censoring at multiple levels through the application of survival analysis methods to water-quality data (Helsel, 2012; Lee, 2017). In this study, the recommended nonparametric Kaplan-Meier technique for datasets with up to 50 percent censored observations was used to calculate decadal and sub-decadal summary statistics (for example, medians; Helsel, 2012). The relatively short period of record, low sampling frequency, or frequent occurrence of censored values for some analytes in some basins made identifying trends using decadal medians difficult. To address this issue, sub-decadal medians were calculated and used for trend analysis. This increased the number of observations at the expense of increased variability.

Mann-Kendall trend tests were then applied to the decadal and sub-decadal median concentrations in each basin for each constituent to identify trends in groundwater quality. Some basins also were sub-divided and trends were assessed in sub-basins of larger basins to focus on changes in water quality at a smaller spatial scale (fig. 1). Results from trend tests on the combined NWIS and SDWIS data and the SDWIS data are presented. The SDWIS trend results are included because they represent drinking water sources (before any treatment) and may therefore be of interest to public water suppliers.

Identified trends were compared to land-use change in each basin. To identify the connection between surface practices and groundwater quality, trends in wells where land use has changed in each basin were evaluated to determine the relationship between land-use change and trends in concentrations of arsenic, nitrate, and dissolved solids. Land-use changes in each basin were identified throughout the study area by comparing land use in 2012 to land use in 1974. The USGS National Water-Quality Assessment Wall-to-Wall Anthropogenic Land Use Trends dataset contains national 60-meter, 19-class mapping of anthropogenic land uses for five periods between 1974 and 2012 (Falcone, 2015). The dataset contains six broad land-use classes including water, developed, semi-developed, production, low use, and very low use/conservation. Developed land includes the built environment such as residences, places of employment, and recreation. Production land includes areas where natural resources are produced such as agricultural or natural resource extraction. These classes were lumped so that urban included developed and semi-developed land, and low use included low use and very low use/conservation in order to increase the number of wells in each class. Wells were classified based on the kind of land-use change (including no change) that had occurred directly at the well location (within 60-m grid cell) from 1974 to 2012. Mann-Kendall trend tests were then applied to decadal and sub-decadal medians in each basin for each constituent for all land-use change classes.

Well characteristics can change as land-use changes. For example, as more development of an area occurs, water demand may increase, prompting an increase in the number of wells or in the depth to which wells are drilled. Water quality can change with depth in a well. To avoid the confounding effects resulting from a potential increase in deeper wells as an area develops over time, NWIS wells shallower than 200 feet depth also were tested. Depth data was not available for many SDWIS wells and so SDWIS data was therefore not used for this part of the analysis. These shallow wells were expected to be the first to experience possible impacts from land-use change as well.

Results: Identification and Quantification of Groundwater-Quality Trends

Results of a comparison of data from each database and the combination of datasets is presented below, followed by a description of the trends analysis, and a comparison of trends to land-use change patterns.

Data Summary and Database Comparison

Generally, there are more data from the SDWIS database than the NWIS database. These results show differences and similarities between datasets from each database and how these differences may influence trend results. Variability across datasets introduces variability into the trend tests, which makes trend identification more difficult.

Arsenic

Widespread measurement of arsenic concentrations in wells began in the mid to late 1970s, roughly coincident with enactment of the Safe Drinking Water Act of 1974 (fig. 2; table 2). The SDWIS database contained more arsenic concentration data than the NWIS database, and generally covered a longer period of record. The number of measurements varied greatly by basin. Some sub-basins had fewer than 10 wells and fewer than 20 samples, and the period of record may only have extended back to the late 1980s, which increases the uncertainty in interpreting results for those areas.

Generally, the percentage of censored data in each basin and sub-basin was low, although many basins had between 30 and 50 percent censored data (table 2). The SDWIS data had a higher percentage of censored values than NWIS arsenic data and several basins had more than 50 percent censoring. This violates the recommendations for fewer than 50 percent censoring for the methods used in this study and therefore the results for these data are less reliable. When combining the NWIS and SDWIS data, there were fewer than 50 percent censored data in each basin except the East Shore Area. The NWIS data have fewer censored values than the SDWIS data.

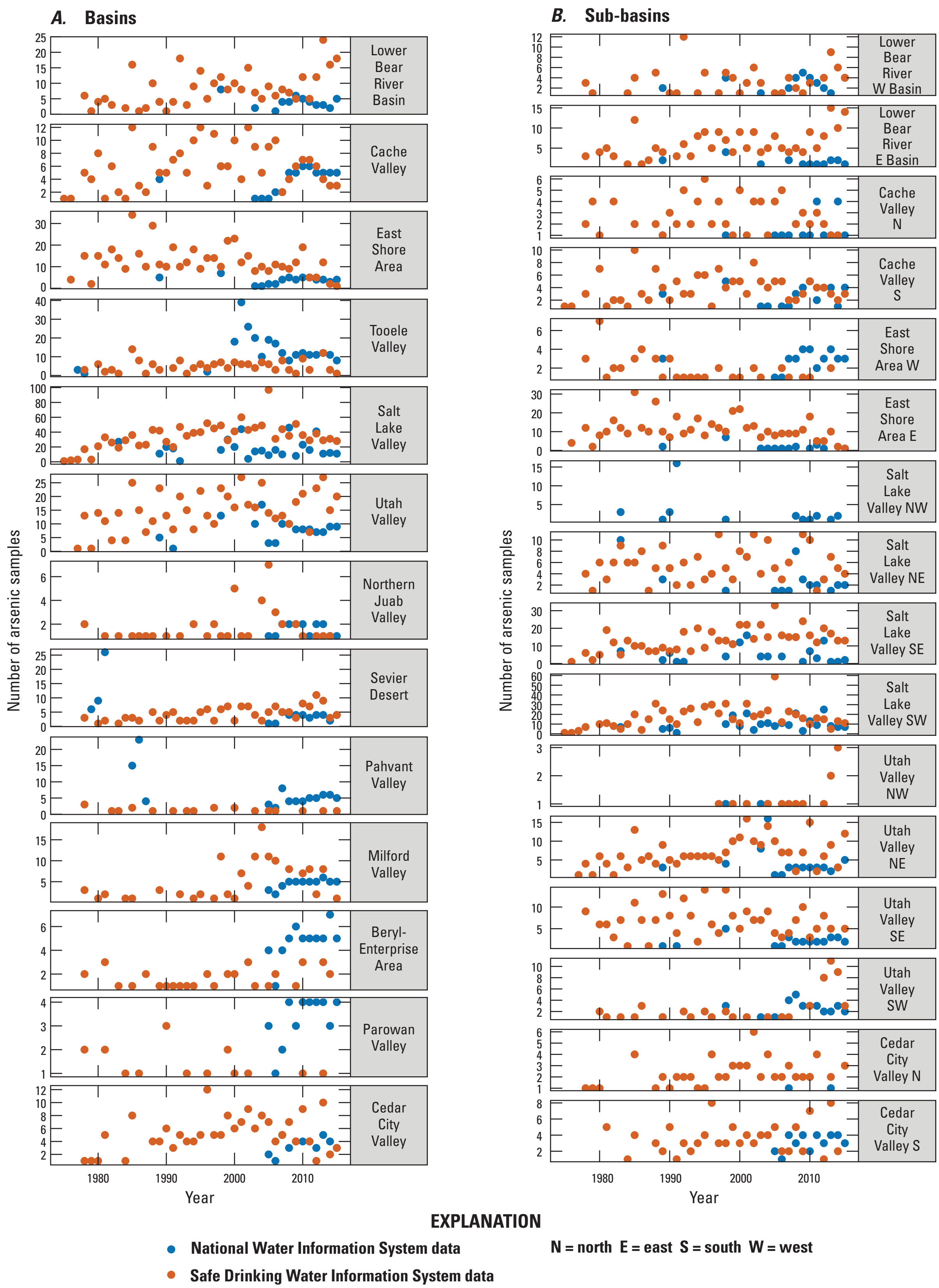


Figure 2. Number of arsenic samples over time in select Utah *A*, basins and *B*, sub-basins in the National Water Information System and Safe Drinking Water Information System datasets.

Table 2. Number of wells and arsenic samples; period of record; and minimum, maximum, and median concentration in select Utah basins and sub-basins for data from the National Water Information System (NWIS), Safe Drinking Water Information System (SDWIS), and combined NWIS and SDWIS data.

[Number in parentheses indicates the total number of wells. **Abbrevations**: µg/L, micrograms per liter; N, north; S, south; E, east; W, west; NE, northeast; NW, northwest; SE, southeast; SW, southwest]

Basin	Number of wells	Starting year	Ending year	Number of samples	Number of censored samples	Percent censored	Minimum concentration (µg/L)	Maximum concentration (µg/L)	Median concentration (µg/L)
Basins									
NWIS and SDWIS data combined (1,337)									
Beryl-Enterprise Area	23	1978	2015	90	15	17	0.04	95.7	3.8
Cache Valley	74	1975	2015	293	116	40	0.02	42.4	0.9
Cedar City Valley	58	1978	2015	212	70	33	0.1	15.7	2
East Shore Area	150	1976	2015	544	306	56	0.1	50	0.7
Lower Bear River Basin	80	1978	2015	356	116	33	0.1	106	2
Milford Valley	43	1978	2015	176	6	3	1	39	6.6
Northern Juab Valley	21	1978	2015	63	27	43	0.19	10	0.7
Pahvant Valley	61	1978	2015	115	17	15	0.21	19	2
Parowan Valley	17	1978	2015	53	6	11	0.5	11.3	3.8
Salt Lake Valley	412	1975	2015	1,814	499	28	0.005	360	2.1
Sevier Desert	78	1978	2015	231	20	9	0.08	730	8
Tooele Valley	125	1977	2015	421	108	26	0.005	206	1.5
Utah Valley	195	1977	2015	704	286	41	0.1	72.9	1.1
NWIS data (598)									
Beryl-Enterprise Area	18	2005	2015	52	1	2	0.04	95.7	3.9
Cache Valley	25	1989	2015	59	7	12	0.02	23.5	1
Cedar City Valley	11	2005	2015	38	0	0	0.3	6.4	0.88
East Shore Area	24	1989	2015	56	6	11	0.1	44	3.7
Lower Bear River Basin	29	1989	2015	51	2	4	0.1	95	1
Milford Valley	23	2005	2015	50	0	0	1.4	34.7	3.2
Northern Juab Valley	9	2005	2015	17	0	0	0.19	2.2	0.68
Pahvant Valley	54	1985	2015	94	7	7	0.21	19	2.3
Parowan Valley	12	2005	2015	36	0	0	1.5	11.3	4
Salt Lake Valley	182	1983	2015	423	48	11	0.005	360	5
Sevier Desert	51	1979	2015	79	2	3	0.08	730	8
Tooele Valley	87	1977	2015	251	30	12	0.005	206	1.8
Utah Valley	73	1989	2015	128	6	5	0.1	18	2.1
SDWIS data (739)									
Beryl-Enterprise Area	5	1978	2014	38	14	37	0.1	10	2.9
Cache Valley	49	1975	2015	234	109	47	0.3	42.4	0.8
Cedar City Valley	47	1978	2015	174	70	40	0.1	15.7	2.4
East Shore Area	126	1976	2015	488	300	61	0.1	50	0.7
Lower Bear River Basin	51	1978	2015	305	114	37	0.2	106	2.3
Milford Valley	20	1978	2015	126	6	5	1	39	9
Northern Juab Valley	12	1978	2014	46	27	59	0.4	10	0.7
Pahvant Valley	7	1978	2015	21	10	48	0.5	10	1
Parowan Valley	5	1978	2013	17	6	35	0.5	8	2

Table 2. Number of wells and arsenic samples; period of record; and minimum, maximum, and median concentration in select Utah basins and sub-basins for data from the National Water Information System (NWIS), Safe Drinking Water Information System (SDWIS), and combined NWIS and SDWIS data.—Continued

[Number in parentheses indicates the total number of wells. **Abbrevations**: µg/L, micrograms per liter; N, north; S, south; E, east; W, west; NE, northeast; NW, northwest; SE, southeast; SW, southwest]

Basin	Number of wells	Starting year	Ending year	Number of samples	Number of censored samples	Percent censored	Minimum concentration (µg/L)	Maximum concentration (µg/L)	Median concentration (µg/L)
Basins—Continued									
SDWIS data (739)—Continued									
Salt Lake Valley	230	1975	2015	1,391	451	32	0.1	50	1.9
Sevier Desert	27	1978	2015	152	18	12	0.5	62	8
Tooele Valley	38	1978	2015	170	78	46	0.1	23	1.1
Utah Valley	122	1977	2015	576	280	49	0.1	72.9	0.9
Sub-basins									
NWIS and SDWIS data combined (969)									
Cache Valley N	22	1978	2015	105	41	39	0.02	42.4	2.0
Cache Valley S	52	1975	2015	188	75	40	0.09	25.0	0.7
Cedar City Valley N	21	1978	2015	74	27	36	0.5	11.7	3.0
Cedar City Valley S	37	1981	2015	138	43	31	0.1	15.7	1.6
East Shore Area E	124	1976	2015	462	282	61	0.1	50.0	0.6
East Shore Area W	26	1978	2015	82	24	29	0.5	42.5	3.1
Lower Bear River Basin E	48	1978	2015	231	84	36	0.1	106.0	1.7
Lower Bear River Basin W	32	1978	2015	125	32	26	0.2	95.0	2.2
Salt Lake Valley NE	66	1978	2015	259	108	42	0.1	60.0	0.8
Salt Lake Valley NW	23	1983	2014	33	4	12	1	360.0	20.0
Salt Lake Valley SE	153	1976	2015	634	233	37	0.1	60.0	0.9
Salt Lake Valley SW	170	1975	2015	888	154	17	0.005	110.0	6.0
Utah Valley NE	97	1977	2015	325	145	45	0.1	72.9	1.0
Utah Valley NW	7	1997	2014	17	1	6	0.5	34.0	4.0
Utah Valley SE	72	1978	2015	272	137	50	0.1	53.0	0.7
Utah Valley SW	19	1980	2015	90	3	3	0.5	18.0	9.2
NWIS data (344)									
Cache Valley N	7	1989	2015	20	3	15	0.02	17.3	5.9
Cache Valley S	18	1989	2015	39	4	10	0.09	23.5	0.9
Cedar City Valley N	2	2007	2013	4	0	0	2	3.0	2.3
Cedar City Valley S	9	2005	2015	34	0	0	0.3	6.4	0.9
East Shore Area E	12	1989	2015	22	6	27	0.1	44.0	0.7
East Shore Area W	12	1989	2015	34	0	0	0.84	42.5	14.0
Lower Bear River Basin E	10	1989	2015	18	2	11	0.1	7.3	1.7
Lower Bear River Basin W	19	1989	2015	33	0	0	0.66	95.0	1.0
Salt Lake Valley NE	26	1983	2015	52	6	12	0.34	60.0	1.1
Salt Lake Valley NW	23	1983	2014	33	4	12	1	360.0	20.0
Salt Lake Valley SE	59	1983	2015	115	13	11	0.12	60.0	1.0

Table 2. Number of wells and arsenic samples; period of record; and minimum, maximum, and median concentration in select Utah basins and sub-basins for data from the National Water Information System (NWIS), Safe Drinking Water Information System (SDWIS), and combined NWIS and SDWIS data.—Continued

[Number in parentheses indicates the total number of wells. **Abbrevations**: µg/L, micrograms per liter; N, north; S, south; E, east; W, west; NE, northeast; NW, northwest; SE, southeast; SW, southwest]

Basin	Number of wells	Starting year	Ending year	Number of samples	Number of censored samples	Percent censored	Minimum concentration (µg/L)	Maximum concentration (µg/L)	Median concentration (µg/L)
Sub-basins—Continued									
NWIS data (344)—Continued									
Salt Lake Valley SW	74	1983	2015	223	25	11	0.005	110.0	8.0
Utah Valley NE	40	1989	2015	61	3	5	0.1	6.0	1.7
Utah Valley NW	3	1998	2004	3	0	0	0.8	4.0	2.7
Utah Valley SE	15	1989	2015	30	3	10	0.4	11.0	0.6
Utah Valley SW	15	1989	2015	34	0	0	0.93	18.0	6.4
SDWIS data (625)									
Cache Valley N	15	1978	2014	85	38	45	0.5	42.4	1.5
Cache Valley S	34	1975	2015	149	71	48	0.3	25.0	0.7
Cedar City Valley N	19	1978	2015	70	27	39	0.5	11.7	3.4
Cedar City Valley S	28	1981	2014	104	43	41	0.1	15.7	2.0
East Shore Area E	112	1976	2015	440	276	63	0.1	50.0	0.6
East Shore Area W	14	1978	2013	48	24	50	0.5	34.0	1.0
Lower Bear River Basin E	38	1978	2015	213	82	38	0.3	106.0	1.6
Lower Bear River Basin W	13	1978	2015	92	32	35	0.2	62.0	3.2
Salt Lake Valley NE	40	1978	2015	207	102	49	0.1	11.0	0.7
Salt Lake Valley SE	94	1976	2015	519	220	42	0.1	23.0	0.9
Salt Lake Valley SW	96	1975	2015	665	129	19	0.1	50.0	5.0
Utah Valley NE	57	1977	2015	264	142	54	0.5	72.9	0.7
Utah Valley NW	4	1997	2014	14	1	7	0.5	34.0	10.8
Utah Valley SE	57	1978	2015	242	134	55	0.1	53.0	0.7
Utah Valley SW	4	1980	2015	56	3	5	0.5	14.8	10.6

The maximum concentration in most basins and all sub-basins was at or above the arsenic MCL of 10 ug/L for NWIS and SDWIS data combined. The NWIS data in several basins including Sevier Valley, Salt Lake Valley, and Tooele Valley had maximum concentrations of more than 100 ug/L. However, for NWIS data, SDWIS data, and combined data, the median concentration in all basins was below 10 ug/L and most were below 5 ug/L. A paired two-sided t-test indicated that the medians of the NWIS and SDWIS datasets, the SDWIS and combined datasets, and the NWIS and combined datasets were not significantly different (p-value greater than 0.05). Among NWIS data, some sub-basins had maximum concentrations below the MCL such as Cedar City Valley North, Cedar City Valley South, Lower Bear River Basin East, Utah Valley Northeast, and Utah Valley Northwest. Among SDWIS data, all sub-basins had maximum concentrations above the MCL.

The distribution of concentrations in individual and combined datasets is shown for each basin and sub-basin in figure 3. Most concentrations in each basin fell below the MCL. However, concentrations in the Sevier Desert, Milford Valley, and Beryl-Enterprise Area were generally elevated relative to the other basins and had more regulatory exceedances. The distribution of concentrations in individual and combined datasets was generally similar within a given basin. However, in some basins the distributions vary; for example, in Milford Valley, the NWIS interquartile range (IQR) was completely below and outside the IRQ of the SDWIS and combined datasets, indicating that the NWIS data was distinctly lower than the SDWIS and combined datasets in this area. The NWIS distribution extended higher than the SDWIS distribution in some basins (for example, the East Shore Area) and lower in others (for example, Milford Valley and Cedar City Valley); the differences between datasets were not systematic across basins. The variability of concentrations also differed by basin. For example, Parowan Valley had a much narrower range of concentrations than the Salt Lake Valley.

The distribution of arsenic concentrations of NWIS, SDWIS, and combined NWIS and SDWIS data is shown for each sub-basin in figure 3. There are several sub-basins that had IQRs that exceed the MCL including the East Shore Area East, Salt Lake Valley Northwest, Salt Lake Valley Southwest, Utah Valley Northwest, and Utah Valley Southwest.

Arsenic concentration data in each basin for each dataset over time are shown in figure 4; concentrations varied substantially by basin. At the time of this study, widespread exceedance of the MCL of 10 ug/L occurred in the studied basins (figs. 3, 4). Some basins had many exceedances (for example, Lower Bear River Basin, East Shore Area, Utah Valley, and Milford Valley), whereas some basins had concentrations that exceeded the regulatory standard by a factor of ten (for example, Tooele Valley, Salt Lake Valley, and Sevier Desert). In some basins, regulatory exceedances were rare (for example, Northern Juab Valley, Pahvant Valley, and Parowan Valley). The MCL changed in 2002 from 50 to 10 ug/L. Many basins had data that exceeded the old standard as well. The locations of wells with samples that exceeded the MCL are shown in figure 5. The Salt Lake Valley had many instances of regulatory exceedance. The greater number of samples taken may account for some of the high number of regulatory exceedances relative to the other basins.

Arsenic concentration data in each sub-basin for each dataset over time are shown in figure 4. In Cache Valley, Cache Valley North had higher concentration data than Cache Valley South, although the high concentration data is generally only from 2000 to 2015; whereas in Cache Valley South, more regulatory exceedances occurred in the period from 1975 to 2000 than in Cache Valley North. In Cedar City Valley, the number, magnitude, and timing of regulatory exceedances was similar. In the East Shore Area, the western sub-basin had more exceedances among NWIS data. Lower Bear River Basin East had fairly regular regulatory exceedances, and the concentrations could be greater than 50 ug/L. In Lower Bear River Basin West, regulatory exceedances were rare, but they could be greater than 50 ug/L when they did occur. In the Salt Lake Valley, the Northwest sub-basin had the highest arsenic concentrations, followed by the southwestern sub-basin. Higher arsenic concentrations on the western and northwestern part of the Salt Lake Valley were consistent with the findings of Thiros (2003); the Northeast and Southeast had similar concentrations, with a few high concentration regulatory exceedances in the mid-1980s and a few infrequent exceedances between the 1980s and 2010s. In Utah Valley, the northeastern part had the highest concentrations, followed by the southeastern part; the northwestern sub-basin has a much shorter period of record compared to the rest of the basin.

The decadal and sub-decadal medians for each dataset and combined datasets are shown for each basin and sub-basin in figure 6. In general, the medians for individual and combined datasets were similar over time; there was no obvious systematic bias. The medians for NWIS, SDWIS, and combined data largely agreed, and the sub-decadal medians were more variable over time, whereas the decadal medians were smoother over time. Several basins had median concentrations that exceeded the MCL. The NWIS medians were consistently higher than the other medians in several basins (for example, the East Shore Area and Salt Lake Valley). The variation among medians was greatest in the Sevier Desert area. In Milford Valley, the NWIS period of record was much shorter than the SDWIS records and so the medians were less comparable to other medians.

In Cache Valley North, the NWIS data had a much shorter period of record than the SDWIS data. In the East Shore Area West, the NWIS medians were consistently higher than the SDWIS or combined data medians. In Utah Valley Northwest there were fewer data and the period of record was shorter, resulting in fewer medians than in other sub-basins, over a shorter period of time. There were only NWIS data in the Salt Lake Valley Northwest.

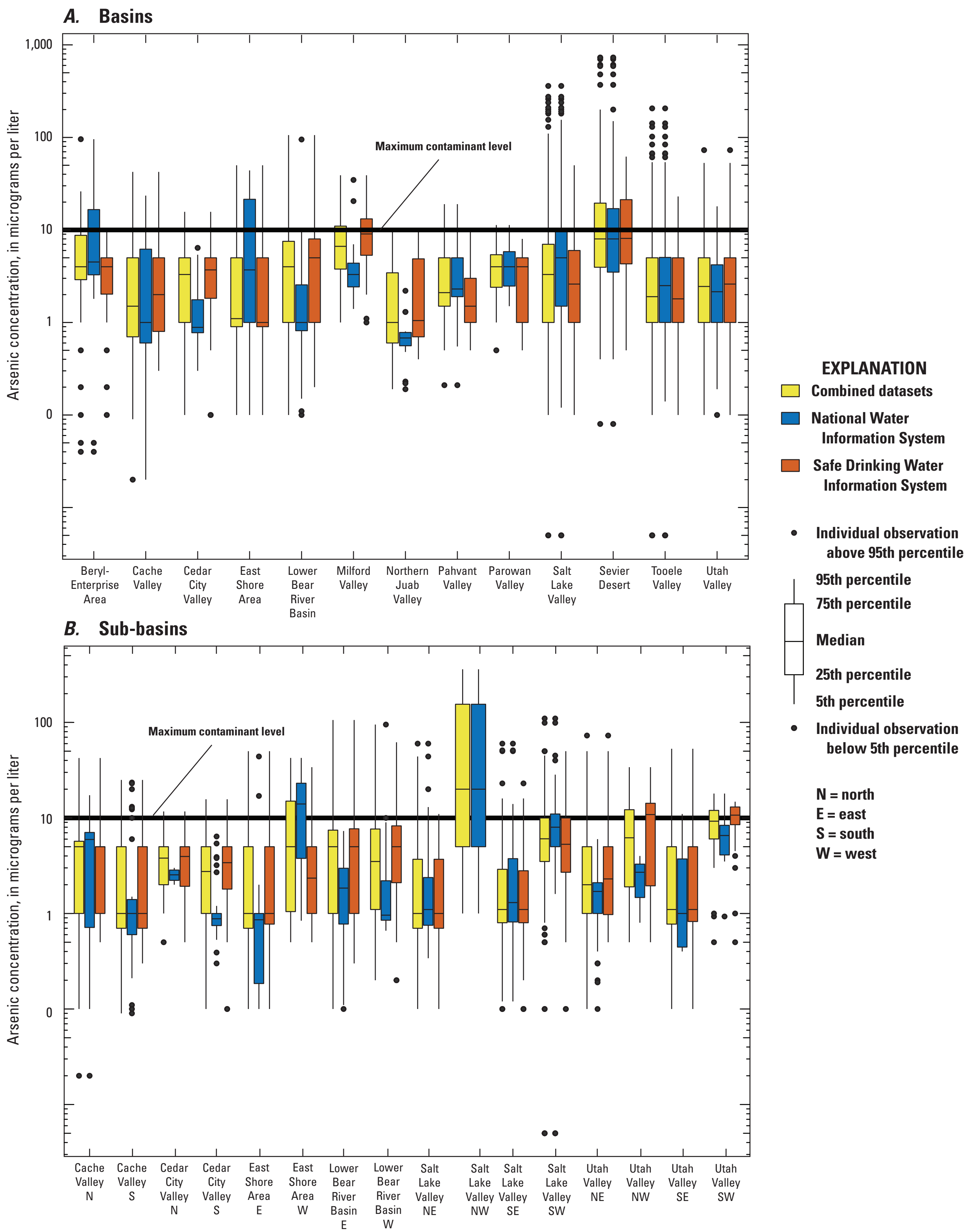


Figure 3. Arsenic concentrations in select Utah *A,* basins and *B,* sub-basins for data from the National Water Information System and Safe Drinking Water Information System, and combined datasets.

Item 1.

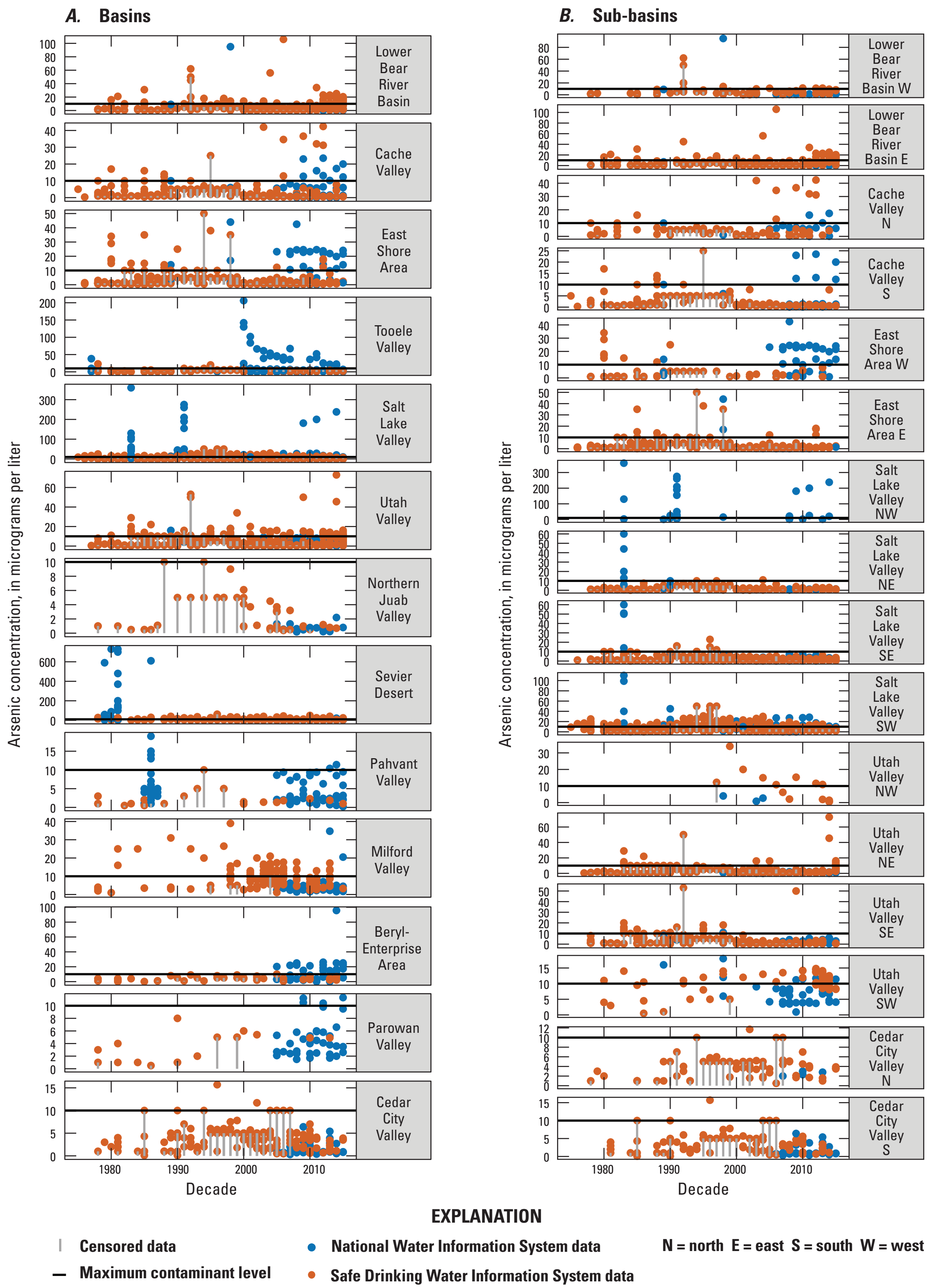


Figure 4. Arsenic concentrations over time by database in select Utah *A,* basins and *B,* sub-basins.

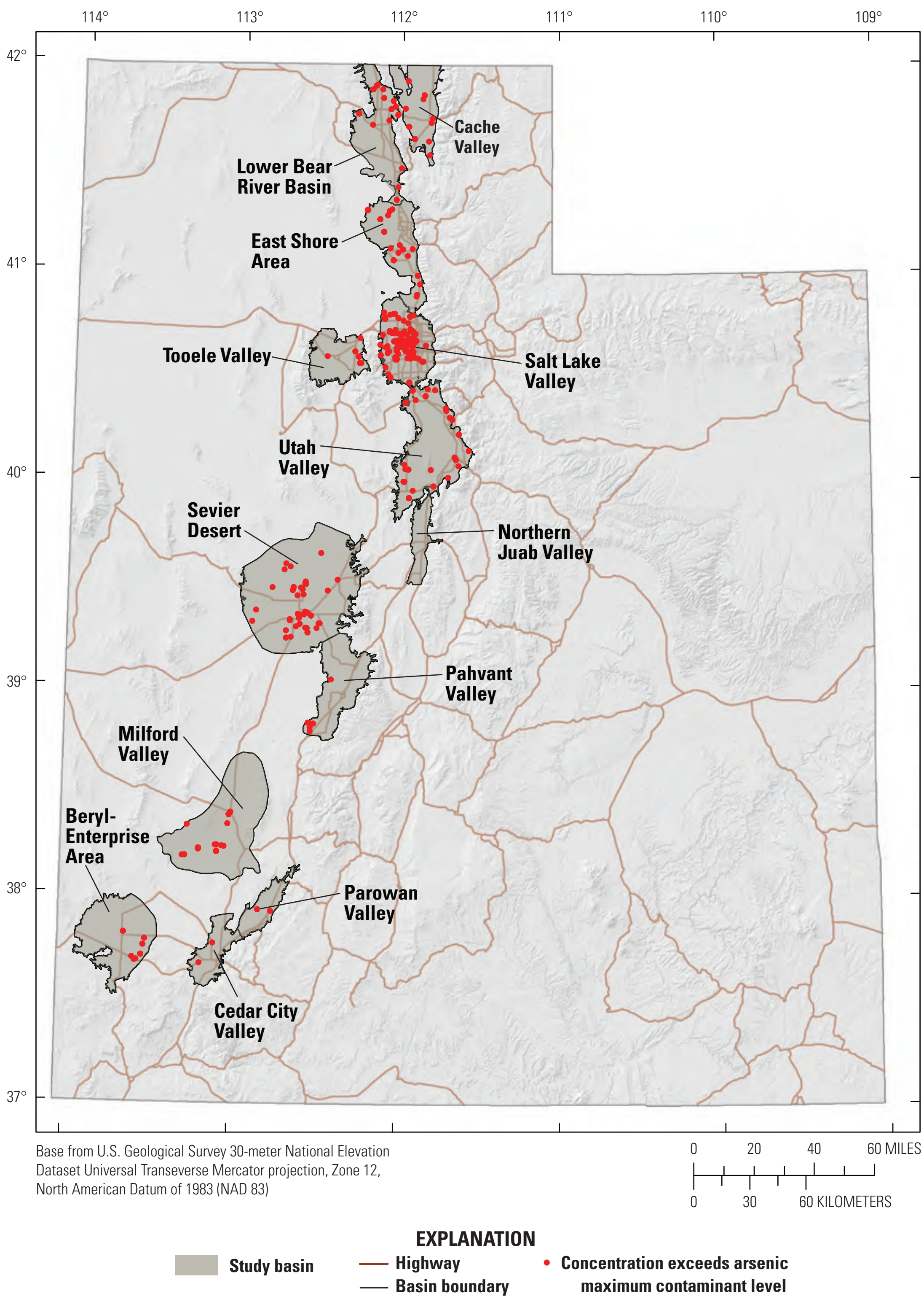


Figure 5. Location of wells with sample concentrations that exceed the maximum contaminant level for arsenic in select basins in Utah.

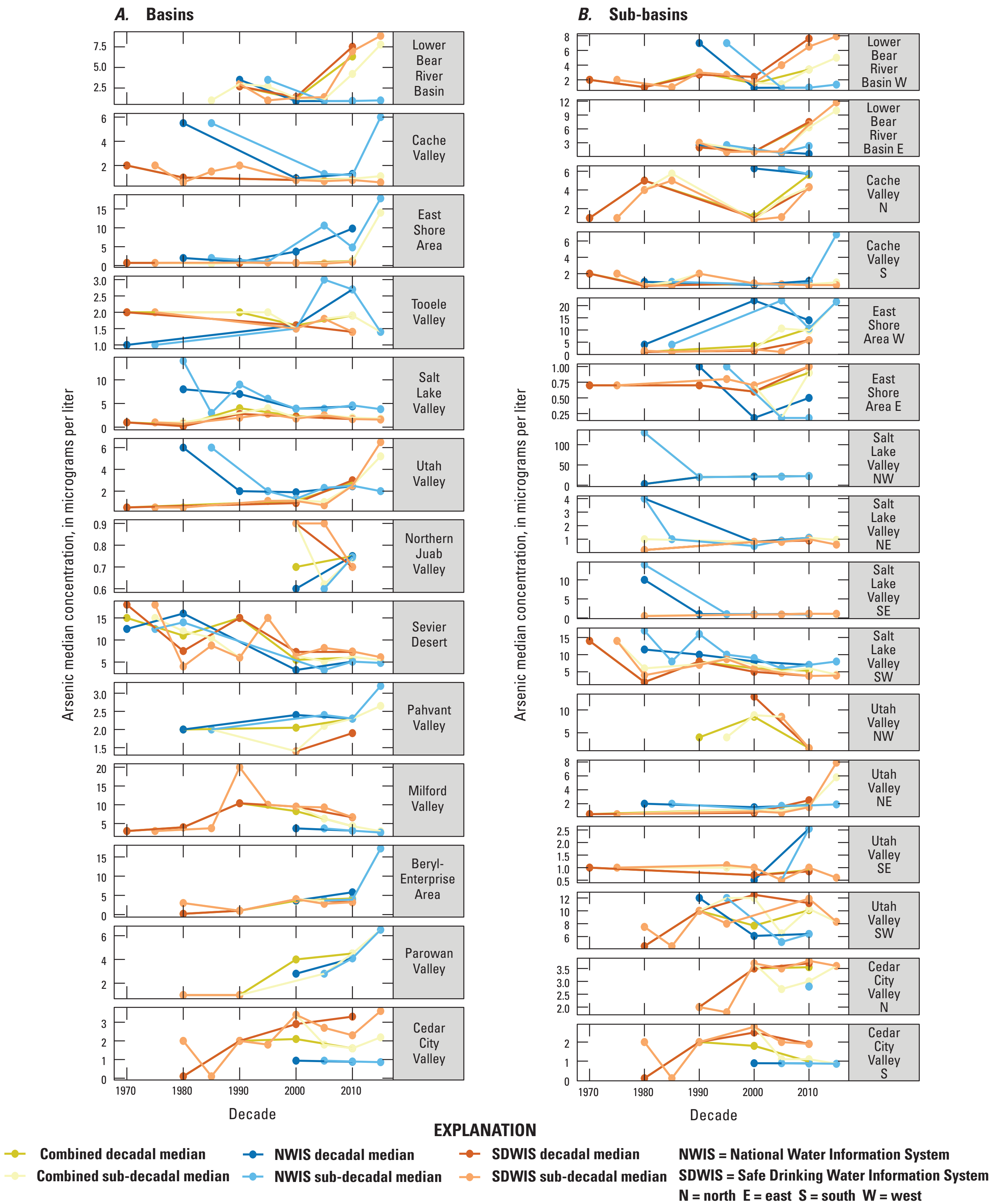


Figure 6. Decadal and sub-decadal median arsenic concentration in select *A,* basins and *B,* sub-basins in Utah.

Nitrate

Widespread measurement of nitrate concentrations in wells began in the mid to late 1970s, roughly coincident with enactment of the Safe Drinking Water Act of 1974, although the purpose of many USGS studies (NWIS data) at that time was to document the suitability of water resources for use (table 3; fig. 7). The SDWIS database contained more nitrate concentration data than the NWIS database, although there were more NWIS data in some basins including the Beryl-Enterprise Area, Pahvant Valley, and Parowan Valley. The number of wells and measurements varied greatly by basin and sub-basin. Several sub-basins had fewer than 10 wells including Utah Valley Northwest (combined NWIS and SDWIS data, NWIS data, and SDWIS data), and Utah Valley Southwest (SDWIS data only); this reduces the ability to detect trends in these areas. Generally, unfiltered nitrate samples from the SDWIS database, filtered nitrate plus nitrite samples from the NWIS database, and unfiltered nitrate plus nitrite samples from the SDWIS database were the most numerous sample types in each basin (fig. 7).

Generally, the percentage of censored measurements in each basin and sub-basin was low and was below 50 percent in all basins (table 3). For the combined datasets, the Sevier Desert had the highest percentage of censored values with 19 percent censored values.

Maximum concentrations exceeded the nitrate MCL of 10 mg/L in all basins except Parowan Valley for NWIS and SDWIS combined data. The NWIS maximum concentration was above the nitrate MCL in most basins, whereas the SDWIS maximum concentration was above the MCL in 6 out of 13 basins. The median concentrations in all basins for NIWS data, SDWIS data, and combined NWIS and SDWIS data were below 5 mg/L. Many sub-basins had maximum concentrations that exceeded the MCL, although the median in all basins for all datasets was well below the MCL. A paired two-sided t-test indicated that the medians of the NWIS and SDWIS datasets and the SDWIS and combined datasets are statistically different (p-value less than 0.05). The medians of the NWIS and combined datasets were not significantly different (p-value greater than 0.05).

The distribution of concentrations in individual and combined datasets is shown for each basin in figure 8. The IQR of concentrations in each basin and for individual and combined datasets fell below the MCL. The distribution of concentrations for individual and combined datasets was generally similar within a given basin. In some basins, the distributions of datasets varied. In Cache Valley and the East Shore Area, the NWIS IQR extended much lower than the IQR of SDWIS or combined datasets. Northern Juab Valley and Pahvant Valley had the highest IQRs relative to the other basins, whereas the Salt Lake Valley had the highest outlier values. The variability of concentrations also differed by basin. For example, the Beryl-Enterprise Area had a much narrower range of concentrations than the Sevier Desert.

The distribution of nitrate concentrations of NWIS, SDWIS, and combined NWIS and SDWIS data also is shown for each sub-basin in figure 8. The IQR of all data types fell below the MCL except NWIS data in Utah Valley Southwest. Most basins had some data above the MCL. The IQR for each data type within a sub-basin were generally similar with a few notable exceptions. The IQR of NWIS data in Cache Valley North and East Shore Area West was much lower than the SDWIS or combined datasets. The IQR of NWIS and combined datasets in the Salt Lake Valley Northwest were the same because there is no SDWIS data from this area. The Salt Lake Valley Northeast had the highest concentration data.

Nitrate concentration data in each basin and sub-basin for each database over time are shown in figure 9. Concentrations varied substantially by basin. Some basins had many or severe MCL exceedances (for example, Cache Valley, Tooele Valley, Salt Lake Valley, Utah Valley, and Pahvant Valley). In some basins, regulatory exceedances were rare or non-existent (for example, Northern Juab Valley, Beryl-Enterprise Area, and Parowan Valley). Exceedances occur in SDWIS and, more commonly, NWIS data. The locations of wells with nitrate samples that exceeded the MCL are shown in figure 10.

Concentrations exceeded the MCL in nearly every sub-basin except Cache Valley South, Cedar City Valley South, Salt Lake Valley Northwest, Utah Valley Northeast, and Utah Valley Northwest. In Cache Valley, Cache Valley North had more high concentration data than Cache Valley South. In Cedar City Valley, the concentration data were similar except for some higher concentration NWIS data from the early 2000s in the northern sub-basin. In the East Shore Area, the West sub-basin had overall lower concentration data, and both areas had very few samples that exceeded the MCL. In the Lower Bear River Basin, the West sub-basin had more data that exceeds the MCL, although these samples were NWIS data that may not represent water used for drinking water. In the Salt Lake Valley, the Northeast and Southwest sub-basins had the highest nitrate concentration data, although these data were from only a few samples. The data in the Northwest sub-basin were all below the MCL. The Southeast sub-basin had some data that exceeded the MCL, although it was all NWIS data that may not represent water used for drinking water. In Utah Valley, the Southwest and Southeast sub-basins had the highest concentrations. All of the data that exceeded the MCL in the Southwest sub-basin came from the NWIS database and may not represent drinking water.

The decadal and sub-decadal median nitrate concentrations for individual and combined datasets in each basin and sub-basin are shown in figure 11. Medians were below the MCL of 10 mg/L in all basins, although they were above the MCL in several sub-basins (Cache Valley North, Utah Valley Southwest, and Cedar City Valley North). In general, the medians for individual and combined datasets were similar within a basin or sub-basin. The NWIS medians were higher than the other medians in several basins (for example, Milford Valley and Cedar City Valley). The variation among medians for different datasets was greatest in Pahvant Valley.

Table 3. Number of wells and nitrate samples; period of record; and minimum, maximum, and median concentration in select Utah basins and sub-basins for data from the National Water Information System (NWIS) and Safe Drinking Water Information System (SDWIS), and combined NWIS and SDWIS data.

[Number in parentheses indicates the total number of wells. **Abbrevations**: mg/L, milligrams per liter; N, north; S, south; E, east; W, west; NE, northeast; NW, northwest; SE, southeast; SW, southwest]

Basin	Number of wells	Starting year	Ending year	Number of samples	Number of censored samples	Percent censored	Minimum concentration (mg/L)	Maximum concentration (mg/L)	Median concentration (mg/L)
NWIS and SDWIS data combined (1,857)									
Beryl-Enterprise Area	35	1975	2015	306	2	1	0.04	10.0	1.93
Cache Valley	97	1975	2015	818	41	5	0.01	18.9	1.26
Cedar City Valley	107	1975	2015	720	15	2	0.02	19.5	1
East Shore Area	212	1975	2015	1,731	212	12	0.01	18.0	1
Lower Bear River Basin	96	1975	2015	809	45	6	0.001	27.9	1.08
Milford Valley	55	1975	2015	377	23	6	0.01	40.3	0.77
Northern Juab Valley	40	1975	2015	208	1	0	0.01	42.0	3.4
Pahvant Valley	78	1975	2015	363	4	1	0.02	43.3	3.2
Parowan Valley	44	1975	2015	160	20	13	0.01	6.4	1.35
Salt Lake Valley	486	1975	2015	3,934	262	7	0.01	86.0	1.4
Sevier Desert	87	1975	2015	412	79	19	1.00E–06	22.0	0.37
Tooele Valley	223	1975	2015	1,032	12	1	0.02	36.9	1.7
Utah Valley	297	1975	2015	2,344	153	7	9.00E–04	46.0	0.83
NWIS data (1,051)									
Beryl-Enterprise Area	29	1975	2015	206	0	0	0.04	10.0	1.96
Cache Valley	37	1979	2015	86	14	16	0.02	8.9	0.6
Cedar City Valley	58	1975	2015	149	0	0	0.035	19.5	2.02
East Shore Area	77	1975	2015	171	54	32	0.01	18.0	0.3
Lower Bear River Basin	42	1975	2015	120	17	14	0.01	27.9	1.68
Milford Valley	34	1975	2015	177	1	1	0.08	40.3	2.49
Northern Juab Valley	28	1975	2015	88	0	0	0.46	42.0	4.9
Pahvant Valley	71	1975	2015	297	3	1	0.05	43.3	3.2
Parowan Valley	39	1975	2015	109	3	3	0.04	6.4	1.71
Salt Lake Valley	239	1976	2015	626	86	14	0.01	86.0	1.43
Sevier Desert	58	1975	2015	127	5	4	0.01	22.0	0.58
Tooele Valley	175	1975	2015	437	8	2	0.02	36.9	2.53
Utah Valley	164	1975	2015	321	36	11	0.02	46.0	1.3
SDWIS data (806)									
Beryl-Enterprise Area	6	1978	2015	100	2	2	0.1	7.2	1.64
Cache Valley	60	1975	2015	732	27	4	0.01	18.9	1.35
Cedar City Valley	49	1977	2015	571	15	3	0.02	10.6	0.9
East Shore Area	135	1976	2015	1,560	158	10	0.01	11.6	1.02
Lower Bear River Basin	54	1977	2015	689	28	4	0.001	15.6	1
Milford Valley	21	1978	2015	200	22	11	0.01	6.4	0.4
Northern Juab Valley	12	1978	2015	120	1	1	0.01	9.7	2.9
Pahvant Valley	7	1978	2015	66	1	2	0.02	9.1	3.2
Parowan Valley	5	1978	2015	51	17	33	0.01	1.2	0.2
Salt Lake Valley	247	1975	2015	3,308	176	5	0.01	70.0	1.4

Table 3. Number of wells and nitrate samples; period of record; and minimum, maximum, and median concentration in select Utah basins and sub-basins for data from the National Water Information System (NWIS) and Safe Drinking Water Information System (SDWIS), and combined NWIS and SDWIS data.—Continued

[Number in parentheses indicates the total number of wells. **Abbrevations**: mg/L, milligrams per liter; N, north; S, south; E, east; W, west; NE, northeast; NW, northwest; SE, southeast; SW, southwest]

Basin	Number of wells	Starting year	Ending year	Number of samples	Number of censored samples	Percent censored	Minimum concentration (mg/L)	Maximum concentration (mg/L)	Median concentration (mg/L)
SDWIS data (806)—Continued									
Sevier Desert	29	1978	2015	285	74	26	1.00E–06	6.2	0.3
Tooele Valley	48	1977	2015	595	4	1	0.02	5.3	1.15
Utah Valley	133	1976	2015	2,023	117	6	9.00E–04	23.1	0.8
Sub-basins									
NWIS and SDWIS data combined (1,295)									
Cache Valley N	28	1977	2015	318	23	7	0.01	18.85	1.7
Cache Valley S	69	1975	2015	500	18	4	0.01	8.84	0.88
Cedar City Valley N	37	1977	2015	291	3	1	0.035	19.5	1.1
Cedar City Valley S	70	1975	2015	429	12	3	0.02	8.98	0.9
East Shore Area E	176	1975	2015	1,549	156	10	0.01	11.6	1.1
East Shore Area W	36	1975	2015	182	56	31	0.01	18	0.2
Lower Bear River Basin E	60	1977	2015	563	42	7	0.001	15.6	0.8
Lower Bear River Basin W	36	1975	2015	246	3	1	0.05	27.9	2.25
Salt Lake Valley NE	82	1976	2015	615	42	7	0.01	86.0	1.6
Salt Lake Valley NW	25	1976	2014	41	29	71	0.01	5.0	0.0
Salt Lake Valley SE	179	1976	2015	1,715	64	4	0.01	21.0	1.2
Salt Lake Valley SW	200	1975	2015	1,563	127	8	0.01	70.0	1.7
Utah Valley NE	165	1976	2015	1,020	47	5	9.00E–04	5.9	0.8
Utah Valley NW	9	1980	2015	32	1	3	0.06	4.6	1.1
Utah Valley SE	92	1975	2015	1,151	89	8	0.01	23.1	0.8
Utah Valley SW	31	1975	2015	141	16	11	0.01	46.0	1.5
NWIS data (617)									
Cache Valley N	10	1979	2015	31	7	23	0.02	8.9	0.1
Cache Valley S	27	1979	2015	55	7	13	0.037	6.7	1.2
Cedar City Valley N	18	1977	2013	39	0	0	0.035	19.5	1.5
Cedar City Valley S	40	1975	2015	110	0	0	0.25	9.0	2.1
East Shore Area E	57	1975	2015	109	17	16	0.01	11.2	1.0
East Shore Area W	20	1975	2014	62	37	60	0.01	18.0	0.0
Lower Bear River Basin E	19	1977	2015	57	16	28	0.01	11.0	0.4
Lower Bear River Basin W	23	1975	2015	63	1	2	0.05	27.9	2.6
Salt Lake Valley NE	39	1976	2015	94	8	9	0.019	86.0	4.3
Salt Lake Valley NW	25	1976	2014	41	29	71	0.01	5.0	0.0
Salt Lake Valley SE	77	1976	2015	208	12	6	0.01	21.0	1.2
Salt Lake Valley SW	98	1976	2015	283	37	13	0.03	25.0	1.9
Utah Valley NE	102	1976	2015	166	24	14	0.02	4.4	0.9
Utah Valley NW	5	1980	2004	5	1	20	0.06	3.1	2.0
Utah Valley SE	30	1975	2015	74	8	11	0.02	15.4	1.5
Utah Valley SW	27	1975	2015	76	3	4	0.05	46.0	4.3

Table 3. Number of wells and nitrate samples; period of record; and minimum, maximum, and median concentration in select Utah basins and sub-basins for data from the National Water Information System (NWIS) and Safe Drinking Water Information System (SDWIS), and combined NWIS and SDWIS data.—Continued

[Number in parentheses indicates the total number of wells. **Abbrevations**: mg/L, milligrams per liter; N, north; S, south; E, east; W, west; NE, northeast; NW, northwest; SE, southeast; SW, southwest]

Basin	Number of wells	Starting year	Ending year	Number of samples	Number of censored samples	Percent censored	Minimum concentration (mg/L)	Maximum concentration (mg/L)	Median concentration (mg/L)
Sub-basins—Continued									
SDWIS data (678)									
Cache Valley N	18	1977	2015	287	16	6	0.01	18.9	2.0
Cache Valley S	42	1975	2015	445	11	2	0.01	8.8	0.8
Cedar City Valley N	19	1977	2015	252	3	1	0.07	10.6	1.1
Cedar City Valley S	30	1977	2015	319	12	4	0.02	6.8	0.7
East Shore Area E	119	1976	2015	1,440	139	10	0.01	11.6	1.1
East Shore Area W	16	1977	2015	120	19	16	0.01	5.4	0.7
Lower Bear River Basin E	41	1977	2015	506	26	5	0.001	15.6	0.8
Lower Bear River Basin W	13	1978	2015	183	2	1	0.2	4.0	2.2
Salt Lake Valley NE	43	1977	2015	521	34	7	0.01	31.7	1.4
Salt Lake Valley SE	102	1976	2015	1,507	52	3	0.01	6.0	1.2
Salt Lake Valley SW	102	1975	2015	1,280	90	7	0.01	70.0	1.7
Utah Valley NE	63	1977	2015	854	23	3	9.00E–04	5.9	0.8
Utah Valley NW	4	1997	2015	27	0	0	0.1	4.6	1.1
Utah Valley SE	62	1976	2015	1,077	81	8	0.01	23.1	0.8
Utah Valley SW	4	1977	2014	65	13	20	0.01	2.2	1.1

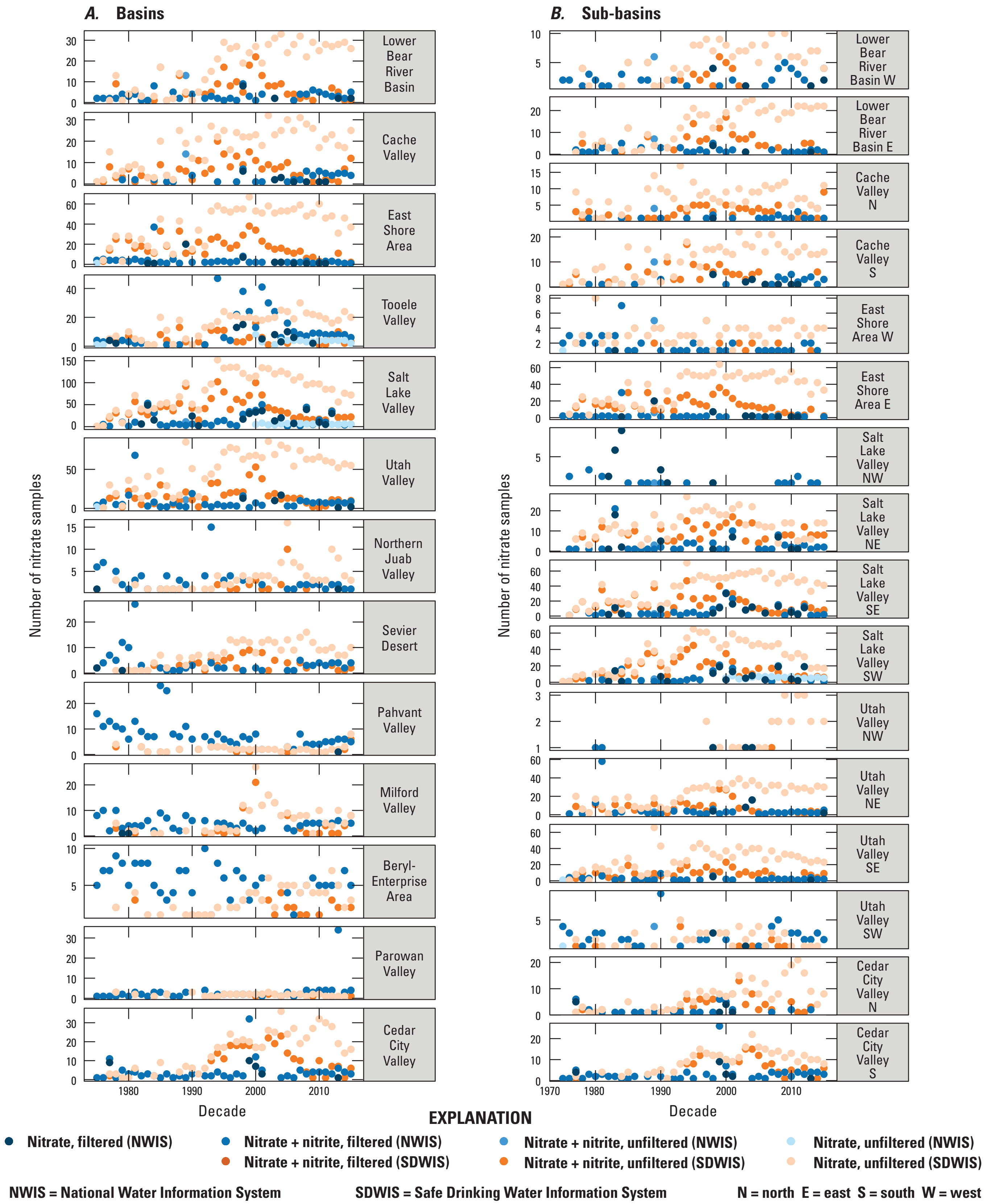


Figure 7. Number of nitrate samples over time in select Utah *A*, basins and *B*, sub-basins in the National Water Information System and Safe Drinking Water Information System datasets.

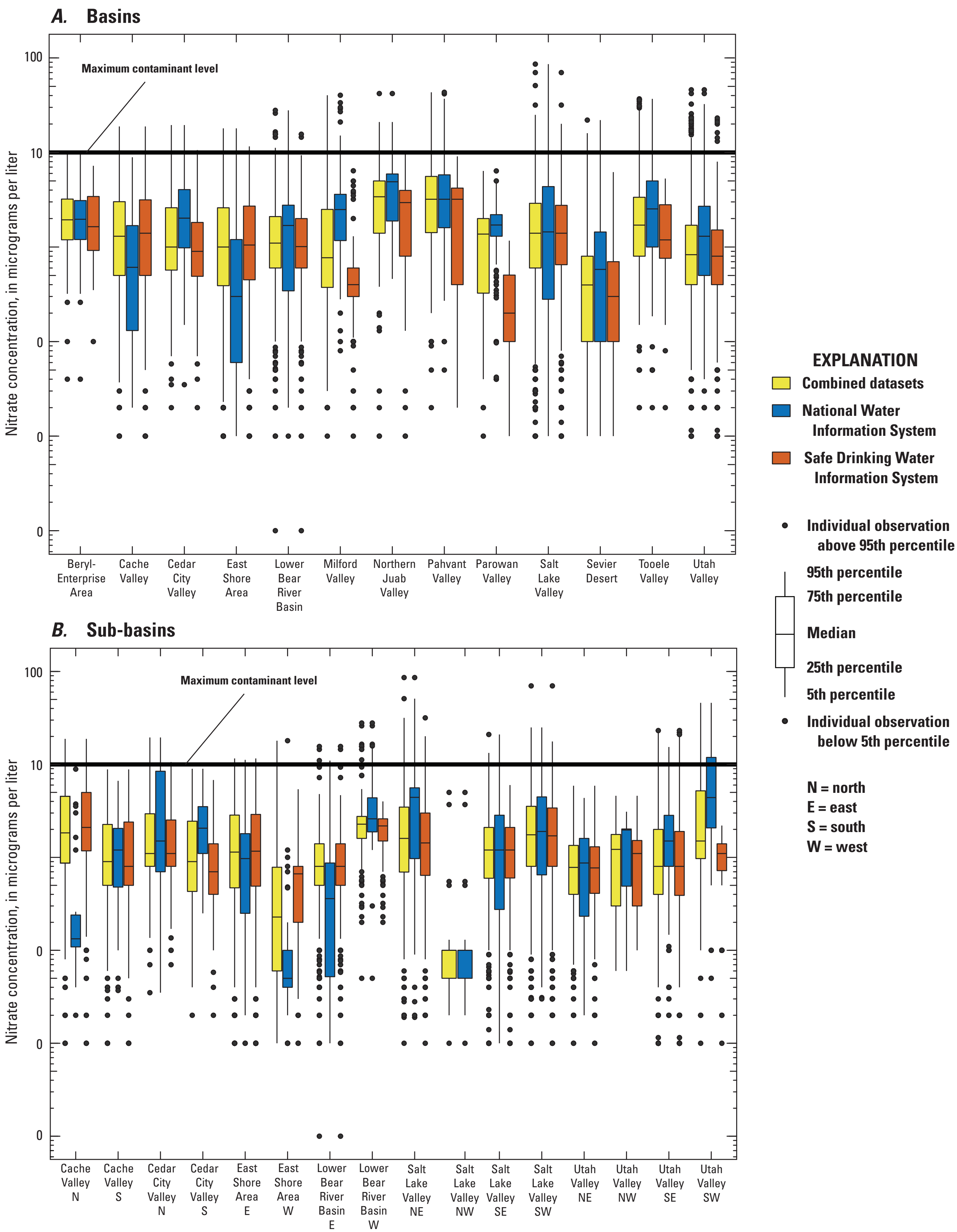
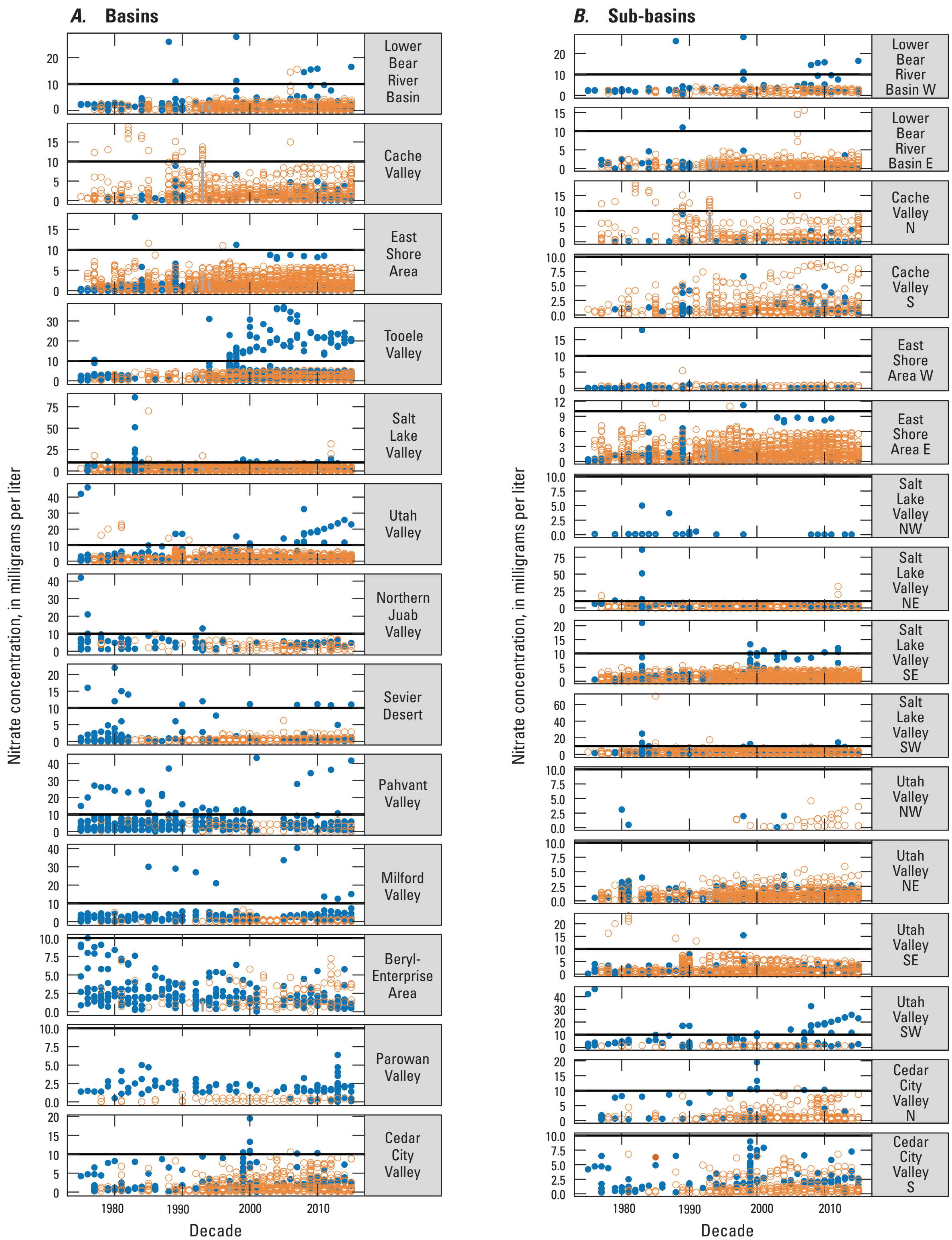


Figure 8. Nitrate concentrations in select Utah *A,* basins and *B,* sub-basins for data from the National Water Information System and Safe Drinking Water Information System, and combined datasets.



EXPLANATION

- Censored data
- Maximum contaminant level
- National Water Information System data
- Safe Drinking Water Information System data

N = north E = east S = south W = west

Figure 9. Nitrate concentrations over time by dataset in select Utah *A,* basins and *B,* sub-basins.

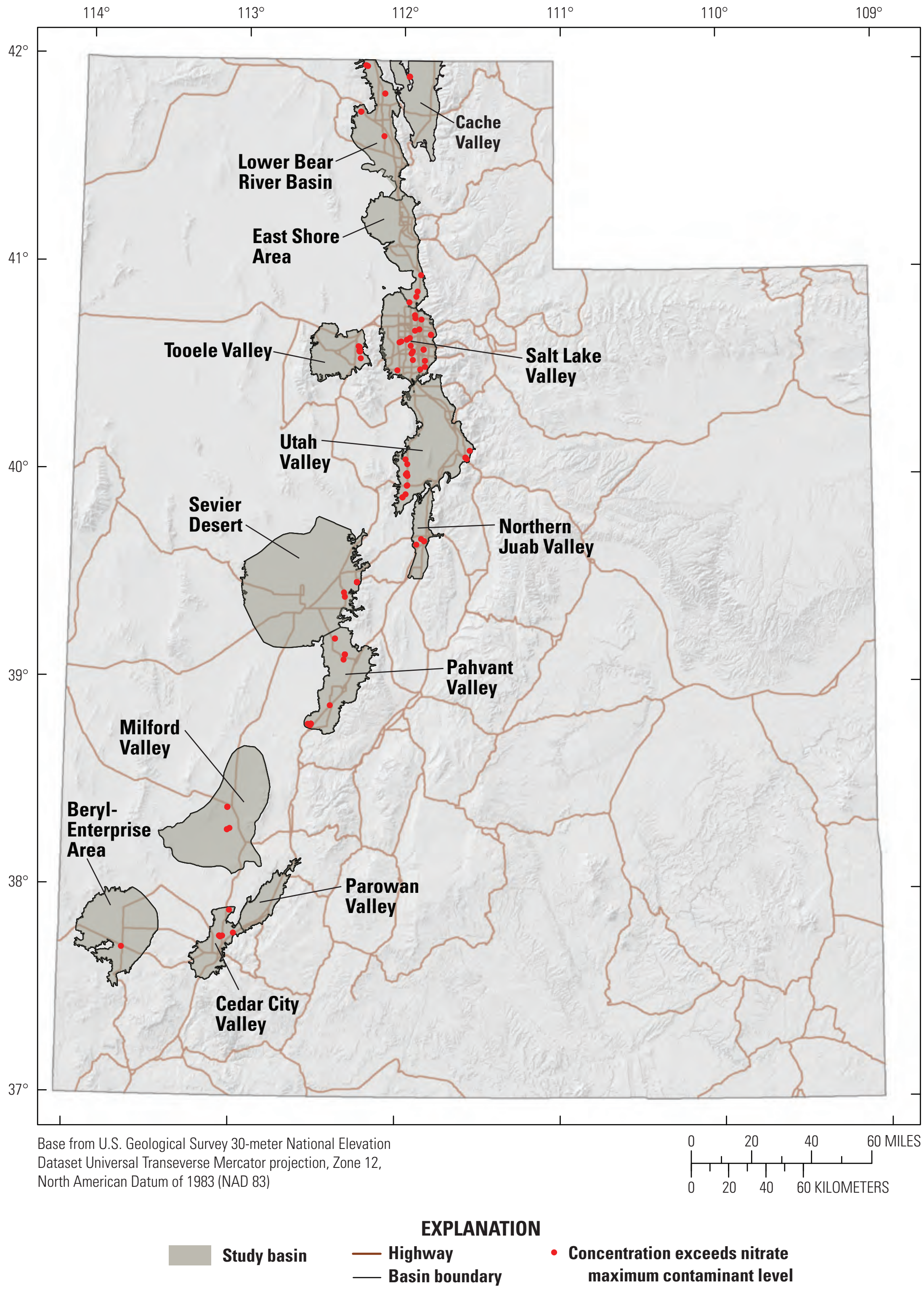


Figure 10. Location of wells with samples that exceed the Maximum Contaminant Level for nitrate in select basins in Utah.

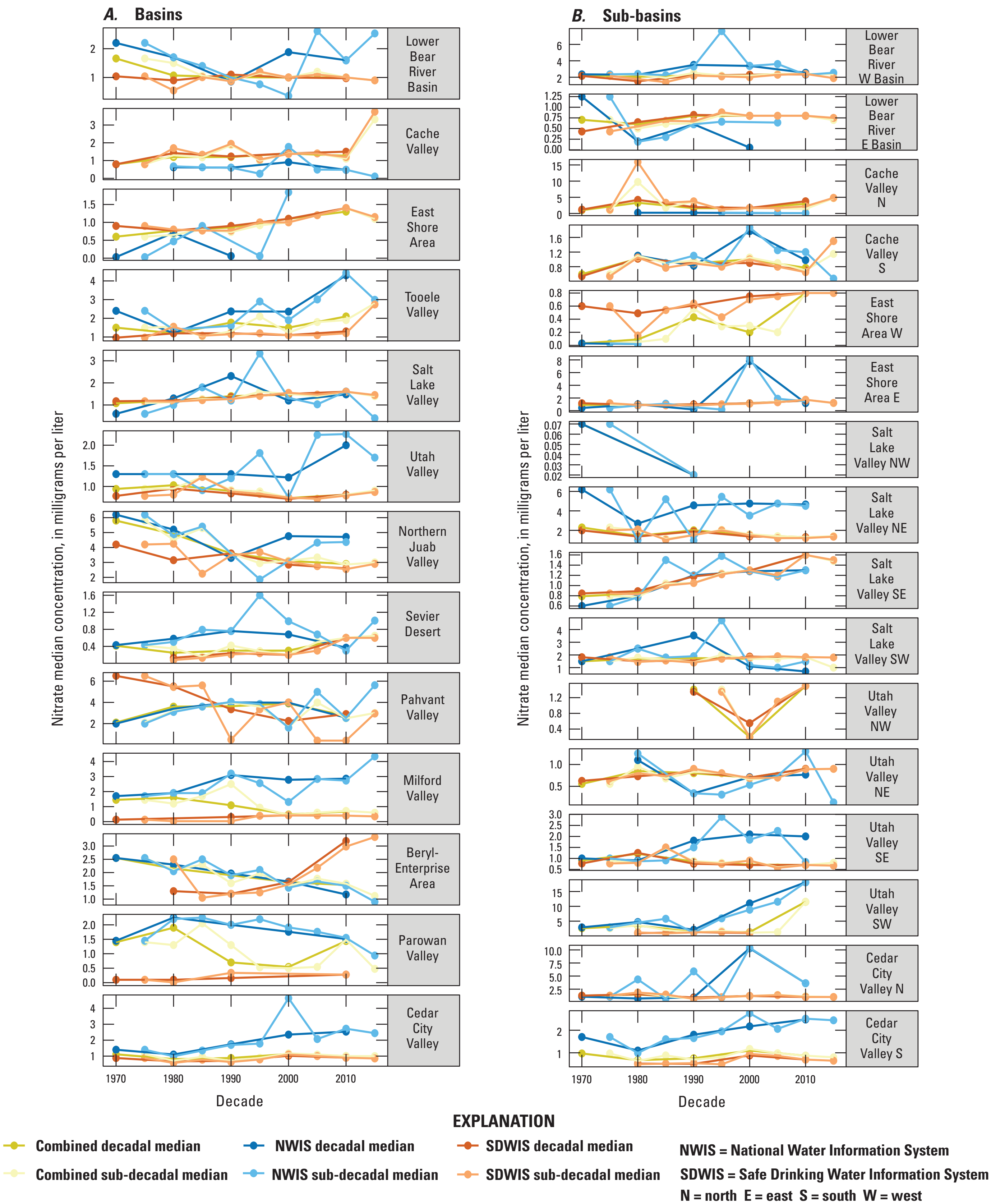


Figure 11. Decadal and sub-decadal median nitrate concentration in select *A*, basins and, *B* sub-basins in Utah.

Dissolved Solids

The period of record and number of measurements of dissolved-solids concentrations in wells is shown in table 4 and figure 12. The SDWIS database contained more dissolved solids concentration data than the NWIS database, although there were more NWIS measurements in some basins including the Beryl-Enterprise Area, Milford Valley, Northern Juab Valley, Pahvant Valley, Parowan Valley, Sevier Desert, and Tooele Valley. Utah Valley Northwest was the only sub-basin with fewer than 10 wells for combined NWIS and SDWIS data, and there were only 18 samples in this area. This makes trend identification more difficult. The number of measurements varied greatly by basin. Generally, dissolved solids as the residual of evaporation from the SDWIS database and as the sum of constituents from the NWIS database were the most numerous sample types in each basin (fig. 12). The sum of constituents depends on the number of constituents measured.

None of the dissolved solids data were censored (table 4). The maximum concentration in all basins was above the dissolved solids SMCL of 500 mg/L. However, the median concentration in many basins was below 500 mg/L. Among NWIS data, eight basins had medians greater than the SMCL of 500 mg/L, whereas among SDWIS data, no basins had medians greater than 500 mg/L. A paired two-sided t-test indicates that the medians of the NWIS and SDWIS datasets, the NWIS and combined datasets, and the SDWIS and combined datasets were statistically different (p-value less than 0.05). The increased variability this introduces makes trend identification more difficult when combining NWIS and SDWIS data.

For combined NWIS and SDWIS data, the maximum dissolved solids concentration in each sub-basin was greater than 500 mg/L. The median in each sub-basin was below the SMCL in all basins except 6 out of 16 sub basins, and the highest median was below the MCL of 2,000 mg/L at 1,270 mg/L in the Salt Lake Valley Northwest. The distribution of concentrations in individual and combined datasets is shown for each basin in figure 13. The IQR of concentrations in each basin and for individual and combined datasets fell below the MCL except in Pahvant Valley. The IQR exceeded the supplier requirements level of 1,000 mg/L in Lower Bear River Basin, Tooele Valley, Sevier Desert, and Pahvant Valley although this was often only for NWIS samples, which are taken from wells with a range of purposes, not just drinking-water supply. Lower water quality may be acceptable when the water is not used for public supply. The IQRs of all basins exceeded the SMCL except in Cache Valley and Parowan Valley, where no IQR exceeded the SMCL. For SDWIS data, the IQR exceeded the SMCL in Cedar City Valley, Northern Juab Valley, Salt Lake Valley, and Tooele Valley. The distribution of concentrations in individual and combined datasets was generally similar within a given basin.

However, in some basins, the distributions of particular datasets vary. The NWIS IQR often extended higher than the SDWIS IQR. This is generally expected because SDWIS samples come from wells used for public supply, and may therefore be biased toward higher quality, whereas NWIS samples come from wells used for a range of purposes including agriculture irrigation or industrial applications where quality considerations are different.

Among sub-basins, the distributions of dissolved-solids concentrations varied substantially, although within each basin the distributions for NWIS, SDWIS, and combined datasets generally aligned (fig. 13). The IQRs for all sub-basins were below the MCL of 2,000 mg/L except in the Salt Lake Valley Northeast. The Salt Lake Valley Northwest had the highest IQR and highest concentration (20,900 mg/L from a shallow well near the Great Salt Lake). The SDWIS IQRs for many sub-basins were below the MCL of 500 mg/L, except in Lower Bear River Basin West; Salt Lake Valley Northeast and Southwest; Utah Valley Northwest and Southwest; and Cedar City Valley South. The NWIS IQR often extended higher than the SDWIS IRQ, although exceptions occurred and there was often substantial overlap.

Dissolved solids concentration data in each basin for each database over time are shown in figure 14. Concentrations varied substantially by basin and sub-basin. Some basins had many or severe MCL exceedances (for example, Tooele Valley, Salt Lake Valley, Sevier Desert, and Pahvant Valley). In some basins, concentrations exceeding the MCL were rare or non-existent (for example, Northern Juab Valley, Beryl-Enterprise Area, and Parowan Valley). Exceedances occurred in SDWIS and, more commonly, NWIS data. The locations of wells with dissolved solids samples that exceeded the MCL are shown in figure 15.

Within and among sub-basins, dissolved-solids concentrations varied (fig. 14). In Cache Valley, the northern sub-basin had more high-concentration data than the southern part. In Cedar City Valley and East Shore Area, both sub-regions had relatively few concentrations greater than 2,000 mg/L. There were a few concentrations greater than 2,000 mg/L in Lower Bear River West and none in Lower Bear River East. In the Salt Lake Valley, the Northwest and Northeast had several samples with concentrations of more than 10,000 mg/L; these were all NWIS data. In the Salt Lake Valley Southeast, all SDWIS data were below 2,000 mg/L and in the Salt Lake Valley Southwest there were only a few SDWIS concentrations greater than 2,000 mg/L. Concentrations were generally lower than 1,000 mg/L in Utah Valley sub-basins, although there were limited data over a shorter period of record in the northeastern area.

Table 4. Number of wells and dissolved solids samples; period of record; and minimum, maximum, and median concentration in select Utah basins and sub-basins for data from the National Water Information System (NWIS) and Safe Drinking Water Information System (SDWIS), and combined NWIS and SDWIS data.

[Number in parentheses indicates the total number of wells. **Abbrevations**: mg/L, milligrams per liter; N, north; S, south; E, east; W, west; NE, northeast; NW, northwest; SE, southeast; SW, southwest]

Basin	Number of wells	Starting year	Ending year	Number of samples	Number of censored samples	Percent censored	Minimum concentration (mg/L)	Maximum concentration (mg/L)	Median concentration (mg/L)
Basins									
NWIS and SDWIS data combined (1,955)									
Beryl-Enterprise Area	36	1975	2015	262	0	0	125	1,950	410
Cache Valley	88	1975	2015	352	0	0	150	1,986	288
Cedar City Valley	104	1975	2015	386	0	0	110	3,070	426
East Shore Area	248	1975	2015	958	0	0	28	4,000	298
Lower Bear River Basin	95	1975	2015	414	0	0	88	2,360	324
Milford Valley	57	1975	2015	370	0	0	156	10,200	456
Northern Juab Valley	40	1975	2015	165	0	0	18	2,940	794
Pahvant Valley	79	1975	2015	340	0	0	10	6,520	961
Parowan Valley	46	1975	2015	134	0	0	135	672	310
Salt Lake Valley	511	1975	2015	2,719	0	0	10	20,900	512
Sevier Desert	96	1975	2015	286	0	0	162	24,300	352
Tooele Valley	246	1975	2015	678	0	0	143	17,000	652
Utah Valley	309	1975	2015	1,083	0	0	55	2,560	314
NWIS data (1,173)									
Beryl-Enterprise Area	31	1975	2015	224	0	0	125	1,950	432
Cache Valley	38	1979	2015	91	0	0	174	1,730	295
Cedar City Valley	60	1975	2015	160	0	0	183	3,070	541
East Shore Area	112	1975	2015	245	0	0	122	4,000	371
Lower Bear River Basin	42	1975	2015	130	0	0	118	1,920	521
Milford Valley	36	1975	2015	194	0	0	189	10,200	547
Northern Juab Valley	28	1975	2015	106	0	0	262	2,940	827
Pahvant Valley	72	1975	2015	311	0	0	305	6,520	1,050
Parowan Valley	41	1975	2015	115	0	0	148	672	304
Salt Lake Valley	265	1976	2015	692	0	0	71	20,900	701
Sevier Desert	69	1975	2015	159	0	0	193	24,300	553
Tooele Valley	201	1975	2015	454	0	0	143	17,000	771
Utah Valley	178	1975	2015	369	0	0	91	2,560	355
SDWIS data (782)									
Beryl-Enterprise Area	5	1978	2014	38	0	0	160	723	304
Cache Valley	50	1975	2015	261	0	0	150	1,986	286
Cedar City Valley	44	1977	2015	226	0	0	110	2,720	368
East Shore Area	136	1976	2015	713	0	0	28	1,656	288
Lower Bear River Basin	53	1977	2015	284	0	0	88	2,360	288
Milford Valley	21	1978	2015	176	0	0	156	948	385
Northern Juab Valley	12	1978	2015	59	0	0	18	1,040	436
Pahvant Valley	7	1978	2015	29	0	0	10	882	380
Parowan Valley	5	1978	2013	19	0	0	135	504	402

Table 4. Number of wells and dissolved solids samples; period of record; and minimum, maximum, and median concentration in select Utah basins and sub-basins for data from the National Water Information System (NWIS) and Safe Drinking Water Information System (SDWIS), and combined NWIS and SDWIS data.—Continued

[Number in parentheses indicates the total number of wells. **Abbrevations**: mg/L, milligrams per liter; N, north; S, south; E, east; W, west; NE, northeast; NW, northwest; SE, southeast; SW, southwest]

Basin	Number of wells	Starting year	Ending year	Number of samples	Number of censored samples	Percent censored	Minimum concentration (mg/L)	Maximum concentration (mg/L)	Median concentration (mg/L)
Basins—Continued									
SDWIS data (782)—Continued									
Salt Lake Valley	246	1975	2015	2,027	0	0	10	2,222	445
Sevier Desert	27	1978	2015	127	0	0	162	1,520	280
Tooele Valley	45	1977	2015	224	0	0	196	2,970	410
Utah Valley	131	1976	2015	714	0	0	55	1,290	298
Sub-basins									
NWIS and SDWIS data combined (1,355)									
Cache Valley N	27	1977	2015	124	0	0	156	1,986	260
Cache Valley S	61	1975	2015	228	0	0	150	576	295
Cedar City Valley N	35	1977	2015	131	0	0	112	2,510	385
Cedar City Valley S	69	1975	2015	255	0	0	110	3,070	485
East Shore Area E	200	1975	2015	785	0	0	28	2,960	296
East Shore Area W	48	1975	2015	173	0	0	158	4,000	308
Lower Bear River Basin E	59	1977	2015	269	0	0	88	1,142	249
Lower Bear River Basin W	36	1975	2015	145	0	0	307	2,360	896
Salt Lake Valley NE	81	1976	2015	463	0	0	84	16,800	582
Salt Lake Valley NW	40	1976	2014	68	0	0	336	20,900	1,270
Salt Lake Valley SE	182	1976	2015	1,046	0	0	10	2,430	268
Salt Lake Valley SW	208	1975	2015	1,142	0	0	10	8,550	696
Utah Valley NE	172	1976	2015	581	0	0	55	1,110	282
Utah Valley NW	9	1980	2014	18	0	0	387	1,510	949
Utah Valley SE	94	1975	2015	375	0	0	96	1,970	325
Utah Valley SW	34	1975	2015	109	0	0	348	2,560	719
NWIS data (695)									
Cache Valley N	11	1979	2015	33	0	0	218	1,730	258
Cache Valley S	27	1979	2015	58	0	0	174	539	307
Cedar City Valley N	18	1977	2013	42	0	0	276	2,510	503
Cedar City Valley S	42	1975	2015	118	0	0	183	3,070	570
East Shore Area E	81	1975	2015	139	0	0	122	2,960	339
East Shore Area W	31	1975	2015	106	0	0	158	4,000	374
Lower Bear River Basin E	19	1977	2015	60	0	0	118	835	236
Lower Bear River Basin W	23	1975	2015	70	0	0	342	1,920	1,020
Salt Lake Valley NE	39	1976	2015	97	0	0	204	16,800	706
Salt Lake Valley NW	40	1976	2014	68	0	0	336	20,900	1,270
Salt Lake Valley SE	82	1976	2015	216	0	0	71	2,430	434
Salt Lake Valley SW	104	1976	2015	311	0	0	206	8,550	778
Utah Valley NE	109	1976	2015	192	0	0	91	1,110	312
Utah Valley NW	5	1980	2004	5	0	0	387	1,510	960

Table 4. Number of wells and dissolved solids samples; period of record; and minimum, maximum, and median concentration in select Utah basins and sub-basins for data from the National Water Information System (NWIS) and Safe Drinking Water Information System (SDWIS), and combined NWIS and SDWIS data.—Continued

[Number in parentheses indicates the total number of wells. **Abbrevations**: mg/L, milligrams per liter; N, north; S, south; E, east; W, west; NE, northeast; NW, northwest; SE, southeast; SW, southwest]

Basin	Number of wells	Starting year	Ending year	Number of samples	Number of censored samples	Percent censored	Minimum concentration (mg/L)	Maximum concentration (mg/L)	Median concentration (mg/L)
Sub-basins—Continued									
NWIS data (695)—Continued									
Utah Valley SE	34	1975	2015	87	0	0	196	1,970	340
Utah Valley SW	30	1975	2015	85	0	0	354	2,560	807
SDWIS data (660)									
Cache Valley N	16	1977	2014	91	0	0	156	1,986	262
Cache Valley S	34	1975	2015	170	0	0	150	576	290
Cedar City Valley N	17	1977	2015	89	0	0	112	1,630	320
Cedar City Valley S	27	1977	2015	137	0	0	110	2,720	423
East Shore Area E	119	1976	2015	646	0	0	28	1,350	290
East Shore Area W	17	1977	2013	67	0	0	178	1,656	274
Lower Bear River Basin E	40	1977	2015	209	0	0	88	1,142	256
Lower Bear River Basin W	13	1978	2014	75	0	0	307	2,360	772
Salt Lake Valley NE	42	1977	2015	366	0	0	84	1,056	540
Salt Lake Valley SE	100	1976	2015	830	0	0	10	1,710	248
Salt Lake Valley SW	104	1975	2015	831	0	0	10	2,222	636
Utah Valley NE	63	1977	2015	389	0	0	55	998	275
Utah Valley NW	4	1997	2014	13	0	0	392	1,290	949
Utah Valley SE	60	1976	2015	288	0	0	96	1,200	320
Utah Valley SW	4	1977	2013	24	0	0	348	954	444

The decadal and sub-decadal dissolved solids medians for each database grouping are shown in figure 16. Median concentrations did not exceed the MCL of 2,000 mg/L in any basin or sub-basin except the Salt Lake Valley Northwest, although medians in many basins exceeded the SMCL of 500 mg/L. In general, the medians for individual and combined datasets were similar within a basin or sub-basin. The NWIS medians were higher than the other medians in several basins (for example, Lower Bear River Basin, Salt Lake Valley, and Sevier Desert). The variation among medians for different databases was greatest in Pahvant Valley. Variations among medians for different datasets were low in Cache Valley, Utah Valley, and Parowan Valley. Agreement among medians increased with time in the Pahvant Valley, Milford Valley, and Beryl-Enterprise Area.

Item 1.

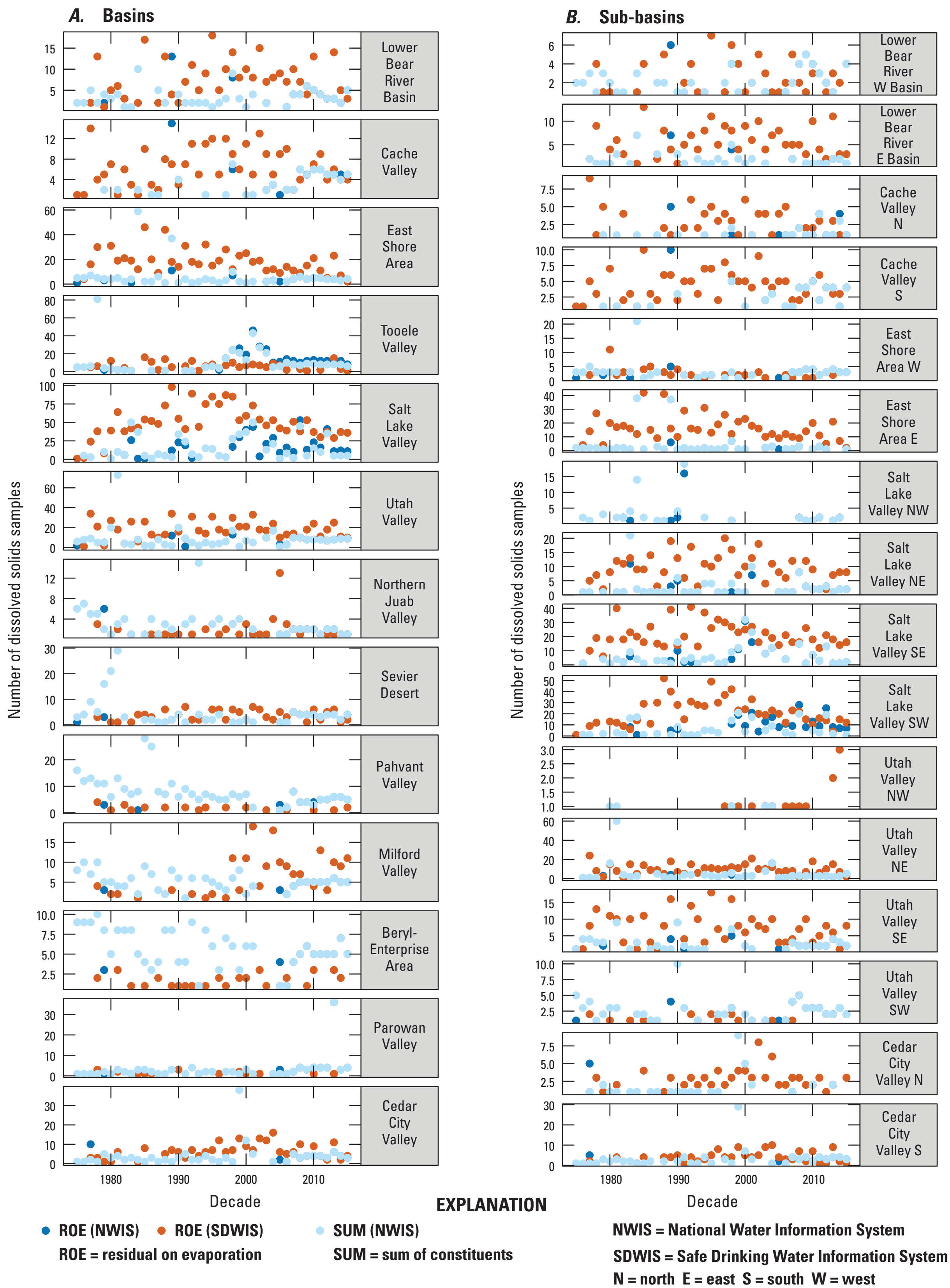


Figure 12. Number of dissolved solids samples over time in select Utah *A*, basins and *B*, sub-basins in the National Water Information System and Safe Drinking Water Information System datasets.

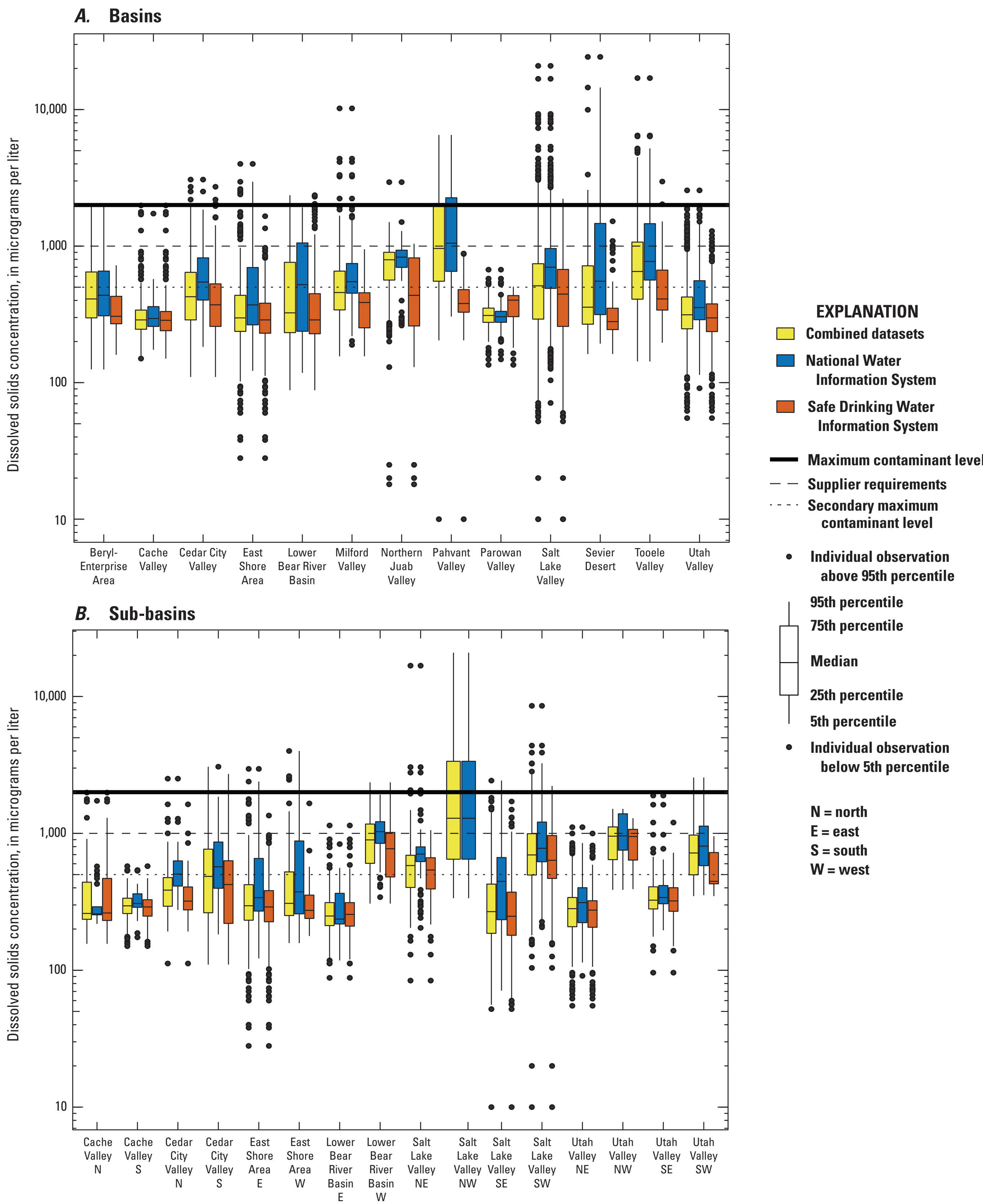


Figure 13. Dissolved-solids concentrations in select Utah *A*, basins and *B*, sub-basins for data from the National Water Information System and Safe Drinking Water Information System, and combined datasets.

Item 1.

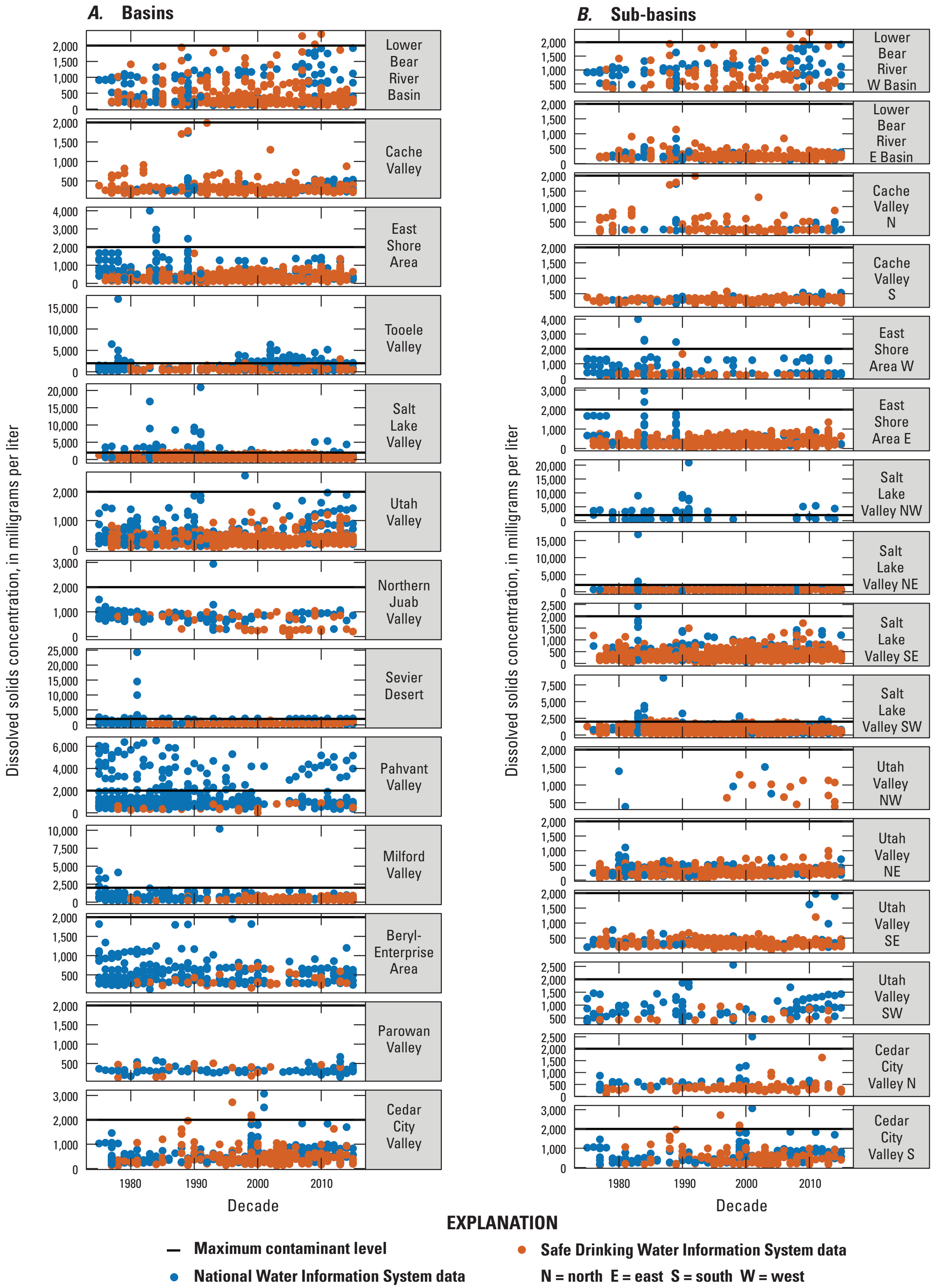


Figure 14. Dissolved-solids concentrations over time by dataset in select Utah *A*, basins and *B*, sub-basins.

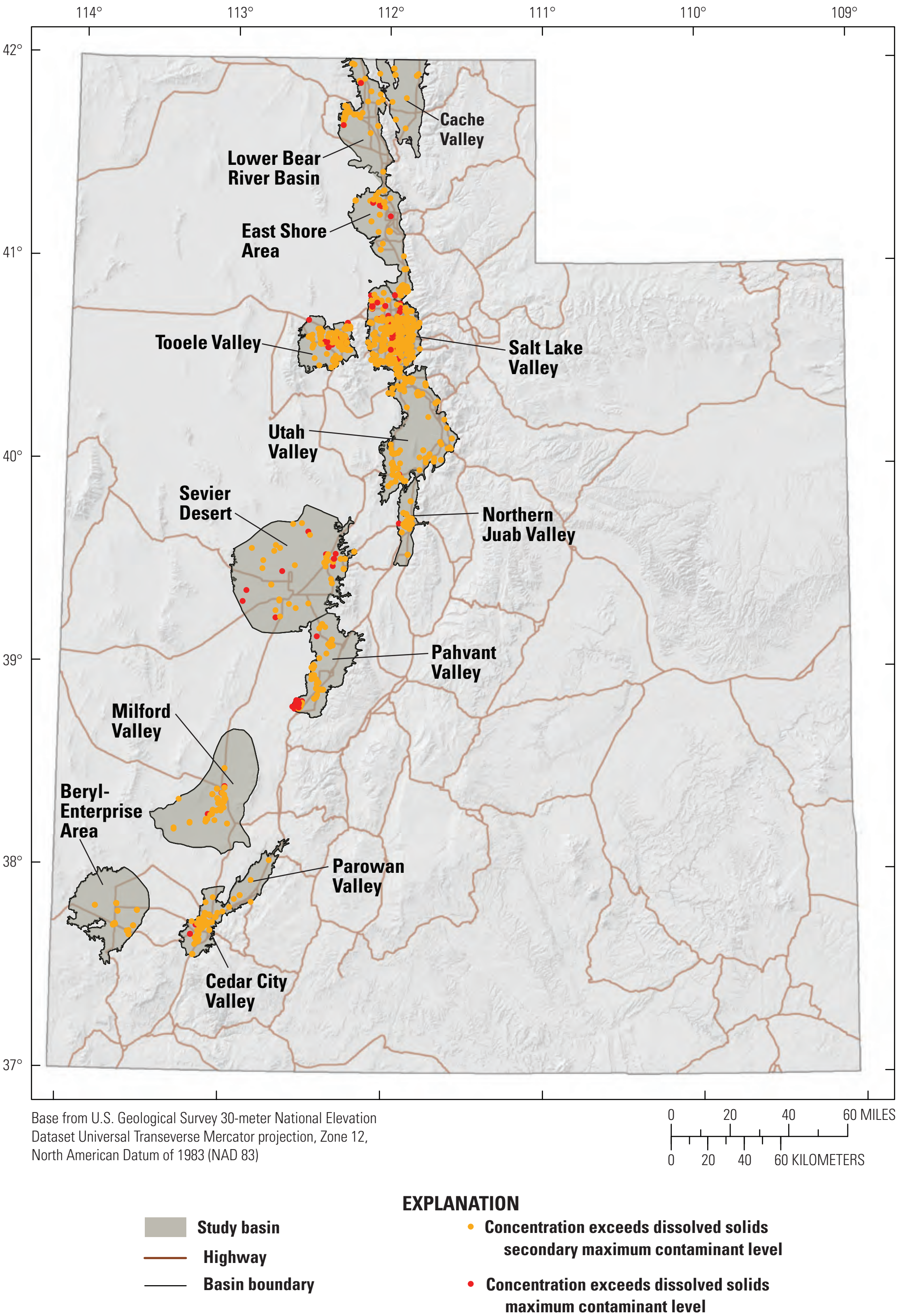


Figure 15. Location of wells with samples that exceed the secondary maximum contaminant level and maximum contaminant level for dissolved solids in select basins in Utah.

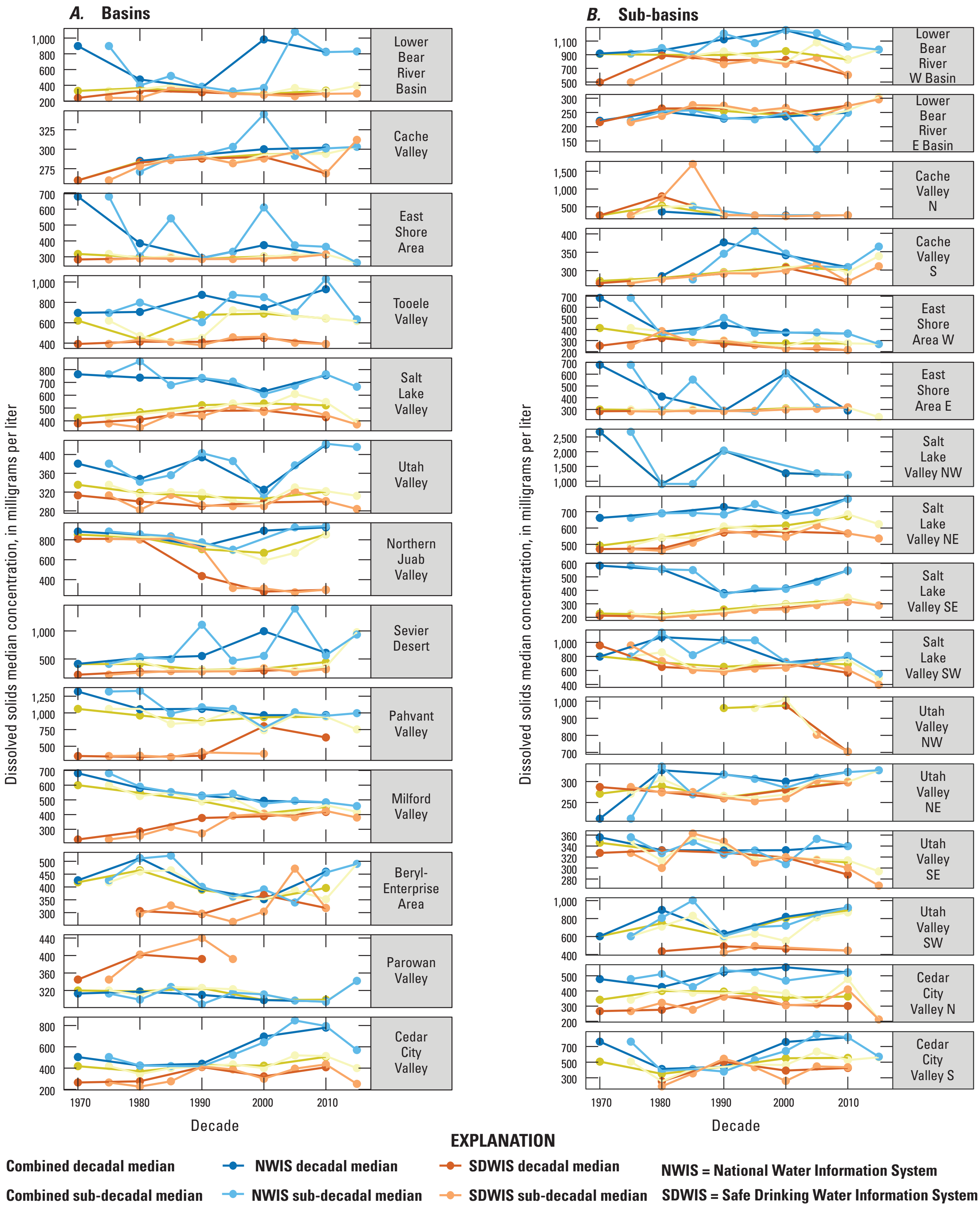


Figure 16. Decadal and sub-decadal median dissolved-solids concentration in select *A*, basins and *B*, sub-basins in Utah.

Trends in Arsenic, Nitrate, and Dissolved Solids from Combined Datasets

Overall, despite differences between the NWIS and SDWIS databases, the increased understanding of general basin-wide conditions justifies combining the datasets. In addition, combining the datasets generally reduces the percentage of censored values in each basin. Combining the NWIS and SDWIS datasets also increases the number of samples, which increases precision in estimates characterizing water-quality conditions. However, combining the datasets also can introduce variability because the range in concentrations can increase, particularly when there are larger differences between the datasets. Further, because there are generally more SDWIS data than NWIS data, the combined dataset results can be dominated by patterns in the SDWIS data.

Long-term trend analysis of groundwater arsenic, nitrate, and dissolved solids evaluated in basins that have experienced increased development and groundwater use show widespread changes in water quality. Trends evaluated in smaller regions of some basins highlight local water-quality conditions.

When there was an insufficient number of decadal medians, trend tests were often only possible using sub-decadal medians. Comparing results of trend tests on decadal and sub-decadal medians indicated that often sub-decadal medians have greater variability than decadal medians. This additional variability can make trend identification more difficult, although analysis of sub-decadal median data more frequently yielded significant groundwater-quality trends compared to analysis of decadal median data. This is in part because of the larger number of sub-decadal median data compared to decadal median data. In these cases, the magnitude and sign of Kendall’s tau (nonparametric correlation coefficient measuring the monotonic association between the dependent and independent variable) for both tests were generally similar, indicating that the additional data available in the sub-decadal median analysis provided additional statistical power without adding noise. This similarity between decadal and sub-decadal analyses supports the robustness of this analysis.

In a few cases, trends were identified in decadal medians, but not in sub-decadal medians. This may be due to the increased variability introduced in some cases by more frequent median calculations. The Mann-Kendall trend test identifies monotonic trends, which are obscured by increased variability. Increasing and decreasing trends were identified in all basins for some constituents except Tooele Valley. Results are presented below and comparisons to trends identified in other areas are described where applicable.

Sample replicate variability can influence the concentrations from which a decadal or sub-decadal median is calculated. Replicate variability of samples taken following USGS sampling and lab protocols has been assessed. For samples with dissolved-solids concentrations between 14 and 1,000 mg/L, the standard deviation of replicates was 7 mg/L and for concentrations between 1,000 and 9,015 mg/L the relative standard deviation was 3 percent (Gross and others, 2012). For samples with nitrate concentrations between 0.05 and 1.0 mg/L, the standard deviation of replicates was 0.043 mg/L and for concentrations between 1 and 58 mg/L the relative standard deviation was 2.9 percent (Mueller and Titus, 2005). The replicate variability is generally less than the variability among different samples from a single site or samples from different sites. The trend test looks at changes in median values over time and so replicate variability or even temporal changes in concentrations must be big enough to influence the median to contribute to a monotonic trend.

Evaluating trends in comparison to land-use change provides some insights into understanding trend drivers. However, when considering land-use change at a well, the number of wells in each land-use change category decreased relative to the number of wells in each basin, and the number of samples and period of record were also often smaller, making trend detection more difficult. Trends, specifically for nitrate and dissolved solids, can occur in areas of increased population and urbanization. However, land use directly surrounding wells is not always useful in identifying trends. Trends in arsenic, nitrate, and dissolved solids were commonly identified among wells in areas where land use did not change. This is in part because there were more wells in areas where land use did not change than there were in areas where land use changed.

Although land use is expected to have a substantial impact on water quality, these results highlight a more complex relationship between land use and water quality, with various spatial and temporal factors influencing surface to subsurface connectivity. Among wells where land use did not change over time, trends in arsenic, nitrate, and dissolved solids were still identified, indicating that factors other than land use directly at the well location impact water quality, including the combination of activities farther away from the well, groundwater travel time, and the timing of land-use transitions. For example, a lag in the time between conversion of land from low use to farming and an increase in nitrate concentration at a well several miles away is expected due to the time required for a sufficient nitrate load, from increased fertilizer application, to enter the groundwater system and move to the well. Changes in nitrate loads upgradient from a well may take decades or more to travel to a well and register as a change in concentration. Even land-use change occurring at a well can have a lag time as nitrate moves through the unsaturated zone.

Arsenic

Evidence for statistically significant increases in decadal or sub-decadal median arsenic concentrations between 0.02 and 0.17 µg/L per year was identified in the Beryl-Enterprise Area, East Shore Area, Utah Valley, Pahvant Valley, and Parowan Valley (table 5; fig. 17). Evidence for decreasing median concentrations of –0.24 µg/L per year was identified in the Sevier Desert. Within sub-basins, evidence for statistically significant increases in decadal or sub-decadal median arsenic concentrations between 0.01 and 0.48 µg/L per year was identified in the East Shore Area West, Salt Lake Valley Northwest, Salt Lake Valley Southeast, and Utah Valley Northeast (table 5; fig. 17). Evidence for decreasing median concentrations of –0.17 µg/L per year was identified in the Salt Lake Valley Southwest. Overall, the sub-basin trend results highlight areas that drive basinwide trends. The increasing trend in the East Shore Area West drove the basinwide increasing trend. The opposing trends in the Salt Lake Valley (increases in the Northwest and Southeast and a decrease in the Southwest) result in an overall result of no trend basinwide. The increase in Utah Valley Northeast drove the basinwide increasing trend.

Nitrate

Evidence for statistically significant increases between 0.01 and 0.02 mg/L per year in decadal or sub-decadal median nitrate concentrations was identified in the East Shore Area and Salt Lake Valley (table 6; fig. 17). Evidence for decreasing median concentrations between –0.005 and –0.08 mg/L per year was identified in the Beryl-Enterprise Area, Milford Valley, Lower Bear River Basin, Northern Juab Valley, and Utah Valley. Within sub-basins, evidence for statistically significant increases between 0.01 and 0.02 mg/L per year in decadal or sub-decadal median nitrate concentrations was identified in the East Shore Area East and West, and Salt Lake Valley Southeast (table 6; fig. 17). Evidence for decreasing median concentrations of –0.01 mg/L per year was identified in Utah Valley Southeast. The increasing trend in the East Shore Area occurred in both the East and West sub-basins. The increasing trend in the Salt Lake Valley Southeast and the decreasing trend in Utah Valley Southeast drove the respective basinwide trends.

Nitrate trend results are similar to or smaller in magnitude than trends identified elsewhere using similar methods. Significant increases in median nitrate concentrations ranged from 0.01 to 0.02 mg/L per year and concentration decreases ranged from 0.005 to 0.08 mg/L per year. The rate of change for all trends was smaller in magnitude than nitrate trends identified in the Columbia Basin, Washington, where wells with high (greater than 10 mg/L) nitrate concentrations had median slopes of 0.35 and 0.46 mg/L per year (Helsel and Frans, 2006) and on a similar order of magnitude as trends in the Central Valley, California, where increases between 0.005 and 0.06 mg/L per year were detected (Burow and others, 2013). The rates of change are within the ranges of increases and decreases calculated in a range of well networks representing a range of land-use and principal aquifers across the U.S., where between 1988 and 2010 nitrate concentrations increased between less than 0.01 and 0.28 mg/L per year and decreased between –0.42 and –0.01 mg/L per year (Lindsey and Rupert, 2012). For a comparison of trends in the southwestern region in this study, no statistically significant trend was identified in alluvial aquifers in the Upper Colorado River Basin, a significant increasing trend of 0.01 mg/L per year was identified in the Nevada Basin and Range basin-fill aquifers, and no significant trend and a decreasing trend of –0.01 mg/L per year were identified in different parts of the Rio Grande Aquifer System (Lindsey and Rupert, 2012). The period of record varies between these studies, but the comparison is meant to give some general context for the slope of the trend line.

Dissolved Solids

Evidence for statistically significant increases of 1 mg/L per year in decadal or sub-decadal median dissolved-solids concentrations was identified in Cache Valley (table 7; fig. 17). Evidence for decreasing median concentrations between –4 and –5 mg/L per year was identified in Milford Valley. The larger differences between NWIS and SDWIS dissolved solids data may make trend identification more difficult, resulting in fewer trends detected.

Within sub-basins, evidence for statistically significant increases between 1 and 7 mg/L per year in decadal or sub-decadal median dissolved-solids concentrations was identified in Cache Valley South, Salt Lake Valley Northeast and Southeast, and Utah Valley Southwest (table 7; fig. 17). Evidence for decreasing median concentrations of between –1 and –3 mg/L per year was identified in the East Shore Area West and Utah Valley Southeast. Although no basinwide trend was identified in the East Shore Area, the western part of the basin had a decreasing trend. Similarly, no trend was identified in the Salt Lake Valley, although the eastern half of the basin had increasing trends. In Utah Valley Southeast and Southwest sub-basins, the opposing signs of trends may account for the lack of overall trend.

Table 5. Arsenic trend test results for National Water Information System and Safe Drinking Water Information System data combined in select basins and sub-basins in Utah between 1975 and 2015.

[Red indicates significant result. **Abbreviations**: µg/L, micrograms per liter; —, no data; N, north; S, south; E, east; W, west; NE, northeast; NW, northwest; SE, southeast; SW, southwest]

Basin	Decadal medians					Sub-decadal medians				
	Tau	Score	Score variance	p-value	Slope (µg/L per year)	Tau	Score	Score variance	p-value	Slope (µg/L per year)
Basins										
Beryl-Enterprise Area	1.00	6	9	[1]0.089	0.15	0.60	9	28	0.133	0.15
Cache Valley	–0.67	–4	9	0.308	–0.02	–0.07	–2	63	0.900	–0.01
Cedar City Valley	0.33	2	9	0.734	0.03	0.07	2	63	0.900	0.00
East Shore Area	0.83	5	8	0.149	0.01	0.67	14	43	[1]0.048	0.02
Lower Bear River Basin	—	—	—	—	—	0.43	9	44	0.230	0.13
Milford Valley	0.40	4	17	0.462	0.07	–0.21	–6	65	0.536	–0.19
Northern Juab Valley	—	—	—	—	—	—	—	—	—	—
Pahvant Valley	—	—	—	—	—	0.80	8	17	[1]0.086	0.05
Parowan Valley	0.83	5	8	0.149	0.13	0.90	9	16	[1]0.043	0.17
Salt Lake Valley	0.20	2	17	0.806	0.03	0.07	2	63	0.900	0.01
Sevier Desert	–0.50	–5	16	0.312	–0.25	–0.58	–21	91	[1]0.036	–0.24
Tooele Valley	–0.50	–3	8	0.470	0.00	–0.53	–8	27	0.181	–0.01
Utah Valley	—	—	—	—	—	0.76	16	43	[1]0.023	0.06
Sub-basins										
Cache Valley N	0.67	4	9	0.308	0.07	0.20	3	28	0.707	0.07
Cache Valley S	–0.17	—	8	1.000	–0.02	–0.18	–5	64	0.618	–0.01
Cedar City Valley N	—	—	—	—	—	0.47	7	28	0.260	0.06
Cedar City Valley S	0.00	0	9	1.000	0.00	–0.19	–4	43	0.649	–0.03
East Shore Area E	0.33	2	9	0.734	0.00	0.10	1	16	1.000	0.00
East Shore Area W	—	—	—	—	—	0.73	11	28	[1]0.060	0.48
Lower Bear River Basin E	—	—	—	—	—	0.20	3	28	0.707	0.28
Lower Bear River Basin W	0.40	4	17	0.462	0.03	0.36	10	65	0.266	0.04
Salt Lake Valley NE	—	—	—	—	—	0.10	1	16	1.000	0.00
Salt Lake Valley NW	1.00	6	9	[1]0.089	0.39	0.00	0	9	1.000	–1.75
Salt Lake Valley SE	—	—	—	—	—	0.80	8	17	[1]0.086	0.01
Salt Lake Valley SW	–0.40	–4	17	0.462	–0.17	–0.61	–17	64	[1]0.046	–0.17
Utah Valley NE	—	—	—	—	—	0.80	8	17	[1]0.086	0.09
Utah Valley NW	—	—	—	—	—	–0.33	–2	9	0.734	–0.11
Utah Valley SE	—	—	—	—	—	–0.33	–5	20	0.367	0.00
Utah Valley SW	0.67	4	9	0.308	0.17	0.18	5	64	0.618	0.06

[1]Significant result.

Item 1.

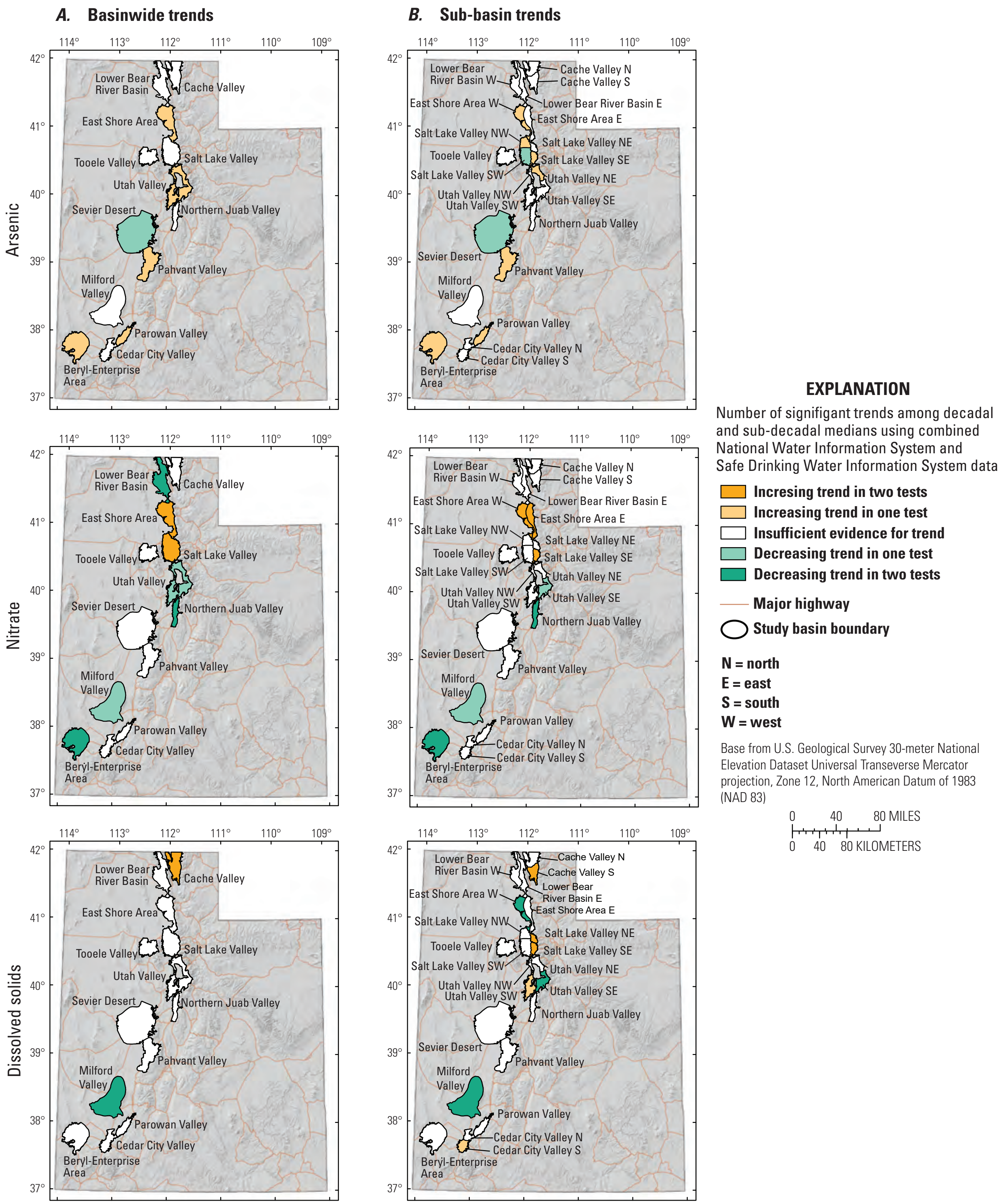


Figure 17. Spatial patterns of trends in arsenic, nitrate, and dissolved solids data from the National Water Information System and the Safe Drinking Water Information System in select basins and sub-basins of Utah.

Table 6. Nitrate trend test results for National Water Information System and Safe Drinking Water Information System data combined in select basins and sub-basins in Utah between 1975 and 2015.

[Red indicates significant result. **Abbreviations**: mg/L, miligrams per liter; —, no data; N, north; S, south; E, east; W, west; NE, northeast; NW, northwest; SE, southeast; SW, southwest]

Basin	Decadal medians					Sub-decadal medians				
	Tau	Score	Score variance	p-value	Slope (mg/L per year)	Tau	Score	Score variance	p-value	Slope (mg/L per year)
Basins										
Beryl-Enterprise Area	–1.00	–10	17	[1]0.027	–0.03	–0.72	–26	92	[1]0.009	–0.03
Cache Valley	0.70	7	16	0.130	0.01	0.33	12	92	0.251	0.01
Cedar City Valley	0.20	2	17	0.806	0.00	0.11	4	92	0.754	0.00
East Shore Area	1.00	10	17	[1]0.027	0.02	0.83	30	92	[1]0.002	0.02
Lower Bear River Basin	–0.90	–9	16	[1]0.043	–0.005	–0.47	–17	91	[1]0.093	–0.02
Milford Valley	–0.60	–6	17	0.221	–0.03	–0.50	–18	92	[1]0.076	–0.02
Northern Juab Valley	—	–10	17	[1]0.027	–0.08	–0.67	–24	92	[1]0.016	–0.06
Pahvant Valley	0.40	4	17	0.462	0.02	0.00	0	92	1.000	0.01
Parowan Valley	–0.20	–2	17	0.806	–0.02	–0.39	–14	92	0.175	–0.02
Salt Lake Valley	1.00	10	17	[1]0.027	0.01	0.56	20	90	[1]0.045	0.01
Sevier Desert	0.30	3	16	0.613	0.00	0.44	16	92	0.118	0.01
Tooele Valley	0.50	5	16	0.312	0.02	0.44	16	92	0.118	0.03
Utah Valley	–0.60	–6	17	0.221	–0.01	–0.50	–18	92	[1]0.076	–0.01
Sub-basins										
Cache Valley N	0.20	2	17	0.806	0.03	0.06	2	92	0.917	0.01
Cache Valley S	0.00	0	17	1.000	0.00	0.14	5	91	0.675	0.00
Cedar City Valley N	–0.40	–4	17	0.462	–0.01	–0.22	–8	92	0.466	–0.01
Cedar City Valley S	0.20	2	17	0.806	0.01	0.06	2	92	0.917	0.00
East Shore Area E	1.00	10	17	[1]0.027	0.01	0.72	26	92	[1]0.009	0.01
East Shore Area W	0.80	8	17	[1]0.086	0.02	0.69	25	91	[1]0.012	0.01
Lower Bear River Basin E	0.50	5	16	0.312	0.00	0.31	11	91	0.295	0.00
Lower Bear River Basin W	0.60	6	17	0.221	0.01	0.19	7	91	0.529	0.00
Salt Lake Valley NE	–0.60	–6	17	0.221	–0.02	–0.44	–16	92	0.118	–0.02
Salt Lake Valley NW	—	—	—	—	—	—	—	—	—	—
Salt Lake Valley SE	1.00	10	17	[1]0.027	0.02	0.78	28	92	[1]0.005	0.02
Salt Lake Valley SW	0.60	6	17	0.221	0.01	0.03	1	91	1.000	0.00
Utah Valley NE	0.40	4	17	0.462	0.00	0.28	10	92	0.348	0.00
Utah Valley NW	—	—	—	—	—	0.33	2	9	0.734	0.04
Utah Valley SE	–0.80	–8	17	[1]0.086	–0.01	–0.33	–12	92	0.251	–0.01
Utah Valley SW	0.00	0	17	1.000	0.04	–0.21	–6	65	0.536	–0.04

[1]Significant value.

Table 7. Dissolved solids trend test results for National Water Information System and Safe Drinking Water Information System data combined in select basins and sub-basins in Utah between 1975 and 2015.

[Red indicates significant result. **Abbreviations**: mg/L, milligrams per liter; —, no data; N, north; S, south; E, east; W, west; NE, northeast; NW, northwest; SE, southeast; SW, southwest]

Basin	Decadal medians					Sub-decadal medians				
	Tau	Score	Score variance	p-value	Slope (mg/L per year)	Tau	Score	Score variance	p-value	Slope (mg/L per year)
Basins										
Beryl-Enterprise Area	–0.40	–4	17	0.462	–2	–0.28	–10	92	0.348	–1
Cache Valley	1.00	10	17	[1]0.027	1	0.89	32	92	[1]0.001	1
Cedar City Valley	0.60	6	17	0.221	2	0.25	9	88	0.395	3
East Shore Area	0.00	0	17	1.000	0	–0.17	–6	92	0.602	0
Lower Bear River Basin	–0.20	–2	17	0.806	–1	0.00	0	92	1.000	0
Milford Valley	–0.80	–8	17	[1]0.086	–5	–0.67	–24	92	[1]0.016	–4
Northern Juab Valley	–0.20	–2	17	0.806	–3	–0.43	–12	65	0.174	–6
Pahvant Valley	–0.40	–4	17	0.462	–2	–0.39	–14	92	0.175	–4
Parowan Valley	–0.40	–4	17	0.462	–1	–0.17	–6	92	0.602	–1
Salt Lake Valley	0.60	6	17	0.221	3	0.44	16	92	0.118	3
Sevier Desert	0.20	2	17	0.806	1	0.22	8	92	0.466	1
Tooele Valley	0.40	4	17	0.462	2	0.11	4	92	0.754	3
Utah Valley	–0.40	–4	17	0.462	–1	–0.22	–8	92	0.466	0
Sub-basins										
Cache Valley N	–0.10	—	16	1.000	0	–0.21	–6	65	0.536	–1
Cache Valley S	0.80	8	17	[1]0.086	1	0.83	30	92	[1]0.002	1
Cedar City Valley N	0.00	0	17	1.000	0	–0.17	–6	92	0.602	–1
Cedar City Valley S	0.60	6	17	0.221	4	0.56	20	92	[1]0.048	5
East Shore Area E	0.40	4	17	0.462	0	0.25	9	91	0.402	0
East Shore Area W	–1.00	–10	17	[1]0.027	–3	–0.56	–20	92	[1]0.048	–3
Lower Bear River Basin E	0.40	4	17	0.462	1	0.28	10	92	0.348	1
Lower Bear River Basin W	–0.40	–4	17	0.462	–1	–0.11	–4	92	0.754	–2
Salt Lake Valley NE	1.00	10	17	[1]0.027	4	0.67	24	92	[1]0.016	4
Salt Lake Valley NW	–0.40	–4	17	0.462	–34	–0.20	–3	28	0.707	–11
Salt Lake Valley SE	0.80	8	17	[1]0.086	4	0.78	28	92	[1]0.005	3
Salt Lake Valley SW	–0.60	–6	17	0.221	–2	–0.22	–8	92	0.466	–4
Utah Valley NE	0.40	4	17	0.462	1	0.22	8	92	0.466	1
Utah Valley NW	—	—	—	—	—	–0.67	–4	9	0.308	–18
Utah Valley SE	–1.00	–10	17	[1]0.027	–1	–0.50	–18	92	[1]0.076	–1
Utah Valley SW	0.80	8	17	0.086	7	0.21	6	65	0.536	5

[1]Significant value.

Dissolved solids trend results were similar to or smaller in magnitude than trends identified elsewhere using similar methods. Significant increases in dissolved solids median concentrations ranged from 1 to 7 mg/L per year and decreases in concentrations ranged from –1 to –5 mg/L per year. The rates of change were within the ranges of increases and decreases calculated in a range of well networks representing a range of land-use and principal aquifers across the U.S., where between 1988 and 2010 dissolved-solids concentrations increased between 1.3 and 33 mg/L per year and decreased between –1.7 and –7.5 mg/L per year (Lindsey and Rupert, 2012). For a comparison between trends from this study and in the southwestern U.S., a statistically significant increasing trend of 4.4 mg/L per year was identified in alluvial aquifers in the Upper Colorado River Basin, and no significant trends were identified in the Nevada Basin and Range basin-fill aquifers or the Rio Grande Aquifer System (Lindsey and Rupert, 2012). The period of record varies among all these studies, but the comparison is meant to give some general context for the slope of the trend line.

Trends in Arsenic, Nitrate, and Dissolved Solids from Safe Drinking Water Information System Data

Evidence for trends in arsenic, nitrate, and dissolved-solids concentrations was identified using SDWIS data, which represents water from public-supply wells prior to any treatment. Increases in median arsenic concentrations between 0.06 and 0.1 µg/L per year were identified in in Cedar City Valley and Utah Valley (table 8; fig. 18). In Utah Valley, an increasing trend was identified in the northeast sub-basin. An increase of 0.16 µg/L per year also was identified in the Lower Bear River Basin West. In the Salt Lake Valley, median concentrations increased 0.02 µg/L per year in the Southeast sub-basin and decreased –0.17 µg/L per year in the Southwest sub-basin.

Increases in median nitrate concentrations between 0.01 and 0.06 mg/L per year were identified in the Beryl-Enterprise Area, East Shore Area, Salt Lake Valley, and Sevier Desert (table 9; fig. 18). In the East Shore Area, the western sub-basin had an increasing trend. In the Salt Lake Valley, the Southeast sub-basin had an increasing trend, whereas the Northeast sub-basin had a decreasing trend. Decreasing trends between –0.04 and –0.11 mg/L per year were identified in Northern Juab Valley and Pahvant Valley.

Increases in median dissolved-solids concentrations between 0.4 and 5 mg/L per year were identified in Cache Valley, East Shore Area, Milford Valley, and Sevier Desert (table 10; fig. 18). The Cache Valley South sub-basin had an increasing trend. The East Shore Area East sub-basin had increasing trends, whereas the western sub-basin had a decreasing trend. In the Salt Lake Valley and Utah Valley, no overall basin trends were identified. However, an increasing trend was identified in the Salt Lake Valley Southeast sub-basin, consistent with findings by Thiros and Spangler (2010). A decreasing trend was identified in Utah Valley Southeast. Decreases in median dissolved-solids concentrations between –16 and –19 mg/L per year were identified in Northern Juab Valley.

Increasing trends are more commonly identified in SDWIS data than combined NWIS and SDWIS data, particularly for nitrate and dissolved solids. Assuming that SDWIS data represent deeper wells and that increased concentrations are due to human impacts on groundwater, these results indicate that the deeper aquifers within study basins have been impacted by human activities. Generally, shallower aquifers are more susceptible to human activity at land surface, so changes to the deeper aquifers indicate that impacts are substantial.

Table 8. Arsenic trend test results for Safe Drinking Water Information System data in select basins and sub-basins in Utah between 1975 and 2015.

[Red indicates significant result. **Abbreviations**: µg/L, micrograms per liter; —, no data; N, north; S, south; E, east; W, west; NE, northeast; SE, southeast; SW, southwest; NW, northwest]

Basin	Decadal medians					Sub-decadal medians				
	Tau	Score	Score variance	p-value	Slope (µg/L per year)	Tau	Score	Score variance	p-value	Slope (µg/L per year)
Basins										
Beryl-Enterprise Area	0.67	4	9	0.308	0.11	0.20	2	17	0.806	0.03
Cache Valley	–0.83	–5	8	0.149	–0.02	–0.43	–12	63	0.167	–0.03
Cedar City Valley	1.00	6	9	[1]0.089	0.10	0.54	15	64	[1]0.081	0.06
East Shore Area	0.33	2	9	0.734	0.00	0.10	1	16	1.000	0.00
Lower Bear River Basin	—	—	—	—	—	0.60	9	28	0.133	0.23
Milford Valley	0.40	4	17	0.462	0.10	0.05	1	44	1.000	0.08
Northern Juab Valley	—	—	—	—	—	—	—	—	—	—
Pahvant Valley	—	—	—	—	—	—	—	—	—	—
Parowan Valley	—	—	—	—	—	—	—	—	—	—
Salt Lake Valley	0.20	2	17	0.806	0.03	0.07	2	65	0.902	0.02
Sevier Desert	–0.70	–7	16	0.130	–0.21	–0.17	–6	92	0.602	–0.07
Tooele Valley	—	—	—	—	—	–0.67	–4	9	0.308	–0.01
Utah Valley	—	—	—	—	—	0.71	15	42	[1]0.031	0.06
Sub-basins										
Cache Valley N	0.17	1	8	1.000	0.04	0.20	3	28	0.707	0.01
Cache Valley S	–0.33	–2	9	0.734	–0.03	–0.32	–9	64	0.319	–0.02
Cedar City Valley N	—	—	—	—	—	0.47	7	28	0.260	0.06
Cedar City Valley S	0.33	2	9	0.734	0.06	0.00	0	25	1.000	0.00
East Shore Area E	0.33	2	9	0.734	0.00	0.50	3	8	0.470	0.01
East Shore Area W	—	—	—	—	—	0.30	3	16	0.613	0.05
Lower Bear River Basin E	—	—	—	—	—	0.53	8	27	0.181	0.35
Lower Bear River Basin W	0.60	6	17	0.221	0.11	0.64	18	65	[1]0.035	0.16
Salt Lake Valley NE	—	—	—	—	—	0.30	3	16	0.613	0.02
Salt Lake Valley SE	—	—	—	—	—	0.90	9	16	[1]0.043	0.02
Salt Lake Valley SW	–0.40	–4	17	0.462	–0.23	–0.57	–16	65	[1]0.063	–0.17
Utah Valley NE	—	—	—	—	—	0.80	8	17	[1]0.086	0.11
Utah Valley NW	—	—	—	—	—	—	—	—	—	—
Utah Valley SE	—	—	—	—	—	–0.40	–6	25	0.314	–0.01
Utah Valley SW	0.67	4	9	0.308	0.24	0.47	7	28	0.260	0.10

[1]Significant value.

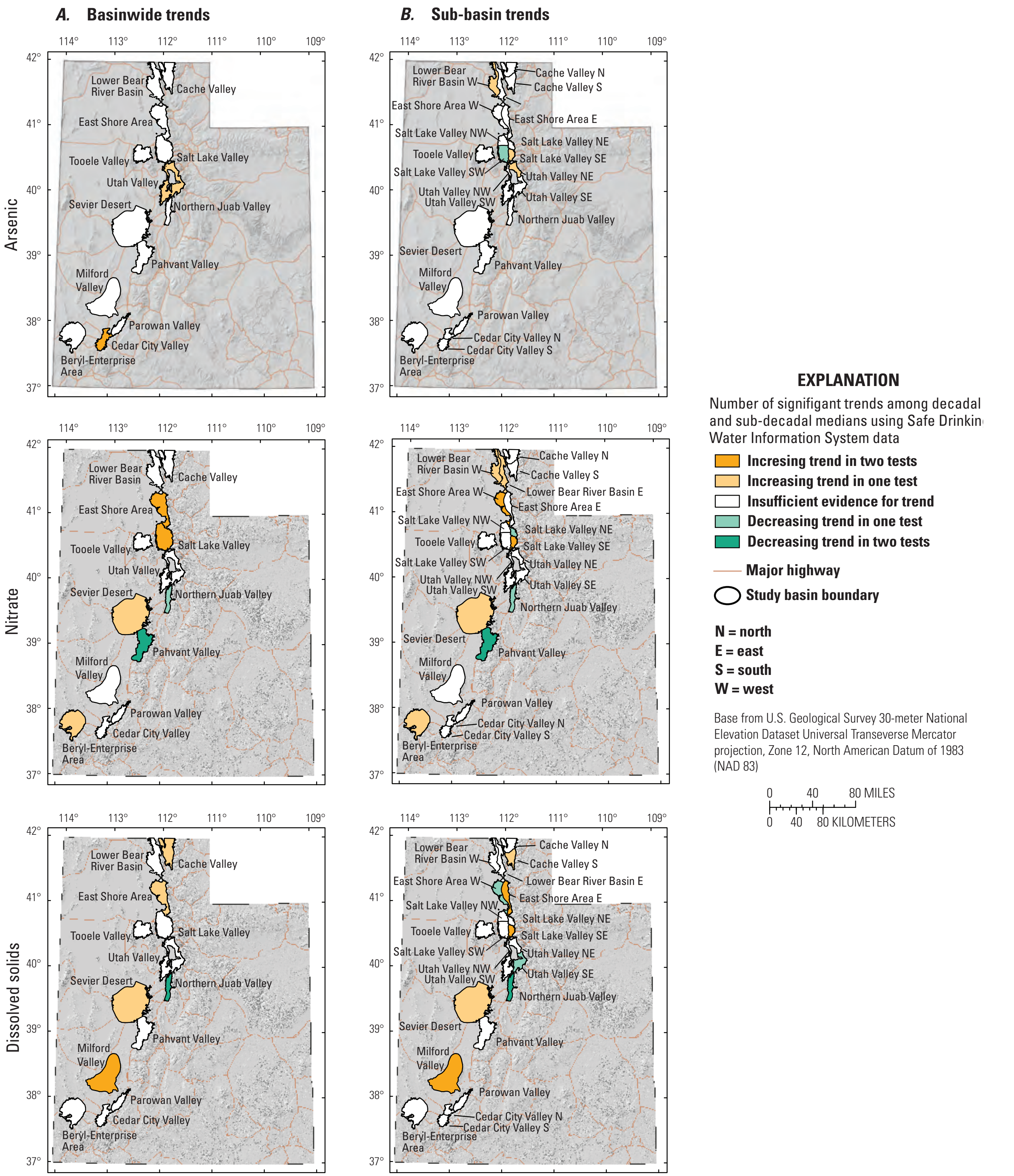


Figure 18. Spatial patterns of trends in arsenic, nitrate, and dissolved solids data from the Safe Drinking Water Information System in select basins and sub-basins of Utah.

Table 9. Nitrate trend test results for Safe Drinking Water Information System data in select basins and sub-basins in Utah between 1975 and 2015.

[Red indicates significant result. **Abbreviations**: mg/L, miligrams per liter; N, north; S, south; E, east; W, west; NE, northeast; SE, southeast; SW, southwest; NW, northwest; —, no data]

Basin	Decadal medians					Sub-decadal medians				
	Tau	Score	Score variance	p-value	Slope (mg/L per year)	Tau	Score	Score variance	p-value	Slope (mg/L per year)
Basins										
Beryl-Enterprise Area	0.67	4	9	0.308	0.05	0.64	18	65	[1]0.035	0.06
Cache Valley	0.60	6	17	0.221	0.02	0.28	10	92	0.348	0.01
Cedar City Valley	0.40	4	17	0.462	0.00	0.33	12	92	0.251	0.01
East Shore Area	0.80	8	17	[1]0.086	0.01	0.56	20	90	[1]0.045	0.01
Lower Bear River Basin	–0.20	–2	17	0.806	0.00	–0.03	—	91	1.000	0.00
Milford Valley	0.67	4	9	0.308	0.01	0.36	10	63	0.258	0.01
Northern Juab Valley	–0.80	–8	17	[1]0.086	–0.04	–0.44	–16	92	0.118	–0.04
Pahvant Valley	–0.80	–8	17	[1]0.086	–0.11	–0.58	–21	91	[1]0.036	–0.10
Parowan Valley	0.67	4	9	0.308	0.01	0.33	2	9	0.734	0.01
Salt Lake Valley	1.00	10	17	[1]0.027	0.01	0.72	26	92	[1]0.009	0.01
Sevier Desert	0.67	4	9	0.308	0.01	0.79	22	65	[1]0.009	0.01
Tooele Valley	0.60	6	17	0.221	0.00	0.39	14	90	0.171	0.01
Utah Valley	–0.20	–2	17	0.806	0.00	–0.11	–4	92	0.754	0.00
Sub-basins										
Cache Valley N	0.20	2	17	0.806	0.03	0.14	5	91	0.675	0.02
Cache Valley S	0.00	0	17	1.000	0.00	0.22	8	92	0.466	0.01
Cedar City Valley N	–0.40	–4	17	0.462	–0.01	–0.25	–9	91	0.402	–0.01
Cedar City Valley S	0.33	2	9	0.734	0.01	0.43	12	65	0.174	0.01
East Shore Area E	0.40	4	17	0.462	0.01	0.44	16	92	0.118	0.01
East Shore Area W	0.80	8	17	[1]0.086	0.01	0.69	25	91	[1]0.012	0.01
Lower Bear River Basin E	0.40	4	17	0.462	0.01	0.47	17	91	[1]0.093	0.01
Lower Bear River Basin W	0.80	8	17	[1]0.086	0.01	0.14	4	65	0.711	0.01
Salt Lake Valley NE	–0.80	–8	17	[1]0.086	–0.01	–0.36	–13	91	0.208	–0.02
Salt Lake Valley SE	1.00	10	17	[1]0.027	0.02	0.78	28	92	[1]0.005	0.02
Salt Lake Valley SW	0.20	2	17	0.806	0.00	0.33	12	92	0.251	0.01
Utah Valley NE	0.60	6	17	0.221	0.01	0.31	11	91	0.295	0.00
Utah Valley NW	—	—	—	—	—	0.33	2	9	0.734	0.05
Utah Valley SE	–0.60	–6	17	0.221	0.00	–0.39	–14	92	0.175	0.00
Utah Valley SW	—	—	—	—	—	0.20	2	17	0.806	0.00

[1]Significant value.

Table 10. Dissolved solids trend test results for Safe Drinking Water Information System data in select basins and sub-basins in Utah between 1975 and 2015.

[Red indicates significant result. **Abbreviations**: mg/L, milligrams per liter; —, no data; N, north; S, south; E, east; W, west; NE, northeast; SE, southeast; SW, southwest; NW, northwest]

Basin	Decadal medians					Sub-decadal medians				
	Tau	Score	Score variance	p-value	Slope (mg/L per year)	Tau	Score	Score variance	p-value	Slope (mg/L per year)
Basins										
Beryl-Enterprise Area	0.33	2	9	0.734	1	0.29	6	43	0.448	1
Cache Valley	0.40	4	17	0.462	0	0.50	18	92	[1]0.076	1
Cedar City Valley	0.60	6	17	0.221	3	0.33	12	92	0.251	2
East Shore Area	0.70	7	16	0.130	1	0.57	16	61	[1]0.054	0.4
Lower Bear River Basin	0.00	0	17	1.000	0	0.17	6	92	0.602	1
Milford Valley	1.00	10	17	[1]0.027	5	0.61	22	92	[1]0.029	5
Northern Juab Valley	–0.80	–8	17	[1]0.086	–16	–0.79	–22	65	[1]0.009	–19
Pahvant Valley	0.60	6	17	0.221	8	0.40	4	17	0.462	1
Parowan Valley	—	—	—	—	—	0.33	2	9	0.734	3
Salt Lake Valley	0.60	6	17	0.221	2	0.17	6	92	0.602	2
Sevier Desert	1.00	10	17	[1]0.027	2	0.50	14	65	0.108	2
Tooele Valley	0.00	0	17	1.000	0	0.00	0	65	1.000	0
Utah Valley	–0.30	–3	16	0.613	0	–0.08	–3	91	0.834	–0
Sub-basins										
Cache Valley N	–0.20	–2	17	0.806	0	–0.29	–8	65	0.386	–1
Cache Valley S	0.40	4	17	0.462	1	0.56	20	92	[1]0.048	1
Cedar City Valley N	0.40	4	17	0.462	1	0.17	6	92	0.602	2
Cedar City Valley S	0.33	2	9	0.734	5	0.29	6	43	0.448	4
East Shore Area E	0.80	8	17	[1]0.086	1	0.79	22	65	[1]0.009	1
East Shore Area W	–0.60	–6	17	0.221	–2	–0.57	–16	65	[1]0.063	–3
Lower Bear River Basin E	0.60	6	17	0.221	1	0.33	12	92	0.251	1
Lower Bear River Basin W	0.00	0	17	1.000	–1	0.05	1	44	1.000	1
Salt Lake Valley NE	0.60	6	17	0.221	3	0.39	14	92	0.175	2
Salt Lake Valley SE	0.80	8	17	0.086	3	0.83	30	92	[1]0.002	3
Salt Lake Valley SW	–0.60	–6	17	0.221	–7	–0.39	–14	92	0.175	–7
Utah Valley NE	0.20	2	17	[1]0.806	0	0.00	0	65	1.000	0
Utah Valley NW	—	—	—	—	—	—	—	—	—	—
Utah Valley SE	–0.60	–6	17	0.221	–1	–0.47	–17	91	[1]0.093	–2
Utah Valley SW	0.00	0	9	1.000	–1	—	—	—	—	—

[1]Significant value.

Linking Trends to Land-Use Change

Broad patterns in land use and land-use change, and related demographic and water-use patterns can be associated with water-quality changes. Although arsenic in groundwater is primarily naturally sourced, humans may influence aquifer geochemical conditions that mediate arsenic concentrations through activities that impact redox conditions and pH (Bexfield and others, 2011). Increasing trends also could be caused by the addition of deeper wells tapping into older groundwater that has had more time to interact with arsenic-bearing rocks in response to growing water demand. Humans can more directly influence arsenic, nitrate, and dissolved solids in groundwater by controlling their sources and practices that mediate loading (water-use practices such as artificial recharge, groundwater pumping, and well depths; Bexfield and others, 2011). Trends in nitrate and dissolved solids indicate that humans, through a range of activities, have impacted groundwater quality over time.

Generally, arsenic trends were not directly linked to land-use change taking place on land immediately surrounding wells. There were not enough data in many basins to do a trend analysis for some land-use change categories. There were fewer data from a fewer number of wells and from a shorter period of time available for each land-use change category in each basin (table 11). The median arsenic concentration over time in each basin for each land-use change category is shown in figure 19.

Basinwide, no significant arsenic trends were identified for wells experiencing any land-use change except a decreasing trend was identified at wells in the Salt Lake Valley where the land use changed from low use to urban (table 12). This decreasing trend may be explained by an increase over time in deeper wells (or samples from deeper wells) seeking cleaner water in response to the increased development or urbanization in areas where groundwater has lower arsenic concentrations. Trends were evaluated in shallow wells (depth less than 200 feet) to test this explanation; however, there were not enough data to identify significant trends in shallow wells experiencing a transition from low use to urban land. In the shallow wells where land use did not change, a significant decreasing trend was identified in the Salt Lake Valley and a significant increasing trend was identified in Utah Valley.

Generally, nitrate trends were not linked to land-use change at wells. There were insufficient data in many basins for many land-use change categories to do a trend test (table 13). The median concentration over time in each basin for each land-use change category is shown in figure 20. Nitrate trends were associated with land-use changes at wells in a few basins (table 14). For example, significant increasing trends were identified in the Cache Valley wells where land had changed from urban to production, presumably resulting from increased fertilizer application associated with agricultural production. However, in Cedar City, a significant positive trend in nitrate was identified among wells experiencing a transition from production to urban. This trend may be related to the timing and nature of the transition to urban land. Nitrate may have accumulated in aquifers from a history of production (fertilizer and manure associated with agriculture and livestock), leading to a positive trend that has been augmented by widespread use of septic systems accompanying development. Construction of sewer systems in and around Enoch began in 1994, although many households use septic systems as their primary means of wastewater disposal (Lowe and Wallace, 2001). Cedar City Valley also has naturally high nitrate concentrations (Lowe and Wallace, 2001). The percentage of land in each basin that has been converted from urban to production also is very low and so the results should be interpreted with caution. Significant increasing and decreasing nitrate trends were identified for wells where land use did not change.

When considering broader land-use change across a basin and the impacts on groundwater-quality trends, the results showing nitrate increases in more urban basins including the Salt Lake Valley and East Shore Area and decreases in other basins with more agricultural production may be counterintuitive. However, it is possible that the impacts of urbanization may have substantial effects on nitrate in groundwater through activities such as overfertilization of urban vegetation (for example, lawns and golf courses) or additional sources of nitrate including vehicles and industrial processes. In a nationwide study of decadal-scale changes in groundwater quality, Lindsey and Rupert (2012) reported a higher percentage of significant increases in nitrate concentrations in urban areas than agricultural areas, although they also reported large increases in nitrate concentrations in agricultural areas. Although agricultural activities are generally considered more important sources of nitrogen to hydrologic systems, the impacts of urban activities can be substantial as well. Further, if nitrate loading from agriculture has not changed substantially, nitrate concentrations would not be impacted.

Generally, dissolved solids trends were not linked to land-use change at wells. There were insufficient data in many basins for many land-use change categories to do a trend test (table 15). Among the different land-use change categories, the "no change" category has the most wells and samples. The median dissolved-solids concentration over time in each basin for each land-use change category is shown in figure 21.

Table 11. Number of wells; period of record; number of arsenic measurements; and minimum, maximum, and median arsenic concentration in each basin for each land-use change category.

[µg/L, micrograms per liter; —, no data]

Basin	Number of wells	Starting year	Ending year	Number of samples	Number of censored samples	Percent censored	Minimum concentration (µg/L)	Maximum concentration (µg/L)	Median concentration (µg/L)
All wells									
Production to low use									
Beryl-Enterprise Area	1	2013	2013	1	0	0	2.8	2.8	—
Milford Valley	1	2011	2011	1	0	0	3.8	3.8	—
Sevier Desert	1	1979	1986	3	0	0	590	730	610
Urban to production									
Cache Valley	1	1989	2013	7	3	43	0.5	5	0.9
East Shore Area	1	1991	1991	1	1	100	5	5	—
Salt Lake Valley	3	1993	2009	10	0	0	5	21	14
Tooele Valley	1	2000	2000	1	0	0	1	1	—
Utah Valley	1	2003	2003	1	0	0	0.4	0.4	—
No change									
Beryl-Enterprise Area	21	1978	2015	81	10	12	0.04	95.7	4
Cache Valley	60	1975	2015	234	88	38	0.02	42.4	0.9
Cedar City Valley	40	1978	2015	144	38	26	0.1	15.7	2
East Shore Area	128	1976	2015	482	275	57	0.1	50	0.7
Lower Bear River Basin	77	1978	2015	342	108	32	0.1	106	2
Milford Valley	42	1978	2015	175	6	3	1	39	6.6
Northern Juab Valley	19	1978	2015	59	27	46	0.23	10	0.7
Pahvant Valley	59	1978	2015	111	17	15	0.21	19	2
Parowan Valley	15	1978	2015	48	6	13	0.5	11.3	3.8
Salt Lake Valley	332	1975	2015	1,443	421	29	0.005	360	1.7
Sevier Desert	74	1978	2015	209	20	10	0.08	730	7.5
Tooele Valley	101	1977	2015	348	80	23	0.005	206	1.6
Utah Valley	137	1977	2015	519	224	43	0.1	53	1
Production to urban									
Cache Valley	9	1979	2013	32	20	63	0.46	10	0.6
Cedar City Valley	1	1997	2014	6	4	67	0.5	5	—
East Shore Area	21	1978	2013	61	30	49	0.5	44	1
Lower Bear River Basin	1	1998	1998	1	0	0	95	95	—
Salt Lake Valley	51	1977	2015	206	54	26	0.3	99	4.4
Sevier Desert	1	1978	2008	11	0	0	10	28	12.2
Tooele Valley	7	1981	2013	24	4	17	0.6	7	2
Utah Valley	26	1978	2015	81	35	43	0.1	72.9	1
Low use to production									
Beryl-Enterprise Area	1	1987	2013	8	5	63	1	10	1
Cache Valley	4	1978	2015	20	5	25	0.5	17.3	5.6
Northern Juab Valley	2	2005	2012	4	0	0	0.19	1.3	—
Pahvant Valley	2	1985	2015	4	0	0	4	6.7	5.9
Parowan Valley	2	2007	2013	5	0	0	2.3	6	2.4
Salt Lake Valley	8	1978	2015	76	9	12	0.005	275	7
Sevier Desert	1	1980	2015	6	0	0	1.8	3	1.9

Table 11. Number of wells; period of record; number of arsenic measurements; and minimum, maximum, and median arsenic concentration in each basin for each land-use change category.—Continued

[µg/L, micrograms per liter; —, no data]

Basin	Number of wells	Starting year	Ending year	Number of samples	Number of censored samples	Percent censored	Minimum concentration (µg/L)	Maximum concentration (µg/L)	Median concentration (µg/L)
All wells—Continued									
Low use to production—Continued									
Tooele Valley	1	1997	2013	5	1	20	1	5	1.4
Utah Valley	10	1998	2015	22	1	5	0.5	18	2.6
Low use to urban									
Cedar City Valley	17	1979	2015	62	28	45	0.5	10	2
Lower Bear River Basin	2	1978	2010	13	8	62	0.5	7	0.6
Salt Lake Valley	18	1980	2015	79	15	19	0.5	155	6.5
Sevier Desert	1	2009	2013	2	0	0	12.4	14.3	—
Tooele Valley	15	1978	2013	43	23	53	0.2	10	0.6
Utah Valley	21	1978	2013	81	26	32	0.5	50	2
Wells less than 200 feet deep									
Urban to production									
Salt Lake Valley	2	1998	2008	3	0	0	5	11.3	5.1
No change									
Beryl-Enterprise Area	2	2005	2011	9	0	0	0.05	9.5	3.3
Cache Valley	9	1983	2015	26	9	35	0.55	13.1	0.7
Cedar City Valley	1	2007	2007	1	0	0	0.57	0.57	—
East Shore Area	10	1978	2015	33	15	45	0.5	22.8	1.3
Lower Bear River Basin	9	1985	2014	22	7	32	0.5	10	1.7
Milford Valley	2	2012	2015	2	0	0	2.9	20.5	—
Pahvant Valley	14	1985	2015	24	1	4	1	19	8.1
Parowan Valley	1	2005	2014	4	0	0	5.3	6.6	5.8
Salt Lake Valley	45	1980	2015	88	19	22	0.5	360	2.1
Sevier Desert	17	1979	2015	22	0	0	3.9	700	7.1
Tooele Valley	20	1991	2014	37	2	5	0.3	5.8	1.7
Utah Valley	19	1978	2015	35	1	3	0.5	12	1.8
Production to urban									
East Shore Area	1	1981	2008	8	8	100	0.5	5	—
Lower Bear River Basin	1	1998	1998	1	0	0	95	95	—
Salt Lake Valley	9	1981	2008	35	3	9	1	99	21
Tooele Valley	1	2000	2003	4	0	0	4.9	7	5.6
Utah Valley	1	2014	2014	1	0	0	5.9	5.9	—
Low use to production									
Cache Valley	1	2005	2015	10	0	0	5.6	8.2	6
Salt Lake Valley	4	1978	2015	18	2	11	1	275	6.4
Utah Valley	1	2008	2013	3	0	0	1	1.1	1
Low use to urban									
Salt Lake Valley	3	1991	2008	6	0	0	5	155	11.1
Tooele Valley	6	2001	2001	6	0	0	0.2	1.8	0.8
Utah Valley	4	1981	2005	12	7	58	0.5	5	0.6

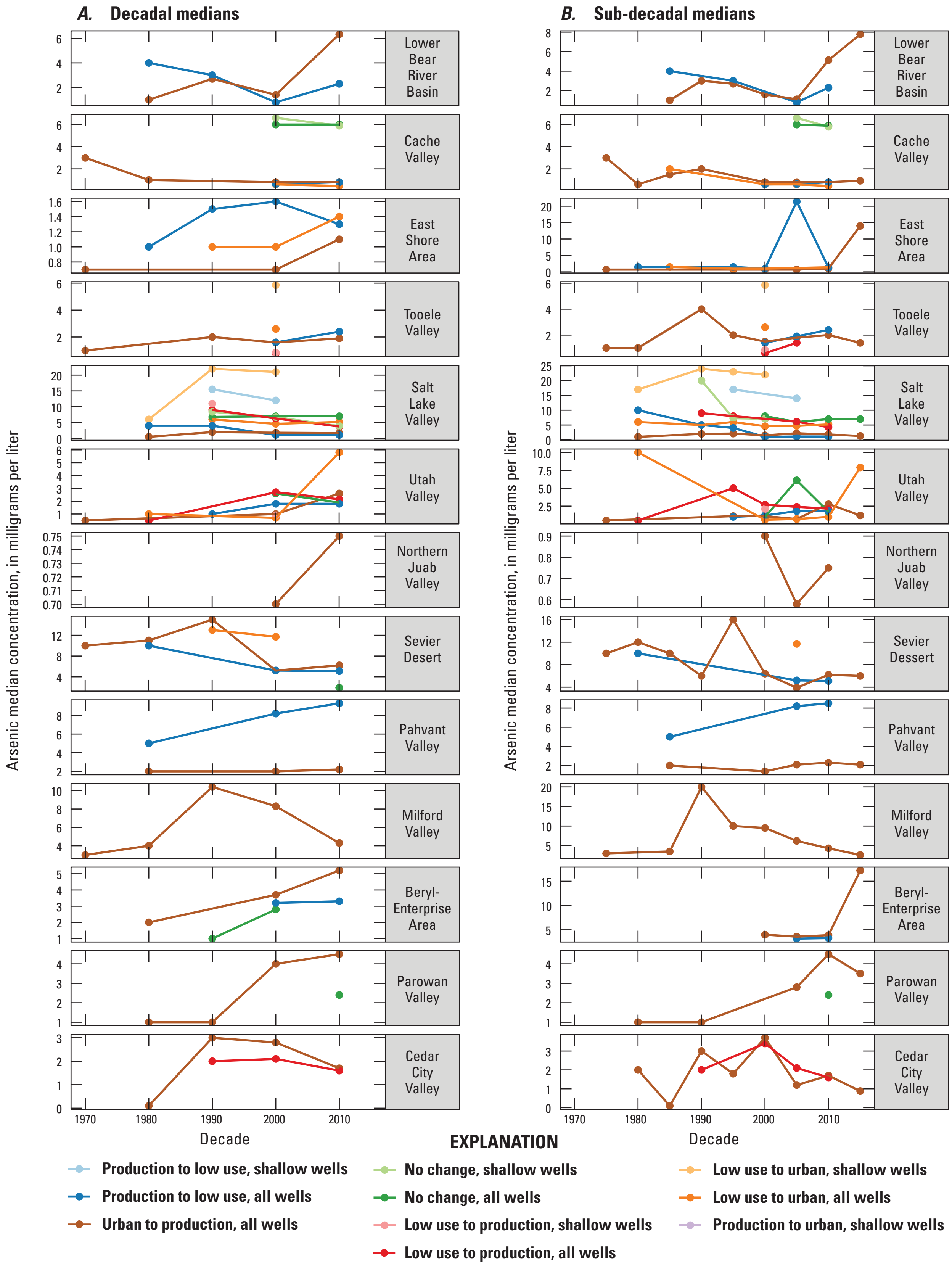


Figure 19. Decadal and sub-decadal median arsenic concentration in select *A*, basins and *B*, sub-basins by land-use change category in Utah.

Table 12. Trend test results for arsenic in basins for each land-use change category.

[Red indicates significant result. **Abbrebiations**: µg/L, micrograms per liter; —, no data]

Basin	Decadal medians					Sub-decadal medians				
	Tau	Score	Score variance	p-value	Slope (µg/L per year)	Tau	Score	Score variance	p-value	Slope (µg/L per year)
All wells										
Production to low use										
Beryl-Enterprise Area	—	—	—	—	—	—	—	—	—	—
Cache Valley	—	—	—	—	—	—	—	—	—	—
Cedar City Valley	—	—	—	—	—	—	—	—	—	—
East Shore Area	—	—	—	—	—	—	—	—	—	—
Lower Bear River Basin	—	—	—	—	—	—	—	—	—	—
Milford Valley	—	—	—	—	—	—	—	—	—	—
Northern Juab Valley	—	—	—	—	—	—	—	—	—	—
Pahvant Valley	—	—	—	—	—	—	—	—	—	—
Parowan Valley	—	—	—	—	—	—	—	—	—	—
Salt Lake Valley	—	—	—	—	—	—	—	—	—	—
Sevier Desert	—	—	—	—	—	—	—	—	—	—
Tooele Valley	—	—	—	—	—	—	—	—	—	—
Utah Valley	—	—	—	—	—	—	—	—	—	—
Urban to production										
Beryl-Enterprise Area	—	—	—	—	—	—	—	—	—	—
Cache Valley	—	—	—	—	—	—	—	—	—	—
Cedar City Valley	—	—	—	—	—	—	—	—	—	—
East Shore Area	—	—	—	—	—	—	—	—	—	—
Lower Bear River Basin	—	—	—	—	—	—	—	—	—	—
Milford Valley	—	—	—	—	—	—	—	—	—	—
Northern Juab Valley	—	—	—	—	—	—	—	—	—	—
Pahvant Valley	—	—	—	—	—	—	—	—	—	—
Parowan Valley	—	—	—	—	—	—	—	—	—	—
Salt Lake Valley	—	—	—	—	—	—	—	—	—	—
Sevier Desert	—	—	—	—	—	—	—	—	—	—
Tooele Valley	—	—	—	—	—	—	—	—	—	—
Utah Valley	—	—	—	—	—	—	—	—	—	—
No change										
Beryl-Enterprise Area	—	—	—	—	—	0.33	2	9	0.734	0.47
Cache Valley	–0.83	–5	8	0.149	–0.03	–0.18	–5	62	0.610	–0.02
Cedar City Valley	0.00	0	9	1.000	0.02	–0.21	–6	65	0.536	–0.02
East Shore Area	—	—	—	—	—	0.33	5	26	0.436	0.02
Lower Bear River Basin	0.67	4	9	0.308	0.17	0.43	9	44	0.230	0.16
Milford Valley	0.40	4	17	0.462	0.07	–0.21	–6	65	0.536	–0.22
Northern Juab Valley	—	—	—	—	—	—	—	—	—	—
Pahvant Valley	—	—	—	—	—	0.40	4	17	0.462	0.01
Parowan Valley	0.83	5	8	0.149	0.13	0.70	7	16	0.130	0.09
Salt Lake Valley	0.00	0	9	1.000	0.02	0.05	1	44	1.000	0.01

Table 12. Trend test results for arsenic in basins for each land-use change category.—Continued

[Red indicates significant result. **Abbrebiations**: µg/L, micrograms per liter; —, no data]

Basin	Decadal medians					Sub-decadal medians				
	Tau	Score	Score variance	p-value	Slope (µg/L per year)	Tau	Score	Score variance	p-value	Slope (µg/L per year)
All wells—Continued										
No change—Continued										
Sevier Desert	–0.20	–2	17	0.806	–0.13	–0.44	–16	90	0.114	–0.14
Tooele Valley	0.33	2	9	0.734	0.02	0.14	4	63	0.706	0.01
Utah Valley	—	—	—	—	—	0.60	9	28	0.133	0.02
Production to urban										
Beryl-Enterprise Area	—	—	—	—	—	—	—	—	—	—
Cache Valley	—	—	—	—	—	–0.83	–5	8	0.149	–0.04
Cedar City Valley	—	—	—	—	—	—	—	—	—	—
East Shore Area	—	—	—	—	—	–0.17	—	8	1.000	0.00
Lower Bear River Basin	—	—	—	—	—	—	—	—	—	—
Milford Valley	—	—	—	—	—	—	—	—	—	—
Northern Juab Valley	—	—	—	—	—	—	—	—	—	—
Pahvant Valley	—	—	—	—	—	—	—	—	—	—
Parowan Valley	—	—	—	—	—	—	—	—	—	—
Salt Lake Valley	—	—	—	—	—	–0.27	–4	27	0.566	–0.03
Sevier Desert	—	—	—	—	—	—	—	—	—	—
Tooele Valley	—	—	—	—	—	—	—	—	—	—
Utah Valley	—	—	—	—	—	0.20	2	17	0.806	0.03
Low use to production										
Beryl-Enterprise Area	—	—	—	—	—	—	—	—	—	—
Cache Valley	—	—	—	—	—	—	—	—	—	—
Cedar City Valley	—	—	—	—	—	—	—	—	—	—
East Shore Area	—	—	—	—	—	—	—	—	—	—
Lower Bear River Basin	—	—	—	—	—	—	—	—	—	—
Milford Valley	—	—	—	—	—	—	—	—	—	—
Northern Juab Valley	—	—	—	—	—	—	—	—	—	—
Pahvant Valley	—	—	—	—	—	—	—	—	—	—
Parowan Valley	—	—	—	—	—	—	—	—	—	—
Salt Lake Valley	—	—	—	—	—	–0.17	—	8	1.000	–0.03
Sevier Desert	—	—	—	—	—	—	—	—	—	—
Tooele Valley	—	—	—	—	—	—	—	—	—	—
Utah Valley	—	—	—	—	—	—	—	—	—	—
Low use to urban										
Beryl-Enterprise Area	—	—	—	—	—	—	—	—	—	—
Cache Valley	—	—	—	—	—	—	—	—	—	—
Cedar City Valley	—	—	—	—	—	–0.33	–2	9	0.734	–0.06
East Shore Area	—	—	—	—	—	—	—	—	—	—
Lower Bear River Basin	—	—	—	—	—	—	—	—	—	—
Milford Valley	—	—	—	—	—	—	—	—	—	—

Table 12. Trend test results for arsenic in basins for each land-use change category.—Continued

[Red indicates significant result. **Abbrebiations**: µg/L, micrograms per liter; —, no data]

Basin	Decadal medians					Sub-decadal medians				
	Tau	Score	Score variance	p-value	Slope (µg/L per year)	Tau	Score	Score variance	p-value	Slope (µg/L per year)
All wells—Continued										
Low use to urban—Continued										
Northern Juab Valley	—	—	—	—	—	—	—	—	—	—
Pahvant Valley	—	—	—	—	—	—	—	—	—	—
Parowan Valley	—	—	—	—	—	—	—	—	—	—
Salt Lake Valley	—	—	—	—	—	–1.00	–10	17	[1]0.027	–0.20
Sevier Desert	—	—	—	—	—	—	—	—	—	—
Tooele Valley	—	—	—	—	—	—	—	—	—	—
Utah Valley	—	—	—	—	—	–0.20	–2	17	0.806	–0.05
Wells less than 200 feet deep										
Production to low use										
Beryl-Enterprise Area	—	—	—	—	—	—	—	—	—	—
Cache Valley	—	—	—	—	—	—	—	—	—	—
Cedar City Valley	—	—	—	—	—	—	—	—	—	—
East Shore Area	—	—	—	—	—	—	—	—	—	—
Lower Bear River Basin	—	—	—	—	—	—	—	—	—	—
Milford Valley	—	—	—	—	—	—	—	—	—	—
Northern Juab Valley	—	—	—	—	—	—	—	—	—	—
Pahvant Valley	—	—	—	—	—	—	—	—	—	—
Parowan Valley	—	—	—	—	—	—	—	—	—	—
Salt Lake Valley	—	—	—	—	—	—	—	—	—	—
Sevier Desert	—	—	—	—	—	—	—	—	—	—
Tooele Valley	—	—	—	—	—	—	—	—	—	—
Utah Valley	—	—	—	—	—	—	—	—	—	—
Urban to production										
Beryl-Enterprise Area	—	—	—	—	—	—	—	—	—	—
Cache Valley	—	—	—	—	—	—	—	—	—	—
Cedar City Valley	—	—	—	—	—	—	—	—	—	—
East Shore Area	—	—	—	—	—	—	—	—	—	—
Lower Bear River Basin	—	—	—	—	—	—	—	—	—	—
Milford Valley	—	—	—	—	—	—	—	—	—	—
Northern Juab Valley	—	—	—	—	—	—	—	—	—	—
Pahvant Valley	—	—	—	—	—	—	—	—	—	—
Parowan Valley	—	—	—	—	—	—	—	—	—	—
Salt Lake Valley	—	—	—	—	—	—	—	—	—	—
Sevier Desert	—	—	—	—	—	—	—	—	—	—
Tooele Valley	—	—	—	—	—	—	—	—	—	—
Utah Valley	—	—	—	—	—	—	—	—	—	—
No change										
Beryl-Enterprise Area	—	—	—	—	—	—	—	—	—	—

Table 12. Trend test results for arsenic in basins for each land-use change category.—Continued

[Red indicates significant result. **Abbrebiations**: µg/L, micrograms per liter; —, no data]

Basin	Decadal medians					Sub-decadal medians				
	Tau	Score	Score variance	p-value	Slope (µg/L per year)	Tau	Score	Score variance	p-value	Slope (µg/L per year)
Wells less than 200 feet deep—Continued										
No change—Continued										
Cache Valley	—	—	—	—	—	—	—	—	—	—
Cedar City Valley	—	—	—	—	—	—	—	—	—	—
East Shore Area	0.33	2	9	0.734	0.01	–0.10	—	16	1.000	0.00
Lower Bear River Basin	–0.67	–4	9	0.308	–0.08	–0.67	–4	9	0.308	–0.08
Milford Valley	—	—	—	—	—	—	—	—	—	—
Northern Juab Valley	—	—	—	—	—	—	—	—	—	—
Pahvant Valley	—	—	—	—	—	—	—	—	—	—
Parowan Valley	—	—	—	—	—	—	—	—	—	—
Salt Lake Valley	–0.67	–4	7	0.245	–0.12	–0.67	–10	27	[1]0.085	–0.29
Sevier Desert	—	—	—	—	—	—	—	—	—	—
Tooele Valley	—	—	—	—	—	—	—	—	—	—
Utah Valley	—	—	—	—	—	1.00	6	9	[1]0.089	0.06
Production to urban										
Beryl-Enterprise Area	—	—	—	—	—	—	—	—	—	—
Cache Valley	—	—	—	—	—	—	—	—	—	—
Cedar City Valley	—	—	—	—	—	—	—	—	—	—
East Shore Area	—	—	—	—	—	—	—	—	—	—
Lower Bear River Basin	—	—	—	—	—	—	—	—	—	—
Milford Valley	—	—	—	—	—	—	—	—	—	—
Northern Juab Valley	—	—	—	—	—	—	—	—	—	—
Pahvant Valley	—	—	—	—	—	—	—	—	—	—
Parowan Valley	—	—	—	—	—	—	—	—	—	—
Salt Lake Valley	—	—	—	—	—	0.00	0	9	1.000	0.03
Sevier Desert	—	—	—	—	—	—	—	—	—	—
Tooele Valley	—	—	—	—	—	—	—	—	—	—
Utah Valley	—	—	—	—	—	—	—	—	—	—
Low use to production										
Beryl-Enterprise Area	—	—	—	—	—	—	—	—	—	—
Cache Valley	—	—	—	—	—	—	—	—	—	—
Cedar City Valley	—	—	—	—	—	—	—	—	—	—
East Shore Area	—	—	—	—	—	—	—	—	—	—
Lower Bear River Basin	—	—	—	—	—	—	—	—	—	—
Milford Valley	—	—	—	—	—	—	—	—	—	—
Northern Juab Valley	—	—	—	—	—	—	—	—	—	—
Pahvant Valley	—	—	—	—	—	—	—	—	—	—
Parowan Valley	—	—	—	—	—	—	—	—	—	—
Salt Lake Valley	—	—	—	—	—	0.30	3	16	0.613	3.58
Sevier Desert	—	—	—	—	—	—	—	—	—	—

Table 12. Trend test results for arsenic in basins for each land-use change category.—Continued

[Red indicates significant result. **Abbrebiations**: µg/L, micrograms per liter; —, no data]

Basin	Decadal medians					Sub-decadal medians				
	Tau	Score	Score variance	p-value	Slope (µg/L per year)	Tau	Score	Score variance	p-value	Slope (µg/L per year)
Wells less than 200 feet deep—Continued										
Low use to production—Continued										
Tooele Valley	—	—	—	—	—	—	—	—	—	—
Utah Valley	—	—	—	—	—	—	—	—	—	—
Low use to urban										
Beryl-Enterprise Area	—	—	—	—	—	—	—	—	—	—
Cache Valley	—	—	—	—	—	—	—	—	—	—
Cedar City Valley	—	—	—	—	—	—	—	—	—	—
East Shore Area	—	—	—	—	—	—	—	—	—	—
Lower Bear River Basin	—	—	—	—	—	—	—	—	—	—
Milford Valley	—	—	—	—	—	—	—	—	—	—
Northern Juab Valley	—	—	—	—	—	—	—	—	—	—
Pahvant Valley	—	—	—	—	—	—	—	—	—	—
Parowan Valley	—	—	—	—	—	—	—	—	—	—
Salt Lake Valley	—	—	—	—	—	—	—	—	—	—
Sevier Desert	—	—	—	—	—	—	—	—	—	—
Tooele Valley	—	—	—	—	—	—	—	—	—	—
Utah Valley	—	—	—	—	—	—	—	—	—	—

[1]Significant value.

Table 13. Number of wells; period of record; number of nitrate measurements; and minimum, maximum, and median nitrate concentration in each basin for each land-use change category.

[mg/L, miligrams per liter; —, no data]

Basin	Number of wells	Starting year	Ending year	Number of samples	Number of censored samples	Percent censored	Minimum concentration (mg/L)	Maximum concentration (mg/L)	Median concentration (mg/L)
All wells									
Production to low use									
Beryl-Enterprise Area	1	2013	2013	1	0	0	1.41	1.41	—
Cedar City Valley	2	1999	1999	2	0	0	0.25	0.39	—
Milford Valley	2	1975	2011	3	0	0	0.77	1.3	1.1
Parowan Valley	1	2013	2013	1	0	0	1.55	1.55	—
Sevier Desert	1	1981	1981	1	0	0	0.02	0.02	—
Tooele Valley	1	1999	1999	4	0	0	0.92	1.71	1.1
Urban to production									
Cache Valley	2	1989	2015	30	0	0	0.77	8.84	5.8
East Shore Area	3	1980	1991	3	0	0	0.6	1.5	0.73
Salt Lake Valley	3	1993	2009	62	1	2	0.2	7.6	4.2
Tooele Valley	1	2000	2000	1	0	0	0.83	0.83	—
Utah Valley	2	1981	2003	2	0	0	2.45	2.5	—

Table 13. Number of wells; period of record; number of nitrate measurements; and minimum, maximum, and median nitrate concentration in each basin for each land-use change category.—Continued

[mg/L, miligrams per liter; —, no data]

Basin	Number of we lls	Starting year	Ending year	Number of samples	Number of censored samples	Percent censored	Minimum concentration (mg/L)	Maximum concentration (mg/L)	Median concentration (mg/L)
All wells—Continued									
No change									
Beryl-Enterprise Area	33	1975	2015	288	2	1	0.04	10	1.9
Cache Valley	79	1975	2015	636	34	5	0.01	18.85	1.3
Cedar City Valley	71	1975	2015	434	12	3	0.02	13.3	0.9
East Shore Area	175	1975	2015	1,521	182	12	0.01	18	1.1
Lower Bear River Basin	93	1975	2015	764	43	6	0.001	27.9	1
Milford Valley	53	1975	2015	374	23	6	0.01	40.3	0.75
Northern Juab Valley	38	1975	2015	195	1	1	0.01	42	3.15
Pahvant Valley	75	1975	2015	354	4	1	0.02	43.3	3.2
Parowan Valley	41	1975	2015	148	20	14	0.01	6.38	1.01
Salt Lake Valley	396	1975	2015	3,240	230	7	0.01	86	1.34
Sevier Desert	83	1975	2015	379	78	21	1.00E–06	22	0.36
Tooele Valley	188	1975	2015	841	12	1	0.02	36.9	1.83
Utah Valley	200	1975	2015	1,732	128	7	9.00E–04	46	0.85
Production to urban									
Cache Valley	11	1977	2015	110	3	3	0.05	8.9	0.8
Cedar City Valley	4	1995	2015	22	0	0	0.93	4.83	3.66
East Shore Area	33	1975	2015	206	29	14	0.01	3	0.45
Lower Bear River Basin	1	1998	1998	1	1	100	0.05	0.05	—
Salt Lake Valley	63	1976	2015	370	7	2	0.03	25	2.42
Sevier Desert	1	1978	2011	16	0	0	0.04	1.1	0.3
Tooele Valley	8	1981	2015	66	0	0	0.3	6.36	2.3
Utah Valley	53	1977	2015	315	12	4	0.01	15.4	1.63
Low use to production									
Beryl-Enterprise Area	1	1987	2015	17	0	0	2.06	5.8	3.81
Cache Valley	4	1976	2015	41	4	10	0.04	4.26	0.25
Cedar City Valley	3	1999	2000	3	0	0	0.521	3.28	2.45
Northern Juab Valley	2	1975	2012	13	0	0	1.68	6.4	5.3
Pahvant Valley	3	1979	2015	9	0	0	4.6	16	6.1
Parowan Valley	2	1979	2013	11	0	0	1.7	2.21	2
Salt Lake Valley	6	1978	2015	110	3	3	0.1	2.2	1
Sevier Desert	1	1976	2015	13	0	0	6	16	11.1
Tooele Valley	7	1994	2013	15	0	0	0.2	3.5	0.4
Utah Valley	15	1975	2015	49	2	4	0.1	32.5	1.6
Low use to urban									
Cache Valley	1	1991	1991	1	0	0	0.01	0.01	—
Cedar City Valley	27	1977	2015	259	3	1	0.035	19.5	1.1
East Shore Area	1	1984	1984	1	1	100	0.1	0.1	—
Lower Bear River Basin	2	1978	2015	44	1	2	0.01	3.5	1.65
Salt Lake Valley	18	1976	2015	152	21	14	0.01	9.16	1.3

Item 1.

Table 13. Number of wells; period of record; number of nitrate measurements; and minimum, maximum, and median nitrate concentration in each basin for each land-use change category.—Continued

[mg/L, miligrams per liter; —, no data]

Basin	Number of we lls	Starting year	Ending year	Number of samples	Number of censored samples	Percent censored	Minimum concentration (mg/L)	Maximum concentration (mg/L)	Median concentration (mg/L)
All wells—Continued									
Low use to urban—Continued									
Sevier Desert	1	1998	2013	3	1	33	0.1	0.3	—
Tooele Valley	18	1977	2015	105	0	0	0.2	4.6	0.9
Utah Valley	27	1976	2015	246	11	4	0.01	23.14	0.4
Wells less than 200 feet deep									
Production to low use									
Tooele Valley	1	1999	1999	4	0	0	0.92	1.71	1.1
Urban to production									
Salt Lake Valley	2	1998	2008	3	0	0	2.74	3.47	3.06
No change									
Beryl-Enterprise Area	5	1975	2011	67	0	0	0.04	10	2.1
Cache Valley	13	1977	2015	55	6	11	0.02	6.66	0.9
Cedar City Valley	8	1977	2013	13	0	0	0.15	5.46	1.04
East Shore Area	14	1978	2014	55	10	18	0.01	18	0.7
Lower Bear River Basin	12	1979	2015	72	11	15	0.01	27.9	0.7
Milford Valley	3	1975	2015	16	0	0	0.597	5.69	1.1
Northern Juab Valley	6	1976	1998	16	0	0	1.1	9.3	2
Pahvant Valley	15	1975	2015	59	2	3	0.1	9.1	2.42
Parowan Valley	1	1986	2014	9	0	0	0.567	2.4	1.82
Salt Lake Valley	65	1976	2015	221	22	10	0.01	86	1.32
Sevier Desert	20	1977	2015	30	0	0	0.01	4.8	0.65
Tooele Valley	49	1979	2015	87	3	3	0.02	31	1.4
Utah Valley	30	1978	2015	61	18	30	0.02	6.19	0.8
Production to urban									
East Shore Area	4	1978	2015	32	2	6	0.1	2.6	0.53
Lower Bear River Basin	1	1998	1998	1	1	100	0.05	0.05	—
Salt Lake Valley	14	1977	2008	43	1	2	0.1	25	1.22
Tooele Valley	1	1999	2003	5	0	0	4.29	4.93	4.46
Utah Valley	5	1980	1981	5	0	0	0.14	3.1	1.5
Low use to production									
Cache Valley	1	1979	2015	19	1	5	0.1	0.26	0.133
Cedar City Valley	1	1999	1999	1	0	0	3.28	3.28	—
Salt Lake Valley	3	1978	2014	40	1	3	0.1	1.8	0.95
Tooele Valley	3	1994	1994	3	0	0	0.54	3.5	2.2
Utah Valley	1	2008	2013	3	0	0	1.88	1.94	1.88
Low use to urban									
Cedar City Valley	1	1999	1999	1	0	0	8.98	8.98	—
Salt Lake Valley	2	1993	2008	15	0	0	0.355	2	0.5
Tooele Valley	6	2001	2001	6	0	0	0.68	1.03	0.83
Utah Valley	7	1981	2008	31	6	19	0.05	1.8	0.2

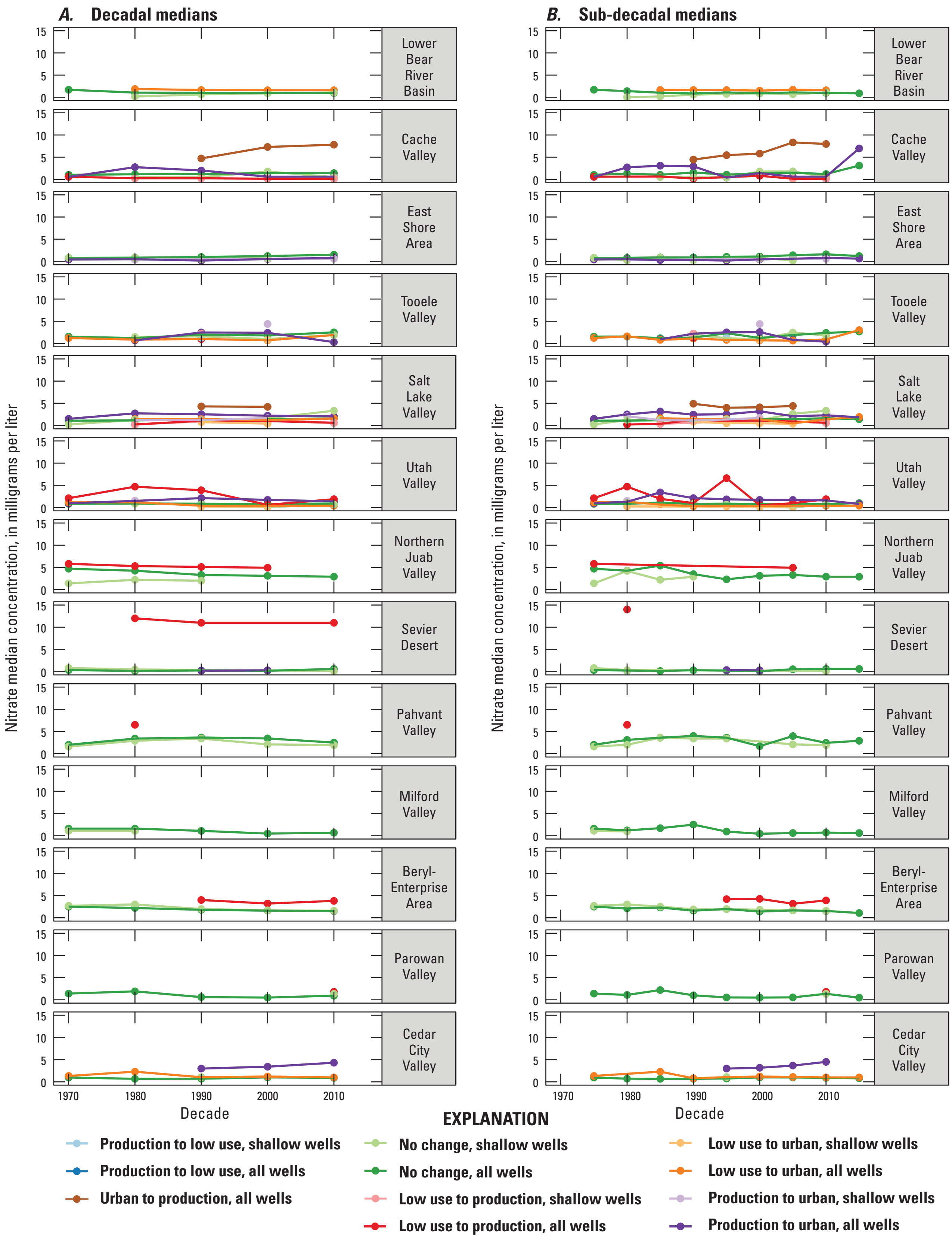


Figure 20. Decadal and sub-decadal median nitrate concentration in select *A*, basins and *B*, sub-basins by land-use change category in Utah.

Table 14. Trend test results for nitrate in basins for each land-use change category.

[Red indicates significant result. **Abbreviations**: mg/L, miligrams per liter; —, no data]

Basin	Decadal medians					Sub-decadal medians				
	Tau	Score	Score variance	p-value	Slope (mg/L per year)	Tau	Score	Score variance	p-value	Slope (mg/L per year)
All wells										
Production to low use										
Beryl-Enterprise Area	—	—	—	—	—	—	—	—	—	—
Cache Valley	—	—	—	—	—	—	—	—	—	—
Cedar City Valley	—	—	—	—	—	—	—	—	—	—
East Shore Area	—	—	—	—	—	—	—	—	—	—
Lower Bear River Basin	—	—	—	—	—	—	—	—	—	—
Milford Valley	—	—	—	—	—	—	—	—	—	—
Northern Juab Valley	—	—	—	—	—	—	—	—	—	—
Pahvant Valley	—	—	—	—	—	—	—	—	—	—
Parowan Valley	—	—	—	—	—	—	—	—	—	—
Salt Lake Valley	—	—	—	—	—	—	—	—	—	—
Sevier Desert	—	—	—	—	—	—	—	—	—	—
Tooele Valley	—	—	—	—	—	—	—	—	—	—
Utah Valley	—	—	—	—	—	—	—	—	—	—
Urban to production										
Beryl-Enterprise Area	—	—	—	—	—	—	—	—	—	—
Cache Valley	—	—	—	—	—	0.8	8	17	[1]0.086	0.19
Cedar City Valley	—	—	—	—	—	—	—	—	—	—
East Shore Area	—	—	—	—	—	—	—	—	—	—
Lower Bear River Basin	—	—	—	—	—	—	—	—	—	—
Milford Valley	—	—	—	—	—	—	—	—	—	—
Northern Juab Valley	—	—	—	—	—	—	—	—	—	—
Pahvant Valley	—	—	—	—	—	—	—	—	—	—
Parowan Valley	—	—	—	—	—	—	—	—	—	—
Salt Lake Valley	—	—	—	—	—	0	0	9	1.000	–0.01
Sevier Desert	—	—	—	—	—	—	—	—	—	—
Tooele Valley	—	—	—	—	—	—	—	—	—	—
Utah Valley	—	—	—	—	—	—	—	—	—	—
No change										
Beryl-Enterprise Area	–1.00	–10	17	[1]0.027	–0.03	–0.72	–26	92	[1]0.009	–0.03
Cache Valley	0.90	9	16	[1]0.043	0.01	0.50	18	92	[1]0.076	0.02
Cedar City Valley	0.20	2	17	0.806	0.00	0.19	7	91	0.529	0.00
East Shore Area	1.00	10	17	[1]0.027	0.02	0.83	30	92	[1]0.002	0.01
Lower Bear River Basin	–0.80	–8	17	[1]0.086	–0.01	–0.47	–17	91	[1]0.093	–0.01
Milford Valley	–0.70	–7	16	0.130	–0.03	–0.50	–18	92	[1]0.076	–0.03
Northern Juab Valley	–1.00	–10	17	[1]0.027	–0.05	–0.58	–21	91	[1]0.036	–0.05
Pahvant Valley	0.20	2	17	0.806	0.01	0.06	2	92	0.917	0.01
Parowan Valley	–0.40	–4	17	0.462	–0.02	–0.50	–18	92	[1]0.076	–0.02
Salt Lake Valley	1.00	10	17	[1]0.027	0.01	0.64	23	91	[1]0.021	0.01

Table 14. Trend test results for nitrate in basins for each land-use change category.—Continued

[Red indicates significant result. **Abbreviations**: mg/L, miligrams per liter; —, no data]

Basin	Decadal medians					Sub-decadal medians				
	Tau	Score	Score variance	p-value	Slope (mg/L per year)	Tau	Score	Score variance	p-value	Slope (mg/L per year)
All wells—Continued										
No change—Continued										
Sevier Desert	0.20	2	17	0.806	0.00	0.31	11	91	0.295	0.01
Tooele Valley	0.60	6	17	0.221	0.02	0.50	18	92	[1]0.076	0.03
Utah Valley	0.00	0	17	1.000	0.00	–0.17	–6	90	0.598	0.00
Production to urban										
Beryl-Enterprise Area	—	—	—	—	—	—	—	—	—	—
Cache Valley	–0.20	–2	17	0.806	–0.04	0.08	3	91	0.834	0.00
Cedar City Valley	—	—	—	—	—	1.00	6	9	[1]0.089	0.10
East Shore Area	0.60	6	17	0.221	0.01	0.44	16	92	0.118	0.01
Lower Bear River Basin	—	—	—	—	—	—	—	—	—	—
Milford Valley	—	—	—	—	—	—	—	—	—	—
Northern Juab Valley	—	—	—	—	—	—	—	—	—	—
Pahvant Valley	—	—	—	—	—	—	—	—	—	—
Parowan Valley	—	—	—	—	—	—	—	—	—	—
Salt Lake Valley	–0.20	–2	17	0.806	–0.02	–0.11	–4	92	0.754	–0.01
Sevier Desert	—	—	—	—	—	—	—	—	—	—
Tooele Valley	–0.33	–2	9	0.734	–0.01	–0.20	–3	28	0.707	–0.02
Utah Valley	0.20	2	17	0.806	0.01	–0.28	–10	92	0.348	–0.02
Low use to production										
Beryl-Enterprise Area	—	—	—	—	—	–0.33	–2	9	0.734	–0.03
Cache Valley	–0.80	–8	17	[1]0.086	–0.01	–0.43	–9	44	0.230	–0.01
Cedar City Valley	—	—	—	—	—	—	—	—	—	—
East Shore Area	—	—	—	—	—	—	—	—	—	—
Lower Bear River Basin	—	—	—	—	—	—	—	—	—	—
Milford Valley	—	—	—	—	—	—	—	—	—	—
Northern Juab Valley	–1.00	–6	9	[1]0.089	–0.02	—	—	—	—	—
Pahvant Valley	—	—	—	—	—	—	—	—	—	—
Parowan Valley	—	—	—	—	—	—	—	—	—	—
Salt Lake Valley	0.00	0	9	1.000	0.00	0.14	3	44	0.764	0.01
Sevier Desert	—	—	—	—	—	—	—	—	—	—
Tooele Valley	—	—	—	—	—	—	—	—	—	—
Utah Valley	–0.40	–4	17	0.462	–0.07	–0.36	–10	65	0.266	–0.04
Low use to urban										
Beryl-Enterprise Area	—	—	—	—	—	—	—	—	—	—
Cache Valley	—	—	—	—	—	—	—	—	—	—
Cedar City Valley	–0.60	–6	17	0.221	–0.01	–0.43	–12	65	0.174	–0.01
East Shore Area	—	—	—	—	—	—	—	—	—	—
Lower Bear River Basin	–1.00	–6	9	[1]0.089	–0.01	–0.33	–5	28	0.452	0.00
Milford Valley	—	—	—	—	—	—	—	—	—	—

Table 14. Trend test results for nitrate in basins for each land-use change category.—Continued

[Red indicates significant result. **Abbreviations**: mg/L, miligrams per liter; —, no data]

Basin	Decadal medians					Sub-decadal medians				
	Tau	Score	Score variance	p-value	Slope (mg/L per year)	Tau	Score	Score variance	p-value	Slope (mg/L per year)
All wells—Continued										
Low use to urban—Continued										
Northern Juab Valley	—	—	—	—	—	—	—	—	—	—
Pahvant Valley	—	—	—	—	—	—	—	—	—	—
Parowan Valley	—	—	—	—	—	—	—	—	—	—
Salt Lake Valley	0.33	2	9	0.734	0.00	–0.14	–3	44	0.764	–0.01
Sevier Desert	—	—	—	—	—	—	—	—	—	—
Tooele Valley	0.00	0	17	1.000	0.00	–0.19	–7	91	0.529	–0.01
Utah Valley	–0.30	–3	16	0.613	–0.02	–0.39	–14	92	0.175	–0.02
Wells less than 200 feet deep										
Production to low use										
Beryl-Enterprise Area	—	—	—	—	—	—	—	—	—	—
Cache Valley	—	—	—	—	—	—	—	—	—	—
Cedar City Valley	—	—	—	—	—	—	—	—	—	—
East Shore Area	—	—	—	—	—	—	—	—	—	—
Lower Bear River Basin	—	—	—	—	—	—	—	—	—	—
Milford Valley	—	—	—	—	—	—	—	—	—	—
Northern Juab Valley	—	—	—	—	—	—	—	—	—	—
Pahvant Valley	—	—	—	—	—	—	—	—	—	—
Parowan Valley	—	—	—	—	—	—	—	—	—	—
Salt Lake Valley	—	—	—	—	—	—	—	—	—	—
Sevier Desert	—	—	—	—	—	—	—	—	—	—
Tooele Valley	—	—	—	—	—	—	—	—	—	—
Utah Valley	—	—	—	—	—	—	—	—	—	—
Urban to production										
Beryl-Enterprise Area	—	—	—	—	—	—	—	—	—	—
Cache Valley	—	—	—	—	—	—	—	—	—	—
Cedar City Valley	—	—	—	—	—	—	—	—	—	—
East Shore Area	—	—	—	—	—	—	—	—	—	—
Lower Bear River Basin	—	—	—	—	—	—	—	—	—	—
Milford Valley	—	—	—	—	—	—	—	—	—	—
Northern Juab Valley	—	—	—	—	—	—	—	—	—	—
Pahvant Valley	—	—	—	—	—	—	—	—	—	—
Parowan Valley	—	—	—	—	—	—	—	—	—	—
Salt Lake Valley	—	—	—	—	—	—	—	—	—	—
Sevier Desert	—	—	—	—	—	—	—	—	—	—
Tooele Valley	—	—	—	—	—	—	—	—	—	—
Utah Valley	—	—	—	—	—	—	—	—	—	—
No change										
Beryl-Enterprise Area	–0.80	–8	17	[1]0.086	–0.03	–0.86	–24	65	[1]0.004	–0.04

Table 14. Trend test results for nitrate in basins for each land-use change category.—Continued

[Red indicates significant result. **Abbreviations**: mg/L, miligrams per liter; —, no data]

Basin	Decadal medians					Sub-decadal medians				
	Tau	Score	Score variance	p-value	Slope (mg/L per year)	Tau	Score	Score variance	p-value	Slope (mg/L per year)
Wells less than 200 feet deep—Continued										
No change—Continued										
Cache Valley	0.17	1	8	1.000	0.00	0.27	4	27	0.566	0.01
Cedar City Valley	—	—	—	—	—	—	—	—	—	—
East Shore Area	–0.33	–2	9	0.734	0.00	–0.14	–3	44	0.764	0.00
Lower Bear River Basin	1.00	6	9	[1]0.089	0.03	0.81	17	44	[1]0.016	0.03
Milford Valley	—	—	—	—	—	—	—	—	—	—
Northern Juab Valley	—	—	—	—	—	0.33	2	9	0.734	0.09
Pahvant Valley	0.00	0	17	1.000	0.00	0.00	0	43	1.000	0.00
Parowan Valley	—	—	—	—	—	—	—	—	—	—
Salt Lake Valley	0.80	8	17	[1]0.086	0.06	0.64	18	65	[1]0.035	0.07
Sevier Desert	—	—	—	—	—	—	—	—	—	—
Tooele Valley	0.33	2	9	0.734	0.02	0.00	0	17	1.000	0.02
Utah Valley	–0.67	–4	9	0.308	–0.01	–0.60	–9	28	0.133	–0.02
Production to urban										
Beryl-Enterprise Area	—	—	—	—	—	—	—	—	—	—
Cache Valley	—	—	—	—	—	—	—	—	—	—
Cedar City Valley	—	—	—	—	—	—	—	—	—	—
East Shore Area	0.67	4	9	0.308	0.01	0.60	9	28	0.133	0.01
Lower Bear River Basin	—	—	—	—	—	—	—	—	—	—
Milford Valley	—	—	—	—	—	—	—	—	—	—
Northern Juab Valley	—	—	—	—	—	—	—	—	—	—
Pahvant Valley	—	—	—	—	—	—	—	—	—	—
Parowan Valley	—	—	—	—	—	—	—	—	—	—
Salt Lake Valley	—	—	—	—	—	0.00	0	17	1.000	0.00
Sevier Desert	—	—	—	—	—	—	—	—	—	—
Tooele Valley	—	—	—	—	—	—	—	—	—	—
Utah Valley	—	—	—	—	—	—	—	—	—	—
Low use to production										
Beryl-Enterprise Area	—	—	—	—	—	—	—	—	—	—
Cache Valley	–1.00	–6	9	[1]0.089	–0.004	—	—	—	—	—
Cedar City Valley	—	—	—	—	—	—	—	—	—	—
East Shore Area	—	—	—	—	—	—	—	—	—	—
Lower Bear River Basin	—	—	—	—	—	—	—	—	—	—
Milford Valley	—	—	—	—	—	—	—	—	—	—
Northern Juab Valley	—	—	—	—	—	—	—	—	—	—
Pahvant Valley	—	—	—	—	—	—	—	—	—	—
Parowan Valley	—	—	—	—	—	—	—	—	—	—
Salt Lake Valley	0.33	2	9	0.734	0.02	0.33	2	9	0.734	0.03
Sevier Desert	—	—	—	—	—	—	—	—	—	—

Table 14. Trend test results for nitrate in basins for each land-use change category.—Continued

[Red indicates significant result. **Abbreviations**: mg/L, miligrams per liter; —, no data]

Basin	Decadal medians					Sub-decadal medians				
	Tau	Score	Score variance	p-value	Slope (mg/L per year)	Tau	Score	Score variance	p-value	Slope (mg/L per year)
Wells less than 200 feet deep—Continued										
Low use to production—Continued										
Tooele Valley	—	—	—	—	—	—	—	—	—	—
Utah Valley	—	—	—	—	—	—	—	—	—	—
Low use to urban										
Beryl-Enterprise Area	—	—	—	—	—	—	—	—	—	—
Cache Valley	—	—	—	—	—	—	—	—	—	—
Cedar City Valley	—	—	—	—	—	—	—	—	—	—
East Shore Area	—	—	—	—	—	—	—	—	—	—
Lower Bear River Basin	—	—	—	—	—	—	—	—	—	—
Milford Valley	—	—	—	—	—	—	—	—	—	—
Northern Juab Valley	—	—	—	—	—	—	—	—	—	—
Pahvant Valley	—	—	—	—	—	—	—	—	—	—
Parowan Valley	—	—	—	—	—	—	—	—	—	—
Salt Lake Valley	—	—	—	—	—	–0.83	–5	8	0.149	–0.03
Sevier Desert	—	—	—	—	—	—	—	—	—	—
Tooele Valley	—	—	—	—	—	—	—	—	—	—
Utah Valley	—	—	—	—	—	–1.00	–6	9	[1]0.089	–0.002

[1]Significant value.

Table 15. Number of wells; period of record; number of dissolved solids measurements; and minimum, maximum, and median dissolved-solids concentration in each basin for each land-use change category.

[mg/L, miligrams per liter; —, no data; NA, not applicable]

Basin	Number of wells	Starting year	Ending year	Number of samples	Number of censored samples	Percent censored	Minimum concentration (mg/L)	Maximum concentration (mg/L)	Median concentration (mg/L)
All wells									
Production to low use									
Beryl-Enterprise Area	1	2013	2013	1	0	0	281	281	—
Cedar City Valley	2	1999	1999	2	0	0	343	352	—
Milford Valley	2	1975	2011	3	0	0	436	3,320	3,230
Parowan Valley	1	2013	2013	1	0	0	267	267	—
Sevier Desert	2	1980	1986	3	0	0	378	2,200	1,840
Tooele Valley	3	1978	1999	6	0	0	674	3,360	957
Urban to production									
Cache Valley	2	1989	2013	10	0	0	304	448	358
East Shore Area	7	1980	1991	9	0	0	242	790	515
Salt Lake Valley	4	1980	2009	12	0	0	1,065	1,600	1,320
Tooele Valley	1	2000	2000	1	0	0	438	438	—
Utah Valley	2	1981	2003	2	0	0	260	353	—

Table 15. Number of wells; period of record; number of dissolved solids measurements; and minimum, maximum, and median dissolved-solids concentration in each basin for each land-use change category.—Continued

[mg/L, miligrams per liter; —, no data; NA, not applicable]

Basin	Number of wells	Starting year	Ending year	Number of samples	Number of censored samples	Percent censored	Minimum concentration (mg/L)	Maximum concentration (mg/L)	Median concentration (mg/L)
All wells—Continued									
No change									
Beryl-Enterprise Area	34	1975	2015	253	0	0	125	1,950	406
Cache Valley	73	1975	2015	273	0	0	150	1,986	290
Cedar City Valley	69	1975	2015	288	0	0	110	3,070	404
East Shore Area	204	1975	2015	835	0	0	28	4,000	300
Lower Bear River Basin	92	1975	2015	397	0	0	88	2,360	338
Milford Valley	55	1975	2015	367	0	0	156	10,200	456
Northern Juab Valley	38	1975	2015	151	0	0	18	2,940	810
Pahvant Valley	76	1975	2015	330	0	0	10	6,520	961
Parowan Valley	43	1975	2015	122	0	0	135	672	312
Salt Lake Valley	413	1975	2015	2,230	0	0	10	20,900	450
Sevier Desert	92	1975	2015	259	0	0	162	24,300	344
Tooele Valley	206	1975	2015	553	0	0	143	17,000	658
Utah Valley	211	1975	2015	791	0	0	55	2,560	313
Production to urban									
Cache Valley	9	1977	2015	41	0	0	174	535	286
Cedar City Valley	5	1977	2014	10	0	0	285	1,460	880
East Shore Area	36	1975	2013	113	0	0	112	2,460	258
Lower Bear River Basin	1	1998	1998	1	0	0	906	906	—
Salt Lake Valley	64	1976	2015	280	0	0	130	8,550	794
Sevier Desert	1	1978	2008	8	0	0	214	262	224
Tooele Valley	9	1978	2013	44	0	0	234	5,080	848
Utah Valley	55	1977	2015	142	0	0	131	1,390	312
Low use to production									
Beryl-Enterprise Area	1	1987	2013	8	0	0	336	723	430
Cache Valley	4	1977	2015	28	0	0	218	504	258
Cedar City Valley	3	1999	2000	3	0	0	369	1,790	761
Northern Juab Valley	2	1975	2012	14	0	0	299	746	698
Pahvant Valley	3	1979	2015	10	0	0	673	3,140	851
Parowan Valley	2	1979	2013	11	0	0	268	333	278
Salt Lake Valley	9	1978	2015	97	0	0	394	1,150	704
Sevier Desert	1	1976	2015	16	0	0	421	629	555
Tooele Valley	7	1978	2013	10	0	0	300	2,100	358
Utah Valley	14	1975	2015	41	0	0	206	1,230	581
Low use to urban									
Cedar City Valley	25	1977	2015	83	0	0	112	2,510	584
East Shore Area	1	1984	1984	1	0	0	2,960	2,960	—
Lower Bear River Basin	2	1978	2010	16	0	0	212	588	256
Salt Lake Valley	21	1976	2015	100	0	0	269	9,290	620

Table 15. Number of wells; period of record; number of dissolved solids measurements; and minimum, maximum, and median dissolved-solids concentration in each basin for each land-use change category.—Continued

[mg/L, miligrams per liter; —, no data; NA, not applicable]

Basin	Number of wells	Starting year	Ending year	Number of samples	Number of censored samples	Percent censored	Minimum concentration (mg/L)	Maximum concentration (mg/L)	Median concentration (mg/L)
All wells—Continued									
Low use to urban—Continued									
Tooele Valley	20	1977	2013	64	0	0	196	6,460	393
Utah Valley	27	1976	2013	107	0	0	96	1,290	278
Wells less than 200 feet deep									
Production to low use									
Tooele Valley	1	1999	1999	4	0	0	674	1,120	803
Urban to production									
Salt Lake Valley	2	1998	2008	3	0	0	1,140	1,240	1,230
No change									
Beryl-Enterprise Area	5	1975	2011	68	0	0	288	1,160	628
Cache Valley	13	1977	2015	36	0	0	162	539	311
Cedar City Valley	8	1977	2013	13	0	0	248	1,350	363
East Shore Area	17	1978	2015	44	0	0	152	4,000	267
Lower Bear River Basin	12	1977	2014	45	0	0	119	1,630	224
Milford Valley	3	1975	2015	19	0	0	376	1,080	551
Northern Juab Valley	6	1976	1998	18	0	0	399	1,070	629
Pahvant Valley	15	1975	2015	60	0	0	426	6,050	3,550
Parowan Valley	1	1986	2014	10	0	0	248	363	304
Salt Lake Valley	64	1976	2015	164	0	0	57	8,970	699
Sevier Desert	20	1977	2015	32	0	0	246	24,300	377
Tooele Valley	45	1978	2014	71	0	0	264	5,010	945
Utah Valley	33	1978	2015	71	0	0	91	2,560	326
Production to urban									
East Shore Area	4	1978	2008	12	0	0	112	613	172
Lower Bear River Basin	1	1998	1998	1	0	0	906	906	NA
Salt Lake Valley	14	1977	2008	49	0	0	390	2,630	528
Tooele Valley	2	1978	2003	7	0	0	557	1,070	963
Utah Valley	7	1980	2014	7	0	0	230	1,390	341
Low use to production									
Cache Valley	1	1979	2015	19	0	0	218	266	257
Cedar City Valley	1	1999	1999	1	0	0	761	761	NA
Salt Lake Valley	4	1978	2013	31	0	0	415	1,150	560
Tooele Valley	1	1978	1978	1	0	0	2,100	2,100	NA
Utah Valley	1	2008	2013	3	0	0	206	218	208
Low use to urban									
Cedar City Valley	1	1999	1999	1	0	0	735	735	NA
Salt Lake Valley	3	1991	2008	8	0	0	652	4,060	843
Tooele Valley	6	2001	2001	6	0	0	350	1,050	726
Utah Valley	7	1979	2005	29	0	0	114	479	232

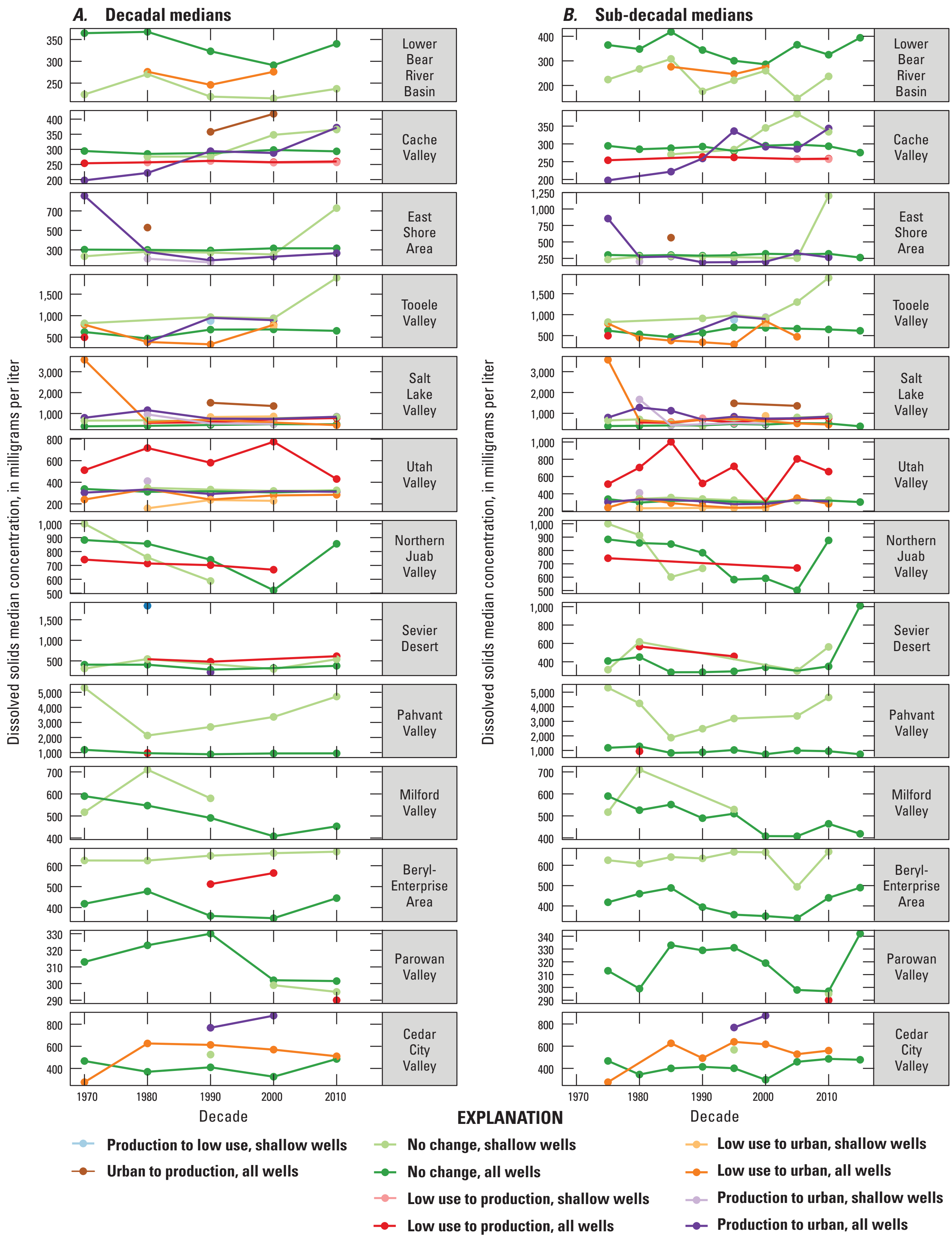


Figure 21. Decadal and sub-decadal median dissolved-solids concentration in select *A*, basins and *B*, sub-basins by land-use change category in Utah.

Dissolved solids trends were generally not associated with land-use change at a well except in a few areas (table 16). Significant increases in dissolved solids concentrations were identified in the Cache Valley wells experiencing a transition from production to urban land, and in the Salt Lake Valley wells experiencing a transition from low use to production. Wells in the Salt Lake Valley experiencing a transition from low use to urban had a significant decreasing trend, although this was not observed in the shallow subset of wells due to insufficient data and so it may be associated with an increase in deeper, cleaner wells to supply urban needs. In a nationwide study of decadal-scale changes in groundwater quality, Lindsey and Rupert (2012) reported more significant increases in dissolved-solids concentrations in urban areas than agricultural areas. Significant decreasing trends also were identified in the Northern Juab Valley wells associated with a transition from low use to production. However, these results represent two wells, which are likely not representative of more widespread water-quality conditions. Significant decreasing trends in Milford Valley and increasing trends in the Salt Lake Valley were identified among wells where land use did not change. Among shallow wells where land use did not change, increasing trends were identified in Beryl-Enterprise Area and Tooele Valley, and a decreasing trend was identified in Utah Valley.

These results highlight the complexity of the relationship between land use and arsenic, nitrate, and dissolved-solids concentrations, and trends that depend on a range of conditions at various spatial and temporal scales. Geologic and geochemical conditions are the most important factors affecting arsenic concentrations in groundwater (Bexfield and others, 2011). Groundwater redox condition, fertilizer application rates, and irrigation practices (Paul and others, 2007) likely all contribute to differences in nitrate concentrations among basins and over time. Fertilizer application rate and sprinkler irrigation have been reported to correlate positively with elevated nitrate concentrations, whereas reducing geochemical conditions have been reported to correlate negatively with elevated nitrate concentrations because of denitrification (Paul and others, 2007). Many of the processes that influence nitrate in groundwater apply to dissolved solids as well, although there are additional processes that control dissolved solids in groundwater. Recharge of surface water containing high dissolved-solids concentrations can increase groundwater concentrations. Surface water can have elevated dissolved solids due to runoff, wastewater discharge, spills, or mining and forestry activities. Groundwater interaction with aquifer material can result in increased dissolved-solids concentrations. For example, concentrations increase along flow paths in Utah Valley and Salt Lake Valley (Anning and others, 2007).

Although arsenic, nitrate, and dissolved solids trends were not generally associated with land-use changes at wells, land use and other human activities are still important drivers of groundwater conditions. Basinwide trends have been detected, despite a relatively small amount of basinwide land-use change. The indirect connection between water quality and land use at wells relates more to the nuanced effects of human activities, which can occur at different spatial and temporal scales, and effects at wells can be affected by travel time lags. Further, land use may not have to change for activity on the land to create impacts to groundwater. For example, building development can increase in an urban area, which may increase dissolved solids in urban runoff that eventually impacts groundwater. The land-use category did not change, but the activity may still impact groundwater. The data available on land-use change does not necessarily capture the distinctions of increased development or population density either.

Table 16. Trend test results for dissolved solids in basins for each land-use change category.

[Red indicates significant result. **Abbreviations**: mg/L, miligrams per liter; —, no data]

Basin	Decadal medians					Sub-decadal medians				
	Tau	Score	Score variance	p-value	Slope (mg/L per year)	Tau	Score	Score variance	p-value	Slope (mg/L per year)
All wells										
Production to low use										
Beryl-Enterprise Area	—	—	—	—	—	—	—	—	—	—
Cache Valley	—	—	—	—	—	—	—	—	—	—
Cedar City Valley	—	—	—	—	—	—	—	—	—	—
East Shore Area	—	—	—	—	—	—	—	—	—	—
Lower Bear River Basin	—	—	—	—	—	—	—	—	—	—
Milford Valley	—	—	—	—	—	—	—	—	—	—
Northern Juab Valley	—	—	—	—	—	—	—	—	—	—
Pahvant Valley	—	—	—	—	—	—	—	—	—	—
Parowan Valley	—	—	—	—	—	—	—	—	—	—
Salt Lake Valley	—	—	—	—	—	—	—	—	—	—
Sevier Desert	—	—	—	—	—	—	—	—	—	—
Tooele Valley	—	—	—	—	—	—	—	—	—	—
Utah Valley	—	—	—	—	—	—	—	—	—	—
Urban to production										
Beryl-Enterprise Area	—	—	—	—	—	—	—	—	—	—
Cache Valley	—	—	—	—	—	—	—	—	—	—
Cedar City Valley	—	—	—	—	—	—	—	—	—	—
East Shore Area	—	—	—	—	—	—	—	—	—	—
Lower Bear River Basin	—	—	—	—	—	—	—	—	—	—
Milford Valley	—	—	—	—	—	—	—	—	—	—
Northern Juab Valley	—	—	—	—	—	—	—	—	—	—
Pahvant Valley	—	—	—	—	—	—	—	—	—	—
Parowan Valley	—	—	—	—	—	—	—	—	—	—
Salt Lake Valley	—	—	—	—	—	—	—	—	—	—
Sevier Desert	—	—	—	—	—	—	—	—	—	—
Tooele Valley	—	—	—	—	—	—	—	—	—	—
Utah Valley	—	—	—	—	—	—	—	—	—	—
No change										
Beryl-Enterprise Area	–0.20	–2	17	0.806	–1	–0.11	–4	92	0.754	–2
Cache Valley	0.20	2	17	0.806	0	0.00	0	92	1.000	0
Cedar City Valley	0.00	0	17	1.000	–1	0.33	12	92	0.251	3
East Shore Area	0.30	3	16	0.613	0	0.08	3	91	0.834	0
Lower Bear River Basin	–0.40	–4	17	0.462	–1	–0.11	–4	92	0.754	–1
Milford Valley	–0.80	–8	17	[1]0.086	–5	–0.67	–24	92	[1]0.016	–4
Northern Juab Valley	–0.60	–6	17	0.221	–5	–0.50	–14	65	0.108	–10
Pahvant Valley	–0.40	–4	17	0.462	–3	–0.44	–16	92	0.118	–7
Parowan Valley	–0.40	–4	17	0.462	0	–0.06	–2	92	0.917	0
Salt Lake Valley	0.80	8	17	[1]0.086	3	0.44	16	92	0.118	3

Table 16. Trend test results for dissolved solids in basins for each land-use change category.—Continued

[Red indicates significant result. **Abbreviations**: mg/L, miligrams per liter; —, no data]

Basin	Decadal medians					Sub-decadal medians				
	Tau	Score	Score variance	p-value	Slope (mg/L per year)	Tau	Score	Score variance	p-value	Slope (mg/L per year)
All wells—Continued										
No change—Continued										
Sevier Desert	–0.40	–4	17	0.462	–1	0.28	10	92	0.348	1
Tooele Valley	0.40	4	17	0.462	1	0.17	6	92	0.602	2
Utah Valley	–0.20	–2	17	0.806	0	–0.08	–3	91	0.834	0
Production to urban										
Beryl-Enterprise Area	—	—	—	—	—	—	—	—	—	—
Cache Valley	0.80	8	17	[1]0.086	4	0.71	15	44	[1]0.035	4
Cedar City Valley	—	—	—	—	—	—	—	—	—	—
East Shore Area	–0.40	–4	17	0.462	–5	–0.14	–4	65	0.711	–2
Lower Bear River Basin	—	—	—	—	—	—	—	—	—	—
Milford Valley	—	—	—	—	—	—	—	—	—	—
Northern Juab Valley	—	—	—	—	—	—	—	—	—	—
Pahvant Valley	—	—	—	—	—	—	—	—	—	—
Parowan Valley	—	—	—	—	—	—	—	—	—	—
Salt Lake Valley	–0.20	–2	17	0.806	–1	–0.14	–4	65	0.711	–4
Sevier Desert	—	—	—	—	—	—	—	—	—	—
Tooele Valley	—	—	—	—	—	—	—	—	—	—
Utah Valley	0.00	0	17	1.000	0	–0.21	–6	65	0.536	0
Low use to production										
Beryl-Enterprise Area	—	—	—	—	—	—	—	—	—	—
Cache Valley	0.60	6	17	0.221	0	0.00	0	17	1.000	0
Cedar City Valley	—	—	—	—	—	—	—	—	—	—
East Shore Area	—	—	—	—	—	—	—	—	—	—
Lower Bear River Basin	—	—	—	—	—	—	—	—	—	—
Milford Valley	—	—	—	—	—	—	—	—	—	—
Northern Juab Valley	—	–6	9	[1]0.089	–2	—	—	—	—	—
Pahvant Valley	—	—	—	—	—	—	—	—	—	—
Parowan Valley	—	—	—	—	—	—	—	—	—	—
Salt Lake Valley	1.00	6	9	[1]0.089	8	0.71	15	44	[1]0.035	7
Sevier Desert	—	—	—	—	—	—	—	—	—	—
Tooele Valley	—	—	—	—	—	—	—	—	—	—
Utah Valley	0.00	0	17	1.000	0	0.07	2	65	0.902	1
Low use to urban										
Beryl-Enterprise Area	—	—	—	—	—	—	—	—	—	—
Cache Valley	—	—	—	—	—	—	—	—	—	—
Cedar City Valley	–0.20	–2	17	0.806	–2	0.14	3	44	0.764	2
East Shore Area	—	—	—	—	—	—	—	—	—	—
Lower Bear River Basin	—	—	—	—	—	—	—	—	—	—
Milford Valley	—	—	—	—	—	—	—	—	—	—

Table 16. Trend test results for dissolved solids in basins for each land-use change category.—Continued

[Red indicates significant result. **Abbreviations**: mg/L, miligrams per liter; —, no data]

Basin	Decadal medians					Sub-decadal medians				
	Tau	Score	Score variance	p-value	Slope (mg/L per year)	Tau	Score	Score variance	p-value	Slope (mg/L per year)
All wells—Continued										
Low use to urban—Continued										
Northern Juab Valley	—	—	—	—	—	—	—	—	—	—
Pahvant Valley	—	—	—	—	—	—	—	—	—	—
Parowan Valley	—	—	—	—	—	—	—	—	—	—
Salt Lake Valley	–0.80	–8	17	[1]0.086	–13	–0.57	–16	65	[1]0.063	–12
Sevier Desert	—	—	—	—	—	—	—	—	—	—
Tooele Valley	–0.33	–2	9	0.734	–3	–0.14	–3	44	0.764	–9
Utah Valley	0.20	2	17	0.806	1	0.07	2	65	0.902	0
Wells less than 200 feet deep										
Production to low use										
Beryl-Enterprise Area	—	—	—	—	—	—	—	—	—	—
Cache Valley	—	—	—	—	—	—	—	—	—	—
Cedar City Valley	—	—	—	—	—	—	—	—	—	—
East Shore Area	—	—	—	—	—	—	—	—	—	—
Lower Bear River Basin	—	—	—	—	—	—	—	—	—	—
Milford Valley	—	—	—	—	—	—	—	—	—	—
Northern Juab Valley	—	—	—	—	—	—	—	—	—	—
Pahvant Valley	—	—	—	—	—	—	—	—	—	—
Parowan Valley	—	—	—	—	—	—	—	—	—	—
Salt Lake Valley	—	—	—	—	—	—	—	—	—	—
Sevier Desert	—	—	—	—	—	—	—	—	—	—
Tooele Valley	—	—	—	—	—	—	—	—	—	—
Utah Valley	—	—	—	—	—	—	—	—	—	—
Urban to production										
Beryl-Enterprise Area	—	—	—	—	—	—	—	—	—	—
Cache Valley	—	—	—	—	—	—	—	—	—	—
Cedar City Valley	—	—	—	—	—	—	—	—	—	—
East Shore Area	—	—	—	—	—	—	—	—	—	—
Lower Bear River Basin	—	—	—	—	—	—	—	—	—	—
Milford Valley	—	—	—	—	—	—	—	—	—	—
Northern Juab Valley	—	—	—	—	—	—	—	—	—	—
Pahvant Valley	—	—	—	—	—	—	—	—	—	—
Parowan Valley	—	—	—	—	—	—	—	—	—	—
Salt Lake Valley	—	—	—	—	—	—	—	—	—	—
Sevier Desert	—	—	—	—	—	—	—	—	—	—
Tooele Valley	—	—	—	—	—	—	—	—	—	—
Utah Valley	—	—	—	—	—	—	—	—	—	—
No change										
Beryl-Enterprise Area	0.80	8	17	[1]0.086	1	0.36	10	65	0.266	1

Table 16. Trend test results for dissolved solids in basins for each land-use change category.—Continued

[Red indicates significant result. **Abbreviations**: mg/L, miligrams per liter; —, no data]

Basin	Decadal medians					Sub-decadal medians				
	Tau	Score	Score variance	p-value	Slope (mg/L per year)	Tau	Score	Score variance	p-value	Slope (mg/L per year)
Wells less than 200 feet deep—Continued										
No change—Continued										
Cache Valley	0.83	5	8	0.149	3	0.60	6	17	0.221	4
Cedar City Valley	—	—	—	—	—	—	—	—	—	—
East Shore Area	0.40	4	17	0.462	3	0.04	1	64	1.000	0
Lower Bear River Basin	–0.20	–2	17	0.806	0	–0.21	–6	65	0.536	–1
Milford Valley	—	—	—	—	—	—	—	—	—	—
Northern Juab Valley	—	—	—	—	—	–0.67	–4	9	0.308	–24
Pahvant Valley	0.20	2	17	0.806	59	0.05	1	44	1.000	14
Parowan Valley	—	—	—	—	—	—	—	—	—	—
Salt Lake Valley	0.60	6	17	0.221	5	0.36	10	65	0.266	6
Sevier Desert	0.00	0	9	1.000	3	0.00	0	9	1.000	3
Tooele Valley	0.67	4	9	0.308	17	0.87	13	28	[1]0.024	26
Utah Valley	–0.67	–4	9	0.308	–1.00	–0.62	–13	44	[1]0.072	—
Production to urban										
Beryl-Enterprise Area	—	—	—	—	—	—	—	—	—	—
Cache Valley	—	—	—	—	—	—	—	—	—	—
Cedar City Valley	—	—	—	—	—	—	—	—	—	—
East Shore Area	—	—	—	—	—	—	—	—	—	—
Lower Bear River Basin	—	—	—	—	—	—	—	—	—	—
Milford Valley	—	—	—	—	—	—	—	—	—	—
Northern Juab Valley	—	—	—	—	—	—	—	—	—	—
Pahvant Valley	—	—	—	—	—	—	—	—	—	—
Parowan Valley	—	—	—	—	—	—	—	—	—	—
Salt Lake Valley	—	—	—	—	—	0.00	0	17	1.000	–1
Sevier Desert	—	—	—	—	—	—	—	—	—	—
Tooele Valley	—	—	—	—	—	—	—	—	—	—
Utah Valley	—	—	—	—	—	—	—	—	—	—
Low use to production										
Beryl-Enterprise Area	—	—	—	—	—	—	—	—	—	—
Cache Valley	–0.17	–1.00	8	1.000	0	—	—	—	—	—
Cedar City Valley	—	—	—	—	—	—	—	—	—	—
East Shore Area	—	—	—	—	—	—	—	—	—	—
Lower Bear River Basin	—	—	—	—	—	—	—	—	—	—
Milford Valley	—	—	—	—	—	—	—	—	—	—
Northern Juab Valley	—	—	—	—	—	—	—	—	—	—
Pahvant Valley	—	—	—	—	—	—	—	—	—	—
Parowan Valley	—	—	—	—	—	—	—	—	—	—
Salt Lake Valley	—	—	—	—	—	0.30	3	16	0.613	4
Sevier Desert	—	—	—	—	—	—	—	—	—	—

Table 16. Trend test results for dissolved solids in basins for each land-use change category.—Continued

[Red indicates significant result. **Abbreviations**: mg/L, miligrams per liter; —, no data]

Basin	Decadal medians					Sub-decadal medians				
	Tau	Score	Score variance	p-value	Slope (mg/L per year)	Tau	Score	Score variance	p-value	Slope (mg/L per year)
Wells less than 200 feet deep—Continued										
Low use to production—Continued										
Tooele Valley	—	—	—	—	—	—	—	—	—	—
Utah Valley	—	—	—	—	—	—	—	—	—	—
Low use to urban										
Beryl-Enterprise Area	—	—	—	—	—	—	—	—	—	—
Cache Valley	—	—	—	—	—	—	—	—	—	—
Cedar City Valley	—	—	—	—	—	—	—	—	—	—
East Shore Area	—	—	—	—	—	—	—	—	—	—
Lower Bear River Basin	—	—	—	—	—	—	—	—	—	—
Milford Valley	—	—	—	—	—	—	—	—	—	—
Northern Juab Valley	—	—	—	—	—	—	—	—	—	—
Pahvant Valley	—	—	—	—	—	—	—	—	—	—
Parowan Valley	—	—	—	—	—	—	—	—	—	—
Salt Lake Valley	—	—	—	—	—	—	—	—	—	—
Sevier Desert	—	—	—	—	—	—	—	—	—	—
Tooele Valley	—	—	—	—	—	—	—	—	—	—
Utah Valley	—	—	—	—	—	–0.17	–1.00	8	1.000	0

[1]Significant value.

Trends Across Analytes and Land-Use Change

Trends across multiple analytes can indicate basinwide changes to the hydrologic system. In comparing the total number of trends (using decadal and sub-decadal medians from combined NWIS and SDWIS data) in each basin across analytes, the water quality in several basins has changed more (fig. 22*A*). Basins with three significant trends across all analytes include the Beryl-Enterprise Area, East Shore Area, and Milford Valley. In the Beryl-Enterprise Area, concentrations of arsenic increased, whereas concentrations of nitrate decreased. In the East Shore Area, concentrations of arsenic and nitrate increased. In Milford Valley, concentrations of nitrate and dissolved solids decreased. Cache Valley, Lower Bear River Basin, Northern Juab Valley, and Salt Lake Valley each had two significant trends, although they were for a single analyte in each basin. This gives increased confidence in the trend result for the particular analyte but does not indicate that trends in other constituents are linked. Utah Valley had two trends across two analytes. The other basins had between zero and one significant arsenic trend.

The East Shore Area, Cache Valley, and Salt Lake Valley had the most increasing trends. The number of increasing trends in a basin can be related to basinwide land use and land-use change patterns, although land-use change is relatively limited. Change occurring in more than 20 percent of a basin area only occurred in the Salt Lake Valley (25 percent), Utah Valley (24 percent), and East Shore Area (20 percent). In basins with the most land-use change, the highest percentage of land changed from production to urban. The total number of increasing trends were correlated with transitions from production to urban land (Pearson correlation coefficient equals 0.77, p-value equals 0.04). However, the limited area of land-use change in many basins reduces confidence in results. Some basins that experienced the most increasing trends such as the East Shore Area and Salt Lake Valley also are where most of the state's population lives and where much of the population growth has occurred. These basins also had substantial areas of agriculture, which may account for the increasing nitrate trends in these basins. The absence of trends in some analytes in some basins may be related to the small amount of land-use change in those basins. For example, there was no nitrate trend in Cache Valley, where about 4 percent of the land had been converted from production to urban and another 4 percent had been converted from low use to production, and effectively replaced the production land lost to urban land. Land use, land-use change, and population all influence water-use practices as well, which can impact water and solute movement through the subsurface.

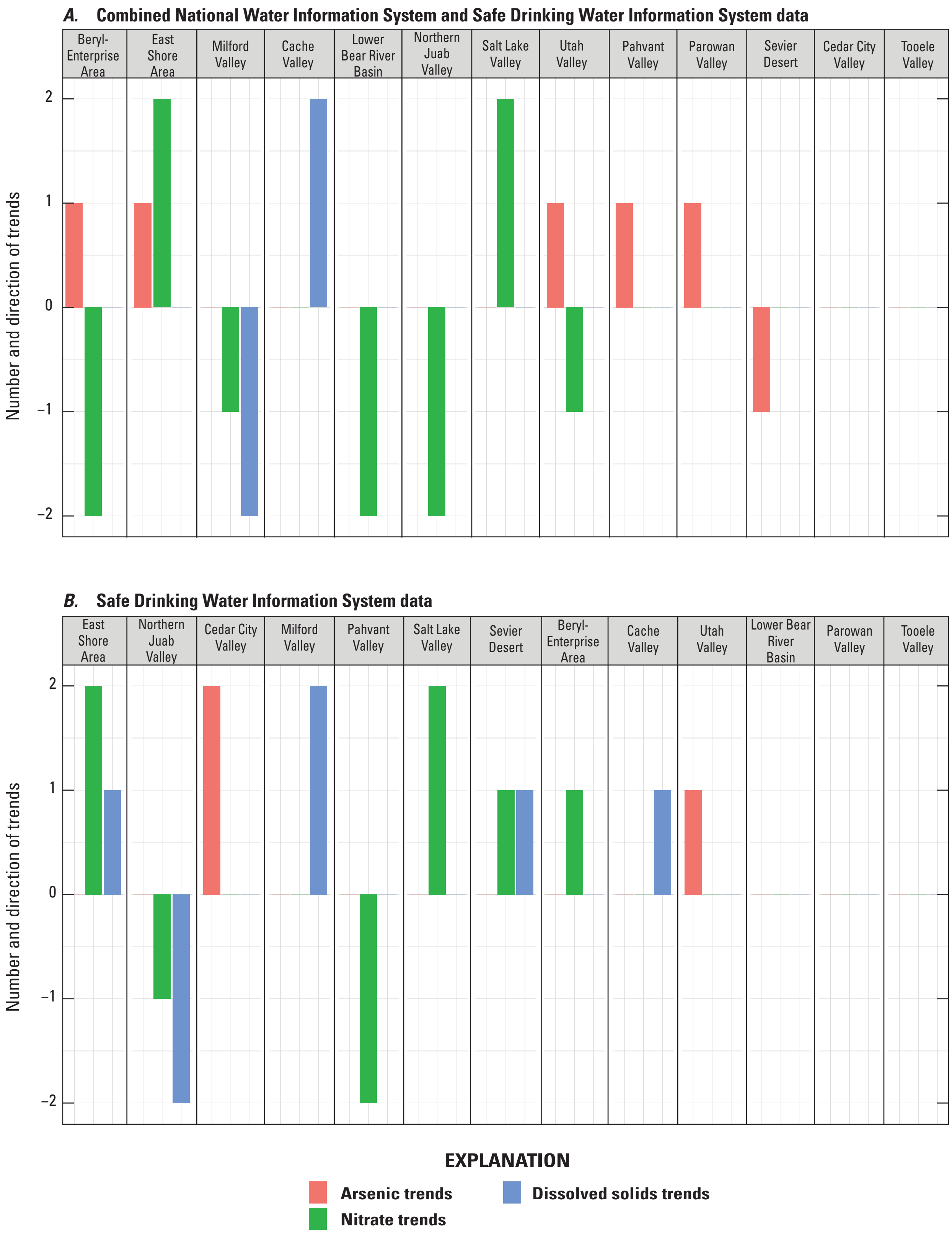


Figure 22. Number and direction of trends for each analyte in each basin for the *A*, National Water Information System and Safe Drinking Water Information System data combined and the *B*, Safe Drinking Water Information System data.

The activity within a basin appears to determine the number and direction of trends more than geographic location, which favors human drivers of trends over natural drivers. Basins proximal to each other with similar geologic conditions, such as the East Shore Area and Lower Bear River Basin had substantially different trend behavior. These basins have similar geologic histories and climate conditions (Bjorklund and McGreevy, 1974; Clark and others, 1990). Both basins lie adjacent to the Great Salt Lake and formed through normal faulting along the Wasatch Fault. Subsequent erosion of the uplifted mountains deposited sediment in the basins and rising and falling of Lake Bonneville further modified sediment deposition and erosion as well as groundwater quality. These basins have a similar temperate and arid climate and similar amounts of precipitations and temperatures. Precipitation in both basins increases significantly in the mountains, which feeds streams and groundwater recharge. Despite these similarities, increasing trends in arsenic and nitrate occurred in the East Shore Area, whereas nitrate decreased in the Lower Bear River Basin. Some of these patterns may be explained by population and land use. The East Shore Area spans Davis and Weber Counties, which had a combined population in 2010 of more than 500,000 people, whereas Box Elder County had almost 50,000 people, of which the Lower Bear River Basin is less than one-fourth of the area (U.S. Census Bureau, 2019). The rate of population growth is estimated to be greater in Weber and Davis counties (10 and 15 percent, respectively) compared to Box Elder County (10 percent) from 2010 to 2018 (U.S. Census Bureau, 2019). The East Shore Area had more urban area, whereas the Lower Bear River Basin had more production (agricultural) land in 1974 and 2012 (Falcone, 2015). The East Shore Area also experienced land-use change across a greater area (20 percent) than the Lower Bear River Basin (5 percent). Further, the East Shore Area had more land converted from production to urban land over this period (13 percent compared to 1 percent in the Lower Bear River Basin).

In comparing the total number of trends using decadal and sub-decadal medians from SDWIS data in each basin across analytes, the water quality in several basins changed the most in the East Shore Area and Northern Juab Valley (three trends in each basin, fig. 22*B*). There were more increasing trends than decreasing trends for all analytes, and increasing trends among SDWIS data were more common than among NWIS and SDWIS data combined. Only Northern Juab Valley and Pahvant Valley had any decreasing trends in data from public-supply wells.

Summary

The U.S. Geological Survey, in cooperation with the Utah Department of Environmental Quality, Division of Water Quality, studied trends in arsenic, nitrate, and dissolved-solids concentrations in basins throughout Utah that have experienced substantial groundwater development. The significance and magnitude of decadal and sub-decadal (5-year) scale trends was determined using data from the National Water Information System (NWIS) and Safe Drinking Water Information System (SDWIS) datasets combined, and from the SDWIS dataset independently. Spatial variation in temporal trends and the relationship to land-use change were evaluated. Additionally, spatial patterns in concentrations and regulatory exceedances of arsenic, nitrate, dissolved solids, and other inorganic contaminants were assessed.

Data stored in the NWIS and SDWIS databases represent water samples taken at different kinds of wells; SDWIS data represent drinking water (before treatment) and NWIS data represent water used for a broader range of purposes. Trends in each basin were tested using SDWIS data separately to identify changes in water that will eventually be used for drinking water. However, combining the datasets increased the number of samples for trend analysis and captured a more complete picture of the overall water-quality conditions within a basin. Decadal and sub-decadal medians were calculated to increase the number of medians available for analysis. Although this more frequent calculation often provided enough medians for trend analysis, it also introduced increased variability in median concentrations over time that could obscure trend identification, particularly with the Mann-Kendall trend test, which identifies monotonic changes.

Changes in decadal and sub-decadal median arsenic, nitrate, and dissolved-solids concentrations over time occurred throughout the basins in this study. Significant trends in arsenic were identified in the Beryl-Enterprise Area, East Shore Area, Utah Valley, Pahvant Valley, Parowan Valley, and Sevier Desert. Rates of median-concentration change ranged between decreases of –0.24 microgram per liter (ug/L) per year and increases of 0.48 ug/L per year across basins and sub-basins. Significant nitrate trends were identified in the Beryl-Enterprise Area, East Shore Area, Milford Valley, Lower Bear River Basin, Northern Juab Valley, Salt Lake Valley, and Utah Valley. Rates of median-concentration change ranged between decreases of –0.08 milligrams per liter (mg/L) per year and increases of 0.02 mg/L per year across basins and sub-basins. More basins had decreasing trends than increasing trends in nitrate. Significant trends in dissolved solids were identified in Milford Valley, Cache Valley, and parts of the East Shore Area, Salt Lake Valley, and Utah Valley. Rates of median-concentration change ranged between decreases of –5 mg/L per year and increases of 7 mg/L per year across basins and sub-basins. Changes within sub-basins can drive or be obscured by inclusion of data from a larger basin. The rates of change for nitrate and dissolved solids were below or similar to rates of change observed nationwide and in the southwestern United States. The similarity between rates of change in Utah and Central Valley, California, is noteworthy in that nitrogen fertilizer application rates and population were substantially higher in the Central Valley.

Public-supply wells experienced a number of increasing trends, particularly for nitrate and dissolved solids. Many of the basins experienced trends in similar direction for nitrate and dissolved solids. The Salt Lake Valley Southeast experienced increases in arsenic, nitrate, and dissolved solids. Increasing trends were more common among data from public-supply wells than among data from all well types combined.

Broad land-use change, as well as population growth, was associated with water-quality changes over time, and land-use change at wells was more loosely associated with trends. However, this was in part affected by a lack of data from wells experiencing different kinds of land-use change. Information about land-use change provided insight into drivers of water-quality changes. Land-use changes directly at wells were only one component of the range of factors that impacted water quality at a well, including land and water use over a larger area surrounding and up-gradient from the well, rates and direction of groundwater movement, and geologic and hydrologic conditions. The controls on groundwater quality were complex and included spatial and temporal variability in the local hydrology, land use, and other human activities. Increasing trends identified in this report occurred in areas that had experienced land-use change, population growth and associated development, and substantial groundwater use. Basins where concentrations of arsenic, nitrate, or dissolved-solids concentrations increased represent areas of potential concern, whereas basins where concentrations decreased represent areas where improvements occurred. Human activity has impacted groundwater quality in Utah, and may continue to do so as the state's population continues to grow.

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For more information concerning the research in this report, contact the
Director, Utah Water Science Center
U.S. Geological Survey
2329 West Orton Circle
Salt Lake City, Utah 84119-2047
801-908-5000
https://ut.water.usgs.gov

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Silver Meadows Development

Traffic Analysis

Prepared for:
Town of Hideout

April 2021

UT21-2270

FEHR PEERS

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1. Executive Summary

This study provides a summary of the potential transportation-related impacts from the proposed Silver Meadows development (formerly named the Richardson Flat development) located on Richardson Flat Road between US-40 and Jordanelle Parkway in Summit County, Utah. This study analyzes the traffic operations and impacts for 2021, 2026, and 2041 background and plus project conditions at key intersections. The plus project analysis includes project trips generated from the proposed project.

1.1 Traffic Conditions

1.1.1 Study Intersections

The following intersections were included in this study:

1) SR-248 & Richardson Flat Road – Currently side-street stop controlled, planned signal,
2) Jordanelle Parkway & Richardson Flat Road – Side-street stop controlled,
3) SR-248 & Jordanelle Parkway/Brown's Canyon Road – Side-street stop controlled, planned signal.

1.1.2 Traffic Volumes

Fehr & Peers previously collected traffic counts at the study intersections to establish a baseline of existing conditions and operations for the area. Weekday peak period traffic counts were recorded from 7:00 AM to 9:00 AM and from 4:00 PM to 6:00 PM on January 15, 2020 at all study intersections.

1.1.3 2021 Background Conditions

The intersections at SR-248 & Richardson Flat Road and at SR-248 & Brown’s Canyon Road were both observed to operate at failing levels of service in the AM and PM peak hours due to few gaps available for left-turn movements from minor roadways. Summit County has identified both intersections as locations for future traffic signal implementations due to existing failing conditions. No additional mitigations aside from those identified by Summit County are recommended as part of this analysis.

1.1.4 2026 Background Conditions

Due to Summit County’s plans to signalize the intersections at SR-248 & Richardson Flat Road and at SR-248 & Brown’s Canyon Road, those intersections were assumed to be signalized for all future condition analyses. Due to the signalization of those intersections, all study intersections operated within acceptable levels of delay during the AM and PM peak hour analyses.

1.1.5 Project Conditions

The proposed mixed-use site will be located between the intersections of SR-248 & Richardson Flat Road and Richardson Flat Road & Jordanelle Parkway, south of SR-248. Trip generation for the project was computed using trip generation rates published in the Institute of Transportation Engineers (ITE) *Trip Generation, 10th Edition*, 2017, and Fehr & Peers' mixed-use development (MXD+) methodology via MainStreet, a Fehr & Peers web application that captures the traffic benefits of developments by looking at interactions among the mixture of land uses and patron usage of alternative modes (i.e., transit, bicycling, and/or walking).

The project is not currently proposed to include any new driveways that connect to SR-248.

The development is expected to generate 718 project gross trips in the AM peak hour and 1,038 project gross trips in the PM peak hour. However, with the nature of a multi-use development, some generated trips travel only internally, or shift to transit or walk/bike modes. Based on the results of the MXD+ analysis, the site is expected to generate 620 net external trips in the AM peak hour and 895 net external trips in the PM peak hour.

1.1.6 2026 plus Project Conditions

Using the volumes forecasted for the 2026 plus project scenario, the three study intersections were observed to continue to operate at acceptable levels of service in the AM and PM peak hours of the 2026 plus project conditions analysis.

1.1.7 2041 Background Conditions

Using the volumes forecasted for the 2041 background scenario, the three study intersections were observed to continue to operate at acceptable levels of service in the AM and PM peak hours of the 2041 background conditions analysis.

1.1.8 2041 plus Project Conditions

Using the volumes forecasted for the 2041 plus project scenario, the three study intersections were observed to continue to operate at acceptable levels of service in the AM and PM peak hours of the 2041 plus project conditions analysis.

1.1.9 Recommended Mitigations

The Summit County Comprehensive Plan identifies that the intersections at SR-248 & Richardson Flat Road and at SR-248 & Brown's Canyon Road are planned to be converted from stop-controlled to signalized intersections. Planned growth from other developments in the area is projected to generate sufficient traffic to warrant traffic signals in future years.

Since all study intersections were observed to operate at acceptable levels of service through the 2041 plus project scenario analyses, no additional mitigations are recommended to be implemented as part of this development.

1.2 Conclusion

Currently, the intersections of SR-248 & Richardson Flat Road as well as SR-248 & Brown's Canyon Road experience unacceptable delays on the side-street turning movements. Summit County is currently planning to install traffic signals at these intersections. With these planned signals, the study intersections were observed to operate at an acceptable level of delay during peak hours in all 2026 and 2041 analyses performed in this study.

1.2.1 LOS Summary

Table 1 reports LOS at each study intersection. For signalized intersections, average vehicular delay and LOS are reported. For unsignalized intersections, the worst movement delay and LOS are reported. Detailed descriptions of the intersection operations can be found in the subsequent chapters. The column for 2021 background conditions reflects conditions with current lane configurations and no mitigations. All columns for future conditions incorporate the planned intersection signals.

Table 1: AM and PM Peak Hour Level of Service Summary

Intersection			2021 Background	2026 Background	2026 plus Project	2041 Background	2041 plus Project
ID	Location	Period	LOS & Sec/Veh	LOS & Sec/Veh	LOS & Sec/Veh	LOS & Sec/Veh	LOS & Sec/Veh
1	SR-248 & Richardson Flat Road[1,2]	AM	**F / 52 (WBL)**	A / 8	A / 9	A / 9	A / 10
		PM	**F / 153 (WBL)**	A / 6	B / 12	A / 7	B / 12
2	Jordanelle Parkway & Richardson Flat Road[2]	AM	A / 9 (EBT)	A / 9 (EBT)	B / 12 (EBT)	A / 9 (EBT)	B / 14 (EBT)
		PM	A / 9 (EBT)	A / 9 (EBT)	B / 14 (EBT)	A / 9 (EBT)	C / 16 (EBT)
3	SR-248 & Jordanelle Parkway/Brown's Canyon Road[1,2]	AM	**F / 55 (EBL)**	B / 18	B / 17	C / 22	C / 21
		PM	**F / 52 (EBL)**	B / 16	B / 20	B / 18	B / 19

1. Intersection average LOS and delay for signalized and roundabout intersections.
2. Worst movement LOS and delay for unsignalized intersections.

Source: Fehr & Peers.

2. Introduction

2.1 Purpose

This study provides a summary of the potential transportation-related impacts from the Silver Meadows multi-use development located on Richardson Flat Road between the intersections of SR-248 & Richardson Flat Road and Richardson Flat Road & Jordanelle Parkway in Richardson Flat, Utah. **Figure 1** for a project location map (source: LDG).

This study analyzes the traffic operations and impacts for 2021 background, 2026 background, 2026 plus project, 2041 background, and 2041 plus project conditions at key intersections, described below in the Scope section. The plus project analysis includes project trips generated from the proposed multi-use site. For each of the evaluation periods, mitigation (roadway geometry changes or operational improvements) actions, if needed, were recommended.

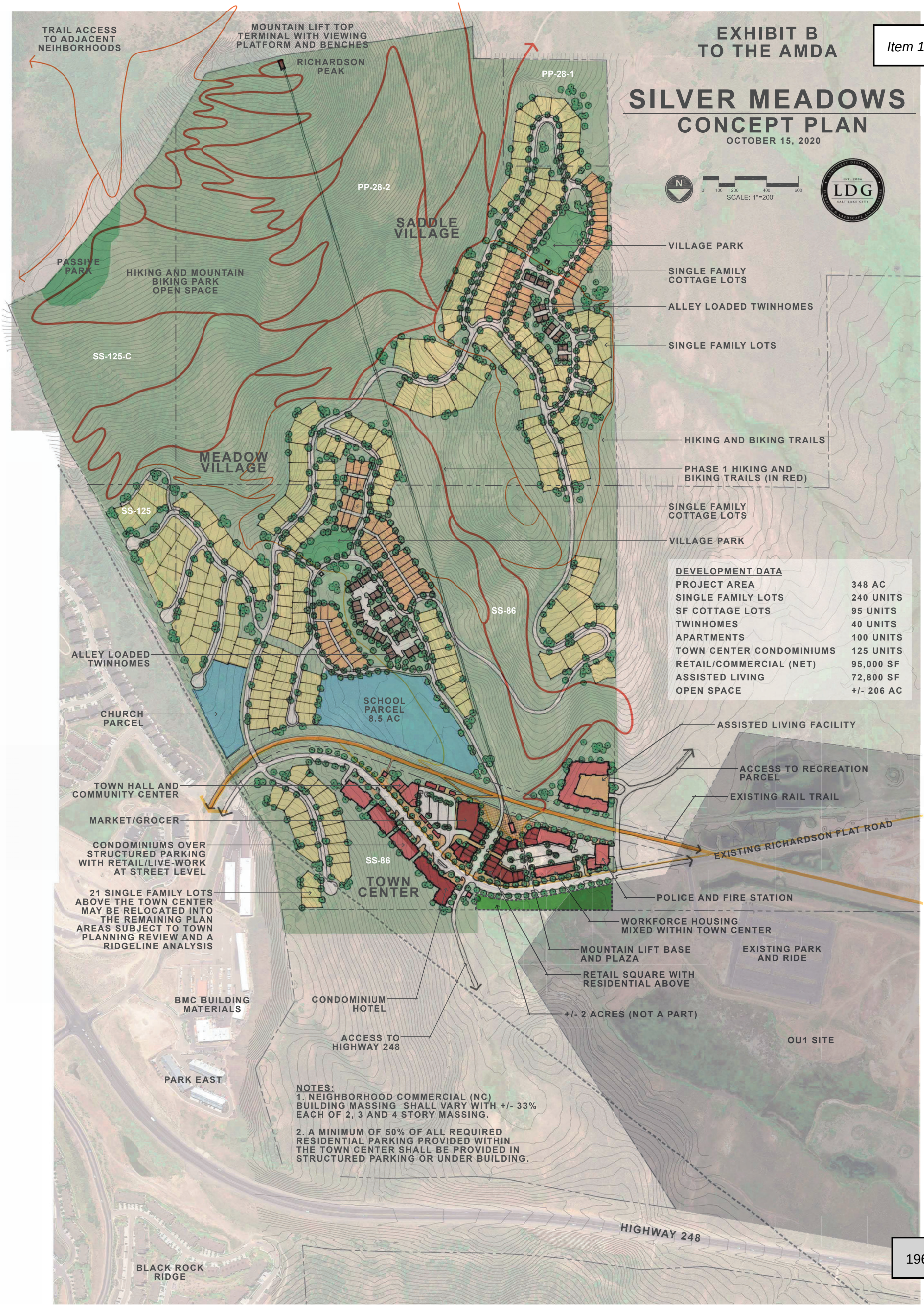
2.2 Scope

This study analyzes the traffic impacts of the project in conjunction with adjacent intersections. Impacts are specifically addressed at the following study intersections:

The following intersections were included in this study:

1) SR-248 & Richardson Flat Road – Currently side-street stop controlled, planned signal,
2) Jordanelle Parkway & Richardson Flat Road – Side-street stop controlled,
3) SR-248 & Jordanelle Parkway/Brown's Canyon Road – Side-street stop controlled, planned signal.

Item 1.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TO THE AMDA
SILVER MEADOWS
CONCEPT PLAN
OCTOBER 15, 2020
N
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LDG
TRAIL ACCESS
TO ADJACENT
NEIHBORHOODS
MOUNTAIN LIFT TOP
TERMINAL WITH VIEWING
PLATFORM AND BENCHES
RICHARDSON
PEAK
PP-28-1
PP-28-2
SADDLE
VILLAGE
PASSIVE
PARK
HIKING AND MOUNTAIN
BIKING PARK
OPEN SPACE
SS-125-C
MEADOW
VILLAGE
SS-125
SS-86
VILLAGE PARK
SINGLE FAMILY
COTTAGE LOTS
ALLEY LOADED TWINHOMES
SINGLE FAMILY LOTS
HIKING AND BIKING TRAILS
PHASE 1 HIKING AND
BIKING TRAILS (IN RED)
SINGLE FAMILY
COTTAGE LOTS
VILLAGE PARK
DEVELOPMENT DATA
PROJECT AREA 348 AC
SINGLE FAMILY LOTS 240 UNITS
SF COTTAGE LOTS 95 UNITS
TWINHOMES 40 UNITS
APARTMENTS 100 UNITS
TOWN CENTER CONDOMINIUMS 125 UNITS
RETAIL/COMMERCIAL (NET) 95,000 SF
ASSISTED LIVING 72,800 SF
OPEN SPACE +/- 206 AC
ALLEY LOADED
TWINHOMES
CHURCH
PARCEL
SCHOOL
PARCEL
8.5 AC
ASSISTED LIVING FACILITY
ACCESS TO RECREATION
PARCEL
EXISTING RAIL TRAIL
EXISTING RICHARDSON FLAT ROAD
TOWN HALL AND
COMMUNITY CENTER
MARKET/GROCER
CONDOMINIUMS OVER
STRUCTURED PARKING
WITH RETAIL/LIVE-WORK
AT STREET LEVEL
SS-86
TOWN
CENTER
21 SINGLE FAMILY LOTS
ABOVE THE TOWN CENTER
MAY BE RELOCATED INTO
THE REMAINING PLAN
AREAS SUBJECT TO TOWN
PLANNING REVIEW AND A
RIDGELINE ANALYSIS
POLICE AND FIRE STATION
WORKFORCE HOUSING
MIXED WITHIN TOWN CENTER
MOUNTAIN LIFT BASE
AND PLAZA
EXISTING PARK
AND RIDE
RETAIL SQUARE WITH
RESIDENTIAL ABOVE
BMC BUILDING
MATERIALS
CONDOMINIUM
HOTEL
+/- 2 ACRES (NOT A PART)
ACCESS TO
HIGHWAY 248
OU1 SITE
PARK EAST
NOTES:
1. NEIGHBORHOOD COMMERCIAL (NC)
BUILDING MASSING SHALL VARY WITH +/- 33%
EACH OF 2, 3 AND 4 STORY MASSING.
2. A MINIMUM OF 50% OF ALL REQUIRED
RESIDENTIAL PARKING PROVIDED WITHIN
THE TOWN CENTER SHALL BE PROVIDED IN
STRUCTURED PARKING OR UNDER BUILDING.
HIGHWAY 248
BLACK ROCK
RIDGE

2.3 Analysis Methodology

LOS is a term that describes the operating performance of an intersection or roadway. LOS is measured quantitatively and reported on a scale from A to F, with A representing the best performance and F the worst. Table 2 provides a brief description of each LOS letter designation and an accompanying average delay per vehicle for both signalized and unsignalized intersections. The Highway Capacity Manual, 6th Edition (HCM 6) methodology was used in this study to remain consistent with "state of the practice" professional standards. This methodology has different quantitative evaluations for signalized and unsignalized intersections. For signalized intersections, the LOS is provided for the overall intersection (weighted average of all approach delays).

Table 2: Level of Service Descriptions

LOS	Description	Signalized Intersections	Unsignalized Intersections
		Avg. Delay (sec/veh)[1]	Avg. Delay (sec/veh)[2]
A	*Free Flow / Insignificant Delay* Extremely favorable progression. Individual users are virtually unaffected by others in the traffic stream.	< 10.0	< 10.0
B	*Stable Operations / Minimum Delays* Good progression. The presence of other users in the traffic stream becomes noticeable.	> 10.0 to 20.0	> 10.0 to 15.0
C	*Stable Operations / Acceptable Delays* Fair progression. The operation of individual users is affected by interactions with others in the traffic stream	> 20.0 to 35.0	> 15.0 to 25.0
D	*Approaching Unstable Flows / Tolerable Delays* Marginal progression. Operating conditions are noticeably more constrained.	> 35.0 to 55.0	> 25.0 to 35.0
E	*Unstable Operations / Significant Delays Can Occur* Poor progression. Operating conditions are at or near capacity.	> 55.0 to 80.0	> 35.0 to 50.0
F	*Forced, Unpredictable Flows / Excessive Delays* Unacceptable progression with forced or breakdown of operating conditions.	> 80.0	> 50.0

1. Overall intersection LOS and average delay (seconds/vehicle) for all approaches.
2. Worst approach LOS and delay (seconds/vehicle) only.

Source: Fehr & Peers descriptions, based on *Highway Capacity Manual, 6th Edition*.

3. Existing 2021 Background Conditions

3.1 Purpose

The 2021 existing conditions analysis examines the pertinent intersections and roadways during the peak travel periods of the day under existing traffic and geometric conditions. Through this analysis, existing traffic operational deficiencies can be identified, and potential mitigation measures recommended.

3.2 Roadway System

The primary roadways that will provide access to the project are described below.

- **SR-248** is a state-owned highway in Summit County that connects Park City with Kamas, Utah. From Wyatt Earp Way to Richardson Flat Road, SR-248 has one travel lane in each direction with a two-way left-turn lane and a speed limit of 50 miles per hour. From the US-40 to the intersection at Brown's Canyon Road, SR-248 widens to have two travel lanes in each direction with a two-way left-turn lane and a speed limit of 65 miles per hour.
- **Richardson Flat Road** has a posted speed limit of 35 mph and is classified as a minor collector road. Richardson Flat Road has a two-lane cross section with one travel lane in each direction throughout the project area. The road is fairly narrow; both travel lanes are 11' and have no shoulder.
- **Jordanelle Parkway / Brown's Canyon Road** has a posted speed limit of 30 mph and is classified as a major collector road. It has a two-lane cross-section with one travel lane in each direction near the project area, except for near the intersection at SR-248, where it widens out to include left and right turn storage lanes.

3.3 Traffic Accident Data

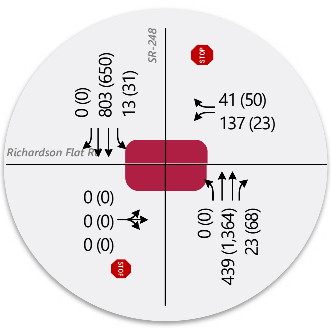
Fehr & Peers obtained 5 years of crash data from 2016 to 2021 to outline safety deficiencies near the project area. The data collected included the location, severity, date, and type of collisions.

From 2016 to 2021, there were 23 total collisions in the within the study area; 16 collisions were intersection-related, six collisions occurred along Richardson Flat Road, and one occurred on Jordanelle Parkway. Of the non-intersection related collisions within the project area, there were four property damage only crashes, two suspected minor injury crashes, and one possible injury crash; no suspected serious injury crashes or fatal crashes were reported along Richardson Flat Road or Jordanelle Parkway. Notably, three of the collisions along Richardson Flat Road involved roadway departures, which may indicate that pavement markings and delineation along Richardson Flat Road is needed, especially as the area continues to develop. Speeding was also involved in two of the crashes along Richardson Flat Road, but those accidents both occurred in snowy or icy conditions, so speeding does not appear to be a significant issue along Richardson Flat Road.

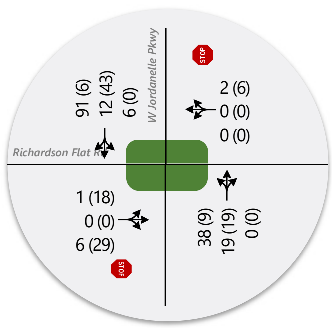
Furthermore, as traffic continues to increase along Richardson Flat Road, the road width may prove to be insufficient. Further study should be conducted to determine if widening the road to accommodate shoulders, bike lanes, striping, or other modifications would be warranted.

3.4 Traffic Volumes

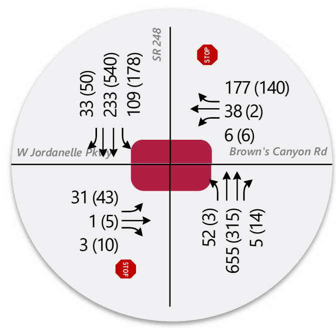
Fehr & Peers collected traffic counts at the study intersections to establish a baseline of existing conditions and operations for the area. AM peak period traffic counts were recorded from 7:00 AM to 9:00 AM and PM peak period traffic counts were recorded from 4:00 PM to 6:00 PM on January 15, 2020 at all study intersections. No monthly or daily adjustment factors were applied to the counts. The existing background weekday peak hour volumes are shown in **Figure 2** and in the Appendix.



1. SR-248/ Richardson Flat Rd



2. W Jordanelle Pkwy/ Richardson Flat Rd



3. SR 248/W Jordanelle Pkwy/ Brown's Canyon Rd

LEGEND

STOP *Stop Sign* *Signalized*

Lane Configuration AM (PM) AM (PM) AM (PM) *Peak Hour Traffic Volume per lane*

Intersection Level of Service (LOS):

AM PM A B C D E F

Figure 2

Existing Conditions

3.5 Level of Service Analysis

Using Synchro 11 software and the HCM 2016 delay thresholds provided in the Introduction, the existing background AM and PM peak hour LOS were computed for each study intersection. The results of this analysis for the AM and PM peak hours are reported in **Table 3** (see Appendix for the detailed LOS report). These results serve as a base for the analysis of the impacts of the proposed mixed-use development.

Table 3: Existing 2021 Background Conditions AM & PM Peak Hour Level of Service

Intersection				Worst Movement[1]			Overall Intersection[2]	
ID	Location	Period	Control	Movement[3]	Delay Sec/Veh	LOS	Avg. Delay Sec/Veh	LOS
1	SR-248 & Richardson Flat Road[1,2]	AM	EB/WB Stop	WBL	52	F	-	-
		PM		WBL	153	F	-	-
2	Jordanelle Parkway & Richardson Flat Road[2]	AM	EB/WB Stop	EBT	9	A	-	-
		PM		EBT	9	A	-	-
3	SR-248 & Jordanelle Parkway/Brown's Canyon Road[1,2]	AM	EB/WB Stop	EBL	55	F	-	-
		PM		EBL	52	F	-	-

1. This represents the worst approach LOS and delay (seconds/vehicle) and is only reported for unsignalized intersections.
2. This represents the overall intersection LOS and delay (seconds/vehicle) and is only reported for signalized intersections.
3. NB=Northbound, SB=Southbound, EB=Eastbound, WB=Westbound

Source: Fehr & Peers.

As shown in **Table 3**, the intersections at SR-248 & Richardson Flat Road and at SR-248 & Brown's Canyon Road both operate at failing levels of service in the AM and PM peak hours due to few gaps available for left-turn movements from minor roadways. The intersection at Jordanelle Parkway & Richardson Flat Road operated at acceptable levels of service.

3.6 Mitigation Measures

Summit County has identified both intersections as locations for future traffic signal implementations due to existing failing conditions. The heavy volumes in the project area indicate that those signals are likely needed and should be implemented as they are warranted.

These mitigations are assumed to be implemented for all 2026 and 2041 analysis configurations since initial analyses without those mitigations showed that the intersections would likely experience failing conditions without them. No additional mitigations aside from those identified by Summit County are recommended as part of this analysis.

4. Future 2026 Background Conditions

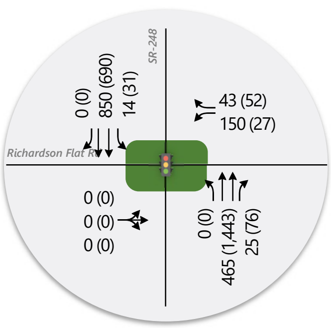
4.1 Purpose

The purpose of the future 2026 background conditions analysis is to evaluate the study intersections during the peak travel periods of the day under projected 2026 traffic volumes. This analysis provides a baseline condition for the year 2026, which can be used to determine future project impacts. This analysis also assumes the mitigations recommended in **Section 3.6** were implemented.

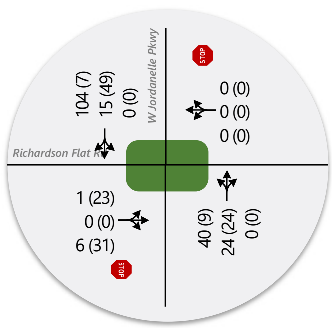
4.2 Traffic Volumes

Fehr & Peers projected 2026 volumes using linear annual growth rates based on Summit County Travel Demand Model and modifications based on observations of the area. The increase in projected volume between the 2019 and 2041 Summit County models indicated between 1.1% and 2.9% growth per year, depending on the segment of road in the study area. The growth rates were applied to the existing 2021 background volumes to formulate the traffic volumes for the future 2026 background conditions. The projected 2026 background peak hour traffic volumes are shown in **Figure 3**.

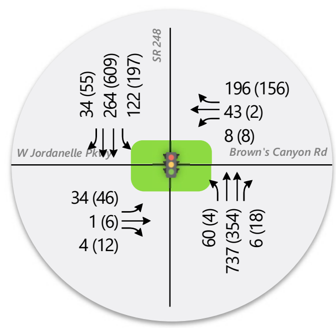
Item 1.



1. SR-248/ Richardson Flat Rd



2. W Jordanelle Pkwy/ Richardson Flat Rd



3. SR 248/W Jordanelle Pkwy/ Brown's Canyon Rd

LEGEND

Stop Sign *Signalized*

Lane Configuration AM (PM) AM (PM) AM (PM) *Peak Hour Traffic Volume per lane*

Intersection Level of Service (LOS):

AM PM A B C D E F

Figure 3

2026 Background Conditions

4.3 Level of Service Analysis

Using Synchro 11 software and the HCM 2016 delay thresholds provided in the Introduction, future 2021 background peak hour LOS was computed for each study intersection. The results of this analysis for the AM and PM peak hours are reported in **Table 4** (see Appendix for the detailed LOS report).

Table 4: Future 2026 Background Conditions AM & PM Peak Hour Level of Service

Intersection				Worst Movement[1]			Overall Intersection[2]	
ID	Location	Period	Control	Movement[3]	Delay Sec/Veh	LOS	Avg. Delay Sec/Veh	LOS
1	SR-248 & Richardson Flat Road[1,2]	AM	Signal	-	-	-	8	A
		PM		-	-	-	6	A
2	Jordanelle Parkway & Richardson Flat Road[2]	AM	EB/WB Stop	EB TH	9	A	-	-
		PM		EB TH	9	A	-	-
3	SR-248 & Jordanelle Parkway/Brown's Canyon Road[1,2]	AM	Signal	-	-	-	18	B
		PM		-	-	-	16	B

1. This represents the worst approach LOS and delay (seconds/vehicle) and is only reported for unsignalized intersections.
2. This represents the overall intersection LOS and delay (seconds/vehicle).
3. NB=Northbound, SB=Southbound, EB=Eastbound, WB=Westbound

Source: Fehr & Peers.

4.4 Mitigation Measures

All intersections operate at acceptable overall levels of service assuming the mitigation measures recommended in the existing conditions analysis, therefore no further traffic operation mitigation measures for future 2026 conditions are recommended.

5. Project Conditions

5.1 Purpose

The project conditions analysis explains the type and intensity of development. This provides the basis for trip generation, distribution, and assignment of project trips to the surrounding study intersections defined in the Introduction.

5.2 Project Description

The proposed Silver Meadows mixed-use site will be located between the intersections of SR-248 & Richardson Flat Road and Richardson Flat Road & Jordanelle Parkway and will consist of single-family, multi-family, assisted living, and second home residential along with some general retail uses. The full list of land uses, and area occupied by each use is listed in **Table 5**. The Silver Meadows development is located south of SR-248. The development proposes no new driveway access locations that tie into SR-248.

5.3 Trip Generation

Trip generation for the project was computed using trip generation rates published in the Institute of Transportation Engineers (ITE) *Trip Generation, 10th Edition*, 2017, and Fehr & Peers' mixed-use development (MXD+) methodology via MainStreet, a Fehr & Peers web application that captures the traffic benefits of developments by looking at interactions among the mixture of land uses and patron usage of alternative modes (i.e., transit, bicycling, and/or walking).

The gross and net external vehicle trips expected to be generated by the mixed-use development, along with the vehicle trip reduction rates (that account for trips that are internal to the site, as well as trips that shift to transit or walk/bike modes) are shown in **Table 5**.

Table 5: Mixed use development Trip Generation

ITE Land Use	ITE Code	Units	Quantity	Daily Total	AM In	AM Out	AM Total	PM In	PM Out	PM Total
(220) - Multifamily Housing Low Rise (Adj Streets, 7-9A, 4-6P)	220	Dwelling Units	40	262	5	15	20	16	10	26
(210) - Single-Family Detached Housing (Adj Streets, 7-9A, 4-6P)	210	Dwelling Units	240	2266	45	134	178	150	88	238
(221) - Multifamily Housing Mid-Rise (Adj Streets, 7-9A, 4-6P)	221	Dwelling Units	100	544	9	27	36	27	17	44
(221) - Multifamily Housing Mid-Rise (Adj Streets, 7-9A, 4-6P)	221	Dwelling Units	125	680	12	33	45	34	21	55
(520) - Elementary School (Adj Streets, 7-9A, 4-6P)	520	Students	250	473	91	77	168	21	22	43
(265) - Timeshare (Adj Streets, 7-9A, 4-6P)	265	Dwelling Units	95	855	23	16	39	26	38	64
(820) - Shopping Center (Adj Street, 7-9A, 4-6P)	820	1,000 Sq. Ft	95	5,806	123	76	199	251	272	523
(254) - Assisted Living (Adj Streets, 7-9A, 4-6P)	254	1,000 Sq. Ft	72.8	305	22	6	28	11	25	35
(560) - Church (Adj Streets, 7-9A, 4-6P)	560	1,000 Sq. Ft	16.37	118	3	2	5	5	6	10
Sub Total				11,309	333	386	718	541	499	1038
Internal Capture				*682*	*41*	*47*	*88*	*67*	*62*	*128*
Shift to Transit				*181*	*4*	*5*	*9*	*7*	*7*	*14*
Shift to Walk/Bike				*17*	*0*	*1*	*1*	*1*	*0*	*1*
TOTAL				**10,429**	**288**	**333**	**620**	**466**	**430**	**895**

Source: Fehr & Peers.

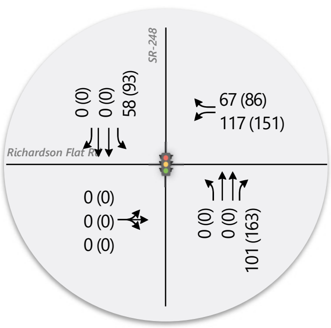
5.4 Trip Distribution and Assignment

Project traffic was assigned to the roadway network based on the proximity to major streets and freeways, roadway network, high population densities, and regional trip attractions. Existing travel patterns observed during data collection also provided helpful guidance to establish these distribution percentages, especially near the site.

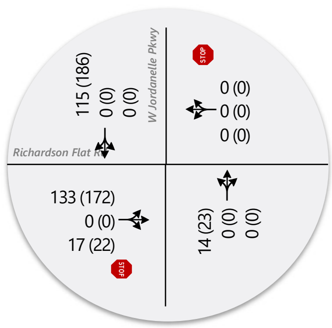
Overall, the project-generated trips were distributed to and from these directions in the project conditions analyses, in the corresponding percentages:

- 35% South (using SR-248 from Richardson Flat Road)
- 20% North (using SR-248 from Richardson Flat Road)
- 20% West (using SR-248 from Brown's Canyon Road)
- 5% East (using Brown's Canyon Road)
- 5% South (using SR-248 from Brown's Canyon Road)

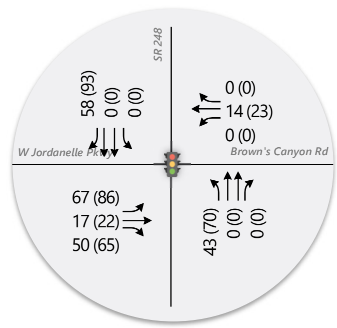
These trip distribution assumptions were used to distribute project-generated traffic to the study area intersections. The volume of project trips generated and distributed to the study intersections is shown in **Figure 4**.



1. SR-248/ Richardson Flat Rd



2. W Jordanelle Pkwy/ Richardson Flat Rd



3. SR 248/W Jordanelle Pkwy/ Brown's Canyon Rd

LEGEND

Stop Sign *Signalized*

Lane Configuration AM (PM) AM (PM) AM (PM) *Peak Hour Traffic Volume per lane*

Intersection Level of Service (LOS):

AM PM A B C D E F

Figure 4

Trip Generation

5.5 Diverted Trips (Select-Link) Analysis

To investigate the amount of traffic that might be diverted from utilizing SR-248 due to the proposed development, a select-link analysis was completed. The Summit-Wasatch Travel Demand Model was utilized to complete this analysis.

Two years were assessed; 2024 and 2041. The traffic analysis zone (TAZ) socio-economic data was modified for TAZ 126, which represents the location of the proposed development. Base conditions assume limited growth in this TAZ for both horizon years. This assumed growth was replaced with the land use development program. While not all anticipated land uses are reflected in the model, the bulk of the development was reflected with the following inputs:

- 505 housing units
- 190 retail employment jobs (representing 95,000 square feet of shopping center use assuming 2 employees per 1,000 square feet).
- 95 condos (representing the timeshare units)

The results of these model runs were compared to base condition model runs for the same year. A segment of SR-248 was chosen for a select link analysis, which allows trips that use this link to be tracked across the model network. This helps address the question, "where are trips going to and coming from that utilize this segment of roadway."

Results for both horizon years show that the distribution and routing of traffic using this segment do not see meaningful change due to the development. However, the development itself does appear to generate traffic that utilizes the SR-248 corridor, which aligns with standard industry trip generation and distribution assumptions. Therefore, no trips were assumed to be diverted from existing or projected background traffic for the analyses in this study.

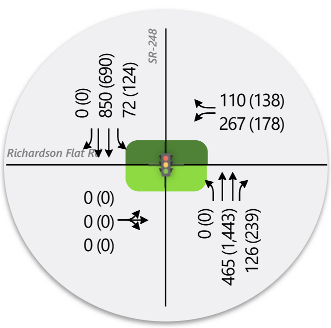
6. Future 2026 plus Project Conditions

6.1 Purpose

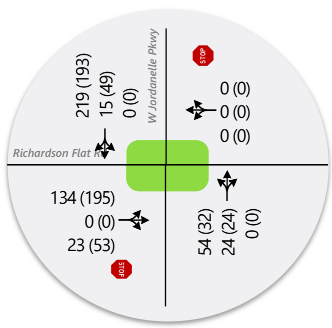
The purpose of the 2026 plus project conditions analysis is to evaluate the impact of the proposed development traffic on the surrounding roadway network. To analyze this impact, the peak hour 2026 background traffic volumes were combined with volumes generated by the proposed project at its peak hour. Intersection LOS analyses were then performed and compared to the results of the background traffic volumes. This comparison shows the impact of the proposed project.

6.2 Traffic Volumes

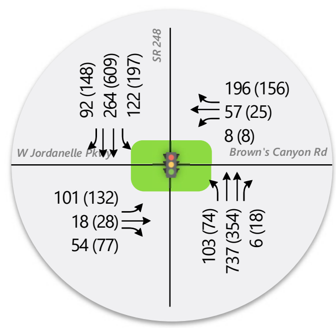
Project-generated traffic was added to the projected 2026 volumes to yield 2026 future plus project peak hour volumes. The AM and PM peak hour traffic volumes at the study intersections are shown in **Figure 5**.



1. SR-248/ Richardson Flat Rd



2. W Jordanelle Pkwy/ Richardson Flat Rd



3. SR 248/W Jordanelle Pkwy/ Brown's Canyon Rd

LEGEND

Stop Sign | Signalized

Lane Configuration — AM (PM) AM (PM) AM (PM) — Peak Hour Traffic Volume per lane

Intersection Level of Service (LOS):

AM PM — A B C D E F

Figure 5

2026 + Project Conditions

6.3 Level of Service Analysis

Using Synchro 11 software and the HCM 2016 delay thresholds provided in the Introduction, 2026 plus project AM and PM peak hour LOS was computed for each study intersection for the conceptual site development. The results of this analysis for the AM and PM peak hours are reported in **Table 6** (see Appendix for the detailed LOS report).

Table 6: Future 2026 Plus Project Conditions AM & PM Peak Hour Level of Service

Intersection				Worst Movement[1]			Overall Intersection[2]	
ID	Location	Period	Control	Movement[3]	Delay Sec/Veh	LOS	Avg. Delay Sec/Veh	LOS
1	SR-248 & Richardson Flat Road[1,2]	AM	Signal	-	-	-	9	A
		PM		-	-	-	12	B
2	Jordanelle Parkway & Richardson Flat Road[2]	AM	EB/WB Stop	EB LT	13	B	-	-
		PM		EB LT	14	B	-	-
3	SR-248 & Jordanelle Parkway/Brown's Canyon Road[1,2]	AM	Signal	-	-	-	17	B
		PM		-	-	-	20	B

1. This represents the worst approach LOS and delay (seconds/vehicle) and is only reported for unsignalized intersections.
2. This represents the overall intersection LOS and delay (seconds/vehicle).
3. NB=Northbound, SB=Southbound, EB=Eastbound, WB=Westbound

Source: Fehr & Peers.

6.4 Mitigation Measures

Using the volumes forecasted for the 2026 plus project scenario, the three study intersections were observed to continue to operate at acceptable levels of service in the AM and PM peak hours of the analysis, therefore no further traffic operation mitigation measures for 2026 plus project conditions are recommended.

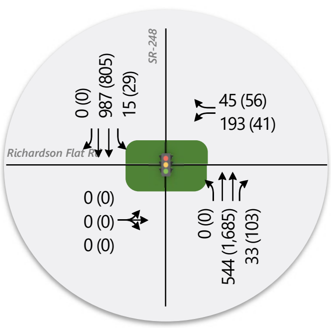
7. Future 2041 Background Conditions

7.1 Purpose

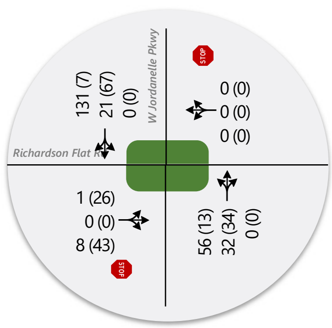
The purpose of the future 2041 background conditions analysis is to evaluate the study intersections during the peak travel periods of the day under projected 2041 traffic volumes. This analysis provides a baseline condition for the year 2041, which can be used to determine future project impacts.

7.2 Traffic Volumes

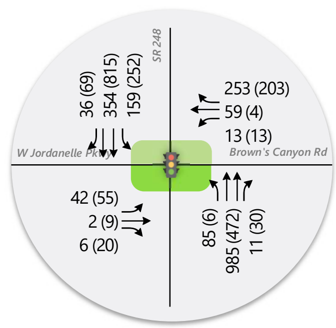
Fehr & Peers projected 2041 volumes using linear annual growth rates based on Summit County Travel Demand Model and modifications based on observations of the area. The increase in projected volume between the 2019 and 2041 Summit County models indicated between 1.1% and 2.9% growth per year, depending on the segment of road in the study area. The growth rates were applied to the existing 2021 background volumes to formulate the traffic volumes for the future 2041 background conditions. The projected 2041 background peak hour traffic volumes are shown in **Figure 6**.



1. SR-248/ Richardson Flat Rd



2. W Jordanelle Pkwy/ Richardson Flat Rd



3. SR 248/W Jordanelle Pkwy/ Brown's Canyon Rd

LEGEND

Stop Sign *Signalized*

Lane Configuration AM (PM) AM (PM) AM (PM) *Peak Hour Traffic Volume per lane*

Intersection Level of Service (LOS):

AM PM A B C D E F

Figure 6

2041 Background Conditions

7.3 Level of Service Analysis

Using Synchro 11 software and the HCM 2016 delay thresholds provided in the Introduction, future 2041 background weekday peak hour LOS was computed for each study intersection. The results of this analysis for the AM & PM peak hour are reported in **Table 7** (see Appendix for the detailed LOS report).

Table 7: Future 2041 Background Conditions AM & PM Peak Hour Level of Service

Intersection				Worst Movement[1]			Overall Intersection[2]	
ID	Location	Period	Control	Movement[3]	Delay Sec/Veh	LOS	Avg. Delay Sec/Veh	LOS
1	SR-248 & Richardson Flat Road[1,2]	AM	Signal	-	-	-	9	A
		PM		-	-	-	7	A
2	Jordanelle Parkway & Richardson Flat Road[2]	AM	EB/WB Stop	EB TH	9	A	-	-
		PM		EB TH	9	A	-	-
3	SR-248 & Jordanelle Parkway/Brown's Canyon Road[1,2]	AM	Signal	-	-	-	22	C
		PM		-	-	-	18	B

1. This represents the worst approach LOS and delay (seconds/vehicle) and is only reported for unsignalized intersections.
2. This represents the overall intersection LOS and delay (seconds/vehicle).
3. NB=Northbound, SB=Southbound, EB=Eastbound, WB=Westbound

Source: Fehr & Peers.

7.4 Mitigation Measures

All study intersections operate at acceptable overall levels of service assuming the mitigation measures recommended in the existing conditions analysis, therefore no further traffic operation mitigation measures for future 2041 conditions are recommended.

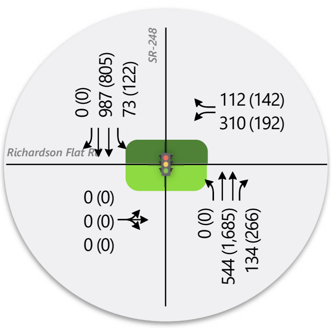
8. Future 2041 plus Project Conditions

8.1 Purpose

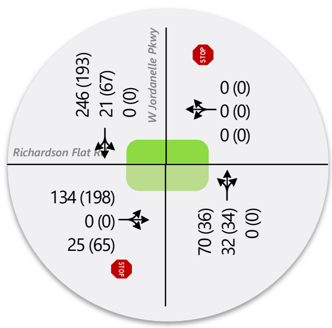
The purpose of the future 2041 plus project conditions analysis is to evaluate the impact of the proposed development traffic on the surrounding roadway network in the year 2041. To analyze this impact, the projected 2041 AM and PM peak hour background traffic volumes were combined with volumes generated by the conceptual development for the AM and PM peak hour. Intersection LOS analyses were then performed and compared to the results of the background traffic volumes. This comparison shows the impact of the conceptual project in 2041.

8.2 Traffic Volumes

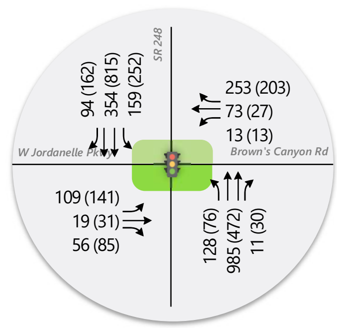
Project-generated traffic was added to the future 2041 background volumes (**Figure 6**) to yield "future 2041 plus project" AM and PM peak hour traffic volumes at the study intersections (**Figure 7**).



1. SR-248/ Richardson Flat Rd



2. W Jordanelle Pkwy/ Richardson Flat Rd



3. SR 248/W Jordanelle Pkwy/ Brown's Canyon Rd

LEGEND

Stop Sign *Signalized*

Lane Configuration — AM (PM) AM (PM) AM (PM) — *Peak Hour Traffic Volume per lane*

Intersection Level of Service (LOS):

AM PM — A B C D E F

Figure 7

2041 + Project Conditions

8.3 Level of Service Analysis

Using Synchro 11 software and the HCM 2016 delay thresholds provided in the Introduction, future 2041 plus project AM and PM peak hour LOS was computed for each study intersection for the conceptual site development. The results of this analysis for the AM and PM peak hours are reported in **Table 8** (see Appendix for the detailed LOS report).

Table 8: Future 2041 plus Project Conditions AM & PM Peak Hour Level of Service

Intersection				Worst Movement[1]			Overall Intersection[2]	
ID	Location	Period	Control	Movement[3]	Delay Sec/Veh	LOS	Avg. Delay Sec/Veh	LOS
1	SR-248 & Richardson Flat Road[1,2]	AM	Signal	-	-	-	10	A
		PM		-	-	-	12	B
2	Jordanelle Parkway & Richardson Flat Road[2]	AM	EB/WB Stop	EB LT	14	B	-	-
		PM		EB LT	16	C	-	-
3	SR-248 & Jordanelle Parkway/Brown's Canyon Road[1,2]	AM	Signal	-	-	-	21	C
		PM		-	-	-	19	B

1. This represents the worst approach LOS and delay (seconds/vehicle) and is only reported for unsignalized intersections.
2. This represents the overall intersection LOS and delay (seconds/vehicle).
3. NB=Northbound, SB=Southbound, EB=Eastbound, WB=Westbound

Source: Fehr & Peers.

8.4 Mitigation Measures

Using the volumes forecasted for the 2041 plus project scenario, the three study intersections were observed to continue to operate at acceptable levels of service in the AM and PM peak hours of the analysis, therefore no further traffic operation mitigation measures for 2041 plus project conditions are recommended.

9. Conclusion

The safety analysis found that in the past five years, three collisions along Richardson Flat Road involved roadway departures, which may indicate that pavement markings and delineation along Richardson Flat Road are needed, especially as the area continues to develop. Furthermore, as traffic continues to increase along Richardson Flat Road, the road width may prove to be insufficient. Further study should be conducted to determine if widening the road to accommodate shoulders, bike lanes, striping, or other modifications would be warranted.

In the existing conditions traffic analyses, the intersections at SR-248 & Richardson Flat Road and at SR-248 & Brown's Canyon Road both operate at failing levels of service in the AM and PM peak hours due to few gaps available for left-turn movements from minor roadways. Fehr & Peers recommends signalizing the intersections at SR-248 & Richardson Flat Road and at SR-248 & Brown's Canyon Road as outlined in the Summit County Comprehensive Plan.

The analysis described in this report shows that the proposed mixed-use development and the surrounding proposed housing development would not significantly impact vehicle level of service and delay at intersections within the immediate vicinity.

Appendix A
Turning Movement Counts

Elite Traffic Data Collection, LLC

379 East 2700 North
Lehi, Utah, 84043
elitetrafficdata@hotmail.com

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File Name : SR-248 and Richardson Flat Road 0700-0900
Site Code : 00000000
Start Date : 1/15/2020
Page No : 1

Groups Printed- TMC

	SR-248 From North					Richardson Flat Road From East					SR-248 From South					Richardson Flat Road From West					
Start Time	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Int. Total
07:00 AM	0	292	5	0	297	3	0	12	0	15	6	56	0	0	62	0	0	0	0	0	374
07:15 AM	0	238	13	0	251	6	0	32	0	38	4	100	0	0	104	0	0	0	0	0	393
07:30 AM	0	213	1	0	214	6	0	29	0	35	8	137	0	0	145	0	0	0	0	0	394
07:45 AM	0	206	3	0	209	12	0	33	0	45	2	106	0	0	108	0	0	0	0	0	362
Total	0	949	22	0	971	27	0	106	0	133	20	399	0	0	419	0	0	0	0	0	1523
08:00 AM	0	201	3	0	204	8	0	38	0	46	7	81	0	0	88	0	0	0	0	0	338
08:15 AM	0	183	6	0	189	15	0	37	0	52	6	115	0	0	121	0	0	0	0	0	362
08:30 AM	0	232	4	0	236	4	0	43	0	47	3	88	0	0	91	0	0	0	0	0	374
08:45 AM	0	228	1	0	229	3	0	43	0	46	3	96	0	0	99	0	0	0	0	0	374
Total	0	844	14	0	858	30	0	161	0	191	19	380	0	0	399	0	0	0	0	0	1448
Grand Total	0	1793	36	0	1829	57	0	267	0	324	39	779	0	0	818	0	0	0	0	0	2971
Apprch %	0	98	2	0		17.6	0	82.4	0		4.8	95.2	0	0		0	0	0	0		
Total %	0	60.4	1.2	0	61.6	1.9	0	9	0	10.9	1.3	26.2	0	0	27.5	0	0	0	0	0	

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Lehi, Utah, 84043
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Site Code : 00000000
Start Date : 1/15/2020
Page No : 1

Groups Printed- TMC

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Start Time	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Int. Total
04:00 PM	0	155	4	0	159	17	0	1	0	18	19	297	0	0	316	0	0	0	0	0	493
04:15 PM	0	146	4	0	150	10	0	10	0	20	13	346	0	0	359	0	0	0	0	0	529
04:30 PM	0	160	3	0	163	10	0	7	0	17	11	315	0	0	326	0	0	0	0	0	506
04:45 PM	0	161	5	0	166	20	0	6	0	26	19	309	0	0	328	0	0	0	0	0	520
Total	0	622	16	0	638	57	0	24	0	81	62	1267	0	0	1329	0	0	0	0	0	2048
05:00 PM	0	159	7	0	166	6	0	3	0	9	12	355	0	0	367	0	0	0	0	0	542
05:15 PM	0	169	10	0	179	15	0	7	0	22	21	345	0	0	366	0	0	0	0	0	567
05:30 PM	0	161	9	0	170	9	0	7	0	16	16	355	0	0	371	0	0	0	0	0	557
05:45 PM	0	161	8	0	169	7	0	8	0	15	16	261	0	0	277	0	0	0	0	0	461
Total	0	650	34	0	684	37	0	25	0	62	65	1316	0	0	1381	0	0	0	0	0	2127
Grand Total	0	1272	50	0	1322	94	0	49	0	143	127	2583	0	0	2710	0	0	0	0	0	4175
Apprch %	0	96.2	3.8	0		65.7	0	34.3	0		4.7	95.3	0	0		0	0	0	0		
Total %	0	30.5	1.2	0	31.7	2.3	0	1.2	0	3.4	3	61.9	0	0	64.9	0	0	0	0	0	

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Site Code : 00000000
Start Date : 1/15/2020
Page No : 1

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	Jordanelle Parkway From North					Richardson Flat Road From East					Jordanelle Parkway From South					Richardson Flat Road From West					
Start Time	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Int. Total
07:00 AM	5	2	1	0	8	0	0	0	0	0	0	7	3	0	10	1	0	0	0	1	19
07:15 AM	16	1	1	0	18	1	0	0	0	1	0	4	5	0	9	2	0	2	0	4	32
07:30 AM	15	2	0	0	17	2	0	0	0	2	0	5	7	0	12	0	0	1	0	1	32
07:45 AM	30	4	1	0	35	0	0	0	0	0	0	5	6	0	11	3	0	0	0	3	49
Total	66	9	3	0	78	3	0	0	0	3	0	21	21	0	42	6	0	3	0	9	132
08:00 AM	27	3	1	0	31	0	0	0	0	0	0	6	16	0	22	2	0	0	0	2	55
08:15 AM	19	3	4	0	26	0	0	0	1	1	0	3	9	1	13	1	0	0	0	1	41
08:30 AM	28	4	3	0	35	0	0	0	0	0	1	3	8	0	12	0	0	4	0	4	51
08:45 AM	35	5	5	0	45	2	0	0	0	2	0	7	9	0	16	0	0	1	0	1	64
Total	109	15	13	0	137	2	0	0	1	3	1	19	42	1	63	3	0	5	0	8	211
Grand Total	175	24	16	0	215	5	0	0	1	6	1	40	63	1	105	9	0	8	0	17	343
Apprch %	81.4	11.2	7.4	0		83.3	0	0	16.7		1	38.1	60	1		52.9	0	47.1	0		
Total %	51	7	4.7	0	62.7	1.5	0	0	0.3	1.7	0.3	11.7	18.4	0.3	30.6	2.6	0	2.3	0	5	

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File Name : Richardson Flat Road and Jordanelle Parkway 1600-1800
Site Code : 00000000
Start Date : 1/15/2020
Page No : 1

Groups Printed- TMC

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Start Time	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Int. Total
04:00 PM	1	8	0	0	9	0	0	0	0	0	0	2	2	0	4	10	0	2	0	12	25
04:15 PM	1	11	2	0	14	1	0	0	0	1	0	4	7	0	11	7	0	2	0	9	35
04:30 PM	3	12	0	0	15	1	0	0	0	1	0	3	0	0	3	3	0	2	0	5	24
04:45 PM	1	10	0	0	11	4	0	0	0	4	0	6	2	0	8	4	0	4	0	8	31
Total	6	41	2	0	49	6	0	0	0	6	0	15	11	0	26	24	0	10	0	34	115
05:00 PM	2	10	0	0	12	1	0	0	0	1	0	3	1	2	6	6	0	5	0	11	30
05:15 PM	2	12	0	0	14	1	0	0	0	1	0	3	4	0	7	13	0	4	0	17	39
05:30 PM	1	11	0	0	12	0	0	0	0	0	0	7	2	0	9	6	0	5	0	11	32
05:45 PM	1	11	0	0	12	0	0	0	0	0	0	4	5	0	9	7	0	1	0	8	29
Total	6	44	0	0	50	2	0	0	0	2	0	17	12	2	31	32	0	15	0	47	130
Grand Total	12	85	2	0	99	8	0	0	0	8	0	32	23	2	57	56	0	25	0	81	245
Apprch %	12.1	85.9	2	0		100	0	0	0		0	56.1	40.4	3.5		69.1	0	30.9	0		
Total %	4.9	34.7	0.8	0	40.4	3.3	0	0	0	3.3	0	13.1	9.4	0.8	23.3	22.9	0	10.2	0	33.1	

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Site Code : 00000000
Start Date : 1/15/2020
Page No : 1

Groups Printed- TMC

	Brown's Canyon Road From North					SR-248 From East					Jordanelle Parkway From South					SR-248 From West					
Start Time	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Int. Total
07:00 AM	35	4	1	0	40	0	112	2	0	114	0	0	7	0	7	6	37	13	0	56	217
07:15 AM	36	5	1	0	42	2	116	9	0	127	0	1	4	0	5	6	54	22	0	82	256
07:30 AM	36	6	1	0	43	2	196	12	0	210	0	0	9	0	9	2	50	21	0	73	335
07:45 AM	52	14	1	0	67	1	163	16	0	180	2	0	9	0	11	10	56	28	0	94	352
Total	159	29	4	0	192	5	587	39	0	631	2	1	29	0	32	24	197	84	0	305	1160
08:00 AM	43	8	1	0	52	0	157	14	0	171	1	1	5	0	7	12	62	30	0	104	334
08:15 AM	46	10	3	0	59	2	139	10	0	151	0	0	8	0	8	9	65	30	0	104	322
08:30 AM	47	5	1	0	53	0	132	17	0	149	1	1	8	0	10	23	60	11	0	94	306
08:45 AM	50	7	3	0	60	3	110	8	0	121	1	0	13	0	14	30	64	29	0	123	318
Total	186	30	8	0	224	5	538	49	0	592	3	2	34	0	39	74	251	100	0	425	1280
Grand Total	345	59	12	0	416	10	1125	88	0	1223	5	3	63	0	71	98	448	184	0	730	2440
Apprch %	82.9	14.2	2.9	0		0.8	92	7.2	0		7	4.2	88.7	0		13.4	61.4	25.2	0		
Total %	14.1	2.4	0.5	0	17	0.4	46.1	3.6	0	50.1	0.2	0.1	2.6	0	2.9	4	18.4	7.5	0	29.9	

Elite Traffic Data Collection, LLC

379 East 2700 North
Lehi, Utah, 84043
elitetrafficdata@hotmail.com

Item 1.

Default Comments
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File Name : SR-248 and Brown's Canyon Road 1600-1800
Site Code : 00000000
Start Date : 1/15/2020
Page No : 1

Groups Printed- TMC

	Brown's Canyon Road From North					SR-248 From East					Jordanelle Parkway From South					SR-248 From West					
Start Time	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Int. Total
04:00 PM	24	1	0	0	25	1	86	1	0	88	2	1	6	0	9	13	95	38	0	146	268
04:15 PM	50	0	1	0	51	0	103	4	0	107	5	2	9	0	16	14	106	32	0	152	326
04:30 PM	23	0	0	0	23	0	111	2	0	113	2	1	5	0	8	9	132	43	0	184	328
04:45 PM	43	0	0	0	43	3	70	2	0	75	2	1	13	0	16	13	120	41	0	174	308
Total	140	1	1	0	142	4	370	9	0	383	11	5	33	0	49	49	453	154	0	656	1230
05:00 PM	30	0	4	0	34	6	100	1	0	107	1	2	9	0	12	12	133	43	0	188	341
05:15 PM	33	1	1	0	35	3	64	0	0	67	4	1	8	0	13	13	144	46	0	203	318
05:30 PM	34	1	1	0	36	2	81	0	0	83	3	1	13	0	17	12	143	48	0	203	339
05:45 PM	31	1	3	0	35	1	76	1	0	78	2	0	8	0	10	12	145	44	0	201	324
Total	128	3	9	0	140	12	321	2	0	335	10	4	38	0	52	49	565	181	0	795	1322
Grand Total	268	4	10	0	282	16	691	11	0	718	21	9	71	0	101	98	1018	335	0	1451	2552
Apprch %	95	1.4	3.5	0		2.2	96.2	1.5	0		20.8	8.9	70.3	0		6.8	70.2	23.1	0		
Total %	10.5	0.2	0.4	0	11.1	0.6	27.1	0.4	0	28.1	0.8	0.4	2.8	0	4	3.8	39.9	13.1	0	56.9	

Appendix B
Detailed Level of Service Reports

Intersection	
Int Delay, s/veh	5.2

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Vol, veh/h	0	0	0	137	0	41	0	439	23	13	803	0
Future Vol, veh/h	0	0	0	137	0	41	0	439	23	13	803	0
Conflicting Peds, #/hr	0	0	0	0	0	0	0	0	0	0	0	0
Sign Control	Stop	Stop	Stop	Stop	Stop	Stop	Free	Free	Free	Free	Free	Free
RT Channelized	-	-	None	-	-	None	-	-	None	-	-	None
Storage Length	-	-	-	0	-	100	100	-	100	100	-	100
Veh in Median Storage, #	-	0	-	-	0	-	-	0	-	-	0	-
Grade, %	-	0	-	-	0	-	-	0	-	-	0	-
Peak Hour Factor	92	92	92	92	92	92	92	92	92	92	92	92
Heavy Vehicles, %	2	2	2	2	2	2	2	2	2	2	2	2
Mvmt Flow	0	0	0	149	0	45	0	477	25	14	873	0

Major/Minor	Minor2			Minor1			Major1			Major2		
Conflicting Flow All	1140	1403	437	942	-	239	873	0	0	502	0	0
Stage 1	901	901	-	477	-	-	-	-	-	-	-	-
Stage 2	239	502	-	465	-	-	-	-	-	-	-	-
Critical Hdwy	7.54	6.54	6.94	7.54	-	6.94	4.14	-	-	4.14	-	-
Critical Hdwy Stg 1	6.54	5.54	-	6.54	-	-	-	-	-	-	-	-
Critical Hdwy Stg 2	6.54	5.54	-	6.54	-	-	-	-	-	-	-	-
Follow-up Hdwy	3.52	4.02	3.32	3.52	-	3.32	2.22	-	-	2.22	-	-
Pot Cap-1 Maneuver	156	139	567	218	0	762	768	-	-	1059	-	-
Stage 1	299	355	-	538	0	-	-	-	-	-	-	-
Stage 2	743	540	-	547	0	-	-	-	-	-	-	-
Platoon blocked, %								-	-		-	-
Mov Cap-1 Maneuver	145	137	567	216	-	762	768	-	-	1059	-	-
Mov Cap-2 Maneuver	145	137	-	216	-	-	-	-	-	-	-	-
Stage 1	299	350	-	538	-	-	-	-	-	-	-	-
Stage 2	700	540	-	540	-	-	-	-	-	-	-	-

Approach	EB	WB	NB	SB
HCM Control Delay, s	0	42.4	0	0.1
HCM LOS	A	E		

Minor Lane/Major Mvmt	NBL	NBT	NBR	EBLn1	WBLn1	WBLn2	SBL	SBT	SBR
Capacity (veh/h)	768	-	-	-	216	762	1059	-	-
HCM Lane V/C Ratio	-	-	-	-	0.689	0.058	0.013	-	-
HCM Control Delay (s)	0	-	-	0	52.1	10	8.4	-	-
HCM Lane LOS	A	-	-	A	F	B	A	-	-
HCM 95th %tile Q(veh)	0	-	-	-	4.4	0.2	0	-	-

Intersection	
Int Delay, s/veh	2.3

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Vol, veh/h	1	0	6	0	0	2	38	19	0	6	12	91
Future Vol, veh/h	1	0	6	0	0	2	38	19	0	6	12	91
Conflicting Peds, #/hr	0	0	0	1	0	1	0	0	1	1	0	0
Sign Control	Stop	Stop	Stop	Stop	Stop	Stop	Free	Free	Free	Free	Free	Free
RT Channelized	-	-	None	-	-	None	-	-	None	-	-	None
Storage Length	-	-	-	-	-	-	-	-	-	-	-	-
Veh in Median Storage, #	-	0	-	-	0	-	-	0	-	-	0	-
Grade, %	-	0	-	-	0	-	-	0	-	-	0	-
Peak Hour Factor	80	80	80	80	80	80	80	80	80	80	80	80
Heavy Vehicles, %	2	2	2	2	2	2	2	2	2	2	2	2
Mvmt Flow	1	0	8	0	0	3	48	24	0	8	15	114

Major/Minor	Minor2			Minor1			Major1			Major2		
Conflicting Flow All	211	209	73	214	266	26	129	0	0	25	0	0
Stage 1	88	88	-	121	121	-	-	-	-	-	-	-
Stage 2	123	121	-	93	145	-	-	-	-	-	-	-
Critical Hdwy	7.12	6.52	6.22	7.12	6.52	6.22	4.12	-	-	4.12	-	-
Critical Hdwy Stg 1	6.12	5.52	-	6.12	5.52	-	-	-	-	-	-	-
Critical Hdwy Stg 2	6.12	5.52	-	6.12	5.52	-	-	-	-	-	-	-
Follow-up Hdwy	3.518	4.018	3.318	3.518	4.018	3.318	2.218	-	-	2.218	-	-
Pot Cap-1 Maneuver	746	688	989	743	640	1050	1457	-	-	1589	-	-
Stage 1	920	822	-	883	796	-	-	-	-	-	-	-
Stage 2	881	796	-	914	777	-	-	-	-	-	-	-
Platoon blocked, %								-	-		-	-
Mov Cap-1 Maneuver	721	660	988	714	614	1048	1457	-	-	1587	-	-
Mov Cap-2 Maneuver	721	660	-	714	614	-	-	-	-	-	-	-
Stage 1	890	817	-	853	769	-	-	-	-	-	-	-
Stage 2	849	769	-	901	772	-	-	-	-	-	-	-

Approach	EB	WB	NB	SB
HCM Control Delay, s	8.9	8.4	5	0.4
HCM LOS	A	A		

Minor Lane/Major Mvmt	NBL	NBT	NBR	EBLn1	WBLn1	SBL	SBT	SBR
Capacity (veh/h)	1457	-	-	938	1048	1587	-	-
HCM Lane V/C Ratio	0.033	-	-	0.009	0.002	0.005	-	-
HCM Control Delay (s)	7.6	0	-	8.9	8.4	7.3	0	-
HCM Lane LOS	A	A	-	A	A	A	A	-
HCM 95th %tile Q(veh)	0.1	-	-	0	0	0	-	-

Intersection	
Int Delay, s/veh	5.5

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Vol, veh/h	31	1	3	6	38	177	52	655	5	109	233	33
Future Vol, veh/h	31	1	3	6	38	177	52	655	5	109	233	33
Conflicting Peds, #/hr	0	0	0	0	0	0	0	0	0	0	0	0
Sign Control	Stop	Stop	Stop	Stop	Stop	Stop	Free	Free	Free	Free	Free	Free
RT Channelized	-	-	None	-	-	None	-	-	None	-	-	None
Storage Length	90	-	90	90	-	-	140	-	245	145	-	460
Veh in Median Storage, #	-	0	-	-	0	-	-	0	-	-	0	-
Grade, %	-	0	-	-	0	-	-	0	-	-	0	-
Peak Hour Factor	95	95	95	95	95	95	95	95	95	95	95	95
Heavy Vehicles, %	2	2	2	2	2	2	2	2	2	2	2	2
Mvmt Flow	33	1	3	6	40	186	55	689	5	115	245	35

Major/Minor	Minor2			Minor1			Major1			Major2		
Conflicting Flow All	950	1279	123	1152	1309	345	280	0	0	694	0	0
Stage 1	475	475	-	799	799	-	-	-	-	-	-	-
Stage 2	475	804	-	353	510	-	-	-	-	-	-	-
Critical Hdwy	7.54	6.54	6.94	7.54	6.54	6.94	4.14	-	-	4.14	-	-
Critical Hdwy Stg 1	6.54	5.54	-	6.54	5.54	-	-	-	-	-	-	-
Critical Hdwy Stg 2	6.54	5.54	-	6.54	5.54	-	-	-	-	-	-	-
Follow-up Hdwy	3.52	4.02	3.32	3.52	4.02	3.32	2.22	-	-	2.22	-	-
Pot Cap-1 Maneuver	215	165	905	153	158	651	1280	-	-	897	-	-
Stage 1	539	556	-	345	396	-	-	-	-	-	-	-
Stage 2	539	394	-	637	536	-	-	-	-	-	-	-
Platoon blocked, %								-	-		-	-
Mov Cap-1 Maneuver	103	138	905	132	132	651	1280	-	-	897	-	-
Mov Cap-2 Maneuver	103	138	-	132	132	-	-	-	-	-	-	-
Stage 1	516	485	-	330	379	-	-	-	-	-	-	-
Stage 2	329	377	-	552	467	-	-	-	-	-	-	-

Approach	EB	WB	NB	SB
HCM Control Delay, s	50.7	18.6	0.6	2.8
HCM LOS	F	C		

Minor Lane/Major Mvmt	NBL	NBT	NBR	EBLn1	EBLn2	EBLn3	WBLn1	WBLn2	WBLn3	SBL	SBT	SBR
Capacity (veh/h)	1280	-	-	103	138	905	132	132	651	897	-	-
HCM Lane V/C Ratio	0.043	-	-	0.317	0.008	0.003	0.048	0.303	0.286	0.128	-	-
HCM Control Delay (s)	7.9	-	-	55.4	31.3	9	33.6	43.7	12.7	9.6	-	-
HCM Lane LOS	A	-	-	F	D	A	D	E	B	A	-	-
HCM 95th %tile Q(veh)	0.1	-	-	1.2	0	0	0.1	1.2	1.2	0.4	-	-

Intersection	
Int Delay, s/veh	2.2

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Vol, veh/h	0	0	0	23	0	50	0	1364	68	31	650	0
Future Vol, veh/h	0	0	0	23	0	50	0	1364	68	31	650	0
Conflicting Peds, #/hr	0	0	0	0	0	0	0	0	0	0	0	0
Sign Control	Stop	Stop	Stop	Stop	Stop	Stop	Free	Free	Free	Free	Free	Free
RT Channelized	-	-	None	-	-	None	-	-	None	-	-	None
Storage Length	-	-	-	0	-	100	100	-	100	100	-	100
Veh in Median Storage, #	-	0	-	-	0	-	-	0	-	-	0	-
Grade, %	-	0	-	-	0	-	-	0	-	-	0	-
Peak Hour Factor	96	96	96	96	96	96	96	96	96	96	96	96
Heavy Vehicles, %	2	2	2	2	2	2	2	2	2	2	2	2
Mvmt Flow	0	0	0	24	0	52	0	1421	71	32	677	0

Major/Minor	Minor2			Minor1			Major1			Major2		
Conflicting Flow All	1452	2233	339	1824	-	711	677	0	0	1492	0	0
Stage 1	741	741	-	1421	-	-	-	-	-	-	-	-
Stage 2	711	1492	-	403	-	-	-	-	-	-	-	-
Critical Hdwy	7.54	6.54	6.94	7.54	-	6.94	4.14	-	-	4.14	-	-
Critical Hdwy Stg 1	6.54	5.54	-	6.54	-	-	-	-	-	-	-	-
Critical Hdwy Stg 2	6.54	5.54	-	6.54	-	-	-	-	-	-	-	-
Follow-up Hdwy	3.52	4.02	3.32	3.52	-	3.32	2.22	-	-	2.22	-	-
Pot Cap-1 Maneuver	92	42	657	48	0	375	911	-	-	446	-	-
Stage 1	374	421	-	143	0	-	-	-	-	-	-	-
Stage 2	390	185	-	595	0	-	-	-	-	-	-	-
Platoon blocked, %								-	-		-	-
Mov Cap-1 Maneuver	75	39	657	45	-	375	911	-	-	446	-	-
Mov Cap-2 Maneuver	75	39	-	45	-	-	-	-	-	-	-	-
Stage 1	374	391	-	143	-	-	-	-	-	-	-	-
Stage 2	336	185	-	552	-	-	-	-	-	-	-	-

Approach	EB	WB	NB	SB
HCM Control Delay, s	0	59.5	0	0.6
HCM LOS	A	F		

Minor Lane/Major Mvmt	NBL	NBT	NBR	EBLn1	WBLn1	WBLn2	SBL	SBT	SBR
Capacity (veh/h)	911	-	-	-	45	375	446	-	-
HCM Lane V/C Ratio	-	-	-	-	0.532	0.139	0.072	-	-
HCM Control Delay (s)	0	-	-	0	153.7	16.1	13.7	-	-
HCM Lane LOS	A	-	-	A	F	C	B	-	-
HCM 95th %tile Q(veh)	0	-	-	-	2	0.5	0.2	-	-

Intersection	
Int Delay, s/veh	4.2

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Vol, veh/h	18	0	29	0	0	6	9	19	0	0	43	6
Future Vol, veh/h	18	0	29	0	0	6	9	19	0	0	43	6
Conflicting Peds, #/hr	0	0	0	2	0	0	0	0	2	0	0	0
Sign Control	Stop	Stop	Stop	Stop	Stop	Stop	Free	Free	Free	Free	Free	Free
RT Channelized	-	-	None	-	-	None	-	-	None	-	-	None
Storage Length	-	-	-	-	-	-	-	-	-	-	-	-
Veh in Median Storage, #	-	0	-	-	0	-	-	0	-	-	0	-
Grade, %	-	0	-	-	0	-	-	0	-	-	0	-
Peak Hour Factor	83	83	83	83	83	83	83	83	83	83	83	83
Heavy Vehicles, %	2	2	2	2	2	2	2	2	2	2	2	2
Mvmt Flow	22	0	35	0	0	7	11	23	0	0	52	7

Major/Minor	Minor2			Minor1			Major1			Major2		
Conflicting Flow All	105	103	58	122	106	25	59	0	0	25	0	0
Stage 1	56	56	-	47	47	-	-	-	-	-	-	-
Stage 2	49	47	-	75	59	-	-	-	-	-	-	-
Critical Hdwy	7.12	6.52	6.22	7.12	6.52	6.22	4.12	-	-	4.12	-	-
Critical Hdwy Stg 1	6.12	5.52	-	6.12	5.52	-	-	-	-	-	-	-
Critical Hdwy Stg 2	6.12	5.52	-	6.12	5.52	-	-	-	-	-	-	-
Follow-up Hdwy	3.518	4.018	3.318	3.518	4.018	3.318	2.218	-	-	2.218	-	-
Pot Cap-1 Maneuver	875	787	1008	853	784	1051	1545	-	-	1589	-	-
Stage 1	956	848	-	967	856	-	-	-	-	-	-	-
Stage 2	964	856	-	934	846	-	-	-	-	-	-	-
Platoon blocked, %								-	-		-	-
Mov Cap-1 Maneuver	865	780	1006	815	777	1049	1545	-	-	1586	-	-
Mov Cap-2 Maneuver	865	780	-	815	777	-	-	-	-	-	-	-
Stage 1	949	848	-	958	848	-	-	-	-	-	-	-
Stage 2	951	848	-	900	846	-	-	-	-	-	-	-

Approach	EB	WB	NB	SB
HCM Control Delay, s	9	8.5	2.4	0
HCM LOS	A	A		

Minor Lane/Major Mvmt	NBL	NBT	NBR	EBLn1	WBLn1	SBL	SBT	SBR
Capacity (veh/h)	1545	-	-	947	1049	1586	-	-
HCM Lane V/C Ratio	0.007	-	-	0.06	0.007	-	-	-
HCM Control Delay (s)	7.3	0	-	9	8.5	0	-	-
HCM Lane LOS	A	A	-	A	A	A	-	-
HCM 95th %tile Q(veh)	0	-	-	0.2	0	0	-	-

Intersection	
Int Delay, s/veh	4.4

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Vol, veh/h	43	5	10	6	2	140	3	315	14	178	540	50
Future Vol, veh/h	43	5	10	6	2	140	3	315	14	178	540	50
Conflicting Peds, #/hr	0	0	0	0	0	0	0	0	0	0	0	0
Sign Control	Stop	Stop	Stop	Stop	Stop	Stop	Free	Free	Free	Free	Free	Free
RT Channelized	-	-	None	-	-	None	-	-	None	-	-	None
Storage Length	90	-	90	90	-	-	140	-	245	145	-	460
Veh in Median Storage, #	-	0	-	-	0	-	-	0	-	-	0	-
Grade, %	-	0	-	-	0	-	-	0	-	-	0	-
Peak Hour Factor	96	96	96	96	96	96	96	96	96	96	96	96
Heavy Vehicles, %	2	2	2	2	2	2	2	2	2	2	2	2
Mvmt Flow	45	5	10	6	2	146	3	328	15	185	563	52

Major/Minor	Minor2			Minor1			Major1			Major2		
Conflicting Flow All	1104	1282	282	988	1319	164	615	0	0	343	0	0
Stage 1	933	933	-	334	334	-	-	-	-	-	-	-
Stage 2	171	349	-	654	985	-	-	-	-	-	-	-
Critical Hdwy	7.54	6.54	6.94	7.54	6.54	6.94	4.14	-	-	4.14	-	-
Critical Hdwy Stg 1	6.54	5.54	-	6.54	5.54	-	-	-	-	-	-	-
Critical Hdwy Stg 2	6.54	5.54	-	6.54	5.54	-	-	-	-	-	-	-
Follow-up Hdwy	3.52	4.02	3.32	3.52	4.02	3.32	2.22	-	-	2.22	-	-
Pot Cap-1 Maneuver	166	164	715	201	156	852	961	-	-	1213	-	-
Stage 1	286	343	-	653	642	-	-	-	-	-	-	-
Stage 2	814	632	-	422	324	-	-	-	-	-	-	-
Platoon blocked, %								-	-		-	-
Mov Cap-1 Maneuver	120	138	715	170	132	852	961	-	-	1213	-	-
Mov Cap-2 Maneuver	120	138	-	170	132	-	-	-	-	-	-	-
Stage 1	285	291	-	651	640	-	-	-	-	-	-	-
Stage 2	670	630	-	346	274	-	-	-	-	-	-	-

Approach	EB	WB	NB	SB
HCM Control Delay, s	43	11.1	0.1	2
HCM LOS	E	B		

Minor Lane/Major Mvmt	NBL	NBT	NBR	EBLn1	EBLn2	EBLn3	WBLn1	WBLn2	WBLn3	SBL	SBT	SBR
Capacity (veh/h)	961	-	-	120	138	715	170	132	852	1213	-	-
HCM Lane V/C Ratio	0.003	-	-	0.373	0.038	0.015	0.037	0.016	0.171	0.153	-	-
HCM Control Delay (s)	8.8	-	-	51.9	32.1	10.1	27	32.7	10.1	8.5	-	-
HCM Lane LOS	A	-	-	F	D	B	D	D	B	A	-	-
HCM 95th %tile Q(veh)	0	-	-	1.5	0.1	0	0.1	0	0.6	0.5	-	-

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	0	0	0	150	0	43	0	465	25	14	850	0
Future Volume (veh/h)	0	0	0	150	0	43	0	465	25	14	850	0
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Work Zone On Approach		No			No			No			No	
Adj Sat Flow, veh/h/ln	1870	1870	1870	1870	0	1870	1870	1870	1870	1870	1870	1870
Adj Flow Rate, veh/h	0	0	0	163	0	47	0	505	27	15	924	0
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Percent Heavy Veh, %	2	2	2	2	0	2	2	2	2	2	2	2
Cap, veh/h	0	6	0	537	0	0	435	1326	591	547	2028	905
Arrive On Green	0.00	0.00	0.00	0.17	0.00	0.05	0.00	0.37	0.37	0.07	0.57	0.00
Sat Flow, veh/h	0	-74814	0	1781	163		1781	3554	1585	1781	3554	1585
Grp Volume(v), veh/h	0	0	0	163	11.9		0	505	27	15	924	0
Grp Sat Flow(s),veh/h/ln	0	1870	0	1781	B		1781	1777	1585	1781	1777	1585
Q Serve(g_s), s	0.0	0.0	0.0	2.6			0.0	3.2	0.3	0.1	4.7	0.0
Cycle Q Clear(g_c), s	0.0	0.0	0.0	2.6			0.0	3.2	0.3	0.1	4.7	0.0
Prop In Lane	0.00		0.00	1.00			1.00		1.00	1.00		1.00
Lane Grp Cap(c), veh/h	0	6	0	537			435	1326	591	547	2028	905
V/C Ratio(X)	0.00	0.00	0.00	0.30			0.00	0.38	0.05	0.03	0.46	0.00
Avail Cap(c_a), veh/h	0	1180	0	2020			804	7533	3360	887	7705	3437
HCM Platoon Ratio	1.00	1.00	1.00	1.00			1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	0.00	0.00	0.00	1.00			0.00	1.00	1.00	1.00	1.00	0.00
Uniform Delay (d), s/veh	0.0	0.0	0.0	11.6			0.0	7.1	6.2	5.0	3.8	0.0
Incr Delay (d2), s/veh	0.0	0.0	0.0	0.3			0.0	0.2	0.0	0.0	0.2	0.0
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0			0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	0.0	0.0	0.0	0.8			0.0	0.5	0.1	0.0	0.0	0.0
Unsig. Movement Delay, s/veh												
LnGrp Delay(d),s/veh	0.0	0.0	0.0	11.9			0.0	7.3	6.2	5.1	4.0	0.0
LnGrp LOS	A	A	A	B			A	A	A	A	A	A
Approach Vol, veh/h		0						532			939	
Approach Delay, s/veh		0.0						7.2			4.0	
Approach LOS								A			A	

Timer - Assigned Phs	1	2	3	4	5	6
Phs Duration (G+Y+Rc), s	6.1	15.5	9.3	0.0	0.0	21.6
Change Period (Y+Rc), s	5.5	7.0	5.5	5.5	5.5	7.0
Max Green Setting (Gmax), s	6.5	62.5	29.5	18.0	5.0	64.0
Max Q Clear Time (g_c+I1), s	2.1	5.2	4.6	0.0	0.0	6.7
Green Ext Time (p_c), s	0.0	3.3	0.4	0.0	0.0	6.9

Intersection Summary	
HCM 6th Ctrl Delay	5.8
HCM 6th LOS	A

Intersection	
Int Delay, s/veh	1.9

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Vol, veh/h	1	0	6	0	0	0	40	24	0	0	15	104
Future Vol, veh/h	1	0	6	0	0	0	40	24	0	0	15	104
Conflicting Peds, #/hr	0	0	0	1	0	1	0	0	1	1	0	0
Sign Control	Stop	Stop	Stop	Stop	Stop	Stop	Free	Free	Free	Free	Free	Free
RT Channelized	-	-	None	-	-	None	-	-	None	-	-	None
Storage Length	-	-	-	-	-	-	-	-	-	-	-	-
Veh in Median Storage, #	-	0	-	-	0	-	-	0	-	-	0	-
Grade, %	-	0	-	-	0	-	-	0	-	-	0	-
Peak Hour Factor	80	80	80	80	80	80	80	80	80	80	80	80
Heavy Vehicles, %	2	2	2	2	2	2	2	2	2	2	2	2
Mvmt Flow	1	0	8	0	0	0	50	30	0	0	19	130

Major/Minor	Minor2			Minor1			Major1			Major2		
Conflicting Flow All	215	215	85	220	280	32	149	0	0	31	0	0
Stage 1	84	84	-	131	131	-	-	-	-	-	-	-
Stage 2	131	131	-	89	149	-	-	-	-	-	-	-
Critical Hdwy	7.12	6.52	6.22	7.12	6.52	6.22	4.12	-	-	4.12	-	-
Critical Hdwy Stg 1	6.12	5.52	-	6.12	5.52	-	-	-	-	-	-	-
Critical Hdwy Stg 2	6.12	5.52	-	6.12	5.52	-	-	-	-	-	-	-
Follow-up Hdwy	3.518	4.018	3.318	3.518	4.018	3.318	2.218	-	-	2.218	-	-
Pot Cap-1 Maneuver	742	683	974	736	628	1042	1432	-	-	1582	-	-
Stage 1	924	825	-	873	788	-	-	-	-	-	-	-
Stage 2	873	788	-	918	774	-	-	-	-	-	-	-
Platoon blocked, %								-	-		-	-
Mov Cap-1 Maneuver	721	658	973	709	605	1040	1432	-	-	1580	-	-
Mov Cap-2 Maneuver	721	658	-	709	605	-	-	-	-	-	-	-
Stage 1	891	825	-	841	759	-	-	-	-	-	-	-
Stage 2	841	759	-	910	774	-	-	-	-	-	-	-

Approach	EB	WB	NB	SB
HCM Control Delay, s	8.9	0	4.8	0
HCM LOS	A	A		

Minor Lane/Major Mvmt	NBL	NBT	NBR	EBLn1	WBLn1	SBL	SBT	SBR
Capacity (veh/h)	1432	-	-	927	-	1580	-	-
HCM Lane V/C Ratio	0.035	-	-	0.009	-	-	-	-
HCM Control Delay (s)	7.6	0	-	8.9	0	0	-	-
HCM Lane LOS	A	A	-	A	A	A	-	-
HCM 95th %tile Q(veh)	0.1	-	-	0	-	0	-	-

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	34	1	4	8	43	196	60	737	6	122	264	34
Future Volume (veh/h)	34	1	4	8	43	196	60	737	6	122	264	34
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Work Zone On Approach		No			No			No			No	
Adj Sat Flow, veh/h/ln	1870	1870	1870	1870	1870	1870	1870	1870	1870	1870	1870	1870
Adj Flow Rate, veh/h	36	1	4	8	45	206	63	776	6	128	278	36
Peak Hour Factor	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Percent Heavy Veh, %	2	2	2	2	2	2	2	2	2	2	2	2
Cap, veh/h	438	415	352	466	364	308	592	1275	569	414	1349	601
Arrive On Green	0.06	0.22	0.22	0.04	0.19	0.19	0.08	0.36	0.36	0.10	0.38	0.38
Sat Flow, veh/h	1781	1870	1585	1781	1870	1585	1781	3554	1585	1781	3554	1585
Grp Volume(v), veh/h	36	1	4	8	45	206	63	776	6	128	278	36
Grp Sat Flow(s),veh/h/ln	1781	1870	1585	1781	1870	1585	1781	1777	1585	1781	1777	1585
Q Serve(g_s), s	0.9	0.0	0.1	0.2	1.1	6.9	1.2	10.2	0.1	2.5	3.0	0.8
Cycle Q Clear(g_c), s	0.9	0.0	0.1	0.2	1.1	6.9	1.2	10.2	0.1	2.5	3.0	0.8
Prop In Lane	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Lane Grp Cap(c), veh/h	438	415	352	466	364	308	592	1275	569	414	1349	601
V/C Ratio(X)	0.08	0.00	0.01	0.02	0.12	0.67	0.11	0.61	0.01	0.31	0.21	0.06
Avail Cap(c_a), veh/h	604	1048	888	681	1048	888	727	4044	1804	793	4604	2054
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Uniform Delay (d), s/veh	16.0	17.3	17.3	17.0	19.0	21.3	10.2	15.0	11.8	11.0	11.9	11.3
Incr Delay (d2), s/veh	0.1	0.0	0.0	0.0	0.2	2.5	0.1	0.5	0.0	0.4	0.1	0.0
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	0.3	0.0	0.0	0.1	0.5	2.6	0.4	3.1	0.0	0.7	0.9	0.3
Unsig. Movement Delay, s/veh												
LnGrp Delay(d),s/veh	16.1	17.3	17.3	17.0	19.1	23.8	10.3	15.5	11.8	11.4	12.0	11.3
LnGrp LOS	B	B	B	B	B	C	B	B	B	B	B	B
Approach Vol, veh/h		41			259			845			442	
Approach Delay, s/veh		16.3			22.8			15.1			11.8	
Approach LOS		B			C			B			B	

Timer - Assigned Phs	1	2	3	4	5	6	7	8
Phs Duration (G+Y+Rc), s	9.8	24.5	6.1	16.7	8.7	25.7	7.7	15.1
Change Period (Y+Rc), s	5.5	7.0	5.5	5.5	5.5	7.0	5.5	5.5
Max Green Setting (Gmax), s	16.5	62.0	7.5	30.5	7.5	71.0	7.5	30.5
Max Q Clear Time (g_c+I1), s	4.5	12.2	2.2	2.1	3.2	5.0	2.9	8.9
Green Ext Time (p_c), s	0.2	5.3	0.0	0.0	0.0	1.7	0.0	0.9

Intersection Summary	
HCM 6th Ctrl Delay	15.4
HCM 6th LOS	B

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	0	0	0	27	0	52	0	1443	76	31	690	0
Future Volume (veh/h)	0	0	0	27	0	52	0	1443	76	31	690	0
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Work Zone On Approach		No			No			No			No	
Adj Sat Flow, veh/h/ln	1870	1870	1870	1870	0	1870	1870	1870	1870	1870	1870	1870
Adj Flow Rate, veh/h	0	0	0	28	0	54	0	1503	79	32	719	0
Peak Hour Factor	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96
Percent Heavy Veh, %	2	2	2	2	0	2	2	2	2	2	2	2
Cap, veh/h	0	4	0	243	0	0	595	2311	1031	367	2805	1251
Arrive On Green	0.00	0.00	0.00	0.06	0.00	0.03	0.00	0.65	0.65	0.06	0.79	0.00
Sat Flow, veh/h	0	-74814	0	1781	28		1781	3554	1585	1781	3554	1585
Grp Volume(v), veh/h	0	0	0	28	24.0		0	1503	79	32	719	0
Grp Sat Flow(s),veh/h/ln	0	1870	0	1781	C		1781	1777	1585	1781	1777	1585
Q Serve(g_s), s	0.0	0.0	0.0	0.8			0.0	13.6	1.0	0.3	2.8	0.0
Cycle Q Clear(g_c), s	0.0	0.0	0.0	0.8			0.0	13.6	1.0	0.3	2.8	0.0
Prop In Lane	0.00		0.00	1.00			1.00		1.00	1.00		1.00
Lane Grp Cap(c), veh/h	0	4	0	243			595	2311	1031	367	2805	1251
V/C Ratio(X)	0.00	0.00	0.00	0.12			0.00	0.65	0.08	0.09	0.26	0.00
Avail Cap(c_a), veh/h	0	686	0	789			810	5217	2327	489	5250	2342
HCM Platoon Ratio	1.00	1.00	1.00	1.00			1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	0.00	0.00	0.00	1.00			0.00	1.00	1.00	1.00	1.00	0.00
Uniform Delay (d), s/veh	0.0	0.0	0.0	23.7			0.0	5.6	3.4	4.6	1.5	0.0
Incr Delay (d2), s/veh	0.0	0.0	0.0	0.2			0.0	0.3	0.0	0.1	0.0	0.0
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0			0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	0.0	0.0	0.0	0.3			0.0	1.9	0.2	0.0	0.0	0.0
Unsig. Movement Delay, s/veh												
LnGrp Delay(d),s/veh	0.0	0.0	0.0	24.0			0.0	5.9	3.4	4.7	1.5	0.0
LnGrp LOS	A	A	A	C			A	A	A	A	A	A
Approach Vol, veh/h		0						1582			751	
Approach Delay, s/veh		0.0						5.8			1.7	
Approach LOS								A			A	

Timer - Assigned Phs	1	2	3	4	5	6
Phs Duration (G+Y+Rc), s	7.4	38.6	7.2	0.0	0.0	45.9
Change Period (Y+Rc), s	5.5	7.0	5.5	5.5	5.5	7.0
Max Green Setting (Gmax), s	5.5	75.0	18.0	18.0	5.0	75.5
Max Q Clear Time (g_c+I1), s	2.3	15.6	2.8	0.0	0.0	4.8
Green Ext Time (p_c), s	0.0	15.9	0.0	0.0	0.0	5.0

Intersection Summary	
HCM 6th Ctrl Delay	4.7
HCM 6th LOS	A

Intersection	
Int Delay, s/veh	3.9

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Vol, veh/h	23	0	31	0	0	0	9	24	0	0	49	7
Future Vol, veh/h	23	0	31	0	0	0	9	24	0	0	49	7
Conflicting Peds, #/hr	0	0	0	2	0	0	0	0	2	0	0	0
Sign Control	Stop	Stop	Stop	Stop	Stop	Stop	Free	Free	Free	Free	Free	Free
RT Channelized	-	-	None	-	-	None	-	-	None	-	-	None
Storage Length	-	-	-	-	-	-	-	-	-	-	-	-
Veh in Median Storage, #	-	0	-	-	0	-	-	0	-	-	0	-
Grade, %	-	0	-	-	0	-	-	0	-	-	0	-
Peak Hour Factor	83	83	83	83	83	83	83	83	83	83	83	83
Heavy Vehicles, %	2	2	2	2	2	2	2	2	2	2	2	2
Mvmt Flow	28	0	37	0	0	0	11	29	0	0	59	8

Major/Minor	Minor2			Minor1			Major1			Major2		
Conflicting Flow All	114	116	65	137	120	31	67	0	0	31	0	0
Stage 1	63	63	-	53	53	-	-	-	-	-	-	-
Stage 2	51	53	-	84	67	-	-	-	-	-	-	-
Critical Hdwy	7.12	6.52	6.22	7.12	6.52	6.22	4.12	-	-	4.12	-	-
Critical Hdwy Stg 1	6.12	5.52	-	6.12	5.52	-	-	-	-	-	-	-
Critical Hdwy Stg 2	6.12	5.52	-	6.12	5.52	-	-	-	-	-	-	-
Follow-up Hdwy	3.518	4.018	3.318	3.518	4.018	3.318	2.218	-	-	2.218	-	-
Pot Cap-1 Maneuver	863	774	999	834	770	1043	1535	-	-	1582	-	-
Stage 1	948	842	-	960	851	-	-	-	-	-	-	-
Stage 2	962	851	-	924	839	-	-	-	-	-	-	-
Platoon blocked, %								-	-		-	-
Mov Cap-1 Maneuver	859	767	997	796	763	1041	1535	-	-	1579	-	-
Mov Cap-2 Maneuver	859	767	-	796	763	-	-	-	-	-	-	-
Stage 1	941	842	-	951	843	-	-	-	-	-	-	-
Stage 2	955	843	-	888	839	-	-	-	-	-	-	-

Approach	EB	WB	NB	SB
HCM Control Delay, s	9.1	0	2	0
HCM LOS	A	A		

Minor Lane/Major Mvmt	NBL	NBT	NBR	EBLn1	WBLn1	SBL	SBT	SBR
Capacity (veh/h)	1535	-	-	933	-	1579	-	-
HCM Lane V/C Ratio	0.007	-	-	0.07	-	-	-	-
HCM Control Delay (s)	7.4	0	-	9.1	0	0	-	-
HCM Lane LOS	A	A	-	A	A	A	-	-
HCM 95th %tile Q(veh)	0	-	-	0.2	-	0	-	-

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	46	6	12	8	2	156	4	354	18	197	609	55
Future Volume (veh/h)	46	6	12	8	2	156	4	354	18	197	609	55
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Work Zone On Approach		No			No			No			No	
Adj Sat Flow, veh/h/ln	1870	1870	1870	1870	1870	1870	1870	1870	1870	1870	1870	1870
Adj Flow Rate, veh/h	48	6	12	8	2	162	4	369	19	205	634	57
Peak Hour Factor	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96
Percent Heavy Veh, %	2	2	2	2	2	2	2	2	2	2	2	2
Cap, veh/h	510	390	330	470	316	268	368	869	388	556	1283	572
Arrive On Green	0.08	0.21	0.21	0.04	0.17	0.17	0.04	0.24	0.24	0.15	0.36	0.36
Sat Flow, veh/h	1781	1870	1585	1781	1870	1585	1781	3554	1585	1781	3554	1585
Grp Volume(v), veh/h	48	6	12	8	2	162	4	369	19	205	634	57
Grp Sat Flow(s),veh/h/ln	1781	1870	1585	1781	1870	1585	1781	1777	1585	1781	1777	1585
Q Serve(g_s), s	0.9	0.1	0.3	0.2	0.0	4.3	0.1	4.0	0.4	3.5	6.4	1.1
Cycle Q Clear(g_c), s	0.9	0.1	0.3	0.2	0.0	4.3	0.1	4.0	0.4	3.5	6.4	1.1
Prop In Lane	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Lane Grp Cap(c), veh/h	510	390	330	470	316	268	368	869	388	556	1283	572
V/C Ratio(X)	0.09	0.02	0.04	0.02	0.01	0.60	0.01	0.42	0.05	0.37	0.49	0.10
Avail Cap(c_a), veh/h	868	1510	1280	820	1429	1211	727	3490	1557	1486	5041	2248
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Uniform Delay (d), s/veh	13.2	14.4	14.5	14.3	15.8	17.6	12.9	14.6	13.2	9.5	11.4	9.7
Incr Delay (d2), s/veh	0.1	0.0	0.0	0.0	0.0	2.2	0.0	0.3	0.1	0.4	0.3	0.1
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	0.3	0.0	0.1	0.1	0.0	1.5	0.0	1.2	0.1	0.9	1.6	0.3
Unsig. Movement Delay, s/veh												
LnGrp Delay(d),s/veh	13.3	14.4	14.5	14.3	15.8	19.8	12.9	14.9	13.3	9.9	11.7	9.8
LnGrp LOS	B	B	B	B	B	B	B	B	B	A	B	A
Approach Vol, veh/h		66			172			392			896	
Approach Delay, s/veh		13.6			19.5			14.8			11.2	
Approach LOS		B			B			B			B	

Timer - Assigned Phs	1	2	3	4	5	6	7	8
Phs Duration (G+Y+Rc), s	11.1	15.2	6.0	13.5	5.7	20.5	7.8	11.7
Change Period (Y+Rc), s	5.5	7.0	5.5	5.5	5.5	7.0	5.5	5.5
Max Green Setting (Gmax), s	29.5	42.0	9.5	35.5	9.5	62.0	11.5	33.5
Max Q Clear Time (g_c+I1), s	5.5	6.0	2.2	2.3	2.1	8.4	2.9	6.3
Green Ext Time (p_c), s	0.5	2.2	0.0	0.0	0.0	4.3	0.0	0.5

Intersection Summary	
HCM 6th Ctrl Delay	13.1
HCM 6th LOS	B

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	0	0	0	267	0	110	0	465	126	72	850	0
Future Volume (veh/h)	0	0	0	267	0	110	0	465	126	72	850	0
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Work Zone On Approach		No			No			No			No	
Adj Sat Flow, veh/h/ln	1870	1870	1870	1870	0	1870	1870	1870	1870	1870	1870	1870
Adj Flow Rate, veh/h	0	0	0	278	0	115	0	484	131	75	885	0
Peak Hour Factor	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96
Percent Heavy Veh, %	2	2	2	2	0	2	2	2	2	2	2	2
Cap, veh/h	0	5	0	447	0	0	374	1146	511	554	1940	865
Arrive On Green	0.00	0.00	0.00	0.25	0.00	0.01	0.00	0.32	0.32	0.12	0.55	0.00
Sat Flow, veh/h	0	-74814	0	1781	278		1781	3554	1585	1781	3554	1585
Grp Volume(v), veh/h	0	0	0	278	14.5		0	484	131	75	885	0
Grp Sat Flow(s),veh/h/ln	0	1870	0	1781	B		1781	1777	1585	1781	1777	1585
Q Serve(g_s), s	0.0	0.0	0.0	5.5			0.0	4.2	2.4	0.9	5.9	0.0
Cycle Q Clear(g_c), s	0.0	0.0	0.0	5.5			0.0	4.2	2.4	0.9	5.9	0.0
Prop In Lane	0.00		0.00	1.00			1.00		1.00	1.00		1.00
Lane Grp Cap(c), veh/h	0	5	0	447			374	1146	511	554	1940	865
V/C Ratio(X)	0.00	0.00	0.00	0.62			0.00	0.42	0.26	0.14	0.46	0.00
Avail Cap(c_a), veh/h	0	950	0	1809			686	4964	2214	744	5144	2294
HCM Platoon Ratio	1.00	1.00	1.00	1.00			1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	0.00	0.00	0.00	1.00			0.00	1.00	1.00	1.00	1.00	0.00
Uniform Delay (d), s/veh	0.0	0.0	0.0	13.1			0.0	10.5	9.8	6.3	5.4	0.0
Incr Delay (d2), s/veh	0.0	0.0	0.0	1.4			0.0	0.2	0.3	0.1	0.2	0.0
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0			0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	0.0	0.0	0.0	1.9			0.0	1.1	0.6	0.2	0.7	0.0
Unsig. Movement Delay, s/veh												
LnGrp Delay(d),s/veh	0.0	0.0	0.0	14.5			0.0	10.7	10.1	6.4	5.6	0.0
LnGrp LOS	A	A	A	B			A	B	B	A	A	A
Approach Vol, veh/h		0						615			960	
Approach Delay, s/veh		0.0						10.6			5.6	
Approach LOS								B			A	

Timer - Assigned Phs	1	2	3	4	5	6
Phs Duration (G+Y+Rc), s	8.8	16.7	13.9	0.0	0.0	25.5
Change Period (Y+Rc), s	6.0	7.0	6.0	6.0	6.0	7.0
Max Green Setting (Gmax), s	7.0	52.0	38.0	18.0	5.0	54.0
Max Q Clear Time (g_c+I1), s	2.9	6.2	7.5	0.0	0.0	7.9
Green Ext Time (p_c), s	0.0	3.5	0.8	0.0	0.0	6.5

Intersection Summary	
HCM 6th Ctrl Delay	8.6
HCM 6th LOS	A

Intersection												
Int Delay, s/veh	5.2											

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Vol, veh/h	134	0	23	0	0	0	54	24	0	0	15	219
Future Vol, veh/h	134	0	23	0	0	0	54	24	0	0	15	219
Conflicting Peds, #/hr	0	0	0	1	0	1	0	0	1	1	0	0
Sign Control	Stop	Stop	Stop	Stop	Stop	Stop	Free	Free	Free	Free	Free	Free
RT Channelized	-	-	None	-	-	None	-	-	None	-	-	None
Storage Length	-	-	-	-	-	-	-	-	-	-	-	-
Veh in Median Storage, #	-	0	-	-	0	-	-	0	-	-	0	-
Grade, %	-	0	-	-	0	-	-	0	-	-	0	-
Peak Hour Factor	83	83	83	83	83	83	83	83	83	83	83	83
Heavy Vehicles, %	2	2	2	2	2	2	2	2	2	2	2	2
Mvmt Flow	161	0	28	0	0	0	65	29	0	0	18	264

Major/Minor	Minor2			Minor1			Major1			Major2		
Conflicting Flow All	310	310	151	325	442	31	282	0	0	30	0	0
Stage 1	150	150	-	160	160	-	-	-	-	-	-	-
Stage 2	160	160	-	165	282	-	-	-	-	-	-	-
Critical Hdwy	7.12	6.52	6.22	7.12	6.52	6.22	4.12	-	-	4.12	-	-
Critical Hdwy Stg 1	6.12	5.52	-	6.12	5.52	-	-	-	-	-	-	-
Critical Hdwy Stg 2	6.12	5.52	-	6.12	5.52	-	-	-	-	-	-	-
Follow-up Hdwy	3.518	4.018	3.318	3.518	4.018	3.318	2.218	-	-	2.218	-	-
Pot Cap-1 Maneuver	642	605	895	628	510	1043	1280	-	-	1583	-	-
Stage 1	853	773	-	842	766	-	-	-	-	-	-	-
Stage 2	842	766	-	837	678	-	-	-	-	-	-	-
Platoon blocked, %								-	-		-	-
Mov Cap-1 Maneuver	616	573	894	583	483	1041	1280	-	-	1581	-	-
Mov Cap-2 Maneuver	616	573	-	583	483	-	-	-	-	-	-	-
Stage 1	809	773	-	797	725	-	-	-	-	-	-	-
Stage 2	797	725	-	810	678	-	-	-	-	-	-	-

Approach	EB	WB	NB	SB
HCM Control Delay, s	12.9	0	5.5	0
HCM LOS	B	A		

Minor Lane/Major Mvmt	NBL	NBT	NBR	EBLn1	WBLn1	SBL	SBT	SBR
Capacity (veh/h)	1280	-	-	645	-	1581	-	-
HCM Lane V/C Ratio	0.051	-	-	0.293	-	-	-	-
HCM Control Delay (s)	8	0	-	12.9	0	0	-	-
HCM Lane LOS	A	A	-	B	A	A	-	-
HCM 95th %tile Q(veh)	0.2	-	-	1.2	-	0	-	-

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	101	18	54	8	57	196	103	737	6	122	264	92
Future Volume (veh/h)	101	18	54	8	57	196	103	737	6	122	264	92
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Work Zone On Approach		No			No			No			No	
Adj Sat Flow, veh/h/ln	1870	1870	1870	1870	1870	1870	1870	1870	1870	1870	1870	1870
Adj Flow Rate, veh/h	105	19	56	8	59	204	107	768	6	127	275	96
Peak Hour Factor	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96
Percent Heavy Veh, %	2	2	2	2	2	2	2	2	2	2	2	2
Cap, veh/h	483	475	403	452	369	313	573	1222	545	402	1235	551
Arrive On Green	0.10	0.25	0.25	0.04	0.20	0.20	0.10	0.34	0.34	0.10	0.35	0.35
Sat Flow, veh/h	1781	1870	1585	1781	1870	1585	1781	3554	1585	1781	3554	1585
Grp Volume(v), veh/h	105	19	56	8	59	204	107	768	6	127	275	96
Grp Sat Flow(s),veh/h/ln	1781	1870	1585	1781	1870	1585	1781	1777	1585	1781	1777	1585
Q Serve(g_s), s	2.7	0.5	1.7	0.2	1.6	7.4	2.3	11.3	0.2	2.7	3.4	2.6
Cycle Q Clear(g_c), s	2.7	0.5	1.7	0.2	1.6	7.4	2.3	11.3	0.2	2.7	3.4	2.6
Prop In Lane	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Lane Grp Cap(c), veh/h	483	475	403	452	369	313	573	1222	545	402	1235	551
V/C Ratio(X)	0.22	0.04	0.14	0.02	0.16	0.65	0.19	0.63	0.01	0.32	0.22	0.17
Avail Cap(c_a), veh/h	620	1048	889	634	989	838	709	3643	1625	674	3927	1752
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Uniform Delay (d), s/veh	15.4	17.5	18.0	18.1	20.8	23.1	11.0	17.1	13.5	12.1	14.4	14.1
Incr Delay (d2), s/veh	0.2	0.0	0.2	0.0	0.2	2.3	0.2	0.5	0.0	0.4	0.1	0.1
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	1.0	0.2	0.6	0.1	0.7	2.8	0.7	3.7	0.1	0.8	1.1	0.9
Unsig. Movement Delay, s/veh												
LnGrp Delay(d),s/veh	15.6	17.6	18.2	18.1	21.0	25.4	11.1	17.7	13.5	12.6	14.5	14.3
LnGrp LOS	B	B	B	B	C	C	B	B	B	B	B	B
Approach Vol, veh/h		180			271			881			498	
Approach Delay, s/veh		16.6			24.2			16.9			14.0	
Approach LOS		B			C			B			B	

Timer - Assigned Phs	1	2	3	4	5	6	7	8
Phs Duration (G+Y+Rc), s	10.4	25.5	6.6	19.9	10.2	25.7	10.2	16.3
Change Period (Y+Rc), s	6.0	7.0	6.0	6.0	6.0	7.0	6.0	6.0
Max Green Setting (Gmax), s	14.0	61.0	7.0	33.0	9.0	66.0	9.0	31.0
Max Q Clear Time (g_c+I1), s	4.7	13.3	2.2	3.7	4.3	5.4	4.7	9.4
Green Ext Time (p_c), s	0.2	5.2	0.0	0.2	0.1	1.9	0.1	1.0

Intersection Summary	
HCM 6th Ctrl Delay	17.1
HCM 6th LOS	B

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	0	0	0	178	0	138	0	1443	239	124	690	0
Future Volume (veh/h)	0	0	0	178	0	138	0	1443	239	124	690	0
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Work Zone On Approach		No			No			No			No	
Adj Sat Flow, veh/h/ln	1870	1870	1870	1870	0	1870	1870	1870	1870	1870	1870	1870
Adj Flow Rate, veh/h	0	0	0	185	0	144	0	1503	249	129	719	0
Peak Hour Factor	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96
Percent Heavy Veh, %	2	2	2	2	0	2	2	2	2	2	2	2
Cap, veh/h	0	2	0	229	0	0	508	1991	888	269	2489	1110
Arrive On Green	0.00	0.00	0.00	0.13	0.00	0.00	0.00	0.56	0.56	0.06	0.70	0.00
Sat Flow, veh/h	0	-112222	0	1781	185		1781	3554	1585	1781	3554	1585
Grp Volume(v), veh/h	0	0	0	185	38.9		0	1503	249	129	719	0
Grp Sat Flow(s),veh/h/ln	0	1870	0	1781	D		1781	1777	1585	1781	1777	1585
Q Serve(g_s), s	0.0	0.0	0.0	7.7			0.0	24.5	6.2	2.1	5.8	0.0
Cycle Q Clear(g_c), s	0.0	0.0	0.0	7.7			0.0	24.5	6.2	2.1	5.8	0.0
Prop In Lane	0.00		0.00	1.00			1.00		1.00	1.00		1.00
Lane Grp Cap(c), veh/h	0	2	0	229			508	1991	888	269	2489	1110
V/C Ratio(X)	0.00	0.00	0.00	0.81			0.00	0.75	0.28	0.48	0.29	0.00
Avail Cap(c_a), veh/h	0	443	0	421			622	3270	1458	371	3457	1542
HCM Platoon Ratio	1.00	1.00	1.00	1.00			1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	0.00	0.00	0.00	1.00			0.00	1.00	1.00	1.00	1.00	0.00
Uniform Delay (d), s/veh	0.0	0.0	0.0	32.2			0.0	12.7	8.7	13.6	4.3	0.0
Incr Delay (d2), s/veh	0.0	0.0	0.0	6.6			0.0	0.6	0.2	1.3	0.1	0.0
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0			0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	0.0	0.0	0.0	3.6			0.0	7.3	1.9	1.0	1.2	0.0
Unsig. Movement Delay, s/veh												
LnGrp Delay(d),s/veh	0.0	0.0	0.0	38.9			0.0	13.3	8.9	14.9	4.3	0.0
LnGrp LOS	A	A	A	D			A	B	A	B	A	A
Approach Vol, veh/h		0						1752			848	
Approach Delay, s/veh		0.0						12.7			5.9	
Approach LOS								B			A	

Timer - Assigned Phs	1	2	3	4	5	6
Phs Duration (G+Y+Rc), s	10.7	49.6	15.8	0.0	0.0	60.3
Change Period (Y+Rc), s	6.0	7.0	6.0	6.0	6.0	7.0
Max Green Setting (Gmax), s	9.0	70.0	18.0	18.0	5.0	74.0
Max Q Clear Time (g_c+I1), s	4.1	26.5	9.7	0.0	0.0	7.8
Green Ext Time (p_c), s	0.1	16.1	0.3	0.0	0.0	5.0

Intersection Summary	
HCM 6th Ctrl Delay	12.4
HCM 6th LOS	B

Intersection	
Int Delay, s/veh	6.9

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Vol, veh/h	195	0	53	0	0	0	32	24	0	0	49	193
Future Vol, veh/h	195	0	53	0	0	0	32	24	0	0	49	193
Conflicting Peds, #/hr	0	0	0	1	0	1	0	0	1	1	0	0
Sign Control	Stop	Stop	Stop	Stop	Stop	Stop	Free	Free	Free	Free	Free	Free
RT Channelized	-	-	None	-	-	None	-	-	None	-	-	None
Storage Length	-	-	-	-	-	-	-	-	-	-	-	-
Veh in Median Storage, #	-	0	-	-	0	-	-	0	-	-	0	-
Grade, %	-	0	-	-	0	-	-	0	-	-	0	-
Peak Hour Factor	83	83	83	83	83	83	83	83	83	83	83	83
Heavy Vehicles, %	2	2	2	2	2	2	2	2	2	2	2	2
Mvmt Flow	235	0	64	0	0	0	39	29	0	0	59	233

Major/Minor	Minor2			Minor1			Major1			Major2		
Conflicting Flow All	284	284	177	317	400	31	292	0	0	30	0	0
Stage 1	176	176	-	108	108	-	-	-	-	-	-	-
Stage 2	108	108	-	209	292	-	-	-	-	-	-	-
Critical Hdwy	7.12	6.52	6.22	7.12	6.52	6.22	4.12	-	-	4.12	-	-
Critical Hdwy Stg 1	6.12	5.52	-	6.12	5.52	-	-	-	-	-	-	-
Critical Hdwy Stg 2	6.12	5.52	-	6.12	5.52	-	-	-	-	-	-	-
Follow-up Hdwy	3.518	4.018	3.318	3.518	4.018	3.318	2.218	-	-	2.218	-	-
Pot Cap-1 Maneuver	668	625	866	636	538	1043	1270	-	-	1583	-	-
Stage 1	826	753	-	897	806	-	-	-	-	-	-	-
Stage 2	897	806	-	793	671	-	-	-	-	-	-	-
Platoon blocked, %								-	-		-	-
Mov Cap-1 Maneuver	651	605	865	574	521	1041	1270	-	-	1581	-	-
Mov Cap-2 Maneuver	651	605	-	574	521	-	-	-	-	-	-	-
Stage 1	800	753	-	868	780	-	-	-	-	-	-	-
Stage 2	868	780	-	734	671	-	-	-	-	-	-	-

Approach	EB	WB	NB	SB
HCM Control Delay, s	14.2	0	4.5	0
HCM LOS	B	A		

Minor Lane/Major Mvmt	NBL	NBT	NBR	EBLn1	WBLn1	SBL	SBT	SBR
Capacity (veh/h)	1270	-	-	687	-	1581	-	-
HCM Lane V/C Ratio	0.03	-	-	0.435	-	-	-	-
HCM Control Delay (s)	7.9	0	-	14.2	0	0	-	-
HCM Lane LOS	A	A	-	B	A	A	-	-
HCM 95th %tile Q(veh)	0.1	-	-	2.2	-	0	-	-

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	132	28	77	8	25	156	74	354	18	197	609	148
Future Volume (veh/h)	132	28	77	8	25	156	74	354	18	197	609	148
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Work Zone On Approach		No			No			No			No	
Adj Sat Flow, veh/h/ln	1870	1870	1870	1870	1870	1870	1870	1870	1870	1870	1870	1870
Adj Flow Rate, veh/h	138	29	80	8	26	162	77	369	19	205	634	154
Peak Hour Factor	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96
Percent Heavy Veh, %	2	2	2	2	2	2	2	2	2	2	2	2
Cap, veh/h	442	416	353	326	265	225	313	743	331	464	968	432
Arrive On Green	0.09	0.22	0.22	0.01	0.14	0.14	0.06	0.21	0.21	0.12	0.27	0.27
Sat Flow, veh/h	1781	1870	1585	1781	1870	1585	1781	3554	1585	1781	3554	1585
Grp Volume(v), veh/h	138	29	80	8	26	162	77	369	19	205	634	154
Grp Sat Flow(s),veh/h/ln	1781	1870	1585	1781	1870	1585	1781	1777	1585	1781	1777	1585
Q Serve(g_s), s	3.7	0.7	2.4	0.2	0.7	5.6	1.9	5.3	0.6	5.0	9.1	4.5
Cycle Q Clear(g_c), s	3.7	0.7	2.4	0.2	0.7	5.6	1.9	5.3	0.6	5.0	9.1	4.5
Prop In Lane	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Lane Grp Cap(c), veh/h	442	416	353	326	265	225	313	743	331	464	968	432
V/C Ratio(X)	0.31	0.07	0.23	0.02	0.10	0.72	0.25	0.50	0.06	0.44	0.66	0.36
Avail Cap(c_a), veh/h	805	1199	1016	585	940	796	574	2648	1181	1044	3510	1566
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Uniform Delay (d), s/veh	17.9	17.7	18.4	20.8	21.6	23.7	16.3	20.1	18.3	14.8	18.6	16.9
Incr Delay (d2), s/veh	0.4	0.1	0.3	0.0	0.2	4.3	0.4	0.5	0.1	0.7	0.8	0.5
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	1.4	0.3	0.8	0.1	0.3	2.2	0.7	1.8	0.2	1.6	3.0	1.5
Unsig. Movement Delay, s/veh												
LnGrp Delay(d),s/veh	18.3	17.8	18.7	20.9	21.7	28.0	16.7	20.7	18.3	15.4	19.4	17.4
LnGrp LOS	B	B	B	C	C	C	B	C	B	B	B	B
Approach Vol, veh/h		247			196			465			993	
Approach Delay, s/veh		18.3			26.9			19.9			18.2	
Approach LOS		B			C			B			B	

Timer - Assigned Phs	1	2	3	4	5	6	7	8
Phs Duration (G+Y+Rc), s	13.2	19.1	6.6	18.8	9.5	22.7	11.3	14.2
Change Period (Y+Rc), s	6.0	7.0	6.0	6.0	6.0	7.0	6.0	6.0
Max Green Setting (Gmax), s	26.0	43.0	9.0	37.0	12.0	57.0	17.0	29.0
Max Q Clear Time (g_c+I1), s	7.0	7.3	2.2	4.4	3.9	11.1	5.7	7.6
Green Ext Time (p_c), s	0.5	2.2	0.0	0.4	0.1	4.6	0.2	0.6

Intersection Summary	
HCM 6th Ctrl Delay	19.6
HCM 6th LOS	B

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	0	0	0	193	0	45	0	544	33	15	987	0
Future Volume (veh/h)	0	0	0	193	0	45	0	544	33	15	987	0
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Work Zone On Approach		No			No			No			No	
Adj Sat Flow, veh/h/ln	1870	1870	1870	1870	0	1870	1870	1870	1870	1870	1870	1870
Adj Flow Rate, veh/h	0	0	0	210	0	49	0	591	36	16	1073	0
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Percent Heavy Veh, %	2	2	2	2	0	2	2	2	2	2	2	2
Cap, veh/h	0	5	0	558	0	0	393	1409	628	504	2039	910
Arrive On Green	0.00	0.00	0.00	0.20	0.00	0.04	0.00	0.40	0.40	0.06	0.57	0.00
Sat Flow, veh/h	0	-74814	0	1781	210		1781	3554	1585	1781	3554	1585
Grp Volume(v), veh/h	0	0	0	210	13.1		0	591	36	16	1073	0
Grp Sat Flow(s),veh/h/ln	0	1870	0	1781	B		1781	1777	1585	1781	1777	1585
Q Serve(g_s), s	0.0	0.0	0.0	3.7			0.0	4.2	0.5	0.2	6.5	0.0
Cycle Q Clear(g_c), s	0.0	0.0	0.0	3.7			0.0	4.2	0.5	0.2	6.5	0.0
Prop In Lane	0.00		0.00	1.00			1.00		1.00	1.00		1.00
Lane Grp Cap(c), veh/h	0	5	0	558			393	1409	628	504	2039	910
V/C Ratio(X)	0.00	0.00	0.00	0.38			0.00	0.42	0.06	0.03	0.53	0.00
Avail Cap(c_a), veh/h	0	1040	0	1424			768	7345	3276	798	7396	3299
HCM Platoon Ratio	1.00	1.00	1.00	1.00			1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	0.00	0.00	0.00	1.00			0.00	1.00	1.00	1.00	1.00	0.00
Uniform Delay (d), s/veh	0.0	0.0	0.0	12.7			0.0	7.7	6.5	5.5	4.6	0.0
Incr Delay (d2), s/veh	0.0	0.0	0.0	0.4			0.0	0.2	0.0	0.0	0.2	0.0
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0			0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	0.0	0.0	0.0	1.2			0.0	0.8	0.1	0.0	0.3	0.0
Unsig. Movement Delay, s/veh												
LnGrp Delay(d),s/veh	0.0	0.0	0.0	13.1			0.0	7.9	6.6	5.5	4.8	0.0
LnGrp LOS	A	A	A	B			A	A	A	A	A	A
Approach Vol, veh/h		0						627			1089	
Approach Delay, s/veh		0.0						7.8			4.8	
Approach LOS								A			A	

Timer - Assigned Phs	1	2	3	4	5	6
Phs Duration (G+Y+Rc), s	6.2	17.9	10.9	0.0	0.0	24.1
Change Period (Y+Rc), s	5.5	7.0	5.5	5.5	5.5	7.0
Max Green Setting (Gmax), s	6.5	69.5	22.5	18.0	6.0	70.0
Max Q Clear Time (g_c+I1), s	2.2	6.2	5.7	0.0	0.0	8.5
Green Ext Time (p_c), s	0.0	4.0	0.5	0.0	0.0	8.7

Intersection Summary	
HCM 6th Ctrl Delay	6.7
HCM 6th LOS	A

Intersection	
Int Delay, s/veh	2.1

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Vol, veh/h	1	0	8	0	0	0	56	32	0	0	21	131
Future Vol, veh/h	1	0	8	0	0	0	56	32	0	0	21	131
Conflicting Peds, #/hr	0	0	0	1	0	1	0	0	1	1	0	0
Sign Control	Stop	Stop	Stop	Stop	Stop	Stop	Free	Free	Free	Free	Free	Free
RT Channelized	-	-	None	-	-	None	-	-	None	-	-	None
Storage Length	-	-	-	-	-	-	-	-	-	-	-	-
Veh in Median Storage, #	-	0	-	-	0	-	-	0	-	-	0	-
Grade, %	-	0	-	-	0	-	-	0	-	-	0	-
Peak Hour Factor	80	80	80	80	80	80	80	80	80	80	80	80
Heavy Vehicles, %	2	2	2	2	2	2	2	2	2	2	2	2
Mvmt Flow	1	0	10	0	0	0	70	40	0	0	26	164

Major/Minor	Minor2			Minor1			Major1			Major2		
Conflicting Flow All	289	289	109	295	371	42	190	0	0	41	0	0
Stage 1	108	108	-	181	181	-	-	-	-	-	-	-
Stage 2	181	181	-	114	190	-	-	-	-	-	-	-
Critical Hdwy	7.12	6.52	6.22	7.12	6.52	6.22	4.12	-	-	4.12	-	-
Critical Hdwy Stg 1	6.12	5.52	-	6.12	5.52	-	-	-	-	-	-	-
Critical Hdwy Stg 2	6.12	5.52	-	6.12	5.52	-	-	-	-	-	-	-
Follow-up Hdwy	3.518	4.018	3.318	3.518	4.018	3.318	2.218	-	-	2.218	-	-
Pot Cap-1 Maneuver	663	621	945	657	559	1029	1384	-	-	1568	-	-
Stage 1	897	806	-	821	750	-	-	-	-	-	-	-
Stage 2	821	750	-	891	743	-	-	-	-	-	-	-
Platoon blocked, %								-	-		-	-
Mov Cap-1 Maneuver	636	588	944	623	529	1027	1384	-	-	1567	-	-
Mov Cap-2 Maneuver	636	588	-	623	529	-	-	-	-	-	-	-
Stage 1	850	806	-	777	710	-	-	-	-	-	-	-
Stage 2	778	710	-	881	743	-	-	-	-	-	-	-

Approach	EB	WB	NB	SB
HCM Control Delay, s	9.1	0	4.9	0
HCM LOS	A	A		

Minor Lane/Major Mvmt	NBL	NBT	NBR	EBLn1	WBLn1	SBL	SBT	SBR
Capacity (veh/h)	1384	-	-	896	-	1567	-	-
HCM Lane V/C Ratio	0.051	-	-	0.013	-	-	-	-
HCM Control Delay (s)	7.7	0	-	9.1	0	0	-	-
HCM Lane LOS	A	A	-	A	A	A	-	-
HCM 95th %tile Q(veh)	0.2	-	-	0	-	0	-	-

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations	↰	↑	↱	↰	↑	↱	↰	↑↑	↱	↰	↑↑	↱
Traffic Volume (veh/h)	42	2	6	13	59	253	85	985	11	159	354	36
Future Volume (veh/h)	42	2	6	13	59	253	85	985	11	159	354	36
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Work Zone On Approach		No			No			No			No	
Adj Sat Flow, veh/h/ln	1870	1870	1870	1870	1870	1870	1870	1870	1870	1870	1870	1870
Adj Flow Rate, veh/h	44	2	6	14	62	266	89	1037	12	167	373	38
Peak Hour Factor	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Percent Heavy Veh, %	2	2	2	2	2	2	2	2	2	2	2	2
Cap, veh/h	402	450	381	466	407	345	571	1462	652	354	1549	691
Arrive On Green	0.06	0.24	0.24	0.04	0.22	0.22	0.08	0.41	0.41	0.10	0.44	0.44
Sat Flow, veh/h	1781	1870	1585	1781	1870	1585	1781	3554	1585	1781	3554	1585
Grp Volume(v), veh/h	44	2	6	14	62	266	89	1037	12	167	373	38
Grp Sat Flow(s),veh/h/ln	1781	1870	1585	1781	1870	1585	1781	1777	1585	1781	1777	1585
Q Serve(g_s), s	1.4	0.1	0.2	0.4	2.0	12.0	2.1	18.4	0.3	4.0	5.0	1.0
Cycle Q Clear(g_c), s	1.4	0.1	0.2	0.4	2.0	12.0	2.1	18.4	0.3	4.0	5.0	1.0
Prop In Lane	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Lane Grp Cap(c), veh/h	402	450	381	466	407	345	571	1462	652	354	1549	691
V/C Ratio(X)	0.11	0.00	0.02	0.03	0.15	0.77	0.16	0.71	0.02	0.47	0.24	0.05
Avail Cap(c_a), veh/h	460	716	607	566	716	607	624	3236	1443	622	3752	1674
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Uniform Delay (d), s/veh	20.3	21.9	21.9	21.2	24.0	27.9	11.4	18.5	13.2	14.0	13.5	12.3
Incr Delay (d2), s/veh	0.1	0.0	0.0	0.0	0.2	3.7	0.1	0.6	0.0	1.0	0.1	0.0
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	0.6	0.0	0.1	0.2	0.9	4.7	0.7	6.3	0.1	1.3	1.7	0.4
Unsig. Movement Delay, s/veh												
LnGrp Delay(d),s/veh	20.4	21.9	22.0	21.3	24.2	31.6	11.5	19.2	13.2	15.0	13.5	12.4
LnGrp LOS	C	C	C	C	C	C	B	B	B	B	B	B
Approach Vol, veh/h		52			342			1138			578	
Approach Delay, s/veh		20.7			29.8			18.5			13.9	
Approach LOS		C			C			B			B	

Timer - Assigned Phs	1	2	3	4	5	6	7	8
Phs Duration (G+Y+Rc), s	11.6	35.2	6.8	22.2	9.7	37.0	8.5	20.5
Change Period (Y+Rc), s	5.5	7.0	5.5	5.5	5.5	7.0	5.5	5.5
Max Green Setting (Gmax), s	17.5	66.0	5.5	27.5	6.5	77.0	5.5	27.5
Max Q Clear Time (g_c+I1), s	6.0	20.4	2.4	2.2	4.1	7.0	3.4	14.0
Green Ext Time (p_c), s	0.3	7.8	0.0	0.0	0.0	2.3	0.0	1.0

Intersection Summary		
HCM 6th Ctrl Delay		19.1
HCM 6th LOS		B

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	0	0	0	41	0	56	0	1685	103	29	805	0
Future Volume (veh/h)	0	0	0	41	0	56	0	1685	103	29	805	0
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Work Zone On Approach		No			No			No			No	
Adj Sat Flow, veh/h/ln	1870	1870	1870	1870	0	1870	1870	1870	1870	1870	1870	1870
Adj Flow Rate, veh/h	0	0	0	43	0	58	0	1755	107	30	839	0
Peak Hour Factor	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96
Percent Heavy Veh, %	2	2	2	2	0	2	2	2	2	2	2	2
Cap, veh/h	0	3	0	225	0	0	555	2478	1105	301	2890	1289
Arrive On Green	0.00	0.00	0.00	0.06	0.00	0.02	0.00	0.70	0.70	0.06	0.81	0.00
Sat Flow, veh/h	0	-74814	0	1781	43		1781	3554	1585	1781	3554	1585
Grp Volume(v), veh/h	0	0	0	43	29.7		0	1755	107	30	839	0
Grp Sat Flow(s),veh/h/ln	0	1870	0	1781	C		1781	1777	1585	1781	1777	1585
Q Serve(g_s), s	0.0	0.0	0.0	1.5			0.0	19.3	1.4	0.3	3.8	0.0
Cycle Q Clear(g_c), s	0.0	0.0	0.0	1.5			0.0	19.3	1.4	0.3	3.8	0.0
Prop In Lane	0.00		0.00	1.00			1.00		1.00	1.00		1.00
Lane Grp Cap(c), veh/h	0	3	0	225			555	2478	1105	301	2890	1289
V/C Ratio(X)	0.00	0.00	0.00	0.19			0.00	0.71	0.10	0.10	0.29	0.00
Avail Cap(c_a), veh/h	0	557	0	614			729	4318	1926	380	4318	1926
HCM Platoon Ratio	1.00	1.00	1.00	1.00			1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	0.00	0.00	0.00	1.00			0.00	1.00	1.00	1.00	1.00	0.00
Uniform Delay (d), s/veh	0.0	0.0	0.0	29.2			0.0	5.9	3.2	5.9	1.5	0.0
Incr Delay (d2), s/veh	0.0	0.0	0.0	0.4			0.0	0.4	0.0	0.1	0.1	0.0
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0			0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	0.0	0.0	0.0	0.6			0.0	3.1	0.3	0.1	0.0	0.0
Unsig. Movement Delay, s/veh												
LnGrp Delay(d),s/veh	0.0	0.0	0.0	29.7			0.0	6.3	3.3	6.0	1.5	0.0
LnGrp LOS	A	A	A	C			A	A	A	A	A	A
Approach Vol, veh/h		0						1862			869	
Approach Delay, s/veh		0.0						6.1			1.7	
Approach LOS								A			A	

Timer - Assigned Phs	1	2	3	4	5	6
Phs Duration (G+Y+Rc), s	7.6	49.6	8.2	0.0	0.0	57.2
Change Period (Y+Rc), s	5.5	7.0	5.5	5.5	5.5	7.0
Max Green Setting (Gmax), s	5.0	76.5	17.0	18.0	5.0	76.5
Max Q Clear Time (g_c+I1), s	2.3	21.3	3.5	0.0	0.0	5.8
Green Ext Time (p_c), s	0.0	21.3	0.0	0.0	0.0	6.1

Intersection Summary	
HCM 6th Ctrl Delay	5.1
HCM 6th LOS	A

Intersection	
Int Delay, s/veh	3.9

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Vol, veh/h	26	0	43	0	0	0	13	34	0	0	67	7
Future Vol, veh/h	26	0	43	0	0	0	13	34	0	0	67	7
Conflicting Peds, #/hr	0	0	0	2	0	0	0	0	2	0	0	0
Sign Control	Stop	Stop	Stop	Stop	Stop	Stop	Free	Free	Free	Free	Free	Free
RT Channelized	-	-	None	-	-	None	-	-	None	-	-	None
Storage Length	-	-	-	-	-	-	-	-	-	-	-	-
Veh in Median Storage, #	-	0	-	-	0	-	-	0	-	-	0	-
Grade, %	-	0	-	-	0	-	-	0	-	-	0	-
Peak Hour Factor	83	83	83	83	83	83	83	83	83	83	83	83
Heavy Vehicles, %	2	2	2	2	2	2	2	2	2	2	2	2
Mvmt Flow	31	0	52	0	0	0	16	41	0	0	81	8

Major/Minor	Minor2			Minor1			Major1			Major2		
Conflicting Flow All	158	160	87	188	164	43	89	0	0	43	0	0
Stage 1	85	85	-	75	75	-	-	-	-	-	-	-
Stage 2	73	75	-	113	89	-	-	-	-	-	-	-
Critical Hdwy	7.12	6.52	6.22	7.12	6.52	6.22	4.12	-	-	4.12	-	-
Critical Hdwy Stg 1	6.12	5.52	-	6.12	5.52	-	-	-	-	-	-	-
Critical Hdwy Stg 2	6.12	5.52	-	6.12	5.52	-	-	-	-	-	-	-
Follow-up Hdwy	3.518	4.018	3.318	3.518	4.018	3.318	2.218	-	-	2.218	-	-
Pot Cap-1 Maneuver	808	732	971	772	729	1027	1506	-	-	1566	-	-
Stage 1	923	824	-	934	833	-	-	-	-	-	-	-
Stage 2	937	833	-	892	821	-	-	-	-	-	-	-
Platoon blocked, %								-	-		-	-
Mov Cap-1 Maneuver	802	722	969	722	720	1025	1506	-	-	1563	-	-
Mov Cap-2 Maneuver	802	722	-	722	720	-	-	-	-	-	-	-
Stage 1	913	824	-	922	822	-	-	-	-	-	-	-
Stage 2	927	822	-	843	821	-	-	-	-	-	-	-

Approach	EB	WB	NB	SB
HCM Control Delay, s	9.4	0	2.1	0
HCM LOS	A	A		

Minor Lane/Major Mvmt	NBL	NBT	NBR	EBLn1	WBLn1	SBL	SBT	SBR
Capacity (veh/h)	1506	-	-	899	-	1563	-	-
HCM Lane V/C Ratio	0.01	-	-	0.092	-	-	-	-
HCM Control Delay (s)	7.4	0	-	9.4	0	0	-	-
HCM Lane LOS	A	A	-	A	A	A	-	-
HCM 95th %tile Q(veh)	0	-	-	0.3	-	0	-	-

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations	↰	↑	↱	↰	↑	↱	↰	↑↑	↱	↰	↑↑	↱
Traffic Volume (veh/h)	55	9	20	13	4	203	6	472	30	252	815	69
Future Volume (veh/h)	55	9	20	13	4	203	6	472	30	252	815	69
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Work Zone On Approach		No			No			No			No	
Adj Sat Flow, veh/h/ln	1870	1870	1870	1870	1870	1870	1870	1870	1870	1870	1870	1870
Adj Flow Rate, veh/h	57	9	21	14	4	211	6	492	31	262	849	72
Peak Hour Factor	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96
Percent Heavy Veh, %	2	2	2	2	2	2	2	2	2	2	2	2
Cap, veh/h	500	433	367	481	367	311	304	939	419	537	1416	632
Arrive On Green	0.08	0.23	0.23	0.04	0.20	0.20	0.04	0.26	0.26	0.17	0.40	0.40
Sat Flow, veh/h	1781	1870	1585	1781	1870	1585	1781	3554	1585	1781	3554	1585
Grp Volume(v), veh/h	57	9	21	14	4	211	6	492	31	262	849	72
Grp Sat Flow(s),veh/h/ln	1781	1870	1585	1781	1870	1585	1781	1777	1585	1781	1777	1585
Q Serve(g_s), s	1.3	0.2	0.6	0.3	0.1	6.8	0.1	6.5	0.8	5.3	10.4	1.6
Cycle Q Clear(g_c), s	1.3	0.2	0.6	0.3	0.1	6.8	0.1	6.5	0.8	5.3	10.4	1.6
Prop In Lane	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Lane Grp Cap(c), veh/h	500	433	367	481	367	311	304	939	419	537	1416	632
V/C Ratio(X)	0.11	0.02	0.06	0.03	0.01	0.68	0.02	0.52	0.07	0.49	0.60	0.11
Avail Cap(c_a), veh/h	713	1187	1006	692	1120	949	532	3030	1351	1301	4577	2041
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Uniform Delay (d), s/veh	14.9	16.4	16.5	16.0	17.9	20.6	14.7	17.3	15.2	11.0	13.1	10.4
Incr Delay (d2), s/veh	0.1	0.0	0.1	0.0	0.0	2.6	0.0	0.5	0.1	0.7	0.4	0.1
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	0.5	0.1	0.2	0.1	0.0	0.2	0.0	2.1	0.3	1.5	3.0	0.5
Unsig. Movement Delay, s/veh												
LnGrp Delay(d),s/veh	15.0	16.4	16.6	16.0	17.9	23.1	14.8	17.8	15.3	11.7	13.5	10.5
LnGrp LOS	B	B	B	B	B	C	B	B	B	B	B	B
Approach Vol, veh/h		87			229			529			1183	
Approach Delay, s/veh		15.5			22.6			17.6			12.9	
Approach LOS		B			C			B			B	

Timer - Assigned Phs	1	2	3	4	5	6	7	8
Phs Duration (G+Y+Rc), s	13.3	18.6	6.5	16.8	5.9	26.0	8.4	14.8
Change Period (Y+Rc), s	5.5	7.0	5.5	5.5	5.5	7.0	5.5	5.5
Max Green Setting (Gmax), s	31.5	44.0	7.5	33.5	7.5	68.0	9.5	31.5
Max Q Clear Time (g_c+I1), s	7.3	8.5	2.3	2.6	2.1	12.4	3.3	8.8
Green Ext Time (p_c), s	0.7	3.1	0.0	0.1	0.0	6.2	0.0	0.7

Intersection Summary	
HCM 6th Ctrl Delay	15.3
HCM 6th LOS	B

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	0	0	0	310	0	112	0	544	134	73	987	0
Future Volume (veh/h)	0	0	0	310	0	112	0	544	134	73	987	0
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Work Zone On Approach		No			No			No			No	
Adj Sat Flow, veh/h/ln	1870	1870	1870	1870	0	1870	1870	1870	1870	1870	1870	1870
Adj Flow Rate, veh/h	0	0	0	323	0	117	0	567	140	76	1028	0
Peak Hour Factor	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96
Percent Heavy Veh, %	2	2	2	2	0	2	2	2	2	2	2	2
Cap, veh/h	0	4	0	483	0	0	342	1198	534	511	1935	863
Arrive On Green	0.00	0.00	0.00	0.27	0.00	0.01	0.00	0.34	0.34	0.12	0.54	0.00
Sat Flow, veh/h	0	-74814	0	1781	323		1781	3554	1585	1781	3554	1585
Grp Volume(v), veh/h	0	0	0	323	15.7		0	567	140	76	1028	0
Grp Sat Flow(s),veh/h/ln	0	1870	0	1781	B		1781	1777	1585	1781	1777	1585
Q Serve(g_s), s	0.0	0.0	0.0	7.0			0.0	5.5	2.8	1.0	8.0	0.0
Cycle Q Clear(g_c), s	0.0	0.0	0.0	7.0			0.0	5.5	2.8	1.0	8.0	0.0
Prop In Lane	0.00		0.00	1.00			1.00		1.00	1.00		1.00
Lane Grp Cap(c), veh/h	0	4	0	483			342	1198	534	511	1935	863
V/C Ratio(X)	0.00	0.00	0.00	0.67			0.00	0.47	0.26	0.15	0.53	0.00
Avail Cap(c_a), veh/h	0	862	0	1642			626	4668	2082	593	4668	2082
HCM Platoon Ratio	1.00	1.00	1.00	1.00			1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	0.00	0.00	0.00	1.00			0.00	1.00	1.00	1.00	1.00	0.00
Uniform Delay (d), s/veh	0.0	0.0	0.0	14.1			0.0	11.3	10.5	7.0	6.3	0.0
Incr Delay (d2), s/veh	0.0	0.0	0.0	1.6			0.0	0.3	0.3	0.1	0.2	0.0
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0			0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	0.0	0.0	0.0	2.5			0.0	1.5	0.8	0.2	1.3	0.0
Unsig. Movement Delay, s/veh												
LnGrp Delay(d),s/veh	0.0	0.0	0.0	15.7			0.0	11.6	10.7	7.1	6.6	0.0
LnGrp LOS	A	A	A	B			A	B	B	A	A	A
Approach Vol, veh/h		0						707			1104	
Approach Delay, s/veh		0.0						11.5			6.6	
Approach LOS								B			A	

Timer - Assigned Phs	1	2	3	4	5	6
Phs Duration (G+Y+Rc), s	9.0	18.6	15.8	0.0	0.0	27.6
Change Period (Y+Rc), s	6.0	7.0	6.0	6.0	6.0	7.0
Max Green Setting (Gmax), s	5.0	54.0	38.0	18.0	5.0	54.0
Max Q Clear Time (g_c+I1), s	3.0	7.5	9.0	0.0	0.0	10.0
Green Ext Time (p_c), s	0.0	4.2	1.0	0.0	0.0	7.9

Intersection Summary	
HCM 6th Ctrl Delay	9.6
HCM 6th LOS	A

Intersection	
Int Delay, s/veh	5.4

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Vol, veh/h	134	0	25	0	0	0	70	32	0	0	21	246
Future Vol, veh/h	134	0	25	0	0	0	70	32	0	0	21	246
Conflicting Peds, #/hr	0	0	0	1	0	1	0	0	1	1	0	0
Sign Control	Stop	Stop	Stop	Stop	Stop	Stop	Free	Free	Free	Free	Free	Free
RT Channelized	-	-	None	-	-	None	-	-	None	-	-	None
Storage Length	-	-	-	-	-	-	-	-	-	-	-	-
Veh in Median Storage, #	-	0	-	-	0	-	-	0	-	-	0	-
Grade, %	-	0	-	-	0	-	-	0	-	-	0	-
Peak Hour Factor	83	83	83	83	83	83	83	83	83	83	83	83
Heavy Vehicles, %	2	2	2	2	2	2	2	2	2	2	2	2
Mvmt Flow	161	0	30	0	0	0	84	39	0	0	25	296

Major/Minor	Minor2			Minor1			Major1			Major2		
Conflicting Flow All	381	381	174	397	529	41	321	0	0	40	0	0
Stage 1	173	173	-	208	208	-	-	-	-	-	-	-
Stage 2	208	208	-	189	321	-	-	-	-	-	-	-
Critical Hdwy	7.12	6.52	6.22	7.12	6.52	6.22	4.12	-	-	4.12	-	-
Critical Hdwy Stg 1	6.12	5.52	-	6.12	5.52	-	-	-	-	-	-	-
Critical Hdwy Stg 2	6.12	5.52	-	6.12	5.52	-	-	-	-	-	-	-
Follow-up Hdwy	3.518	4.018	3.318	3.518	4.018	3.318	2.218	-	-	2.218	-	-
Pot Cap-1 Maneuver	577	552	869	563	455	1030	1239	-	-	1570	-	-
Stage 1	829	756	-	794	730	-	-	-	-	-	-	-
Stage 2	794	730	-	813	652	-	-	-	-	-	-	-
Platoon blocked, %								-	-		-	-
Mov Cap-1 Maneuver	546	513	868	514	423	1028	1239	-	-	1569	-	-
Mov Cap-2 Maneuver	546	513	-	514	423	-	-	-	-	-	-	-
Stage 1	772	756	-	738	679	-	-	-	-	-	-	-
Stage 2	739	679	-	784	652	-	-	-	-	-	-	-

Approach	EB	WB	NB	SB
HCM Control Delay, s	14.2	0	5.6	0
HCM LOS	B	A		

Minor Lane/Major Mvmt	NBL	NBT	NBR	EBLn1	WBLn1	SBL	SBT	SBR
Capacity (veh/h)	1239	-	-	580	-	1569	-	-
HCM Lane V/C Ratio	0.068	-	-	0.33	-	-	-	-
HCM Control Delay (s)	8.1	0	-	14.2	0	0	-	-
HCM Lane LOS	A	A	-	B	A	A	-	-
HCM 95th %tile Q(veh)	0.2	-	-	1.4	-	0	-	-

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	109	19	56	13	73	253	128	985	11	159	354	94
Future Volume (veh/h)	109	19	56	13	73	253	128	985	11	159	354	94
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Work Zone On Approach		No			No			No			No	
Adj Sat Flow, veh/h/ln	1870	1870	1870	1870	1870	1870	1870	1870	1870	1870	1870	1870
Adj Flow Rate, veh/h	114	20	58	14	76	264	133	1026	11	166	369	98
Peak Hour Factor	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96
Percent Heavy Veh, %	2	2	2	2	2	2	2	2	2	2	2	2
Cap, veh/h	438	498	422	447	407	345	551	1411	629	346	1462	652
Arrive On Green	0.09	0.27	0.27	0.04	0.22	0.22	0.09	0.40	0.40	0.10	0.41	0.41
Sat Flow, veh/h	1781	1870	1585	1781	1870	1585	1781	3554	1585	1781	3554	1585
Grp Volume(v), veh/h	114	20	58	14	76	264	133	1026	11	166	369	98
Grp Sat Flow(s),veh/h/ln	1781	1870	1585	1781	1870	1585	1781	1777	1585	1781	1777	1585
Q Serve(g_s), s	3.8	0.7	2.3	0.5	2.7	12.9	3.5	20.2	0.3	4.4	5.6	3.2
Cycle Q Clear(g_c), s	3.8	0.7	2.3	0.5	2.7	12.9	3.5	20.2	0.3	4.4	5.6	3.2
Prop In Lane	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Lane Grp Cap(c), veh/h	438	498	422	447	407	345	551	1411	629	346	1462	652
V/C Ratio(X)	0.26	0.04	0.14	0.03	0.19	0.76	0.24	0.73	0.02	0.48	0.25	0.15
Avail Cap(c_a), veh/h	473	723	613	525	678	575	587	2878	1284	551	3264	1456
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Uniform Delay (d), s/veh	19.9	22.5	23.1	22.9	26.4	30.4	12.5	21.1	15.1	15.5	16.0	15.3
Incr Delay (d2), s/veh	0.3	0.0	0.1	0.0	0.2	3.5	0.2	0.7	0.0	1.0	0.1	0.1
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	1.6	0.3	0.9	0.2	1.2	5.1	1.2	7.2	0.1	1.5	2.0	1.1
Unsig. Movement Delay, s/veh												
LnGrp Delay(d),s/veh	20.2	22.5	23.3	23.0	26.6	33.9	12.8	21.9	15.2	16.6	16.1	15.4
LnGrp LOS	C	C	C	C	C	C	B	C	B	B	B	B
Approach Vol, veh/h		192			354			1170			633	
Approach Delay, s/veh		21.4			31.9			20.8			16.1	
Approach LOS		C			C			C			B	
Timer - Assigned Phs	1	2	3	4	5	6	7	8				
Phs Duration (G+Y+Rc), s	12.5	36.9	7.4	26.0	11.3	38.0	11.4	22.0				
Change Period (Y+Rc), s	6.0	7.0	6.0	6.0	6.0	7.0	6.0	6.0				
Max Green Setting (Gmax), s	16.0	64.0	5.0	30.0	7.0	73.0	7.0	28.0				
Max Q Clear Time (g_c+I1), s	6.4	22.2	2.5	4.3	5.5	7.6	5.8	14.9				
Green Ext Time (p_c), s	0.3	7.6	0.0	0.2	0.0	2.5	0.0	1.1				
Intersection Summary												
HCM 6th Ctrl Delay			21.2									
HCM 6th LOS			C									

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		✥		↰		↱	↰	↑↑	↱	↰	↑↑	↱
Traffic Volume (veh/h)	0	0	0	192	0	142	0	1685	266	122	805	0
Future Volume (veh/h)	0	0	0	192	0	142	0	1685	266	122	805	0
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Work Zone On Approach		No			No			No			No	
Adj Sat Flow, veh/h/ln	1870	1870	1870	1870	0	1870	1870	1870	1870	1870	1870	1870
Adj Flow Rate, veh/h	0	0	0	200	0	148	0	1755	277	127	839	0
Peak Hour Factor	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96
Percent Heavy Veh, %	2	2	2	2	0	2	2	2	2	2	2	2
Cap, veh/h	0	2	0	273	0	0	492	2264	1010	272	2691	1200
Arrive On Green	0.00	0.00	0.00	0.15	0.00	0.01	0.00	0.64	0.64	0.08	0.76	0.00
Sat Flow, veh/h	0	-74814	0	1781	200		1781	3554	1585	1781	3554	1585
Grp Volume(v), veh/h	0	0	0	200	40.7		0	1755	277	127	839	0
Grp Sat Flow(s),veh/h/ln	0	1870	0	1781	D		1781	1777	1585	1781	1777	1585
Q Serve(g_s), s	0.0	0.0	0.0	9.6			0.0	31.8	6.9	1.9	6.7	0.0
Cycle Q Clear(g_c), s	0.0	0.0	0.0	9.6			0.0	31.8	6.9	1.9	6.7	0.0
Prop In Lane	0.00		0.00	1.00			1.00		1.00	1.00		1.00
Lane Grp Cap(c), veh/h	0	2	0	273			492	2264	1010	272	2691	1200
V/C Ratio(X)	0.00	0.00	0.00	0.73			0.00	0.78	0.27	0.47	0.31	0.00
Avail Cap(c_a), veh/h	0	417	0	377			629	3091	1379	276	3091	1379
HCM Platoon Ratio	1.00	1.00	1.00	1.00			1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	0.00	0.00	0.00	1.00			0.00	1.00	1.00	1.00	1.00	0.00
Uniform Delay (d), s/veh	0.0	0.0	0.0	36.2			0.0	11.7	7.2	17.1	3.5	0.0
Incr Delay (d2), s/veh	0.0	0.0	0.0	4.5			0.0	0.9	0.1	1.2	0.1	0.0
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0			0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	0.0	0.0	0.0	4.4			0.0	9.4	2.0	1.7	1.3	0.0
Unsig. Movement Delay, s/veh												
LnGrp Delay(d),s/veh	0.0	0.0	0.0	40.7			0.0	12.6	7.3	18.3	3.5	0.0
LnGrp LOS	A	A	A	D			A	B	A	B	A	A
Approach Vol, veh/h		0						2032			966	
Approach Delay, s/veh		0.0						11.8			5.5	
Approach LOS								B			A	
Timer - Assigned Phs	1	2	3	4	5	6						
Phs Duration (G+Y+Rc), s	10.8	61.1	17.8	0.0	0.0	71.9						
Change Period (Y+Rc), s	6.0	7.0	6.0	6.0	6.0	7.0						
Max Green Setting (Gmax), s	5.0	75.0	17.0	18.0	5.0	75.0						
Max Q Clear Time (g_c+I1), s	3.9	33.8	11.6	0.0	0.0	8.7						
Green Ext Time (p_c), s	0.0	20.4	0.2	0.0	0.0	6.1						
Intersection Summary												
HCM 6th Ctrl Delay			11.7									
HCM 6th LOS			B									

Intersection	
Int Delay, s/veh	7.4

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Vol, veh/h	198	0	65	0	0	0	36	34	0	0	67	193
Future Vol, veh/h	198	0	65	0	0	0	36	34	0	0	67	193
Conflicting Peds, #/hr	0	0	0	1	0	1	0	0	1	1	0	0
Sign Control	Stop	Stop	Stop	Stop	Stop	Stop	Free	Free	Free	Free	Free	Free
RT Channelized	-	-	None	-	-	None	-	-	None	-	-	None
Storage Length	-	-	-	-	-	-	-	-	-	-	-	-
Veh in Median Storage, #	-	0	-	-	0	-	-	0	-	-	0	-
Grade, %	-	0	-	-	0	-	-	0	-	-	0	-
Peak Hour Factor	83	83	83	83	83	83	83	83	83	83	83	83
Heavy Vehicles, %	2	2	2	2	2	2	2	2	2	2	2	2
Mvmt Flow	239	0	78	0	0	0	43	41	0	0	81	233

Major/Minor	Minor2			Minor1			Major1			Major2		
Conflicting Flow All	326	326	199	366	442	43	314	0	0	42	0	0
Stage 1	198	198	-	128	128	-	-	-	-	-	-	-
Stage 2	128	128	-	238	314	-	-	-	-	-	-	-
Critical Hdwy	7.12	6.52	6.22	7.12	6.52	6.22	4.12	-	-	4.12	-	-
Critical Hdwy Stg 1	6.12	5.52	-	6.12	5.52	-	-	-	-	-	-	-
Critical Hdwy Stg 2	6.12	5.52	-	6.12	5.52	-	-	-	-	-	-	-
Follow-up Hdwy	3.518	4.018	3.318	3.518	4.018	3.318	2.218	-	-	2.218	-	-
Pot Cap-1 Maneuver	627	592	842	590	510	1027	1246	-	-	1567	-	-
Stage 1	804	737	-	876	790	-	-	-	-	-	-	-
Stage 2	876	790	-	765	656	-	-	-	-	-	-	-
Platoon blocked, %								-	-		-	-
Mov Cap-1 Maneuver	609	571	841	520	492	1025	1246	-	-	1566	-	-
Mov Cap-2 Maneuver	609	571	-	520	492	-	-	-	-	-	-	-
Stage 1	776	737	-	844	762	-	-	-	-	-	-	-
Stage 2	845	762	-	693	656	-	-	-	-	-	-	-

Approach	EB	WB	NB	SB
HCM Control Delay, s	15.6	0	4.1	0
HCM LOS	C	A		

Minor Lane/Major Mvmt	NBL	NBT	NBR	EBLn1	WBLn1	SBL	SBT	SBR
Capacity (veh/h)	1246	-	-	654	-	1566	-	-
HCM Lane V/C Ratio	0.035	-	-	0.485	-	-	-	-
HCM Control Delay (s)	8	0	-	15.6	0	0	-	-
HCM Lane LOS	A	A	-	C	A	A	-	-
HCM 95th %tile Q(veh)	0.1	-	-	2.7	-	0	-	-

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	141	31	85	13	27	203	76	472	30	252	815	162
Future Volume (veh/h)	141	31	85	13	27	203	76	472	30	252	815	162
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Work Zone On Approach		No			No			No			No	
Adj Sat Flow, veh/h/ln	1870	1870	1870	1870	1870	1870	1870	1870	1870	1870	1870	1870
Adj Flow Rate, veh/h	147	32	89	14	28	211	79	492	31	262	849	169
Peak Hour Factor	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96
Percent Heavy Veh, %	2	2	2	2	2	2	2	2	2	2	2	2
Cap, veh/h	519	491	416	435	362	307	346	1053	470	537	1311	585
Arrive On Green	0.12	0.26	0.26	0.05	0.19	0.19	0.09	0.30	0.30	0.16	0.37	0.37
Sat Flow, veh/h	1781	1870	1585	1781	1870	1585	1781	3554	1585	1781	3554	1585
Grp Volume(v), veh/h	147	32	89	14	28	211	79	492	31	262	849	169
Grp Sat Flow(s),veh/h/ln	1781	1870	1585	1781	1870	1585	1781	1777	1585	1781	1777	1585
Q Serve(g_s), s	4.0	0.9	3.0	0.4	0.8	8.4	2.0	7.7	1.0	6.2	13.5	5.1
Cycle Q Clear(g_c), s	4.0	0.9	3.0	0.4	0.8	8.4	2.0	7.7	1.0	6.2	13.5	5.1
Prop In Lane	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Lane Grp Cap(c), veh/h	519	491	416	435	362	307	346	1053	470	537	1311	585
V/C Ratio(X)	0.28	0.07	0.21	0.03	0.08	0.69	0.23	0.47	0.07	0.49	0.65	0.29
Avail Cap(c_a), veh/h	706	991	840	588	826	700	481	2563	1143	1041	3557	1587
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Uniform Delay (d), s/veh	16.3	18.8	19.6	19.8	22.4	25.5	14.8	19.5	17.2	12.2	17.8	15.1
Incr Delay (d2), s/veh	0.3	0.1	0.3	0.0	0.1	2.7	0.3	0.3	0.1	0.7	0.5	0.3
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	1.6	0.4	1.1	0.2	0.4	3.2	0.7	2.7	0.3	1.9	4.5	1.7
Unsig. Movement Delay, s/veh												
LnGrp Delay(d),s/veh	16.6	18.8	19.8	19.8	22.5	28.2	15.2	19.8	17.2	12.9	18.3	15.4
LnGrp LOS	B	B	B	B	C	C	B	B	B	B	B	B
Approach Vol, veh/h		268			253			602			1280	
Approach Delay, s/veh		17.9			27.1			19.1			16.8	
Approach LOS		B			C			B			B	

Timer - Assigned Phs	1	2	3	4	5	6	7	8
Phs Duration (G+Y+Rc), s	14.8	24.1	7.2	21.8	9.9	29.1	11.8	17.2
Change Period (Y+Rc), s	6.0	7.0	6.0	6.0	6.0	7.0	6.0	6.0
Max Green Setting (Gmax), s	28.0	46.0	7.0	34.0	9.0	65.0	13.0	28.0
Max Q Clear Time (g_c+I1), s	8.2	9.7	2.4	5.0	4.0	15.5	6.0	10.4
Green Ext Time (p_c), s	0.7	3.1	0.0	0.4	0.1	6.6	0.2	0.8

Intersection Summary	
HCM 6th Ctrl Delay	18.6
HCM 6th LOS	B