Virginia City/Six Mile Canyon Area Drainage Master Plan

Executive Summary

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PREPARED FOR: STOREY COUNTY
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Table of Contents

List of Figures

List of Tables

1.0 INTRODUCTION

1.1 Project Purpose

Virginia City is located on the eastern side of the Flowery Range on a steep slope. During rain events, water and sediment from the canyons to the west of town enter the developed area. Due to the steepness of the terrain, runoff reaches high velocities, carrying sediment and eroding unpaved areas throughout the town. Throughout the town there is minimal existing storm drain infrastructure so the majority of runoff is directed onto and adjacent to streets. This not only creates hazardous road conditions but significant maintenance requirements for the County.

Runoff from the west ultimately enters Six Mile Canyon. Six Mile Canyon is a narrow two lane roadway which has become a vital connection from the Dayton Valley area to Virginia City and Reno. During large storm events, this road often becomes impassable with runoff overtopping the road and washouts and sediment impacting travel.

O Street, Virginia City, NV

Storey County requested that an overall plan be developed to address flooding and stormwater impacts for Virginia City and Six Mile Canyon. The Virginia City and Six Mile Canyon Area Drainage Master Plan (VCADMP) identifies and evaluates sources of potential flood risk and proposes potential mitigation measures within the Virginia City and Six Mile Canyon drainage area. The VCADMP accomplishes this with three stages. The first stage identifies and quantifies flood and sedimentation risks within the project area by collecting evidence from residents, topographic data, and field conditions through surveys. The collected information is then used to develop a hydrologic and hydraulic model to quantify hazards. The second stage will develop mitigation alternatives and phasing to partially or wholly mitigate the hazards identified. The third stage will provide stakeholder coordination and public outreach about the project through a series of public meetings to inform community members of the existing hazards and to present the mitigation alternatives.

1.2 Project Location

The VCADMP study area is approximately 16.9 square miles and is located on the eastern slope of the Flowery Range. Virginia City, an unincorporated town within the study area, sits approximately 11 miles northeast of Carson City, Nevada. The entire study limits are within Storey County, with the exception of a small area of the upper portions of the watershed that extend into Washoe County. The project has two primary focus areas: Virginia City proper, and sections along Six Mile Canyon. Reference Figure 2.1 for a Vicinity Map of the project extents.

1.3 Previous Studies

1.3.1 Previous Area Drainage Master Plans

The watershed encompassed by this study area was included in the Dayton Valley Area Drainage Master Plan (DVADMP), prepared by JE Fuller and Lumos & Associates in August 2019. However, the Virginia City area was not studied in detail and projects to mitigate flood did not include Virginia City and Six-Mile Canyon. This ADMP builds on the 2019 Dayton Valley Report to identify mitigations and project relevant for the Virginia City and 6-Mile Canyon area of Storey County.

1.3.2 Flood Insurance Studies

The Federal Emergency Management Agency (FEMA) Flood Insurance Study (FIS) for Storey County was collected and reviewed. The FIS, prepared in 2009, encompassed the entire County with a focus on flooding related to the Truckee River and Long Valley Creek, both outside of the study area for this ADMP.

1.4 Historical Flowpath Assessment

No analysis has been performed on historical flowpaths due to the lack of alluvial fans within the study limits. All drainages within the study limits are within steep canyons and ravines, therefore forcing runoff into consistent washes or creeks with every storm event.

1.5 Carson River Mercury Superfund Site and Effects

In 1995 the U.S. Environmental Protection Agency (EPA) signed a Record of Decision (ROD) for the Carson River Mercury Superfund Site (CRMS). THE CRMS comprises a broad landscape and, to address areas not specifically investigated, the remedy included implementation of institutional controls to ensure characterization of mercury levels in surface soils in areas of residential development near known or suspected to be impacted by mercury, and addressing impacted soils, as necessary.

The Long-Term Sampling and Response Plan (LTSRP) developed by the EPA in 1995 identifies and outlines these institutional controls and provides a management plan to characterize, manage, and control impacted soils on residential properties within the CRMS.

When CRMS contaminants of concern levels exceed an action level, there are generally two remediation methods for reducing exposure risk: 1. Excavating contaminated soils for appropriate disposal, and 2. Capping contaminated soils with two feet of clean fill.

Typically, Storey County has approached work in these areas by minimizing excavation and not relocating any potentially contaminated soil to any other parts of the community. Accumulated sediment from storm events is typically removed from roadways and replaced as roadside berms.

2.0 HYDROLOGIC AND HYDRAULIC MODELING

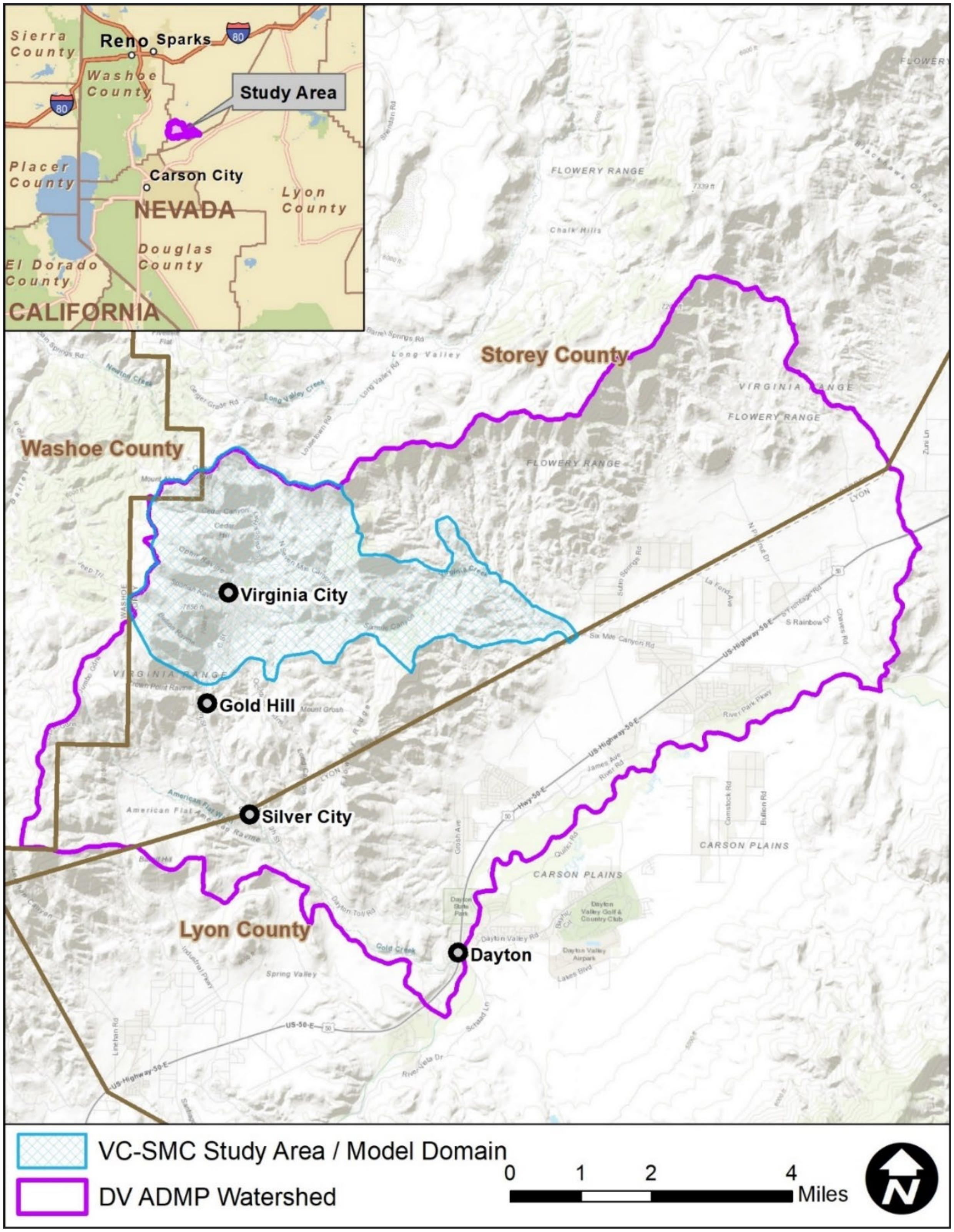
2.1 Method Description

Since the Dayton Valley ADMP (DVADMP) (JE Fuller, 2019) modeling area covers the Virginia City and Six Mile Canyon (VC-SMC) study area (Figure 2.1), the procedures and modeling approach applied for this study are based on the DVADMP. The following hydrologic and infiltration approaches used in the overall DVADMP study were applied here:

- Infiltration was simulated using runoff Curve Number (CN) methodology.
- Rainfall depths were based on the NOAA Atlas 14 (NOAA14) precipitation estimates.
- The temporal distribution of the 6-hour storms was based on the balanced mass curve, while the 24-hour storms were based on the Nevada Department of Transportation (NDOT) GLE mass curve. Only the 24-hour storms were used in the VC-SMC ADMP.

All modeling, both hydrologic and hydraulic, was done using the FLO-2D Pro software[1] package, Build No. 21.08.23 with an executable dated September 17, 2021. This version has been used for multiple area drainage master studies, has substantial improvements in model runtime when compared with previous versions, and has been approved by the Flood Control District of Maricopa County through their FLO-2D version approval process. FLO-2D was selected for the current study to maintain method consistency with the DVADMP and because it is a combined rainfall-runoff model (i.e., both hydrologic and hydraulic processes are simulated within the model).

FIGURE 2.1 VC SMC STUDY AREA IN RELATION TO THE DVADMP WATERSHED



2.2 Precipitation Development

As a part of the VC-SMC ADMP, two design storms were simulated:

- 25-year, 24-hour
- 100-year, 24- hour

Storey County does not have design storms identified in county regulations. The 24-hour durations were chosen to be consistent with Lyon County drainage regulations as this system eventually discharges to Lyon County.

2.3 Model Results

2.3.1 Depth and Discharge Results

Flow depth and discharge results from the existing conditions FLO-2D modeling are shown from Figure 2.2 to Figure 2.5. Existing Conditions 25-year, 24-hour Discharge Results**.** These figures are for general illustrative purposes and not practical for obtaining detailed information at site-specific locations which includes the grid-based results for the maximum flow depth, maximum peak discharge, maximum velocity, and other FLO-2D results.

FIGURE 2.2 EXISTING CONDITIONS 100-YEAR, 24-HOUR FLOW DEPTH RESULTS

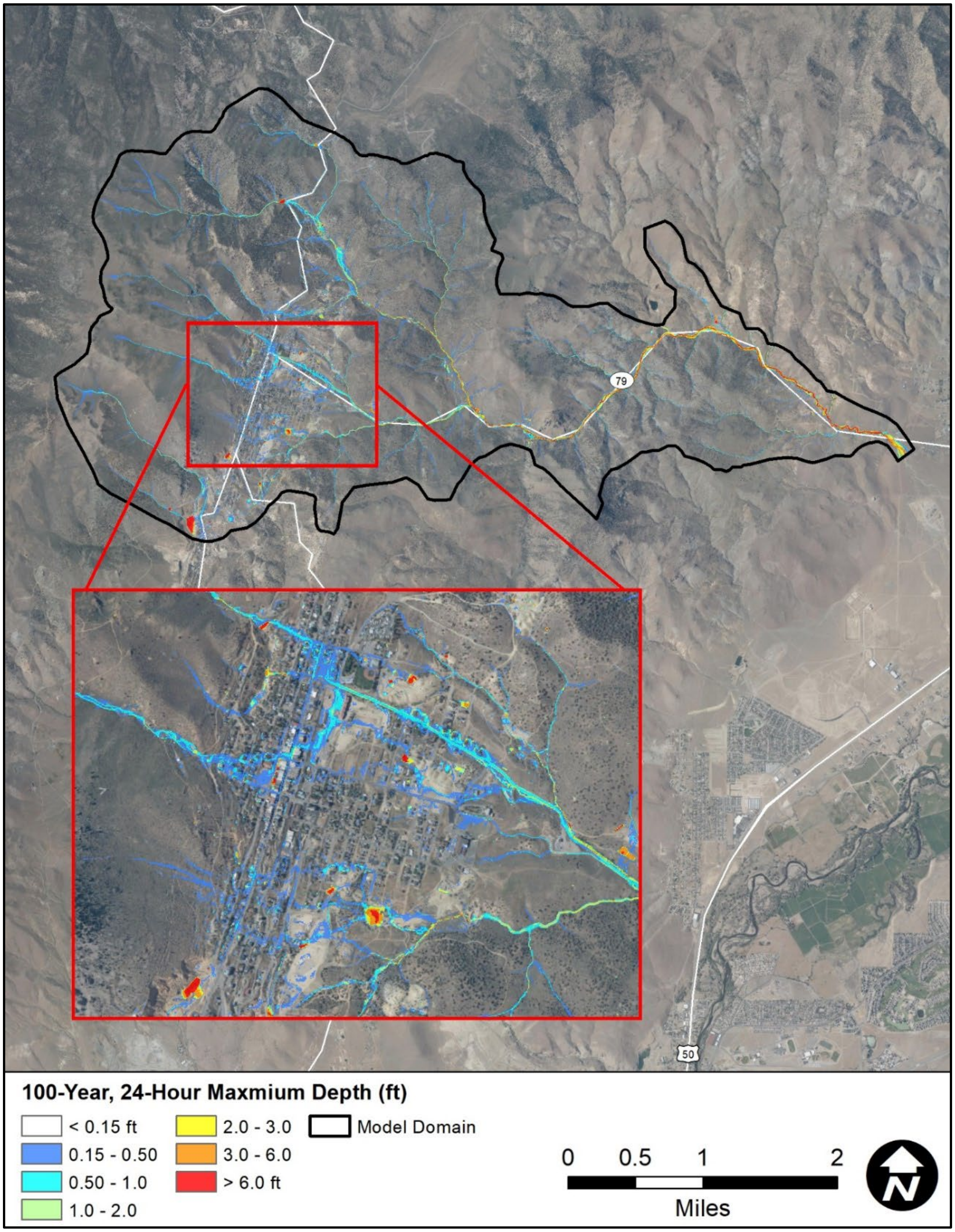


FIGURE 2.3 EXISTING CONDITIONS 25-YEAR, 24-HOUR FLOW DEPTH RESULTS

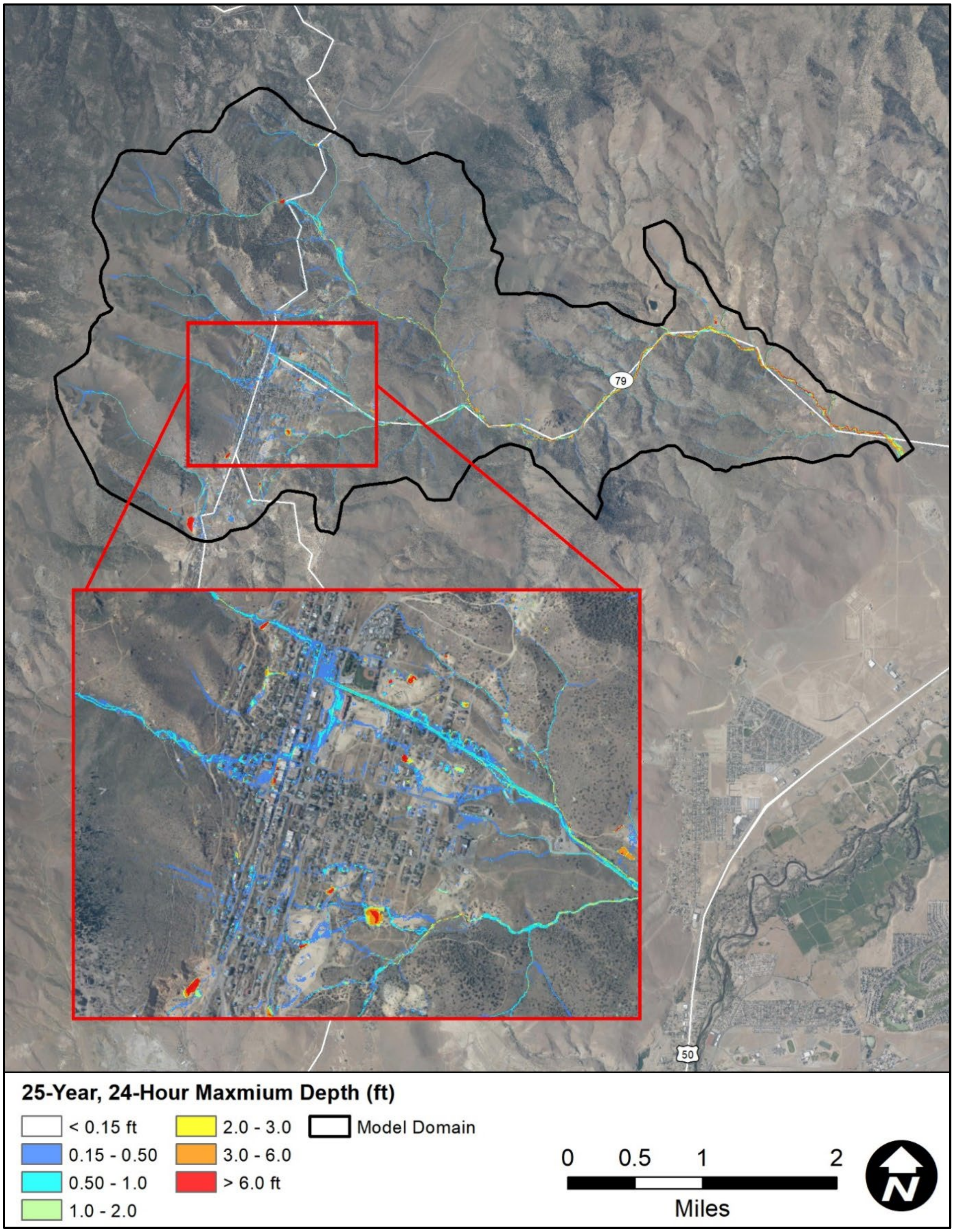


FIGURE 2.4 EXISTING CONDITIONS 100-YEAR, 24-HOUR DISCHARGE RESULTS

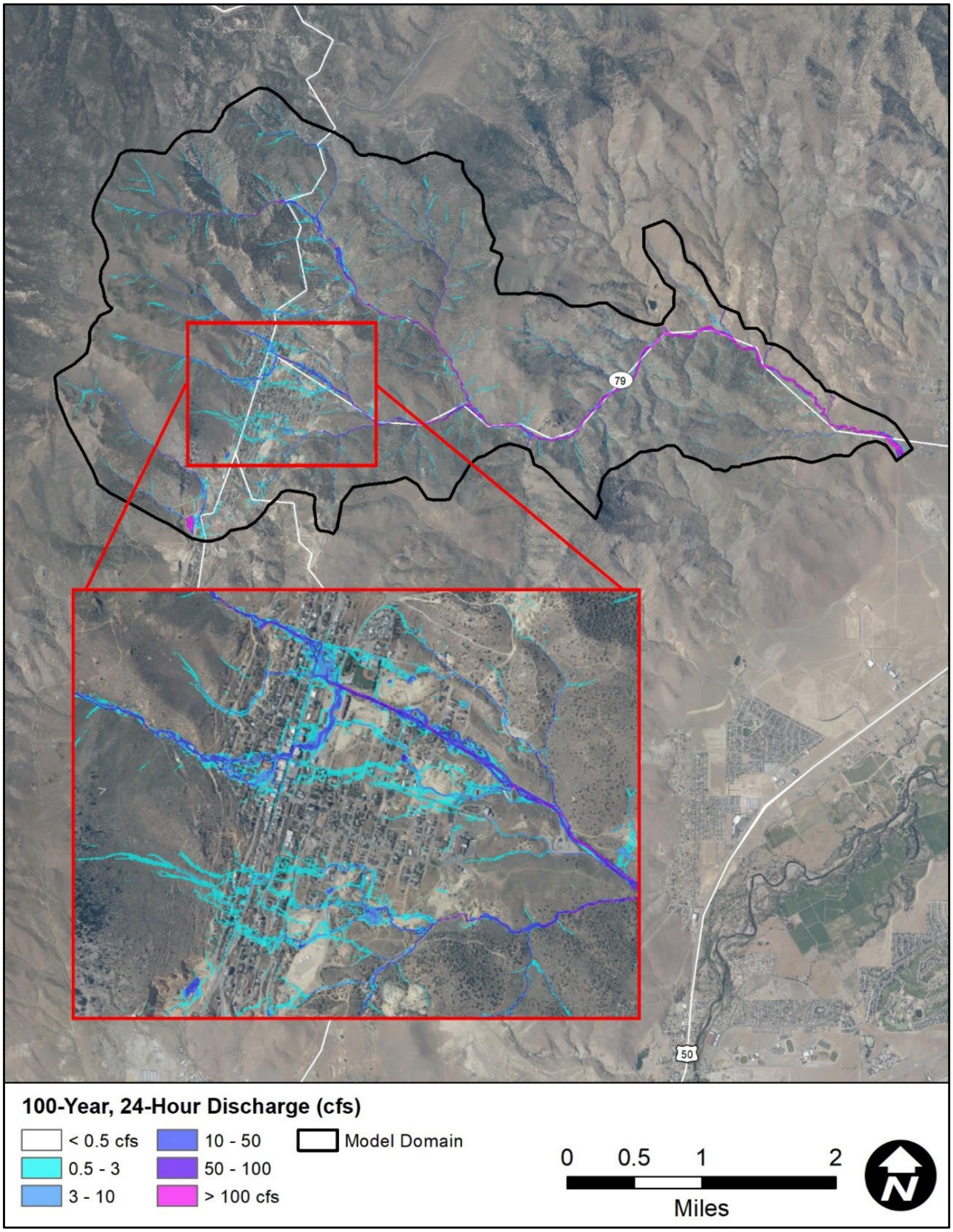
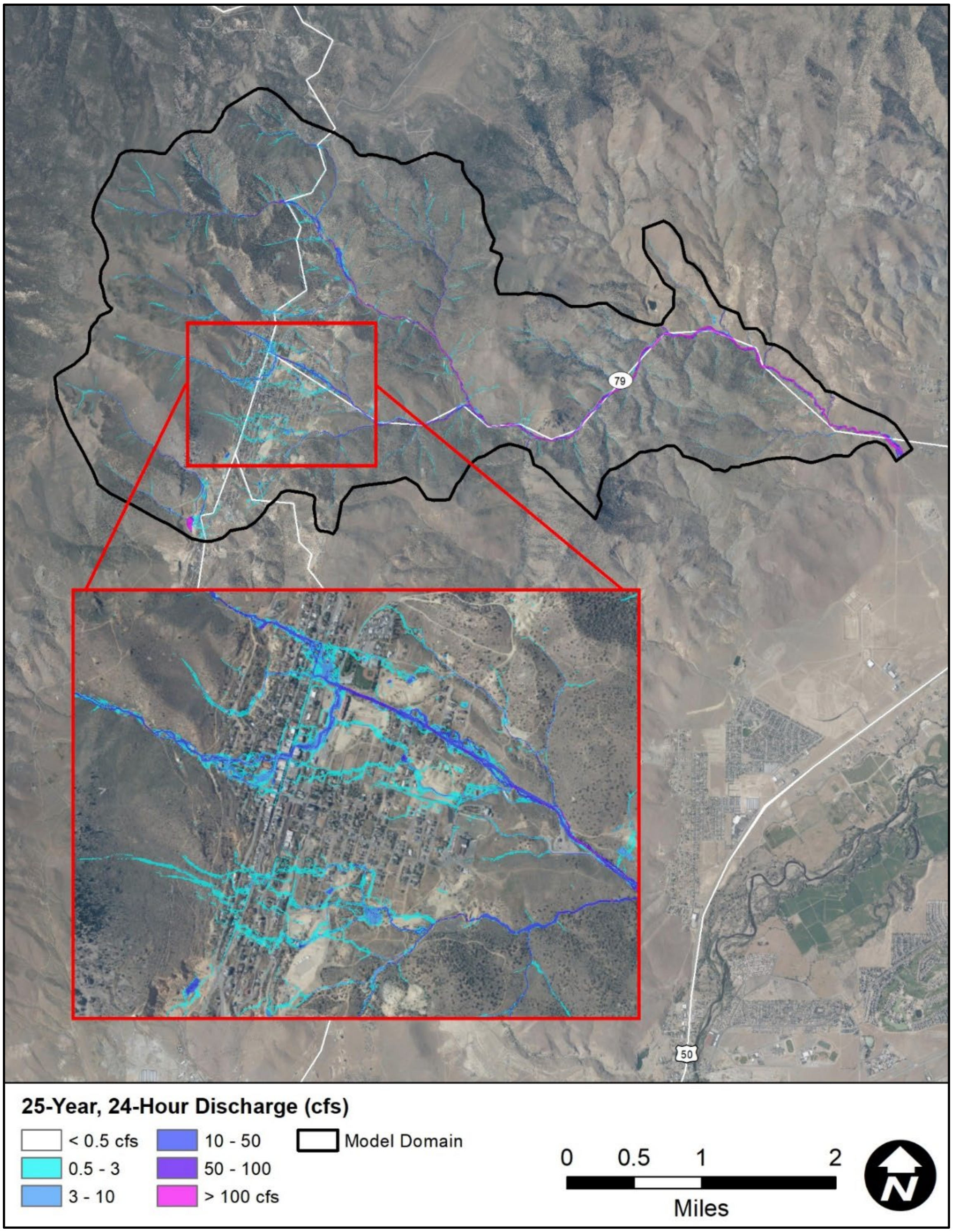


FIGURE 2.5 EXISTING CONDITIONS 25-YEAR, 24-HOUR DISCHARGE RESULTS



2.4 Verification of Results

2.4.1 Comparison with the Dayton Valley ADMP

Since the DVADMP results are part of an approved study that was verified with historical flooding documentation and the 100-year USGS regression equation for the Eastern Sierras Region 5 (USGS, 1997), the VC-SMC FLO-2D results were compared with DVADMP at the most downstream location of Six Mile Canyon. The comparison location and the hydrographs from the two studies are shown in Figure 2.6. The VC-SMC hydrograph is consistent with the earlier DVADMP results but shows a slightly lower peak due to Manning's n value adjustments.

2.4.2 Field Verifications and Meeting with County Employees

On June 21, 2022, Lumos and JEF staff conducted a site visit and reviewed the preliminary modeling results. This information was presented to the County and public at a public meeting held that same evening. The preliminary results generally depicted what had been observed during storm events; however, observed flows were also noted in areas not indicated in the modeling results. Therefore, velocities were reviewed by running additional model outputs. It was determined that these additional areas of observed flows were areas where resultant flow depths were too shallow to show in the model animation. However, the velocity results verified flows in these areas matched the observed conditions. Lumos staff met again with County employees on September 28, 2022 with the results of the additional review described above. Lumos staff met again with County employees on June 22, 2023. The significant storm events and winter snow conditions created numerous flooding conditions within the study area throughout the previous several months. This meeting and site visit reviewed and compared the modeled flooding areas with major problem areas identified by County staff from the winter and spring storms. The flooding areas correlated well with the model results and were incorporated into the evaluation for flood mitigation potential.

2.4.3 Historical Flooding Documentation

As a part of the public outreach effort, the project team collected flood photos from residents and County staff within the project area. Additionally, Lumos staff documented flood flows during a storm event on August 9, 2022. Residents and County staff also provided photo documentation of the severe rain events that occurred in January and June of 2023.

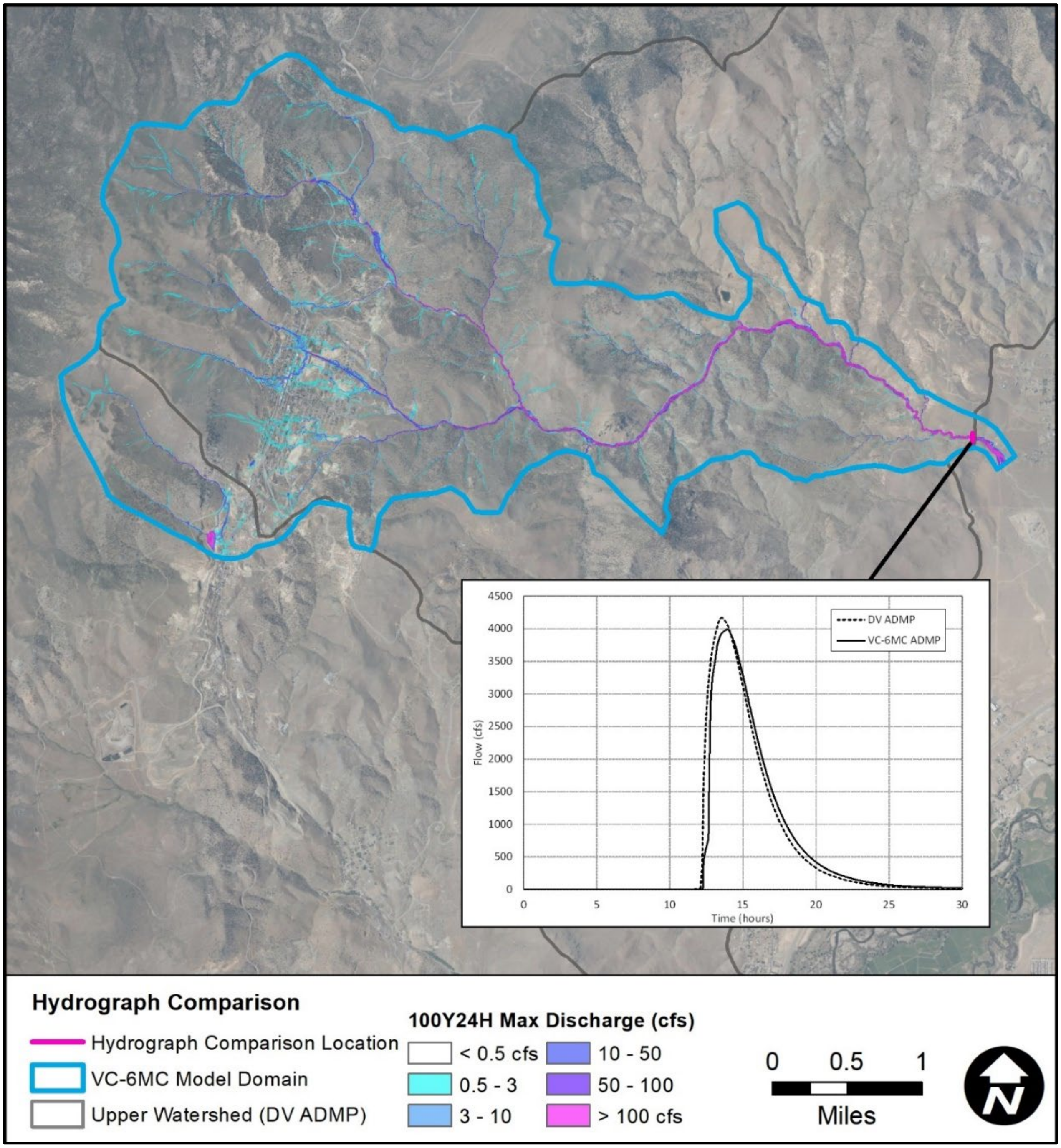
2.4.4 Summary

The existing conditions FLO-2D models were created using the best available information for land cover, land use, topography, and hydrology. Utilizing the FLO-2D model maintained consistency with the earlier DVADMP. Like all models, the VC-SMC FLO-2D models simulate a spectrum of potential conditions during a range of storm events. The models cannot duplicate actual, observed storm events at all locations within the community due to the vast number of variables that change with each unique storm event.

The modeling results reflect the complex flooding and sedimentation hazards that exist within the VC-SMC study area. The results provide valuable, quantitative, and detailed information on which future planning and development decisions can be based. The existing conditions models also serve as a foundation on which potential mitigation alternatives can be assessed (see Section 4.0).

Although the ADMP FLO-2D modeling effort was not intended to replicate an actual historical flood event, the comparison of the modeling results with previous studies indicate that the results are reasonable. However, updated mapping and new FLO-2D modeling are recommended if significant changes to the topography or surface features occur in the future.

FIGURE 2.6 100-YEAR, 24-HOUR HYDROGRAPH COMPARISON ON SIX MILE CANYON



2.5 Sedimentation Analysis

2.5.1 Site Visit

Lumos identified three watersheds of interest that drain to Virginia City where flood control basins may be implemented (see Figure 2.7). JE Fuller performed a site visit to verify field conditions (i.e., typical surface cover and soil conditions) in the three watersheds in September 2022. Examples of typical surface cover (left) and soil conditions (right) observed in the field are shown in Figure 2.8. The soil was generally gravelly sand, and these observations helped determine what methodology and parameters were used in the sediment yield analysis. Tables 2.1 and 2.2 provide estimates of sediment yield and peak discharge for use in design.

FIGURE 2.7 WATERSHEDS OF INTEREST

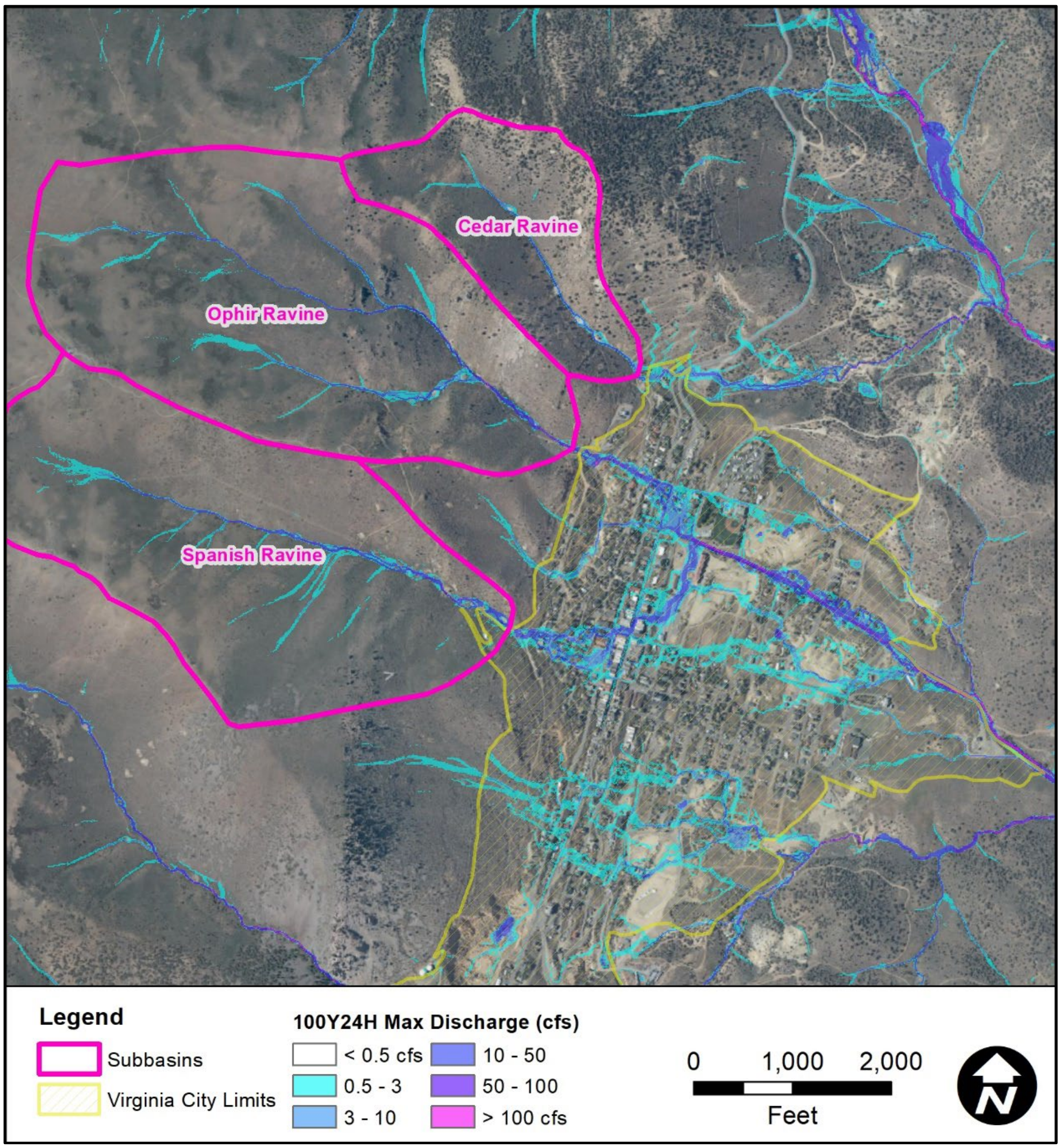


FIGURE 2.8 TYPICAL EXAMPLES OF SURFACE COVER (LEFT) AND SOIL CONDITIONS (RIGHT)

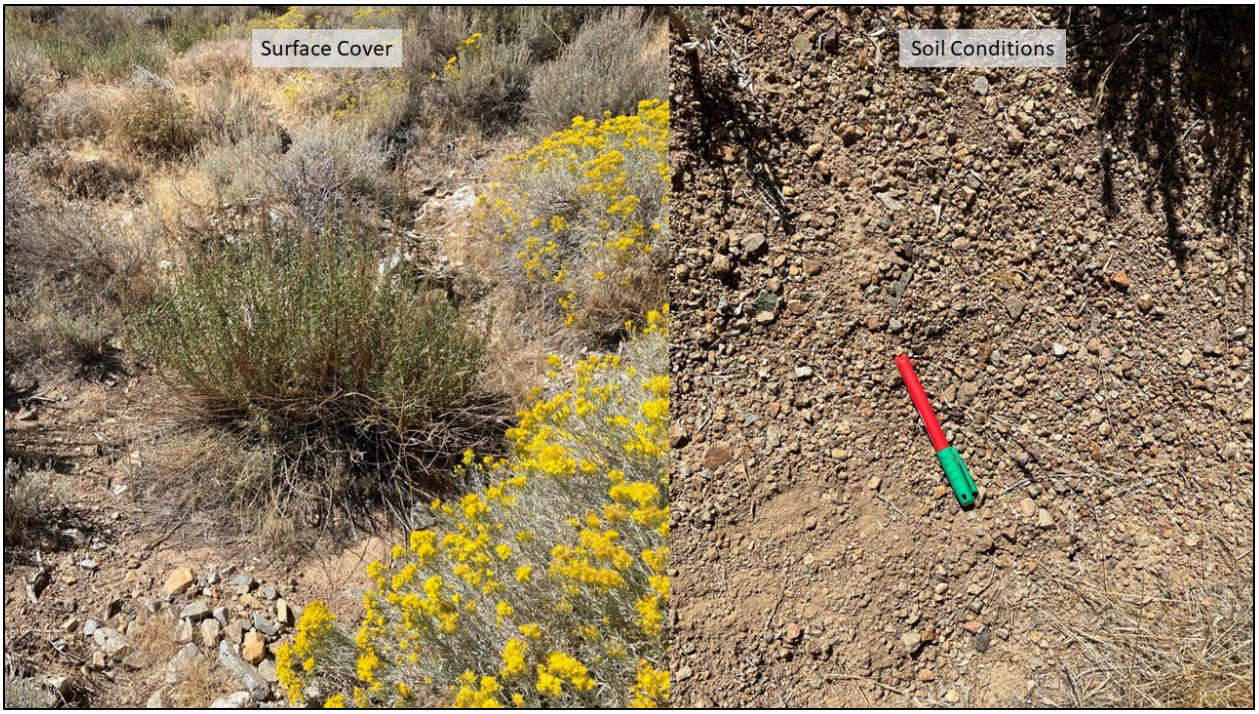


TABLE 2.1 SEDIMENT YIELD ESTIMATES (AC-FT)

Concentration Point	Basin Area	100-Year	50-Year	25-Year	10-Year	5-Year	2-Year	Annual
	sq. miles	ac-ft	ac-ft	ac-ft	ac-ft	ac-ft	ac-ft	ac-ft
Cedar Ravine	0.15	0.55	0.31	0.36	0.1	0.06	0.02	0.05
Ophir Ravine	0.45	1.12	0.4	0.72	0.14	0.08	0.03	0.09
Spanish Ravine	0.4	0.28	0.55	0.17	0.19	0.12	0.04	0.07

TABLE 2.2 PEAK DISCHARGE SOURCE FOR MUSLE ANALYSIS

Concentration Point	100-Year*	50-Year**	25-Year*	10-Year**	5-Year*	2-Year*
	cfs	cfs	cfs	cfs	cfs	cfs
Cedar Ravine	45	36	32	30	29	28
Ophir Ravine	156	123	106	96	93	91
Spanish Ravine	31	11	19	3	2	2

2.6 Results Interpretation

The results displayed in the previous sections, as well as the site visit described in Section 2.5.1 were analyzed by Lumos to form consolidated focus-areas for the VCADMP. The modeled and mapped flow-areas, along with field-verified site observations, showed that the flood flowpaths of highest concern progressed from the Spanish Ravine to the south, and the Ophir/Cedar Ravines to the north. In addition, concentrated flows along Six Mile Canyon Road showed evidence of flooding and erosive behavior. These focus areas formed the basis for flood mitigation measures described in Section 4.0.

3.0 LOCALIZED FLOOD CONTROL MEASURES

3.1 Introduction

Within Virginia City proper and along Six Mile Canyon, several flood control measure opportunities were identified that would have a significant impact on localized flooding and the resultant maintenance requirements after a flood event. These measures are discussed in this section to provide the County with smaller, less costly measures that can be implemented in concert with the regional alternatives discussed in the previous section.

3.2 Virginia City Flood Control Measures

3.2.1 Surface Flow in Streets

Within Virginia City proper, most streets have no formal roadside conveyances. The exceptions are a few sections of AC lined roadside swales or AC berms and a few drainage culverts. Runoff from most storm events collects quickly and reaches high velocities (>8 fps). Flows typically run west to east until road cross slopes divert water to flow north or south, depending on the street. The high velocity of these discharges mobilize sediments, gravels and larger cobbles to erode from the road shoulders. As runoff slows, these materials are deposited at low points or at slope changes along the road. As a result, maintenance of public and private property is costly and challenging for County staff and residents.

A potential mitigation solution would be to construct shallow, paved AC swales along primarily the east/west running streets where runoff from previous storm events have removed the existing shoulder material and created channels would benefit the community. These AC swales are proposed at existing road intersections where it may not be feasible to install culverts to convey flows beneath the existing roadways. Broad (8-ft width typically) AC or concrete valley gutters with shallow depths to flowlines should be constructed to convey flows through the intersections. By keeping the swale wide with a shallow depth to flowline, snow plowing operations should not damage the swales.

Most streets have no formal roadside conveyances.

Additionally, where there are existing catch basins and short sections of storm drain pipe, the County should review the functionality and maintenance requires of each system. Through our field visits during and after storm events, there were notable areas where existing facilities do not appropriately capture road runoff (South L Street for example) and where unstabilized discharge points create significant erosion (discharge point of existing storm drain in South L Street). Additional drop inlets or AC/paved swales across existing roads would help convey flows to existing drop inlet structures. Outlets should be stabilized with rock riprap to ensure slopes do not erode.

3.2.2 Private Driveway Runoff

All future development should be required to stabilize private driveways. Stabilization could include AC or concrete paving or placement of gravel, depending on the slope of the driveway. Driveway stabilization measures should be required to extend to the existing road, into the public Right-Of-Way. Any existing roadside conveyance channels should be propagated through the installation of culverts or swales.

3.3 Six Mile Canyon Flood Control Measures

3.3.1 Six Mile Canyon Culvert Improvements

Regular maintenance of the roadside channels should be included in the County's operations and maintenance budget. Due to the limited right of way and minimal shoulders, construction of a roadside channels along the entire roadway is not feasible without significant graded and slope stabilization. However, the County will see significant benefit by including regular maintenance of the existing channels in their operations and maintenance budget.

Along with the regular maintenance of the roadside channels, installation of new culverts at all low points in the channels to convey flows from the roadside channel to the main drainage channel will alleviate much of the roadside channel overtopping. Proposed culverts should be a minimum of 18-inch diameter smooth interior walled pipe (HDPE or PVC) to provide hydraulic efficiencies. Inlets and outlets to the pipes should be lined with rock riprap.

The County will see significant benefit from including regular maintenance in their budget.

3.3.2 Six Mile Canyon Access Road/Driveway Connections

With the increase in development in primarily the eastern portion of Six Mile Canyon, a standard for access road/driveway connections to Six Mile Canyon Road should be adopted by the County. A rolling-dip style driveway approach is suggested for all future developments. If there is an existing roadside channel that should be continued through the proposed driveway, a new culvert with a minimum diameter of 15-inches should be required to be installed.

3.3.3 Existing Culverts Inlet/Outlet Protection

There are several smaller culverts that cross Six Mile Canyon Road and have erosion issues during small and large events. These culverts often have no flared end sections or headwalls, therefore creating inefficient and erosive hydraulics. The scour and erosion could be minimized by adding a headwall with rock riprap stabilized inlets and outlets, therefore forcing the storm water into the culvert efficiently.

3.3.4 Roadway Slope Protection

Six Mile Canyon has several locations where the stream is gradually eroding closer to the existing roadway shoulder and slope. In an attempt to prevent undercutting of the slope, roadway slope protection is recommended.

4.0 PROPOSED FLOOD MITIGATION PROJECTS

4.1 Introduction

Lumos was tasked with developing a series of potential flood mitigation projects based on the modeling outlined in Section 2.0 and various site visits in known problem-areas. The investigation demonstrated Virginia City is flooded by discharge water from Spanish Ravine to the south, and Ophir and Cedar Ravines to the north. In addition, known flood hazards issues along Six Mile Canyon were included as part of the flood mitigation effort.

Concept Design Plans for the 25-year, 24-hour storm events were prepared for key flood mitigation Projects. During the initial phases of this project, site limitations due to the steep topography were discussed and noted. This report built upon the 25-year, 24-hour; and the 100-year, 24-hour DVADMP hydrology for the ADMP with no substantial modifications. With the site limitations it was agreed that proposed mitigation alternatives within Virginia City proper would aim to address flows from the 25-year, 24-hour event with consideration of the 100-year, 24- hour event flows. The 100-year, 24-hour flows were the basis for proposed improvements along Six Mile Canyon.

The key Projects are described in subsequent sections. The Concept Design Plans were developed to a 15% preliminary design level. The Plans' intended use is to capture general characteristics of the proposed improvements and provide adequate information for budgetary cost estimates, so that informed recommendations can be developed. The various design components, including detention basins extents and capacities, pipe alignments, inlet/outlet structures, are not final. The design components and full scope of work will need to be refined before each project progresses to final design. The final design will also incorporate additional considerations that are beyond the scope of the VCADMP, such as utility conflicts, construction limitations, land acquisition and other specific design considerations based on final alignments and proposed project components.

4.2 Detention Basin/Channel/Culvert Concept Design Characteristics

The proposed designs were selected due to the limited existing storm drain infrastructure, available land in Virginia City and the topography of the surrounding areas. Multiple scenarios are proposed to allow for selection based on available funds and desired phasing.
The model ran three mitigation scenarios, but the projects can be phased in several orders. Projects 1, 2a and 2b were included in the model as shown in Table 4.1. As indicated above, Project 3 was not included in the model as the existing basin does not have sufficient size to meet the 25-year, 24-hour storm event design criteria.

Project 1 includes two sub-projects: the construction of a detention basin in Spanish Ravine, hereby called SRB, and the construction of a detention basin in Ophir Ravine, hereby called ORB. These basins are not interconnected and can be built separately on different timelines, as desired by the County. Each basin would have an outlet pipe and emergency overflow weir. In addition, each basin would be fenced and would have access to allow maintenance vehicles to enter the basin for removal of sediment and debris. Existing access roads would be perpetuated around the basins.

Project 2a builds upon Project 1 to provide additional flood alleviation from small and large events. Project 2a connects the SRB to the ORB via a 48” storm drain pipe. This project also connects ORB to Seven Mile Canyon by crossing over Highway 431 and discharging just east of the Highway via a 48" storm drain pipe. This project requires the construction of Project 1 and would need to be built as one uniform project.

Project 2b is an alternative to Project 2a and connects ORB to Six Mile Canyon via a 30" storm drain pipe, instead of Seven Mile canyon.

Project 3 is an existing basin (OEP). The history of the basin is unknown at this time. This project is a standalone project and can be implemented for a cheaper price with a large benefit for smaller storm events.

The following combination of projects can be seen in Table 4.1. Project maximum flow depths, maximum discharges and percentage of flow reductions for each alternative are shown on Figures 4.1 to 4.15.

TABLE 4.1 PROJECT INDEX

Project Number	Included Projects
1	SRB, ORB
2a	SRB, ORB, STOC, OTSC
2b	SRB, ORB, STOC, OTCC
3	OEP
4	SMC

Sediment loading was considered but was not a governing design feature due to limited buildable area for detention basins. Each basin was analyzed taking into consideration the sediment volume for three times the annual estimated load plus a single 100 year storm event. Reference Table 4.2 for the desired and provided sediment storage.

TABLE 4.2 DESIRED AND PROVIDED SEDIMENT STORAGE

Basin	3 x Annual Load*	100 Year Single*	Desired Storage*	Provided*
Ophir Ravine	0.27	1.12	1.39	2.06
Spanish Ravine	0.21	0.28	0.49	1.83

* All values are in Acre-Feet

The basin for Spanish Ravine provides approximately 0.75 acre-feet additional usable volume The Ophir Ravine Basin provides approximately 0.67 acre-feet additional usable volume. O&M manuals will be provided during final design.

FIGURE 4.1 PROJECT NUMBER 1 – 25 YEAR, 24 HOUR MAX DEPTH (FT)

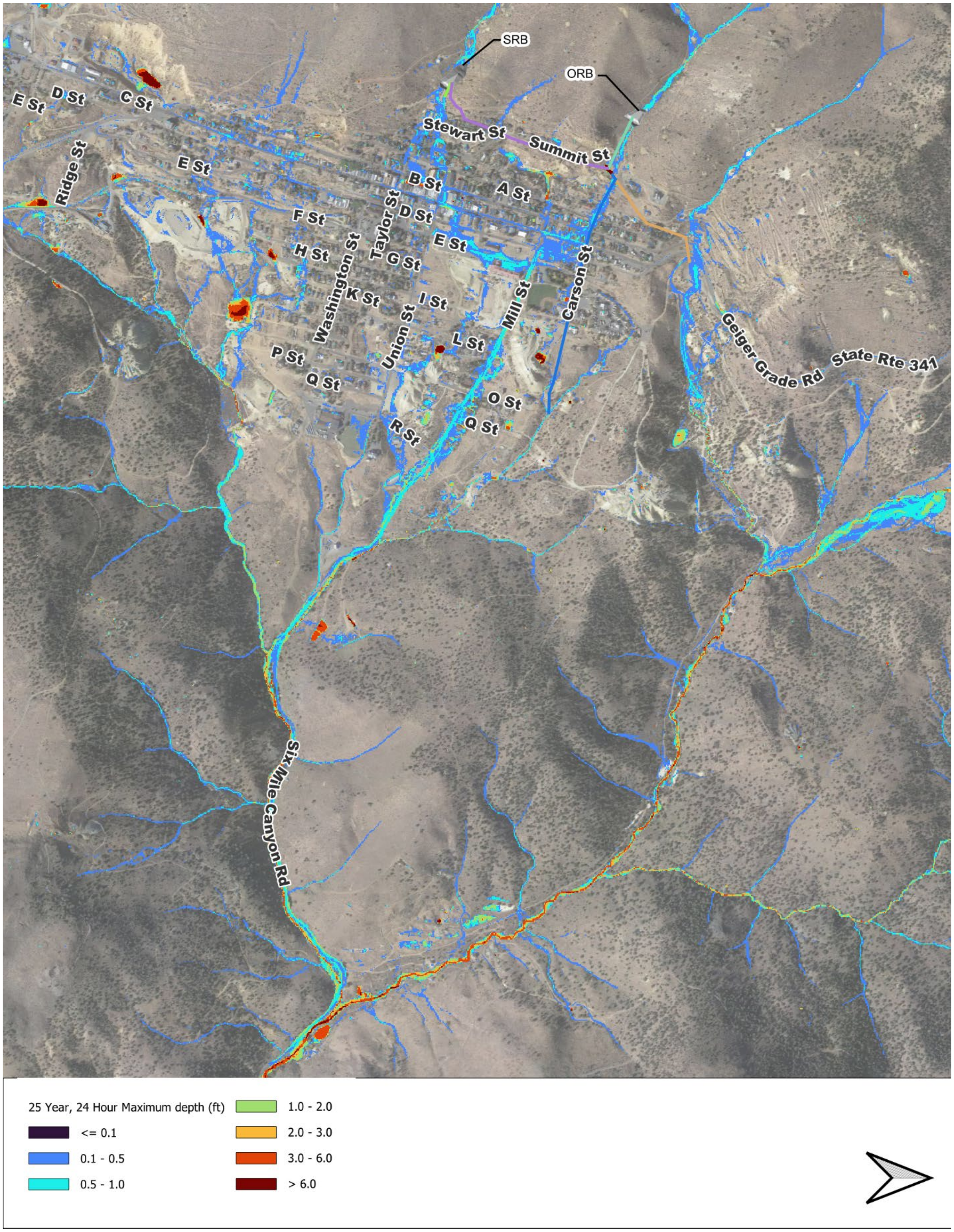


FIGURE 4.2 PROJECT NUMBER 1 – 25 YEAR, 24 HOUR DISCHARGE (CFS)

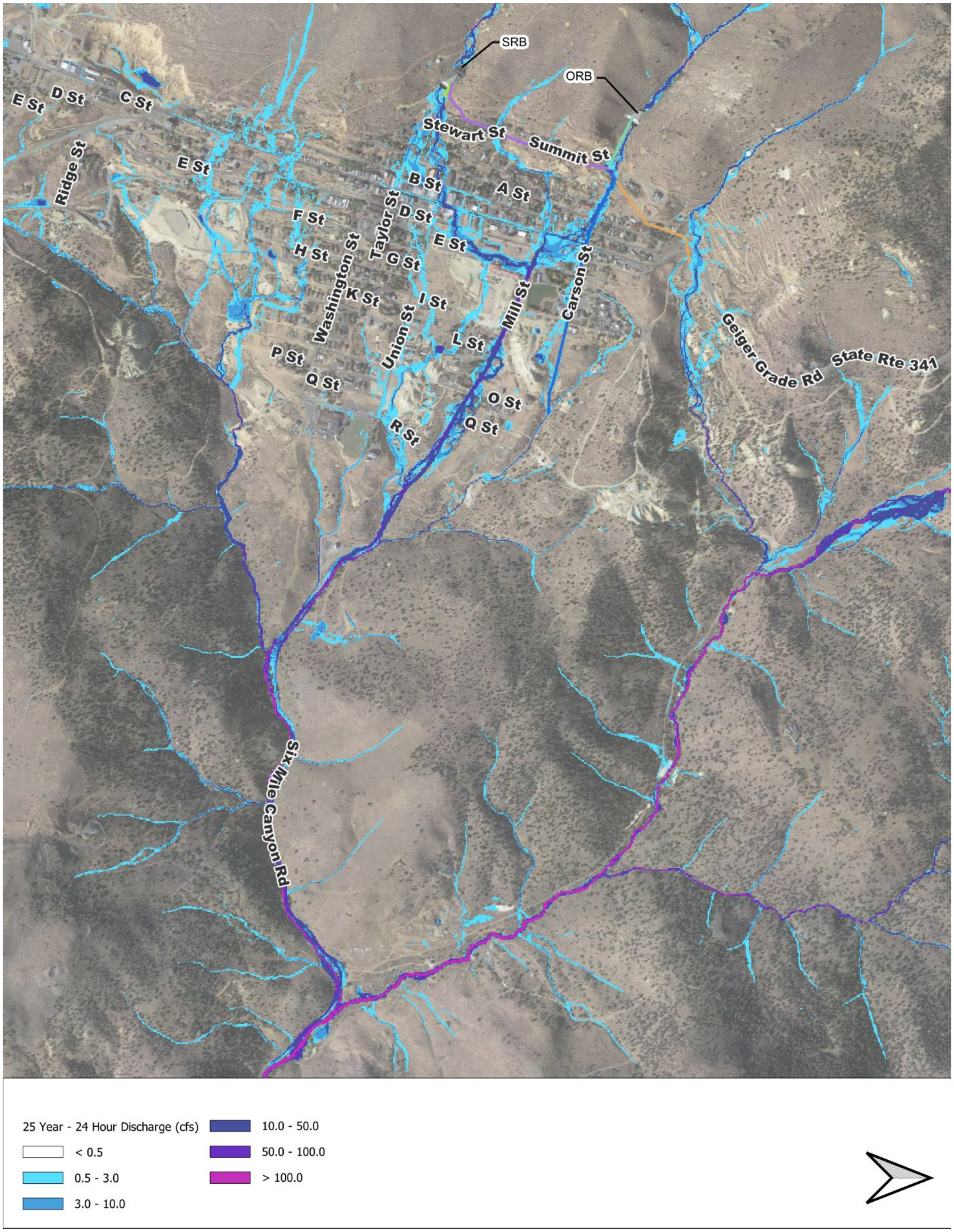


FIGURE 4.3 PROJECT NUMBER 2A – 25 YEAR, 24 HOUR MAX DEPTH (FT)

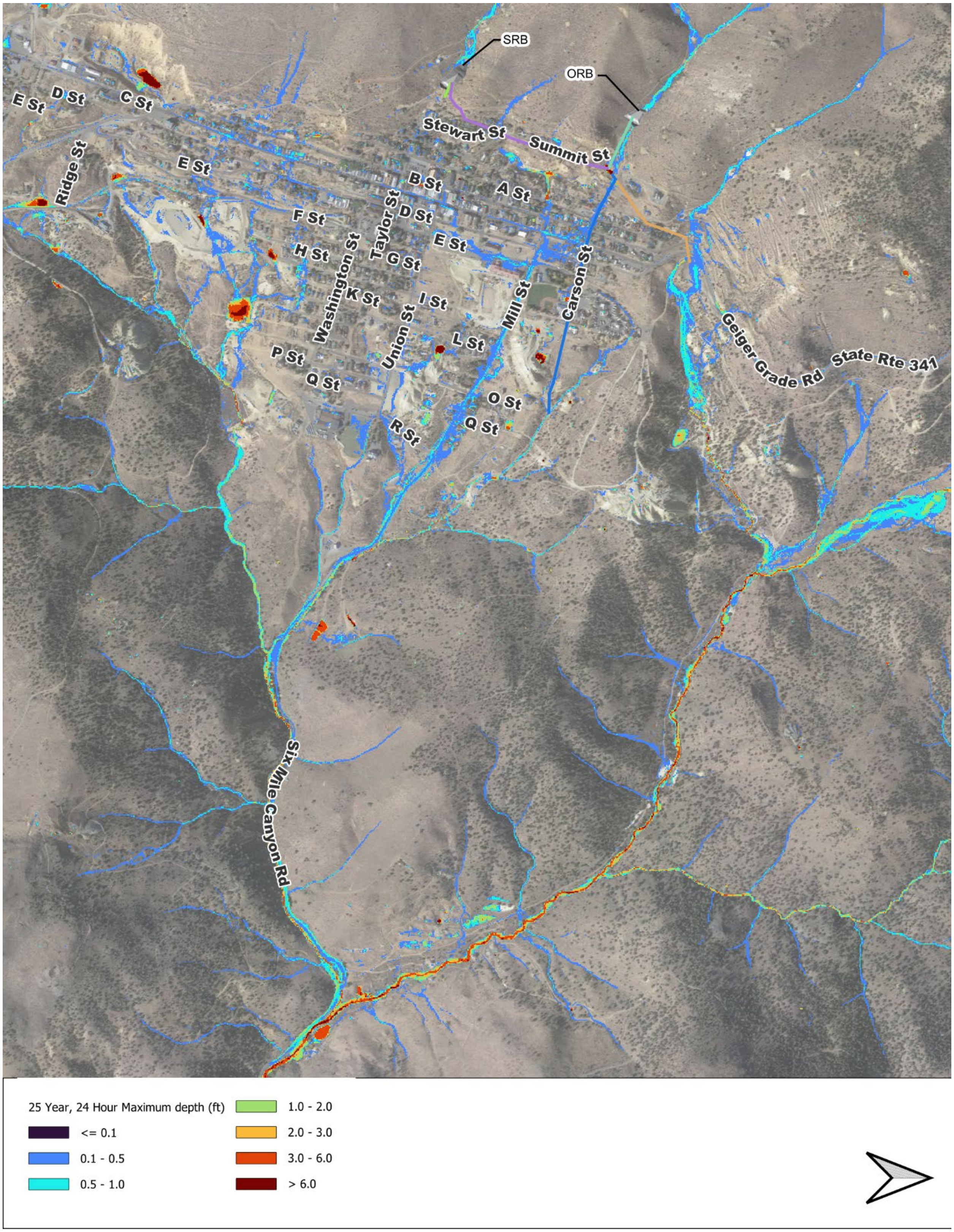


FIGURE 4.4 PROJECT NUMBER 2A – 25 YEAR, 24 HOUR DISCHARGE (CFS)

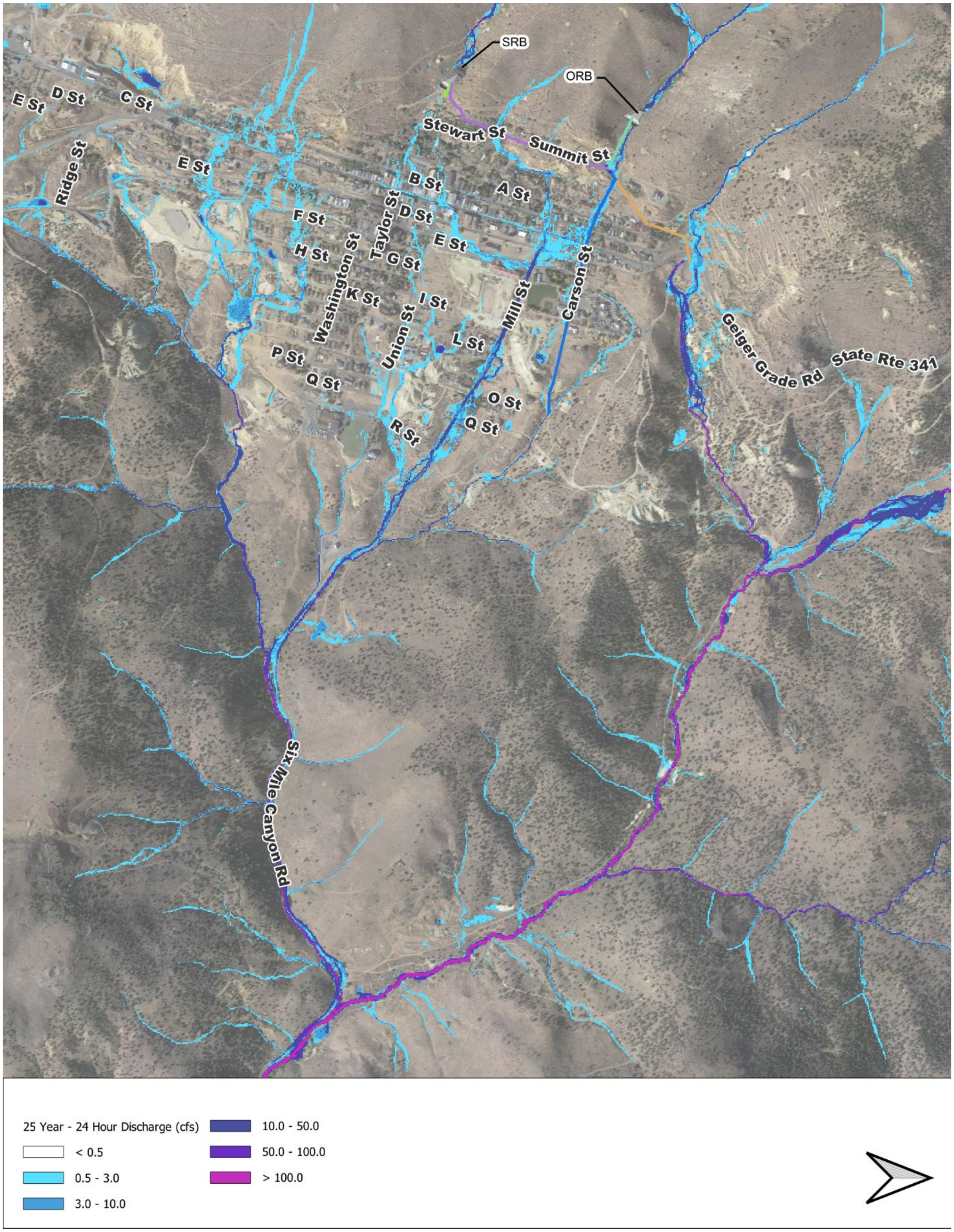


FIGURE 4.5 PROJECT NUMBER 2B – 25 YEAR, 24 HOUR MAX DEPTH (FT)

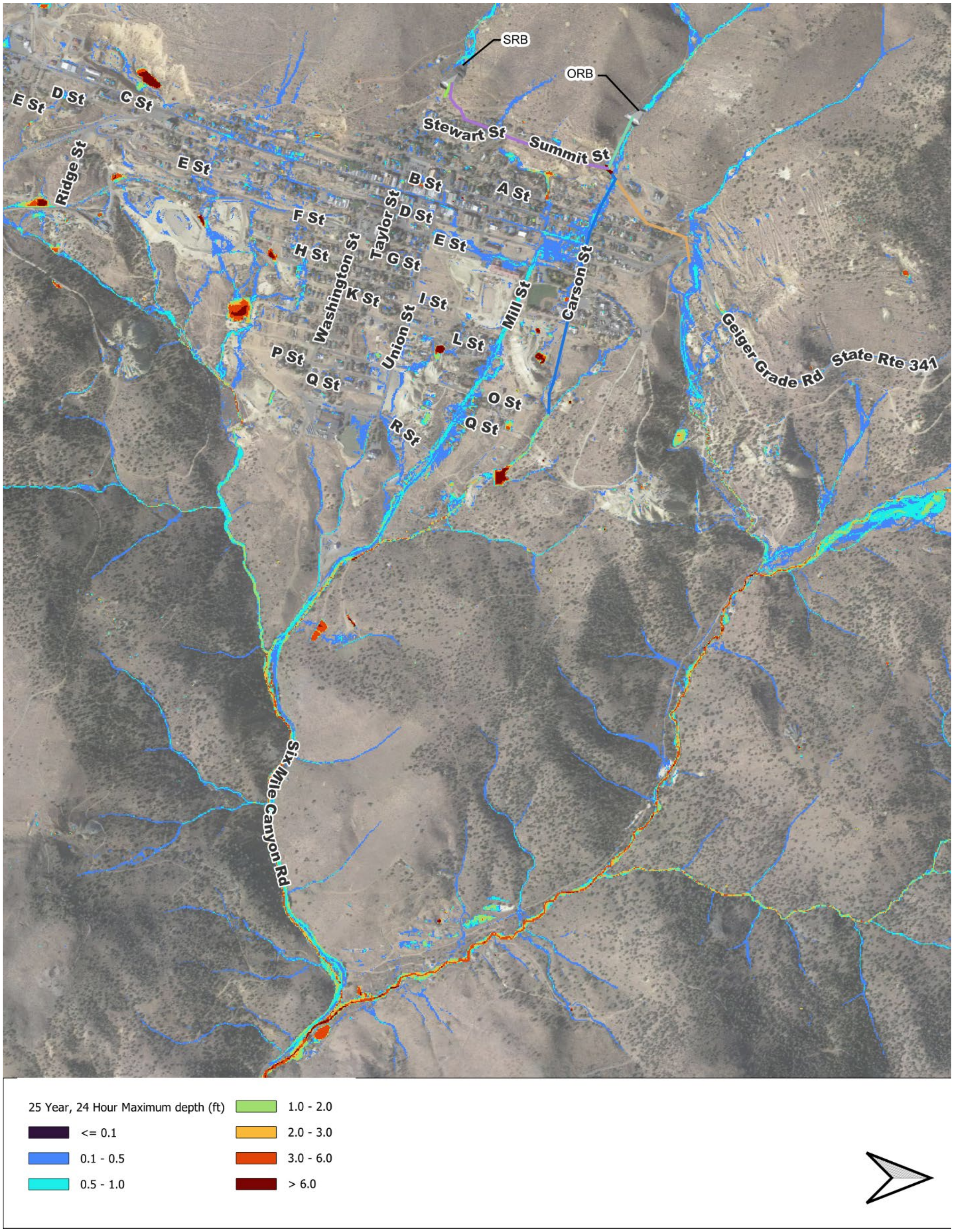


FIGURE 4.6 PROJECT NUMBER 2B – 25 YEAR, 24 HOUR DISCHARGE (CFS)

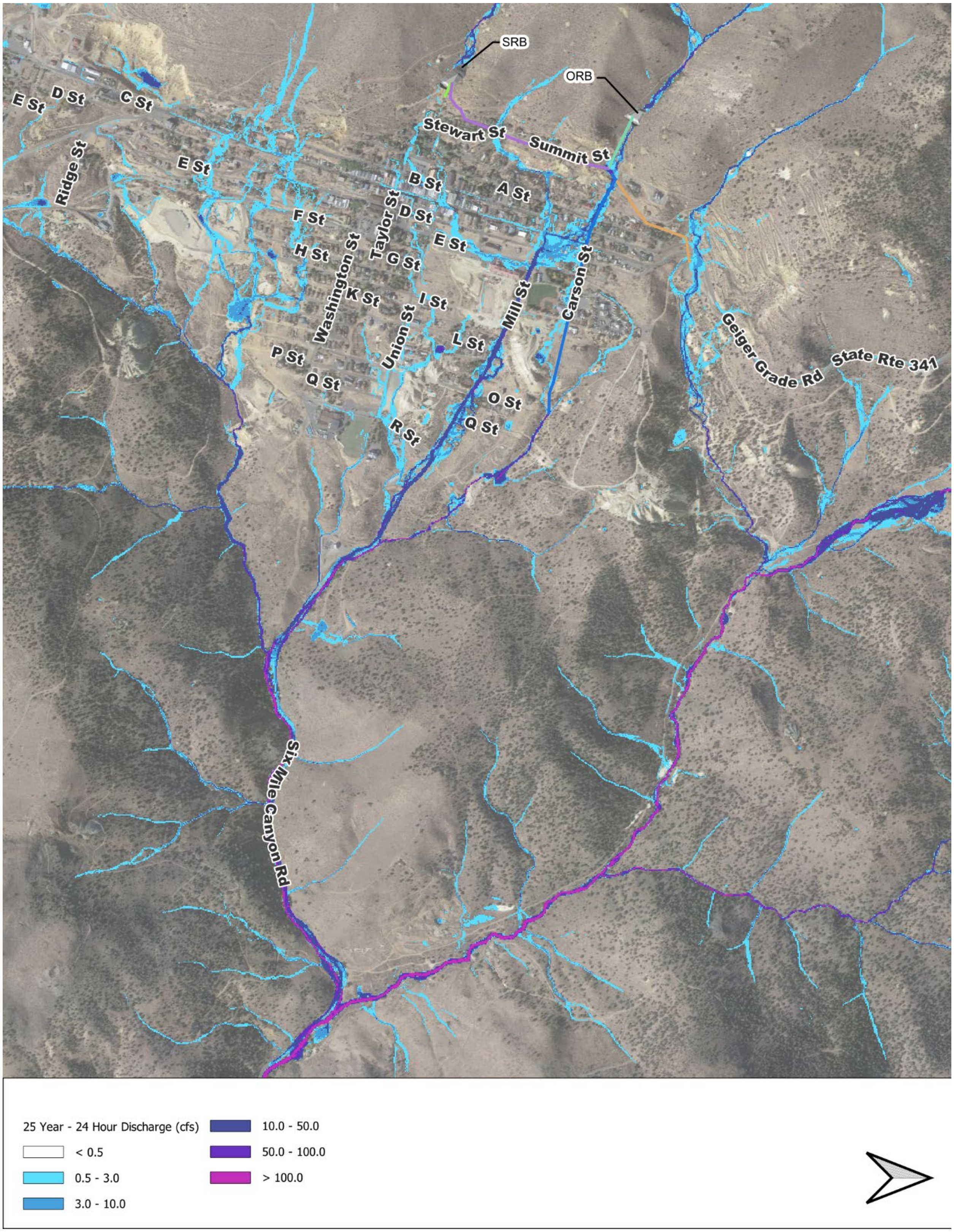


FIGURE 4.7 PROJECT NUMBER 1 – 100 YEAR, 24 HOUR MAX DEPTH (FT)

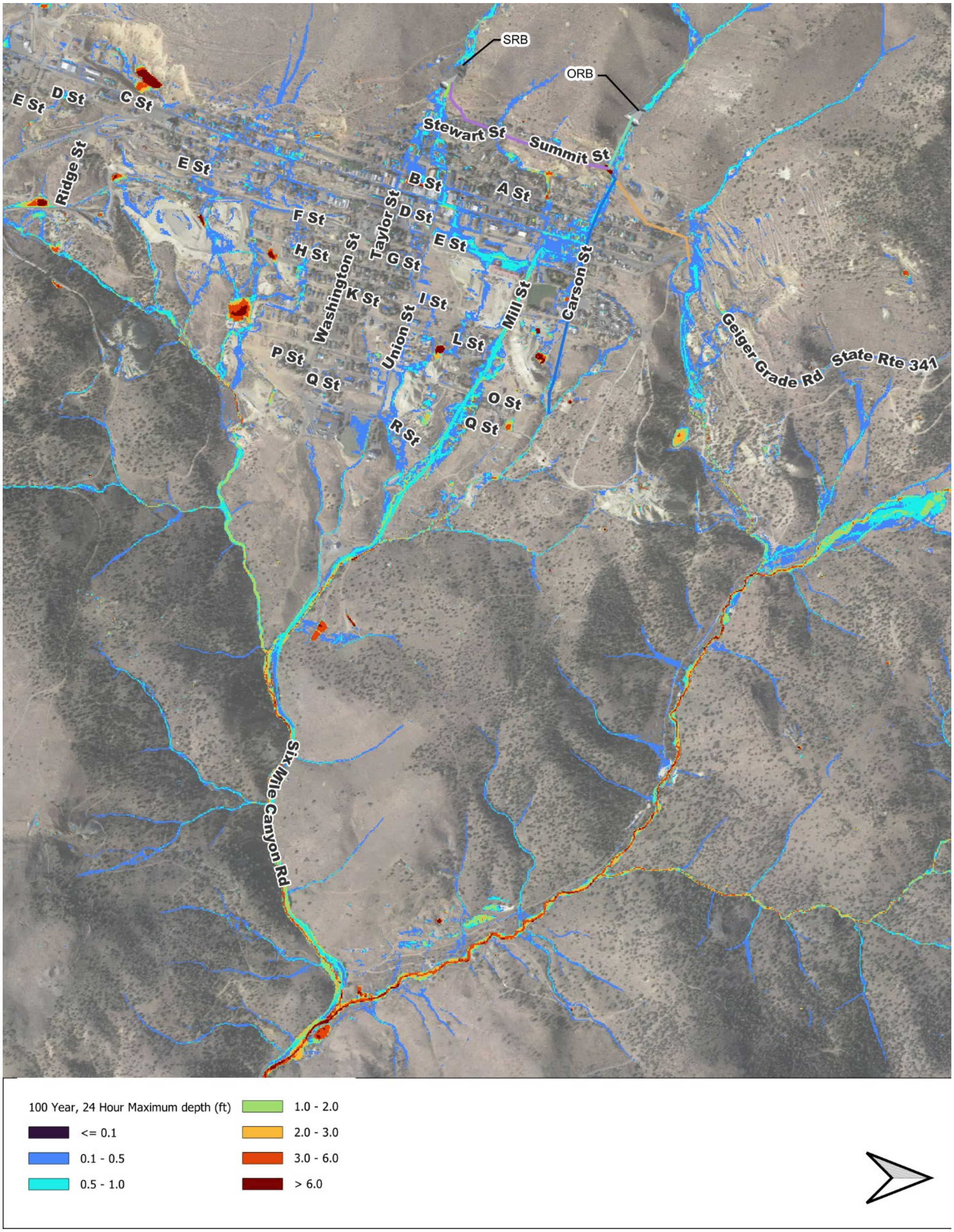


FIGURE 4.8 PROJECT NUMBER 1 – 100 YEAR, 24 HOUR DISCHARGE (CFS)

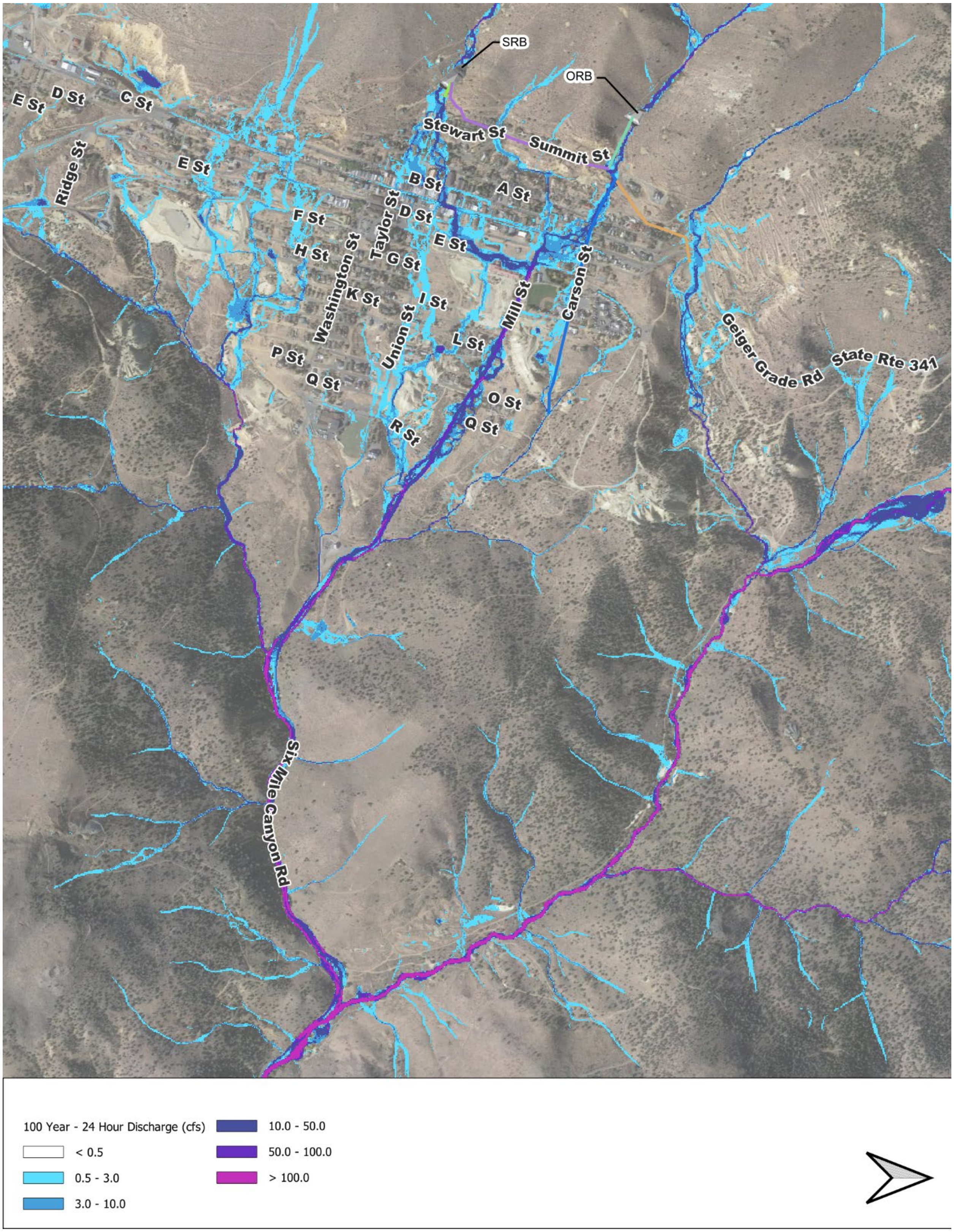


FIGURE 4.9 PROJECT NUMBER 2A – 100 YEAR, 24 HOUR MAX DEPTH (FT)

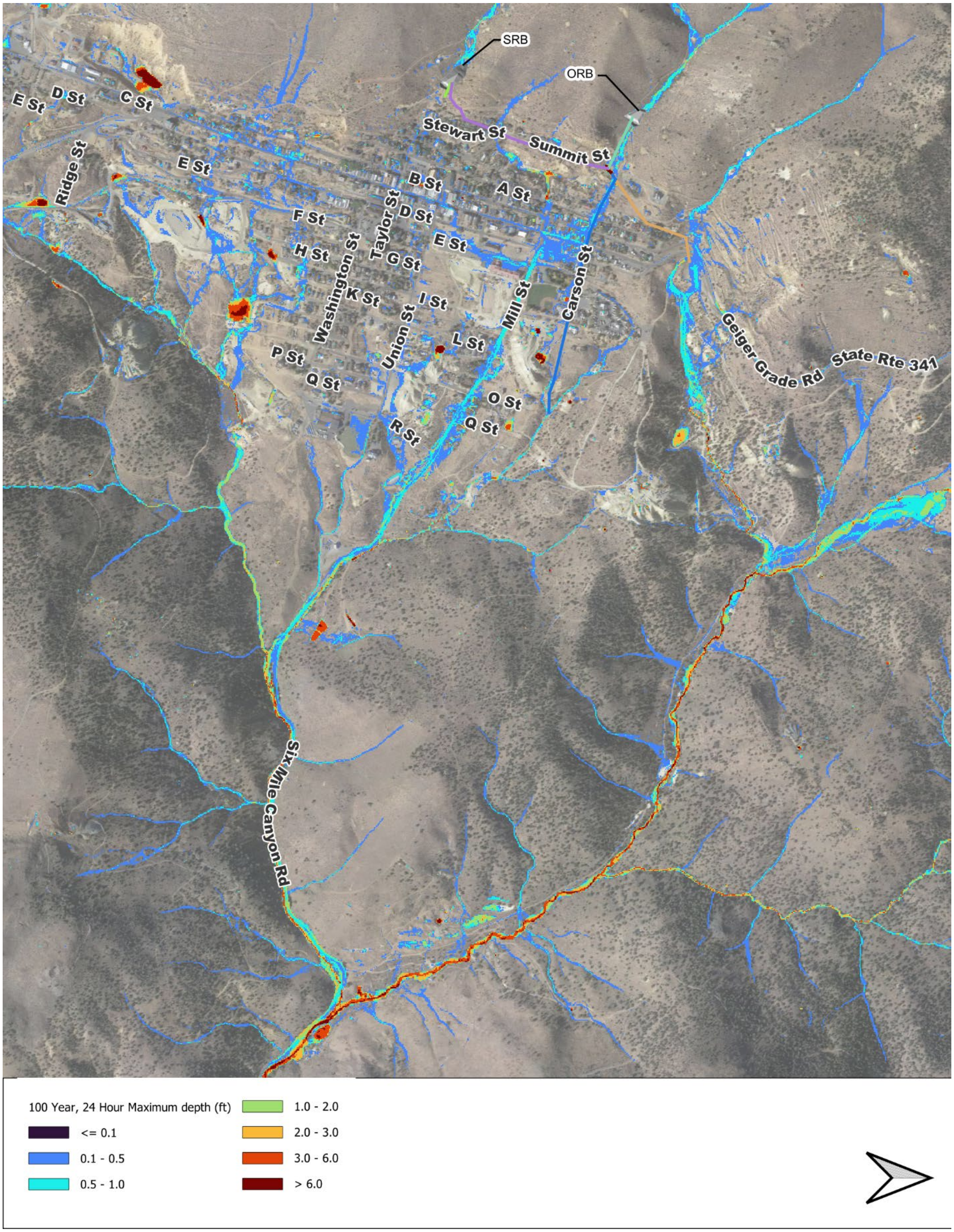


FIGURE 4.10 PROJECT NUMBER 2A – 100 YEAR, 24 HOUR DISCHARGE (CFS)

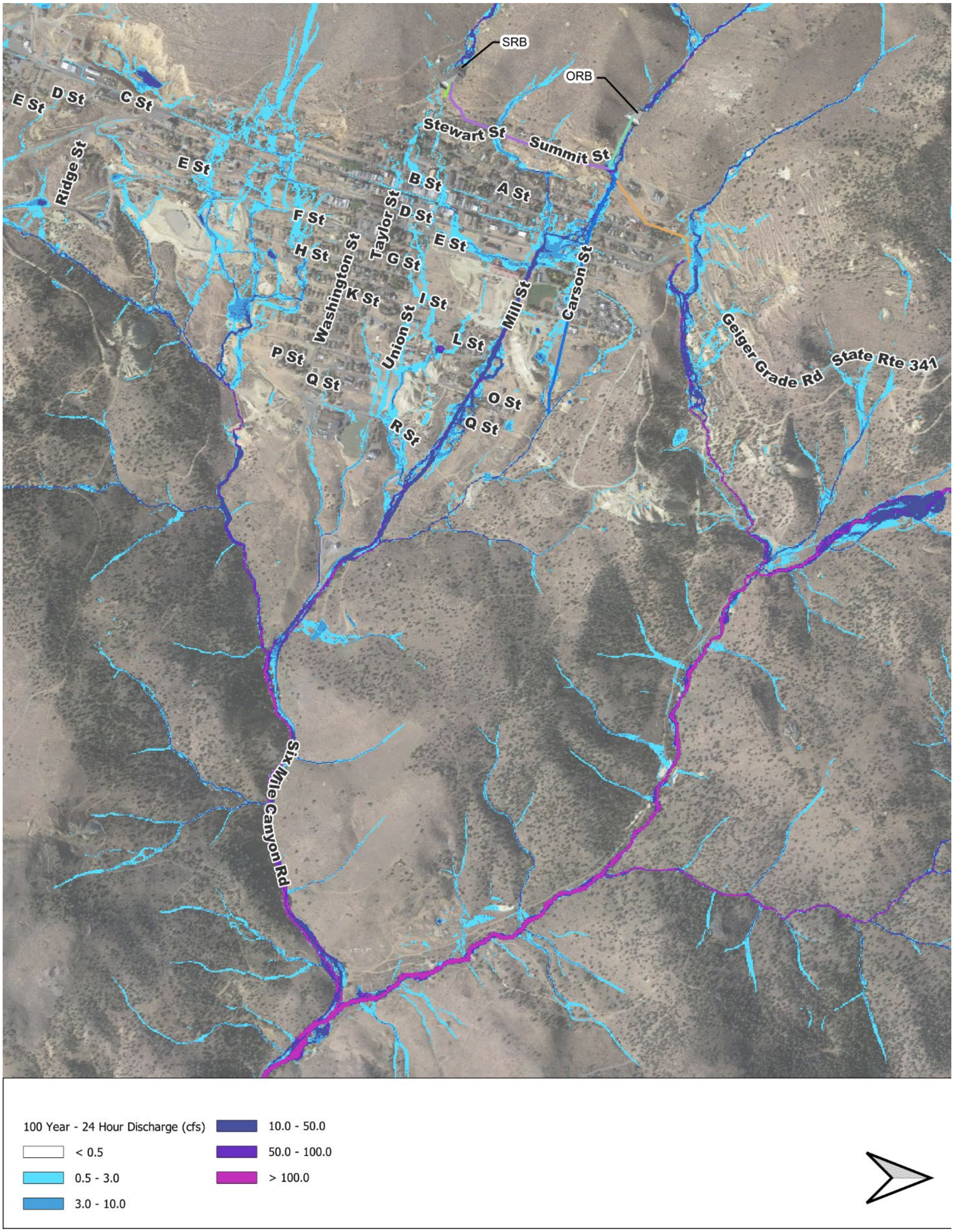


FIGURE 4.11 PROJECT NUMBER 2B – 100 YEAR, 24 HOUR MAX DEPTH (FT)

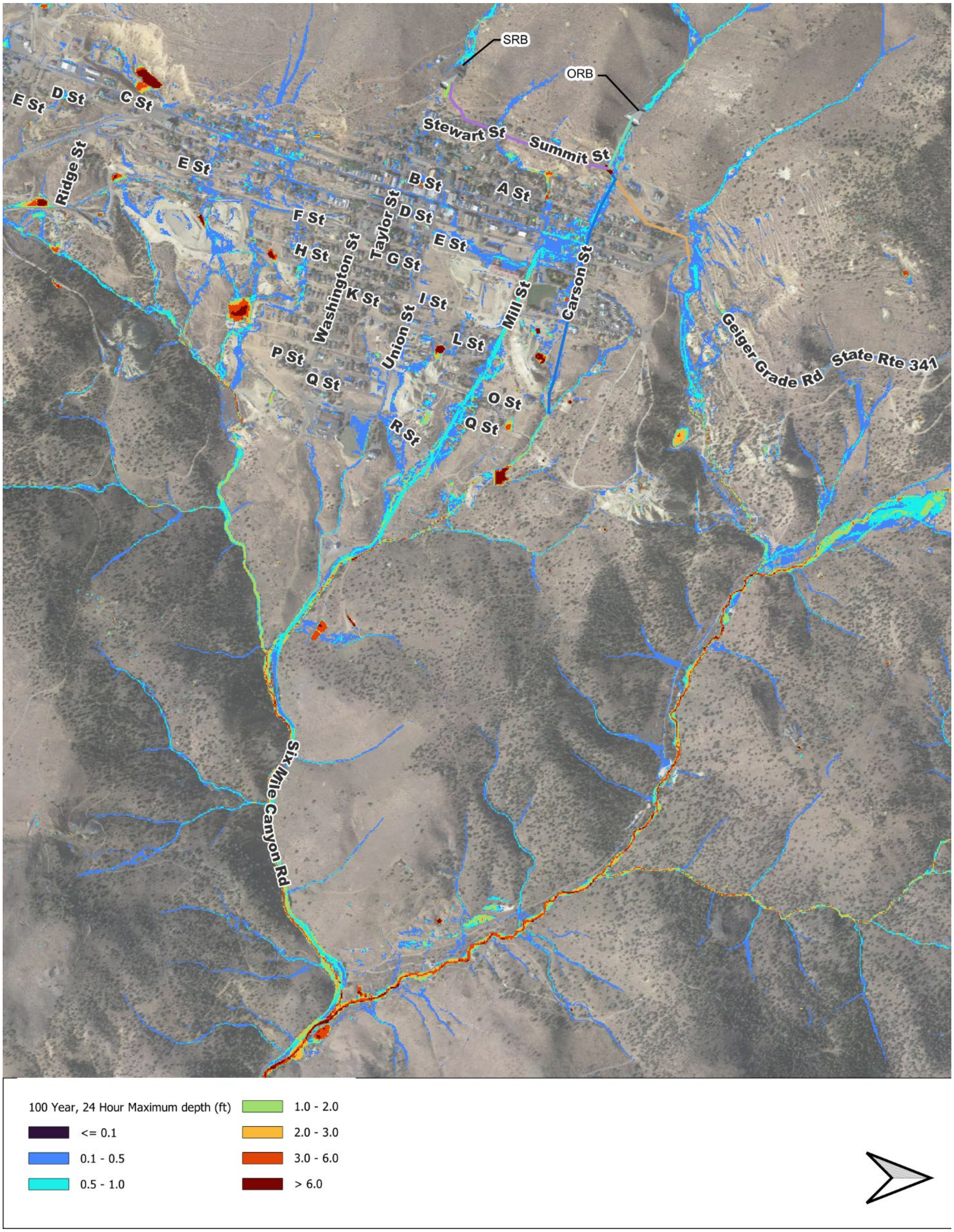


FIGURE 4.12 PROJECT NUMBER 2B – 100 YEAR, 24 HOUR DISCHARGE (CFS)

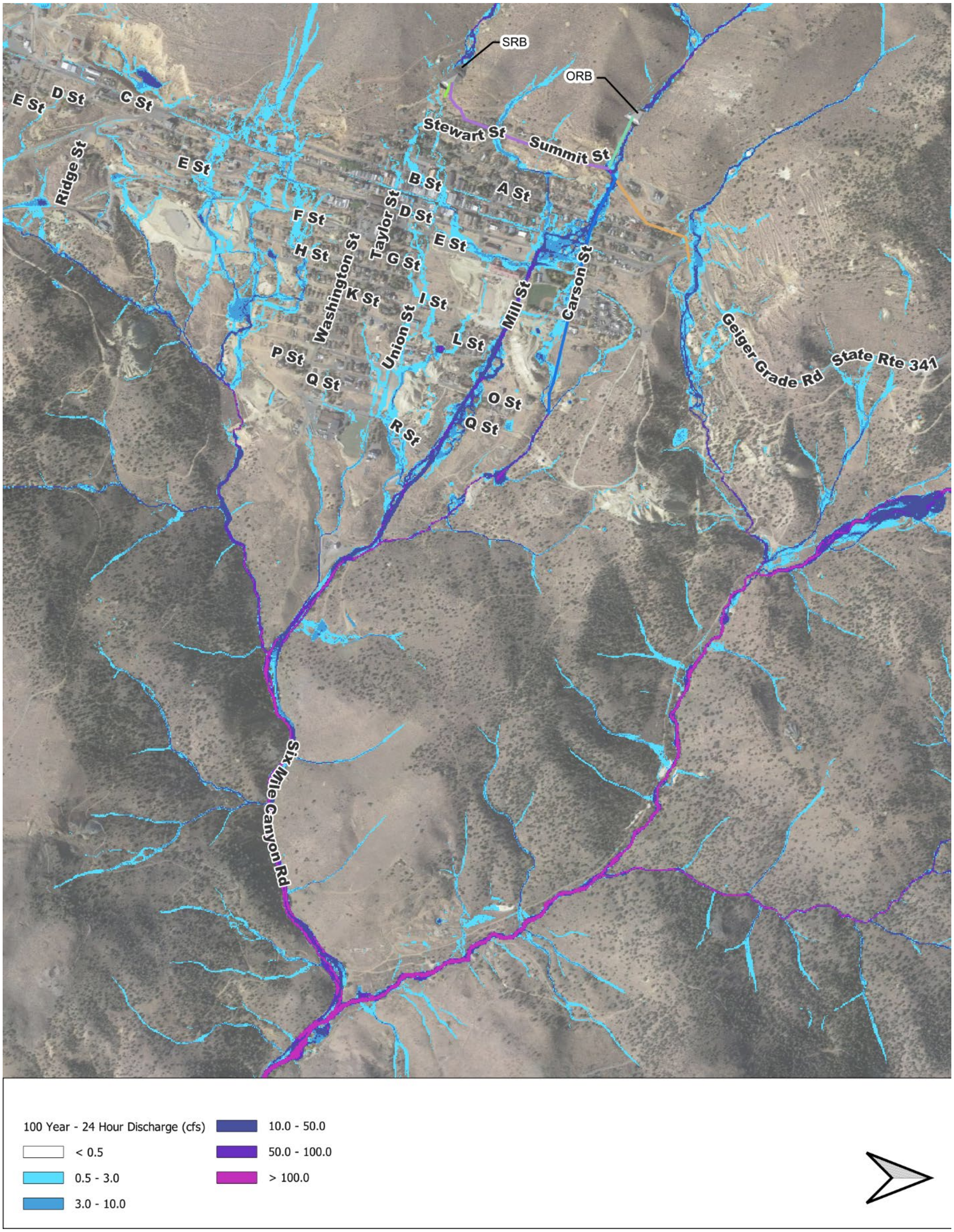


FIGURE 4.13 PROJECT NUMBER 1 – 25 YEAR, 24 HOUR FLOW REDUCTION (%)

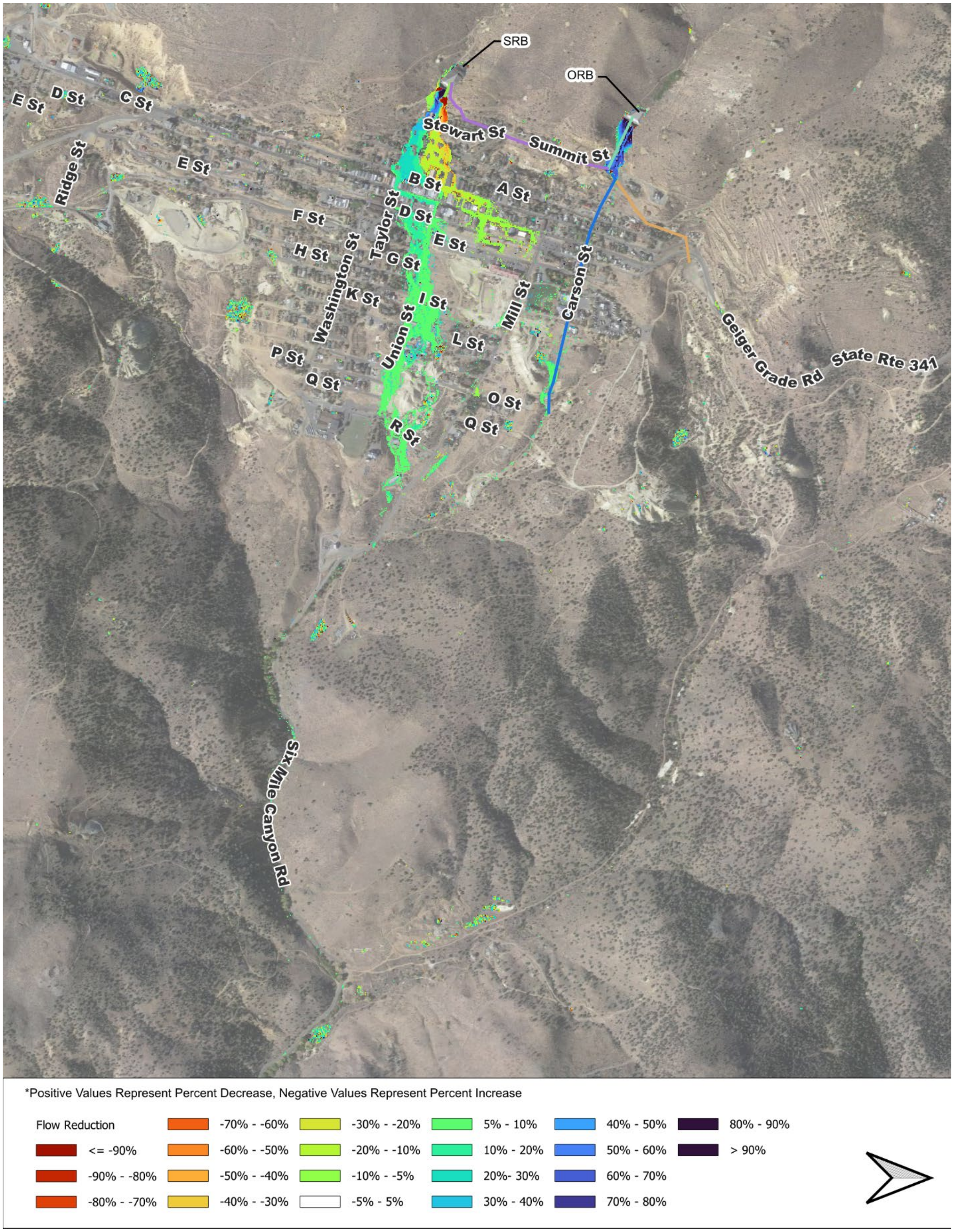


FIGURE 4.14 PROJECT NUMBER 2A – 25 YEAR, 24 HOUR FLOW REDUCTION (%)

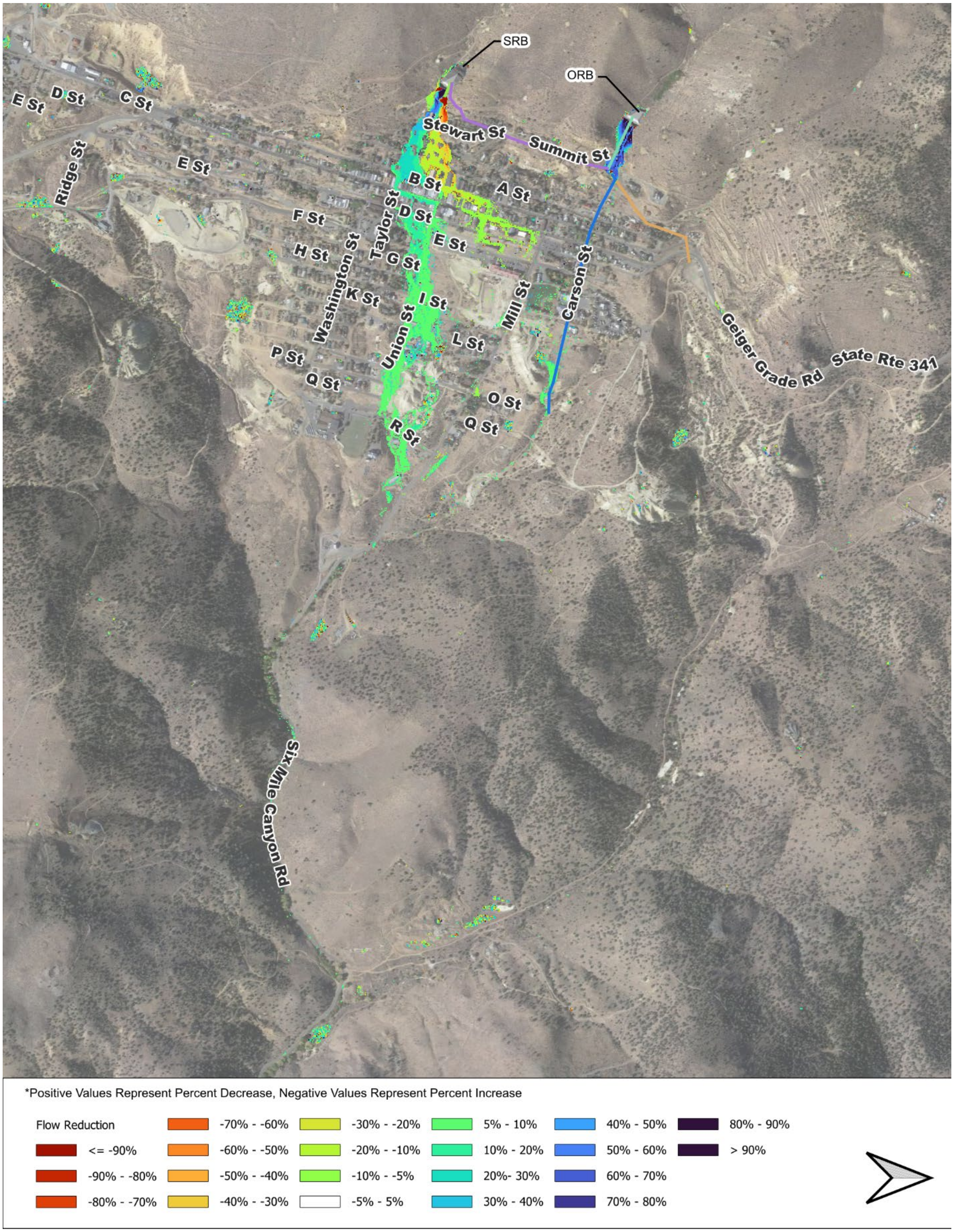
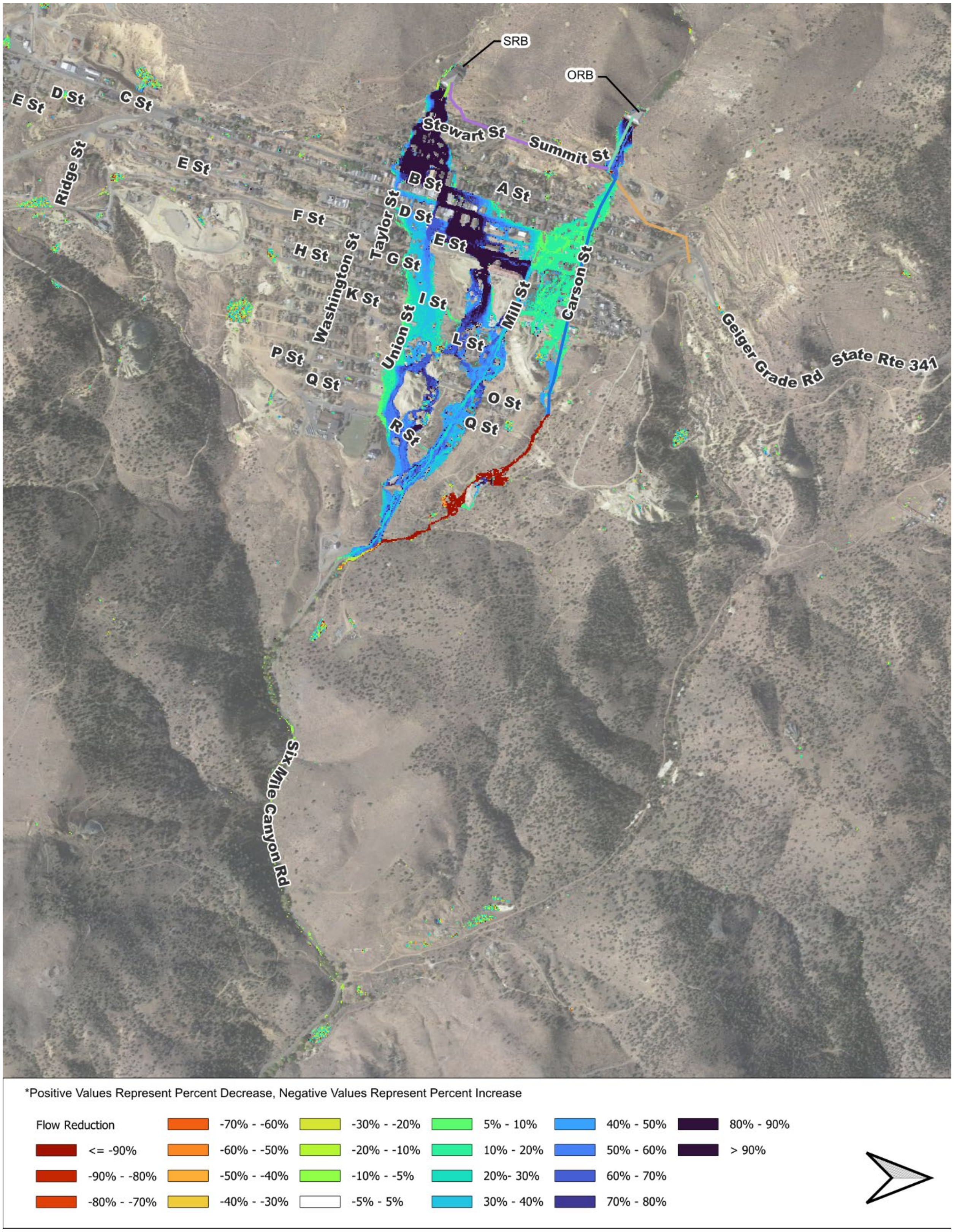


FIGURE 4.15 PROJECT NUMBER 2B – 25 YEAR, 24 HOUR FLOW REDUCTION (%)



4.3 Six Mile Canyon Design Characteristics

Six Mile Canyon culverts regularly overtop wash out portions of the road. The Flo-2D model coincides with field observations for the larger events. Most culvert crossings overtop and produce water depths of 1-4 feet above the crown of the road. Most locations along Six Mile Canyon show depths in the 6-8 feet range.

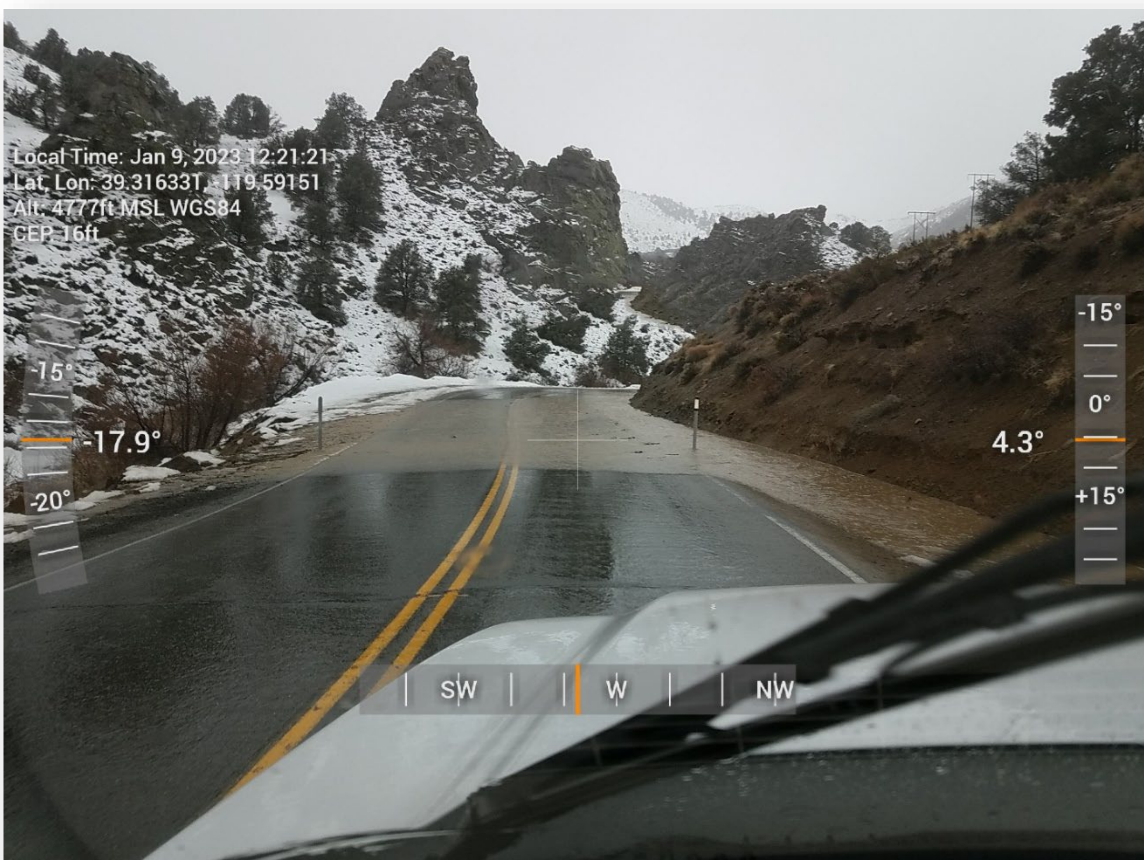
There are four primary types projects proposed for work along Six Mile Canyon Road to mitigate these conditions:

1. Modify two existing culverts to improve the hydraulic function of the culverts;
2. Maintain existing channel and roadside ditches;
3. Construct culverts at low points in the existing roadside channels; and,
4. Implement a County standard for driveway connections to Six Mile Canyon Road.

It was originally thought that many of the culverts were undersized, therefore forcing excess runoff to overtop the road and erode the shoulder and sometimes the actual drivable lanes. Closer investigation revealed the majority of culverts have proper capacity, but are blocked by sediment and organic debris. Many of the culverts restrict stormwater flows because they are filled halfway with sediment. Furthermore, larger storms wash dead brush, tree branches, and trees downstream to the nearest culvert, block the entrance to the culvert, and further exacerbate the blockage.

Dead brush, tree branches, and trees washing downstream, further exacerbating the issue.

Additionally, the majority of roadside channels that run along portions of Six Mile Canyon Road are shallow and unlined because of narrow shoulders in many locations. Significant storms quickly fill these channels with sediment and overtop, causing storm water to sheet flow across the roadway. The right-of-way width for the road is approximately 60 feet throughout the Storey County portion of the road with steep slopes and the main drainage channel immediately adjacent to the road. There is little opportunity to increase the size of any roadside channel without easement acquisition and major grading and slope stabilization measures. Within these roadside channels, there are some connections to existing culverts that allow for the runoff to be conveyed under Six Mile Canyon Road to discharge to the main channel or connected channels that convey flows to the main channel. At low points without connecting culverts or channels, water and sediment collects until the road is overtopped and the runoff eventually finds its way to the main channel. Not only does this create hazardous road conditions with water and sediment on the road, it also has created some significant erosion of the embankment of the main channel at the point the runoff joins the main channel.



Roadside channels become filled with sediment and overtop, causing sheet flow across the roadway.

There is increasing development along Six Mile Canyon Road. Most new driveways are unpaved roads simply bladed in to connect to Six Mile Canyon Road. Due to the steep nature of the canyon, during storm events these unpaved driveways serve as conduits for stormwater, creating points of concentrated flows and significant sediment transport onto Six Mile Canyon Road itself.

4.4 Basin System Flood Mitigation Conceptual 15% Design Costs and Maintenance Estimates

4.4.1 Preliminary Cost Estimates

Preliminary cost estimates were prepared for the drainage facilities which capture storm water of the 25-year, 24-hour storm event. In addition to initial construction costs, non-construction costs were also considered which include additional environmental and BLM permitting, design, and construction services. Table 4.3 includes preliminary costs estimates for each alternative. Grant funding and loan interest calculations were not included as part of this analysis; however, the project could be phased over a period of time to reduce the financial impact. A detailed cost estimate for each alternative can be found in Attachment A. Right-of-way and/or easement acquisition costs are not included in these estimates and will need to be factored in to the overall project costs.

TABLE 4.3 ENGINEERS ESTIMATE OF COSTS FOR EACH ALTERNATIVE

Project	Construction Costs	Non-Construction Costs
SRB	$1,153,000	$230,600
ORB	$1,158,000	$231,600
STOC	$1,335,000	$267,000
OTCC	$884,000	$176,800
OTSC	$1,451,000	$290,200
OEP	$37,000	$7,400
SMC	$138,000	$27,600

4.4.2 Annual O&M Costs

It is estimated that all basins will some level of debris and sediment removal, repairs to the slopes, and vegetation maintenance after the work is complete. Table 4.4 shows the estimated yearly maintenance cost for each alternative.

TABLE 4.4 ESTIMATED ANNUAL O&M FOR EACH ALTERNATIVE

Expense Type	SRB	ORB	OEP
Additional O&M Costs			
Maintenance/RipRap Repairs[1,2]	$32,400	$32,400	$32,400
Debris Removal/Disposal[1,2]	$56,400	$56,400	$56,400
Revegetate	$11,600	$7,600	$5,500
Total	**$100,400**	**$96,400**	**$94,300**

[1] Assume maintenance and debris removal in each pond every 3 years (schedule one pond every 1 year).
[2] Costs based on 2021 FEMA Schedule of Equipment Rates.
[3] Average cost to reseed one pond based on vegetation cots in construction cost estimate

4.4.3 Lifecycle Cost Analysis

A life cycle present worth analysis was prepared for a 20-year period considering the estimated total project costs and the annual O&M costs. Salvaged and valuable materials like sand excavated during construction and during routine maintenance were not considered in the analysis. The life cycle cost analysis and net present value (NPV) for each alternative are presented in Table 4.5.

TABLE 4.5 LIFE CYCLE COST ANALYSIS

Alternative	Present Value		20-Yr NPV[4]
	Total Project Cost[1]	O&M[2] (for 20 Yrs)	
SRB	$1,383,600	$1,775,800	$3,159,400
ORB	$1,389,600	$1,705,100	$3,094,700
OEP	$44,400	$1,667,900	$1,712,300
Total	**$2,817,600**	**$5,148,800**	**$7,966,400**

All improvements shown within the 15% plan set are preliminary but the volumes and quantities obtained from the designs provide an approximate estimate for the expected costs of the project.

4.5 Future Design Considerations

4.5.1 Right-of-Way Access and Easements

The proposed infrastructure has several right of way access intersections with existing County right of way, Bureau of Land Management managed parcels and private land. The County is currently in the process of acquiring the BLM parcel to the west of Virginia City where the Spanish Ravine and Ophir Ravine Basins would be constructed. As of the drafting of this report, that acquisition has not yet been completed.

As a part of any proposed project, coordination with affected property owners would be necessary to secure appropriate drainage and construction easements. The following Table 4.6 summarizes potential parcels that could be included in County efforts to secure required drainage and construction easements if these alternatives are furthered in design for future construction. Figure 4.16 illustrates the same information of potentially affected parcels where drainage and construction easements would be required.

TABLE 4.6 POTENTIALLY AFFECTED PARCELS REQUIRING EASEMENTS

APN		
001-291-01	001-273-01	001-301-10
001-033-18	001-211-01	001-163-07
001-301-05	001-033-10	001-032-06
001-213-02	001-033-15	001-212-04
001-271-02	001-021-05	001-303-01
001-272-02	001-033-16	001-011-01

FIGURE 4.16 POTENTIALLY AFFECTED PARCELS REQUIRING EASEMENTS

4.5.2 Cultural Resources

The Virginia City Historic District is a National Historic Landmark that includes the community of Virginia City as well as adjacent communities and open lands containing historic and archeological features associated with mining activities. According to the National Park Service, the Virginia City Historic District includes 400 buildings and covers 14,750 acres across the communities of Virginia City, Gold Hill, Silver City and Dayton.

During the construction of any proposed improvements, it is likely that cultural resources may be encountered. Pursuant to Nevada Revised Statutes (NRS) 383.121, all departments, commissions, boards and other agencies of the State and its political subdivisions shall cooperate with the Nevada State Historic Preservation Office (SHPO) in order to salvage or preserve historic evidence located on property owned or controlled by the United States, the State of Nevada or its political subdivisions. Specifically, "…when any agency of the State or its political subdivisions is preparing or has contracted to excavate or perform work of any kind on property owner or controlled by the United States, the State of Nevada or its political subdivisions which may endanger historic, prehistoric or paleoenvironmental evidence found on the property, or when any artifact, site or other historic or prehistoric evidence is discovered in the course of such excavation or work, the agency or contractor hired by the agency shall notify the Office and cooperate with the Office to the fullest extent practicable…to preserve or permit study of such evidence before its destruction, displacement or removal." (NRS 383.121.2). If federal dollars are proposed for any of the projects, additional consultation for compliance with the National Environmental Policy Act (NEPA) may be required.

During construction, it may be required that an archaeological monitor be present during all ground disturbing activities. Costs for SHPO consultation, NEPA compliance and any required archaeological monitor should be taken into consideration not only for projects costs but for project timelines.

4.5.3 Carson River Mercury Superfund Site

Building proposed projects are constrained since the area in and around Virginia City falls within the Carson River Mercury Superfund Site (see Figure 4.17). For any proposed project, soil characterization sampling to detect contaminated soils should be completed during the early phase of the project. If contaminated soils are likely to be encountered, the County will need to coordinate with the Nevada Division of Environmental Protection to develop an appropriate course of action which could include avoidance of areas of contaminated soil, onsite containment of soil or removal/remediation of the contaminated soil, and /or extra BMPs on subject parcels to prevent the migration of contaminated soil.

FIGURE 4.17 SUPERFUND INVESTIGATION AREAS