Excerpts from the Army Corp of Engineers Technical Assistance – Flooding and Debris Flow from the Silver King Fire,   Jul 22 2024

For: Marysvale, Downtown, Bullion Creek, Beaver Creek, Deer Creek, Hwy 89

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The State of Utah requested Technical Assistance from the US Army Corps of Engineers (USACE) Sacramento District on 17-Jul-2024 under the PL84-99 Emergency Response. In response to the Silver King Fire causing the removal of vegetation and potential for debris flows, the State of Utah requested Technical Assistance to evaluate the potential for debris and flood flows. **USACE deployed two civil engineers from the Sacramento District with expertise in hydraulics and geotechnical engineering**. The scope of the deployment was to provide an assessment of site conditions and to evaluate the potential for debris flow/landslide initiation. Upon request, USACE provided approximate debris flow mapping as an emergency management tool to local and State officials to inform their community emergency action and flood readiness planning efforts. USACE also provided guides for sandbagging and notifications.

As of 25-Jul-2024, the Silver King Fire encompassed an area of an estimated 18,266 acres in the Intermountain Region of Fishlake National Forest, approximately 3 miles west of the Town of Marysvale. **Within this acreage, the US Forest Service's Burn Area Emergency Response (BAER) team has estimated that approximately 12% (2,200 Ac.) of this area exhibits high soil burn severity where all or nearly all pre-fire groundcover has been generally consumed. The BAER Team has also estimated that roughly 48% (8,740 Ac.) exhibits moderate soil burn severity,** while 36% (6,500 Ac.) exhibits low soil burn severity. A small percentage of the land area (4%, 820 Ac.) within the burn scar represents an area that remained unburned or slightly burned, retaining its tree canopy and ground litter. During the site assessment, it was reported approximately 80 percent containment by wildland firefighting crews.

Due to the removal of vegetation within the burn scar, the ability for the vegetation and ground to absorb precipitation has **been dramatically altered, increasing the potential short-term risk of flash flooding and debris flows to the downstream communities for the next three to five years** until vegetation is re-established. **Utah is prone to intense cloudburst thunderstorms that produce high intensity, short duration rainfall and has a known history of flash flooding and debris flows.** Several of the surrounding mountain peaks (10,000-12,000 ft) influence local weather patterns. The ash from wildfires can cause the soils to become hydrophobic ("water repellant") which reduces infiltration and increase surface water runoff potential. **Precipitation that would normally be absorbed into the ground or intercepted by vegetation would instead accumulate on the surface and increase runoff volume. As a result, the increased runoff volume, in combination with freshly exposed ground surfaces due to vegetation loss, has a greater potential to result in amplified development of surficial erosion culminating in large scale sediment transport, debris flows and landslide conditions.**

The Silver King Fire occurred on rugged mountainous terrain with extremely steep slopes (up to 75% slopes). The USGS estimated that many of the drainages within the burn scar have an increased likelihood of debris flows from a 15-minute precipitation event with an intensity of 32 mm/hr, roughly equivalent to 0.32 inches of rainfall in 15 minutes. The Fishlake National Forest ravines and drainages

is estimated to have up to an 80 – 100% probability of debris flow occurring. This ephemeral drainage discharges directly towards many homes on the western edge of the Town of Marysvale and travels through the center of the town until it discharges into the Sevier River. The Utah Division of Emergency Management (Utah DEM) has requested assistance to better understand expected downstream impacts if debris flows were to occur to aid in the town's emergency planning to protect its 370 residents, irrigation infrastructure, and cultural and environmental resources. The local economy is driven by the agriculture and recreation/tourism industries. The objectives of the Utah DEM for this incident are to mitigate the potential for flood and debris flow, prepare the community for potential debris flows, protect life safety, and reduce impacts to critical infrastructure and property downstream.

The Silver King Fire has been described as a high likelihood of resulting debris flows that can be expected with seasonal snowmelt and typical monsoonal rains for several years until the watershed recovers. Emergency Response was provided due to the incoming rain that was expected in the area that could have resulted in immediate flooding. A list of recommendations to consider for managing the flood risk and reduce life and property loss is in Section 7.

Within the town (map no. 3), the greatest impacts would likely be to roadways. Roads may need to be closed until cleared by crews. **Sediment on roads is extremely difficult to safely drive on because it often contains clay material which is very slippery when wet.** Further, driving through sediment will track it increasing the areas needing cleanup. **It was assumed in the hydraulic model that the debris would quickly clog the roadway crossings and culverts causing the flow to overtop the roadway. Along Highway 89, the model calculates 5 feet of debris on the roadway at Pine Creek, and up to 3 feet between the creek and Bullion Ave, then less than 2 feet deep until 400 N. Throughout the town the area east of 100 W would be most directly impacted with up to 3 feet of sediment**. Residents are encouraged to maintain a ready stockpile of sandbags at each doorway, window well, or foundation opening within 3 feet of the ground level. Openings can be quickly sealed with sandbags and poly sheeting which will keep most of the sediment and water from entering interior areas (Figure 1). Of particular importance, is to seal the lower 2 feet of the doors for the fiber communication building (95 E Bullion Ave) and the pump control building at the city park (Figure 1).

5.2 Pine Creek (Bullion Canyon) The debris flow model started about 0.5 miles upstream of the spring collector well along Bullion Canyon Road (map no. 6). **Generally, the flow will stay within 250 feet of the creek, and low and wide sections would encounter greater accumulation of debris than deep and narrow sections. The established trees and thick vegetation will likely help to slow the flow, but if forces are great enough, vegetation could become dislodged and contribute to the flows**. **Many sections of Bullion Canyon Road may experience debris accumulation making safe passage difficult. The roadway may need to be closed until crews can clear the roadway. Sediment on roads is extremely difficult to safely drive on, especially at speed, because it often contains clay material which is very slippery when wet. It is expected that up to 3 feet of sediment could be deposited at the well**. The well could be protected by covering with poly sheeting to prevent sediment contamination, then weighted with a pile of sandbags, and finally placing a concrete Jersey barricade on the upstream side of the sandbags would protect the sandbags from direct impact and prevent shifting of the pile.

5.3 Beaver Creek The debris flow model begins on Beaver Creek at the fire perimeter and extends to the Sevier River. Generally, the flow is confined to the lowest portion of the creek and avoids impacting Beaver Creek Road except for the culvert crossing (map no. 7 and 8**). It was assumed that all culverts**

would become clogged, and flows would overtop the roadway. Just west of Highway 89, the flow will fan out but remain less than 2 feet deep. Debris depths could be about 1 foot deep as it crosses over Highway 89, possibly resulting it its closure. East of Highway 89, depths are much shallower as it spreads out occupying the lowest portions of the Sevier River floodplain.

Deer Creek The debris flow model begins on Deer Creek at the fire perimeter (map no. 15) and continues to the Sevier River for about 2 miles downstream (map no. 13). **At the confluence and extending downriver are several private residences and a few RV parks. This area attracts many visitors who would generally be less informed about sudden flood risk. The buildings at the mouth of Deer Creek (map no. 12) as well as further downstream along Highway 89 within about 200 feet of the river may be subject to up to 3 feet of debris depths.** This area is generally the same flooded land that would normally be experienced from the Sevier River during periods of high water, but the difference here would be that a debris flood may occur outside of the seasonal window that the Sevier River would normally be running high from spring snowmelt.

People at campgrounds and recreating along the river and trail system should be made aware of the increased risk and monitor weather changes to avoid being directly below the drainage. Posting signs at the mouth of the canyon and for users of the RV parks warning them of the flash flood conditions would help to inform non-locals. Highway 89 may overtop with up to 2 feet of debris where it crosses Deer Creek. The highway may need to be closed until crews can clear the roadway. Sediment on roads is extremely difficult to safely drive on, especially at speed, because it often contains clay material which is very slippery when wet.

The Deer Creek Water Association has some infrastructure about a half mile up the canyon from Highway 89. This infrastructure may be subject to up to two feet of accumulation. The association is encouraged to protect their infrastructure from sediment and water contamination or damage (see Section 5.2 for a description of possible methods).

5.**5 Impacts to Sevier River It may be possible that the debris flows could enter the Sevier River and choke its conveyance capacity. If this occurs, the river may backup impounded waters (map nos. 9-13) and inundate lands throughout the meandering floodplain until the stream can reestablish itself or the blockage is cleared. See Section 6 for the FEMA floodplain maps that show potential flooded areas on the Sevier River. The upstream Piute Reservoir may be able to cut releases while the blockage is cleared**.

5.6 Large-scale Intervention Strategies The debris flow modeling was developed assuming that there was no structural intervention in place to redirect or confine the flows. It is understood that the Town of Marysvale and Piute County are considering constructing upstream debris basins (some are already underway) on smaller lateral drainages. These basins would likely reduce the amount of sediment that would occur for smaller debris flows on the side drainages over the course of a season, however for the rain event that was modeled, debris basins on the main creeks would likely lack the storage capacity required (Table 3). Nonetheless, routine monitoring and periodic excavation will be required to ensure they perform as intended. For constructed structures or embankments intended to redirect flows, carefully consider where those flows would be redirected to, to ensure that unacceptable risk isn't being transferred from one property to another. **An engineer who specializes in flood risk may be needed to evaluate the effects of induced flooding from the construction of these types of structures. In situations where constructing an earthen embankment is intended to deflect or temporarily detain**

debris flows, it is recommended that a licensed professional engineer be retained to properly design and observe the construction of the structure. A concrete Jersey Barrier, such as those used in transportation applications, could be placed on the debris side to armor the baskets which in turn serve to buttress the concrete barrier to keep it from shifting.

Mitigation Strategies Several mitigation strategies may be considered by the Town of Marysvale community, working in conjunction with State and Federal partners. The following recommendations may reduce damages and potential life loss because of debris flows**. 1. Until the watershed recovers over the next several years, be diligent to keep the public informed about the increased risk of flooding potential and encourage them to remain vigilant. Increased community awareness to debris flow potential pathways can be incorporated into an early warning and evacuation strategy. Remind residents of the risk prior to spring runoff and monsoonal season**

Encourage residents to seek high ground upon sensing any ground shaking (e.g., earthquake activity) or hearing rumbling noise from upstream, paying close attention to occurrences following periods of precipitation.

In the event of an evacuation order, take the P's (in this order): People, Pets, Phone (and chargers), Payment (credit cards, cash), Passport (or form of ID), Prescriptions (and eye glasses, essential medical equipment), Photos, Papers (personal documents, insurance policies, deeds, trusts, birth certificate)…and then if you still have time, grab anything else. Residents are encouraged to prepare in advance by compiling the personal documents on a hard drive and include them in a "go-bag" with a few day's clothes, and to identify a safe location to evacuate to.

2**. Monitor weather forecasts. Minor precipitation events are known to trigger a debris flow. Debris flows can travel fast and have significant force to damage structures, move vehicles, and bury items and people (engulfment hazard).** The National Weather Service as reported that a temporary weather station will be established within the footprint of the burn scar to provide increased fidelity on weather conditions. The local weather forecast can be retrieved from the NWS for Marysvale, UT at Latitude 38.449296110742935, Longitude -112.23076865812824. https://forecast.weather.gov/MapClick.php?lat=38.438150000000064&lon=- 112.25566999999995 3.

Develop a community public alert strategy to employ if a debris flow event is believed to be imminent. In addition to the CodeRED Mobile Alert App that is being adopted by the County Emergency Management, the USACE Engineer Pamphlet 1110-2-17 is a guide to public alerts and warnings for flood emergencies: https://www.publications.usace.army.mil/Portals/76/Users/182/86/2486/EP%2

Display warning signs along roadways, at campgrounds and public areas, and at trail entrance/junctions leading into the burn area for awareness of possible flash flood conditions.

5**. If a debris flow event were to occur, it is likely that Bullion Canyon, Beaver Creek, and Deer Creek debris flows may occur simultaneously. Be prepared to respond to several areas.**

6. **If debris flows enter the Sevier River, it may cause the river to dam potentially resulting in upstream flooding. Coordinate with the Piute Reservoir dam operator about the potential need to alter releases until the blockage can be cleared.**

7. **Structures which are impacted by debris flow depths greater than 2 feet may suffer structural and water damage; debris flow depths greater than 6 feet would very likely suffer structural damage; and debris flow depths greater than 9 feet would likely be catastrophic. Homeowners located adjacent to existing drainages within potential debris flow paths are encouraged have a plan for temporary housing in the event the structure should endure damages and consider acquiring flood insurance.**

8. **Water and sediment damage could be expected without effective flood fighting measures**. For depths less than about 3 feet, temporary measures, such as sandbags, may be effective to hold back debris flows from entering doors, windows, and other openings such as vents into crawl spaces. Homeowners are encouraged to place sandbags at building openings prior to rainfall because debris flows could occur shortly after the onset of precipitation, and flows could travel downslope from the drainages to structure within minutes. Placing sandbags along property lines is not an effective use of a scarce commodity. See Appendix C for sandbagging guides.

9. Explore alternative methods to stabilize the ravine and gullies within the watersheds. Placing erosion control features such as bales of hay, straw waddles, or riprap in the gullies would slow the movement of small volumes of debris and sediment but would require active monitoring and routine maintenance to maintain effectiveness. Stabilizing the affected areas of the mountain may be performed with an aerial broadcast of grass seed or mulch. These concepts have not been evaluated by USACE for effectiveness.

10. **Inspect and be prepared to clean out existing and newly constructed debris basins following moderate to heavy precipitation events.** Known basins are shown on Map 2.

11. In coordination with the irrigation company, close diversion gates to avoid the intake of sediment into the canal system if debris flows are imminent. After a flow, inspect the structure for damage and operability, and clear accumulated debris as needed.

12. **Consider constructing permanent impoundment structures for both sediment retention and flood control such as debris dams in the small drainages feeding Pine Creek (Bullion Canyon), Beaver Creek, and Deer Creek to catch large rocks and sediment (described in Section 5.6).** This concept or engineering design has not been evaluated by USACE for effectiveness.

13. Consider constructing features to divert debris flows from high consequence areas as described in Section 5.6. Further engineering analysis should be performed to better specify the location, height, and effectiveness of diversion walls.

14. **Existing Faults are mapped in the east side of the Tushar Range, which includes the burn scar. If a seismic event of significant magnitude occurs in the region, anticipate an increased likelihood of debris flow from soils that have been disturbed and are more readily erodible.**

15. **Use extreme caution while driving over sediment laden roadways, even for drivers accustomed to driving on snow. Mud tends to be stickier than snow and can create a suction-like effect on tires making it harder to regain control. Snow, on the other hand, often provides more consistent traction, especially with the right tires. Mud is also heavier which causes vehicles to become stuck more easily than with snow and may require a tow from another vehicle.**

16. Community land-use planning may be the most practical means of reducing risks associated with debris flows identified within primary and secondary drainages regardless of the initiating mechanism or

landslide volume. The Town Council, Planning and Zoning Committee may wish to consider evaluating landslide/debris flow, and flood hazard potential within areas throughout Town.

On 5-Aug-2024, the United States Forest Service published a Burned Area Emergency Response (BAER) report to present fire incident facts and describe post-wildfire watershed conditions. Included in the report was an estimation of probabilistic likelihood of debris flow conditions in the different drainages of the burn scar. The debris flow probabilities for each drainage were determined, highlighting the need for debris flow modeling of creeks that flow to the Sevier River. Additionally, an estimate of debris flow volume was provided for each drainage. Those estimates were used to calculate the volumetric concentration in the debris flow model. Two additional maps were also provided: a Soil Burn Severity map, and a combined hazard map which relates probability of a flow with expected volume for an overall hazard classification. **The debris flow probability maps were formulated in response to a peak 15-minute rainfall intensity of 32mm/hour. This rainfall intensity is equivalent to the to the accumulation of 0.32 inches of rain in 15 minutes. This rainfall event has a 1-year recurrence interval for the middle of the burned area, meaning it is a very likely event (99% probability) of occurring on any given year.**

Due to the loss of vegetation within the burn scar, the ability for the ground to absorb water has been dramatically altered, increasing the potential short-term risk of flash flooding and debris flows to the downstream communities and for the next 3-5 years until vegetation is re-established.

Rowley et al (1988) report that regional landslide debris in the Marysvale Valley consists of unconsolidated, angular, unsorted materials that moved downslope. The authors note, "**two major landslides are mapped in the eastern part of the quadrangle. There are indications of recent movement on the landslides, including fresh ridges, cracks, ponds, and bent trees" (**opt cit, pg.12). Rowley et al (1988) identify that "**the town of Marysvale is vulnerable to flooding for it lies on the floodplain of Pine Creek, a stream that drains a large area of the Tushar Mountains. Flash floods are probable along most perennial or intermittent streams, especially those draining the Tushar Mountains." In addition to gravitational forces and precipitation, earthquakes are another potential initiating trigger without useful or detectable precursor**s (Scott et al., 2001). Numerous north-northeast and north-northwest high-angle basin range faults have been mapped in the Tushar range (Figure 3), including the Marysvale fault which may be of large displacement (Rowley et al. 1988). Lesser poorly understood Quaternary age faults including the Sevier Valley-Marysvale-Circleville area faults (No. 2500) and Tushar Mountains (east side) fault (No. 2501), and moderately well understood Beaver Basin faults (No. 2492a) have also been mapped within the region (Black and Hecker, 1999; Black et al. 2004). Rowley et al. (1988) note that **"this part of Utah is within a seismically active belt and earthquakes have been felt In the Marysvale quadrangle in the past."**

As the debris flow translates down slope, larger clasts dispersed within the matrix may be deposited, and flows may become dominated by higher proportions of weaker cohesive soil content characteristic of saturated mudflows as illustrated in Figure 7.

The U.S. Geological Survey Landslide Hazard Program reports that "**wildfire can significantly alter the hydrologic response of a watershed to the extent that even modest rainstorms can produce dangerous flash floods and debris flows." Wildfires can cause the soils to become hydrophobic (water repellant) which can reduce the soil's ability to absorb water (infiltrating), increasing runoff, and contributing to flooding and debris flows on burned mountainous areas. The ash layer on top of the soil is usually water absorbent (hydrophilic) but is usually washed away (buoyant) from the soil surface during the**

first few rainstorms after a fire, transported as part of the initial debris flow. The USFS BAER soil burn severity maps show that 60% of the burn area has experienced a moderate or high burn severity, exhibiting a high degree of hydrophobicity.

The BAER debris flow maps depict the probability of debris flow, volume of debris flow, and combined debris flow hazard in response to a peak 15-minute rainfall intensity of 32mm/hour. **This rainfall intensity is equivalent to the to the accumulation of 0.32 inches of rain in 15 minutes during a high intensity thunderstorm. This rainfall event has a 1-year recurrence interval for the middle of the burned area, meaning it is a nearly certain (99% probability) of occurring on any given year. According to locals, rains during the monsoonal season typically last for 5 to 30 minutes long, with high intensity. Therefore, a 30-minute storm duration was assumed when developing the rainfall runoff volume.**

Parameter Pine Creek (Bullion) Watershed Area1 14,570 Acres Beaver Creek 14,120 Acres Deer Creek 5,720 Acres Average Slope1 47%

Unit Hydrograph Simple Triangular Peak Flow Bullion Creek 1,350 cfs Beaver Creek 1,140 cfs Deer Creek 680 cfs

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Marysvale Town says “Stay Safe – Evacuate when you hear the Flood Watch!”