DEPARTMENT OF
ECOLOGY
State of Washington

Dam Safety Incident Report

Benson Creek Flood, August 2014

Okanogan County near Twisp, WA

DSO Files OK 48-0320, -0308, -0328

by

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Incident Summary

On the evening of Thursday, August 21, 2014, the fire-swept Benson Creek watershed received from 0.4 to 0.9 inches of rain in a one-hour period. There were high runoff flows and numerous mudslides throughout the watershed. By the next day, State Highway 153 was closed 6 miles south of Twisp, and three of the five Wenner Lakes in Finley Canyon were empty. Fortunately, there were no fatalities, injuries or missing persons from this flooding.

On Friday, August 22nd and through the weekend, diligent efforts by dam owners, local contractors, and county, state and federal officials re-opened the spillways for the remaining two dams. The last of the runoff flows receded without further incident.

Photos and maps of the area are included at the end of this report. Refer to Table of Contents for specifics.

Acknowledgements

Responding to this incident was quite a team effort. The Dam Safety Office gratefully acknowledges cooperation and collaboration with the following people and organizations during this incident:

- Rabel Dam owners
- McHugh's Excavating, Twisp
- Hawkins Dam owner
- Okanogan Co. Emergency Management
- National Weather Service, Spokane
- USDA NRCS, Ephrata
- USDA NRCS, Spokane
- WDFW North Central Region
- WDFW Engineering, Olympia
- WDFW Maintenance, Yakima
- Methow Conservancy
- McMillen Engineering, Boise, ID
- WSDOT Hydraulics Office
- WSDOT North Central Region
- State Climatologist Office
- USFS BAER team, Wenatchee

Dam Safety Incident Report

Benson Creek Flood, August 2014, Okanogan County, WA

Incident Report

Benson Creek Watershed

The Benson Creek watershed is located in SW Okanogan County about 6 miles SE of Twisp, in north central Washington State. (See Maps 1-3.) Benson Creek has three major sub-basins:

1. Finley Canyon (drainage area: 18.3 square miles).
2. Upper Benson Creek (drainage area: 15.6 square miles).
3. Lower Benson Creek (drainage area: 4 square miles).

The total drainage area for Benson Creek is 38 square miles when it empties into the Methow River.

In Lower Finley Canyon, there are five man-made lakes known as the Wenner Lakes. For purposes of this incident report, they are numbered from 1 to 5 going downstream (north to south), and described as follows:[1]

- Chalfa Dam impounds Wenner Lake No. 1 (may be called Wenner Lake 3 on some maps). Chalfa Dam is 15 feet high, has a crest length of 320 feet, and impounds a volume of 50 acre-feet. Wenner Lake No. 1 has a surface area of 9 acres. An open-channel spillway is provided at the right abutment (right when looking downstream).

- The dam for Wenner Lake No. 2 impounds a volume of slightly less than 10 acre-feet. An open-channel spillway is provided at the right abutment.

- The dam for Wenner Lake No. 3 impounds a volume of 4 acre-feet. A small culvert spillway is provided near the right abutment.

- Rabel Dam impounds Wenner Lake No. 4 (may be called Wenner Lake 2 on some maps). Rabel Dam is 15 feet high, has a crest length of 400 feet, and impounds a volume of 100 acre-feet. Wenner Lake No. 4 has a surface area of 11 acres. An open-channel spill-way is provided at the left abutment.

[1] For readers not familiar with these types of calculations, an acre-foot is a volume one foot deep over an area of one acre. This is equivalent to 43,560 cubic feet, or 325,850 gallons. A football field 300 feet (100 yards) long and 160 feet wide has an area of 1.1 acres. "Acre-feet" is abbreviated "ac-ft."

- Hawkins Dam impounds Wenner Lake No. 5 (may be called Wenner Lake 1 on some maps). Hawkins Dam is 35 feet high, has a crest length of 350 feet, and impounds a volume of 35 acre-feet, although the lake is not as deep as the dam height. Wenner Lake No. 5 has a surface area of 4 acres. An open-channel spillway is provided at the right abutment.

The Chalfa, Rabel and Hawkins Dams are regulated by the Washington State Dam Safety Office (DSO).

In Upper Finley Canyon, about 10.3 square miles of drainage area are somewhat isolated from the middle and lower canyon by a large, naturally-occurring berm about 40 feet high that extends across the canyon. The depression upstream of this berm appears to be almost a mile long, receives stream flows from the upstream watershed, but doesn't seem to have a surface outlet. It appears that the gravels in the valley bottom are sufficiently permeable to allow runoff flows to go subsurface beneath this berm and re-emerge in the creek farther downstream.

Volume calculations by Dam Safety hydrologists estimate this depression can impound a volume of more than 2,700 acre-feet. We are still analyzing how quickly or slowly runoff flows upstream of this berm would flow into the downstream canyon, and how to incorporate this feature in our hydrologic model calculations.

Carlton Complex Fire

In mid-July, lightning started several forest fires that eventually combined to form the Carlton Complex Fire. The Carlton Complex Fire eventually burned more than 256,000 acres in SW Okanogan County, one of the largest forest fires in Washington State history. The burned area includes most of the Finley Canyon watershed and Lower Benson Creek sub-basin, and a large portion of the Upper Benson Creek watershed. Two residential structures in Lower Finley Canyon downstream of the Wenner Lakes dams were among the structures destroyed by the fire. The fire was finally 100% contained on August 25th.

Depending on burn severity, fires can affect burned-area soils by reducing the effective ground cover, reducing the amount of soil structure, and forming water repellent layers that reduce infiltration. Guidance compiled by U.S. Forest Service Burned Area Emergency Response (BAER) hydrologists indicates post-fire soils may allow very little infiltration, such that a very high percentage of any subsequent rainfall becomes runoff. This effect would be in addition to pre-fire conditions where rainfall intensity in excess of soil infiltration rates would be expected to generate surface runoff.

Thunderstorm on August 21st

On the evening of Thursday, August 21, 2014, starting at about 6pm, the sub-basins within the Benson Creek watershed received from 0.4 to 0.9 inches of rain in a one-hour period. A couple locations outside the Benson Creek watershed received up to an inch of rain within the one-hour period.

High runoff flows and numerous mudslides occurred throughout the area. By Friday morning, State Highway 153 was closed 6 miles south of Twisp, two of the five lakes in Finley Canyon were empty, and a third lake was in the process of draining and would be substantially empty by evening. At SR-153, at the culvert that conveyed Benson Creek beneath SR-153, a considerable volume of mud was deposited at the entrance to the culvert. Benson Creek flows overtopped (flooded) the roadway and eroded the downstream face of the road embankment, compromising the support for the roadway and caving off part of the asphalt pavement.

Upstream in Lower Finley Canyon, high runoff flows in conjunction with spillway blockages overtopped the embankments at Wenner Lakes No. 1, 2, 3 and 4. At Chalfa Dam (Wenner Lake No.1), floating debris partially obstructed the spillway. At Wenner Lake No.2, erosion in the spillway channel down-cut upstream into the lake, draining the 10 ac-ft. volume of the lake. At Wenner Lake No.3, erosion of the embankment in the vicinity of the culvert down-cut upstream into the lake, draining the 4 ac-ft. volume of the lake.

At Rabel Dam (Wenner Lake No.4), a debris flow from the hillside on the left side of the dam obstructed the spillway. Active intervention by the dam owners re-opened the spillway in time to prevent further damage to the dam and spillway.

At Hawkins Dam (Wenner Lake No.5), a debris flow from the hillside on the right side of the dam caused some obstruction of the spillway, although we did not see indications that the dam overtopped. However, erosion in the spillway channel down-cut upstream into the lake, draining the 35 ac-ft. volume of the lake. This lake is the farthest downstream of the five Wenner Lakes.

Fortunately, as noted by Okanogan County Emergency Management, there were no fatalities, injuries or missing persons from this flooding.

Day-by-Day Responses by Dam Owners and Government Agencies

This section summarizes the day-by-day responses by dam owners and government agencies related to the incident at the dams. Responses to the road closure at SR-153 or other incidents are outside the scope of this report.

Friday, August 22nd

- Dam Safety Office (DSO) received notification from dam owner about high flows and blocked spillway at Rabel Dam (Wenner Lake No.4) about 12:00 noon. Rabel Dam owner also reported that upstream Chalfa Dam (Wenner Lake No.1) had high flows and blocked spillway. Rabel Dam owner had equipment (track hoe) available on site to open the blocked spillway, requested DSO guidance.

- DSO notified Okanogan County Emergency Management and Okanogan County Sheriff's Office about the dam incident.

Friday, August 22nd (continued)

- DSO dispatched two Dam Safety Engineers from Olympia to Okanogan County; ETA 7:00pm at the site.

- DSO coordinated by phone with dam owner and Okanogan County Emergency Management, facilitated direct connection between dam owner and County Emergency Management so they can coordinate directly with each other.

- Okanogan County Emergency Management convened a response team including a hydrologist from the National Weather Service (NWS) Spokane office and biologist from State Fish & Wildlife (WDFW). Met in Twisp, then traveled to the site. NWS hydrologist requested technical assistance from engineers in local office for USDA Natural Resources Conservation Service (NRCS).

- DSO notified WDFW Regional staff in Ephrata and engineering staff in Olympia about the reported situation at Chalfa Dam. WDFW owns Chalfa Dam. WDFW maintenance staff will respond. Note: Property ownership and maintenance is a separate function from WDFW's regulatory functions.

- Rabel Dam owners and local excavation contractor, with guidance from USDA-NRCS, excavated a new spillway channel and worked to open the existing spillway channel.

- DSO engineers arrived on site, met with County Emergency Management and dam owner. Rabel Dam owner reported that engineers from USDA-NRCS had already been on site, provided guidance for opening the blocked spillway and excavating an additional spillway channel which owner is following. Observations and photographs by DSO staff, although daylight was fading.

Saturday, August 23rd

- DSO engineers returned to site. More detailed observations and photographs. Provided guidance to owners for Rabel and Chalfa Dams for opening their spillways.

- Spillway for downstream Hawkins Dam (Wenner Lake No.5) had eroded, pond was completely drained.

- Work continued on opening the spillway for Rabel Dam (Wenner Lake No.4).

- At smaller upstream Wenner Lake Dams 2 and 3 (not in DSO jurisdiction), the spillways had eroded and both ponds were completely drained.

- Some work on opening the spillway for Chalfa Dam (Wenner Lake No.1).

Sunday, August 24th

- DSO engineers returned to site. More detailed observations and photographs. Provided guidance to Chalfa Dam owner for opening their spillway.

- Work continued on opening the spillway for Chalfa Dam (Wenner Lake No.1).

Monday, August 25th

- DSO engineers returned to site. More detailed observations and photographs.

- DSO engineers were informed by dam owner that work will resume on Tuesday, 26th, for Rabel Dam (Wenner Lake No.4).

- DSO engineers on site until about 12:00 noon, then returned to Olympia.

- DSO notified State Hydraulics Engineer in Dept of Transportation (WSDOT) that DSO engineers are responding to and investigating this incident.

Wednesday and Thursday, August 27th and 28th

- Follow-up site visit by Dam Safety Supervisor and DSO hydrologists. Met with Hawkins Dam owner, representative from Methow Conservancy, Rabel Dam owners, engineers from WSDOT regional office, Okanogan County Emergency Management. Observations, photographs and field measurements by DSO staff.

Week of September 2nd through 5th and continuing

- Follow-up discussions and correspondence between Dam Safety and NWS-Spokane, State Climatologist, USFS-Wenatchee BAER hydrologists, WSDOT, dam owners, dam owner's engineering consultant, and Methow Conservancy.

Dam/Spillway Failures

As noted previously, high runoff flows in conjunction with spillway blockages overtopped (flooded over) the embankments at Wenner Lakes No. 1, 2, 3 and 4. At Chalfa Dam (Wenner Lake No.1), floating debris partially obstructed the spillway. Some small erosion channels had started to form on the downstream face of the embankment from the overtopping flows, but did not cut into the dam crest by the time the overtopping flows receded.

At Wenner Lake No.2, erosion in the spillway channel down-cut upstream into the lake, draining the 10 ac-ft. volume of the lake. At Wenner Lake No.3, erosion of the embankment in the vicinity of the culvert down-cut upstream into the lake, draining the 4 ac-ft. volume of the lake.

Downstream Wenner Lake No.4 has a surface area of 11 acres. Depending on how quickly the volumes from Lakes 2 and 3 were released, these volume inflows to Lake 4 could have briefly

raised the water level against Rabel Dam by as much as 1.3 feet until the water levels in Lake 4 receded.

At Rabel Dam (Wenner Lake No.4), a debris flow from the hillside on the left side of the dam obstructed the spillway. Active intervention by the dam owners re-opened the spillway in time to prevent further damage to the dam and spillway. Some erosion channels had started to form on the downstream face of the embankment from the overtopping flows, but did not cut into the dam crest by the time the overtopping flows receded.

Wenner Lake No.5 is the farthest downstream of the five Wenner Lakes. At Hawkins Dam (Lake 5), a debris flow from the hillside on the right side of the dam caused some obstruction of the spillway, although we did not see indications that the dam overtopped. However, erosion in the spillway channel down-cut upstream into the lake, draining the 35 ac-ft. volume of the lake. By mid-day on Friday, the lake was about half-empty, and substantially empty by that evening.

Erosion in the Hawkins Dam spillway scoured a channel 360 feet long, ranging in width from 18 to 45 feet wide and ranging in depth from 8 to 18 feet deep, with an estimated volume of about 6,600 cubic yards. The period of time that it took for this erosion to occur, and for the pond to drain, is still being analyzed and will be examined further in the hydrologic modeling of the Benson Creek watershed.

Future Activities

Hydrologic modeling

At this time, DSO is still compiling the input data for a more-detailed hydrologic model to estimate flow rates at various locations in the watershed, including new dam safety inflow design flood values for the Chalfa, Rabel and Hawkins Dams. What follows are some details about the direction of the modeling effort.

The hydrology model for Benson Creek watershed will consider four major sub-basins:

- Upper Finley Canyon upstream of the large cross-canyon berm that isolates the upper 10 square miles of watershed.
- Middle and Lower Finley Canyon where the five Wenner Lakes are located.
- Upper Benson Creek above the confluence with Finley Canyon.
- Lower Benson Creek between Finley Canyon and the Methow River.

In order to calculate spillway design flows for each of the three major dams, the Middle and Lower Finley Canyon sub-basin will be further subdivided into four smaller sub-basins:

- Tributary to Chalfa Dam (Wenner Lake No.1)
- Tributary to Rabel Dam (Wenner Lake No.4)
- Tributary to Hawkins Dam (Wenner Lake No.5)
- Lower Finley Canyon below Hawkins Dam.

Considering the relatively small size of the various Wenner Lakes compared to the size of the upstream watershed, and the small surcharge storage volumes in the lakes compared to the runoff volumes from the watershed, the modeling effort will simplify the calculations by omitting the reservoir routing and spillway calculations. As a practical matter, Dam Safety's experience with these types of calculations has been that, in many cases, the early part of the design storm fills up the available surcharge storage such that the peak runoff flows go through the reservoir and over the spillway with minimal attenuation of the peak flow rate.

Dam Safety hydrologists are still compiling the basic input data for the hydrology model, including:

- Rainfall depths and design storm hyetographs for the three dam safety storm scenarios.
- Snowpack and snowmelt estimates.
- Drainage areas, times of concentration, hydrograph lag times, and soil infiltration rates (or lack thereof) in each sub-basin.
- Channel reach routing parameters for upstream sub-basins. Considering the lack of information about channel geometry, channel routing will most likely use a simple lag time based on channel slope and estimated water velocity.

We are also still researching the cross-canyon berm and large depression area in Upper Finley Canyon. We are exploring several possible approaches and need to do some trial calculations to decide how to model this feature.

Emergency Action Plans (EAPs)

As part of DSO's technical assistance to dam owners, draft EAPs were compiled for the Chalfa, Rabel and Hawkins Dams and sent to the owners for finalization. The EAP for the Hawkins Dam has been finalized with the owner, so that EAP will be in place if and when the owner decides to rebuild the spillway and refill the reservoir. The draft EAPs for the Rabel and Chalfa Dams are still with the owners awaiting their finalization. Once completed, a copy will be filed with Dam Safety.

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Photographs

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1. Chalfa Dam (Wenner Lake No.1) spillway on Aug 23rd, looking downstream (south).

2. Chalfa Dam (Wenner Lake No.1) spillway entrance on Aug 23rd, looking left (east).

3. Wenner Lake No.2 eroded spillway on Aug 24th, looking upstream (north).

4. Wenner Lake No.2 dam and eroded spillway on Aug 24th, looking downstream (south).

5. Wenner Lake No.3 eroded spillway on Aug 27th, looking upstream (north).

6. Wenner Lake No.3 dam and eroded spillway on Aug 27th, looking right (west).

7. Rabel Dam (Wenner Lake No.4) existing spillway on Aug 23rd, blocked by debris flow, looking downstream (south).

8. Rabel Dam (Wenner Lake No.4) new spillway channel on Aug 23rd, looking downstream (south).

9. Rabel Dam (Wenner Lake No.4) downstream face on Aug 23rd, small erosion gully from overtopping flows; looking upstream (north).

10. Rabel Dam (Wenner Lake No.4) new spillway channel on Aug 27th, pilot channel, looking downstream left (south).

11. Rabel Dam (Wenner Lake No.4) new spillway on Aug 27th, high-flow channel to right of pilot channel; looking downstream (south).

12. Rabel Dam (Wenner Lake No.4) on Aug 27th, valley at left abutment, source of debris flow that blocked the spillway; looking east. At the large trees, sediment is 5 feet thick.

13. Rabel Dam (Wenner Lake No.4) on Aug 27th, new diversion channel at left abutment, looking downstream (south).

14. Hawkins Dam (Wenner Lake No.5) eroded spillway on Aug 25th, looking upstream (north).

15. Hawkins Dam (Wenner Lake No.5) eroded spillway on Aug 25th, looking downstream (south).

16. Lower Finley Canyon, downstream of Hawkins Dam on Aug 28th, debris flow from west side hillslope; looking west.

17. Lower Finley Canyon, downstream of Hawkins Dam on Aug 28th, debris flow from east side hillslope; looking east.

18. Lower Finley Canyon at Benson Creek Road on Aug 28th, looking upstream (north).

19. Upper Benson Creek above Finley Canyon on Aug 28th, looking left (south).

20. Benson Creek below Finley Canyon on Aug 28th, looking downstream (west).

21. Benson Creek at SR-153 on Aug 28th, looking left (south).

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Maps

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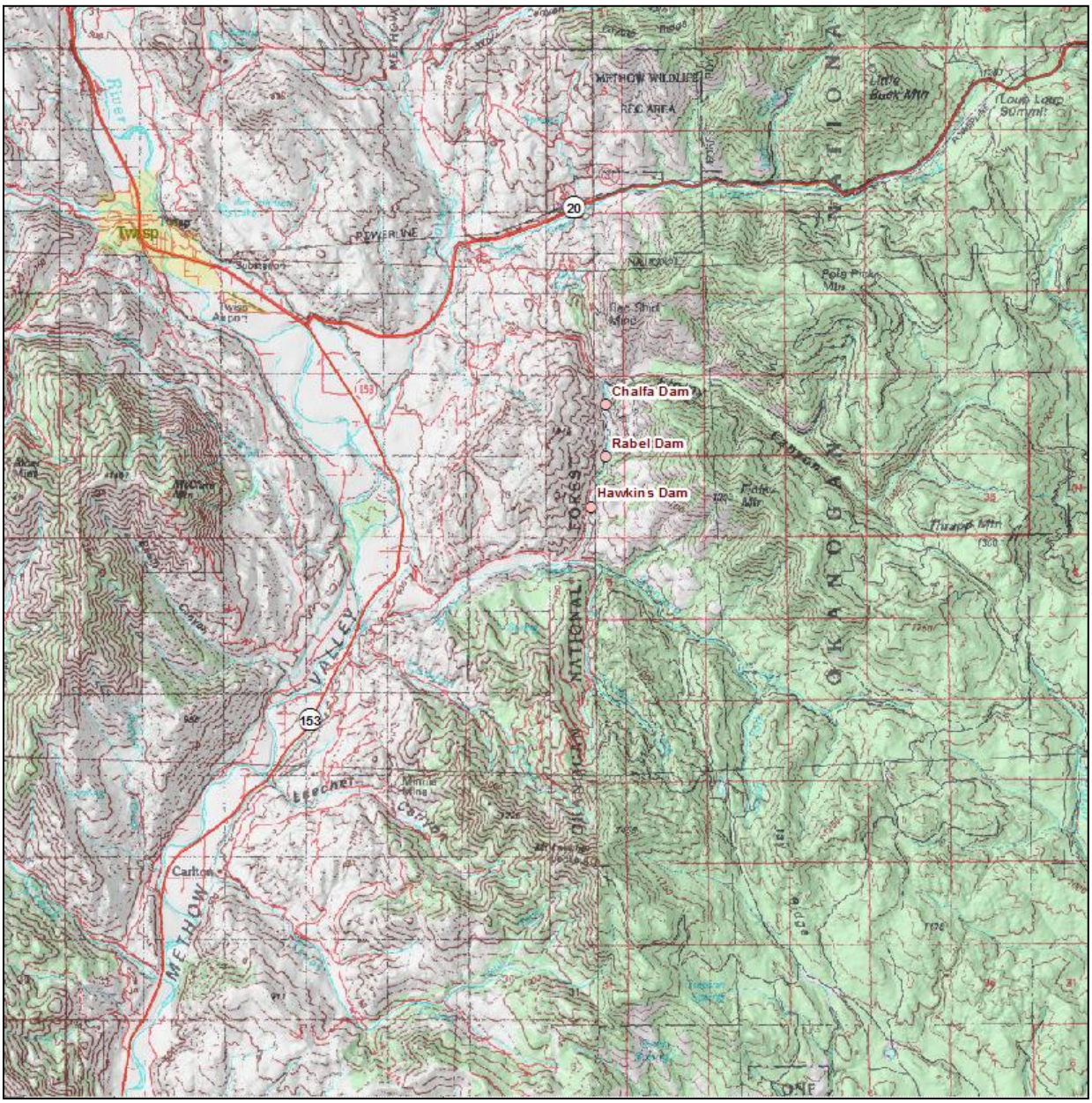
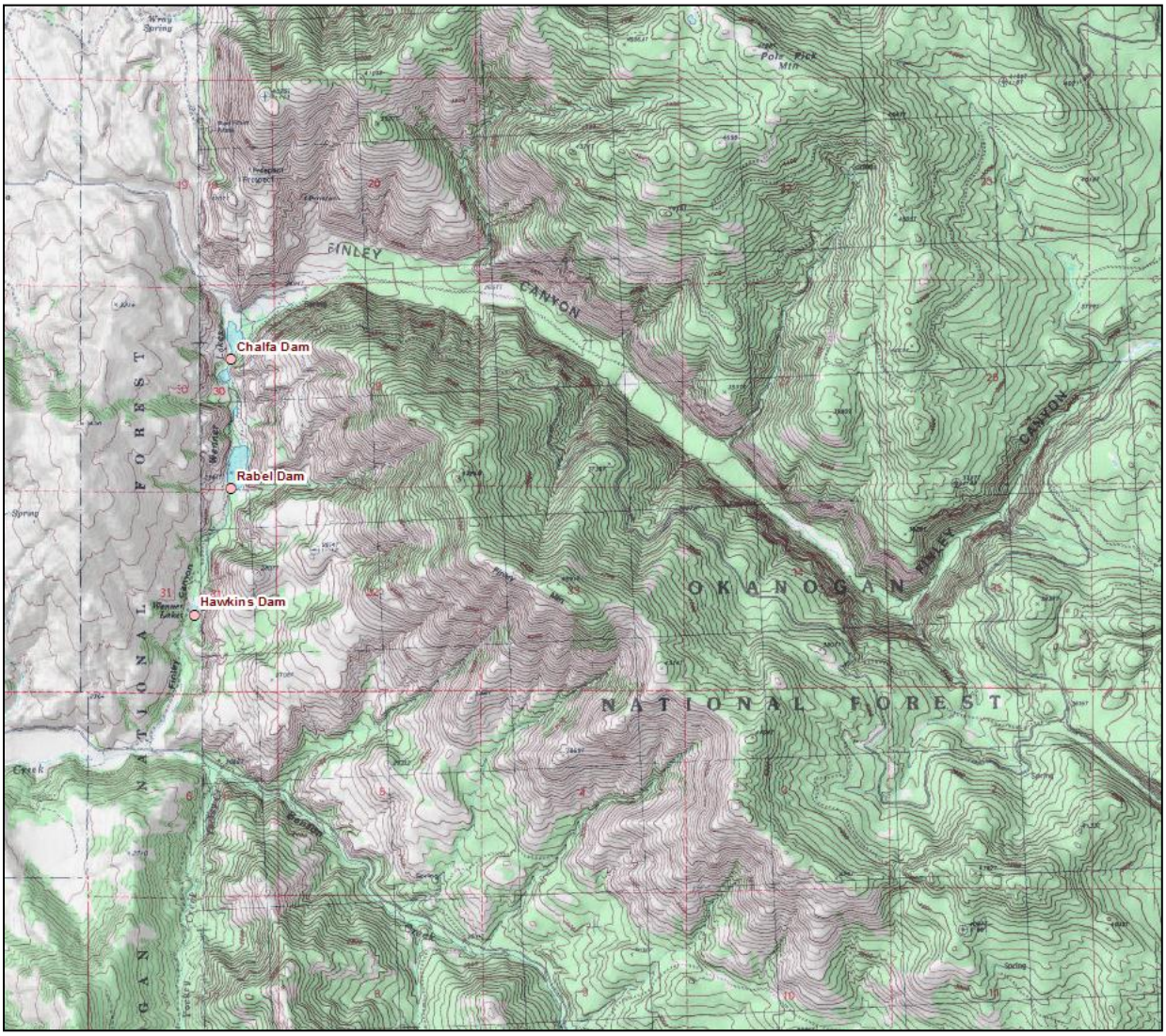
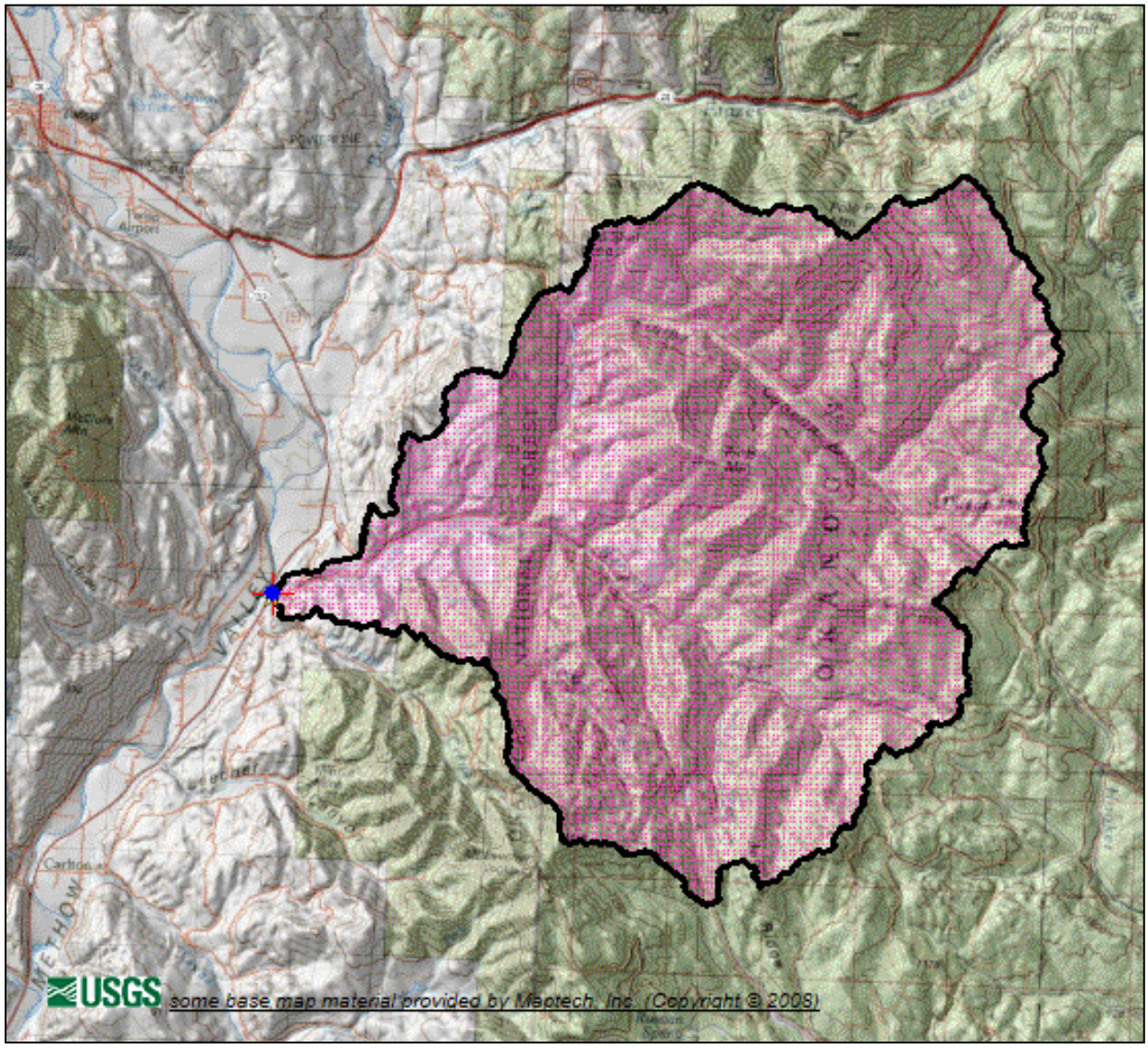


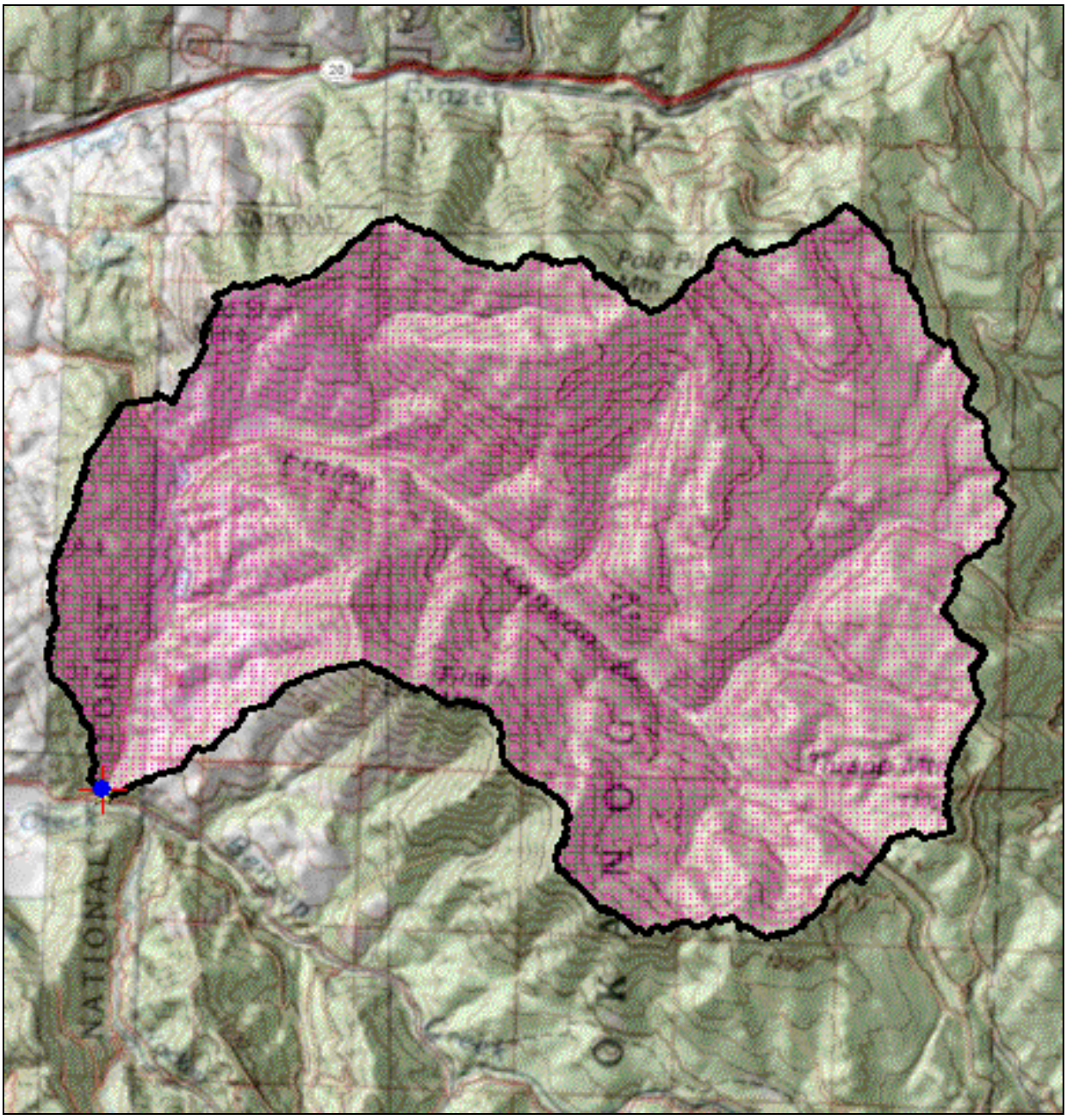
1. Vicinity map for Benson Creek watershed near Twisp in north central Washington.



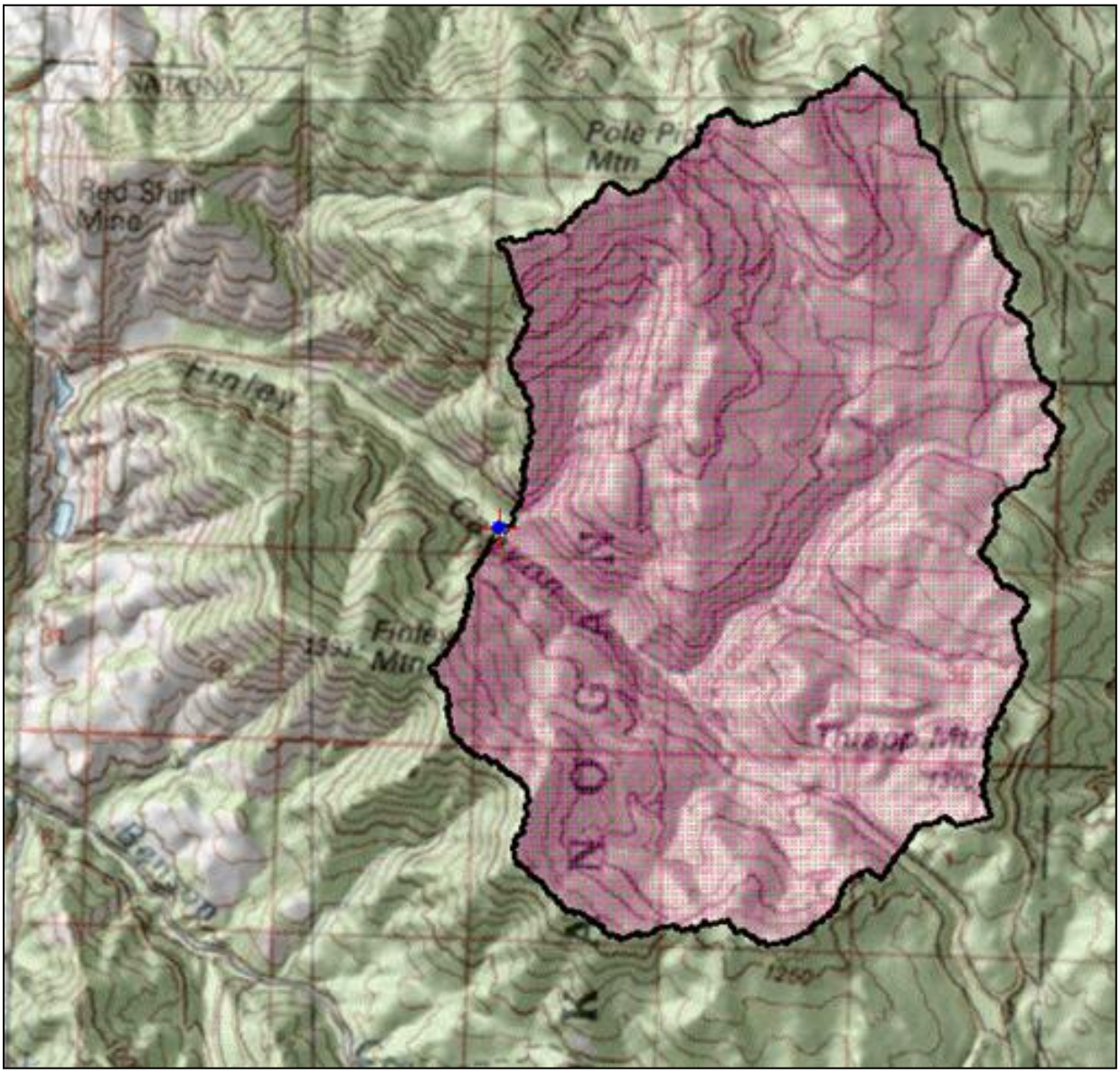
2. Dam locations in Benson Creek Finley Canyon sub-basin.



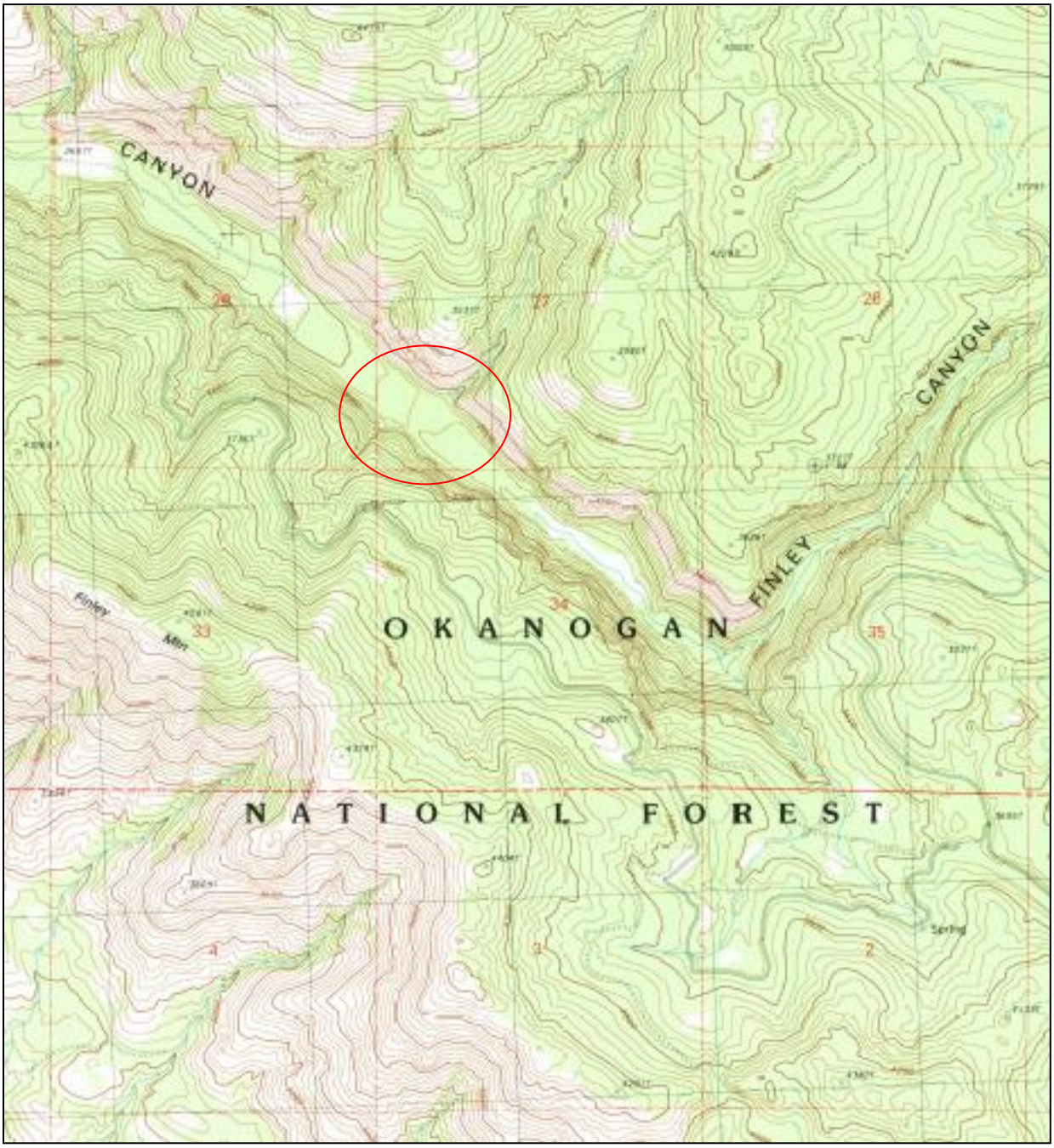
3. Benson Creek watershed near Twisp. Drainage area 38 sq. miles.



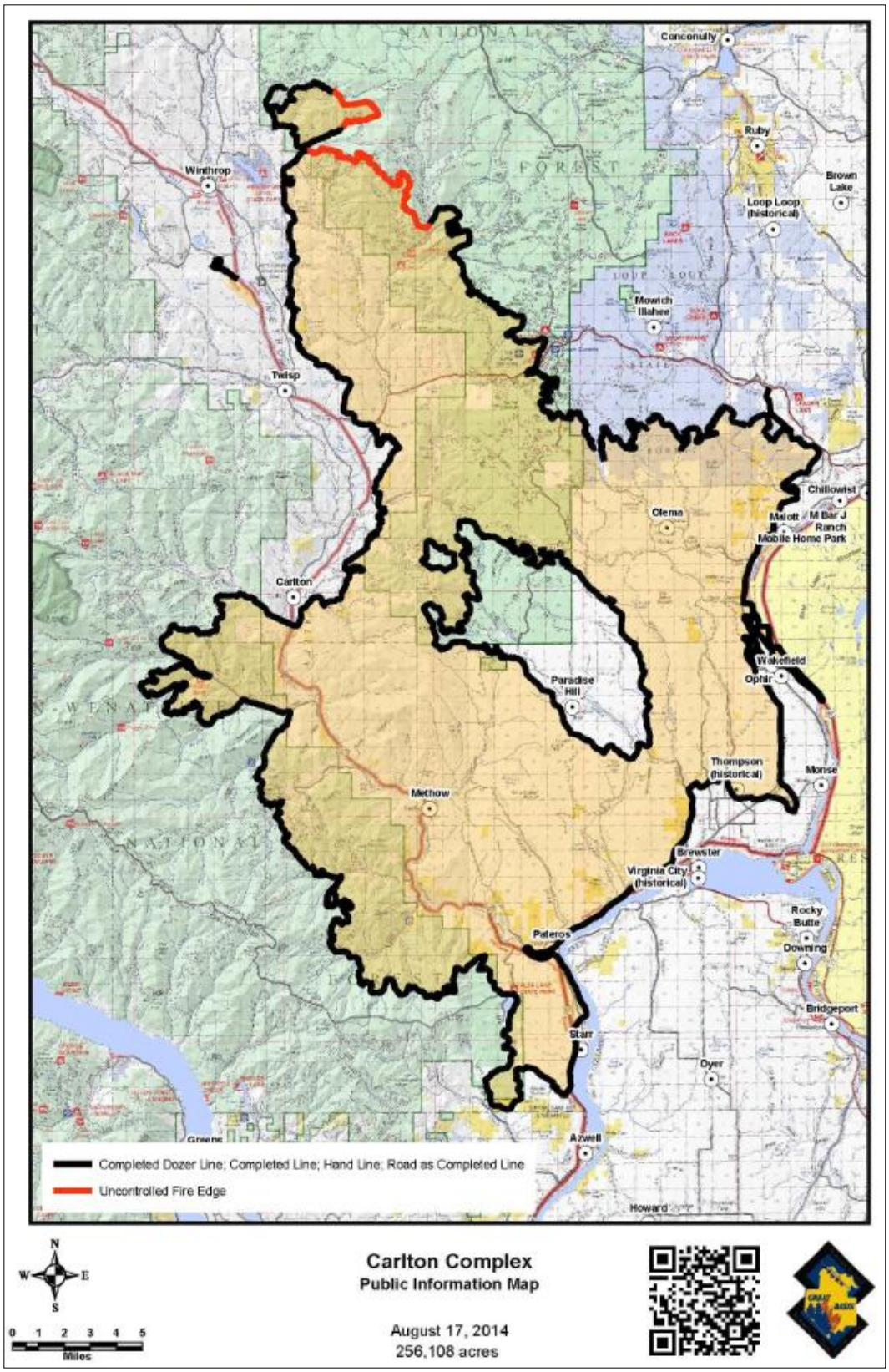
4. Benson Creek Finley Canyon sub-basin. Drainage area 18.3 sq. miles.



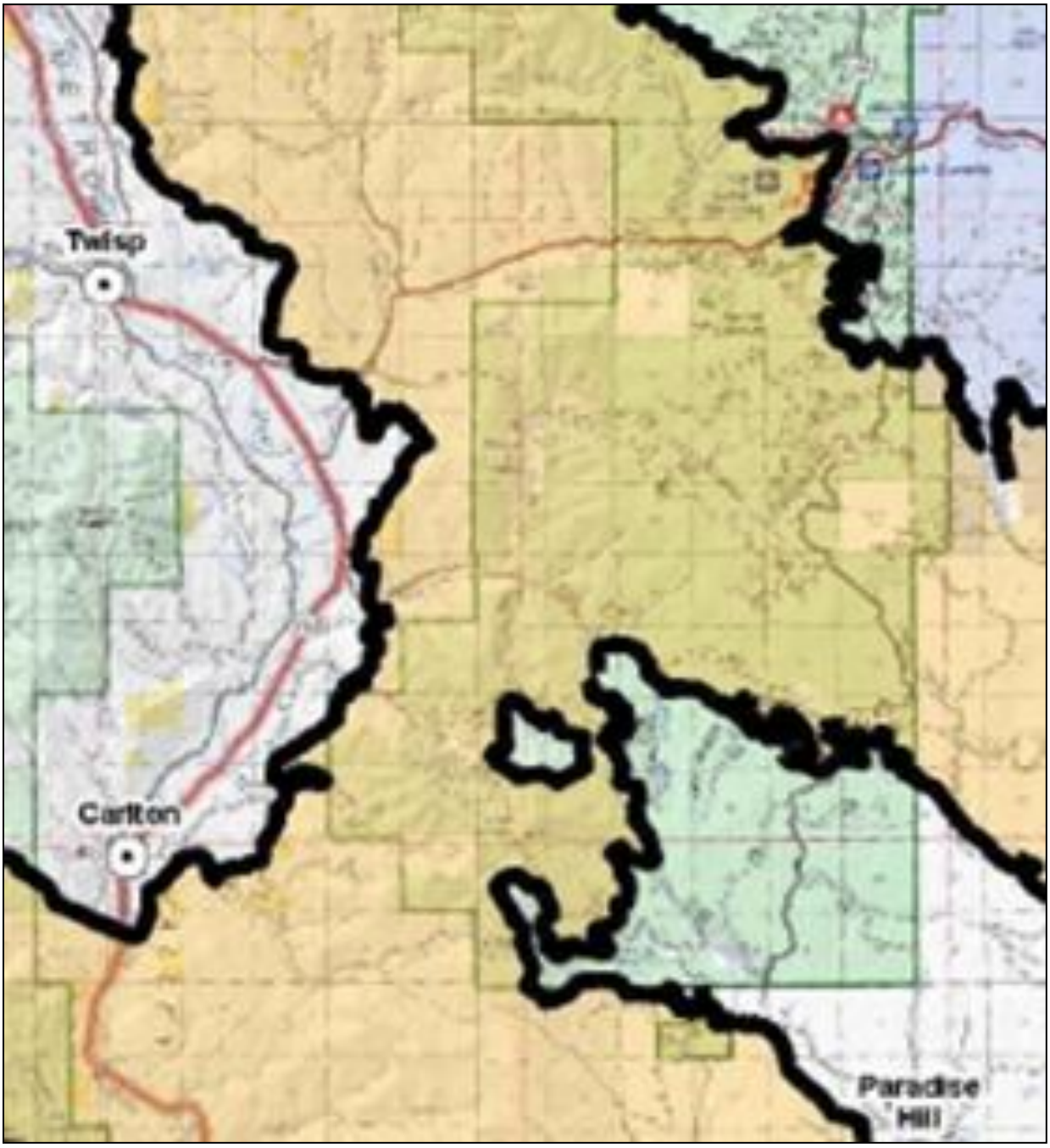
5. Upper Finley Canyon above cross-canyon berm. Drainage area 10.3 sq. miles.



6. Upper Finley Canyon, cross-canyon berm. Upstream drainage area 10.3 sq. miles. Map contour interval is 40 feet.



7. Fire map for Carlton Complex Fire.



8. Fire map for Carlton Complex Fire, close-up of Benson Creek area.