APPENDIX D

INVESTIGATION AND ANALYSIS REPORT

USDA NRCS
United States Department of Agriculture
Natural Resources Conservation Service

McMILLEN, LLC

Investigation and Analysis Report for Silver Lake Flat Dam

Appendix D

American Fork-Dry Creek Watershed
Utah County, Utah

The purpose of the Investigation and Analyses Report is to present information that supports the formulation, evaluation and conclusions of the Preliminary Draft Supplemental Watershed Plan No. 9 and Environmental Assessment #2 (PDraft Plan-EA #2). The report is required and must be included as an appendix to the PDraft Plan-EA #2.

The procedures, techniques, assumptions, and the scope and intensity of the investigations for each subject is described in sufficient detail so that a reader not familiar with the watershed or its problems can form an opinion on the adequacy of the PDraft Plan-EA #2. This report supplements information contained in the PDraft Plan-EA #2 and is not intended to replace or duplicate information contained in the PDraft Plan-EA #2.

April 2013

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INVESTIGATION AND ANALYSIS REPORT

D.1 Introduction

The planning studies presented in this Investigation and Analysis Report are based on standard methods, procedures, and computer programs used and approved for use by the Natural Resources Conservation Service (NRCS). The following information gives a summary of the investigation and analysis for the key planning studies in the preparation of the Preliminary Draft Supplemental Watershed Plan No.9 and Environmental Assessment #2 (PDraft Plan-EA #2) for the rehabilitation of Silver Lake Flat Dam. Additional information relevant to each of the sections provided in this report is available as part of the administrative record for the project upon request. Requests for additional information can be sent to the following address:

USDA-NRCS
Wallace F. Bennett Federal Building
125 S State St., Room 4010
Salt Lake City, UT 84138-1100

D.2 Sedimentation

Silver Lake Flat Dam is a multi-purpose structure that primarily provides water storage but also has incidental benefits to flood control, sediment retention and recreation. The original designed sediment storage capacity was 24 acre-feet (0.16 acre-feet/square mile/year) which was to account for 50 years of sediment deposition starting in 1971 (Alpine Soil Conservation District *et al.* 1958). The trap efficiency of the reservoir was estimated to be 95 percent with 25 percent of the sediment yield expected to deposit above the crest elevation. This results in an annual sediment accumulation in the reservoir of 0.63 acre feet.

The sediment investigations and analyses presented in the original watershed work plan (Alpine Soil Conservation District *et al.* 1958) consisted of the following elements:

- Measuring channel and gully voids in the watershed area above the reservoir.
- Size analysis studies in channels.
- Measuring deposits in debris basins and on flood fans in the watershed.
- Transect measurements of eroding areas to obtain percentages of the various sediment sizes.
- Sampling suspended load material in Silver Creek.
- Transposing sediment rates in neighboring drainages.
- Studying plant cover-condition inventories of the watershed.

The principal sediment source for Silver Lake Flat Reservoir is gullied, alluvial filled valleys within the 4.29 square mile watershed. Mining operations upstream of the reservoir have caused considerable erosion in the past, but none of the mines are currently operating. Mine dumps and access roads will continue to be eroded by rills and gullies, and are expected to contribute a small amount of sediment to the reservoir in the future. Timber harvesting is being controlled in the watershed and present erosion rates are likely much lower than those that existed at the time the dam was constructed. Most of the sediment is delivered to Silver Creek through high volume rain on snow runoff and summer flash flood events. Approximately half of the watershed is also located in a designated wilderness area that is not disturbed and is not expected to input excess sediment into the reservoir.

D.2.1 Reservoir Survey Methodology

In July 2012, a bathymetric sediment survey was conducted on the reservoir by the Oceanside Group (on behalf of NRCS) to map and compute the sediment accumulation below the reservoir water level since the original dam construction in 1971. The bathymetric survey was completed using a single beam depth sounder to obtain reservoir bottom elevations. The bathymetric survey was supplemented with 2012 survey data gathered from the Utah Department of Water Resources around the exposed portions of the reservoir during low water conditions. The ground survey was completed using high accuracy land surveying equipment. Light Detection and Ranging (LiDar) data was also obtained in 2010 to supplement the survey data for areas that were not surveyed at the Silver Lake Flat Reservoir. The results of all three surveys were combined to create a topographic map of the bottom of the reservoir. A common control datum was used to assure the bathymetric, ground, and LiDar survey data were properly merged together by NRCS. Specific survey methods and data used to create the reservoir bottom profile are available upon request from the NRCS State Office in Salt Lake City, Utah at the address described in Section D.1. Figure D-1 shows the reservoir stage storage curve based on the results of the surveys (NRCS 2013a).

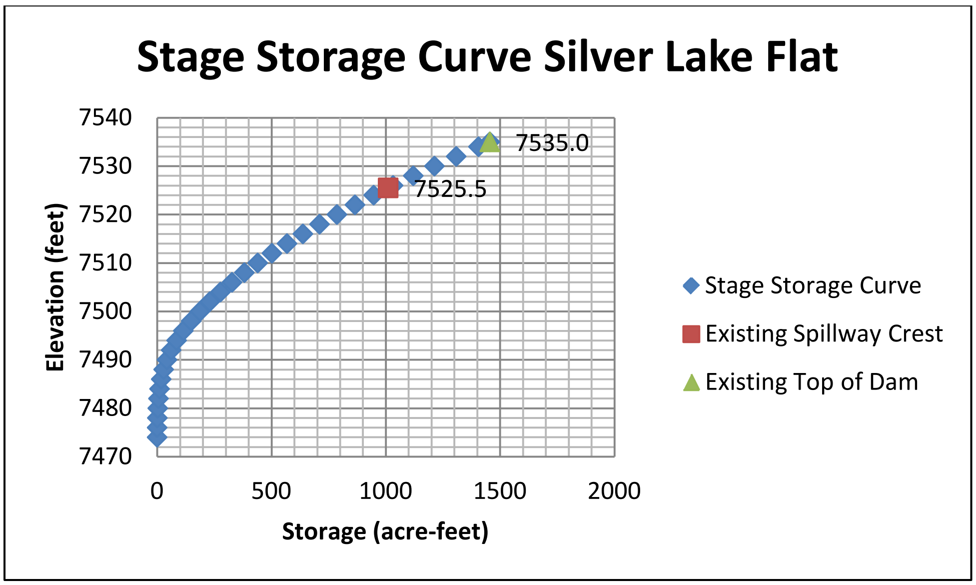

Figure D-1. Stage Storage Capacity Chart

This existing topographic data was compared to the original as-built topography data of the reservoir before inundation (Soil Conservation Service [SCS] 1972) using current Geographic Information System (GIS) and Computer Aided Drawing (CAD) mapping software. The as-built topography did not match current conditions and was determined to be inadequate for further sediment accumulation computations. Thus, the difference between the as-built profile and the current profile could not be used to determine the volume replaced by sediment over the past 42 years. Instead, multiple sediment accumulation calculation methods were analyzed to determine the annual sediment rate into the reservoir.

D.2.2 Predicted Sediment Accumulation

NRCS used the original designed sediment storage capacity (Alpine Soil Conservation District *et al.* 1958) and the survey information for the reservoir to identify the sediment volume accumulation and rate per year since 1971. Detailed results of this analysis are presented in the report *Sedimentation and Trap Efficiency of Silver Lake Flat Reservoir* (NRCS 2013a). Due to the lack of suitable topographic survey from dam construction in 1971, a model was not prepared to identify the volume of sediment accumulation in the reservoir over the past 42 years. Therefore, the calculated sedimentation rate of 0.63

acre-feet/year was used to determine the existing sediment volume in the reservoir (26.53 acre-feet) since 1971. The current elevation of the Silver Lake Flat Dam spillway crest is 7525.5 feet. Raising the height of the spillway crest to 7528.0 feet (2.5-foot increase) would extend the dam service life for 71 years starting in 2017 for sedimentation (NRCS 2013a). This 2.5-foot increase would create an additional 44 acre-feet of storage for sediment accumulation in the reservoir before the economic life of the dam and reservoir is surpassed. The new trap efficiency of the reservoir was estimated to stay the same at 95 percent but the new sediment yield expected to deposit above the crest elevation is 10 percent. Figure D-2 shows the proposed elevations for both the 50-year and 100-year sediment storage (NRCS 2013a).

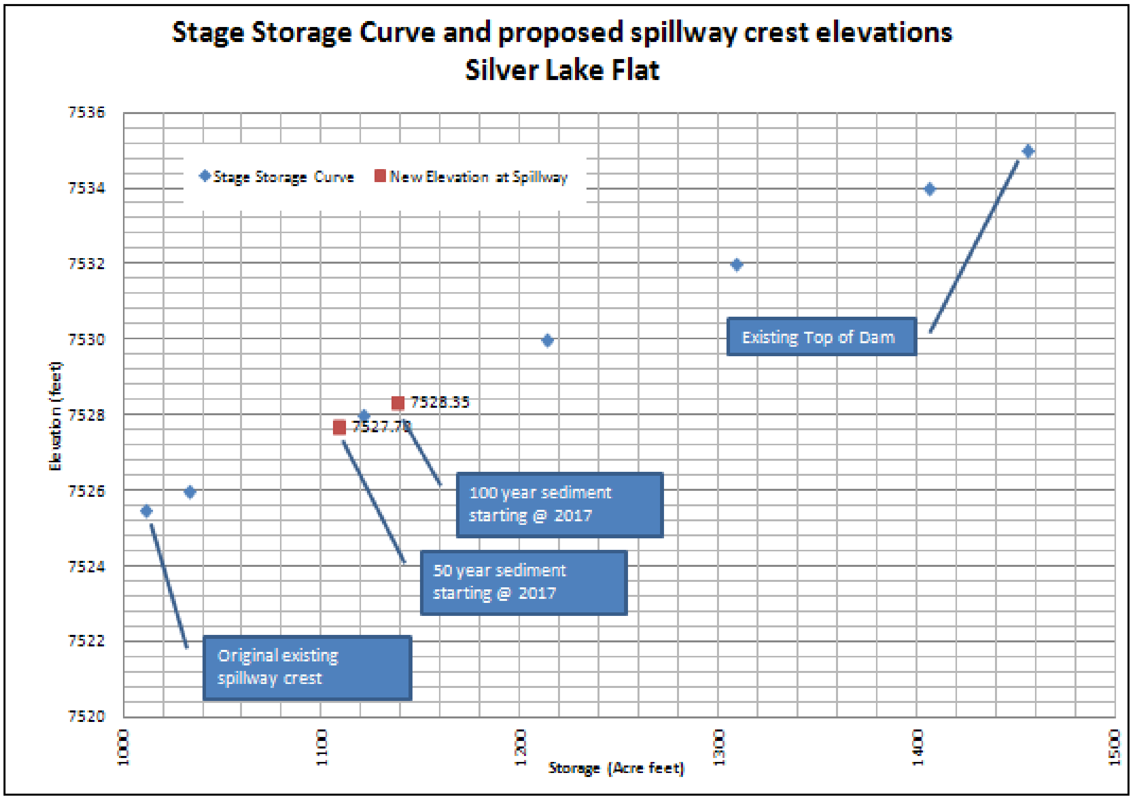

Figure D-2. Stage Storage Curve and Proposed Spillway Crest Elevation

The sediment storage life of Silver Lake Flat Dam over the next 71 years (starting in 2017) is dependent on the overall maintenance and management of the upper watershed which is completely located within the boundary of the U.S. Forest Service (USFS) Uinta-Wasatch-Cache National Forest (UWCNF). These lands are managed exclusively by the USFS for recreation and minor timber operations. It is reasonable to expect the erosion and sediment yield rates to continue as it has over the last 42 years to yield an average 0.63 acre-feet/year into Silver Lake Flat Reservoir. Speculation about the future effects of climate change on the upper watershed vegetation is beyond the scope of this analysis, therefore, climate change effects is not considered in the predicted sediment yield rate to the reservoir.

D.3 Breach Routing Analysis

The breach analysis was conducted based on standard NRCS methods and procedures to determine the Hazard Classification. A detailed description of the Breach Routing Analysis is located in the report *Silver Lake Flat Breach Analysis and Hazard Classification* (NRCS2013b). Survey data used for the hydrology and hydraulic data was acquired and developed by NRCS State Office engineering staff. This survey data was used in the analyses for each of the programs used to develop the two breach scenarios.

The primary breach was located at the left abutment and the secondary breach was located at the right abutment. Numerous breach equations and models were used to determine breach discharges, routes and times from Silver Lake Flat Dam to American Fork City. According to NRCS policy, the most conservative results will be used for the breach routing analysis and hazard classification. The breach analyses consisted of using NRCS Simplified Dam Breach Technical Release 66 (TR66), Hydrologic Engineering Centers River Analysis System (HEC-RAS) unsteady flow, and Flo2D, a 2-dimensional hydraulic program, to route the breach.

D.3.1 Breach Criteria

The primary breach analysis used NRCS TR66 to route the hydrograph from Silver Lake Flat to Tibble Fork Reservoir. HEC-RAS was used to continue the breach routing from Tibble Fork Reservoir to the opening of American Fork Canyon in the town of Highland. Tibble Fork Reservoir was assumed to not breach and during modeling volumes from Tibble Fork Reservoir was not add to the hydrograph. From the mouth of American Fork Canyon in Highland, the breach routing was finally continued using Flo2D through American Fork City. The breach Q for the primary breach is approximately 72,000 cfs and attenuates to approximately 51,000 cfs at Tibble Fork Reservoir.

The secondary breach was only routed from Silver Lake Flat to Tibble Fork Reservoir. Since the primary breach was larger, the secondary breach routing was terminated at the Tibble Fork Reservoir. The breach Q for the secondary breach is approximately 43,470 cfs and attenuates to approximately 37,300 cfs at Tibble Fork Reservoir.

A rainy day breach was assumed with a water surface at the top of the dam when the breach occurs. The structural height of the dam was 110 feet with a total storage of 1,109 acre-feet.

D.3.2 Hazard Classification

The NRCS breach analysis (2013b) with flood inundation maps was completed to document the Hazard Classification of Silver Lake Flat Dam. The dam was originally designed and built as a High Hazard dam and is still classified as a High Hazard dam. NRCS TR66 breach criterion was used for the study and HEC GeoRAS and HEC-RAS was used to create geometry data and model the breach discharge. Breach inundation area maps are depicted in Figures D-3, D-4, and D-5.

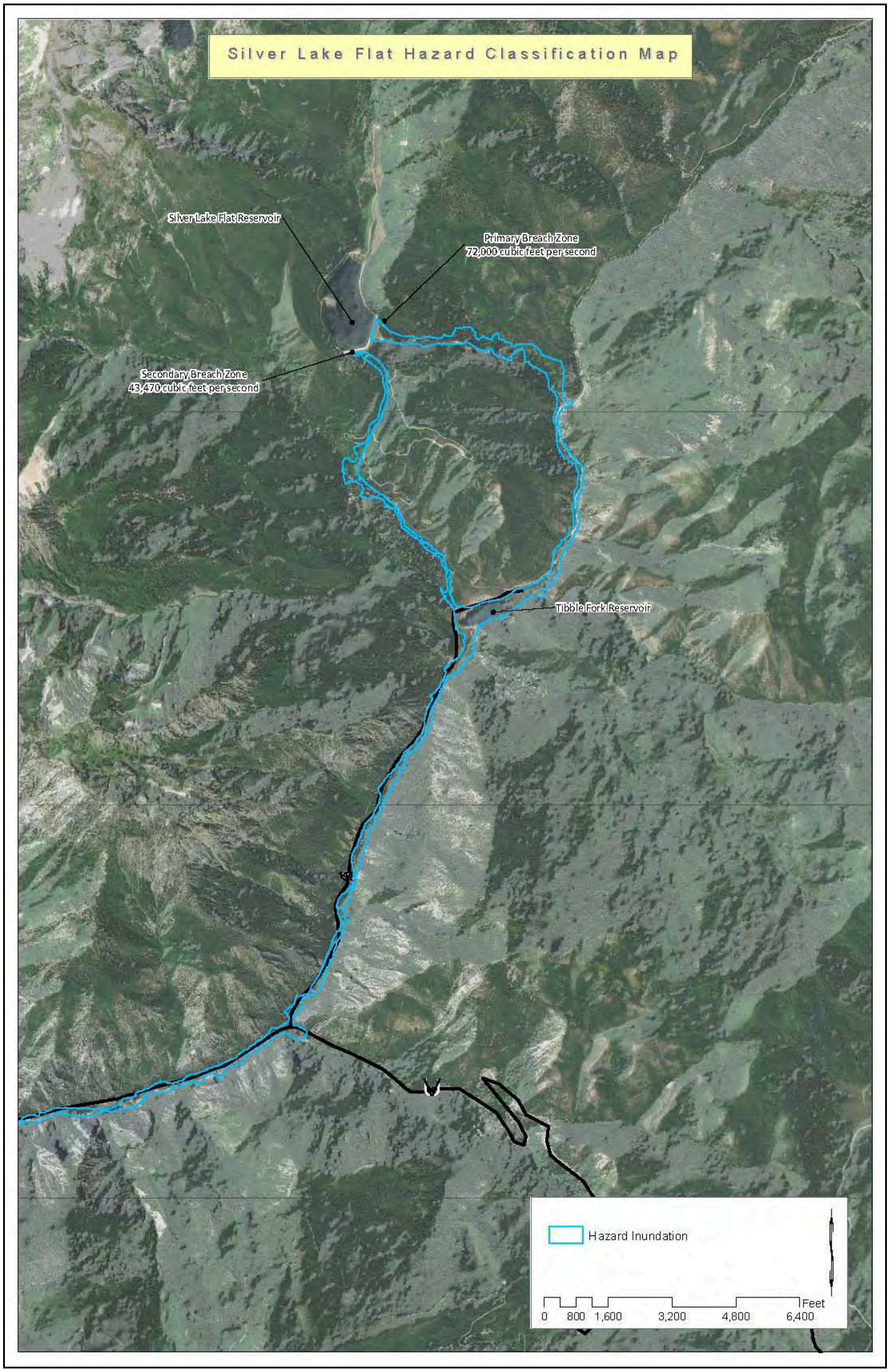

Figure D-3. Breach Inundation Map 1

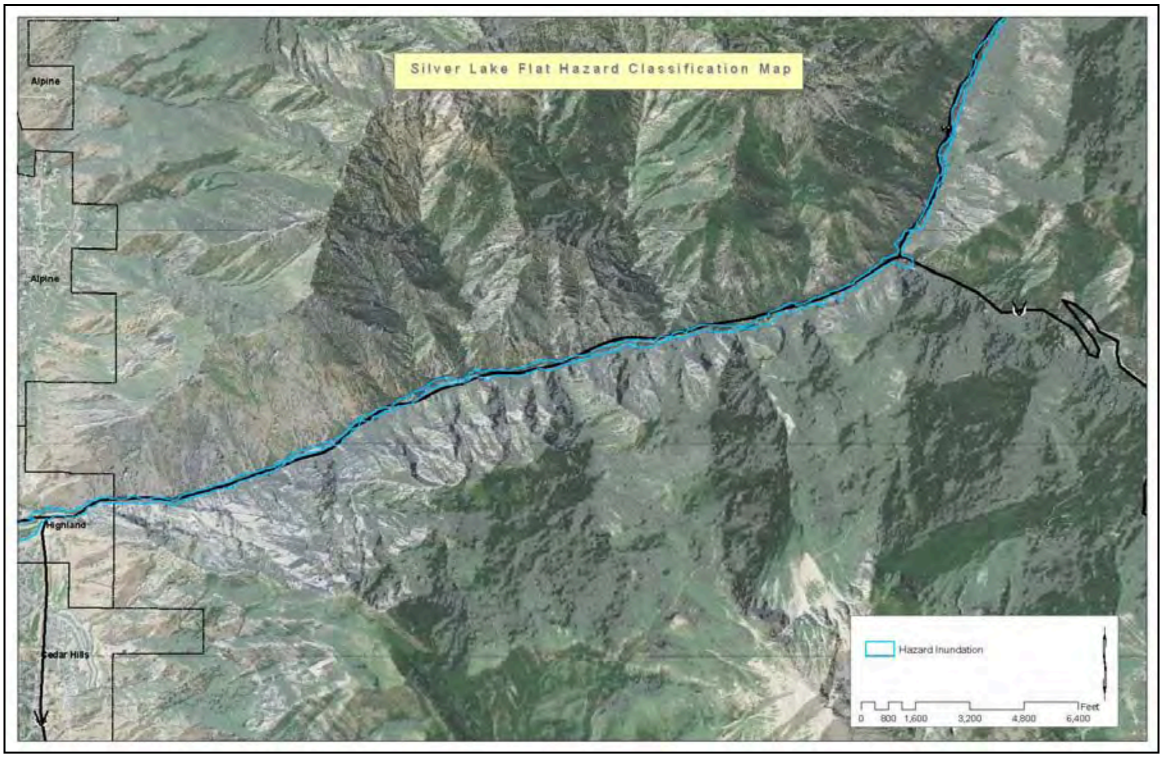

Figure D-4. Breach Inundation Map 2

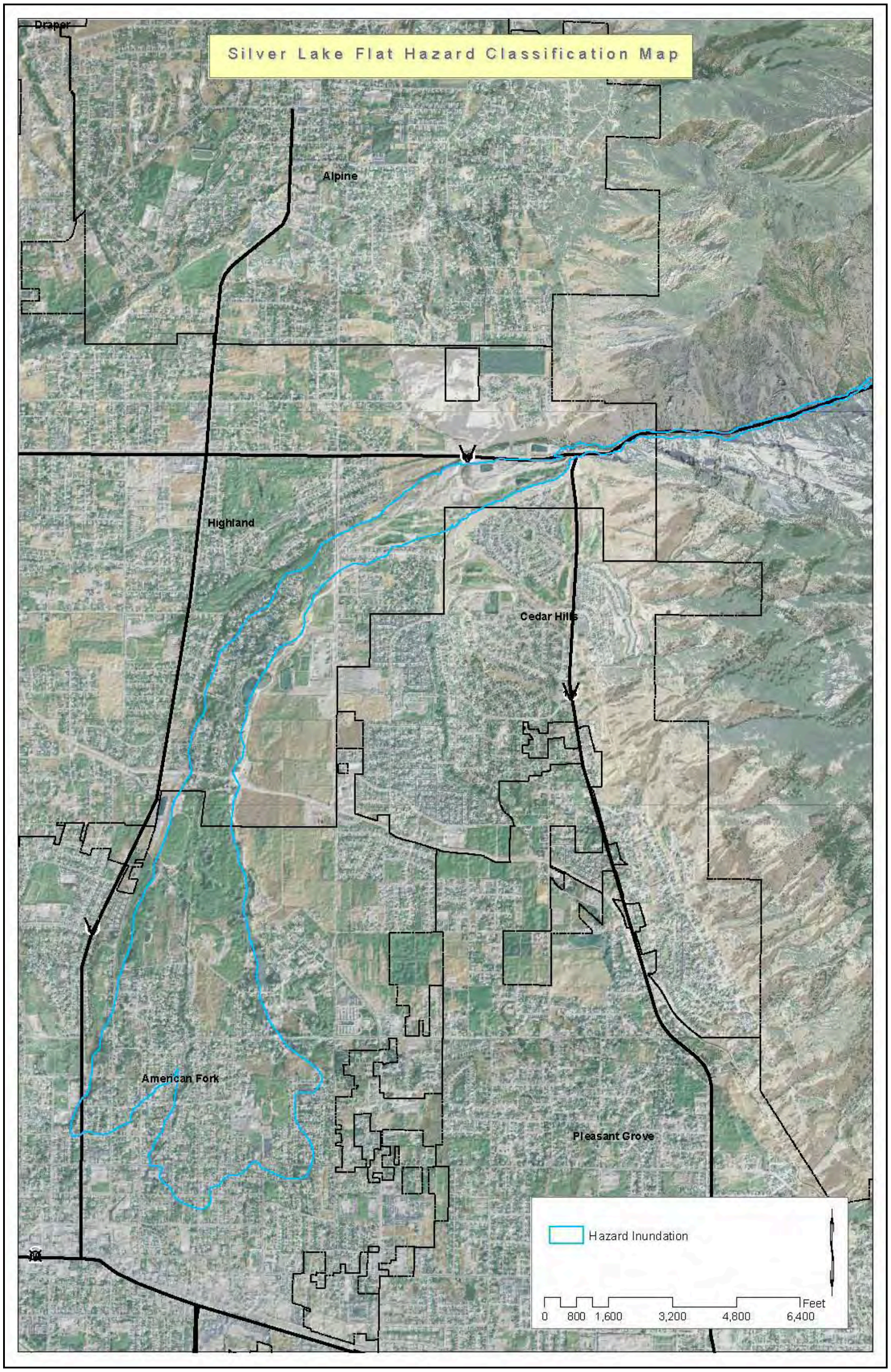

Figure D-5. Breach Inundation Map 3

The primary breach location travels down Silver Creek drainage to Forest Road 085 which meets with the North American Fork River which is approximately 5000 feet downstream of the Silver Lake Flat Dam. The secondary breach location travels down a unnamed drainage to Granite Flat Campground Road which is approximately 4,000 feet downstream of the Silver Lake Flat Dam. There are a few camp sites and trail heads present along the inundation path. Tibble Fork reservoir is located in the inundation area and has a high recreational use throughout the year.

The breach inundation zones continue from Tibble Fork Reservoir to the State Highway 92 that is continued on to State Highway 144 to the mouth of the American Fork Canyon. The section from Tibble Fork Reservoir to State Highway 92 is approximately 10,000 feet in length. State highway 144 also parallels the river and has pullouts for both picnicking and camping. Also located along State Highway 144 is the Timpanogos Cave National Monument with permanent housing in the inundation zone. The section from State Highway 144 to the mouth of American Fork Canyon is approximately 5 miles in length. From the mouth of the American Fork Canyon the inundation zones opens into 3 communities. These communities are Highland, Cedar Hills, and American Fork City. The breach inundation zone is a high residential area with golf courses (2), a debris basin, baseball fields, and schools among other community structures.

The potential for development from Silver Lake Flat Dam to the mouth of American Fork Canyon is limited since it is located within the boundary of the USFS UWCNF. Development is increasing on a continual basis in the cities of Highland, Cedar Hills, and American Fork. Timpanogos Highway (State Highway 144) is currently a 4 lane high capacity throughway through these cities.

Due to the high use in the Silver Lake Flat Dam breach inundation area from recreationalist, campers, etc, the presence of State Highway 92 and 142, and high residential areas in the cities of American Fork, Cedar Hills, and Highland, Silver Lake Flat Dam is currently classified as a High Hazard Dam (NRCS 2013b).

D.3.3 Population at Risk

Dam failures and associated flash floods can result in high fatality rates, especially when flooding overwhelms an unsuspecting group of people. Dam failures that produce slowly rising floods tend to result in lower fatality rates. Buildings located within the dam breach inundation zone have a high risk of being damaged during a dam failure; furthermore, any persons located within those buildings have a high risk of fatality. The loss-of-life resulting from a dam failure is influenced by three factors: 1) dam failure, 2) number and location of people exposed to the dam breach, and 3) loss of life amongst the threatened population (Homeland Security 2011).

In order to determine the population-at-risk (PAR) from a dam failure, an analysis was performed to identify the number of buildings within the flood inundation zone as specified for the Flood Comparison Method in the 2011 Homeland Security Report *Methods for Estimating Loss of Life Resulting from Dam Failure*. There are six steps for estimating the PAR and loss-of-life using this method:

1. Choose a dam failure scenario to evaluate;
    - Dam failure from flood water overtopping at the dam crest
2. Evaluate the area flooded by the dam failure;
    - The inundation area is identified on Figures D-3 through D-5
3. Estimate the average number of people at risk from the dam failure;
    - The PAR was identified by overlaying the flood inundation area on Utah County GIS parcel information (Utah County 2013) and aerial photographs

- o There are 173 buildings located within the flood inundation area that has an inundation depth of two feet or greater

Table D-1. Population at Risk

Location	Night		Day	
	Summer	**Non-Summer**	**Summer**	**Non-Summer**
Mile 0.0 to 10.0 (American Fork Canyon)				
USFS Granite Flat Campground	50	0	25	0
USFS Tibble Fork Reservoir	0	0	50	20
USFS Mile Rock Picnic Area	0	0	10	0
USFS Martin Picnic Area	0	0	10	0
USFS Roadhouse Picnic Area	0	0	10	0
USFS Echo Picnic Area	0	0	10	0
USFS Grey Cliffs Picnic Area	0	0	10	0
USFS Little Mill Campground	50	0	25	0
NPS Timpanogos Cave National Monument	20	20	100	20
USFS American Fork Canyon Entrance Station	0	0	5	0
Subtotal	*120*	*20*	*255*	*40*
Mile 10.0 to 15.0 (Highland, Alpine, American Fork, and Lehi)				
Buildings (3 people per building)	519	519	260[1]	260[1]
Cedar Hills Golf Club	0	0	160	0
Fox Hollow Golf Course	0	0	160	0
American Fork High School	0	0	10	2,000[2]
Subtotal	*519*	*519*	*590*	*2,260*
TOTAL	**639**	**539**	**845**	**2,300**

[1] Population is estimated to be 50% of value at night.
[2] American Fork High School is located in an area of inundation 2 feet or greater.

4. Evaluate the danger posed by the flood: Compare the peak discharge from the dam failure to a more common flood;
    - o A dam failure would create a surge of 72,000 cfs at the dam and 57,600 cfs (80% of dam) at the mouth of American Fork Canyon flowing down the inundation path
    - o The 10-year flood flow is approximately 274 cfs at the dam and 528 cfs at the mouth of American Fork Canyon (USGS 2013)
    - o The addition of 528 cfs would not cause any noticeable increase in flood volumes from the dam breach flood flows
5. Select a fatality rate based on the flood ratio and the distance from the dam; and
    - o The flood inundation path was broken into two segments:
        - ▪ Mile 0.0 to 10.0: Silver Lake Flat Dam down to the mouth of the American Fork Canyon. This canyon is very steep and incised and flows are not expected to attenuate quickly.
        - ▪ Mile 10.0 to 15.0: Mouth of the American Fork Canyon to the end of the flood inundation mapping. This area is located within the cities of Highland, Alpine, American Fork, and Lehi
    - o Ratio of Peak Discharge from Dam Failure to 10-Year Flood Discharge
        - ▪ More than 100
            - • Mile 0.0 to 10.0 Ratio = 263
                - o 0.75 fatality rate
            - • Mile 10.0 to 15.0 Ratio = 110
                - o 0.37 fatality rate

6. Present life-loss estimates.

Table D-2. Loss-of-Life Estimate

Location	Night		Day	
	Summer	Non-Summer	Summer	Non-Summer
Mile 0.0 to 10.0 (American Fork Canyon)	90	15	192	30
Mile 10.0 to 15.0 (Highland, Alpine, American Fork, and Lehi)	193	193	219	837
TOTAL	**283**	**208**	**409**	**867**

D.4 Geologic Analysis

The information presented in this Geologic Analysis section is a summary of the following two reports: *Final Geologic Evaluation, Silver Lake Flat Dam, Utah County, Utah* (NRCS 2012a) and *Final Seismic Hazard Evaluation, Silver Lake Flat Dam, Utah County, Utah* (NRCS 2012b).

D.4.1 Seismic Evaluation

The seismic evaluation is a summary of the seismic hazard evaluation for Silver Lake Flat Dam. Two important components in determining exposure to seismic risk for any dam are the risk of an earthquake occurring near enough to produce significant ground motions in the dam foundation and the response of the structure and foundation in such an event. In evaluating potential seismic exposure of Silver Lake Flat Dam and determining the Maximum Credible Earthquake and attendant peak ground accelerations, a thorough evaluation of potential seismogenic sources was performed.

Since Silver Lake Flat Dam is under Utah State Dam Safety jurisdiction, both deterministic and probabilistic analysis of seismic hazard must be employed to compute anticipated earthquake ground motions at the site and site response. For deterministic analysis, several steps are involved including review of the seismotectonic setting, identification of known potential seismic sources (faults), and evaluation of potential ground motions associated with each using current attenuation model. This last step requires specification of certain fault parameters (e.g. fault dip, width of rupture surface, maximum credible earthquake magnitude, etc.) from known or inferred data. These parameters are then input into mathematical attenuation relationships that model site ground motions in response to an earthquake on any one seismic source. Resultant ground motions can then be used to develop anticipated site response spectra for analysis of foundation stability. In 2008 a new series of attenuation relationships were created to identify seismic parameters in a certain area. These include relationships developed by Abrahamson & Silva (2008), Boore & Atkinson (2008), Campbell & Bozorgnia (2008), Chiou & Youngs (2008) and Idriss (2008). These Next Generation Attenuation relations have been used for the seismic evaluation.

A deterministic evaluation was done (6 cases were evaluated) using the Provo section of the Wasatch Fault which is the most critical source identified that could be a hazard to Silver Lake Flat Dam. The highest deterministic value was from the Provo section of the Wasatch Fault dipping 75° with a magnitude of 7.5. The highest ground motion is the Median + σ (g) with a value of 0.49g. The seismic parameters of 0.49g generated from a magnitude 7.5 event as determined from the deterministic calculations (Next Generation Attenuation) is the Maximum Credible Earthquake and is the recommended ground acceleration and magnitude to be used for analysis of the dam foundation for Silver Lake Flat Dam rehabilitation (NRCS 2012b).

D.4.2 Seismotectonic Setting

The Intermountain Seismic Belt (ISB) is a north-trending zone of historical seismicity that roughly coincides with the edge of the Basin and Range Physiographic Province. The ISB runs more than 1,500 kilometers (km) from Montana down to northern Arizona and southern Nevada. The ISB includes major active faults within Utah such as the Wasatch Fault Zone in northern Utah. The Wasatch Fault is a normal fault exhibiting predominantly vertical movement with the west side of the fault displaced down relative to the east. This fault has abundant evidence of surface-rupturing events during the Holocene. Within the fault there is evidence of late Quaternary normal faulting abounds, as well as historic seismicity, most of it characterized by shallow focus, small magnitude events, punctuated periodically by larger surface rupturing earthquakes of surface wave magnitude of 6.5-7.5.

Silver Lake Flat Dam occurs within seismic zone 3 of the International Conference of Building Officials (1997). Figure D-6 is a copy of the USGS 2,475 Year Return (2% P.E. in 50 years) Random Earthquake Peak Ground Accelerations map (2008 Hazard Data). Silver Lake Flat Dam is located in the 0.29 to 0.35 g (40 to 50% g) peak ground accelerations for the 2,475 year return period.

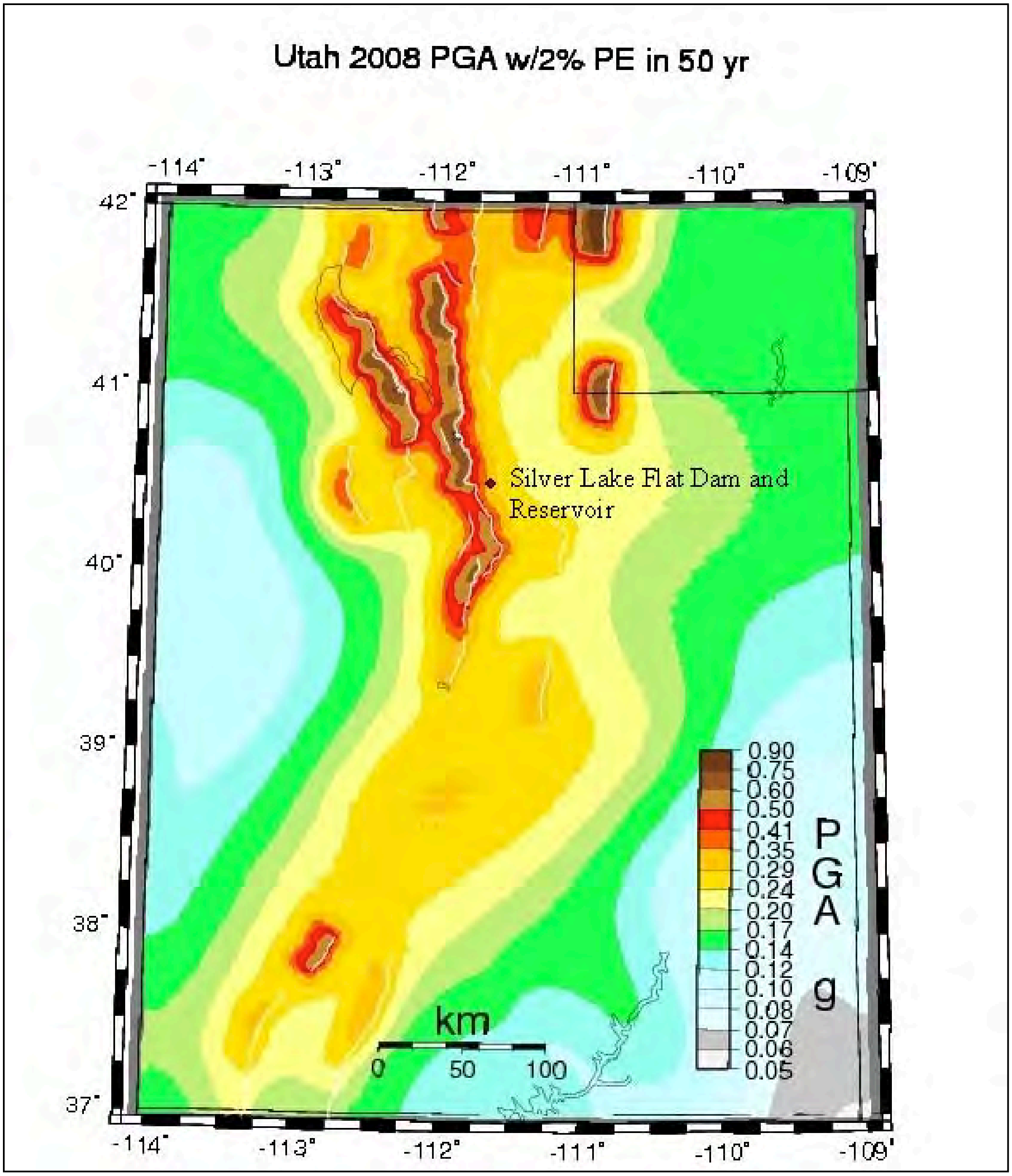

Figure D-6. 2,475 Year Return Random Earthquake Peak Ground Accelerations

D.4.3 Historic Earthquakes

Records of historic seismicity for Utah show a concentration of activity along the Wasatch Fault Zone and other faults in the eastern Basin and Range within the ISB. There are 48 documented earthquakes greater than a magnitude of 5.0 along the ISB reaching from northern Montana down to southern Utah. Table D-3 (University of Utah Seismograph Stations 2011) lists all the earthquakes greater than magnitude 4.0 that have occurred with a radius of 100 km of Silver Lake Flat Dam. The largest earthquakes within 100 km are three magnitude 5.7 earthquakes that occurred 19.9, 44.9, and 52.4 miles (32.1, 72.3, and 84.3 km) from Silver Lake Flat Dam. The closest earthquake to the dam with a magnitude greater than 4 is the May 24, 1953 event at a distance of 8.2 miles (13.2 km) and had a magnitude of 4.3.

Table D-3. Earthquakes with a Magnitude Greater than 4.0 within a 100 km Radius

Date	Magnitude	Distance from Silver Lake Flat Dam (km)
May 22, 1910	5.7	32.1
August 1, 1900	5.7	72.3
May 13, 1914	5.7	84.3
September 5, 1962	5.2	43.8
February 13, 1958	5.0	25.4
July 15, 1915	5.0	29.0
March 7, 1949	5.0	32.1
February 22, 1943	5.0	42.2
July 18, 1894	5.0	84.3
September 30, 1977	4.5	99.4
May 24, 1980	4.4	67.7
May 24, 1953	4.3	13.2
September 28, 1952	4.3	20.9
October 1, 1972	4.3	26.0
December 1, 1853	4.3	29.0
August 12, 1951	4.3	29.0
June 30, 1938	4.3	32.1
February 2, 1955	4.3	39.2
April 10, 1943	4.3	42.2
May 12, 1955	4.3	49.6
May 8, 1950	4.3	51.6
April 8, 1914	4.3	58.0
February 5, 1916	4.3	59.5
August 11, 1915	4.3	84.3
May 24, 1906	4.3	84.3
November 28, 1958	4.3	88.8
December 1, 1958	4.3	88.8
December 2, 1958	4.3	88.8
December 1, 1853	4.3	89.4
January 18, 1950	4.3	97.9
March 16, 1992	4.12	33.8
October 11, 1977	4.04	99.2
July 9, 1963	4.0	65.6

* Data obtained from University of Utah Seismograph Stations (2011)

The Silver Lake Flat Dam area has been historically seismically active and the potential for a large earthquake exists. However, few historic earthquakes of large magnitude (over 6.0) have been documented in Utah. On March 12, 1934 a 6.6 M event (Hansel Valley earthquake) occurred approximately 102.1 miles (164.3 km) from Silver Lake Flat Dam, followed by a 6.1 M event the next day. On November 14, 1901, in Sevier County, Utah a greater than 6.5 M (exact size not known) event occurred about 122 miles (196 km) south-southwest of Silver Lake Flat dam. No earthquakes over magnitude 7.0 are documented in Utah; however, a large magnitude 7.1 to 7.7 event occurred near Hebgen Lake, Montana. This earthquake appears to be a model of what may happen along the Wasatch Fault based on similar surface height rupture (Terracon 1997).

Despite the seemingly rare occurrence of large magnitude events, the late Quaternary record demonstrates repeated surface displacement events in alluvial deposits, particularly along segments of the Wasatch Fault Zone. Given the observed Quaternary record, future large magnitude earthquakes with attendant surface displacement can be expected in Utah. Arabasz *et al.* (1992) indicate that the threshold for surface rupture within the Basin and Range appears to be about magnitude 6.3+0.2 based on evaluation of historic earthquakes with surface rupture in eastern California and Nevada as well as those within the ISB. They go on to state that the upper threshold magnitude for faulting within the ISB, and particularly along the Wasatch Front is in the range of magnitude 7.5-7.7 based on evaluation of maximum observed displacements for single events. In addition, they make the case that the seismogenic source zone for major earthquakes in the Basin and Range is generally at depths no greater than 15 to 17 km.

D.4.4 Seismic Sources

According to NRCS TR60, a radius search of 62 miles should be performed to locate historically active faults. However, this radius was reduced to 20 miles because the Wasatch Fault Zone (Provo section) is located within 5 miles of Silver Lake Flat Dam and could generate up to a magnitude 7.2 to 7.5 event. An event at this magnitude would overshadow other faults greater than 20 miles away. The mapped active Quaternary faults within 20 miles of Silver Lake Flat Dam are listed below in Table D-4 in ascending order from closest to furthest. The most significant of these in terms of potential impact to the dam are located west of the dam and all are normal faults characteristic of the Basin and Range and High Plateaus transition zone with the nearest being the Wasatch Fault Zone. Based on the lengths of the indicated active fault segments for each, a potential maximum magnitude has been determined using regression relationships developed by Wells and Coppersmith (1994) for normal faults.

Table D-4. Active Faults within a 20 Mile Radius

Fault	Distance from Silver Lake Flat Dam (km)	Active Length (km)	Potential Maximum Magnitude
Wasatch Fault Zone Provo Section	8	69.5	7.22
Wasatch Fault Zone Salt Lake City Section	8.3	46	7.11
Frog Valley Fault	11.9	5	6.09
Round Valley Faults	12.3	11.5	6.45
Utah Lake Faults and Folds	13.8	30	6.85
Parleys Park Fault	14.6	4	6.00
West Valley Fault Zones	18.8	15.5	6.86

* Data obtained from Halling *et al.* (2002)

D.4.5 Geology

Silver Lake Flat Dam and Reservoir are located in the American Fork drainage in the Wasatch Mountains. The Wasatch Mountains separate two provinces with the Middle Rocky Mountains physiographic province on the east side and the Basin and Range Physiographic Province on the west side. The Wasatch Fault occurs to the west of Silver Lake Flat Dam approximately 5 miles (8 km) and is the structural element that separates the two provinces.

The geologic units in the immediate vicinity of reservoir that are most pertinent to the project include:

- Quaternary alluvial deposits (Qal): (stream gravel, valley fill and low angle alluvial cones),
- Quaternary Glacial Deposits including the glacial morainal deposits composed dominantly of monzonite and metamorphic (Qm): (may include some glacial outwash),
- Tertiary Tibble Formation (Tt): (coarse red conglomerate, with some greenish reworked tuff, breccia and white algal limestone),

- Mississippian Doughnut Formation (Mdo): (thin-bedded dark gray fine-grained fossiliferous silty limestone), and
- Mississippian Humburg Formation (Mh): (dark- to light-gray limestone interbedded with sandstone).

The foundation of the dam is mostly Qm and Qal with bedrock (Mdo and Tt) below these Quaternary deposits. The bedrock was originally thrusted placing older rocks on younger rocks. This thrust fault was later re-activated by crustal extension into a normal fault (Deer Creek Fault). The Deer Creek Fault occurs approximately 90 feet below the left abutment of the dam. The Deer Creek Fault is not a Quaternary fault and is not considered active (NRCS 2012a). The last movement of the Deer Creek Fault was normal (Constenius *et al.* 2003) and the movement on this fault continued through Oligocene to early Miocene (40 to 18 Ma); therefore, the last movement on this fault is probably older than 18 Ma. Additionally, since the fault is not a Quaternary fault (older than 1.65 Ma), seismic activity is not anticipated along this fault.

The dam is located on a terminal moraine with a lateral moraine on the left abutment and a medial moraine on the right abutment. The surficial glacial deposits are underlain by older moraines and outwash materials. Glacial lake deposits consist of varved clays and clayey sand and underlie part of the upstream foundation. These glacial deposits are difficult to correlate in the subsurface. Most of the foundation is dense to very dense and the softer material is found in lens or thin layers. The level of the reservoir is only at maximum from April to early August. A blanket and a cut-off trench were added to minimize the saturation of the foundation and alluvium below the embankment. The efficiency of the natural clay blanket, cut-off trench and blanket (non-porous material), and the short time the reservoir is filled does not allow the upper foundation above the cutoff trench and the embankment to saturate. However, groundwater still occurs at depths below the cut-off trench in the foundation.

D.4.6 Landslides

A historical landslide is located on the hill near the left abutment of the dam that probably predates the most recent glacial episode (NRCS 2012a). NRCS (1995) stated the evidence this unconsolidated material is landslide material is the presence of shale and limestone in the trenches dug. Additionally, it states there is no upstream source of shale and limestone and the rocks would not have survived in glacial transport; therefore, the left abutment is not totally of glacial origin (NRCS 1995). NRCS (1995) stated this area has no large vegetation, while to the southeast the trees and stumps show curvature (J-shape trunks) due to active soil creep processes. These J-shaped trees are located at the base of the hill just above the reservoir high water elevation. If this landslide does predate the most recent glacial episode then this glacial event would remove geomorphic evidence of the ancient landslide. The LiDAR depicted in Figure D-7 (NRCS 2012a) demonstrates the continuity of the hill with no evidence of an active landslide; however, the hillslope has abundant soil creep as do many slopes in the region. If the left abutment hill were to fail, it has the potential to affect the reservoir and dam. However, the hill has experienced three to four events in the last 6,000 years that could have triggered this left abutment hill to fail. This hill did not fail during these seismic events during the last 6,000 years and suggests the left abutment hill is most likely stable (NRCS 2012a).

A small landslide has been documented near the existing spillway on the right side. This landslide is associated with an area of active seep and should be mitigated during the proposed rehabilitation by collecting the seepage and discharging the seepage into the new stilling basin. A small slide occurred at this location in 1984 and partially filled the spillway. This event was noted to be relatively minor, did not impact the integrity of the spillway and was not of dam safety concern (NRCS 2012a).

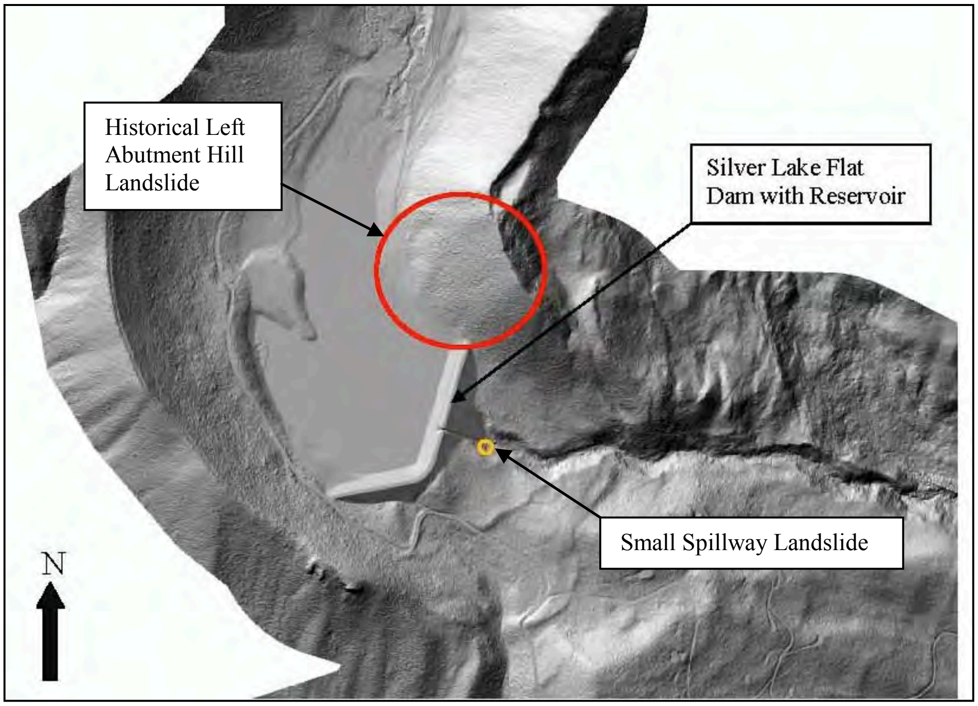

Figure D-7. Landslides

D.4.7 Groundwater Springs and Seeps

Examination of data from the piezometers, historic water levels recorded during drilling, and observations of the seeps downslope of the embankment indicate that the embankment is mostly dry while water is occurring in the foundation. However, several springs and seeps have been documented at and near the dam embankment as shown in Figure D-8 (NRCS 2012a):

- Groin Seep: Seepage has been documented in the left downstream groin of the dam off of the embankment. This seep is active during normal to wetter precipitation years and not visible in dry years. Only clear water has been noted flowing from this seep.
- Spillway Seep: Seepage has been documented on the southern side of the spillway near the stilling basin. This seepage is associated with a small landslide area and water has been noted to spill over the concrete walls into the spillway. This seep is active during normal to wetter precipitation years. Only clear water has been noted flowing from this seep.
- Horse Trail Seep: Seepage has been documented approximately 300 feet downstream of the right embankment of the dam. This seepage crosses underneath the access road and daylights into wetland area. Flowing water is present year-round with higher volumes when the reservoir is at high levels. Only clear water has been noted in the flows.

Figure D-8. Groundwater Springs and Seeps

These seeps and springs indicate that water is seeping through the foundation of the dam below the cutoff wall. The conveyance route for this water may occur in sand and gravel in the glacial moraine material or the Horse Trail Seep may be following relict fluvial deposits. A review of all the data suggests the presence of two distinct and separate aquifers at the dam site: a shallow perched aquifer, and a deep and confined aquifer.

The groundwater for both the left abutment Groin Seep and the Spillway Seep should be collected and discharged away from the embankment. This may be accomplished by modifying the toe drain system on the left abutment and designing a collection and discharge system for the Spillway Seep. The Horse Trail Seep does not impact the embankment but appears to be connected to the reservoir. Utah Division of Water Rights (UDWRt) Dam Safety has requested that a collection and monitoring system be installed (UDWRt 2012b) to the Horse Trail Seep to monitor for erosion and measurement of seepage flow rates in relation to the reservoir water level.

D.4.8 Geologic Hazards Summary

The following Table D-5 (NRCS 2012a) summarizes the geologic hazards and associated rating for Silver Lake Flat Dam and Reservoir.

Table D-5. Geologic Hazard Summary

Geologic Hazard	Hazard Rating		
	Probably[1]	Possible[2]	Unlikely[3]
Earthquake			
Ground Shaking	X		
Liquefaction		X	
Surface Faulting			X

Geologic Hazard	Hazard Rating		
	Probably[1]	Possible[2]	Unlikely[3]
Tectonic Deformation			X
Slope Failure		X	
Seiche		X	
Slope Failure (Non-Seismic)			
Rock Wall			X
Landslide	X		
Debris Flow		X	
Avalanche (Snow)		X	
Foundation Problems			
Collapsible Soils			X
Expansive Clays			X
Sensitive Clays			X
Organic Soils			X
Soluble Salts			X
Pipable/Erodible Soils		X	
Karst			X
Sinkholes	X		
Differential Settlement			X
Non-Engineered Fill			X
Hydrologic			
Shallow Groundwater		X	
Springs/Seeps	X		
Flooding Stream/Lake		X	
Upstream Dam Failure		X	
Spillway Capacity	X		
Dam Overtopping	X		

[1] Probable – evidence is strong that the hazard exists and mitigation measures should be taken.
[2] Possible – hazard may exist but evidence is uncertain and further study is recommended.
[3] Unlikely – no evidence was found to indicate that the hazard is present.

D.5 Geotechnical Analysis

The information presented in this Geotechnical Analysis section is a summary of the following two reports: *Final Geologic Evaluation, Silver Lake Flat Dam, Utah County, Utah* (NRCS 2012a) and *Silver Lake Flat Dam, Dam Safety Upgrades, 60% Design Report* (Utah Division of Water Resources [UDWRe] 2013a).

D.5.1 Seepage

D.5.1.1 Piezometers

An evaluation of the piezometer data collected from Silver Lake Flat Dam was completed to obtain a reasonable phreatic surface through the embankment for slope stability analysis and for guidance for the steady state seepage analysis. Nineteen piezometers have been placed in the embankment and foundation of the dam since construction. Of these nineteen piezometers, only five show any response to the fluctuating reservoir levels. Four of those are foundation piezometers at various locations near the downstream toe of the dam. The other fourteen piezometers are non-responsive, indicating the phreatic surface is below the depth of the piezometer. Based on these observations, the embankment and foundation show effective drainage resulting in a relative low phreatic surface through the dam embankment.

D.5.1.2 Toe Drains

No formal drain flow measurements have been made on the two drain discharge pipes. The right toe drain collection system has never shown evidence of seepage discharge, suggesting relatively drained conditions beneath the right portion of the embankment. The left toe drain collection system is estimated to flow 20 gallons per minute (gpm) with the reservoir full to 2 gpm when the reservoir is low.

D.5.1.3 Transient Phreatic Surface

The transient or operational phreatic surface was based on the piezometers showing water level fluctuations during normal reservoir operation. The operational phreatic surface was used to help define and provide boundaries for the steady state seepage analysis. Three sections of the dam were evaluated, specifically:

7. The maximum section at approximate station 15+00
8. The section through the spillway alignment at approximate station 16+00
9. The right embankment at station 19+79

The phreatic surface under transient seepage conditions and used in each of the three specific cross-sections follows the same pattern depicted in Figure D-9.

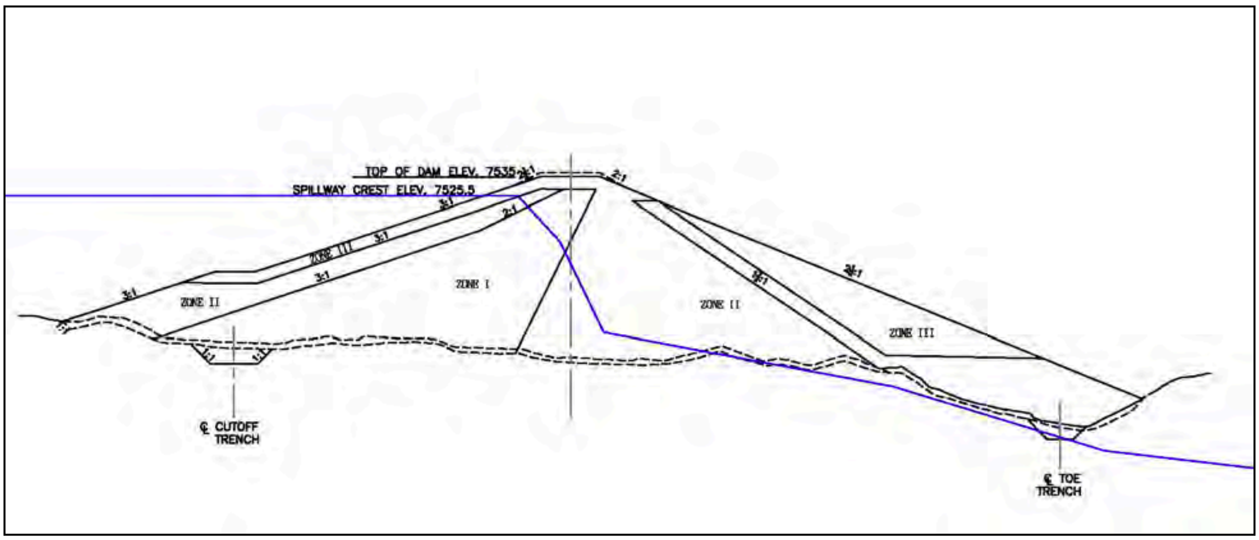

Figure D-9. Transient Phreatic Surface Cross Section

D.5.1.4 Permeabilities – Steady State

In spite of the annual drawdown of the dam, the lack of steady state condition data experienced at the dam and the similar projected pattern of use in the future has caused the UDWRt Dam Safety to request a steady state seepage analysis be completed for the project and used in the stability and deformation analyses. Due to potential embankment damage of in situ permeability testing, no permeability tests were performed as part of the current investigation. In addition, a review of the original investigation drilling did not show any permeability testing of the foundation. It is recognized that this steady state seepage scenario is approximate, including the permeabilities estimates assigned.

A helpful consideration in refining the permeabilities was the available piezometric data under the transient seepage conditions since construction of the dam. In running the steady state seepage analysis, permeabilities were carefully adjusted to take into consideration the known transient seepage/piezometric conditions. A description and permeability assignment is presented below for each subject soil:

Zone I Core
Zone I embankment material varies from clayey and silty sand (SCSM) to clayey and silty gravel (GC-GM). Due to the approximate nature of the seepage analysis, a mid-level approach to assigning values was used, specifically, a Kv = 5 ft/yr and Kh/Kv = to 6.5; as such, the Kh = 35 ft/yr.

Zone II Shell
Zone II embankment material generally consists of clayey and silty gravels (GC-GM). The mid-level approach values used are Kv = 200 fr/yr and a Kh/Kv = to 6.5, the Kh = 1300 ft/yr.

Zone III Shell (quasi-chimney)
Zone III quasi-chimney embankment material includes minus 5% fines and 18-inch maximum particle size. Due to the broadly graded nature of the construction materials, the Zone III Shell is considered to be well graded gravel with sand (GW). The mid-level approach values used are Kv = 2,000 ft/yr and a Kh/Kv = to 3, results in a Kh = 6,000 ft/ yr.

Zone III Shell
Zone III shell embankment material is the same as the Zone III quasi-chimney, except the fines vary between 0 to 10%. From the bulk sieve analysis the Zone III material is broadly and relatively evenly graded with approximately 30% minus #4 sieve, and is considered a GW-GM. The mid-level approach values used are Kv= 1,000 ft/yr and Kh/Kv = to 6.5, Kh = 6,500 ft/yr.

Unconsolidated Foundation (0 – 15 feet)
The upper foundation materials consist of well graded sand and gravels (SW & GW), silty sand (SM) and silty gravel (GW). The mid-level approach values used are Kh = 1,000 ft/ yr and the Kh/Kv be approximately 3, resulting in a Kv of 350 ft/yr.

Unconsolidated Foundation (15 feet to Bedrock)
The foundation materials beneath the upper foundation and overlying bedrock consist of silty sands and gravels (SM & GM), clayey sand and clayey gravel (SC & GC), some well graded sands (SW), clays (CL), and poorly graded gravels (GP). The mid-level approach values used are Kh of about 2,000 ft/yr, and the Kh/Kv be approximately 2, resulting in a Kv of 1,000 ft/yr.

Alluvial Foundation
Borings SPT-2 and SPT-3 were located within the alluvial channel. An alluvial layer approximately 15 to 20 feet thick was encountered overlying the morainal foundation. This material mainly consisted of silty sand (SM) and silty gravel (GM), with some clay (CL) and silt (ML) layers. The blow counts in this zone varied between 10 and refusal. An average friction angle of 33 degrees with no cohesion was assigned.

Varved Clay
Thin layers of varved clay were identified in SPT 10-1 and SPT 10-4, and described by Holland and Griswold (1968) as existing upstream of the centerline of the dam. It was reported by Holland and Griswold that this material had shear values in excess of 31 degrees. This material was assigned a friction angle of 31 degrees, and cohesion of 500 psf.

Bedrock Foundation
The bedrock materials beneath the unconsolidated foundation consist of fractured limestone. The mid-level approach values used are Kh of 750 ft/yr and the Kh/Kv equal to 3, resulting in a Kv of 250 ft/yr for the limestone.

Figure D-10 presents the location of the different zones of Silver Lake Flat Dam.

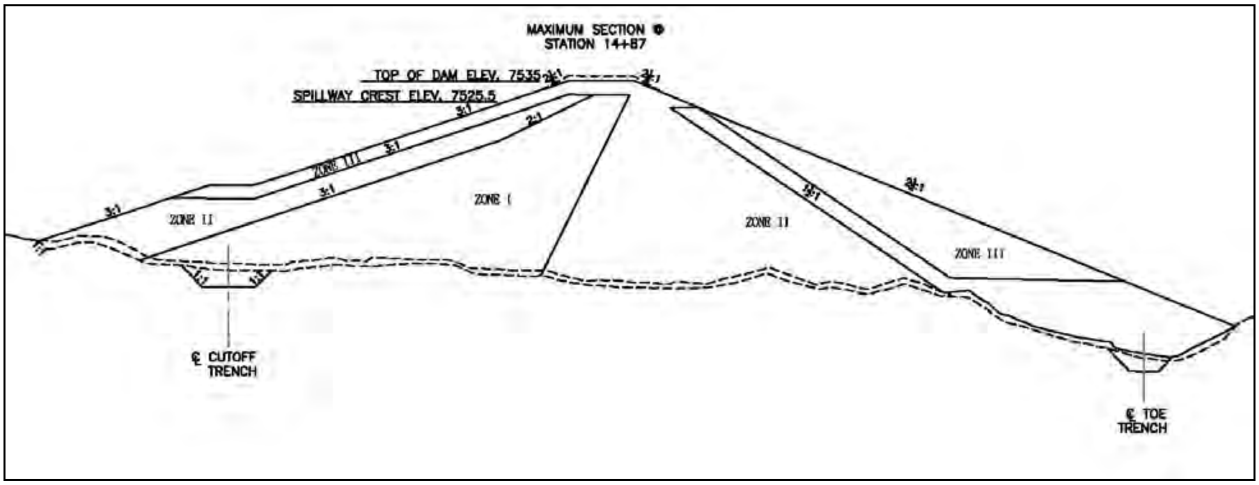

Figure D-10. Dam Zones

D.5.1.5 Seepage Analysis and Steady State Phreatic Surface

A seepage analysis through the embankment was conducted to evaluate the steady state condition and potential build-up of pore pressures for the 2.5 feet increase in water level. Two critical cross sections representing the spillway section and maximum section were modeled for the seepage analysis, then subsequently evaluated for slope stability. The numerical seepage model for Silver Lake Flat Dam was developed using SEEP/W 2012 (GEOSLOPE Version 8.0.7.6129), a finite element program tailored for modeling groundwater and embankment seepage. The SEEP/W total head boundary condition, reservoir water elevation 7528 feet, was modeled for each cross-section. The phreatic surface at each node was constant with depth and equal to the reservoir elevation on the upstream side of the embankment. At downstream locations along the face of the dam, toe and foundation where potential seepage might occur, a total flux boundary condition was modeled and potential seepage reviewed.

After the initial seepage parameters were estimated, results from the SEEP/W models were compared to the pore water pressures measured in the piezometers installed along the corresponding cross section. Data from four piezometers were used as a guide in this evaluation. Reference points were placed in the model at the same location as the highest piezometer level and then the total predicted head at the node was compared to the corresponding piezometer reading. After reviewing the results for the four piezometers, the material properties in each modeled cross-section were varied until a reasonable match above the transient water levels, was obtained between the predicted SEEP/W phreatic elevation and the actual piezometer readings.

D.5.2 Liquefaction

Liquefaction is the condition where saturated, loose, granular soils lose strength due to pore pressure buildup during a seismic event. A liquefaction triggering analysis of the embankment and unconsolidated foundation materials was conducted from boring samplings drilled in 1996 and 1998 and the borings drilled specifically for this study in 2010. This analysis was conducted in accordance with NCEER 2004 (Youd and Idriss 2001). This method correlates the cyclic stress ratio causing liquefaction with the corrected SPT blow count and fines content. The induced cyclic stress ratio is computed based on earthquake magnitude, maximum acceleration, effective stress, and the depth below ground surface. The factor of safety against liquefaction is defined as the ratio of the cyclic stress ratio causing liquefaction to the induced cyclic stress ratio. Factors of safety with a ratio of less than 1.1 are assumed to liquefy. For this study a maximum credible earthquake with a moment magnitude of 7.5 and peak ground acceleration of 0.49 were used in the analysis.

The zones of liquefaction from the above analyses were plotted on the geologic cross-section at the centerline of the dam. A portion of the geologic section with the plotted liquefaction zones is shown in Figure D-11. From this figure it can be seen that generally a zone is found in the upper portion of the foundation, and liquefiable zones occur in the upper half of the alluvial foundation as well. Due to the depositional nature of the foundation, these areas are most likely thinly bedded and not continuous. For the purpose of analysis it was conservatively assumed that pocketed zones 15 feet thick, covering 50% of the length in the upper portion and the alluvial section of the foundation are liquefiable.

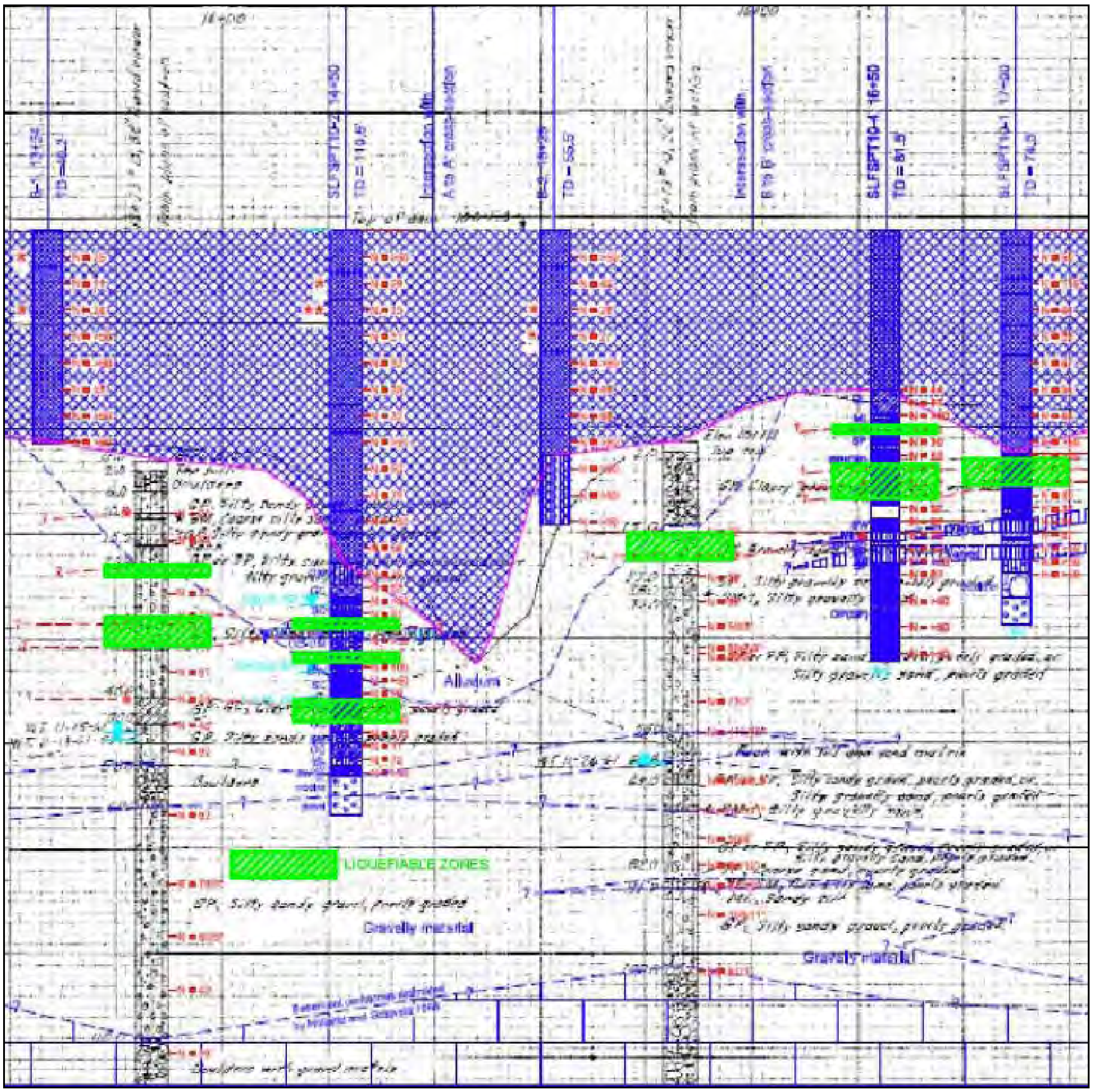

Figure D-11. Liquefaction Zones

D.5.3 Cyclic Softening

The surficial geology of the dam consists of glacial moraine deposits, including boulders, cobbles, gravels, sands, silts, and some clays. A liquefaction analysis of the blow count data was accomplished on all of the low and moderate SPT data, including blows measured on a per inch basis for finer grained soils. Due to the potential for cyclic softening during earthquake loading, the fine grained silts and clays were evaluated for the potential of cyclic softening. The standard methodology involves the determination of Cyclic Stress Ratio (CSR) and the Cyclic Resistance Ratio (CRR), the ratio (CRR/CSR) of which provides a factor of safety for cyclic softening.

The CSR was calculated at a value of 0.285 and the CRR was calculated to be equal to 0.178. The factor of safety, CRR/CSR, is equal to 0.625. This value is less than 1.2 and indicates the subject layer will cyclically soften. The cyclic shear strength was determined to be 0.83 (undrained shear strength (SHANSEP)) = 0.83 (1229) = 1020 psf.

D.5.4 Slope Stability

D.5.4.1 Material Properties

The material properties are based on field descriptions, blow count data, laboratory testing, and correlation tables. Three correlations were performed to correlate the blows per foot to friction angle. The correlations used were Meyerhoff (1956), Schmertmann (1975), and Peck, Hansen, and Thornburn (1974). In using these correlations the lowest calculated value was generally taken into account in choosing the friction angle for the material. These three methodologies were used due to their more conservative results. A description of each of the materials is explained in Section D.5.1.4 and the material strength properties are summarized in Table D-6.

Table D-6. Material Strength Properties

Material	Saturated Unit Weight (pcf)	Friction Angle (degrees)	Cohesion (psf)
Zone I	123	33	150
Zone II	132	34	0
Zone III	136	36	0
Upper Foundation	115	32.5	0
Lower Foundation	130	35	0
Alluvial Foundation	125	33	0
Varved Clay	115	31	500
Bedrock	140	40	1,000

D.5.4.2 Stability Analysis

Stability analyses were performed using the computer program Slope/W. The analysis satisfied general limit equilibrium requirements, and used Spencer's Method (Spencer 1967) to compute factors of safety, which satisfies both force and moment equilibrium. Three cross sections were analyzed for the dam embankment.

- Spillway (station 16+00);
- Maximum Section of Embankment (station 15+10); and
- Deepest Section of Embankment (station 19+79).

Spillway Cross Section (Station 16+00)

Since the spillway sits directly on the embankment at the highest section of the dam, an analysis of the stability of the spillway cross-section was performed. The phreatic surface calculated in the steady state seepage analysis was used for this analysis, except that the water surface was modified at the downstream area to bring the water surface to the ground surface to more closely represent the conditions at the downstream when water is being released either through the spillway or the outlet. This cross-section resulted in a residual strength of 675 psf for the liquefiable zones within the alluvial material, and a liquefiable strength of 800 and 1000 psf for the materials in the upper morainal foundation.

A slope stability analysis based on the current configuration of the embankment at the spillway including material and geometry was performed. Trial failure surfaces were evaluated with a random circle approach using Spencer's Method (Spencer 1967) and the results are listed in Table D-7. It is noted that the existing dam does not meet minimum requirements for either of the downstream conditions.

Table D-7. Existing Slope Stability Factors of Safety - Spillway

Stability Condition	Calculated Factor of Safety	Required Min. Factor of Safety
Static: Upstream	2.36	1.5
Static: Downstream	1.35	1.5
Rapid Drawdown: Upstream	1.26	1.2
Post-Earthquake: Upstream	2.15	1.2
Post-Earthquake: Downstream	1.08	1.2

In order to satisfy static and post-earthquake slope stability requirements for the downstream slope, various configurations were evaluated to increase the downstream stability. The option that worked best with the spillway function was the sloping berm at the downstream slope. Through trial and error a configuration of a berm with a 4 horizontal to 1 vertical slope, beginning at an elevation of 7470 feet, was found to be the best option. Slope stability analyses were run on this cross-section with the 4:1 berm and the results of these analyses are summarized in Table D-8.

Table D-8. Design Slope Stability Factors of Safety - Spillway

Stability Condition	Calculated Factor of Safety	Required Min. Factor of Safety
Static: Downstream	1.70	1.5
Post-Earthquake: Downstream	1.30	1.2

Maximum Section of Embankment Cross Section (Station 15+10)

The section of the dam with the highest embankment is located in the stream channel at station 15+10. The phreatic surface calculated in the steady state seepage analysis was used for this analysis, except that the water surface was modified at the downstream area to bring the water surface closer to the ground surface. This was done to more closely represent the saturated soils and seeps observed at the groin in this location. This cross-section resulted in residual strength of 240 psf at the upstream toe, 460 psf beneath the upstream slope, 970 psf beneath the crest, and 1,600 psf beneath the downstream slope.

A slope stability analysis based on the design configuration, with a 4:1 berm starting at elevation 7470 feet, was performed. Trial failure surfaces were evaluated with a random circle approach using Spencer's Method (Spencer 1967) and the results are listed in Table D-9. From this table it can be seen that this section meets all static and post-earthquake stability requirement.

Table D-9. Design Slope Stability Factors of Safety – Max Embankment

Stability Condition	Calculated Factor of Safety	Required Min. Factor of Safety
Static: Upstream	2.49	1.5
Static: Downstream	1.82	1.5
Rapid Drawdown: Upstream	1.25	1.2
Post-Earthquake: Upstream	1.96	1.2
Post-Earthquake: Downstream	1.38	1.2

Deepest Section of Embankment Cross Section (Station 19+79)
A cross-section located at station 19+79 was run because it is the area with the highest embankment and a steeper slope of 2 horizontal to 1 vertical. No steady state seepage was done at this cross-section so the phreatic surface was estimated based on the seepage analyses done at the spillway and maximum sections, along with piezometric data.

The borings located near this cross-section did not show any liquefiable zones; however, due to the pocketed nature of the liquefiable zones it was assumed a liquefiable zone exists beneath the downstream slope. The residual strength used for this zone was 800 psf. Trial failure surfaces were evaluated with a random circle approach using Spencer's Method (Spencer 1967) and the results are listed in Table D-10. From this table it can be seen that this section meets all static and post-earthquake stability requirement.

Table D-10. Slope Stability Factors of Safety – Station 19+79

Stability Condition	Calculated Factor of Safety	Required Min. Factor of Safety
Static: Upstream	2.17	1.5
Static: Downstream	1.53	1.5
Rapid Drawdown: Upstream	1.21	1.2
Post-Earthquake: Upstream	1.90	1.2
Post-Earthquake: Downstream	1.21	1.2

D.5.4.3 Embankment Zones and Internal Stability

The construction of the dam was completed in 1972 and it has been in satisfactory operation for over 40 years. The embankment does not reach a steady state seepage condition due to the upstream cutoff trench and effective Zone I core. This is further supported by a short storage season, with filling in the spring and in large measure being drawn down by mid-July to early August, and the embankment never reaching a steady state seepage scenario.

An evaluation of the embankment materials follows borrow area investigations, construction laboratory testing, recent embankment exploratory drilling, and laboratory testing. The embankment zone materials are summarized per specifications and "As-Built Drawings" as follows:

- Zone I – Minimum 25% fines, and 6-inch maximum particle size
- Zone II – 5 to 25% fines, and 8-inch maximum particle size
- Zone III Embankment (US face and DS transition zone) - minus 5% fines, and 18-inch maximum particle size
- Zone III Embankment (DS face) - minus 10% fines, and 18-inch maximum particle size

The existing zoned embankment, based on a review of all the available data including limited gradation data, does not meet all internal stability conditions. However, it does meet the principal filter criteria. Supplemental to the filter criteria, it is expected that construction of the zones was completed consistent with the specifications to maintain uniformity and minimize segregation. The other two areas of permeability and uniformity are not as critical, considering the history and safe function of the dam. As such, no embankment provisions for the static performance of the dam are recommended as part of this dam safety upgrade design.

D.5.4.4 Miscellaneous Embankment

A number of additional and modified provisions, including remediation measures, are necessary as part of the planned remedial work.

D.5.4.4.1 Embankment Modifications

Due to the increase in the high water level, three items are needed for the proper function of the enlarged facility:

- Raise Zone I - Zone I will need to be raised 3 feet for the 100-year storm freeboard.
- Blankets – The right and left blankets will also need to be raised 3 feet for the increased reservoir head and freeboard.
- Riprap - Deficiencies in the approximate top 30 feet of the upstream riprap face exist. Supplemental riprap is needed across the full length of the dam embankment.

D.5.4.4.2 Sinkholes

Two sinkhole areas have developed in the blanket since completion of the dam, the first in 1995, and the second in 2012. Both sinkholes were located in the left abutment blanket area and the 1995 sinkholes were subsequently repaired, whereas the 2012 sinkholes were temporarily repaired. The 1995 incident involved an alignment of sinkholes observed about 500 feet upstream of the left abutment and tending generally to follow the shoreline. Remedial work involved the excavation of a 200-foot long trench, 5 feet deep (top one foot Zone II armoring and one to 4 feet into the Zone I blanket) and 70 feet wide. Filter fabric was placed in the bottom of the trench and the Zone I and II were replaced per previous configuration.

The 2012 sinkhole was observed about 290 feet left of the intake structure and roughly along the upper intake reservoir level. An alignment of other minor depressions was observed and ran downslope approximately 50 feet. The sinkhole and related depressions received temporary treatment in the fall of 2012, with planned full remediation as part of the dam rehabilitation work. The temporary remediation included over-excavation of the sinkhole and depressions by hand shovel and backfilling with high slump cement. The sinkhole took about two bags of ready mix cement.

Due to the past sinkhole history of the left abutment blanket, sinkholes will likely continue to develop in the blankets. Regular inspection of this vulnerability is a necessary part of dam and reservoir operation. In addition, with seepage occurring in downstream areas, concern exists as to the integrity of the varved clay in the reservoir basin. The ancient glacial lake deposits (varved clay) were keyed into at the upstream toe of the dam. These varved clays are relatively thick, but are variable. It is possible that some seepage/sinkhole activity has occurred with time and is contributing to the seepage downstream. It is recommended that during construction, when the reservoir basin is drained, a close examination of the surface area below the conservation pool be completed. Any problems or apparent deficiencies should be rectified during the construction period.

D.5.4.4.3 Blanket

In addition to the sinkholes observed on the left abutment, sinkholes may develop in the right abutment blanket area. Concern exists about the steep area of the right abutment blanket where the approximate maximum fetch directly encounters the steep portion of the blanket. Serious erosion at the steep portion of the blanket has taken place, removing the Zone II armoring and exposing the Zone I blanket. No apparent sinkholes were observed, but due to the vulnerability of the area it is recommended that the Zone I blanket be built up and armored with riprap to preclude future seepage problems.

In additionally, small runoff flows from the Forest Service Road flow into the lower portion of the reservoir, down the far right abutment and over the blanket area. The erosion action of the stream has cut over one-foot deep into the blanket. Appropriate channeling and armoring of this channel is needed as part of the upgrade work.

D.5.5 Piping

D.5.5.1 Toe Drain Compatibility and Internal Stability

An evaluation of the existing toe drains at the dam was performed to determine their suitability. The following toe drain information is presented for internal stability considerations. The performance of Silver Lake Flat Dam for over 40 years has been good with no indication of internal piping concerns. The performance of the embankment dam has been successful due to the effectiveness of the design provisions to minimize seepage and the effective drainage of the embankment and foundation, as well as having a short storage season precluding a steady state seepage scenario.

It was initially recommended by UDWRe that the existing toe drain system be abandoned and replaced with an appropriately design system. This would involve grouting off the collection and discharge pipes. Due to the isolation of the existing granular drains by the grouting work, the relatively acceptable materials in the existing granular drain trenches could be left safely beneath the embankment. The existing drain system is considered to be acceptable and does not need to be replaced.

It is recommended, however, that an isolated filter system be placed at the discharge ends of the left toe drain to collect seepage and filter all seepage prior to discharge (Figure D-12). The isolated collection systems should be monitored with a piezometer to provide information as to any blockage that may occur. This provision would allow for continued drainage and provide information of potential internal deterioration in the existing drains, precluding excessive internal erosion. In addition, it is recommended that a filter envelope be placed over the end of the right drain discharge pipes and around the end of the extended outlet conduit. Due to the isolated collection system at the end of the left toe drain discharge pipe, no filter envelope will be needed there.

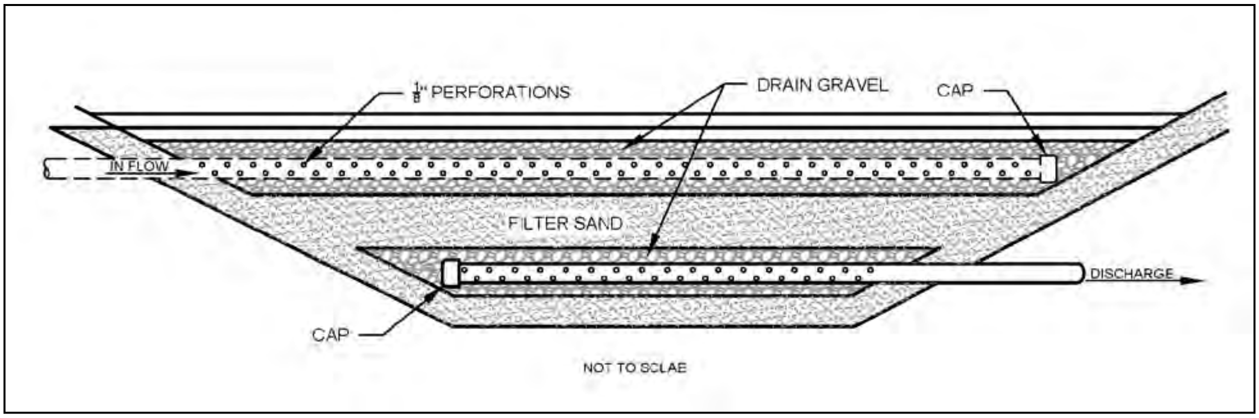

Figure D-12. Drain Isolated Filter System

D.5.5.2 Chimney Drain and Transverse Cracking

The purpose of this section is to describe the reason for not including a formal chimney drain in the Dam Safety upgrade design of Silver Lake Flat Dam, based on existing conditions and a recommended Transverse Crack Transition Zone (TCTZ).

D.5.5.2.1 Phreatic Surface and Embankment Seepage

Based on piezometer data, the phreatic surface through the maximum section of the dam is low, indicating the effective function of the upstream cutoff trench, impervious Zone I, and drainage characteristics of the Zone II and foundation. Outside of the maximum section all of the downstream toe and vicinity piezometers show water levels notably below the ground surface, suggesting no or little seepage water in the downstream portion of the embankment. At the maximum section where the highest likely phreatic surface exists and highest level of seepage occurs, seepage water likely flows through the downstream portion of the embankment, and at relatively low levels above the foundation embankment contact. These flows are effectively collected in drains at the downstream toe. As such, the need for a chimney drain to lower the phreatic surface within the embankment under existing conditions is not needed.

D.5.5.2.2 Wide Zone I and Zone II

The broadly and coarse grained zones of the dam are internally stable, as long as no cracking occurs within the dam. Most of the problems in regards to sinkholes occur at initial filling where potential hydraulic cracks can occur, resulting in internal instability, including sinkholes and potential catastrophic failure. Silver Lake Flat Dam has been functioning for over 40 years and hydraulic cracks are not a concern. Silver Lake Flat Dam was designed with a wide Zone I core and wide downstream Zone II. The Zone II is not specifically a designed filter; however, in addition to the wide zone, the downstream Zone II includes approximately 30% well graded sand and could/would act as a very thick filter layer. These two items minimize the above mentioned cracking and internal instability deficiencies.

D.5.5.2.3 Downstream Zone III

It is of note that the original design did not include a chimney drain. However, a modification made to the downstream Zone III shell during construction provides a provision that will/can act as a quasi filter/chimney drain. The original design called for less than 5% fines in the full downstream Zone III shell. A change was made during construction to limit the minus 5% fines to a 10-foot wide section only, located at the downstream Zone II contact. The remaining downstream portion of the Zone III was constructed with minus 10% fines. This in effect allows for interception and partial confinement of any seepage in the minus 5% Zone III layer in the event the phreatic surface raises and makes contact with the Zone III. The placement of the proposed sloping downstream berm to half the height of the embankment provides additional confinement to the quasi filter/chimney drain in the downstream half of the embankment.

D.5.5.2.4 Transverse Crack Transition Zone

Transverse cracking within the embankment due to an earthquake is possible. The severity of transverse cracking due to an earthquake is heavily dependent upon the deformation of the embankment caused by the earthquake ground motions. An embankment provision is recommended for slope stability and deformation purposes, including that the sloping downstream berm at the maximum section be implemented. With this provision, the depth of the potential cracking is expected to be about 6 feet deep. In addition, the steepness of the right abutment at the spillway will likely result in the specific location of potential transverse cracking. As such, a Transverse Crack Transition Zone (TCTZ) is recommended, to be constructed at the right abutment of the maximum section, in the area of the existing spillway, and extending 300 feet from station 13+50 to 16+50. The transition zone would extend into the embankment to a depth of 10 feet and tie into the quasi filter/chimney drain as shown on Figure D-13.

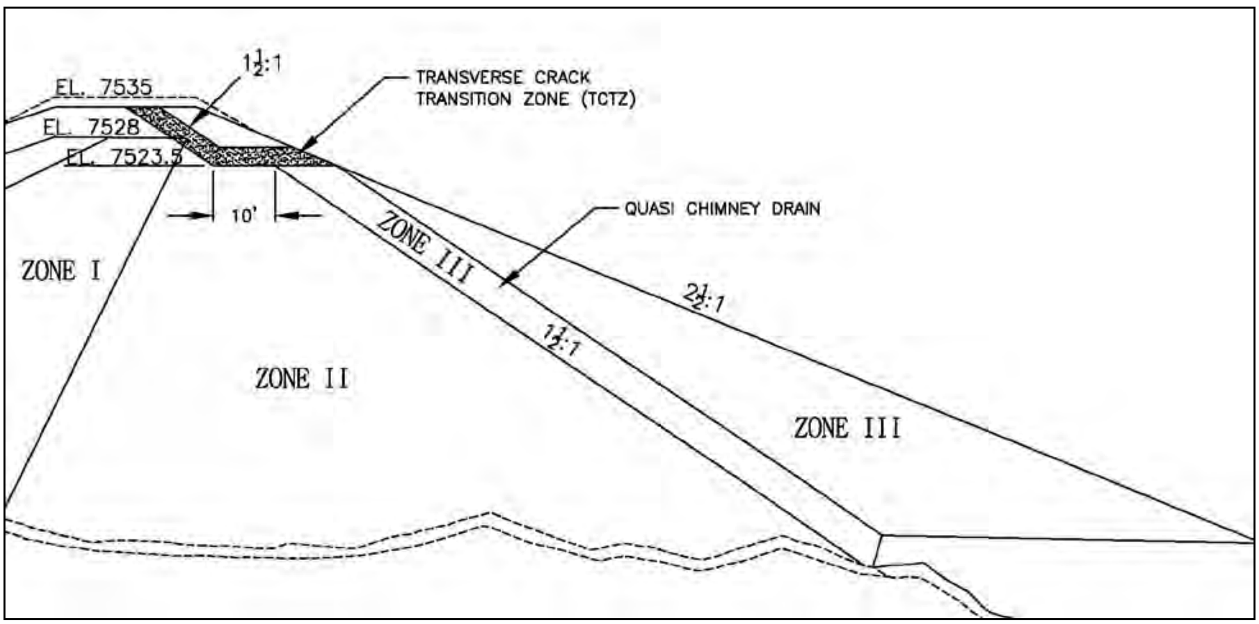

Figure D-13. Transverse Crack Transition Zone

D.5.5.3 Miscellaneous Collections Systems

Due to the downstream seepage in the left groin and right groin next to the spillway and the Horse Trail Springs, water sampling and testing was accomplished to provide guidance as to the potential source of the seepage. The testing showed that the seepage was similar enough to reservoir water to indicate the source for all three seeps is the reservoir, with seepage beneath and around the embankment and constructed features. None of the three seeps have piping/collection systems installed and the following provisions are recommended and included in the design.

D.5.5.3.1 Groin Seep Collection System

Seepage at the left groin occurs within a week or two of reaching full reservoir conditions. Following commencement of draw down the seepage ends within two to three weeks. Seepage flows peak at about 5 gpm of measured flow, and always occur at the same location in the groin and at the approximate drop off into the existing stream channel. It is apparent that a relatively permeable layer located at the foundation of the dam on the left side conveys reservoir seepage water along the foundation of the dam to the seep location. The existing left toe drain apparently does not intercept this permeable left abutment seepage zone, or it is possible that the drain is over taxed.

It is recommended that a two-stage filter drain and collection pipe be placed along the existing toe of the left abutment to intercept the spring flows. The collection system would be located beneath the proposed stability berm and extend from an approximate top elevation of 7490 down to the toe to approximate bottom elevation of 7425, and be about 400 feet in length.

D.5.5.3.2 Spillway Seep Collection System

The spillway seep is located on the right side and downstream portion of the spillway and has remained relatively constant with flows reaching approximately 2 gpm under full reservoir conditions. It is recommended that a two-stage filter drain collection system and discharge pipe be constructed at the site, with discharge of spring flows at the downstream toe for monitoring.

D.5.5.3.3 Horse Trail Seep Collection System

The horse trail seep area is located about 300 feet downstream of the right dog-leg of the dam. Seepage appeared the second year after completion of the dam, and has flowed upwards of 300 gpm under full reservoir conditions every year since 1972. These flows vary according to the level of the reservoir, and are notably lower when the reservoir is drawn down.

The spring area is longitudinal and circular (~500 feet long and 100 feet wide) in a downstream direction, and covers approximately one-half acre. The seepage apparently comes directly downstream in a southerly direction beneath an ancient stream cut channel supplying water to the top and north end of the seepage area. Six test pits were excavated along the eastern margin of the seep area in the fall of 2012 to evaluate the subsurface soil conditions and determine the mechanism responsible for seepage at the exit points within the seepage area. The test pits provided a means to document the subsurface conditions; however, only a limited amount of information was obtained due to the limitations due to sloughing of the banks caused by the granular nature of the material and the high ground water inflows. In test pit 6 a glacial varved layer was encountered that apparently provides the mechanism for the perched water table in the spring area.

To mitigate internal stability concerns during earthquake loading, a 150-foot long drain trench to be constructed 70 feet across the top (north), and 80 feet along the northeasterly portion of the spring area is planned for construction. The trench would extend to a maximum depth of 12 feet, or one foot into the glacial varved layer if encountered, and would include a 2 stage filter drain, and a collection and discharge pipe.

D.6 Sediment Quality

Sediment in the reservoir was sampled in 2010 and 2011 to determine the presence of heavy metals primarily from historical mining activity upstream of the reservoir. The following metals in Table D-11 were analyzed.

Table D-11. Heavy Metal Analysis Constituents

Constituent	Common Name	Constituent	Common Name
Sb	Antimony	Mn	Manganese
As	Arsenic	Mo	Molybdenium
Ba	Barium	Ni	Nickel
Cd	Cadmium	Ag	Silver
Cr	Chromium	Se	Selenium
Co	Cobalt	Sr	Strontium
Cu	Copper	Sn	Tin
Fe	Iron	Zn	Zinc
Pb	Lead	Zr	Zirconium
Mg	Magnesium	Hg	Mercury

Sediment samples were collected from the reservoir (5) and below the dam embankment (4). The samples below the embankment were analyzed to get an understanding of pre-mining sediment quality conditions. The geochemistry results were compared to standard Environmental Protection Agency (EPA) screening criteria and As, Cd, Cu, Pb, Ni, and Zn had some values that were above any one of the criteria. Further testing was performed using the Synthetic Precipitation Leaching Procedure (SPLP) on the elements of interest. Additionally to determine if any elements were above the Hazardous Waste Limit, the Toxicity Characteristics Leaching Procedure (TCLP) was administered. Only As, Cd, and Pb had some values above the common range found in soils but these values are still below the Hazardous Waste Limit. Therefore, the sediment in the reservoir does not need to be treated as hazardous waste. However, the sediment is still contaminated and should be handled appropriately (NRCS 2012a).

D.7 Water Quality

Water quality samples were collected from the reservoir and from the Groin Seep on June 18, 2012. These samples were tested for Aluminum, Arsenic, Iron, Lead, and Mercury. A second set of water quality samples were collected from the reservoir, Groin Seep, toe drain outfall, Spillway Seep, and Horsetrail Seep on June 21, 2012. These samples were tested for solutes, tritium, and oxygen and deuterium isotopes as well as pH, temperature, dissolved oxygen, and specific conductance.

The stable isotopes and Tritium results indicate the reservoir and groundwater are similar and from the same water source (NRCS 2012a). The Tritium (3H) results of 5.8 to 6.7 Tritium Units (TU) indicate the water is modern (<5 to 10 years) (Motzer 2012). The reservoir water solutes and specific conductance is slightly different than the groundwater and that is because the groundwater has been filtered by the ground changing some of the properties (NRCS 2012a).

The location of the reservoir in the National Forest and proximity to a wilderness area suggests the water quality should be fairly clean. There is no indication that the water is corrosive to the metal or concrete components of the dam from the samples collected (NRCS 2012a).

D.8 Hydrology

The UDWRe used ArcMap GIS to delineate the Silver Lake Flat watershed and to determine the hydrologic parameters as presented in their report titled *Silver Lake Flat Reservoir, Flood Hydrology Report* (UDWRe 2013b). The watershed drainage area is 4.28 square miles ranging in elevation from 7,434 to 11,478 feet above mean sea level (MSL) at the watershed divide. The hydrologic parameters were computed using the methods developed for flood hydrology studies in the Design of Small Dams (United States Bureau of Reclamation 1987). A unit and flood hydrograph for the drainage area were computed using methods outlined in the NRCS National Engineering Handbook for the 100-year and the PMP storm. In order to further refine the flood hydrograph for Silver Lake Flat Dam and Reservoir, the time of concentration was calibrated using sample locations within the Tibble Fork watershed. The numbers presented in this hydrology section are the calibrated numbers for the project.

D.8.1 100-Year Storm

A 6-hour storm with a return period of 100 years was estimated to produce 2.69 inches of precipitation (NOAA Atlas 14, Volume VI – Utah) at Silver Lake Flat Dam. This precipitation was distributed using a 6-hour local storm distribution (derived from HMR-49). For the 100-year storm, a saturated soil moisture condition AMC-III was assumed which was calculated to have a curve number of 49. The local time of concentration used in this analysis was 1.19 hours. The peak flow for the 100-year flood was 835 cfs and produced a volume of 144 acre-feet (UDWRe 2013b). This 100 year AMC-III storm was modeled to document the inflow design flood (IDF) procedures for Utah Dam Safety statutes.

D.8.2 Probably Maximum Precipitation (PMP)

The 72-hour general storm, and the 24-hour and 6-hour local storms were all developed for the Silver Lake Flat watershed. The precipitation and distribution of the storms were based on the report PMP Estimates for Short-Duration, Small-Area Storms in Utah (USU 1995). The state requires that the IDF is developed for an average soil moisture condition of AMC-II which was calculated to have a curve number of 49. For the 72-hour general storm, the PMP is 10.62 inches. This storm produced a 743 cfs probable maximum flood (PMF). The local time of concentration of 1.19 hours was used in the 24- and 6-hour analyses. The precipitation for the 24-hour storm was estimated to be 8.9 inches. This storm was distributed using the NOAA Atlas 14 distribution which produced a PMF of 1,884 cfs. The 6-hour PMP was estimated to be 7.89 inches. This precipitation was distributed using the same 6-hour storm distribution used for the 100-year storm. The inflow design flood, produced by the 6-hour storm, was estimated to be 3,462 cfs. A summary of the probable maximum floods developed for this watershed is shown in Table D-12.

Table D-12. Calibrated Inflow Design Flood

100-Year 6-Hour	PMP 6-Hour	PMP 24-Hour	PMP 72-Hour
835 cfs	3,462 cfs	1,884 cfs	743 cfs

D.8.3 Reservoir Flood Routing

The inflow hydrograph from the 100-year and PMP storm were routed through the existing spillway. The maximum discharge out of the spillway is 838 cfs. The following summarizes the hydrology flows into the reservoir (UDWRe 2013b):

- The calibrated 100-year rainfall flood with a AMCIII (Tc 1.19 hour and CN 69) has a peak inflow of 835 cfs. This inflow will route through the reservoir using only the principal weir wall spillway. The peak outflow is 151 cfs with a maximum water surface elevation of 7528 feet.
- Based on the calculated USU Local PMP, the IDF of 3,462 cfs (CN of 49 and calibrated Tc of 1.19 hour) and a volume of 477 acre-feet will require a new spillway to handle this volume of water. Under current spillway conditions, the dam is overtopped with a peak outflow of 996 cfs.
- A new spillway is needed to safely pass IDF flood event. By increasing the width of the spillway, it will handle the 6-hour IDF of 869 cfs and flood flows will not overtop the dam.

D.8.4 Reservoir Drain Time

The UDWRe Storm program was used to calculate the drain time of the reservoir through the current low-level outlet structure. The reinforced concrete pipe is 30 inches in diameter and 600 feet long. It was found that the reservoir would drain in three days through the 30-inch pipe when the pipe is completely open (UDWRe 2013b).

D.9 Inspections

D.9.1 Annual

Silver Lake Flat Dam is inspected on an annual basis with representatives from UDWRt Dam Safety, NRCS and NUCWCD. The inspection examines all components of the dam that are visible during the time of the visit including the embankment, abutments/foundation, reservoir basin, spillway, outlet, and instrumentation. Depending on the stage of the reservoir, the upper intake tower (low-level outlet) may or may not be visible. The lower intake tower has been inundated since the first filling of the reservoir in 1971 and is not visible at any time of the year. This tower requires underwater inspection as-needed and there have been no recorded underwater inspections to date.

The last inspection of the dam was performed on July 12, 2012 (UDWRt 2012a). There was 0 cfs flowing over the spillway and between 10-15 cfs flowing through the low-level outlet. The reservoir storage level was approximately 20 feet below the spillway crest and the intake towers were inundated. There were no comments or immediate action items noted on the inspection report. Overall, the dam and associated components are in “good” condition with minor vegetation clearing and right abutment toe drain maintenance required.

D.9.2 Toe Drain Outlet

An inspection of the right abutment toe drain was performed by UDWRe in June 2012 to locate the drain outlet and unplug this drain, if necessary. A backhoe was used to clear the outlet of the drain and there was no evidence of a plug observed that could block water draining from the dam.

D.10 Agency Coordination

Project scoping questions, comments and concerns were requested from government agencies during the preliminary scoping period for the project, both orally at public meetings and via written submittal of comments. A scoping notice was prepared and sent to interested government agencies on April 11, 2012. The list of recipients the scoping notice was sent to is located in Chapter 9.0 of the PDraft Plan-EA #2 and is not duplicated in this section of this Investigation and Analysis Report.

The government agency scoping period officially opened on April 11, 2012 and ended on May 11, 2012 for a total of 31 days. There were zero (0) oral or written comments received for the Silver Lake Flat Dam Rehabilitation project from a government agency during the scoping period.

Agency coordination will be completed during the release of the Draft Plan-EA for comment. Comments received during this review period will be included in the Final Plan-EA and summarized in this section of this Investigation and Analysis Report.

D.11 Alternative Evaluation

This section discusses the evaluation of alternatives for Silver Lake Flat Dam Rehabilitation. Three alternatives for the rehabilitation of Silver Lake Flat Dam were evaluated in detail which includes the following alternatives:

- No Action
- Rehabilitation Dam – Replace Spillway
- Rehabilitation Dam – Left Abutment Closed Spillway

Preliminary cost estimates were computed for the alternatives listed above and the following procedure were used:

- Cost estimates were based on April 2011 U.S. dollars;
- Dam rehabilitation and roadway improvements costs account for estimated quantities of material;
- Disturbed areas within the construction easement would be restored to the original condition and seeded; and
- Costs associated with mitigation of potential environmental and cultural/historical impacts were not included.

D.11.1 No Action

The No Action alternative consists of the Sponsor choosing to leave the dam "As-Is" and not rehabilitate it to meet current NRCS and Utah State Dam Safety regulations (UDWRt 2013) and engineering standards (NRCS 2005). There are two potential results of this No Action Alternative:

1. No Action – Dam Failure: The dam would fail during a PMF event resulting in severe flooding in the American Fork Canyon potentially resulting in a loss-of-life; or
2. No Action – State Dam Decommissioning: The Sponsor would receive a legal mandate to rehabilitate or decommission the dam from UDWRt Dam Safety.

Decommissioning the dam would consist of removing the concrete principal spillway and low-level outlet associated with the construction of a controlled breach (cut) through the embankment to allow unimpeded flow of Silver Creek. The excavated embankment and sediment accumulated in the reservoir would be placed in a stockpile on a suitable upland on-site location. Any salvaged topsoil from the embankment would be re-distributed on the exposed reservoir areas and seeded with an appropriate native seed mixture. The constructed breach would eliminate the dam's ability to store water, reduce flood volumes in Silver Creek and impound sediment flowing downstream. However, the breach of the dam would eliminate the "high hazard" of an unexpected failure of the dam and the potential loss-of-life. The downstream flooding and sediment transport conditions would be similar to those that existed prior to the construction of the dam. The Sponsor currently holds a Special Use Permit for the operation and maintenance of the dam on USFS UWCNF land and no additional land rights are anticipated.

The dam failure scenario includes impacting up to 2,300 residents in Highland, Alpine, American Fork, and Lehi cities that would continue to live below a dam structure with documented deficiencies in spillway capacity and integrity that does not meet current dam safety standards as described in section D.3.3. The worst-case-scenario under the No Action Alternative is the failure of the dam during a PMF event resulting in severe flooding in the American Fork Canyon potentially resulting in a loss-of-life.

The construction cost estimated for the No Action Alternative involving the decommissioning of the dam is approximately $4,595,000 as detailed in Table D-13.

Table D-13. No Action – State Dam Decommissioning Construction Cost Estimate

Item	Quantity	Unit	Unit Price	Cost
Mobilization	1	LS	$190,000	$190,000
Clearing	1	LS	$10,000	$10,000
Traffic Control	1	LS	$300,000	$300,000
USFS Road Improvements	1	LS	$50,000	$50,000
Care & Diversion of Stream	1	LS	$80,000	$80,000
Breach Excavation and Placement in Basin	125,000	CY	$6	$750,000
Spillway Demolishing & Removal Off Site	1	LS	$35,000	$35,000
Relocate Existing Water Line	1000	FT	$10	$10,000
Riprap Removal & Placed on Breach Slopes	2500	CY	$50	$125,000
Place New Stream Channel in Reservoir	1	LS	$75,000	$75,000
Riprap Armor for New Stream Channel	800	CY	$50	$40,000
Top Soil Mixed w/Zone I for Reservoir Basin	1	LS	$2,000,000	$2,000,000
Revegetation of Reservoir Basin & Breach	1	LS	$250,000	$250,000
Riprap Armor & Plunge Pool for Breach	1000	CY	$80	$80,000
			Construction Subtotal	$3,995,000
			Contingency (15%)	$600,000
			Total	**$4,595,000**

D.11.2 Rehabilitate Dam – Replace Spillway

Rehabilitation of the dam would consist of measures to meet current NRCS and Utah Dam Safety regulations (UDWRt 2013) , current engineering standards (NRCS 2005) and extend the life of the dam for 71 years starting in 2017. Rehabilitation of the dam would include the following measures:

- Place riprap on the existing upstream face of the dam to protect the slope from erosion at varying water surface elevations in the reservoir;
- Place and compact additional fill on the downstream face of the dam to increase slope stability;
- Raise the elevation of the spillway 2.5 feet to add extra storage capacity in the reservoir without overtopping the dam during the PMF. The new storage capacity would be increased from the existing capacity of 1,011 ac-ft to 1,120 ac-ft;
- Replace existing spillway to pass the PMF;
- Install a toe drain at the downstream toe of the dam to collect and convey seepage water away from the dam infrastructure;
- Install a seepage monitoring system on the downstream side of the right abutment;
- Install a monitoring trench along the upper end of Horse Trail spring to monitor the ground water connection of the Silver Lake Flat reservoir to the seepage seen at the spring;
- Replace the two (2) low-level outlet gates in the reservoir;
- Clear vegetation for dam rehabilitation and maximum reservoir water surface raise;
- Improvements to the existing unpaved USFS Silver Lake Flat Road from the Granite Flat Campground past the dam to the northern side of the reservoir, including the installation of 0.5- to 1-foot of gravel and road drainage features, would be required for heavy machinery, cement and dump truck access to the project site;
- Utilize the Horse Transfer Station off of Granite Flat Campground Road, dispersed parking area on the west side of the reservoir and the Silver Lake Trailhead as staging areas; and
- Address any ecological mitigation required by regulating agencies resulting from the proposed construction activities.

Replacing the spillway would consist of demolishing the existing spillway and removing all material from the dam. A new open channel concrete spillway designed to pass the PMF would be installed in the same location as the existing spillway. The existing low level outlet would also be extended to the new spillway outlet. Rehabilitating the dam using the prescribed methods above would not modify the dam hazard classification of high hazard (Class "C").

Table D-14. Rehabilitate Dam - Replace Spillway Parameters

Description	Existing Conditions	Dam Rehabilitation
Spillway Crest (feet)	7525.5 El	7528 El
Spillway Dimensions (feet)	10 W x 3 H x 320 L	17 W x 7 H x 477 L
Top of Dam (feet)	7535 El	7535 El
Top Width of Dam (feet)	23	23

The construction cost estimated for the Rehabilitate Dam – Replace Spillway is approximately $3,537,600 as detailed in Table D-15.

Table D-15. Rehabilitate Dam – Replace Spillway Construction Cost Estimate

Item	Quantity	Unit	Unit Price	Cost
Mobilization	1	LS	$146,500	$146,500
Clearing, Tree Removal & Wood Chipping	1	LS	$95,000	$95,000
Quality Control	1	LS	$120,000	$120,000
Traffic Control	1	LS	$110,000	$110,000
USFS Road Improvements	1	LS	$50,000	$50,000
USFS Horse Trail Modifications	1	LS	$10,000	$10,000
Dewatering, Care & Diversion of Stream	1	LS	$105,000	$105,000
Down Stream Stability Berm	6,000	CY	$12	$72,000
Outlet Extension	150	FT	$200	$30,000
Relocate Existing Water Line	1200	FT	$10	$12,000
Riprap for Upstream Face	5310	CY	$80	$424,800
Raise Fish Parking Area	2200	CY	$15	$33,000
Transfer Station Staging Area Repairs	1	LS	$45,000	$45,000
Right Abutment Riprap Protection	2170	CY	$80	$173,600
Raise Abutment Blankets	1	LS	$50,000	$50,000
Left Toe Drain Extension	1	LS	$12,000	$12,000
Left & Right Toe Drain Isolation System	1	LS	$15,000	$15,000
Spillway Seep Drain	1	LS	$16,000	$16,000
Left Groin Drain	1	LS	$42,000	$42,000
Horse Trail Springs Collection Drain	1	LS	$155,000	$155,000
Riprap Plunge Pool	1	LS	$6,000	$6,000
Reinforced Concrete Spillway & Stilling Basin	1	LS	$850,000	$850,000
Replace Intake Gates, Operator & Staff Gage	1	LS	$85,000	$85,000
Crest Filter Zone	1	LS	$138,000	$138,000
Zone I Crest Raise	1	LS	$220,000	$220,000
Crest Finish Road Base	610	CY	$25	$15,250
Sinkhole Treatment	1	LS	$5,000	$5,000
Instrumentation Replacement	1	LS	$40,000	$40,000
			Construction Subtotal	$3,076,150
			Contingency (15%)	$461,450
			Total	**$3,537,600**

D.11.3 Rehabilitate Dam – Left Abutment Closed Spillway

Rehabilitation of the dam would consist of measures to meet current NRCS and Utah State Dam Safety regulations (UDWRt 2013), current engineering standards (NRCS 2005) and extend the life of the dam for 71 years as described in the Rehabilitate Dam – Replace Spillway Alternative.

The existing spillway would be completely demolished and filled in with compacted fill material. A new spillway would be installed on the left abutment at the toe of the dam on the downstream face in the existing upland. The spillway would be sized to pass the PMF. The existing low level outlet would also be extended to the new spillway outlet. Rehabilitating the dam using the prescribed methods above would not modify the dam hazard classification of high hazard (Class "C").

Table D-16. Rehabilitate Dam - Left Abutment Closed Spillway Parameters

Description	Existing Conditions	Dam Rehabilitation
Spillway Crest (feet)	7525.5 El	7528 El
Spillway Dimensions (feet)	10 W x 3 H x 320 L	20 W x 7 H x 700 L
Top of Dam (feet)	7535 El	7535 El
Top Width of Dam (feet)	23	23

The construction cost estimated for the Rehabilitate Dam – Left Abutment Closed Spillway is approximately $4,029,200 as detailed in Table D-17.

Table D-17. Rehabilitate Dam – Left Abutment Closed Spillway Construction Cost Estimate

Item	Quantity	Unit	Unit Price	Cost
Mobilization	1	LS	$170,000	$170,000
Clearing, Tree Removal & Wood Chipping	1	LS	$95,000	$95,000
Quality Control	1	LS	$120,000	$120,000
Traffic Control	1	LS	$110,000	$110,000
USFS Road Improvements	1	LS	$50,000	$50,000
USFS Horse Trail Modifications	1	LS	$10,000	$10,000
Dewatering, Care & Diversion of Stream	1	LS	$105,000	$105,000
Down Stream Stability Berm	6,000	CY	$12	$72,000
Outlet Extension	150	FT	$200	$30,000
Relocate Existing Water Line	1200	FT	$10	$12,000
Riprap for Upstream Face	5310	CY	$80	$424,800
Raise Fish Parking Area	2200	CY	$15	$33,000
Transfer Station Staging Area Repairs	1	LS	$45,000	$45,000
Right Abutment Riprap Protection	2170	CY	$80	$173,600
Raise Abutment Blankets	1	LS	$50,000	$50,000
Left Toe Drain Extension	1	LS	$12,000	$12,000
Left & Right Toe Drain Isolation System	1	LS	$15,000	$15,000
Spillway Seep Drain	1	LS	$16,000	$16,000
Left Groin Drain	1	LS	$42,000	$42,000
Horse Trail Springs Collection Drain	1	LS	$155,000	$155,000
Riprap Plunge Pool	1	LS	$10,000	$10,000
Reinforced Concrete Spillway & Stilling Basin	1	LS	$1,250,000	$1,250,000
Replace Intake Gates, Operator & Staff Gage	1	LS	$85,000	$85,000
Crest Filter Zone	1	LS	$138,000	$138,000
Zone I Crest Raise	1	LS	$220,000	$220,000
Crest Finish Road Base	610	CY	$25	$15,250
Sinkhole Treatment	1	LS	$5,000	$5,000

Instrumentation Replacement	1	LS	$40,000	$40,000
			Construction Subtotal	$3,503,650
			Contingency (15%)	$525,550
			Total	**$4,029,200**

D.12 Economic Evaluation

The NRCS National Watershed Manual was used as a reference for the economic analysis along with the Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (P&G) (U.S. Water Resources Council 1983). P&G was developed to define a consistent set of project formulation and evaluation instructions for all federal agencies that carry out water and related land resource implementation studies. The basic objective of P&G is to determine whether or not benefits from proposed actions exceed project costs. P&G also requires that the "National Economic Development" or NED Alternative, which maximizes monetary net benefits, be selected for implementation unless there is an overriding reason for selecting another alternative based on federal, state, local, or international concerns related to the social and environmental accounts.

Critical to direction and focus of the PDraft Plan-EA #2 is the project sponsor's purpose and need for requesting assistance from NRCS. For this PDraft Plan-EA #2, the sponsor's purpose and need is to maintain irrigation water storage at Silver Lake Flat Dam to continue to provide irrigation water to northern Utah County.

D.12.1 Economic Benefits

Silver Lake Flat Dam provides irrigation water storage with incidental benefits to flood protection, sediment reduction and recreation. The benefit estimate for this project is based on the original 1958 Watershed Work Plan economic analysis. In that analysis, flood reduction benefit categories included crop and pasture, road and bridge, urban, and other agriculture for other elements of the watershed project excluding Silver Lake Flat Dam. Irrigation and recreation were the only benefits assigned to the Silver Lake Flat Dam project.

A net present value analysis was conducted for the Silver Lake Flat Dam Rehabilitation project in order to determine the net benefits. The following values and assumptions were used to calculate the net present value of the stored water in Silver Lake Flat Reservoir upon rehabilitation project completion:

- Storage of 985 ac-ft of irrigation water annually (NRCS 2013a)
- Irrigation water is used for both agricultural irrigation (primarily alfalfa hay and grass hay) and secondary irrigation (lawns, parks, schools and church grounds) (Franson 2013)
- Examination of photos and field visits conclude that agricultural irrigation comprises approximately 30% (296 ac-ft) and that the other 70% (689 ac-ft) is used for secondary irrigation purposes
- Agricultural Irrigation Water
    - The agricultural irrigation analysis is based on the assumption that approximately half of the irrigated hay is alfalfa and half of the hay is grass (other hay)
        - Alfalfa hay is $180 per ton (Utah Department of Agriculture Market News 2013)
        - Grass hay is valued at $150 ton (Internet Hay Exchange 2013)
    - Approximately five acre-inches of water will grow an additional ton of hay per acre (Donavan and Meek 1983; Grimes *et al.* 1992).
    - Irrigation water application efficiency is estimated to average 80% while delivery efficiency is estimated to be 60%
        - Overall efficiency is calculated to be 48%. (NRCS, 2013)

  - Production costs are estimated at $79 per ton (Utah Department of Agriculture Market News 2013)
  - The annual rate of increase of water value for agricultural irrigation is 2%, based on increasing scarcity and demand.
- Secondary Irrigation Water
  - Values are based on the following information:
    - Pleasant Grove Public Works charges the following rates for secondary irrigation use for 12 months:
      - Lots less than 0.5 acres - $20.85 per month
      - Lots 0.5 - 0.99 acres - $24.96 per month
      - Lots 1.0 acres and larger- $29.07 per month
    - The following assumptions were made to estimate water use:
      - 2 acre-inches per acre of water use per week from May through September
      - Lots 0.5 acres to 0.99 were estimated as the average size of 0.75 acres
      - Lots greater than 1.0 acre were assumed to average 2 acres in size
      - Approximately 70% of the lots are less than 0.5 acres in size
      - Approximately 20% of the lots are between 0.5 acres and 0.99 acres in size
      - Approximately 5% of the lots are greater in size than 1.0 acres
    - Approximately 50% of the value of the water is in the delivery system and management
- The annual discount rate is 2.75% (Utah Department of Agriculture Market News 2013)

D.12.1.1 Agricultural Benefits

Input values and results for the use of agricultural irrigation water are summarized in Table D-18.

Table D-18. Present Value Analysis of Agricultural Irrigation Water

Item	Unit
Value of Alfalfa	$180/ton
Value of Other Hay	$150/ton
Average Unit Value	$165/ton
Production Cost	$79/ton
Net Value of Hay	$86/ton
Irrigation Application Efficiency	80%
Irrigation Water Delivery Efficiency	60%
Overall Irrigation Water Use Efficiency	48%
Net Value of Water	$99/ac-ft
Total Stored Water Volume	976 ac-ft
Agricultural Irrigation Water Volume	296 ac-ft
Annual Benefit	$29,300
Annual Increase in Water Value	2.00%
Discount Rate	2.75%
Life of Project	71 yr
Net Present Value	**$1,630,000**

From the table, the average value of hay in north Utah County is $165 per ton. Production costs are assumed to be similar to those in Davis County, Utah of $79 per ton resulting in a net value of $86 per ton. Approximately 10.4 acre-inches (0.87 ac-ft) per acre are needed to grow an additional ton of hay. In total, 296 ac-ft will provide agricultural irrigation water to grow 340 tons of hay resulting in a net value of

$30,000 in the first year. In year 71, the hay yield from agricultural irrigation water is expected to be worth $117,000. Overall, the net present value of 71 years worth of agricultural irrigation water storage in Silver Lake Flat Reservoir is approximately $1,630,000.

D.12.1.2 Non-Agricultural Benefits

Input values and results for the use of secondary irrigation water are summarized in Table D-19.

Table D-19. Present Value Analysis of Secondary Irrigation Water

Item	Unit
Annual Water Cost Lot <0.5 acres (Monthly Cost for 12 months)	$250
Annual Water Cost Lot 0.5-0.99 acres (Monthly Cost for 12 months)	$300
Annual Water Cost Lot Greater than 1.0 acres (Monthly Cost for 12 months)	$350
Annual Water Use per Lot <0.5 acres - Lot Size 0.5 acres	1.7 ac-ft
Annual Water Use per Lot 0.5-0.99 acres - Lot Size 0.75 acres	2.5 ac-ft
Annual Water Use per Lot >1.0 acres - Lot Size 2 acres	6.7 ac-ft
Annual Water Use by Lots <0.5 acres	414 ac-ft
Annual Water Use by Lots 0.5-0.99 acres	164 ac-ft
Annual Water Use by Lot >1.0 acres	110 ac-ft
Total Stored Water Volume	976 ac-ft
Secondary Irrigation Water Volume	689 ac-ft
Gross Revenue	$191,254
Cost to Deliver Water (50% of Gross Revenue)	$95,627
Net Revenue or Annual Benefit	$95,627
Annual Increase in Water Value	2.00%
Discount Rate	2.75%
Life of Project	71 yr
Net Present Value	**$5,150,000**

From the table, the average annual cost per lot to irrigate with secondary irrigation water ranges from $250 to $350. This analysis has estimated approximately 331 lots using secondary irrigation with a water use of 700 ac-ft. This analysis assumes a cost of 50% of the value of the annual fees to deliver and manage the water. The current net value of the water delivered is approximately $96,000 in the first year. Water value is expected to increase 2% over the life of the project and the annual value in year 71 is expected to be $382,000. Overall, the net present value of 71 years worth of secondary irrigation water storage is approximately $5,150,000.

D.12.1.3 Recreation Benefits

In addition to the value of irrigation water storage, the reservoir has a recreation value. General estimates of recreational use at Silver Lake Flat Reservoir consist of an average of ten cars per day. The UWCNF collects a fee of $6 per car at the base of the American Fork Canyon. Based on recreation use at the reservoir, it is estimated that the UWCNF collects approximately $1,800 from vehicles accessing Silver Lake Flat each month. The access road to Silver Lake Flat is accessible by motor vehicle approximately five months a year; therefore, the annual value of recreation at Silver Lake Flat Dam and Reservoir is calculated to be $9,000. The UWCNF entrance fee has not been projected to increase in value under this economic analysis during the 71-year life of the dam. Using the same 2.75% discount as used in the irrigation water storage analysis, the value of recreation over the 71-year life of the project is calculated to be approximately $289,000. This recreation benefit analysis does not incorporate other benefits including increased revenue to angler supply retailers in local communities, fuel use or other economic benefits.

D.12.1.4 Flood Control Benefits

Silver Lake Flat Dam was not designed to provide any flood control benefits. Any benefits to flood control downstream of the dam are considered to be incidental and are not analyzed in this economic evaluation.

D.12.1.5 Economic Benefit Summary

The economic benefit of the project is $7,069,000 as summarized in Table D-20.

Table D-20. Economic Benefit Summary

Benefit	Amount	Annual Amount
Agricultural Irrigation Storage	$1,630,000	$30,000
Secondary Irrigation Storage	$5,150,000	$96,000
Recreation	$289,000	$9,000
Total	**$7,069,000**	**$135,000**

D.12.2 Project Costs

Based on the project costs associated with each of the alternatives as compared to the economic life of the project, the total annualized costs were calculated. Table D-21 lists these annualized costs.

Table D-21. Economic Costs and Alternatives Comparison

Alternative	Construction Cost	Technical Assistance	Annual O & M	Annual Cost
No Action – Dam Failure	$20,000,000	$5,585,000	$14,000	$824,000
No Action – State Dam Decommissioning	$4,595,000	$1,283,000	$14,000	$189,000
Rehabilitate Dam – Replace Spillway	$3,538,000	$988,000	$32,000	$178,000
Rehabilitate Dam – Left Abutment Closed Spillway	$4,030,000	$1,125,000	$32,000	$152,000

D.12.2 Project Benefit-Cost Ratio

Table D-22 summarizes the benefits and costs of the alternatives analyzed for the project.

Table D-22. Economic Benefit-Cost Ratio

Alternative	Average Annual Benefit	Average Annual Cost	Benefit-Cost Ratio
No Action – Dam Failure	$18,000	$838,000	0.03
No Action – State Dam Decommissioning	$18,000	$203,000	0.09
Rehabilitate Dam – Replace Spillway	$227,000	$178,000	1.3
Rehabilitate Dam – Left Abutment Closed Spillway	$227,000	$184,000	1.2

D.13 Environmental Evaluation

The Environmental Evaluation (EE) is a NRCS planning process as described in the NRCS National Planning Procedures Handbook (NRCS 2006). The EE identifies and analyzes the economic, environmental, and social concerns for a project. This planning process is then summarized on the CPA-52 Environmental Evaluation form for Conservation Planning. This EE planning process started with the identification of problems and opportunities and continues through the application and evaluation of the project.

A CPA-52 Environmental Evaluation form was completed for the project (Attachment A) during the beginning stages of the project and it reflects the preliminary resource impact analysis for the rehabilitation of Silver Lake Flat Dam according to guidance found in the National Environmental Compliance Handbook (NRCS 2011). The CPA-52 form identified resources that would require further analysis in the PDraft Plan-EA #2 and these resources are summarized in Chapter 1. Refer to Chapter 4-Environmental Consequences of the PDraft Plan-EA #2 for a detailed impact analysis for resources that were not eliminated from detailed study.

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ATTACHMENT A

CPA-52 ENVIRONMENTAL EVALUATION

U.S. Department of Agriculture Natural Resources Conservation Service	NRCS-CPA-52 6/2010	A. Client Name:	*NORTH UTAH COUNTY WATER CONSERVANCY DISTRICT*
ENVIRONMENTAL EVALUATION WORKSHEET		**B. Conservation Plan ID #** (as applicable): **Program Authority** (optional):	*Silver Lake Flat Dam* *WF-07 - Watershed Rehab*

D. Client's Objective(s) (purpose):
Rehabilitation of Silver Lake Flat Dam for the Sponsoring Local Organization (SLO) - under the NRCS Watershed Rehabilitation Program.

C. Identification # (farm, tract, field #, etc as required):
American Fk-Dry Crk PL566 Watershed - Utah County, Utah
SWNW Sec. 6, 4S 3E
USGS Quad: Dromedary Peak
40.50363, -111.65706

E. Need for Action:	F. Alternatives: No Action √ if RMS ☐	Alternative 1 √ if RMS ☐	Alternative 2 √ if RMS ☐
1) Auxiliary Spillway is undersized & does not meet required PMP criteria, 2) Liquefiable soil material in a section of the foundation of the dam, 3) Embankment filter zones do not meet current filtering criteria, 4) Seismic stability need-embank/wks. 5) Monitor seep area downstream of the embankment by capturing seep volume in a trench & outlet into a collection system& realeased downstream	*Assumes no Federal Project. SLO would operate the dam as is until State Dam Safety would mandate rehab of the structure to meet engineering criteria or failure of the dam under the PMP. SLO would have only partial funds to rehab the structure.Eventually would have to perform a "Sponsor's Breach" to relieve the hazard to the downstream community.* ***Est Cost: ~$ 1,250,000***	***Rehab to meet High Hazard Class (the NED):*** *1) Excavate downstream slope - replace with adequate filter material, 2) Spillway removal & reconstruction with a concrete box chute 3) Extend principal spillway outlet works & appurtenances, 4) Construct sesmic stability berm- @ downstream toe area, 6) Raise dam crest 1 to 3 feet with compacted soil.* ***Est Cost: $3,500,000***	***Federal Decommissioning:*** *results in complete removal of the embankment and deposited sediment, reconnection and restoration of the stream & floodplain, construction of rock drop structures and a drainage channel and revegetation.* ***Est Cost: $5,000,000***

Resource Concerns

In Section "F" below, analyze, record, and address concerns identified through the Resources Inventory process. (See FOTG Section III - Resource Quality Criteria for guidance).

G. Resource Concerns and Existing / Benchmark Conditions (Analyze and record the existing/benchmark conditions for each identified concern)	H. Effects of Alternatives: No Action — Amount, Status, Description (short and long term)	√ if does NOT meet QC	Alternative 1 — Amount, Status, Description (short and long term)	√ if does NOT meet QC	Alternative 2 — Amount, Status, Description (short and long term)	√ if does NOT meet QC
SOIL						
Erosion (Ephemeral Gully) *Erosion in the upper watershed - eventually depositing about 74 acre-feet of sediment in the reservoir*	*Erosion will likely stay about same as it has for the last 40 years. Climate change may increase occurrence of gullies at minor areas within the watershed*	NOT meet ☐ QC	*Not expected to change-much...watershed in lands managed as Wilderness. Climate Change may result in increase of overall occurrence of minor gullies*	NOT meet ☐ QC	*Short-term increase after decommission and re-establishment of vegetation in valley.Long-term (+) conditions.*	NOT meet ☐ QC
Erosion (Sheet and Rill) *Upper watershed range managed by USFS - as Wilderness*	*Expected to stay the same as last 40 years. Alotments grazed according USFS policy.. Climate change may result in more sheet & rill erosion on average.*	NOT meet ☐ QC	*Expected to stay the same as last 40 years. Alotments grazed according USFS policy.. Climate change may result in more sheet & rill erosion on average.*	NOT meet ☐ QC	*Increased sheet & rill around construction areas until re-seeded and establishment of vegetation.*	NOT meet ☐ QC
		NOT meet ☐ QC		NOT meet ☐ QC		NOT meet ☐ QC
WATER						
Quantity (Reduced Capacity of Conveyances by Sed. Deposition) *Reservoir capacity being diminished - and threatening irrigation storage for water share-holders in the future.*	*If assume reservoir eventually have to be breached due to regulatory requirements- capacity for storage would be lost.*	NOT meet ☐ QC	*Treatment in the upper watershed can help slow the amount of sediment reaching the reservoir and extend the storage life of the reservoir. Wilderness area-expect storage loss ~1.5-2.0 ac-ft/year*	NOT meet ☐ QC	*Reservoir storage would no longer exist.*	NOT meet ☐ QC
		☐ NOT meet ☐ QC		☐ NOT meet ☐ QC		☐ NOT meet ☐ QC

G. Resouce Concerns and Existing / Benchmark Conditions (Analyze and record the existing/benchmark conditions for each identified concern)	**H. (continued)**					
	No Action		***Alternative 1***		***Alternative 2***	
	Amount, Status, Description (short and long term)	√ if does NOT meet QC	Amount, Status, Description (short and long term)	√ if does NOT meet QC	Amount, Status, Description (short and long term)	√ if does NOT meet QC
AIR						
No resouce concern identified		NOT meet ☐ QC		NOT meet ☐ QC		NOT meet ☐ QC
PLANTS						
Condition (Impacts to Endangered or Threatened Plants) *Ute ladies-tresses = not documented in area = No effect*	*Ute ladies-tresses = not documented in area = No effect*	NOT meet ☐ QC	*Ute ladies-tresses = not documented in area = No effect*	NOT meet ☐ QC	*Ute ladies-tresses = not documented in area = No effect*	NOT meet ☐ QC
		NOT meet ☑ QC		NOT meet ☐ QC		NOT meet ☑ QC
ANIMALS						
Fish and wildlife (Impacts to Declining Species, Species of Concern) *Bald eagle,Black swift, Bobolink, Boreal toad, Ferrunginous hawk,Fringed myotis, Kit fox, Short-eared owl, Townsend's big-eared bat*	*Possible destruction of fish habitat in the stream downstream of the dam if the dam fails*	NOT meet ☑ QC	*Temporary relocation during dewatering of reservoir and clearing of trees within the project area*	NOT meet ☐ QC	*Loss of lake habitat*	NOT meet ☑ QC
Fish and wildlife (Impacts to Endangered or Threatened *June sucker, Least chub, Canada Lynx, greater sage grouse, yellow-billed cuckoo. [All not documented in area = No effect].*	*June sucker, Least chub, Canada Lynx, greater sage grouse, yellow-billed cuckoo. [All not documented in area = No effect]*	NOT meet ☑ QC	*June sucker, Least chub, Canada Lynx, greater sage grouse, yellow-billed cuckoo. [All not documented in area = No effect]*	NOT meet ☑ QC	*June sucker, Least chub, Canada Lynx, greater sage grouse, yellow-billed cuckoo. [All not documented in area = No effect]*	NOT meet ☐ QC
HUMAN - Economic and Social Considerations						
Capital *W/ proposed action - NRCS covers 65% of costs with another portion from State Dam Safety*	*Sponsor/s would eventually have to cover cost of rehabilition or lose use of the reservoir. Adverse effects to downstream businesses*		*About 90% of installation of rehabilitation elements paid with NRCS and State Dam Safety Financial Assistance. Continued irrigation of croplands and City uses*		*Federal Decommission would pay for 65% of the cost for this alternative.*	
Risk *Sponsor concern for decreased capacity of the reservoir & long-term structure performance*	*Increasing risk of engineering performance of the structure (hydrologic, seismic, embankment filtering, irrigation storage).Threat to life and property*		*Reduced risk to life & property with rehabilitation of the dam. Continued ag operations with irrigation water, maintainence of water rights.*		*Increased risk of flooding in the City of Ferron without the dam. Need to replace reservoir water source with another source to serve irrigation needs.*	
Public Health and Safety *Currently Silver Lake Flat Dam does not meet High Hazard Class dam safety & engineering performance criteria.*	*Increasing risk to public health and safety over time. Eventual Dam Safety order to breach dam due to non-compliance with required engineering criteria*		*Improved public health and safety with rehabilitation of the structure*		*Increased risk of flooding through American Fork-Dry Creek corridors,Cities downstream*	

Special Environmental Concerns: Environmental Laws, Executive Orders, policies, etc.

In Section "I" complete and attach applicable Environmental Procedures Guide Sheets for documentation. Items with a "●" may require a federal permit or consultation/coordination between the lead agency and another government agency. In these cases, effects may need to be determined in consultation with another agency. Planning and practice implementation may proceed for practices not involved in consultation.

I. Special Environmental Concerns (Document compliance with Environmental Laws, Executive Orders, policies, etc.)	**J. Impacts to Special Environmental Concerns**					
	No Action		***Alternative 1***		***Alternative 2***	
	Status and progress of compliance. (Complete and attach Guide Sheets as applicable)	√ if needs further action	Status and progress of compliance. (Complete and attach Guide Sheets as applicable)	√ if needs further action	Status and progress of compliance. (Complete and attach Guide Sheets as applicable)	√ if needs further action
●Clean Air Act	*Upon Review, No Action Needed*	☐	*See Attached Documentation* Multiple large earth moving equipment. Temporary	☐	*See Attached Documentation* Multiple large earth moving equipment. Temporary	☐
●Clean Water Act / Waters of the U.S.	*Upon Review, No Action Needed* *Until action to rehabilitate the structure is taken.*	☐	*See Attached Documentation* *ACOE permit required (404 or NWP 27; County grading permit*	☑	*See Attached Documentation* *ACOE permit required (404 or NWP 27; County grading permit*	☐
●Coastal Zone Management	*Upon Review, Not Applicable*	☐	Upon Review, Not Applicable	☐	Upon Review, Not Applicable	☐
Coral Reefs	*Upon Review, Not Applicable*	☐	Upon Review, Not Applicable	☐	Upon Review, Not Applicable	☐
●Cultural Resources / Historic Properties	*Upon Review, No Action Needed*	☐	See Attached Documentation *No effect*	☑	See Attached Documentation *No effect*	☐
●Endangered and Threatened Species None documented	*Upon Review, No Action Needed*	☐	See Attached Documentation *No effect*	☑	Upon Review, No Action Needed *No effect*	☐
Environmental Justice	*Upon Review, Not Applicable*	☐	Upon Review, Not Applicable	☐	Upon Review, Not Applicable	☐
●Essential Fish Habitat	Upon Review, No Action Needed	☐	Upon Review, No Action Needed	☐	Upon Review, No Action Needed	☐
Floodplain Management Addressed in plan	See Attached Documentation Addressed in Plan/EA	☐	See Attached Documentation Addressed in Plan/EA	☐	See Attached Documentation Addressed in Plan/EA	☐
Invasive Species Not concern	Upon Review, No Action Needed Addressed in Plan/EA	☐	See Attached Documentation Addressed in Plan/EA	☐	See Attached Documentation Addressed in Plan/EA	☐
●Migratory Birds/Bald and Golden Eagle Protection Act Neotropical migrants, bald & golden eagles	Upon Review, No Effect *Populations remain relatively static*	☐	See Attached Documentation *Construction activities to avoid or minimize disturbance April 1 through August 15. See Plan*	☐	See Attached Documentation *Natural succession to woody spp to enhance habitat along Ferron Creek corridor. In Plan*	☐
Prime and Unique Farmlands *None present*	Upon Review, Not Applicable	☐	Upon Review, Not Applicable	☐	Upon Review, Not Applicable	☐
Riparian Area *Corridor downstream of principal /auxiliary spillway outlet*	See Attached Documentation *Sediment deposition on banks after eventual breach of dam*	☐	See Attached Documentation *Vegetation disturbance and clearing*	☐	See Attached Documentation *Enhanced buffer and shade for aquatic habitat*	☐
●Wetlands *Seep area downstream face-auxiliary spillway; seep area downstream of dog-leg of the dam - on horse trail;*	Upon Review, No Action Needed *Seep downstream of dog-leg area would likely dry-up after eventual breach of dam*	☐	See Attached Documentation *Short term (-) to aquatic habitat during drawdown of reservoir for construction. Conservation pool to be maintained during construction*	☐	See Attached Documentation *Seep downstream of dog-leg area would likely dry-up after eventual breach of dam*	☐
●Wild and Scenic Rivers	Upon Review, Not Applicable	☐	Upon Review, Not Applicable	☐	Upon Review, Not Applicable	☐

K. Other Agencies and Broad Public Concerns	***No Action***	***Alternative 1***	***Alternative 2***
Easements, Permissions, Public Review, or Permits Required and Agencies Consulted. *Sponsor follows all requirements.*	*No Action needed, until future work is required to update and/or perform specific maintenance where a permit may be required.*	*USFS, USFWS & State agencies consulted during preliminary planning/scoping. Permits would be acquired by the Sponsor: ACOE 404 or Nationwide permit 27; Stream Alt, USFS Special Use Permit for road access/staging areas, NHPA Sec 106 consultation for CR will be completed prior to implementation.*	*USFS, USFWS & State agencies consulted during preliminary planning/scoping. Permits would be acquired by the Sponsor: ACOE 404 or Nationwide permit 27; Stream Alt, USFS Special Use Permit for road access/staging areas, NHPA Sec 106 consultation for CR will be completed prior to implementation.*
K. (continued) Other Agencies and Broad Public Concerns	***No Action***	***Alternative 1***	***Alternative 2***
Cumulative Effects Narrative (Describe the cumulative impacts considered, including past, present and known future actions regardless of who performed the actions)	*Future w/o proposed Fed. Action (existing, past, other present, reasonably foreseeable): Would likely pursue alternative funding to rehab Silver Lake Flat Dam to protect property & safety. Does not meet need or desired Future Condition.*	*Meet State/Federal Dam Safety and performance criteria for a High Hazard Class dam. Continues irrigation service; Continues Recreation opportunities and provides water for fish and wildlife*	*Decommission of the structure does not meet the desired future condition. Irrigation service would have to be developed somewhere else, recreation at open water would stop, irrigation water users would need to develop new water source, There would be heavier recreation impacts on other water bodies for fishingand other activities.*
L. Mitigation		*On-site monitoring for CR during implementation will inform any additional mitigation that may be needed. Seeding of disturbed areas would be completed using a prescribed seed mix.*	*On-site monitoring for CR during implementation will inform any additional mitigation that may be needed. Seeding of disturbed areas would be completed using a prescribed seed mix.*
M. Preferred Alternative — √ preferred alternative	☐	☑	☐
Supporting reason		*Meets Watershed Rehabilitation (WF-07) program objectives and purpose & need for the project.*	
N. Context (Record context of alternatives analysis)	national	national	national

The significance of an action must be analyzed in several contexts such as society as a whole (human, national), the affected region, the affected interests, and the locality.

O. Determination of Significance or Extraordinay Circumstances

Intensity: Refers to the severity of impact. Impacts may be both beneficial and adverse. A significant effect may exist even if the Federal agency believes that on balance the effect will be beneficial. Significance cannot be avoided by terming an action temporary or by breaking it down into small component parts.

If you answer ANY of the below questions "yes" then contact the State Environmental Liaison as there may be extraordinary circumstances and significance issues to consider and a site specific NEPA analysis may be required.

Yes	No	
☑	☐	• Is the preferred alternative expected to cause significant effects on public health or safety?
☐	☑	• Is the preferred alternative expected to significantly effect unique characteristics of the geographic area such as proximity to historic or cultural resources, park lands, prime farmlands, wetlands, wild and scenic rivers, or ecologically critical areas?
☐	☑	• Are the effects of the preferred alternative on the quality of the human environment likely to be highly controversial?
☐	☑	• Does the preferred alternative have highly uncertain effects or involve unique or unknown risks on the human environment?
☐	☑	• Does the preferred alternative establish a precedent for future actions with significant impacts or represent a decision in principle about a future consideration?
☐	☑	• Is the preferred alternative known or reasonably expected to have potentially significant environment impacts to the quality of the human environment either individually or cumulatively over time?
☐	☑	• Will the preferred alternative likely have a significant adverse effect on ANY of the special environmental concerns? Use the Evaluation Procedure Guide Sheets to assist in this determination. This includes, but is not limited to, concerns such as cultural or historical resources, endangered and threatened species, environmental justice, wetlands, floodplains, coastal zones, coral reefs, essential fish habitat, wild and scenic rivers, clean air, riparian areas, natural areas, and invasive species.
☐	☑	• Will the preferred alternative threaten a violation of Federal, State, or local law or requirements for the protection of the environment?

P. The information recorded above is based on the best available information:

In the case where a non-NRCS person (i.e. a TSP) assists with planning they are to sign the first signature block and then NRCS is to sign the second block as the responsible federal agency for the planning action.

Signature (TSP if applicable)	Title	Date
	Water Resources Coordinator	
Signature (NRCS)	**Title**	**Date**

The following sections are to be completed by the Responsible Federal Official (RFO)

Q. NEPA Compliance Finding (check one)

The preferred alternative:

		Action required
☐	1) is **not a federal action** where the agency has control or responsibility.	Document in "R.1" below. No additional analysis is required
☐	2) is a federal action that is **categorically excluded** from further environmental analysis **and** there are no extraordinary circumstances.	Document in "R.2" below. No additional analysis is required
☐	3) is a federal action that has been **sufficiently analyzed** in an existing Agency state, regional, or national NEPA document **and** there are no predicted significant adverse environmental effects or extraordinary circumstances.	Document in "R.1" below. No additional analysis is required.
☐	4) is a federal action that has been sufficiently analyzed in another Federal agency's NEPA document (EA or EIS) that addresses the proposed NRCS action and its' effects **and has been formally adopted by NRCS**. NRCS is required to prepare and publish the agency's own Finding of No Significant Impact for an EA or Record of Decision for an EIS when adopting another agency's EA or EIS document. **Note: This box is not applicable to FSA.**	Contact the State Environmental Liaison for list of NEPA documents formally adopted and available for tiering. Document in "R.1" below. No additional analysis is required
☑	5) is a federal action that has **NOT** been sufficiently analyzed or may involve predicted significant adverse environmental effects or extraordinary circumstances and may require an EA or EIS.	Contact the State Environmental Liaison. Further NEPA analysis required.

R. Rationale Supporting the Finding

R.1 Findings Documentation	*The proposed project will assist the Sponsors meet the current High Hazard Class dam safety engineering performance criteria and allow the structure to continue to operate and provide benefits for public health and safety, agriculture and recreation. The preperation of a Plan-EA is recommended.*
R.2 Applicable Categorical Exclusion(s) (more than one may apply)	*Does not meet categorical exclusion definition due to the propsed change in the footprint area of the existing dam.*

I have considered the effects of the alternatives on the Resource Concerns, Economic and Social Considerations, Special Environmental Concerns, and Extraordinary Circumstances as defined by Agency regulation and policy.

S. Signature of Responsible Federal Official:

Signature	Title	Date
	State Resource Conservationist	

Additional notes

Scoping activities were performed to identify applicable resource concerns. A listing of those activities can be found in the Silver Lake Flat Rehabilitation Plan/EA document. The concerns were incorporated into the Plan-EA. The total scoping process utilized coordination meetings, site visits, and public meetings. The information gathered through this process is maintained as part of the Administrative Record in the form of trip reports, meeting minutes, technical specialist reviews, comments received, etc. The resource considerations for this large scale type of project is captured more completely in the ***Silver Lake Flat Dam Rehabilitation Plan/EA***.