Appendix D

Investigation and Analysis Report

Saratoga Springs Watershed
Utah County, Utah
Saratoga Springs Flood Prevention Project

Investigation and Analysis Report

Draft

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Prepared for:

United States Department of Agriculture
Natural Resources Conservation Service

City of Saratoga Springs, Utah

Prepared by:

Adaptive Environmental Planning, LLC

Bowen Collins & Associates

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1.0 Introduction

The purpose of this Investigation and Analysis (I&A) Report is to present information that supports the formulation, evaluation, and conclusions of the Saratoga Springs Watershed Plan and Environmental Assessment (Plan-EA) for the Saratoga Springs Flood Prevention Project (Project), located within the in Utah County, Utah. The report is required and must be included as an appendix to the Plan-EA.

The procedures, techniques, assumptions, scope, and intensity of the investigations for each subject are described in sufficient detail so that a reader not familiar with the project areas or their issues can form an opinion on the adequacy of the Plan-EA. This report supplements information contained in the Plan-EA and is not intended to replace or duplicate information contained therein.

The planning studies presented in this I&A Report are based on standard methods and procedures used and approved for use by the United States Department of Agriculture Natural Resources Conservation Service (NRCS). The following information summarizes the investigation and analysis for the key planning studies conducted in the preparation of the Plan-EA. References in this I&A analysis are included in Section 8.0 of the Plan-EA. Additional information relevant to each section provided in this report is available upon request as part of the administrative record for the project. However, most of the information has been summarized from technical memorandums, reports, and studies that are included in Appendix E of the Plan-EA. Requests for additional information can be submitted to the following address:

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

1.1 Project Location

The Saratoga Springs Watershed (Watershed) includes 8,590 acres of land situated around the City of Saratoga Springs Utah. The ridge of the Lake Mountains is the upper extent of the Watershed and the lower extent ends at Utah Lake (refer to Map B1 in Appendix B of the Plan-EA). The Project includes flood prevention improvements along 3 drainages in the Watershed (Burnt, Lott, and Clark Canyon drainages). Burnt and Lott Canyons are analyzed as one site for improvement (Site 1) and Clark Canyon as another site for improvement (Site 2).

2.0 Hydraulic and Hydrology Analysis

Information in this section is summarized from an engineering technical memorandum (TM) completed for the Project (Bowen Collins & Associates [BC&A] 2024a, included in Appendix E of the Plan-EA).

2.1 Data Sources

Data sources used to complete the hydrologic and hydraulic (H&H) analysis are included in Table 2-1. Topographic datum and coordinate system used for analysis included North American Vertical Datum 1988 (vertical datum), North American Datum of 1983 (geodetic datum), and State Plane Utah Central (coordinate system).

Table 1. Data Sources

Data	Source	Description
LiDAR	Utah Automated Geographic Reference Center (UGRC) 2014, 2018	0.5-meter resolution bare-earth digital terrain model datasets along the Wasatch Front and throughout Central Utah.
Aerial Imagery	ESRI, via ArcMap 10.8.1	Aerial imagery was used for the background of the figures and drawings and to determine existing land uses for hydrologic models
Field Survey	BC&A Field Reconnaissance	Field reconnaissance was completed by BC&A in July and November, 2021 to confirm site conditions, drainage paths, landcover, hydraulic structures, and damaged facilities.
Soil Characteristics	Preliminary Geotechnical Assessment (Rosenberg and Associates 2021)	Rosenberg and Associates performed limited field evaluations at four potential debris basin sites
Soil Data	NRCS 2020	Web Soil Survey, Soils Survey Geographic Database (SSURGO) mapping data was used to determine hydrologic soil type for hydrologic models.
Land Cover Data	Multi-Resolution Land Characteristics Consortium (MRLC) 2019	National Land Cover Dataset. Surface cover characteristics for hydrologic models were determined from land cover.
Rainfall Data	NOAA Hydrometeorological Design Studies Center, Precipitation Frequency Data Server (PFDS)	NOAA Atlas 14 precipitation used to develop design rainfall depths, accessed August 2021.

2.2 Hydrology

A detailed hydrologic model was developed for Burnt, Lott, and Clark Canyon drainages to understand existing and future flooding conditions of flooding. The model was developed using the Hydrologic Engineering Center Hydraulic Modeling System (HEC-HMS) software. Using the data sources listed in Table 1 combined with field investigations, a drainage area boundary was developed. The boundary extents consist of the total area draining to proposed debris basin locations at each canyon. The drainage areas include Burnt Canyon (0.39 square miles [mi^2]), Lott Canyon (1.10 mi^2), Clark Canyon north (0.28 mi^2), and Clark Canyon south (0.87 mi^2), as depicted in Figure 1.

The Soil Conservation Service (SCS) Unit Hydrograph method was used in the hydrologic model to convert rainfall to runoff and the parameter input value for watershed lag time was calculated using the National Engineering Handbook (NEH) 630.10502(a) method. Runoff Curve Numbers (CNs) were estimated for each drainage area based on soil type and land cover determined by inspection of aerial imagery, the NLCD, and hydrologic soil groups from the SSURGO (NRCS 2020). Composite CNs were calculated based on a weighted area basis. The calculated composite CNs and hydrologic parameters are presented in Table 2.

Table 2. Summary of Sub-basin Hydrologic Parameters

Drainage Basin	Area (acres)	Composite CN	Time of Concentration (Tc) (minutes)	Lag Time (minutes)
Burnt Canyon	250	83	22	13
Lott Canyon	702	76	44	26
Clark Canyon North	179	74	22	13
Clark Canyon South	556	71	47	28

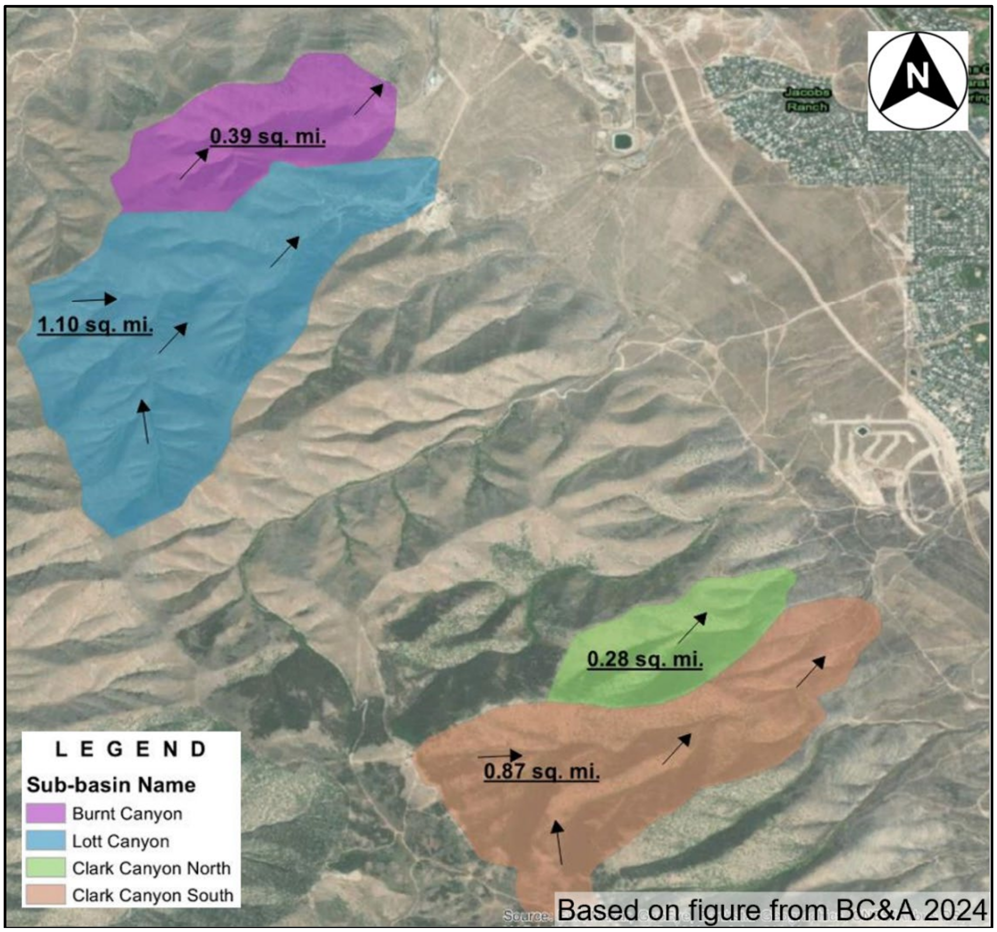

Figure 1. Drainage Areas

The 24-hour design storm depths were obtained from the National Oceanic and Atmospheric Administration (NOAA) Precipitation Frequency Data Server (PFDS) and included NOAA Atlas 14 total storm depths for various recurrence intervals. Point storm depth estimates for recurrence intervals from 2 to 500 years were obtained from the NOAA PFDS and adjusted for an areal reduction factor using the procedure described in NOAA Technical Report 24 (NOAA 1980). The areal reduction factor was calculated at 0.97 based on 2.5 mi^2 generalized storm area. NOAA Atlas 14-point storm areal adjusted depths are provided in Table 3.

NOAA Rainfall distributions were created from the areally reduced storm depths using NRCS

WinTR-20 software and the procedures described in NEH 630.04 (NRCS 2010). Design hydrographs for each basin were created using the USACE HEC-HMS software and computed based on the standard Soil Conservation Service (SCS) Unit Hydrograph method. The design peak discharges calculated for the drainage basins for each NOAA recurrence interval are provided in Table 4.

Table 3. Areal Adjusted Design Storm Depths (inches)

Drainage Basin	Recurrence Interval (year)						
	2	5	10	25	50	100	500
Burnt/Lott Canyons	1.13	1.35	1.53	1.76	1.95	2.13	2.69
Clark Canyon	1.29	1.54	1.75	2.04	2.25	2.47	2.99

To meet both NRCS and Utah Dam Safety requirements, other design storms were analyzed, including Spillway Evaluation Precipitation (SEP), Probable Maximum Precipitation (PMP), Principal Spillway Hydrograph (PSH), Auxiliary Spillway Hydrograph (ASH), Freeboard Hydrograph (FBH), Inflow Design Flood (IDF) and AMC III. Information on the hyetographs is summarized below. The design peak discharges calculated for the drainage basins for each storms below are provided in Table 4.

- PMP/SEP: The SEP was evaluated for a 24- and 72-hour general storm, and a 6-hour local storm. The PMP was evaluated for a 24-hour general storm. The storm temporal distributions for the SEP storms were developed using Hydrometeorological Report 49 (HMR49) methods. The PMP storm temporal distribution was based on the 5-point rainfall distribution as defined in the National Engineering Handbook (NEH) 630, Chapter 21. The storm resulting in the highest reservoir water surface elevation (6-hour local SEP) was selected as the NRCS FBH and Utah Dam Safety IDF.
- PSH: The PSH was calculated using the methods found in NEH 630, Chapter 21.
- ASH: NRCS determination of the ASH followed Technical Release 60 calculations where the ASH is P100 + 0.26 (SEP-P100) (NRCS 2019). This storm is also called the Stability Design Hydrograph (SDH).
- AMC III: The AMC III storm scenario was determined by evaluating the 24-hour, 100-year event on a saturated watershed by adjusting the curve numbers and initial abstraction values of the sub-basins within the watershed from NRCS-published values for AMC II conditions to AMC III conditions.

Table 4. HEC-HMS Peak Discharge Results

Design Storm Type	Storm Description	Sub-basin Peak Discharge (cfs)				Runoff Volume (acre-ft)			
		Burnt Canyon	Lott Canyon	Clark Canyon North	Clark Canyon South	Burnt Canyon	Lott Canyon	Clark Canyon North	Clark Canyon South
24-hr	2-yr	36	12	5	5	4	4	1	2
	5-yr	69	38	18	19	6	8	2	5
	10-yr	104	74	35	43	8	12	4	8
	25-yr	160	139	67	90	11	18	6	13
	50-yr	213	204	98	139	14	23	7	17
	100-yr	273	283	136	201	16	28	9	22
	500-yr	493	587	255	400	25	48	13	35
NRCS	6-hr Local SEP (FBH)	1873	3674	1027	2416	156	388	92	266
	24-hr General PMP	196	509	126	369	148	363	87	252
	PSH	50	76	21	41	-	-	-	-
	6-hr ASH	220	457	116	287	45	93	22	58
	24-hr ASH	71	154	40	106	50	107	27	73
Utah Dam Safety	72-hr General SEP	158	427	105	317	232	596	144	426
	100-yr, 6-hr1	137	261	75	192	30	53	14	38
	100-yr, 24-hr1	51	109	31	86	39	76	21	60

1 – AMC III

yr = year, hr = hour, cfs = cubic feet per second

2.3 Hydraulic Modeling

2.3.1 Existing Conditions Flood Model

Hydraulic modeling was performed using HEC-RAS software (version 5.0.7) to evaluate existing and alternative flood conditions. Since major overland flooding occurs throughout the alluvial fan floodplain, it was determined that the best modeling approach would be a two-dimensional (2D) flow analysis. The runoff hydrographs for the drainage areas were input for unsteady flow into the existing conditions hydraulic model for the 2 through 500-year frequency floods.

The modeling surface was developed using 0.5-meter resolution LiDAR data (UGRC 2014, 2018). The model included a 20-foot by 20-foot cell size and break lines were added to align the cell faces with natural breaks in the underlying terrain. A Manning's roughness coefficient (n-value) was assigned to each cell by subdividing the floodplain area into various surface roughness subareas based on land use. The N-values used in the model include 0.06 for developed/residential areas and 0.04 for channel/brush/open areas. The upstream boundary condition was placed at the basin discharge hydrographs and the downstream boundary was placed at Utah Lake.

2.3.2 Action Alternative Conditions Flood Model

Alternatives considered for modeling included debris basin improvements and channel improvements for each alternative. An alternative matrix of options that were evaluated is provided below. Refer to the Plan-EA and the PR&G report included in Appendix E of the Plan-EA for alternative decision-making on selecting feasible alternatives for flooding and economic analyses.

Table 5. Options for Alternative Hydraulic Modeling

Drainage Basin	Option for Alternative Modeling	Description
Site 1 Burnt/Lott Canyon	Debris Basin Improvements	Constructs a debris basin to attenuate all flows up to and including a 100-year flood before activation of the auxiliary spillway.
	Channel Improvements	Increase channel capacity to convey the 100-year flood flow from the drainage areas to Utah Lake.
Site 2 Clark Canyon	Debris Basin Improvements	Constructs a debris basin to attenuate all flows up to and including a 100-year flood before activation of the auxiliary spillway.
	Debris Basin Improvements	Constructs a debris basin to attenuate all flows up to and including a 50-year flood before activation of the auxiliary spillway.
	Channel Improvements	Increase channel capacity to convey the 100-year flood flow from the drainage areas to Utah Lake.
	Channel Improvements	Increase channel capacity to convey the 50-year flood flow from the drainage areas to Utah Lake.

The hydraulic model used for the existing condition analysis was modified for each alternative condition to run the 2- through 500-year flood events and determine inundation depths and extents.

2.3.3 Flood Modeling Results

The BC&A 2D model output was imported into a GIS mapping program to support the flood analysis. Flood inundation extents and depths for existing and alternative conditions were overlain with structures and roads by Adaptive Environmental Planning, LLC in GIS to quantify impacts. Refer to the PR&G Analysis Report included in Appendix E of the Plan-EA for quantification of structures and roads inundated for each of the alternative conditions. The results were used to support damage reduction benefit calculations for the economic analysis as presented in the PR&G Analysis Report.

2.3.1 Debris Basin Modeling

Multiple analyses were performed to aid in concept design development for the debris basin alternatives included in detailed study in the Plan-EA. These analyses were performed for determination of basin sizing, auxiliary and principal spillway sizing, dam feature elevations, and stability/integrity. A dam breach analysis was also performed to identify the dam hazard classes. A description of the methods, assumptions, and results of these analyses are described below.

2.3.1.1 Debris Basin Configuration

The debris basin configuration for Site 1 was developed to include capacity for 50 years of sediment storage and to contain the 100-year flood flow without activation of the auxiliary spillway. The maximum principal spillway outflow during the 100-year flood was adjusted to not exceed the capacity of the downstream storm drainage facilities (≤10.4 cfs).

The debris basin configuration for Site 2 was developed to include capacity for 50 years of sediment storage and to contain the 50-year flood flow without activation of the auxiliary spillway. The 100-year flood flow was also routed through this debris basin configuration. It was found that the auxiliary spillway would activate during the routing of the 100-year flood flow, but the existing channels downstream of the debris basin have sufficient capacity to convey the combined principal and auxiliary spillway discharge. Therefore, this debris basin configuration provides flood protection for up to and including a 100-year flood, even though the auxiliary spillway would activate after a 50-year flood.

The auxiliary spillway crest for all debris basins were sized to safely pass the IDF/FBH. The IDF/FBH was modeled through HEC-HMS to determine spillway dimensions, freeboard, and maximum flow through the spillway. The debris basin structural table included in Section 6.11.2 of the Plan-EA includes information on the debris basin configuration and capacities.

2.3.1.2 Auxiliary Spillway Evaluations

NRCS TR-60 requires two hydrographs (ASH and FBH), be safely conveyed through the auxiliary spillway. The ASH and FBH were routed through the NRCS Water Resource Site Analysis (SITES) model to verify the stability and integrity of the auxiliary spillway. Soil parameters assumed for the SITES model were based on a preliminary geotechnical investigation performed by Rosenberg and Associates in 2021 and are included in Table 6.

Table 6. Soil Parameters for SITES Auxiliary Spillway Model

Debris Basin	Dry Density (lbs/cu-ft)	Plasticity Index	Headcut Index	Percent Clay	Representative Diameter (in)
Burnt Canyon	150	0	10	0	12
Lott Canyon	150	0	10	0	12
Clark Canyon North	150	0	10	0	12
Clark Canyon South	90	5	0.1	18	0.1

lbs/cu-ft = pounds per cubic foot, in = inches

The SITES model indicated that the in-situ rock auxiliary spillways for Burnt, Lott, and Clark Canyon North would pass both hydrographs safely with minimal erosion. The preliminary geotechnical analysis found that the proposed location of the Clark Canyon South auxiliary spillway is not within a bedrock layer. The SITES model indicated that the earthen spillway for Clark Canyon South would have significant erosion but would not breach. Additional geotechnical analysis of the Clark Canyon South auxiliary spillway will be necessary during design of the project to better understand the extents of erosion and to determine if an earthen auxiliary spillway is feasible. For the purpose of this Plan EA and based on the preliminary geotechnical investigations, it is assumed that an earthen auxiliary spillway may not be feasible and armoring will be required at Clark Canyon South to prevent erosion.

TR-60 also requires that the principal spillway passes the PSH on a watershed under normal soil moisture conditions (AMCII), without overtopping earth and vegetated auxiliary spillways. However, the proposed auxiliary spillways for Burnt, Lott, and Clark Canyon will be excavated into bedrock, and Clark Canyon South would be armored. NRCS TR-60 allowable average frequency of use and permissible velocities for in-situ rock auxiliary spillways is determined based on knowledge of the hardness, condition, durability, attitude, weathering characteristics, and structure of the rock formation. The Burnt Canyon and Lott Canyon debris basins do not activate during routing of the PSH. The Clark Canyon debris basins also do not activate during the routing of the PSH.

Based on preliminary geotechnical evaluations (Rosenburg Associates 2021), the Burnt Canyon, Lott Canyon, and Clark Canyon North auxiliary spillways would be built within competent bedrock where no additional channel armoring is anticipated. Additional geotechnical analysis is recommended during the design phase of the project to better understand the bedrock characteristics on site to confirm the integrity of the material for auxiliary spillway use.

The Clark Canyon South debris basin is anticipated to include an armored earthen auxiliary spillway. Armoring for this auxiliary spillway is sized to protect against major erosion during the passing of the FBH. The peak discharge and max depth water depth when routing the FBH are 2,350 cfs and 5 feet, respectively. Armoring to protect against erosion for these flow parameters is riprap with a D50 of 24 inches. A concrete cutoff wall integrated with the auxiliary spillway is also recommended to prevent headcut progression. The final sizing of the riprap and concrete cutoff wall will be sized based on the final hydrologic/hydraulic analyses performed and additional geotechnical data obtained during design.

2.3.1.3 Outlet Orifice Capacity Evaluations

Utah Dam Safety requires all outlets to have capacity to evacuate 90% of the active storage of the reservoir in 30 days, neglecting reservoir inflows. Based on the BC&A model, 90% of the active storage capacity of the reservoir would evacuate between 0.5 and 5 days, depending on the dam. Therefore, the principal spillway design meets the Utah outlet orifice minimum capacity requirements.

2.3.1.4 Normal Pool Hazard for Seismic Analysis

A normal pool hazard classification for seismic analysis was conducted by BC&A. The analysis determined that the low precipitation, high temperatures, high principal spillway capacities, and high infiltration rates of the sandy soils results in dry conditions with no reservoir pool under normal conditions. Therefore, the normal pool hazard classification for all debris basins is “low hazard.”

2.3.1.5 Dam Breach Analysis

A dam breach analysis was conducted by BC&A to determine the NRCS dam hazard potential classification. The breach analysis was completed per TR-60 methods. The peak breach discharge (Q_{max}) was calculated for each debris basin using the TR-60 method breach hydrograph development spreadsheet, supplied by NRCS-Utah. The peak breach discharge calculated for each debris basin is included in Table 7.

Table 7. Peak Breach Discharge

Debris Basin	Q_{max}
Burnt Canyon	5,035
Lott Canyon	5,373
Clark Canyon North	4,711
Clark Canyon South	7,684

The 2D model downstream of the debris basins used for the existing condition flood modeling was used for the breach modeling. The volume of water used for the analysis assumes that no sediment storage has occurred to simulate the worst-case breach volume scenario. The model results were used to determine the population at risk and associated loss of life (risk index) for the dam breaches. The NRCS Consequences of Dam Failure computation worksheet for population at risk and loss of life were used. The NRCS dam class was assigned based on the results of the computation worksheet. The population at risk, loss of life (risk index), and NRCS dam hazard class for each debris basin is provided in Table 8.

Table 8. Peak Breach Discharge

Debris Basin	Population at Risk	Loss of Life (risk index)	NRCS Dam Class
Burnt Canyon	45	3	High Hazard Potential
Lott Canyon	63	4	High Hazard Potential
Clark Canyon North	11	1	High Hazard Potential
Clark Canyon South	15	5	High Hazard Potential

3.0 Flooding Loss of Life Risk Analysis

A risk assessment was performed by BC&A to determine the hazard for flooded areas and if there is potential for loss of life during flooding. The U.S. Bureau of Reclamation (USBR) Downstream Hazard Classification Guidelines (USBR 1988) was referenced for this analysis, which includes identification of depth of flooding and velocities to identify the level of hazard. High danger zones, where it is assumed that lives are in jeopardy, are anticipated where flood depth times velocity is approximately five square feet per second (ft^2/s) for adults or two ft^2/s for children. These depth/velocity conditions occur during routing of the 100-year flood at Burnt, Lott, and Clark Canyon drainages under the existing conditions, therefore it was determined that risk to loss of life is present.

For alternative conditions, the potential for loss of life for a 100-year flood after installation of measures to protect from up to and including a 50-year flood, was performed using the same criteria for the existing conditions described above. The results indicated that the depth and velocities at Burnt and Lott Canyons during routing of the 100-year flood would still result in risk to loss of life. At Clark Canyon, there is not a risk to loss of life during routing of the 100-year flood because the downstream conveyance channel has sufficient capacity to safely pass the design outflow from the debris basins that provide flood attenuation for up to and including a 50-year flood. Additionally, the other alternative that increases channel capacity to safely convey a 50-year flood, substantially reduces flooding during a 100-year flood to the extent that it removes the risk to loss of life.

4.0 Sedimentation Analysis

A sedimentation analysis was conducted by BC&A to determine a sediment yield rate for each of the debris basin drainage areas. The analysis used the USDA map of sedimentation rates in Utah (Bridges 1973) and the Rangeland Hydrology and Erosion Model Web Tool (RHEM) to calculate a sediment yield rate. The two sediment yield rates were averaged to determine the rate for Plan-EA concept design. The rate of sediment deposition into the debris basins was then calculated applying a trap efficiency of 98% for Burnt/Lott Canyons, and 96% for Clark Canyons. The results of the sedimentation analysis are provided in Table 9.

Table 9. Sedimentation Analysis Results Summary

Debris Basin	Sediment Yield Rate (ac-ft/mi2/yr)	Drainage Area (mi2)	Deposition Rate (ac-ft/yr)	Trap Efficiency	50 Years Deposition (ac-ft)1	100 years Deposition (ac-ft)1
Burnt Canyon	0.16	0.39	0.0624	98%	3.1	6.2
Lott Canyon	0.19	1.10	0.2090	98%	10.0	20.1
Clark Canyon North	0.19	0.28	0.0532	96%	2.6	5.1
Clark Canyon South	0.17	0.87	0.1479	96%	7.1	14.2

Ft/mi2/yr = feet per mile squared per year, ac-ft/yr = acre-feet per year

1 – Values rounded up to the nearest tenth.

5.0 Geotechnical Analysis

A preliminary geotechnical assessment was performed by Rosenberg Associates (Rosenburg Associates 2021, attached to the engineering TM that is included in Appendix E of the Plan-EA). Eight test pits were excavated onsite with a backhoe and an assessment was performed to evaluate:

- General geologic conditions and potential geologic constraints to construction.
- General suitability of the native soils for support of the proposed dam embankments.
- Anticipated soil characteristics for us in preliminary modeling of spillway erosion.
- To recommend second phase investigations necessary during final design.

The Rosenburg Associates 2021 preliminary assessment found bedrock at all dam locations to be 1.5 to 5 feet deep with backhoe refusal in the bedrock. The Rosenburg Associates analysis found that dam embankment foundations would require excavation to exposed limestone bedrock if present and treatment of the rock as appropriate. The potential for seepage and piping through fractures in limestone bedrock could be high and require measures to reduce seepage. Dam abutments would require cutoff trenches into competent limestone bedrock and dental rock grout may be needed to reduce permeability. Erosion measures were not anticipated for auxiliary spillway constructed in competent limestone bedrock. Erosion protection measures are needed where spillways extend through unconsolidated alluvial fan deposits. A headcut evaluation was performed by CMT in accordance with the NRCS 2001 *Field Procedures Guide for the Headcut Erodibility Index.* The headcut erodibility index calculated for each dam is provided in Table 10.

Table 10. Headcut Erodibility Index

Debris Basin	Exploration Location	Subsurface Condition	Preliminary Kh Value
Burnt Canyon	TP-1	Weathered limestone bedrock	10
Lott Canyon	TP-3	Weathered limestone bedrock	10
Clark Canyon North	TP-5	Weathered limestone bedrock	10
Clark Canyon South	TP-7	Silty gravel soil	0.1

The preliminary geotechnical assessment identified a collapsible soil hazard for alluvial fan sediments with laboratory test results showing 3.2% collapse when wetted at a load of 1,000 pounds per square foot (Rosenburg Associates 2021, attached to the engineering TM that is included in Appendix E of the Plan-EA). Seismic activity from active faults was found to result in moderated to strong ground shaking. Liquefaction and ground lurching were not considered a hazard for the proposed debris basin locations. Seismically induced differential compaction, earthquake-induced seiches/flooding, and seismically induced landslides/rockfalls hazards were judged to be low.

Further evaluations for subsurface investigation, laboratory testing, headcut erodibility analyses, seepage potential, collapsible soils, embankment foundations, and seismic conditions for embankment slopes were recommended.

6.0 Engineering

6.1 Design Criteria

Alternatives selected for detailed study in the Plan-EA, as determined through the PR&G Analysis (refer to PR&G Analysis Report included in Appendix E of the Plan-EA), were further developed to support the environmental analysis in the Plan-EA. Conceptual designs were developed for one alternative at Site 1 Burt/Lott Canyon and two alternatives at Site 2 Clark Canyon. These include the Debris Basin Improvements Alternative at Site 1 and Site 2 and the Channel Improvements Alterative at Site 2. Design criteria for conceptual design was based on:

- TR-60 Earth Dams and Reservoirs (NRCS 2019)
- Requirements for the Design, Construction and Abandonment of Dams (Utah Division of Water Rights 2016)

- National Engineering Handbook (NRCS 2004)
- National Engineering Manual (NRCS 2017)
- NRCS Code 584 Channel Bed Stabilization (NRCS 2021b)
- NRCS Code 402 Dam (NRCS 2020)
- TR-74 Lateral Earth Pressures (SCS 1989)
- Design of Rock Chutes (Robinson, et al, 1998)
- Hydrometeorological Report No. 49 (USACE 1984)

6.2 Cost Estimates

Installation costs for the Project consist of construction, engineering, permitting, real property rights, and administrative time for the Sponsor and NRCS. The construction cost estimates for alternatives were computed using 2023 dollars. Costs account for estimated quantities of material and labor. Estimated construction costs are based on computed work quantities multiplied by the appropriate unit cost for that type of work. Unit costs are based on current market prices from similar projects. A 20% contingency was applied to all construction costs. Engineering, permitting and administrative time were calculated assuming costs would be a percentage of the construction total with engineering at 10%, permitting at 0.5%, SLO admin time at 4%, and NRCS admin time at 6%. Real property rights values to obtain easements were provided by the City of Saratoga Springs and based on a percentage of the county assessed land value. The O&M costs were determined over a 100-year Project life.

The detailed costs for the alternatives for detailed study in the Plan-EA are included as an attachment to the PR&G Report in Appendix E of the Plan-EA.

7.0 GIS Data and Calculations

Project maps were produced using QGIS version 3.16. All data sets used a projected coordinate system of NAD 1983 Utah Central (ftUS). Measurement calculations for distance and areas were performed using ellipsoid methods.

8.0 Historic/Cultural

Cultural surveys were conducted and a Cultural Resource Assessment prepared (Certus Environmental Solutions, LLC [Certus] 2024, attached in Appendix E of the Plan-EA). A file search and archival review was conducted on October 28, 2021 for a ½-mile buffer around the survey area and included a detailed review of the Utah Division of State History Sego and HUB databases, historical topographic maps/aerial photos, historic General Land Office maps, historical air photos, and Utah statewide historic contexts. The field work was performed on November 3 and 4, 2021 and September 1, 2024, by Principal Investigator, Sheri Murray Ellis. Ms. Ellis meets all standards for professional qualifications for both archaeology and architectural history and for both prehistoric and historic period resources. The field survey included walking parallel transects spaced no more than 15 meters apart on 197.8 acres of land. A desktop review was also performed for the benefited area to identify known cultural resources in these areas that would experience reduced impacts from flooding with implementation of the Project alternatives. The results of the survey are incorporated into the Plan-EA.

9.0 Aquatic Resource Delineation

An aquatic resource delineation was completed and a report prepared to identify jurisdictional waters of the U.S. (BC&A 2021). The delineation was conducted in accordance with the USACE Wetlands Delineation Manual (USACE 1987) and the Arid West Supplement (USACE 2008). The field survey was performed on June 28, 2021 and August 23, 2021 by BC&A biologist, Merissa Davis. National Wetlands Inventory data from the U.S. Fish and Wildlife Service and NRCS hydric soil data was reviewed prior to performing field work. The results of the survey are incorporated into the Plan-EA and a copy of the report is provided in Appendix E of the Plan-EA.

10.0 Vegetation, Noxious Weeds, and Invasive Plants

Vegetation cover in the Watershed was identified from the National Land Cover Database (NLCD) classes (Multi-Resolution Land Characteristics Consortium [MRLC] 2019). Dominant vegetation types within the land cover areas and noxious/invasive plants were identified by biologist Greg Allington and resource specialist Bobbi Preite. Site visits were performed on July 7, 2019, November 9, 2021, and July 19, 2023.

11.0 Decision-Making Process

The decision-making process for this Project followed the PR&G (CEQ 2013 and 2014), and the National Planning Procedures Handbook (NRCS 2021a). The PR&G followed an eight-step evaluation process and NRCS planning followed a nine-step process. The PR&G eight-step planning process completed for the Project is documented in the PR&G Analysis Report included in Appendix E of the Plan-EA. A summary of the NRCS nine-step planning process completed for the Project is provided in Section 1.1.1 of the Plan-EA.

12.0 PR&G Evaluation and Economics

The PR&G evaluation process includes guiding principles to assist in decision making and weighing tradeoffs of Project alternatives, and the use of an ecosystem services framework to describe the comprehensive set of benefits that people receive from nature characterized as ecological goods and services provided by a healthy, functioning environment. The PR&G analysis for the Project is documented in the PR&G Analysis Report included in Appendix E of the Plan-EA.

The National Watershed Program Manual (NRCS 2024) was used as a reference for the economic analysis, along with PR&G (CEQ 2013 and 2014), NRCS Department Manual (DM) 95000-013 (USDA 2017), and the NRCS Decision Memorandum for PR&G (NRCS 2018). The economic analysis was completed by Long Watershed Planning Economics, LLC. The analysis included the Future with Federal Investment (FWFI) alternatives and the Future Without Federal

Investment (FWOFI) alternative or the No Action Alternative.

The economic evaluation used a quantification and valuation of flood damages with and without the project measures by flooding depth for each modeled storm event. Monetary economic benefits due to project action identified for the analysis included flood prevention to buildings and roads. Flood damage reduction benefits were assessed based on the equivalent annual damage reduction expected through implementation of the FWFI Alternatives as compared with the FWOFI baseline.

Average annual flood damages were calculated using the cumulative probability method as specified in the URB1 manual (SCS 1990). The 2- through 500-year storm events, modeled by BC&A in HEC-RAS, were used to determine flood damages. Inundated structures and roads were classified into one of three categories: inundated less than 1 foot, inundated 1 to 3 feet, or inundated greater than 3 feet, for each storm event.

Structure depth-damage functions were collected from the USACE to use for each type of structure (USACE 2004). A depth damage function for two story homes with a basement was used for residences and the appropriate depth-damage function was used for other structures. Replacement values were estimated from property tax records and realtor data. For structures without tax records (schools and churches) replacement values were based on construction costs collected from RS Means estimates, then adjusted accordingly.

Damages for roads were estimated through resulting costs for cleanup of sediment and debris left by storms, and for resurfacing arterial flat rural roads. Resurfacing of flat rural roads was estimated by the U.S. Department of Transportation (USDOT 2019). Street sweeping costs per curb mile to remove deposited debris and sediment from flooding were collected and updated to current costs.

The period of analysis for all alternatives is 102 years. All costs and benefits over the evaluation period were discounted to a net present value, then annualized over the period of analysis using the 2025 Federal Water Resources Discount Rate of 3.0%. The cost and benefit comparison for the Alternatives included in detail analysis in the Plan-EA based on the economic analysis performed is presented in Table 11 through Table 14. Refer to the PR&G Analysis Report in Appendix E of the Plan-EIS for additional information. The average annual values in the PR&G Analysis Report may not match with the values below because these values have been updated from the NRCS 2023 discount rate of 2.5% to the NRCS 2025 discount rate of 3.0%.

Table 11. Average Annual Flood Damage Reduction Site 1 Burnt/Lott Canyon

Type	Flood Damage		FWFI Flood Damage Reduction
	FWOFI	FWFI Alternative	
Buildings	$2,117,800	$34,000	$2,083,800
Roads	$59,500	$1,600	$57,900
Total	**$2,177,300**	**$35,600**	**$2,141,700**

Table 12. Average Annual Flood Damage Reduction Site 2 Clark Canyon

Alternative	Item	Flood Damage	FWFI Flood Damage Reduction
FWOFI	Buildings	$4,581,000	$0
	Roads	$62,300	$0
FWOFI Total		**$4,643,000**	**$0**
FWFI (Debris Basin Improvements Alternative)	Buildings	$17,000	$4,564,000
	Roads	$300	$62,000
FWFI Total		**$17,300**	**$4,626,000**
FWFI (Channel Improvements Alternative)	Buildings	$9,600	$4,571,400
	Roads	$200	$62,100
FWFI Total		**$9,800**	**$4,633,500**

Table 13. Average Annual Alternative Costs

Alternative	O&M	Installation	Total
FWOFI	$17,000	$0	**$17,000**
FWFI Site 1 Burnt/Lott Canyons (Debris Basin Improvements Alternative)	$28,300	$373,400	**$401,700**
FWFI Site 2 Clark Canyon (Debris Basin Improvements Alternative)	$30,100	$299,500	**$329,600**
FWFI Site 2 Clark Canyon (Channel Improvements Alternative)	$37,600	$269,400	**$307,000**

Table 14. Comparison of Average Annual Benefits and Costs

Site	Total Cost	Total Benefit	Benefit Cost Ratio	Net Benefits
FWOFI	$17,000	$0	-	($17,000)
Site 1 Burnt/Lott Canyon (Debris Basin Improvements Alternative)	$401,700	$2,141,700	5.3	$1,740,000
Site 2 Clark Canyon (Debris Basin Improvements Alternative)	$329,600	$4,626,000	14.0	$4,296,400
Site 2 Clark Canyon (Channel Improvements Alternative)	$307,000	$4,633,500	15.1	$4,326,500