Technical Memorandum

Henrys Fork Basin Study

Dam Raise Alternatives

Technical Series No. PN-HFS-003

Prepared by

CH2MHILL®

For

Bureau of Reclamation, Idaho Water Resource Board, and Henrys Fork Watershed Council

November 2012

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Part I – Introduction and Methodology

SECTION 1

Alternatives Introduction

1.1 Alternatives Overview

A brief summary of each dam raise alternative is provided in the sections that follow, with dam and reservoir locations depicted in Exhibit 1-1. More detailed descriptions of each alternative and lists of their sub-alternatives (if applicable) are provided in the alternative-specific sections at the end of the report.

1.2 Island Park Dam Raise

The Island Park Dam Raise Alternative consists of raising Island Park Reservoir normal pool by one to eight feet to increase reservoir storage by 8,000 to 74,000 acre-feet (af). The one foot raise would be accomplished by replacing the rubber bladder on the spillway, and the eight foot raise would be accomplished by building up the entire embankment and raising the spillway. Island Park Reservoir is located directly on the Henrys Fork River at the Town of Island Park and would require no secondary water sources. When full, the proposed one foot reservoir raise could provide a roughly 44-foot drop to the existing hydropower facility on the Henrys Fork River at the base of the dam, and the eight foot dam raise would provide a roughly 51-foot drop to a proposed new hydropower facility. A variation of this alternative includes expansion of the Crosscut Canal, which would allow water released from the reservoir to be transferred to the Lower Teton Basin.

1.3 Ashton Dam Raise

The Ashton Dam Raise Alternative consists of raising Ashton Dam by approximately 43 feet to a total height of 100 feet to increase reservoir storage by 20,400 af to a total of 30,200 af. Ashton Reservoir is located directly on the Henrys Fork River at the City of Ashton, and would require no secondary water sources. When full, Ashton Reservoir could provide a roughly 80-foot drop to a proposed new hydropower facility at the base of the dam. A variation of this alternative includes expansion of the Crosscut Canal, which would allow water released from the reservoir to be transferred to the Lower Teton Basin.

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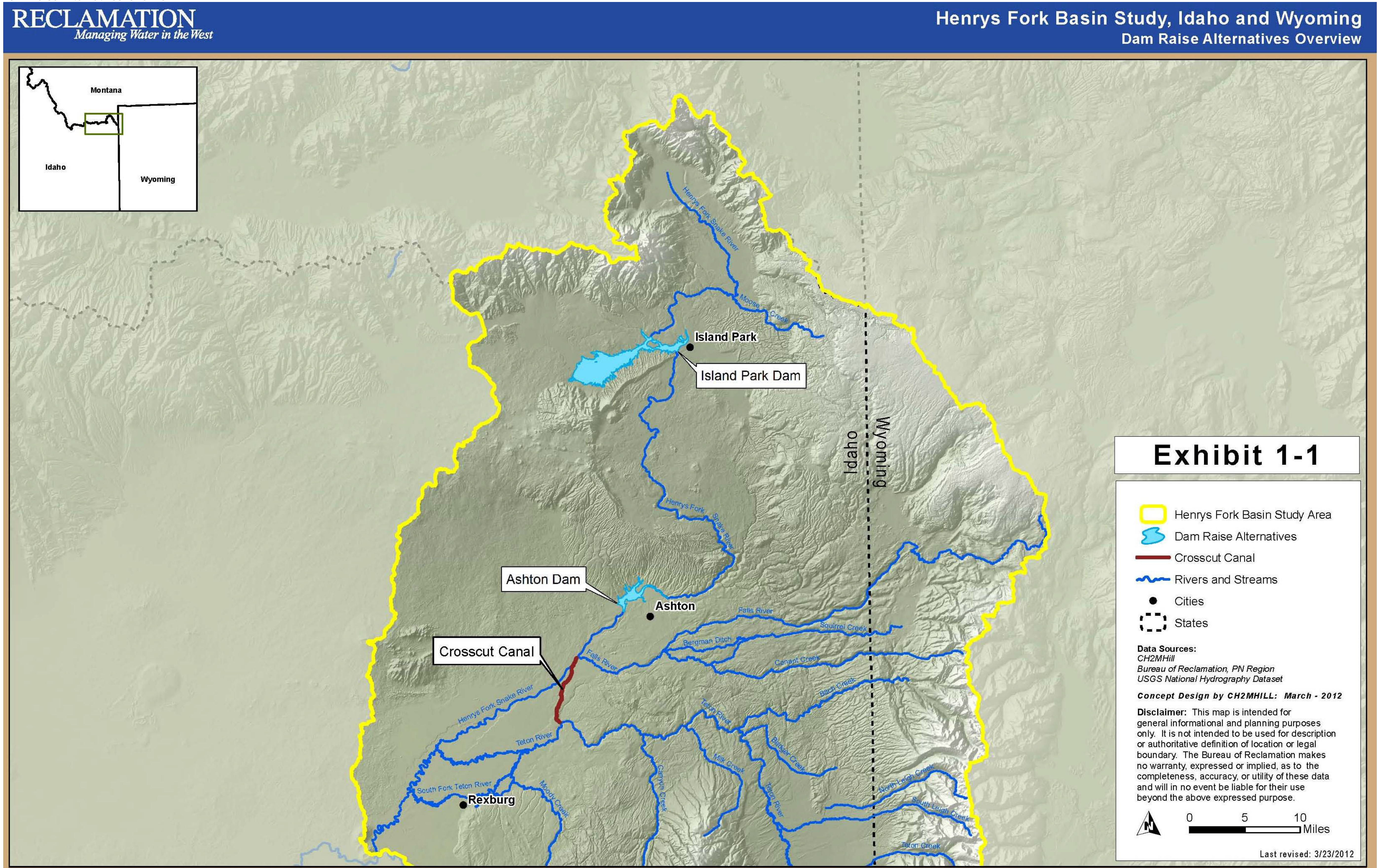
EXHIBIT 1-1
Dam Raise Alternatives Overview



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SECTION 2

Evaluation Approaches, Assumptions, and Limitations

2.1 Overview

This section describes the approaches, assumptions, limitations, and data used in the reconnaissance-level evaluations. The methodology described here is applicable to each alternative, except as noted in the alternative-specific sections in Part II of this report.

2.2 Engineering Approaches

2.2.1 Hydrology

The hydrologic assessment was performed using StreamStats, a Web-based Geographic Information System (GIS) implemented by each state and managed by the USGS using ESRI GIS software tools. Users can obtain flow statistics, drainage-basin characteristics, and other information for user-selected sites on streams. If a user selects an ungaged site, StreamStats will delineate the drainage-basin boundary, measure basin characteristics, and estimate stream flow statistics using regional regression equations under the assumption of natural (unregulated) flow conditions.

2.2.1.1 StreamStats Output

Four primary types of data were downloaded and summarized from StreamStats for each watershed:

- Watershed Delineation: delineated in Web-based GIS and downloaded as shape files.
- Watershed Characteristics: area, mean annual precipitation and mean basin elevation.
- Regression-Based Estimates of Stream Flow: average annual flow rate and average percentile flow rates by month (exceeded 20 percent, 50 percent, or 80 percent of the time). These were converted to average runoff volumes.
- Standard Estimation Errors: The stream flow estimates are regression-based statistics. The standard estimation error is one standard deviation (+/-) from the best estimate, expressed as a percent. Roughly two-thirds (68.2 percent) of the indicated statistic for gaged sites fell within the standard error range indicated. Actual standard error for an ungaged site may or may not be comparable, depending on how similar the ungaged site is to regional gaged sites.

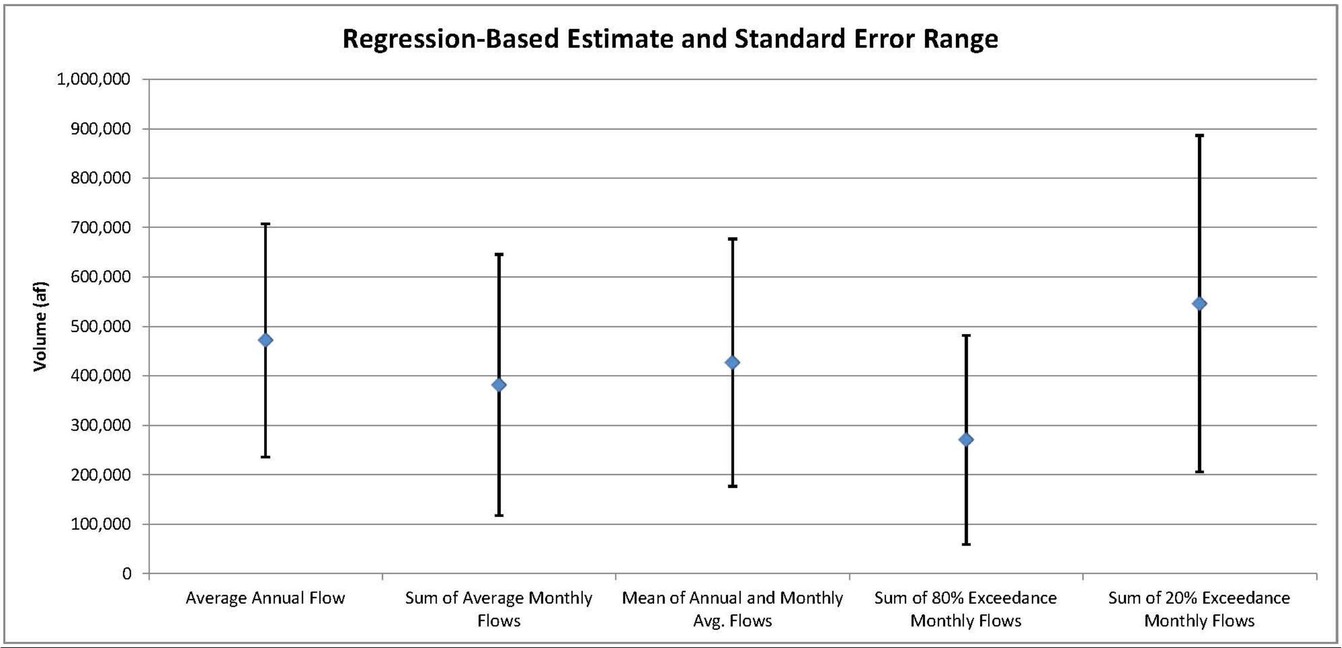
2.2.1.2 Hydrologic Summary

Using the Henrys Fork River at Island Park as an example, the StreamStats output is summarized in Exhibit 2-1. The primary table and associated chart in Exhibit 2-1 are intended to provide a high-level overview of the watershed hydrology and associated levels of uncertainty. Rows 1 to 3 of the table present the watershed characteristics, Rows 4 to 6 summarize average annual flow volumes, and Rows 7 and 8 summarize low-flow (80 percent exceedance) and high-flow (20 percent exceedance) conditions.

Column 4 indicates whether the statistic should be considered biased. Columns 5 to 7 present the standard estimation error for each statistic reported by StreamStats. StreamStats provided a single error statistic by month, which was summarized in the table as the lowest, mean, and highest standard error when monthly statistics were summed or averaged over longer periods. Columns 8 to 10 present a standard confidence interval based on reported standard estimation errors. It should be noted that results in Columns 8 to 10 do not derive directly from the summary statistics in Columns 5 to 7, but are rather calculated using standard errors and statistics for each individual month.

EXHIBIT 2-1
Hydrology for Island Park Reservoir (Henry's Fork River) Watershed

1	2	3	4	5	6	7	8	9	10
				Standard Estimation Error (%)			68% Confidence Interval		
No.	**Statistic**	**Units**	**Bias**	**Low**	**Mean**	**High**	**Low**	**Best Estimate**	**High**
1	Watershed Area	(sq. mi.)	None	----	----	----	----	500	----
2	Mean Annual Precipitation	(inches)	None	----	----	----	----	33.3	----
3	Mean Basin Elevation	(feet)	None	----	----	----	----	7,070	----
4	Average Annual Flow	(af)	None	----	50%	----	236,013	472,026	708,040
5	Sum of Average Monthly Flows	(af)	None	46%	73%	96%	117,540	381,650	645,760
6	Mean of Annual and Monthly Avg. Flows	(af)	None	----	----	----	**176,776**	**426,838**	**676,900**
7	Sum of 80% Exceedance Monthly Flows	(af)	Underestimates	57%	83%	100%	59,133	270,563	481,994
8	Sum of 20% Exceedance Monthly Flows	(af)	Overestimates	37%	64%	81%	206,081	546,331	886,581



DEFINITION: The **"standard error range"** is the regression-based estimate +/- one standard deviation. Roughly two-thirds (68.2%) of the indicated statistic for gaged sites fell within the standard error range indicated. Results for ungaged sites may or may not be comparable, depending on how similar they are to the gaged sites used to develop the regression equation.

There were three alternative approaches to estimating average annual runoff volumes in Rows 4 to 6: direct calculation, sum of average monthly flows, and the average of these two statistics. Direct calculation of mean annual flow is an unbiased statistic. The sum of average monthly flows should also be a relatively unbiased estimate of mean annual flows. Although average annual runoff volumes are not typically produced by 12 sequential average-runoff months, the resulting skew relative to calculating average annual runoff directly should be mostly random (approximately normally distributed). With no clear preference for one method of calculating the mean annual flow, the results of both methods were averaged.

Percentile estimates were only available on a monthly basis, so monthly estimates were summed in Rows 7 and 8. Although the percentile estimate for each month should be unbiased, the resulting annual sum is expected to be skewed relative to a direct estimate of percentile annual flows. The reason for the skew is that seasonally extreme weather conditions (wet or dry) rarely persist at the same percentile severity for 12 continuous months. Therefore, percentile annual estimates are typically less extreme than the sum of percentile monthly estimates.

The standard estimation error was used to calculate the low and high bounds for the standard (68.2 percent) confidence interval. The interpretation is that the true average annual runoff is not known for an ungaged site, but based on regression analysis of gaged sites, there is a range of values that likely captures the mean. There is a best estimate of the mean runoff, and low and high values that bracket the mean runoff for roughly two-thirds of regional gaged sites. This best estimate and bracketing range of estimates is shown graphically in Exhibit 2-1, and indicates that the level of uncertainty is fairly high. The actual flow volume available at the ungaged site is not known.

2.2.1.3 Potentially Available Water

The primary table in Exhibit 2-1 does not necessarily indicate how much water would be available for impoundment. To determine a design yield from each watershed, a number of factors need to be considered, including water rights, exchange rights, the storage concept (is the reservoir sized for carry-over storage from wet years, reliable yield during drought conditions, or average yield conditions), reservoir operations, instream-flow thresholds, requirements for flushing flows, and other factors. These analyses were not part of the study at this reconnaissance level.

For the new surface storage alternatives (Technical Series Number PN-HFS-002), the potential water available for storage from each watershed was defined as the average excess spring runoff. However, since both dam raise alternatives are located on regulated systems with upstream dams, the average unregulated excess spring runoff approach was invalid. At this stage of the study, lacking more detailed information, it was assumed that sufficient excess water would be available for additional storage at Island Park and Ashton Reservoirs, but that assumption would require confirmation during a future phase.

2.2.2 Crosscut Canal Conveyance

The current capacity of the existing Crosscut Canal is approximately 600 cfs at the upstream end of the canal and approximately 400 cfs at the downstream end (FMID, personal communication, 2011). To better enable Henrys Fork Basin alternatives to help meet demands in the Lower Teton Basin, an evaluation was conducted to expand the hydraulic capacity of the Crosscut Canal by 400 to 600 cfs, depending on the reach, to achieve a uniform conveyance capacity of 1,000 cfs.

Dimensions for an expanded Crosscut Canal were evaluated with the Bentley FlowMaster, Version 8i (FlowMaster) software package, which uses Manning's equation to perform flow calculations. Required input parameters included cross-sectional dimensions, longitudinal slope, and channel roughness (Manning's "n"). Canal parameters for capacity iterations were generally in accordance with Reclamation's Canal Design Flowchart (Reclamation, 2010) for the five canal sections reported in the profile and section design drawings (Reclamation, 1936).

Exhibit 2-2 summarizes the key physical characteristics of the canal, and the differences between existing and proposed flow areas were used to determine excavation quantities and other costs defined in Section 2.3.4.2 – *Crosscut Canal*.

EXHIBIT 2-2
Crosscut Canal Characteristics

Section	Length (mi)	Manning's Roughness (n)	Longitudinal Slope	Side Slope	Existing Condition		Proposed Expansion	
					Capacity (cfs)	Flow Area (sq. ft)	Capacity (cfs)	Flow Area (sq. ft)
1	2.0	0.0225	0.0003	1.5H:1V	589	197	1,000	286
2	0.6	0.0225	0.0003	1.5H:1V	754	241	1,000	293
3	0.6	0.0225	0.0009	1.5H:1V	562	143	1,000	246
4	1.1	0.0225	0.0005	1.5H:1V	407	132	1,000	262
5	2.3	0.0225	0.0004	1.5H:1V	399	140	1,000	282

2.2.3 Hydropower Potential

Hydropower generation benefits were not considered in this study, but hydropower potential was estimated. Penstocks were laid out from the outlet works below the dam to a tentative powerhouse location. Hydropower potential was calculated based on an estimated design flow (assuming 80 percent of the reservoir capacity was released uniformly over a 270 day period), head between the full reservoir water surface elevation and the ground elevation at the powerhouse, 90 percent generator efficiency, 90 percent turbine efficiency, and an efficiency loss of 3 percent per mile of penstock.

2.3 Cost Estimation

2.3.1 Purpose

Relative construction costs were developed for the dam raise alternatives for the sake of comparison. The costs are relative costs only, and should not be used for budget planning. Detailed site-specific design information has not been developed; therefore, the costs are based on high-level assumptions that may be significantly modified if design progresses. As such, the costs are intended to represent relative scaled costs using a limited number of factors, and are intended only for the purpose of differentiating one alternative from another to help screen alternatives prior to detailed analysis.

2.3.2 Excluded Costs and Benefits

The Total Relative Construction Cost is not intended to represent all costs for the project, and therefore may be misleading if used as the sole basis for comparing relative costs by alternative. Some of the known costs that have been excluded include the following:

- Supplemental pumping and conveyance infrastructure for water distribution from the reservoir
- Provision for fish passage (upstream or downstream)
- Land acquisition and easements
- Lifecycle costs for operation, maintenance, and replacement.
- Impacts to wildlife and migration corridors
- Extraordinary permitting costs
- Costs to amend an existing FERC hydropower license
- Impacts to existing infrastructure, including utilities and roads
- Litigation
- Delay due to approval challenges
- Acquisition or negotiation of water rights or exchange rights

Conversely, this cost estimate does not include potential project benefits. Some of the known potential benefits for some alternatives may include:

- Hydropower
- Water supply
- Emergency water supply or firm yield
- Recreation
- Supplemental fish flows
- Flood control

It should also be noted that only a limited number of alternatives and sub-alternatives have been evaluated. In some cases, potential variations or improvements to alternatives have been identified. Relative costs for revised alternatives should be considered separately if carried forward.

2.3.3 Approach

A cost spreadsheet was developed to calculate relative, representative system costs for each dam-delivery system, broken out by the following major system components: Crosscut Canal, dam embankment, emergency spillway, outlet works and service spillway, penstock, and hydropower facilities. In general, cost calculations were based on physical or operational data that could be readily measured, assumed, or calculated in a consistent manner without performing site-specific design. The basis of cost for each system component is described in the sections that follow.

2.3.4 Cost Basis

2.3.4.1 Crosscut Canal

Canal costs were based on four components, as summarized in Exhibit 2-3. Unit costs were selected as representative values for similar earthwork projects.

EXHIBIT 2-3
Crosscut Canal Cost Components

Cost Component	Assumptions	Unit Costs
Excavation Volume	Channel side slope and velocity generalized to 1.5H:1V and 3.5 fps, respectively, based on the Canal Design Flowchart (Reclamation, 2010) ranges. Manning's n taken as 0.0225 for Crosscut Canal (Reclamation, 1936). Depth and width were iterated to achieve the velocity target and minimize flow area. Added 2 feet above minimum freeboard for average constructed freeboard in the field. Slope was calculated from topographic maps and length of canals. Assumed a flat lateral hill slope for a simple trapezoidal cut shape volume.	$8.00 / CY
Local Fill Volume	100% of excavated volume to fill uneven terrain and construct side embankments for freeboard allowance.	$8.00 / CY
Parallel Gravel Access Road	Width of road and one road or two based on the Canal Design Flowchart (Reclamation, 2010). Cost based on estimated material volumes and costs and previous projects.	$200,000 / mi / 20-ft width
Migration Crossings	Assume provide a concrete and earth cap on the canal every 0.5 miles for animal crossings, each 100-ft long and the width of the canal plus 5-ft abutments on each side. Unit cost based on an average concrete thickness of 2 feet. Unit price double that for the canal liner based on structural components and extensive earthwork and planting.	$5,926 / ft-width ($800 / CY)

2.3.4.2 Dam – Embankment

Embankment costs for the dam raises and new saddle dikes were based on total embankment volume, a "Remoteness Factor" and a "Foundation Factor." The representative unit cost ($10/CY) represents a weighted average of all embankment materials, including relatively low-cost local cut and fill and higher-cost imported materials such as low-permeability core material, filter/seepage material, riprap, and foundation treatment. Site-specific adjustment to this unit cost was facilitated by providing two subjective factors to account for perceived site challenges. Future refinements will be possible once site-specific borrow locations, material properties, embankment dimensions, and volumes are developed.

2.3.4.3 Dam – Emergency Spillway

Costs for sub-alternatives that included new emergency spillways were based on abutment cut volume at an excavation price of $20/CY, a subjective "Site Factor," and a lump sum allowance of $1 million to provide a concrete weir and lining, a spillway chute, and a stilling basin. Future refinements will be possible once inflow design floods and specific spillway concepts are developed.

2.3.4.4 Dam – Outlet Works and Service Spillway

For the alternatives that included a dam crest raise, a lump sum base allowance of $1 million dollars was assigned to a standard 150-ft high tower outlet configuration. This base cost was then scaled up and down based on the ratio of the dam height to the 150-ft standard. An additional "Site Factor" was included to allow for subjective site conditions.

2.3.4.5 Penstock

Because all sub-alternatives assumed that the powerhouse would be located at the toe of the dam, the penstock was assumed to be integral with the outlet works and was not priced separately.

2.3.4.6 Hydropower

Hydropower costs were based on a cost curve used for pump stations, but using output power in place of input power. A 2002 CH2M HILL cost curve was factored up by 1.39 based on the ENR index ratio between the 3rd quarter of 2002 and the 4th quarter of 2011, and the input to the cost curve was the powerhouse generating potential. The full reservoir head above the stream was used for powerhouse costs. The design flow rate was based on discharging 80 percent of the total reservoir storage capacity uniformly over 270 days. Detailed operational scenarios, including variable reservoir head, were not evaluated. KW output was based on 90 percent generator efficiency, 90 percent turbine efficiency, and an efficiency loss of 3 percent per mile of penstock.

2.3.5 Total Relative Construction Cost

Costs for the system components described in Section 2.3.4 – *Cost Basis* were summed to produce the Base Field Cost, which is the relative expected cost of listed field-based construction work. This figure is increased by 20 percent to account for unlisted construction items, and by 5 percent to account for mobilization. Together, the Base Field Cost, unlisted items, and mobilization sum to the Field Cost without Contingency. Adding a 30 percent contingency for uncertainty produces the Total Field Cost. Non-field costs (such as engineering, permitting, legal and administrative costs) are calculated as 30 percent of the Total Field Cost and were added to produce a relative Total Relative Construction Cost for comparing alternatives.

2.4 Basin Water Needs

Basin water needs are discussed in the *Draft Henrys Fork Watershed Basin Study Water Needs Assessment* (Reclamation, 2012). The ability of each alternative to meet basin water needs is discussed in the alternative-specific sections later in this report.

2.5 Legal, Institutional, or Policy Constraints

There are many administrative considerations, both legal and institutional, that place restrictive limitations on water-related issues. All water rights in the Henrys Fork Basin and downstream would be fully protected and remain unchanged. Existing in-basin and out-of-basin water users would retain all their present water rights and entitlements without modifications. New water rights, if available, would be obtained from the State of Idaho and administered under Idaho State laws.

Local, state, and federal laws and policies must be considered when evaluating additional surface water storage in the Henrys Fork Basin. These include regulatory and administrative requirements related to surface and groundwater rights, property rights, public health and safety, environmental concerns, and resource conservation. The following subsections give a partial listing of Federal and State regulatory guidelines that may pertain to implementation of any of the proposed surface water storage alternatives identified in the Henrys Fork Basin Study.

2.5.1 Federal Laws and Executive Orders

Following is a partial listing of Federal laws and Executive Orders (EO) that may pertain to implementation of any of the proposed alternatives identified in the Henrys Fork Basin Study:

- Antiquities Act of 1906
- American Indian Religious Freedom Act of 1978
- Archaeological Resources Protection Act of 1979, as amended

- Archaeological and Historic Preservation Act of 1974
- Clean Air Act of 1970, as amended
- Endangered Species Act of 1973, amended in 1979, 1982, and 1988
- Executive Order 11988 - Floodplain Management
- Executive Order 11990 - Protection of Wetlands
- Executive Order 12875 - Enhancing the Intergovernmental Partnership
- Executive Order 12898 - Federal Actions to Address Environmental Justice
- Federal Land Policy and Management Act
- Federal Water Pollution Control Act (commonly referred to as the Clean Water Act)
- Fish and Wildlife Coordination Act of 1958, as amended
- Historic Sites Act of 1935
- National Environmental Policy Act of 1969
- National Historical Preservation Act of 1966, as amended
- Native American Graves Protection and Repatriation Act of 1990
- Noise Control Act of 1972, amended in 1978
- Occupational Safety and Health Administration
- Hazard Communication Standards
- Resource Conservation and Recovery Act
- Rivers and Harbors Act of 1899
- Safe Drinking Water Act, Title 28, Public Law 89-72, as amended
- Wild and Scenic Rivers Act (United States Code, Title 16, Chapter 28)

2.5.2 State Laws and Policy

State regulatory processes should be considered in the evaluation of new storage projects, and some of the relevant laws and policies include the following:

- Water rights:
  - The necessary water rights must be obtained and administered in accordance with state law including Chapter 2, Title 42, Idaho Code.
  - For new water right permit applications, Section 42-203A requires that the following criteria be considered:
    - whether the proposed use will reduce the quantity of water under existing water rights, or
    - whether the water supply itself is insufficient for the purpose for which it is sought to be appropriated, or
    - whether it appears to the satisfaction of the director that such application is made in good faith, is not made for delay or speculative purposes, or
    - whether the applicant has sufficient financial resources with which to complete the work involved therein, or
    - whether it will conflict with the local public interest as defined in section 42-202B, Idaho Code, or
    - whether it is contrary to conservation of water resources within the state of Idaho, or
    - whether it will adversely affect the local economy of the watershed or local area within which the source of water for the proposed use originates, in the case where the place of use is outside of the watershed or local area where the source of water originates.

- A new project should be consistent with policies set forth in the State Water Plan implemented by the Idaho Water Resource Board (IWRB). Pertinent policies include:
  - State protected river designations: When designated as a natural river in accordance with Section 42-1734A, Idaho Code, the following activities are prohibited:
    - Construction or expansion of dams or impoundments
    - Construction of hydropower projects
    - Construction of water diversion works
    - Dredge or placer mining
    - Alterations of the stream bed
    - Mineral or sand and gravel extraction within the stream bed
  - By designating a recreational river, the IWRB shall determine which of the activities prohibited under a natural designation shall be prohibited in the specified reach and may specify the terms and conditions under which activities that are not prohibited may go forward. Designations and their corresponding recommendations are documented in the Henrys Fork Basin Plan, Idaho Water Resource Board, 1992.
  - State minimum stream flow water rights: Management of the Snake River consistent with minimum stream flow water rights established at the Milner, Murphy, Weiser, Johnson Bar and Lime Point gaging stations is fundamental to State policy. In addition, a number of minimum stream flow water rights have been developed in the Henrys Fork Basin. Each minimum stream flow was established to address specific management objectives, and together, the minimum stream flows form an integrated plan for management of the Basin and Snake River as a whole. The basis and intention of the minimum stream flows as well as the current management of the system should be included in the evaluation of a new project tributary to the Snake River to ensure consistency with the State Water Plan and State regulatory obligations.
  - Eastern Snake Plain Aquifer Comprehensive Aquifer Management Plan (ESPA CAMP 2009): The long-term goal of the ESPA CAMP is to incrementally achieve an annual net addition of 600,000 af to the aquifer water budget, with a short-term target of between 200,000 af and 300,000 af. A new project in the Henrys Fork Basin should support the ESPA CAMP objectives.
- Pursuant to Section 42-1737, Idaho Code, approval by the IWRB is required for all project proposals involving the impoundment of water in a reservoir with an active storage capacity in excess of 10,000 af.
- Water Quality Certification from the Idaho Department of Health and Welfare in connection with the Federal Clean Water Act.
- Obtain approval of engineering designs, operation, and maintenance through the Idaho Safety of Dams program.
- Stream Channel Alteration Permit for improvements made to the channel to accommodate flood flows and routine releases.
- Coordinate with the IDWR floodplain manager to confirm compliance with the National Flood Insurance Program (NFIP) requirements in Idaho.

At this stage of the Study, specific county and city planning and zoning and environmental regulations are not listed in detail, but would need to be considered prior to implementation.

2.6 Environmental Benefits and Impacts

During earlier phases of this study, a matrix was developed that identified alternative-specific benefits and impacts related to:

- Impacted river segments
- Change in connectivity

- State Aquatic Species of Special Concern (Yellowstone Cutthroat Trout and Rainbow Trout)
- Natural environment (including wildlife habitat impacts, federally listed species, wetlands, State species of concern, and special river designations)

The matrix was populated based on review of existing literature and input from Basin stakeholders. Matrix results are summarized below for each alternative.

2.7 Land Management, Recreation and Infrastructure Impacts and Benefits

The same matrix also summarized benefits and impacts related to land management, recreation, and infrastructure. Matrix results for these are also summarized below for each alternative.

2.8 Key Assumptions and Limitations

- Hydrology is uncertain: Legal water available is not known. Physical water availability has been approximated based on regression equations, but actual runoff has not been measured, and firm yield has not been evaluated. Complete water balance and refined operations have not been evaluated.
- Storage potential is preliminary: A limited number of site and alignment alternatives have been explored, and judgment has been used to balance maximum storage potential with efficient embankment configurations.
- System water balance was not evaluated: At this stage, no accounting was done for direct precipitation on the reservoir, seepage losses in the reservoir, or evaporation losses from the reservoir. Water balance considerations were not evaluated at this stage and will depend on the elevation-capacity relationship for each reservoir, how the reservoir is operated, and whether drought conditions are considered.
- Embankment configurations are generalized: Site-specific materials and material properties have not been evaluated, and optimized dam approaches have not been proposed. A detailed evaluation of dam-raise design considerations should be performed in future phases to assess feasibility.
- Cost estimates are comparative and preliminary: Future concept refinements could potentially change the ranking of alternatives by cost. Costs are relative and are not intended for budgeting.
- Detailed geotechnical evaluation is deferred: Geologic and geotechnical site analysis is based on available geologic literature, soil mapping, and review of geotechnical literature and reports. No field reconnaissance or geologic mapping was conducted as part of this investigation and analysis.
- No quantitative hazards analysis was performed.

2.9 Data Sources

2.9.1 Storage and Needs Studies

- Bureau of Reclamation (Reclamation). 2012. Draft Henrys Fork Watershed Basin Study Water Needs Assessment, March.
- Idaho Water and Energy Resources Research Institute (IWRRI). 1981. A Preliminary Appraisal of Offstream Reservoir Sites for Meeting Water Storage Requirements in the Upper Snake River Basin, for the U.S. Army Corps of Engineers, Walla Walla District, February.
- Idaho Water Resource Board (IWRB). 1992. Comprehensive State Water Plan – Henrys Fork Basin.
- Van Kirk, R., Rupp, S., and J. De Rito. 2011. Ecological Streamflow Needs in the Henrys Fork Watershed, September.

2.9.2 Hydrology

- United States Geological Survey (USGS), 2011, StreamStats Idaho: http://water.usgs.gov/osw/streamstats/idaho.html

  Six reports document the regression equations available in StreamStats for Idaho, the errors associated with the estimates, and the methods used to develop the equations and to measure the basin characteristics used in the equations.

  - Hortness, J. E., and Berenbrock, Charles, 2001, Estimating Monthly and Annual Streamflow Statistics at Ungaged Sites in Idaho: U.S. Geological Survey Water Resources-Investigations Report 01-4093, 36 p.
  - Berenbrock, Charles, 2002, Estimating the Magnitude of Peak Flows at Selected Recurrence Intervals for Streams in Idaho: U.S. Geological Survey Water Resources-Investigations Report 02-4170, 59 p.
  - Hortness, J. E., and Berenbrock, Charles, 2001, 2003, Estimating the Magnitude of Bankfull Flows for Streams in Idaho: U.S. Geological Survey Water Resources-Investigations Report 03-4261, 36 p.
  - Hortness, J.E., 2006, Estimating low-flow frequency statistics for unregulated streams in Idaho: U.S. Geological Survey Scientific Investigations Report 2006-5035, 31 p.
  - Wood, M.S., Rea, Alan, Skinner, K.D., and Hortness, J.E., 2009, Estimating locations of perennial streams in Idaho using a generalized least-squares regression model of 7-day, 2-year low flows: U.S. Geological Survey Scientific Investigations Report 2009-5015, 26 p.
  - Rea, Alan, and Skinner, K.D., 2009, Estimated perennial streams of Idaho and related geospatial datasets: U.S. Geological Survey Data Series 412, 32 p.

2.9.3 Geotechnical Review

- Aerial photographs: National Agriculture Imagery Program (NAIP). 2009. 1-meter color imagery (GIS-based web service).
- Soil maps: NRCS 1:24,000 soil map units (1988).
- Topographic maps: USGS 1:24,000 Quadrangle (GIS-based web service).
- Available water well logs in the vicinity of the project.
- Gilbert, J.D., Ostenaa, D., and C. Wood. 1983. Seismotectonic Study, Island Park Dam and Reservoir, Minidoka Project, Idaho-Wyoming. Bureau of Reclamation, Seismotectonic Report 83-1.
- Gilbert, J.D., Ostenaa, D., and C. Wood. 1983. Seismotectonic Study, Jackson Lake Dam and Reservoir, Minidoka Project, Idaho-Wyoming. Bureau of Reclamation, Seismotectonic Report 83-8.
- Patrick, D.M., and C.B. Whitten. 1981. Geological and Seismological Investigations at Ririe Dam, Idaho, Miscellaneous Paper GL-81-7, for the U.S. Army Corps of Engineers, Walla Walla District, September.
- Reclamation. 2010. Island Park Dam, Comprehensive Facility Review, Minidoka Project, Pacific Northwest Region, December.
- URS Greiner Woodward Clyde. 2000. Preliminary Probabilistic Seismic Hazard Analyses: Island Park, Grassy Lake, and Jackson Lake Dams – Minidoka Project; Palisades Dam – Palisades Project; Ririe Dam – Ririe Project; Eastern Idaho and Western Wyoming, for the Bureau of Reclamation, June.

2.9.4 Cost Development

- Cost indices: Engineering News-Record. 2012. http://enr.construction.com/economics/historical_indices/
- Proprietary projects with similar design components

2.9.5 Crosscut Canal

- Canal design guidelines: Reclamation. 2010. Appendix A – General Canal Design Flowchart, Draft Feasibility-Level Engineering Report, Continued Phased Development of the Columbia Basin Project – Enlargement of the East Low Canal and Initial Development of the East High Area, Odessa Subarea Special Study, October.
- Reclamation. 1936. Crosscut Canal Profile and Sections, Upper Snake River Project-Idaho.

SECTION 3

Island Park Dam Raise

3.1 Alternative Description

3.1.1 Overview

The Island Park Dam Raise Alternative consists of raising Island Park Reservoir normal pool by one to eight feet to increase reservoir storage by 8,000 to 74,000 acre-feet (af). The one foot raise would be accomplished by replacing the rubber bladder on the spillway, and the eight foot raise would be accomplished by building up the entire embankment and raising the spillway. Island Park Reservoir is located directly on the Henrys Fork River at the Town of Island Park and would require no secondary water sources. When full, the proposed one foot reservoir raise could provide a roughly 44-foot drop to the existing hydropower facility on the Henrys Fork River at the base of the dam, and the eight foot dam raise would provide a roughly 51-foot drop to a proposed new hydropower facility. A variation of this alternative includes expansion of the Crosscut Canal, which would allow water released from the reservoir to be transferred to the Lower Teton Basin.

3.1.2 Alternative Variations

The following sub-alternatives were identified by varying the dam raise concept.

- IP-1: Raise Island Park Reservoir operating pool 1-foot by replacing an existing 1-foot-high rubber bladder on the spillway with a new, operable 2-foot-high rubber bladder to produce an additional 8,000 af of storage.
- IP-1_CC: Same as IP-1 but also includes expansion of the Crosscut Canal to provide water to the Lower Teton Basin.
- IP-8: Raise entire Island Park Dam embankment approximately 8 feet to produce an additional 74,000 af of storage.
- IP-8_CC: Same as IP-8 but also includes expansion of the Crosscut Canal to provide water to the Lower Teton Basin.

3.1.3 Operational Assumptions

Detailed operations have not been evaluated or distinguished by alternative. Preliminary, generalized, non-binding operational assumptions were described in Sections 2.2 and 2.3 to evaluate potential water availability and design flow to identify sub-alternatives and develop relative costs.

3.2 Key Findings

The Island Park Dam Raise would provide additional water storage for the Henrys Fork Basin, and potentially for the Teton Basin via cross-basin transfer using the Crosscut Canal, effectively enhancing water supply by capturing excess peak flows and redistributing that water during periods of higher demand. The available storage would enhance the in-basin water budget by retaining an additional 8,000 to 74,000 af during the annual high flow period and storing that water until more critical, higher demand periods. This storage water could help satisfy unmet irrigation demands in the North Fremont, Lower Watershed (via the Crosscut Canal), and Egin Bench irrigated regions. Reservoir releases during low flow periods would improve connectivity in other downstream river segments, including the Middle Henrys Fork River, Lower Henrys Fork River, North Fork Teton River, and South Fork Teton River, which have all been identified as having additional ecological streamflow needs. Additional impoundment would typically occur during periods when connectivity is not an issue, and flow decreases would not be expected to impact any populations of Yellowstone cutthroat trout, but a priority rainbow trout fishery in the Henrys Fork River could be impacted. The out-of-basin water budget would be temporarily reduced by up to 8,000 or 74,000 af during the annual high flow period when water is retained in the reservoir, but some or all of that quantity may be available at a later time for numerous out-of-basin uses, including needs resulting from climate change; agricultural needs; domestic, municipal, and industrial needs; ecological needs; and for recharge of the ESPA. Exhibit 3-1 provides a tabular summary of the key findings.

EXHIBIT 3-1
Key Findings from the Reconnaissance Evaluation

Estimated Cost per af	Impact on In-Basin Water Budget	Impact on Out-of-Basin Water Budget	Change in Connectivity of Impacted River Segment
$100 - $2,900	8,000 to 74,000 af, to be retained during the annual high flow period and released during high demand periods.	8,000 to 74,000 af reduction during the annual high flow period, in accordance with priority rights. Part or all of this quantity would be available later for out-of-basin needs.	Improvement in connectivity of downstream river segments, including Middle Henrys Fork River, Lower Henrys Fork River, North Fork Teton River, and South Fork Teton River. Potential impacts to supply sources, none of which contain conservation populations of Yellowstone cutthroat trout.

3.3 Engineering Results

3.3.1 Hydrology

The Henrys Fork River is impounded by Island Park Dam and was the only water supply source evaluated (Exhibit 3-2, on the following page). Exhibit 3-3 presents a summary of total water from the single source based on analyses using StreamStats (USGS, 2011; see Section 2.2.1 – *Hydrology*).

EXHIBIT 3-3
Water Potentially Available for Storage at Island Park Reservoir

Source	Watershed Area (sq. mi)	Quantity (af/year)
Henrys Fork River [a]	500	426,838

[a] Quantity reported for regulated systems is total estimated water in system. Excess spring runoff calculation was considered invalid for these systems because of upstream dam regulation.

3.3.2 Existing Dam Configuration

3.3.2.1 Embankments

Island Park Dam is a zoned earthen embankment structure on the Henrys Fork of the Snake River (see Exhibit 3-4). The existing dam was constructed between 1935 and 1938. The structure impounds about 127,000 af of water at elevation 6302.0. A hydroelectric powerplant was added in 1994.

The existing dam has a crest length of 1,607 feet and a crest width of 35 feet. In 1985 the dam crest was raised from elevation 6309.0 to elevation 6312.0. In 1984, the right end of the dam (about 400 feet long) was reconstructed after removal of potentially liquefiable loose volcanic ash found in the foundation.

The existing dam has a hydraulic height of 75 feet. The upstream face of the dam is protected by 3 feet of riprap placed on a 2 horizontal: 1 vertical (H:V) slope in the upper portion of the structure and 4H:1V to 5H:1V in the lower portions of the structure. The downstream face of the existing dam is constructed at a 2H:1V and is protected by a rockfill zone of variable thickness. The internal zoning within the structure is not currently available for review (Reclamation, 2010).

A 7,950-foot long dike extends from the left end of the dam and has upstream slopes of 3H:1V with 2 feet of riprap, while the downstream slopes are 2H:1V with no slope protection. The crest width of the dike varies from 24 feet to 39 feet. The crest of the dike was also raised in 1985 from elevation 6309.0 to 6312.0.

3.3.2.2 Spillways

A service spillway is located at the right abutment and consists of a concrete bathtub-type crest and inlet (see Exhibit 3-5) connecting to a 17 foot high horseshoe-shaped tunnel that transitions to a nearly horizontal 13-foot diameter circular tunnel section. The spillway crest is 260 feet long, with long sections on either side that are approximately 99 feet long each and connected by a horseshoe shaped section at the end that is 62 feet long.

EXHIBIT 3-2
Island Park Dam Raise Alternative: Hydrology

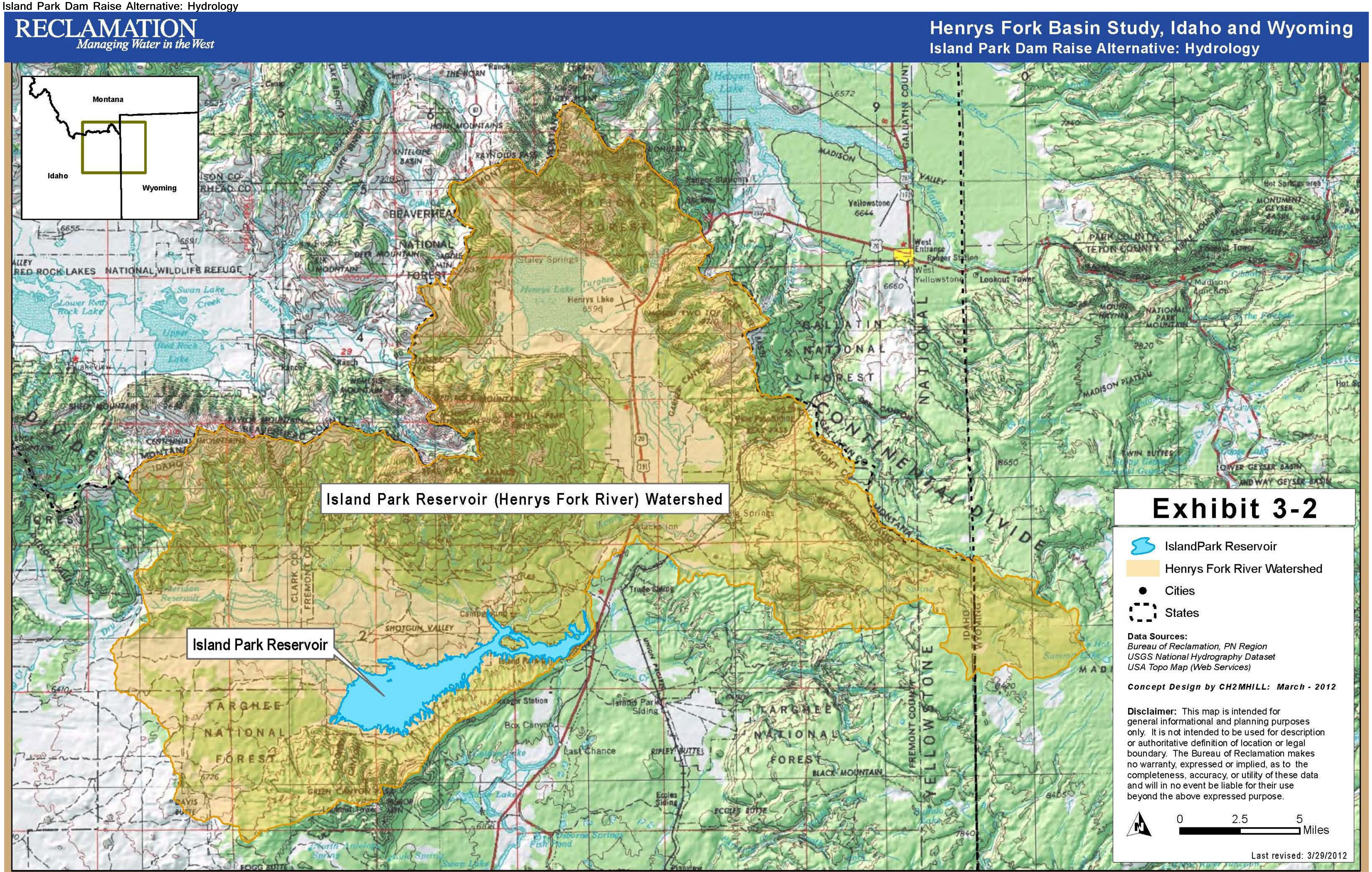


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EXHIBIT 3-4
Island Park Dam Raise Alternative: Plan View of Dam

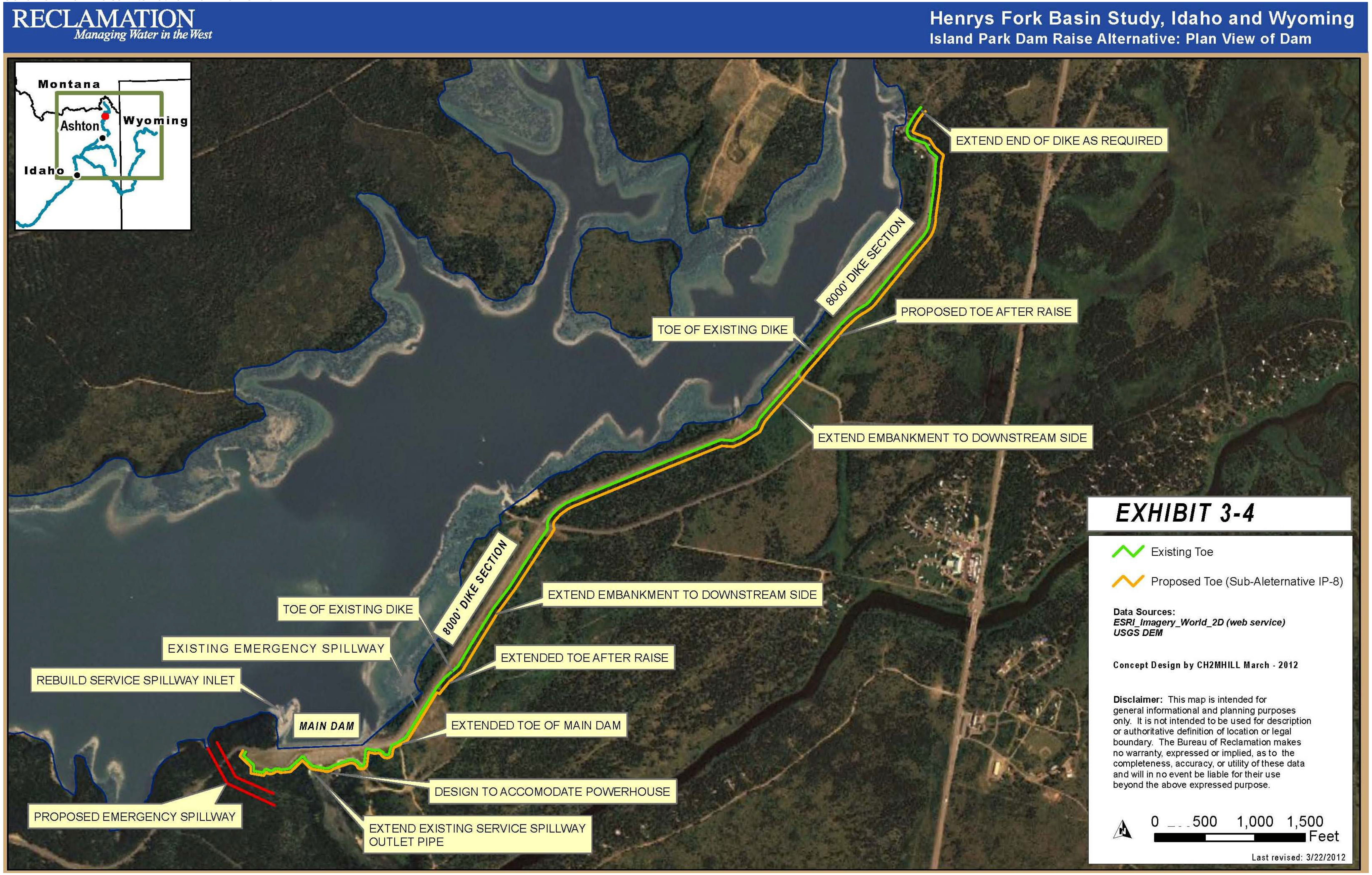

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EXHIBIT 3-5
Island Park Dam Raise Alternative: Service Spillway

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The 62-foot upstream portion has an ogee shape with a top elevation of 6303.0. The remaining 198 feet of the crest is also an ogee concrete weir with a top elevation of 6302.0 feet, but this segment includes an inflatable bladder that, when inflated, provides a final crest elevation of 6303.0. The concrete lining of the spillway inlet and tunnel was extensively repaired in 1979. Crest modifications and the inflatable bladder crest installation at the bathtub inlet were performed in 1996. The design discharge capacity of the service spillway is approximately 5,000 cubic feet per second (cfs) at water surface elevation 6305.0.

An emergency spillway was excavated within the dike and lined with riprap. It is trapezoidal-shaped and has an invert crest that is 500 feet wide at elevation 6309.0. The spillway sides are sloped at 2.5H:1V from the spillway crest to the dike crest.

3.3.2.3 Foundation

The dam foundation is thought to consist of alluvium and/or colluvium overlying bedrock. Bedrock under the dam is thought to consist of rhyolite tuff (Mesa Falls Tuff) and/or basalt (Gerrit Basalt). The depth of overburden is unknown; however, steep slopes and rock outcrops in some areas along the sides of the valley suggest that rock could be encountered at relatively shallow depths. The abutments of the dam are thought to encounter colluvium, talus, and possible landslide deposits overlying rhyolite tuff (Mesa Falls Tuff) including pumice and volcanic ash (Gilbert et al., 1983). Exhibit 3-6 presents a profile along the dam axis and highlights geologic features that could affect the foundation.

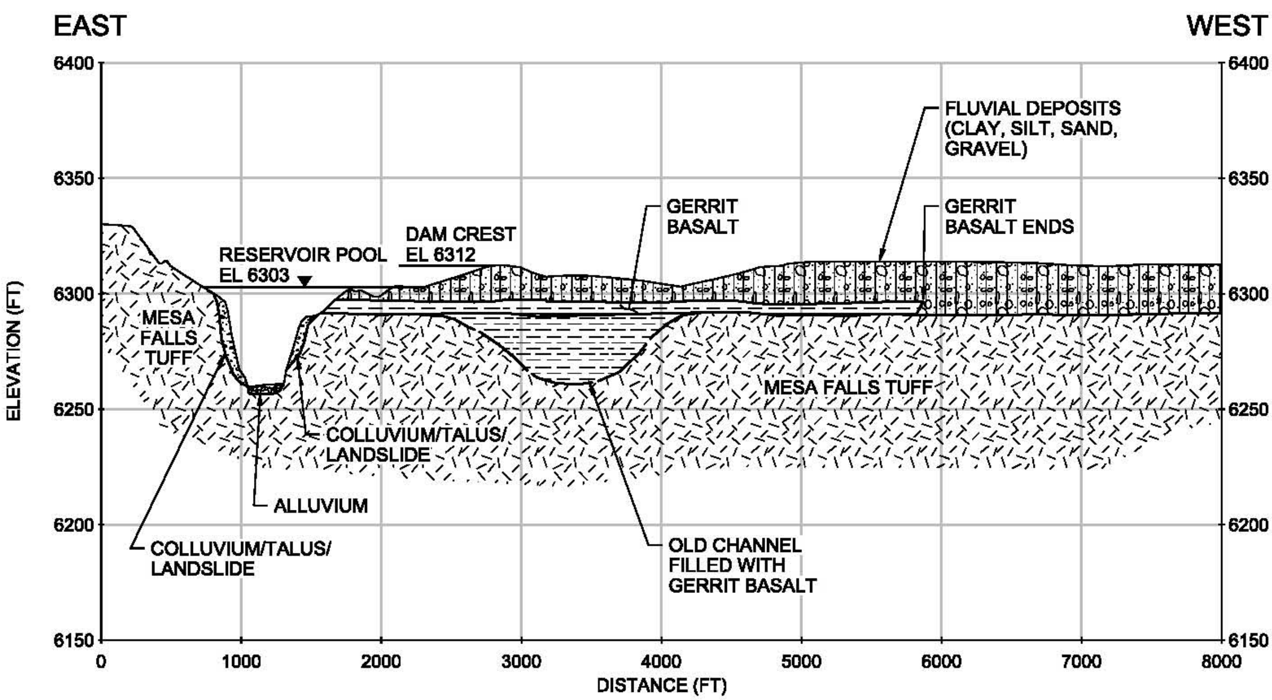


EXHIBIT 3-6
Island Park Dam Geologic Profile

3.3.3 Proposed Dam Configuration

3.3.3.1 One-Foot Bladder Raise Sub-Alternative

This sub-alternative would require replacing the existing 1-foot inflatable bladder on the two sides of the service spillway with a 2-foot bladder, and adding a 1-foot ogee-shaped concrete cap to the 62-foot horseshoe-shaped end section, to raise the reservoir water surface one foot to elevation 6304. It is currently unknown whether the existing concrete base to which the new rubber dams attach would require modification, but the base width could be widened by adding concrete if required. Inflatable bladders in other locations have been used to retain water heights exceeding 11 feet, so one foot of additional height should be readily achievable. The combined capacity of the service spillway and emergency spillway will need to be evaluated in future phases to ensure their ability to safely pass the inflow design flood.

3.3.3.2 Eight-Foot Dam Embankment Raise Sub-Alternative

This sub-alternative would require raising the existing dam by approximately 8 feet to elevation 6320, with a corresponding raise in normal operating pool from 6303 to 6311.

Although the internal zoning of the dam is not currently available for review, it is likely that a design could be developed that would accommodate such a raise and allow extending impervious and drainage zones within the dam as needed. Assuming slopes similar to existing slopes (2H:1V upstream and downstream for the main dam and 3H:1V upstream and 2H:1V downstream for the 8,000-foot long dike), and assuming the dam would be raised by extending the embankment to the downstream side of the existing embankments, the base of the downstream side of the dam would be widened by approximately 32 to 62 feet, depending on the cross-section location.

Exhibit 3-4 illustrates the approximate increased downstream footprint of the dam and dike raise. Extending embankments in the downstream direction would impact existing structures including the existing powerhouse and tailrace, service spillway inlet and discharge pipe, and emergency spillway. These structures would all require extensions, protective retaining walls, or other modifications that would preserve the integrity and function of the facilities while accommodating the increased fill and pool height. Raising the dam may also impact the powerhouse, and the structure may require modifications to accommodate the increased head and capacity.

Exhibit 3-7 illustrates the concept of raising the dam by showing an approximate section of the raised embankment at the main dam and at the dike. Saddle dams may also be required at some locations around the perimeter of the lake.

Embankment for the dam raise may require internal drainage zones and the construction of an internal cutoff or tie to the existing core of the dam. The internal drainage zones may be required to control seepage and internal piping. The cutoff may be required if the additional head results in increased seepage and could be constructed of foundation grouting, sheet piles, or other materials. The construction of the embankments may include a variety of naturally available materials including silt, sand, gravel and rockfill. Suitable borrow sources would need to identified during a later phase of study, but the geology of the area suggests that suitable materials are locally available.

It is assumed that the existing service spillway and discharge tunnels and pipes could be modified to accommodate the increased head. However, because the increased dam height poses greater potential for erosion from concentrated flows, the existing riprap-lined emergency spillway may need to be replaced. An alternative emergency spillway alignment around the right abutment has been identified to accommodate a more erosion-resistant structure with a higher weir elevation.

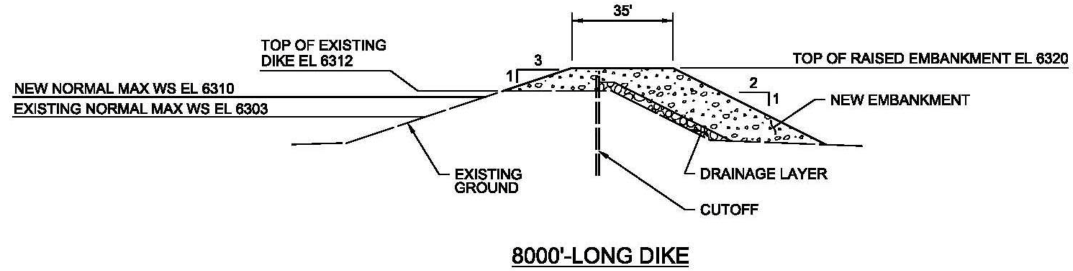
3.3.4 Crosscut Canal

The Crosscut Canal, which runs from the Henrys Fork River to the lower Teton River, allows inter-basin transfer of water. The current capacity of the existing Crosscut Canal is approximately 600 cfs at the upstream end of the canal and approximately 400 cfs at the downstream end (FMID, personal communication, 2011). To better enable this alternative to help meet demands in the Lower Teton basin, hydraulic capacity of the Crosscut Canal would be expanded to 1,000 cfs for two of the sub-alternatives (IP-1_CC and IP-8_CC), as described in Section 2.2.2 – *Crosscut Canal Conveyance*.

3.3.5 Hydropower Potential

When full, the proposed one foot reservoir raise (IP-1) could provide a roughly 44-foot drop to the existing hydropower facility on the Henrys Fork River at the base of the dam, and the eight foot dam raise (IP-8) would provide a roughly 51-foot drop to a proposed new hydropower facility. As presented in Exhibit 3-8, hydropower potential associated with Island Park Reservoir would vary from approximately 640 to 1,087 kW.

EXHIBIT 3-7
Island Park Dam Existing and Proposed Cross-Sections



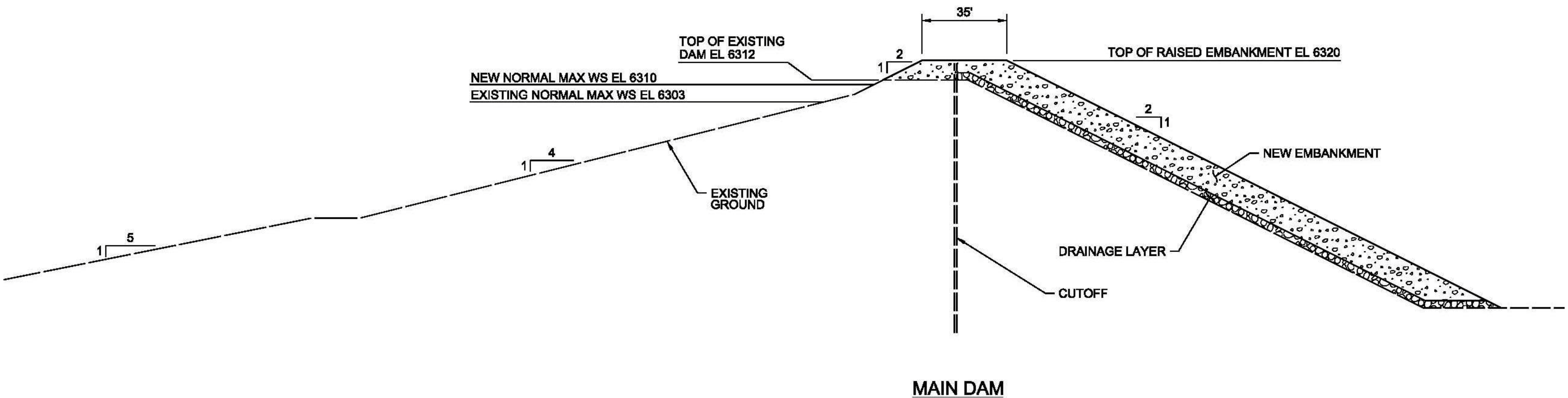


EXHIBIT 3-8
Island Park Hydropower Potential

Sub-Alternative	Design Flow (cfs)	Penstock Length (mi)	Head (ft)	Power Potential (kW)
IP-1, IP-1_CC	212	0[a]	44	640
IP-8, IP-8_CC	311	0[a]	51	1,087

[a] It is assumed that turbines are located at the bottom of the outlet works. Therefore, no penstocks are needed.

3.4 Cost Estimate

A summary of the cost per af of incremental (beyond existing) water stored for each sub-alternative is presented in Exhibit 3-9. These costs include hydropower facilities and expansion of the Crosscut Canal. A more detailed breakdown of each cost element is provided in Exhibit 3-10.

EXHIBIT 3-9
Island Park Dam Raise Cost Estimate Summary

Sub-Alternative	Total Storage Volume (af)	Incremental Storage Volume (af)	Total Construction Cost[a]	Cost Per Incremental Unit Yield ($/acre-foot)
IP-1	142,000	8,000	$850,000	100
IP-1_CC	142,000	8,000	$22,980,000	2,900
IP-8	208,000	74,000	$29,330,000	400
IP-8_CC	208,000	74,000	$51,470,000	700

[a] Total estimated construction costs were rounded to the nearest $10,000 and unit costs were rounded to the nearest $100.

EXHIBIT 3-10
Detailed Relative Construction Cost for Island Park Dam Raise Sub-Alternatives

				Estimated Costs by Sub-Alternative			
Component	Quantity[a]	Unit	Cost Basis	IP-1	IP-1_CC	IP-8	IP-8_CC
Dam - Embankment	0 670,000	CY	embankment, remoteness factor, foundation factor	$0	$0	$8,040,000	$8,040,000
Dam – Emergency Spillway	0 62,963	CY	spillway excavation, lump sum (weir, chute, stilling, bladder)	$0	$0	$2,259,259	$2,259,259
Dam –Outlet Works and Service Spillway	1	LS	outlet tower, site factor, scaling factor	$400,000	$400,000	$966,667	$966,667
Penstock	0	Miles	design flow, length and diameter	$0	$0	$0	$0
Hydropower	644 909	KW	KW (head and design flow), penstock length and diameter	$0	$0	$2,617,811	$2,617,811
Crosscut Canal Enlargement	6.6	Miles	excavation, local fill, parallel gravel access roads, migration crossings	$0	$10,480,060	$0	$10,480,060

EXHIBIT 3-10
Detailed Relative Construction Cost for Island Park Dam Raise Sub-Alternatives

				Estimated Costs by Sub-Alternative			
Component	**Quantity[a]**	**Unit**	**Cost Basis**	**IP-1**	**IP-1_CC**	**IP-8**	**IP-8_CC**
Base Field Cost				$400,000	$10,880,060	$13,883,737	$24,363,797
Unlisted Items (20%)				$80,000	$2,176,012	$2,776,747	$4,872,759
Mobilization (5%)				$20,000	$544,003	$694,187	$1,218,190
Field Cost w/out Contingency				$500,000	$13,600,075	$17,354,671	$30,454,746
Contingency (30%)				$150,000	$4,080,023	$5,206,401	$9,136,424
Total Field Cost				$650,000	$17,680,098	$22,561,073	$39,591,170
Non-Field Cost (30%)				$195,000	$5,304,029	$6,768,322	$11,877,351
Total Relative Construction Cost				$845,000	$22,984,127	$29,329,394	$51,468,521

[a] When two quantities are listed, first quantity is for sub-alternative IP-1 (and IP-1_CC) and second quantity is for sub-alternative IP-8 (and IP-8_CC).

3.5 Basin Water Needs

The storage provided by the Island Park Dam Raise would enhance the in-basin water budget by retaining an additional 8,000 to 74,000 af during the annual high flow period and storing that water until more critical, higher demand periods during the summer and early fall. Water stored in the reservoir would help satisfy unmet irrigation demands in the North Fremont, Lower Watershed (via the Crosscut Canal), and Egin Bench irrigated regions (Reclamation, 2012). Reservoir releases would also be used to enhance ecological in-stream flows (see Section 3.7.2 – *Change in Connectivity*).

The out-of-basin water budget would be temporarily reduced by up to 8,000 to 74,000 af during the annual high flow period when water is retained in the reservoir, but some or all of that quantity may be available at a later time for numerous out-of-basin uses, including needs resulting from climate change; agricultural needs; domestic, municipal, and industrial needs; ecological needs; and for recharge of the ESPA (Reclamation, 2012).

3.6 Legal, Institutional, or Policy Constraints

Legal, institutional, and policy constraints that may affect the implementation of this alternative are described in Section 2.5 – *Legal, Institutional, or Policy Constraints*.

3.7 Environmental Benefits and Impacts

3.7.1 Impacted River Segments

River segments potentially impacted by various sub-alternatives include the Henrys Fork, Teton, and South Fork Teton Rivers, as identified in Exhibit 3-11.

3.7.2 Change in Connectivity

Potential impacts to river connectivity consist of decreased flow (impoundment in the reservoir) for river segments providing reservoir supply and increased flow for river segments receiving reservoir releases. As described in Section 2.2.1.3 – *Potentially Available Water*, additional impoundment would likely occur during the excess spring runoff period and reservoir releases would likely occur during more critical low flow periods in the summer and fall. Potential impacts to connectivity of each impacted river segment are identified in Exhibit 3-11. In addition to the segments listed in Exhibit 3-11, enhanced connectivity would be experienced in other downstream river segments, including the Lower Henrys Fork River, North Fork Teton River, and South Fork Teton River, which have all been identified as having additional ecological streamflow needs (Van Kirk et al., 2011).

EXHIBIT 3-11

Impacts to Connectivity, Yellowstone Cutthroat Trout, and Special River Designations for Affected River Reaches

			Connectivity		State Aquatic Species of Special Concern			Special Designation[a]				
Surface Storage Site	Sub-Alternative	Impacted River Segments	Flow Decrease (Supply Source)	Flow Increase (Receives Reservoir Releases)	Yellowstone Cutthroat Trout (YCT) Presence	Rainbow Trout (RBT) Priority Fishery[b]	YCT Conservation and Management Tier[c] and RBT Fishery Rating	BLM/USFS Eligible Stream	State Natural River	State Recreational River	Designated Wilderness[d]	Rating
Island Park	IP-1, IP-8	Henrys Fork	•	•		•	RBT Priority					None
Island Park	IP-1_CC, IP-8_CC	Henrys Fork	•	•		•	RBT Priority					None
		Teton[e]		•	•		YCT Conservation					None
		South Fork Teton[e]		•	•		YCT Conservation					None

Notes:

[a]Special designations noted in this exhibit apply to the river reach impounded, diverted for water supply, or directly receiving return flows (if applicable).

[b]Based on personal communications with IDFG, rainbow trout are the primary focus in the Henrys Fork Watershed, whereas YCT are the primary focus in the Teton Watershed.

[c]Three tiers for prioritizing YCT conservation and management options per Montana Fish Wildlife & Parks database (2009) supplemented with anticipated data revisions per personal communications with IDFG.

1) **core conservation** populations composed of > 99 percent cutthroat trout genes;
2) **conservation** populations that generally "have less than 10 percent introgression, but in which introgression may extend to a greater amount depending upon circumstances and the values and attributes to be preserved"; and
3) **sport** populations of cutthroat trout that, "at a minimum, meet the species phenotypic expression defined by morphological and meristic characters of cutthroat trout."

[d]Per the 1997 Revised Forest Plan - Targhee National Forest.

[e]River segments may receive cross-basin water transfer via the Crosscut Canal.

Legend

State Aquatic Speices of Special Concern (YCT and RBT)

YCT Core / RBT Priority	Core Conservation Population of YCT or Priority RBT Fishery
YCT Conservation	Conservation Population of YCT
YCT Sport / None	None or Sport Population of YCT

Special Designation

Federal	Federal Wild and Scenic River (WSR) or Wilderness Area
State/ Eligible Federal	State Protected (Natural and Recreational) or eligible Federal WSR
None	None

3.7.3 State Aquatic Species of Special Concern

The Henrys Fork River is home to a priority rainbow trout fishery, but the reservoir inundation area is not in crucial habitat for Yellowstone cutthroat trout, and no substantial Yellowstone cutthroat trout population has been identified. State Aquatic Species of Special Concern in potentially impacted river segments are indicated in Exhibit 3-11.

3.7.4 Other Environmental Factors

The proposed enlargement of the Island Park Reservoir inundation area serves as a migration corridor for big game. Species tracked by the United States Fish and Wildlife Service (USFWS) known to occur in the area include two federally listed threatened species, the grizzly bear and the Canadian lynx, and two candidate species, the wolverine and the greater sage grouse. The Island Park area is home to several species considered at-risk by the Bureau of Land Management (BLM), the U.S. Forest Service (USFS), and the Idaho Department of Fish and Game (IDFG), including American avocet (Recurvirostra americana), American white pelican (Pelecanus erythrorhynchos), bald eagle, black-crowned night-heron (Nycticorax nycticorax), California gull (Larus californicus), Caspian tern (Hydroprogne caspia), common loon (Gavia immer), Forster’s tern (Sterna forsteri), Franklin’s gull (Leucophaeus pipixcan), sandhill crane, sharp-tailed grouse, trumpeter swan, western grebe (Aechmophorus occidentalis), white-faced ibis (Plegadis chihi), and Wyoming ground squirrel (Spermophilus elegans nevadensis). The expanded reservoir would impact wetlands in the lower reaches of Sheridan Creek, Icehouse Creek, Hotel Creek, and others, likely affecting an area between 1 and 200 acres. This reach of the Henrys Fork River has no special designations.

Potential wildlife habitat impacts, federally listed species, and wetlands habitat impacts within the reservoir inundation area are also summarized in Exhibit 3-12, while State of Idaho aquatic species of special concern (Yellowstone cutthroat trout and rainbow trout) and special river designations for all potentially impacted river segments are summarized in Exhibit 3-11.

3.8 Land Management, Recreation and Infrastructure impacts and benefits

Island Park Reservoir is located on private, state, and federal land; has a low recreation and economic rating for the 1-foot raise and a moderate rating for the 8-foot raise; and is rated as having a moderate number of potential infrastructure impacts for the 1-foot raise (primarily roads) and high number of potential infrastructure impacts for the 8-foot raise (roads, docks, and approximately 100 structures), as summarized in Exhibit 3-13.

3.9 Assumptions and Limitations

General assumptions and limitations applicable to all of the surface-storage alternatives are described in Section 2.8 – *Key Assumptions and Limitations*. Additional assumptions and limitations specific to this alternative are listed below:

- Excavation for the open spillway under Sub-Alternative IP-8 would likely be in colluvial soils and/or rock. It is possible that the spillway may be in soft erodible materials and if an open channel spillway is used, it may require concrete or rock linings that are suitable to match the intended spillway flows. A lined concrete spillway was assumed for costing purposes. Alternative spillway approaches should also be investigated once the inflow design flow has been established and local site conditions are better understood.
- Existing freeboard (approximately 9 feet) would be maintained for Sub-Alternative IP-8.
- For Sub-Alternative IP-1, a lump sum allowance was included for raising the service spillway by 1-foot through installation of new inflatable bladders. See Exhibit 3-10.

EXHIBIT 3-12
Impacts to Wildlife Habitat, Federally Listed Species, and Wetland Habitat at the Reservoir Site

Surface Storage Site	Wildlife Habitat[a]			Federally Listed Species			Wetland/Habitat Value	
	Big Game Winter Range	Big Game Migration Corridors	Rating	At-Risk (USFS & BLM sensitive species, and Idaho Species of Greatest Conservation Need)[b]	Threatened, Endangered, Candidate and Experimental Nonessential Species[c]	Rating	NWI Wetlands	Rating
Island Park			None	american avocet, american white pelican, bald eagle, black-crowned night-heron, galifornia gull, caspian tern, common loon, foster's tern, franklin's gull, sandhill crane, sharp-tailed grouse, trumpeter swan, western grebe, white-faced ibis, wyoming ground squirrel	grizzly bear, Canada lynx, sage grouse, wolverine	Federal Terrestrial / Sensitive	•	Moderate

Notes:

[a]Sources of Wildlife Habitat data

[1]Per review comments from Trout Unlimited, Friends of the Teton River, and American Rivers.

[2]Per personal communications with IDFG on the Sand Creek and Teton Canyon winter ranges.

[3]Per the USFS 1997 Revised Forest Plan - Targhee National Forest.

[b]Per IDFG special species February 2011 GIS dataset (1-mile buffer area).

[c]Threatened and Endangered and Candidate species list obtained from USFWS; however, location specific information based on data compiled by Trout Unlimited, Friends of the Teton River, and American Rivers (unless otherwise specified, some identified in the IDFG February 2011 dataset).

Legend

Wildlife Habitat

Winter Range	Winter Range Habitat
Migration	Migration Corridor
None	None

Federally Listed Species

Federal Aquatic/ Prime Conservation	Federally Listed Aquatic Species and Prime Conservation Area[h]
Federal Terrestrial/ Sensitive	Federally Listed Terrestrial Species and State Species of Greatest Conservation Need
None	None

Wetland and Habitat Values

Extensive	Extensive wetland impacts (> 200 Acres)
Moderate	Moderate wetland impacts (>1 - 200 Acres)
None/Minimal	<1 Acre

EXHIBIT 3-13
Land Management Implications and Impacts to Recreation/Economic Value and Infrastructure at the Reservoir Site

		Land Management Data[a]					Recreation/Economic Value								Infrastructure[e]				
Surface Storage Site	Sub-Alternative	Private	Federal	State	Conservation Easements[b]	Rating	Boating	Fishing	Yellowstone National Park	Guiding/ Outfitting	Scenic/ Natural Features[c]	Cultural/ Historic Resources[c]	Land Recreation	Rating	Roads	Structures	Habitation	Additional Infrastructure Notes	Rating
Island Park	IP-1, IP-1_CC	•	•	•		Federal	•[d]	•[b]						Low	•				Moderate
Island Park	IP-8, IP-8_CC	•	•	•		Federal	•[d]	•[b]				•[d]	•[d]	Moderate	•	•	•	Approximately 100 structures affected	High

Notes:

[a]Land management data per the BLM Idaho Surface Management Agency (2010). For federal government lands, the data displays the managing agency which may or may not be the same as the agency that "owns" the land.

[b]Per feedback from Trout Unlimited, Friends of the Teton River, American Rivers, and the Henry's Fork Foundation.

[c]Per the Resource Evaluation (IWRB 1992)

[d]Per personal communications with the Henrys Fork Foundation.

[e]Preliminary impacts based on cursory review of aerial photography.

Legend

Land Management

Federal/ Conservation	Federal, Conservation Easement
State	State
Private	Private

Recreation/Economic Value

High	Significant Impacts to Recreation/ Economic Values
Moderate	Moderate Impacts to Recreation/ Economic Values
Low	Minimal Impacts to Recreation/ Economic Values

Infrastructure

High	Impacts to major infrastructure/development
Moderate	Moderate impacts to human environment
Few	Few impacts to human environment

- It is possible that the existing service spillway and its discharge tunnel could be modified to accommodate the increased head under Sub-Alternative IP-8, but for the sake of being conservative the cost estimate assumed full replacement. Minor changes to the outlet works and full replacement of the service spillway would comparable in cost to full installation of a tower outlet works for the new surface storage alternatives.
- A new hydropower facility would be required for Sub-Alternative IP-8 because of increased design flows and because extension of the downstream face of the embankment may impact the existing facility.

3.10 Evaluation Criteria

3.10.1 Stakeholder Group Measurable Criteria

There are four Stakeholder Group Measurable Criteria, with results summarized in Exhibit 3-14:

- Water Supply: The net change for in basin and out of basin water budgets in af is described above in Section 3.5 and summarized in Section 3.2.
- Water Rights: Water rights were not specifically addressed during this level of study, but known legal, institutional, and policy constraints are summarized in Section 3.6.
- Environmental Considerations: Environmental benefits and impacts are summarized above in Section 3.7.
- Economics: The estimated reconnaissance-level field cost to construct the project is summarized in Section 3.4.

EXHIBIT 3-14
Stakeholder Group Measurable Criteria Summary

Stakeholder Group Measurable Criteria	Criteria Characterization
Water Supply (in-basin water transfer)	8,000 - 74,000 af/yr
Water Supply (out-of-basin water transfer)	8,000 - 74,000 af/yr
Legal, Institutional, or Policy Constraints (yes, no)	Yes
Environmental Considerations (net positive, negative or neutral)	Negative to Positive[1]
Economics (reconnaissance-level field costs for implementation)	$850,000 - $51,470,000

[1] – Net environmental impact would depend on reservoir operations; further analysis required in future phase of study.

3.10.2 Federal Viability Tests

The four federal viability tests used to evaluate potential projects are listed below:

- Acceptability
- Effectiveness (extent to which basin needs are met)
- Completeness (extent to which all needs are met)
- Efficiency (relative construction/implementation cost per af)

For alternatives that are carried forward to future phases of the Basin Study, the information needed to evaluate each of the criteria listed above will be further developed and refined.

SECTION 4
Ashton Dam Raise

4.1 Alternative Description

4.1.1 Overview

The Ashton Dam Raise Alternative consists of raising Ashton Dam by approximately 43 feet to a total height of 100 feet to increase reservoir storage by 20,400 af to a total of 30,200 af. Ashton Reservoir is located directly on the Henrys Fork River at the City of Ashton, and would require no secondary water sources. When full, Ashton Reservoir could provide a roughly 80-foot drop to a proposed new hydropower facility at the base of the dam. A variation of this alternative includes expansion of the Crosscut Canal, which would allow water released from the reservoir to be transferred to the Lower Teton Basin.

4.1.2 Alternative Variations

Several alternative alignments for the raised dam were considered, as documented in Section 4.3.3 – *Proposed Dam Configuration*. However, only a single preferred dam concept was carried through cost development, with a possible conveyance variation as noted below:

- A-43: Reconstruct Ashton Dam just downstream of the existing structure, raising the crest by approximately 43 feet to produce an additional 20,400 af of storage.
- A-43_CC: Same as A-43 but also includes expansion of the Crosscut Canal to provide water to the Lower Teton Basin.

4.1.3 Operational Assumptions

Detailed operations have not been evaluated or distinguished by alternative. Preliminary, generalized, non-binding operational assumptions were described in Sections 2.2 and 2.3 to evaluate potential water availability and design flow to identify sub-alternatives and develop relative costs.

4.2 Key Findings

The Ashton Dam Raise would provide additional water storage for the Henrys Fork Basin, and potentially for the Teton Basin via cross-basin transfer using the Crosscut Canal, effectively enhancing water supply by capturing excess peak flows and redistributing that water during periods of higher demand. The available storage would enhance the in-basin water budget by retaining an additional 20,400 af during the annual high flow period and storing that water until more critical, higher demand periods. This storage water could help satisfy unmet irrigation demands in the North Fremont, Lower Watershed (via the Crosscut Canal), and Egin Bench irrigated regions. Reservoir releases during low flow periods would improve connectivity in other downstream river segments, including the Middle Henrys Fork River, Lower Henrys Fork River, North ForkTeton River, and South Fork Teton River, which have all been identified as having additional ecological streamflow needs. Additional impoundment would typically occur during periods when connectivity is not an issue, and flow decreases would not be expected to impact any populations of Yellowstone cutthroat trout, but a priority rainbow trout fishery in the Henrys Fork River could be impacted. The out-of-basin water budget would be temporarily reduced by up to 20,400 af during the annual high flow period when water is retained in the reservoir, but some or all of that quantity may be available at a later time for numerous out-of-basin uses, including needs resulting from climate change; agricultural needs; domestic, municipal, and industrial needs; ecological needs; and for recharge of the ESPA. Exhibit 4-1 provides a tabular summary of the key findings.

EXHIBIT 4-1
Key Findings from the Reconnaissance Evaluation

Estimated Cost per af	Impact on In-Basin Water Budget	Impact on Out-of-Basin Water Budget	Change in Connectivity of Impacted River Segment
$800 - $1,900	20,400 af, to be retained during the annual high flow period and released during high demand periods.	20,400 af reduction during the annual high flow period, in accordance with priority rights. Part or all of this quantity would be available later for out-of-basin needs.	Improvement in connectivity of downstream river segments, including Middle Henrys Fork River, Lower Henrys Fork River, North Fork Teton River, and South Fork Teton River. Potential impacts to supply sources, none of which contain conservation populations of Yellowstone cutthroat trout.

4.3 Engineering Results

4.3.1 Hydrology

The Henrys Fork River is impounded by Ashton Dam and was the only water supply source evaluated (Exhibit 4-2). Exhibit 4-3 presents a summary of total water from the single source based on analyses using StreamStats (USGS, 2011; see Section 2.2.1 – *Hydrology*).

EXHIBIT 4-3
Water Potentially Available for Storage at Ashton Reservoir

Source	Watershed Area (sq. mi)	Quantity (af/year)
Henrys Fork River[1]	1,096	760,748

[1] – Quantity reported for regulated systems is total estimated water in system. Excess spring runoff calculation was considered invalid for these systems because of upstream dam regulation.

4.3.2 Existing Dam Configuration

4.3.2.1 Embankment

Ashton Dam is an embankment structure on the Henrys Fork of the Snake River (see Exhibits 4-4 and 4-5). The structure impounds approximately 9,800 af of water at elevation 5156.6 feet and is currently operated as a run-of-the-river facility. A hydroelectric powerplant contains two generating units rated at 2,500 kilowatts (kW) and one generating unit rated at 2,850 kW (7,850 kW total capacity).

The existing dam is approximately 450 feet long and 57 feet tall (approximate height from base to spillway crest). The crest elevation of the dam is generally 5156.6 but rises to elevation 5161.6 beside the spillway. The dam is earth and rock-filled and has a downstream slope covered with roller compacted concrete and an upstream slope stabilized by additional rock fill. The existing dam cross-section is presented in Exhibit 4-6.

In consultation with the Federal Energy Regulatory Commission (FERC), PacifiCorp began rehabilitation of Ashton Dam in 2010-2011 to mitigate seepage and piping (internal erosion) risks posed by a deteriorating upstream silt core within the dam. The rehabilitation involves excavating and reconstructing a significant portion of the core and upstream embankment. Other improvements by PacifiCorp include constructing a new bypass tunnel, replacing the headrace retaining wall, replacing the concrete crest structure, and adding a concrete overlay to an unprotected portion of rockfill between the spillway and the powerhouse.

EXHIBIT 4-2
Ashton Dam Raise Alternative: Hydrology

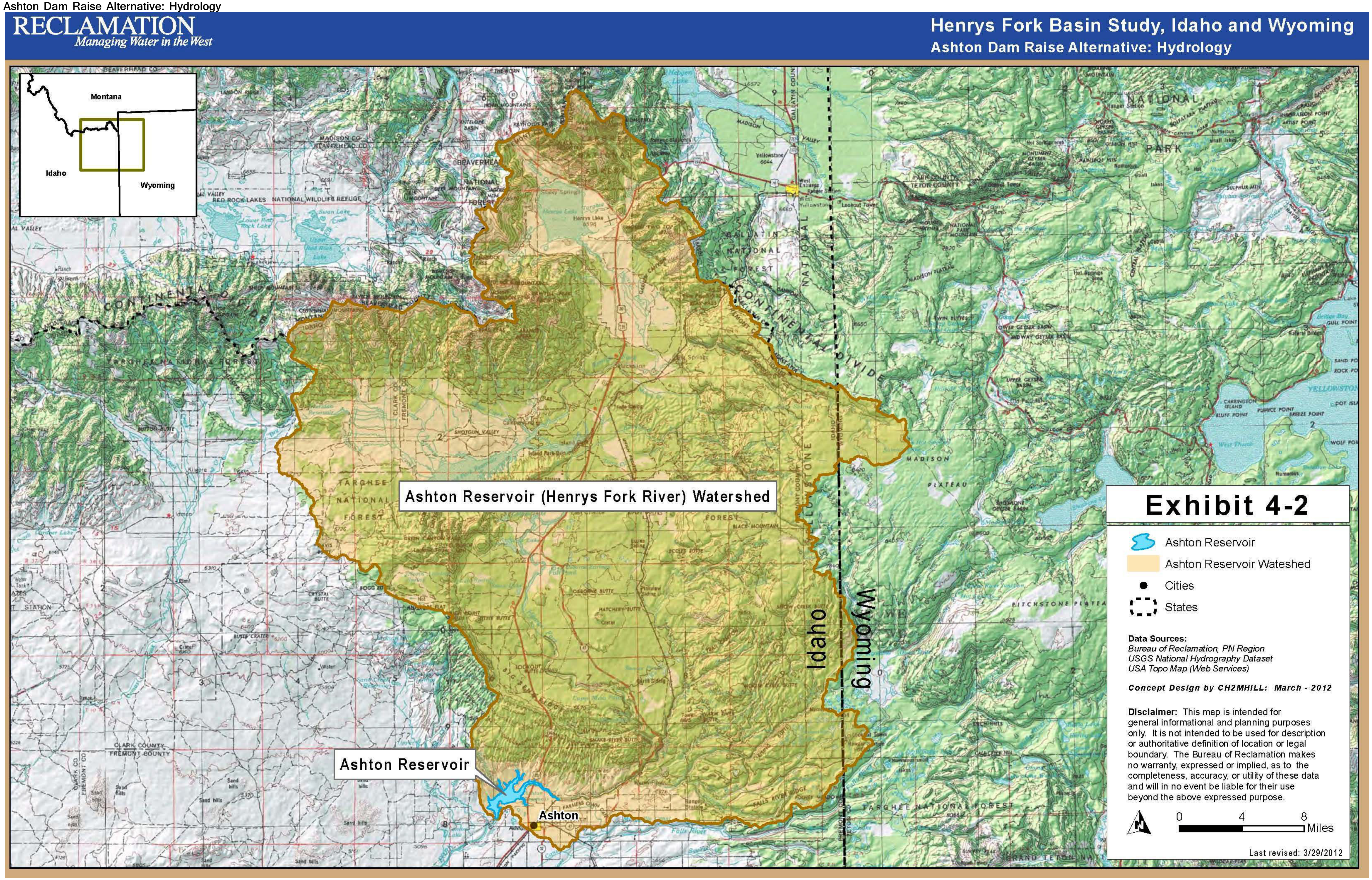


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EXHIBIT 4-4
Ashton Dam Raise Alternative: Existing and Proposed Reservoir Footprints

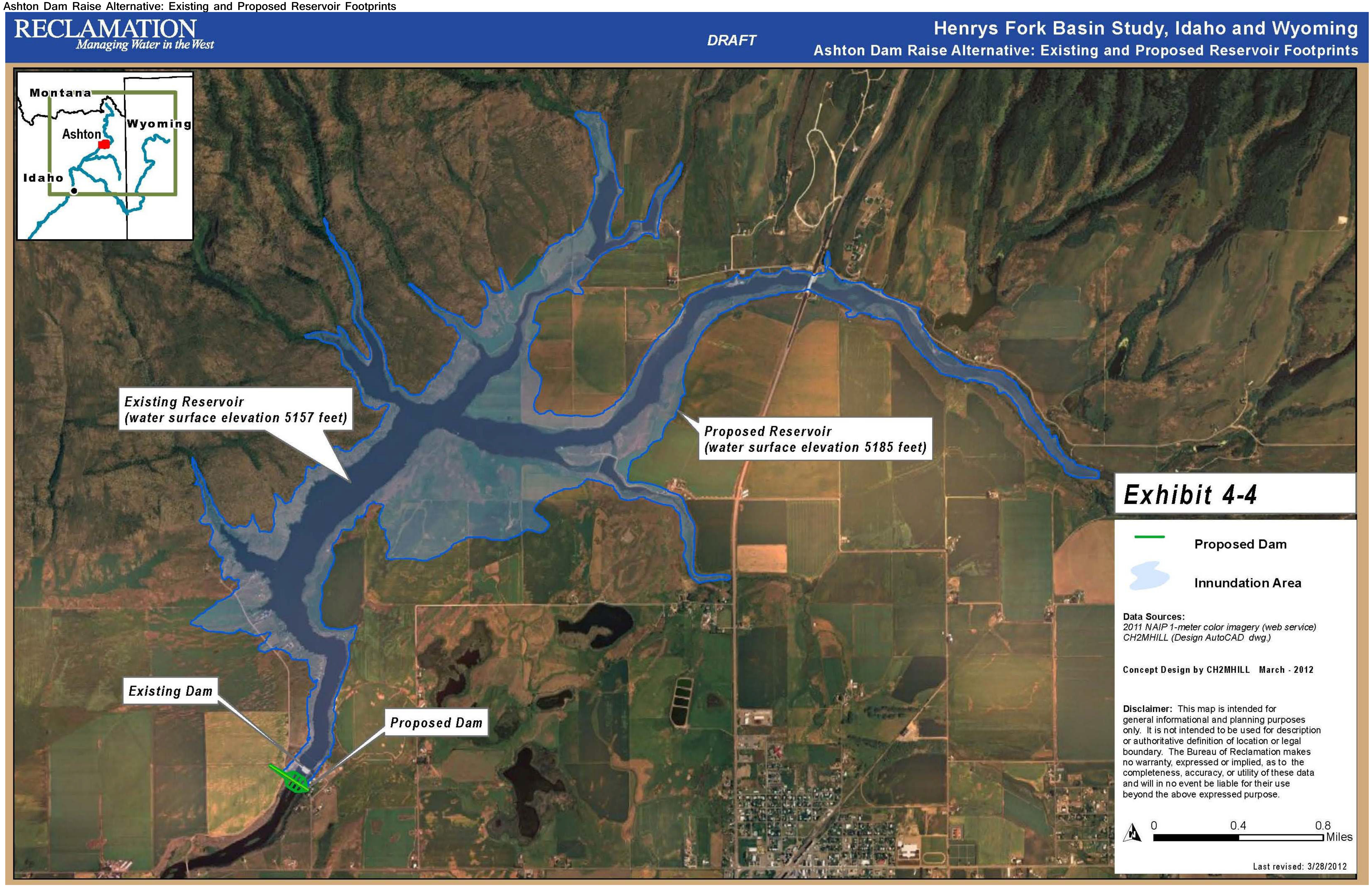

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EXHIBIT 4-5
Ashton Dam Raise Alternative: Proposed Dam and Appurtenant Structures

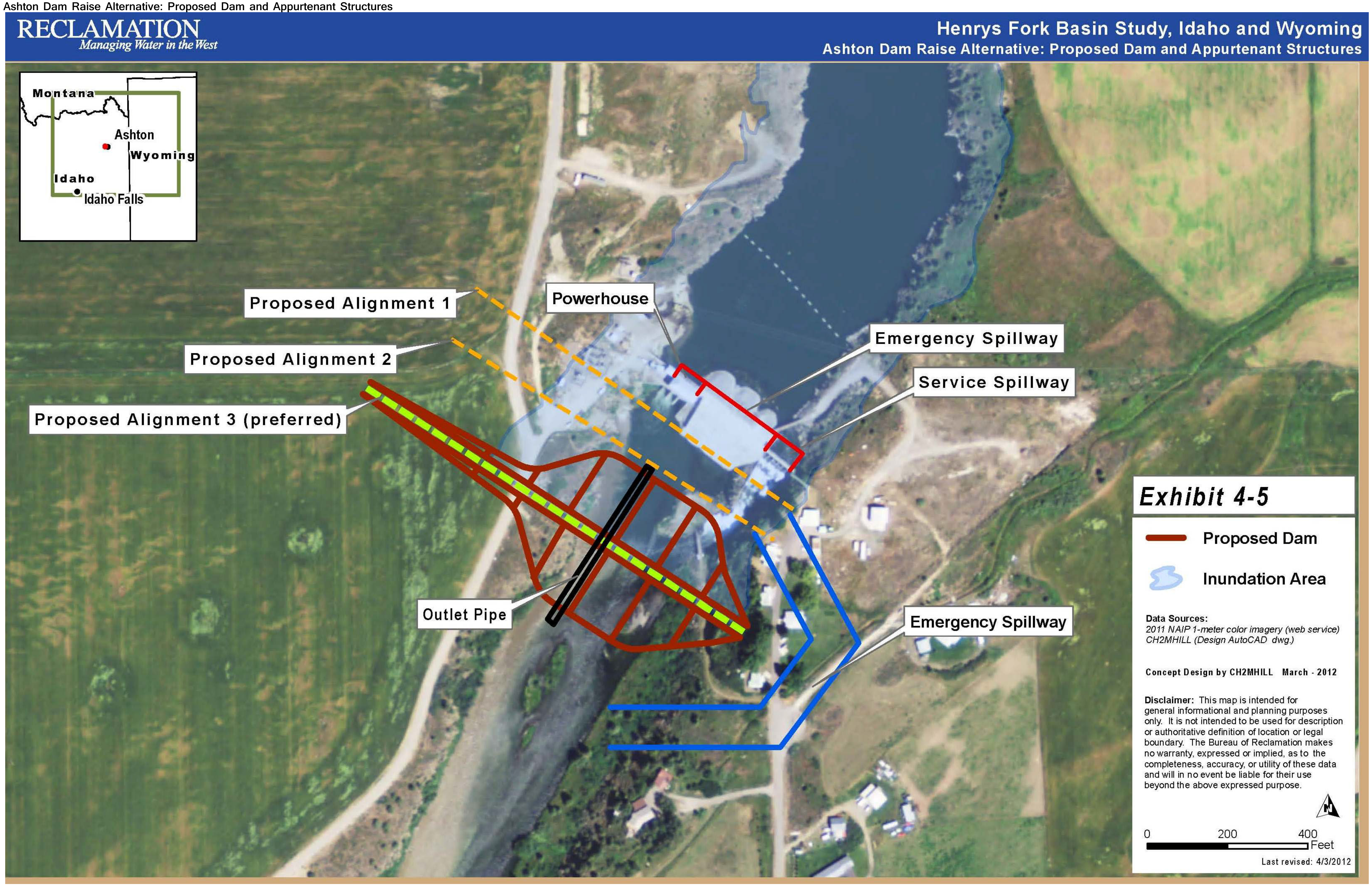

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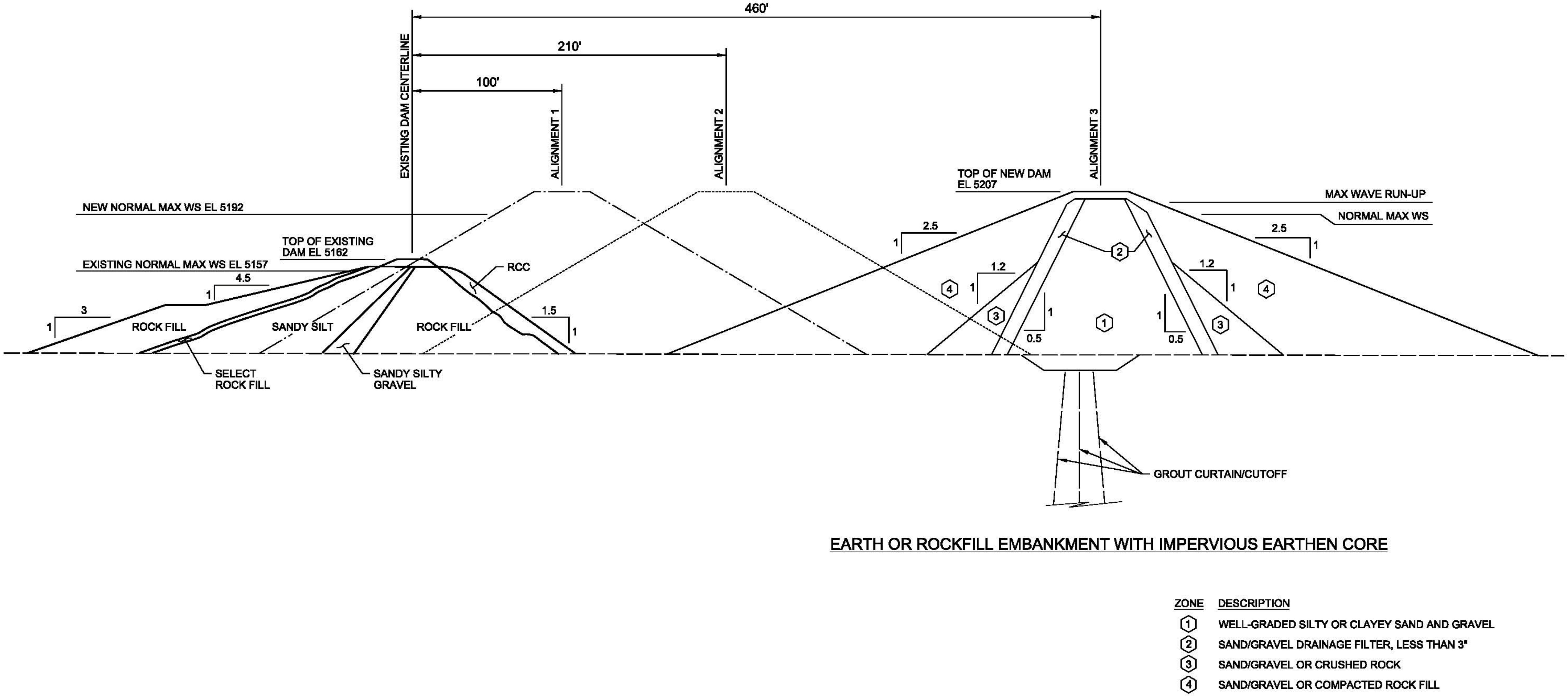
EXHIBIT 4-6
Ashton Dam Existing and Proposed Cross-Sections



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4.3.2.2 Spillway and Powerhouse

Water surface elevation of Ashton Reservoir is controlled by a 70-foot wide powerhouse structure with intakes near the right side of the dam and an 82-foot wide reinforced concrete service spillway with six 10-foot high radial gates on the left side of the dam. The central portion of the dam is composed of an approximately 200-foot wide emergency overflow spillway composed of a reinforced concrete crest section and a roller compacted concrete (RCC) cap extending over the downstream portion of the embankment. The emergency spillway contains training walls on either side of the RCC section. There are two-foot high flashboards on the crest of the dam to prevent spillage from reservoir wave action.

4.3.2.3 Foundation

Rock is exposed at or near the surface along the sidewalls of the river valley and within the reservoir area, and it is expected that rock may be encountered at relatively shallow depths throughout the area. The rock near the dam site is mapped primarily as Huckleberry Ridge Tuff and Falls River Basalt. Huckleberry Ridge Tuff is flat-lying at the site and no faults are mapped in the vicinity of the dam. However, tuffaceous rock that underlies the dam abutments could be fractured, interbedded, transmissive, and weakly-cemented in places. It is likely that alluvial sediments exist in the river bottom, but the depth of these sediments is unknown. Exhibit 4-7 presents a profile along the dam axis and highlights geologic features that could affect the foundation.

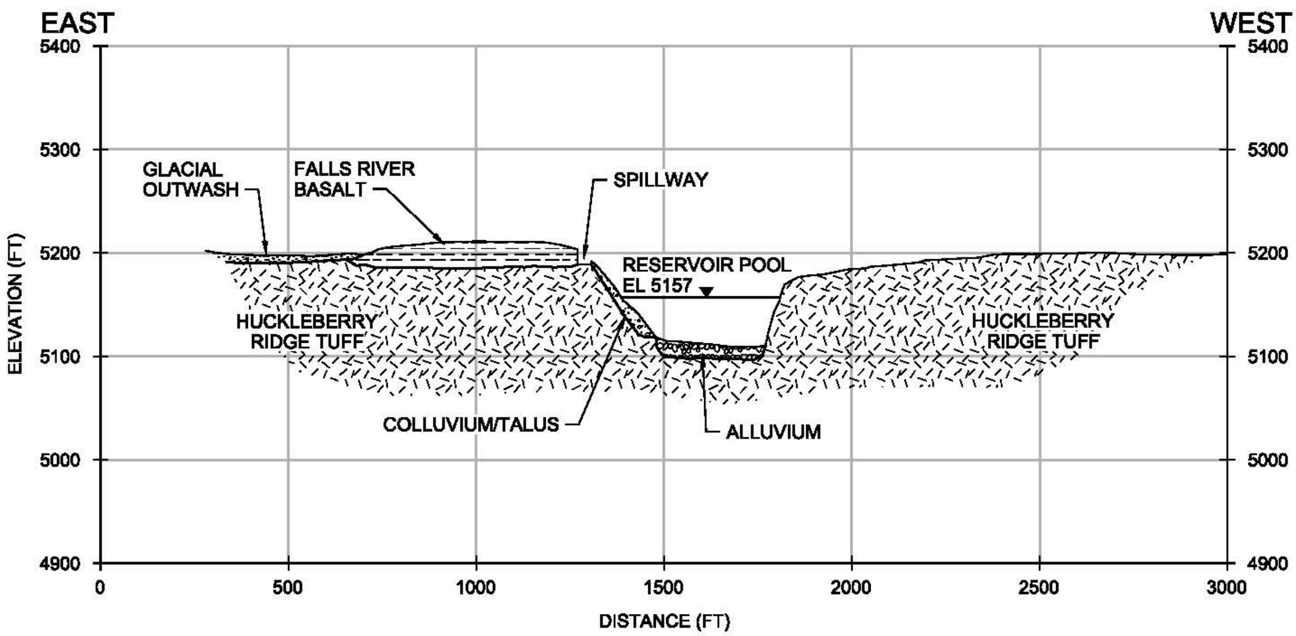

EXHIBIT 4-7
Ashton Dam Geologic Profile

4.3.3 Proposed Dam Configuration

The Ashton Dam Raise Alternative consists of raising Ashton Dam by 43 feet to elevation 5,200 to maximize storage potential within local topographic constraints.

4.3.3.1 Alignment

Three dam alignments were considered, as presented in Exhibits 4-5 and 4-6. Alignment 1 entails a downstream raise of the existing embankment, which would present substantial design issues and construction challenges. Since the dam would be raised to almost twice its current height, substantial changes to the existing embankment would likely be required to provide a safe and reliable seepage cutoff. Modification of the existing powerhouse, pipelines, spillway, and other dam appurtenances would also have a major influence on the design and construction of the enlarged structure. Furthermore, if conditions within the existing embankment were found during construction to be different than assumed in the design, it could lead to costly delays and design modifications.

Alignment 2 entails leaving the existing embankment as a berm at the toe of the upstream slope to reduce a small portion of the required fill material. This approach may avoid some of the design and constructability issues associated with Alignment 1, since the existing embankment is not integral to most of the new embankment, but suitability of the existing rock fill for inclusion at the toe of the new embankment is unknown.

Alignment 3 is located far enough downstream to allow construction of an entirely new dam without incorporating the existing structure within the new embankment. Alignment 3 appears to offer the following advantages and was selected as the preferred alignment for this evaluation:

- Rock is exposed in the canyon walls, but depth to rock under the dam is unknown. It is more likely that predictable foundation and abutment conditions could be confirmed by selecting a location downstream of the existing dam.
- During construction, the existing dam could provide impoundment for diversion as well as continue current functions, including hydroelectric generation, flood control, and recreation. To maintain stream diversion for a dry construction site and hydropower functions, the existing powerhouse draft tube/outlet works pipe could likely be tied directly to a diversion pipe or tunnel. Groundwater dewatering for construction of cutoff and drainage elements in the foundation of the new dam could potentially be tied into this system, or more likely would be provided through separate pumping.
- A new dam could be constructed at this location without being influenced by the unfavorable foundation conditions at the existing dam.
- It may be possible to phase construction and temporary reservoir drawdown to use some of the existing embankment as a borrow source for shell material.

4.3.3.2 Embankment

Exhibit 4-5 shows the general locations for the proposed dam, appurtenant structures, and emergency spillway. A rockfill or granular earthfill dam would be constructed along Alignment 3 to impound the Henrys Fork River and create an enlarged Ashton Reservoir. The cross-section presented in Exhibit 4-6 shows a typical configuration for the proposed dam at this location, which features a central core with filter blanket drains and earthfill/rockfill shells. A concrete grout curtain/cutoff would also be required to limit seepage through the dam foundation. The bottom of the valley at the proposed dam location is at an approximate elevation of 5,100 feet and the top of the dam would be at an approximate elevation of 5,200 feet for a maximum height of about 100 feet. The length of the dam at this elevation would be about 1,120 feet, which includes a dike approximately 450 feet long on the right abutment. The resulting reservoir would have about 30,200 af of storage, representing an additional 20,400 af beyond the existing 9,800 af of storage. When full, the reservoir’s surface area would be approximately 1,250 acres, compared to an existing normal pool of 400 acres.

4.3.3.3 Emergency Spillway and Outlet Works

A potential spillway alignment has been identified on the left abutment, and the dam would require a low-level outlet that provides a safe way to drain the reservoir and integrate with ultimate water distribution and hydropower schemes. The lowest part of the existing valley is located near the right abutment, which would serve as a likely location for the outlet.

4.3.3.4 Foundation

Foundation conditions along Alignment 3 would be anticipated to be similar to the existing dam site (discussed in Section 4.3.2.3 – *Foundation*). The depth to rock along this alignment is unknown but steep slopes and rock mapping along the sides of the valley suggest that rock could be encountered at relatively shallow depths on the slopes.

4.3.4 Crosscut Canal

The Crosscut Canal, which runs from the Henrys Fork River to the lower Teton River, allows inter-basin transfer of water. The current capacity of the existing Crosscut Canal is approximately 600 cfs at the upstream end of the canal and approximately 400 cfs at the downstream end (FMID, personal communication, 2011). To better enable this alternative to help meet demands in the Lower Teton basin, hydraulic capacity of the Crosscut Canal would be expanded to 1,000 cfs, as described in Section 2.2.2 – *Crosscut Canal Conveyance*.

4.3.5 Hydropower Potential

When full, the enlarged Ashton Reservoir could provide a roughly 80-foot drop to a proposed new hydropower facility. As presented in Exhibit 4-8, hydropower potential associated with Ashton Reservoir would be approximately 250 kW. Note that the existing Ashton Dam hydropower facility contains generating units (Section 4.3.2 – *Existing Dam Configuration*) far exceeding the potential estimated here. The method used to estimate hydropower potential is documented in Section 2.2.3 – *Hydropower Potential* and is primarily intended to provide a common basis for comparison against other surface storage alternatives.

EXHIBIT 4-8
Ashton Hydropower Potential

Sub-Alternative	Design Flow (cfs)	Penstock Length (mi)	Head (ft)	Power Potential (kW)
All	45	0[1]	80	250

[1] – It is assumed that turbines are located at the bottom of the outlet works. Therefore, no penstocks are needed.

4.4 Cost Estimate

A summary of the cost per af of incremental (beyond existing) water stored is presented in Exhibit 4-9. These costs include hydropower facilities and expansion of the Crosscut Canal. A more detailed breakdown of each cost element is provided in Exhibit 4-10.

EXHIBIT 4-9
Ashton Dam Raise Cost Estimate Summary

Sub-Alternative	Total Storage Volume (af)	Incremental Storage Volume (af)	Total Construction Cost[1]	Cost Per Incremental Unit Yield ($/acre-foot)
A-43	30,200	20,400	$17,140,000	$800
A-43_CC	30,200	20,400	$39,280,000	1,900

[1] – Total estimated construction costs were rounded to the nearest $10,000 and unit costs were rounded to the nearest $100.

EXHIBIT 4-10
Detailed Relative Construction Cost for Ashton Dam Raise

				Estimated Costs by Sub-Alternative	
Component	**Quantity**	**Unit**	**Cost Basis**	**A-43**	**A-43_CC**
Dam - Embankment	370,000	CY	embankment, remoteness factor, foundation factor	$4,440,000	$4,440,000
Dam – Emergency Spillway	37,037	CY	spillway excavation, lump sum (weir, chute, stilling, bladder)	$1,740,741	$1,740,741
Dam – Outlet Works and Service Spillway	1	LS	outlet tower, site factor, scaling factor	$1,166,667	$1,166,667
Penstock	0	Miles	design flow, length and diameter	$0	$0
Hydropower	250	KW	KW (head and design flow), penstock length and diameter	$766,713	$766,713
Crosscut Canal Enlargement	6.6	Miles	excavation, local fill, parallel gravel access roads, migration crossings	$0	$10,480,060

EXHIBIT 4-10
Detailed Relative Construction Cost for Ashton Dam Raise

				Estimated Costs by Sub-Alternative	
Component	**Quantity**	**Unit**	**Cost Basis**	**A-43**	**A-43_CC**
Base Field Cost				$8,114,121	$18,594,181
Unlisted Items (20%)				$1,622,824	$3,718,836
Mobilization (5%)				$405,706	$929,709
Field Cost w/out Contingency				$10,142,651	$23,242,726
Contingency (30%)				$3,042,795	$6,972,818
Total Field Cost				$13,185,446	$30,215,543
Non-Field Cost (30%)				$3,955,634	$9,064,663
Total Relative Construction Cost				$17,141,080	$39,280,207

4.5 Basin Water Needs

The storage provided by the Ashton Dam Raise would enhance the in-basin water budget by retaining an additional 20,400 af during the annual high flow period and storing that water until more critical, higher demand periods during the summer and early fall. Water stored in the reservoir would help satisfy unmet irrigation demands in the North Fremont, Lower Watershed (via the Crosscut Canal), and Egin Bench irrigated regions (Reclamation, 2012). Reservoir releases would also be used to enhance ecological in-stream flows (see Section 4.7.2 – *Change in Connectivity*).

The out-of-basin water budget would be temporarily reduced by up to 20,400 af during the annual high flow period when water is retained in the reservoir, but some or all of that quantity may be available at a later time for numerous out-of-basin uses, including needs resulting from climate change; agricultural needs; domestic, municipal, and industrial needs; ecological needs; and for recharge of the ESPA (Reclamation, 2012).

4.6 Legal, Institutional, or Policy Constraints

Legal, institutional, and policy constraints that may affect the implementation of this alternative are described in Section 2.5 – *Legal, Institutional, or Policy Constraints*.

4.7 Environmental Benefits and Impacts

4.7.1 Impacted River Segments

River segments potentially impacted by various sub-alternatives include the Henrys Fork, Teton, and South Fork Teton Rivers, as identified in Exhibit 4-11.

EXHIBIT 4-11

Impacts to Connectivity, Yellowstone Cutthroat Trout, and Special River Designations for Affected River Reaches

			Connectivity		State Aquatic Species of Special Concern			Special Designation[a]				
Surface Storage Site	Sub-Alternative	Impacted River Segments	Flow Decrease (Supply Source)	Flow Increase (Receives Reservoir Releases)	Yellowstone Cutthroat Trout (YCT) Presence	Rainbow Trout (RBT) Priority Fishery[b]	YCT Conservation and Management Tier[c] and RBT Fishery Rating	BLM/USFS Eligible Stream	State Natural River	State Recreational River	Designated Wilderness[d]	Rating
Ashton	A-43	Henrys Fork	•	•		•	RBT Priority		•			None
Ashton	A-43_CC	Henrys Fork	•	•		•	RBT Priority		•			None
		Teton[e]		•	•		YCT Conservation					None
		South Fork Teton[e]		•	•		YCT Conservation					None

Notes:

[a]Special designations noted in this exhibit apply to the river reach impounded, diverted for water supply, or directly receiving return flows (if applicable).

[b]Based on personal communications with IDFG, rainbow trout are the primary focus in the Henrys Fork Watershed, whereas YCT are the primary focus in the Teton Watershed.

[c]Three tiers for prioritizing YCT conservation and management options per Montana Fish Wildlife & Parks database (2009) supplemented with anticipated data revisions per personal communications with IDFG.

1) **core conservation** populations composed of > 99 percent cutthroat trout genes;
2) **conservation** populations that generally "have less than 10 percent introgression, but in which introgression may extend to a greater amount depending upon circumstances and the values and attributes to be preserved"; and
3) **sport** populations of cutthroat trout that, "at a minimum, meet the species phenotypic expression defined by morphological and meristic characters of cutthroat trout."

[d]Per the 1997 Revised Forest Plan - Targhee National Forest.

[e]River segments may receive cross-basin water transfer via the Crosscut Canal.

Legend

State Aquatic Speices of Special Concern (YCT and RBT)

YCT Core / RBT Priority	Core Conservation Population of YCT or Priority RBT Fishery
YCT Conservation	Conservation Population of YCT
YCT Sport / None	None or Sport Population of YCT

Special Designation

Federal	Federal Wild and Scenic River (WSR) or Wilderness Area
State/ Eligible Federal	State Protected (Natural and Recreational) or eligible Federal WSR
None	None

4.7.2 Change in Connectivity

Potential impacts to river connectivity consist of decreased flow (impoundment in the reservoir) for river segments providing reservoir supply and increased flow for river segments receiving reservoir releases. As described in Section 2.2.1.3 – *Potentially Available Water*, additional impoundment would likely occur during the excess spring runoff period and reservoir releases would likely occur during more critical low flow periods in the summer and fall. Potential impacts to connectivity of each impacted river segment are identified in Exhibit 4-11. In addition to the segments listed in Exhibit 4-11, enhanced connectivity would be experienced in other downstream river segments, including the Lower Henrys Fork River, North Fork Teton River, and South Fork Teton River, which have all been identified as having additional ecological streamflow needs (Van Kirk et al., 2011).

4.7.3 State Aquatic Species of Special Concern

The Henrys Fork River is home to a priority rainbow trout fishery, but the reservoir inundation area is not in crucial habitat for Yellowstone cutthroat trout, and no substantial Yellowstone cutthroat trout population has been identified. State Aquatic Species of Special Concern in potentially impacted river segments are indicated in Exhibit 4-11.

4.7.4 Other Environmental Factors

The proposed enlargement of the Ashton Reservoir inundation area serves as a migration corridor and as winter range for big game. Species tracked by the USFWS that are known to occur in the area include two federally listed threatened species, the grizzly bear (Ursus arctos horribilis) and the Canadian lynx (Lynx canadensis), and two candidate species, the wolverine (Gulo gulo luscus) and the greater sage-grouse (Centrocercus urophasianus). The bald eagle (Haliaeetus leucocephalus), black-crowned night-heron (Nycticorax nycticorax), California gull (Larus californicus), Caspian tern (Hydroprogne caspia), common loon (Gavia immer), Forster’s tern (Sterna forsteri), Franklin’s gull (Leucophaeus pipixcan), sandhill crane (Grus canadensis tabida), sharp-tailed grouse, trumpeter swan (Cygnus buccinator), western grebe (Aechmophorus occidentalis), and white-faced ibis (Plegadis chihi), considered at-risk by the BLM, USFS, and IDFG, are also found in the area. The expanded reservoir would impact wetlands in the lower reaches of Baker Springs, Rattlesnake Creek, and other tributaries, likely affecting an area between 1 and 200 acres. The reach of the Henrys Fork River upstream that would be inundated is designated as a State Natural River.

Potential wildlife habitat impacts, federally listed species, and wetlands habitat impacts within the reservoir inundation area are also summarized in Exhibit 4-12, while State of Idaho aquatic species of special concern (Yellowstone cutthroat trout and rainbow trout) and special river designations for all potentially impacted river segments are summarized in Exhibit 4-11.

4.8 Land Management, Recreation and Infrastructure impacts and benefits

Ashton Reservoir is located on private, federal, and conservation easement land; has a high recreation and economic rating; and is rated as having a large number of potential infrastructure impacts, as summarized in Exhibit 4-13.

4.9 Assumptions and Limitations

General assumptions and limitations applicable to all of the surface-storage alternatives are described in Section 2.8 – *Key Assumptions and Limitations*. Additional assumptions and limitations specific to this alternative are listed below:

- Although a rockfill or granular earthfill dam was considered for costing purposes in this evaluation, a range of potential dam types (including roller compacted concrete) should be considered until more site-specific details become available.

EXHIBIT 4-12

Impacts to Wildlife Habitat, Federally Listed Species, and Wetland Habitat at the Reservoir Site

Surface Storage Site	Wildlife Habitat[a]			Federally Listed Species			Wetland/Habitat Value	
	Big Game Winter Range	Big Game Migration Corridors	Rating	At-Risk (USFS & BLM sensitive species, and Idaho Species of Greatest Conservation Need)[b]	Threatened, Endangered, Candidate and Experimental Nonessential Species[c]	Rating	NWI Wetlands	Rating
Ashton	•[4]	•[1]	Migration	american avocet, american white pelican, bald eagle, black-crowned night-heron, galifornia gull, caspian tern, common loon, foster's tern, franklin's gull, sandhill crane, sharp-tailed grouse, trumpeter swan, western grebe, white-faced ibis	grizzly bear, Canada lynx, wolverine, sage grouse	Federal Terrestrial / Sensitive	•	Moderate

Notes:

[a]Sources of Wildlife Habitat data

[1]Per review comments from Trout Unlimited, Friends of the Teton River, and American Rivers.

[2]Per personal communications with IDFG on the Sand Creek and Teton Canyon winter ranges.

[3]Per the USFS 1997 Revised Forest Plan - Targhee National Forest.

[4]Per personal communications with the Henrys Fork Foundation.

[b]Per IDFG special species February 2011 GIS dataset (1-mile buffer area).

[c]Threatened and Endangered and Candidate species list obtained from USFWS; however, location specific information based on data compiled by Trout Unlimited, Friends of the Teton River, American Rivers, the IDFG February 2011 dataset, and personal communications with the Henrys Fork Foundation.

Legend

Wildlife Habitat

Winter Range	Winter Range Habitat
Migration	Migration Corridor
None	None

Federally Listed Species

Federal Aquatic/ Prime Conservation	Federally Listed Aquatic Species and Prime Conservation Area[h]
Federal Terrestrial/ Sensitive	Federally Listed Terrestrial Species and State Species of Greatest Conservation Need
None	None

Wetland and Habitat Values

Extensive	Extensive wetland impacts (> 200 Acres)
Moderate	Moderate wetland impacts (>1 - 200 Acres)
None/Minimal	<1 Acre

EXHIBIT 4-13
Land Management Implications and Impacts to Recreation/Economic Value and Infrastructure at the Reservoir Site

	Land Management Data[a]					Recreation/Economic Value								Infrastructure[d]				
Surface Storage Site	Private	Federal	State	Conservation Easements[b]	Rating	Boating	Fishing	Yellowstone National Park	Guiding/ Outfitting	Scenic/ Natural Features[c]	Cultural/ Historic Resources[c]	Land Recreation[c]	Rating	Roads	Structures	Habitation	Additional Infrastructure Notes	Rating
Ashton	•	•		•	Federal/ Conservation	•[b]	•[b,c]		•[b]				High	•		•		High

Notes:

[a]Land management data per the BLM Idaho Surface Management Agency (2010). For federal government lands, the data displays the managing agency which may or may not be the same as the agency that "owns" the land.

[b]Per feedback from Trout Unlimited, Friends of the Teton River, American Rivers, and the Henry's Fork Foundation.

[c]Per the Resource Evaluation (IWRB 1992)

[d]Preliminary impacts based on cursory review of aerial photography.

Legend

Land Management

Federal/ Conservation	Federal, Conservation Easement
State	State
Private	Private

Recreation/Economic Value

High	Significant Impacts to Recreation/ Economic Values
Moderate	Moderate Impacts to Recreation/ Economic Values
Low	Minimal Impacts to Recreation/ Economic Values

Infrastructure

High	Impacts to major infrastructure/development
Moderate	Moderate impacts to human environment
Few	Few impacts to human environment

- A new hydropower facility, emergency spillway, and outlet works would be required for the new dam as proposed. However, if a concept that raised the dam while utilizing a portion of the existing embankment was selected during final design, some of the existing appurtenant structures may be modified instead of replaced.
- Excavation for the open spillway would likely be in colluvial soils and/or rock. It is possible that the spillway may be in soft erodible materials and if an open channel spillway is used, it may require concrete or rock linings that are suitable to match the intended spillway flows. A lined concrete spillway was assumed for costing purposes. Alternative spillway approaches should also be investigated once the inflow design flow has been established and local site conditions are better understood.
- Costs for the new embankment assumed utilization of new sources of material. Salvage of select elements from the existing facilities may be feasible but would require more detailed evaluation.
- The proposed dam's crest height would be 43 feet higher than existing, but the pool would only be raised 28 feet because the proposed dam concept includes 15 feet of freeboard (existing dam has virtually none), consistent with the other new surface storage alternatives. Note that a new RCC dam with very little freeboard could be considered in a future phase of study to increase potential storage.

4.10 Evaluation Criteria

4.10.1 Stakeholder Group Measurable Criteria

There are four Stakeholder Group Measurable Criteria, with results summarized in Exhibit 4-14:

- Water Supply: The net change for in basin and out of basin water budgets in af is described above in Section 4.5 and summarized in Section 4.2.
- Water Rights: Water rights were not specifically addressed during this level of study, but known legal, institutional, and policy constraints are summarized in Section 4.6.
- Environmental Considerations: Environmental benefits and impacts are summarized above in Section 4.7.
- Economics: The estimated reconnaissance-level field cost to construct the project is summarized in Section 4.4.

EXHIBIT 4-14
Stakeholder Group Measurable Criteria Summary

Stakeholder Group Measurable Criteria	Criteria Characterization
Water Supply (in-basin water transfer)	20,400 af/yr
Water Supply (out-of-basin water transfer)	20,400 af/yr
Legal, Institutional, or Policy Constraints (yes, no)	Yes
Environmental Considerations (net positive, negative or neutral)	Negative to Positive[1]
Economics (reconnaissance-level field costs for implementation)	\$17,140,000 - \$39,280,000

[1] – Net environmental impact would depend on reservoir operations; further analysis required in future phase of study.

4.10.2 Federal Viability Tests

The four federal viability tests used to evaluate potential projects are listed below:

- **Acceptability**
- **Effectiveness** (extent to which basin needs are met)
- **Completeness** (extent to which all needs are met)
- **Efficiency** (relative construction/implementation cost per af)

For alternatives that are carried forward to future phases of the Basin Study, the information needed to evaluate each of the criteria listed above will be further developed and refined.