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Managing Water in the West

High Lakes Stabilization Technical Memorandum

Garfield Basin Lakes

Superior, Five Point, Drift and Bluebell

Uinta Basin Replacement Project

U.S. Department of the Interior
Bureau of Reclamation
Provo Area Office
Provo, Utah

April 2009

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prepared by

Provo Area Office
Upper Colorado Region

U.S. Department of the Interior
Bureau of Reclamation
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Concurrence

The undersigned concur with the recommendations identified in this Technical Memorandum. This Technical Memorandum will serve as a Decision Memorandum.

David Marble, Assistant Utah State Engineer, Dam Safety — Date

Reed R. Murray — Date
Department of the Interior
CUPCA Office

Harv Forsgren
Regional Forester — Date
U.S. Forest Service

Michael C. Weland
Executive Director — Date
Utah Reclamation Mitigation and Conservation Commission

Contents

Introduction

The Uinta Basin Replacement Project (UBRP Project) was authorized by Section 203 of the Central Utah Project Completion Act [CUPCA: Titles II through VI of P.L. 102-575, as amended]. The UBRP Project is located in Duchesne County near the towns of Altamont, Upalco, and Roosevelt, within the Uinta Basin of northeastern Utah. Its purposes are to increase efficiency, enhance beneficial uses, and achieve greater water conservation within the Uinta Basin. The Central Utah Water Conservancy District (District) is implementing the water development portions of the UBRP Project, and the Utah Reclamation Mitigation and Conservation Commission (Mitigation Commission) is responsible for mitigating project impacts to fish, wildlife and wetland habitats. Funding for mitigation measures is provided under Title II of CUPCA through the U.S. Department of the Interior. The Final Environmental Assessment for the UBRP Project was prepared by the District and was signed by the Department of the Interior in October 2001. Project construction began in 2003. The Commission issued a Decision Notice and Finding of No Significant Impact in February 2004 for implementing fish and wildlife mitigation features of the UBRP Project. The stabilization project is one of those requirements.

A component of the UBRP Project is that thirteen high mountain lakes formerly used to store water rights would be stabilized at No-Hazard levels, and the water rights transferred downstream for storage in the enlarged Big Sand Wash Reservoir, another feature of the UBRP Project. The stabilization of the thirteen reservoirs is mitigation for the enlargement of Big Sand Wash Reservoir. Because of the breach potential of the High Lakes Dams, and the difficulty in monitoring and maintaining these dams in the Wilderness area, the Mitigation Commission is undertaking the stabilization of thirteen of these dam structures. The storage water rights will be transferred downstream in the expanded Big Sand Wash Reservoir where maintenance and monitoring is practical. These wilderness dams vary in size, hazard rating and condition and have peak breach flow potential ranging from hundreds to several thousand cubic feet per second (cfs). Breach flows of this magnitude far exceed the carrying capacity of existing streams and they would cause extensive damage to the downstream forest resource, campgrounds, trails, roads, dams and in some cases, private property and residents. The “Do Nothing” option was not considered appropriate because of the eventuality of the deterioration and catastrophic failure of these dams.

There are no absolute criteria for defining a No-Hazard dam. The Utah State Engineer is authorized to make that determination. Section R655-10-5 of The State of Utah Statutes and Administrative Rules for Dam Safety dated July 1996 states “The State Engineer is the ultimate authority on the hazard classification designation for a given dam”. The Forest Service also has dam safety responsibilities and the two agencies have outlined a number of protocols regarding dam safety matters in a memorandum of understanding between the two agencies (attached as Appendix A). Therefore, all decisions and recommendations regarding these structures are mutually agreed on by both parties.

Essentially, the No-Hazard rating is achieved by demonstrating that in the event of failure, there is no appreciable damage or adverse affects downstream of the dam. For the more significant structures, this demonstration is accomplished through a dam break analysis. Various stabilized reservoir elevations are assumed and the resulting flood from a sunny day break is compared to the existing downstream channel capacity. When the analyses show that a stabilized reservoir elevation would result in a flood that can be contained within the downstream channel, the dam can be considered to be No-Hazard. A guidance design criterion from the State of Utah is that the dam break should produce a maximum flow of less than 500 cubic feet per second (cfs).

Stabilization of the thirteen high mountain lakes at No-Hazard levels will provide constant lake water levels year-round. Nine of the lakes (Bluebell, Drift, Five Point, Superior, Water Lily, Farmers, East Timothy, White Miller, and Deer) are located in the Upper Yellowstone River watershed and four (Brown Duck, Island, Kidney and Clements) are in the Brown Duck Basin of upper Lake Fork watershed. Consequently, streamflows originating in these upper watersheds will return to natural hydrologic runoff patterns, wilderness fishery and recreational values will be restored within the High Uintas Wilderness Area (HUWA), and operation and maintenance impacts will be eliminated in the HUWA.

The thirteen reservoirs are located in the High Uintas Wilderness Area. The U.S. Forest Service, Moon Lake Water Users Association, U.S. Bureau of Reclamation and Duchesne County Water Conservancy District all have knowledge and experience with operation, maintenance and stabilization of the high mountain lakes. The Commission entered into Interagency Agreement No. 05-AA-UT-1300 with Reclamation to provide engineering, design, construction, and oversight services for the stabilization project. This technical memorandum is a work product under the Interagency Agreement and addresses design criteria needed to achieve a “No Hazard” rating as defined by the State of Utah and as agreed to by the Forest Service, for four lakes to be stabilized in Garfield Basin.

Typically, the stabilization of these dams will require the excavation of a spillway notch, with stable side slopes, through the middle of the embankment and either removal or plugging of the existing low level outlet. An armored, stabilized low level channel would then be constructed in the notch to pass normal runoff as well as large storm events without jeopardizing the remaining structure by impounding excess water. In some cases the embankment may be removed or buttressed to decrease the height and increase the stability and ability of the remaining embankment to withstand any seismic event or overtopping during extreme events. This work is the minimum necessary to stabilize these dam structures and restore natural hydrologic flows to the greatest extent possible, while still meeting a "No Hazard" dam safety rating.

White Miller, Water Lily, and Farmers Lakes were stabilized in 2006. Clements Lake was stabilized in 2007. Brown Duck and Island Lakes were stabilized in 2008. Kidney Lake is the only lake in the Brown Duck Basin that remains to be stabilized; it is planned for 2009. All four lakes

(Superior, Five Point, Drift and Bluebell) in the Garfield Basin are also proposed for stabilization in 2009. The stated objective for these lakes is to create conditions such that any dam, if remaining, is assigned a "No Hazard" classification with a minimum design life of 100 years (essentially a permanent fix).

An additional constraint is that each dam stabilization project needs to be completed in one construction season (usually July through September) because of the vulnerability of a partially removed embankment. A partially completed dam could easily overtop and fail from snow melt runoff or storms, even if the outlet were still in place and open. Breach flow potential would be extensive even from the reduced lake storage volumes. Existing spillways would be too high to assist in flood routing under these circumstances and it would be prohibitive to build auxiliary or temporary spillways over the excavated embankment or on bedrock at the proper level, even if it could be located (see Appendix A).

Multi-year construction projects to stabilize a single dam have serious potential problems, including:

- Increased vulnerability to failure from hydraulic overloading when partial breaches may not be adequately stabilized;
- High potential for erosion and soil disruption from over-wintering and unexpected weather events;
- Additional required work and disturbance to reconstruct and stabilize the dam at the end of each construction season;
- Increased mobilization and demobilization costs from additional work cycles;
- Increased site disturbance from multi-year operations at camps, travel routes, and activity on-site;
- The U.S. Forest Service does not allow riprap spillways on moderate-hazard earth fill dams; therefore any intermediate "spillway" or outlet channel on a partially stabilized dam would be required to be hardened, probably with concrete; and
- High potential for unexpected, early adverse weather conditions which could close the construction project prior to adequate stabilization.

In addition, because these dams were constructed at the turn of the century there is no guarantee that plans are accurate. Once breached, there may be unexpected materials or inappropriate materials in the dam that would not support a partial breach option. A partial breach may also create unanticipated new flow regimes.

Other considerations with multi-year projects include:

- Uncertainty of weather from year to year which may require additional measures to ensure partially breached dams are secure;
- Longer exposure of crews to accident vectors during the multi-seasons;
- Increased risk of personnel changes leading to loss of skills and experience; and
- Loss of availability of equipment.

Based on past experience, success with multi-year staged construction projects has been low.

The Forest Service does not recommend planning for a multi-year project to stabilize an individual dam. Further, they have advised that at the completion of each season of activity the partially-stabilized dam will be required to fully meet State of Utah and U.S. Forest Service dam safety specifications. Due to the existing condition of many of the dams, achieving this requirement could entail even more extensive work and could be more difficult to achieve than completing the stabilization to its final proposed configuration.

It was determined that this risk possibility was inconsistent with the projects goals of safety and stabilization as well as minimum impact and the preservation of the Wilderness resources and values.

As indicated by the concurrence page, the purposes of this memorandum are to document the design decisions and rationale used in the final designs and to ensure each of the participating agencies are in agreement with and approve of the final designs. This memorandum describes the design of the four proposed stabilized dams in the Garfield Basin.

Many of the design considerations and much of the logic and approach to this project is applicable for each of the dams. As such, the narratives described for Superior Lake are not fully repeated for each of the other three. Although there is some repetition, it is avoided to the extent possible to maintain a readable report.

The appendices contain design drawings and backup data that support the design conclusions and recommendations. Appendix A contains a copy of the MOU between the State of Utah and U.S. Forest Service for dam safety. Appendix B contains design drawings showing a location map and applicable details for each lake. Appendix C contains portions of the HEC-1 output files for the inflow hydrology. The total output file for this work contains numerous pages, most of which is hydrograph data not necessarily meaningful to most readers. Rather than include the entire output, a select page containing relevant flow data is provided. The remaining output will be kept on file and made available upon request. Table 1 (below) contains a brief summary of storm hydraulics. Appendix D contains a summary table of construction quantities for the designed work. Appendix E contains a summary of the Simplified Dam Break analyses. The total output file for the dam break analysis also contains additional pages kept on file and available upon request. Appendix F contains historical drawings of the dams and associated features.

Another item of note concerns the apparent elevation discrepancies between the various data sets. Each dam was topographically surveyed using global positioning satellite (GPS) equipment. The elevations measured and used for the drawings are actual elevations tied to the State Plane Coordinate System. However, the Digital Elevation Models (DEM) used for the hydrology and dam break analyses were obtained from the U.S. Geologic Survey (USGS) data base which does not match the State Plane elevations. Because of these differences, model adjustments were made accordingly. As long as the relative differences in elevation are accounted for, the data will be accurate and usable. Although some of the elevations for spillway and dam heights in the DEMs do not match the actual elevations as obtained through the surveys, they are still applicable because the relative differences are consistent. Table 2 (below) summarizes this data.

Table 1. Summary of SCS Type II 6-hour 100-Year Storm Hydraulics

Lake	Surface Area (ac)	Res. Volume (ac ft)	Dam Height (ft)	Basin Area (sq mi)	100 yr. Storm (in)	Peak Runoff (cfs)	Maximum Routed Flow (cfs)
Superior	38	320	15	2.1	2.78	1,093	320
Five Point	87	627	15	1.9	2.75	719	178
Drift	31	158	12	0.5	2.75	1,070	62
Bluebell	48	235	8	0.6	2.74	1,255	75

Table 2: Elevation Data used in this Technical Memorandum

Lake	Top of Dam	Stabilized Breach Elevation	"Natural" Lake Elevation	Invert of Existing Outlet Works
Superior	11,170.0	11,162.0	11,162.0	11,158.0
Five Points	11,006.0	10,997.0	10,997.0	10,995.0
Drift	11,065.0	11,054.5	11,054.5	11,054.0
Bluebell	10,896.0	10,891.5	10,891.5	10,890.0

Design Considerations

A number of issues and considerations must be accounted for in the design. These include the following:

- Inflow hydrology
- Dam break analysis
- Outlet works removal or plugging with associated cutoffs and filters
- Outlet channel configuration including width, armoring, and side slopes
- Downstream connection to existing channel needs to accommodate drop in elevation between outlet channel and original ground. The downstream connection will be arranged in the field.
- All reasonable efforts will be made to blend outlet channel into the natural drainage in the area, to the extent that it does not require a significant increase in resources to do so.

Superior Lake

Superior Lake is located near the top of Garfield Creek. It has a surface area of about 38 acres at the existing spillway and holds approximately 320 acre-feet of water. The dam is a homogeneous earthfill embankment with stone riprap facing. The dam is 15 feet high and has a 20-inch diameter low-level outlet pipe (38 feet long) located at the maximum section.

The existing outlet channel from Superior Lake is diverted from its natural channel about 0.2 miles downstream of Superior Lake Dam, and a small canal conveys the water into Five Point Lake. As part of the stabilization project, the channel will be rehabilitated to restore the outlet flows from Superior Lake to its natural drainage. A Stream Channel Alteration Permit will be requested from the State of Utah if necessary to complete this work.

Inflow Hydrology

The Superior Lake drainage basin is 2.0 square miles in area and is comprised of partially wooded slopes, interspersed with brush and grassy areas. Significant areas of rock and talus slopes are also present. The Watershed Modeling System (WMS) software package was used to model the drainage basin using the DEM obtained from the USGS web site. Hydrologic characteristics for the basin were then incorporated for full analysis. The 100-year, 6-hour storm estimate of 2.78 inches was obtained from the National Oceanic and Atmospheric Administration's (NOAA) Precipitation Frequency Data Server, Atlas 14, Volume 1, Version 3. This storm has a peak runoff of 1,093 cfs. However, when routed through the reservoir, the peak runoff is attenuated to a maximum flow of 320 cfs through the spillway.

The Basin Average method was combined with the U.S. Soil Conservation Service (SCS) Type-II, 6-hour curve to define the series. The SCS curve number method was used to model the basin losses, with a curve number of 82.4 (corresponding to AMC III "fair" conditions). The SCS method was used within WMS to compute a Lag time of 1.5 hours. The Muskingum-Cunge method was used for stream routing with averaged stream characteristics based on actual survey data and/or the DEM. Actual reservoir area-capacity curves were input for routing purposes.

Dam Break Analysis

The Simple Dam Break (SMPDBK) model contained within the WMS package was used to model multiple runs of dam break scenarios using varying parameters.

Various breach elevations were modeled to obtain maximum flows in the downstream channel so that the effects of a dam break could be understood and acceptable limits set. The dam break scenario table in Appendix C tabulates the results of various reservoir elevations and the corresponding dam break maximum flow. A guidance design criterion from the State of Utah is that the dam break should produce a maximum flow of less than 500 cfs.

A 15-foot-wide breach was used with a 300 minute time-to-breach, corresponding to half of the inflow hydrograph. A sunny day break of Superior Lake Dam with the outlet channel at elevation 11,162 produces a maximum flow of zero. This is because the elevation 11,162.0 is a bedrock outcropping below which scour would not be expected.

Outlet Works

In order to have a no hazard classification there can be no operable outlet works. The existing outlet works could either be left in place and plugged, or the entire outlet works could be removed. In either case the existing outlet works gate would be removed.

If all necessary equipment could be used, the preferred choice would be to remove the outlet pipe, re-compact the trench from which it is pulled, and build the new outlet channel over top of the trench, with adequate protection to prevent erosion and down cutting. The outlet channel's excavated side slopes would need to be flat enough to ensure a good bond between the new compacted backfill and the undisturbed existing ground. This would be a critical area that would need to be addressed to ensure that a seepage path is not created at the interface. The backfill would be compacted to a minimum density of 95 percent of maximum as determined by the standard proctor test (ASTM D698).

However, a significant challenge is involved in re-compacting the fill material removed when the outlet pipe is pulled, to a satisfactory density. This task is not likely feasible under conditions involving hand labor and primitive or traditional tools; it is also not likely to be achieved through use of powered compactors that might be flown-in to the site via helicopter.

Leaving the outlet pipe in place and plugging the pipe with cement is the proposed alternative. The outlet pipes at Clements Lake, Brown Duck Lake and Island Lake were treated in this manner and were done effectively. The outlet pipe at Superior Lake is about 38 feet in length. It would require only about 3 CY of cement to seal completely.

As shown on the drawings, the plugged outlet pipe will be protected on the upstream and downstream ends with a grouted rock gabion basket cutoff wall. The plugged outlet pipe will have additional protection at the downstream end in the form of a filter material that will prevent migration of fines in the event that some water is able to flow through the grouted pipe. The upstream cutoff will be designed to prevent any water flows through the grouted pipe, but the filter is an additional protection that provides redundancy in the design and will help to ensure a permanent fix.

The filter material will consist of a well-graded sand that will be obtained onsite. During excavation, sandy materials encountered will be stockpiled for use as the downstream filter. A 3/8-inch minus screen will be utilized to remove any oversized material. The filter will be placed to a length of 8 feet of the outlet works trench resulting in an approximate volume of 5 cubic yards of material required**.** In the unlikely event that adequate sand is not available from onsite excavations, contingency plans would be required. This would include either locating an adequate source within the proximity of the work or flying in bagged sand by helicopter. Geotextile fabrics were not considered due to the potential of plugging over time.

Outlet Channel

Based on the results of the dam break analysis and as shown on the drawings, the maximum recommended outlet channel invert elevation is 11,162.0 feet. The elevation will be set with a grouted gabion wall (unless bedrock is encountered at the designed elevation). The standard design for the outlet channel will include 3 such grouted gabions – one at the upstream end, one at the downstream end, and one in between. The general approach will be to over-excavate the outlet channel by 1 foot; the grouted gabion wall will be buried 2 feet into the channel, with 1 foot sticking above the floor of the outlet channel. That 1 foot void will be filled with sized and placed riprap and fines. If the excavated outlet channel encounters bedrock, then the requirement for grouted gabions may be revised or eliminated.

The recommended channel width at the invert is 15 feet. Keeping the outlet channel a minimum width of 15 feet will help reduce plugging due to ice, snow, and debris. It is expected that the outlet channel will be excavated down to the level of existing bedrock. If bedrock is not encountered, the outlet channel will be armored with a 24-inch layer of 12” D_{50} riprap along the invert and for a vertical height of 4 feet on the side slopes. The remainder of the outlet channel side slopes will consist of smaller riprap armoring. The armoring of the invert and side slopes will provide protection against erosion and will ensure stable and permanent side slopes. It is critical that the toes of the side slopes do not experience erosion because of slope stability issues. Without toe protection, substantial erosion or undermining of the bottom of the side slopes could result in a complete slope failure.

A slope stability analysis was performed on the side slopes of the outlet channel. The slopes were required to be flat enough to allow a safety factor of at least 1.5 against failure. The existing embankment consists of cohesionless silty sands and an assumed friction angle of 32 degrees was used. Typical friction angle values for this type of material range from 30 to 32 degrees. To allow a higher friction angle than what was assumed would require a more thorough investigation of the material. Because of the nature of the materials, the cohesion was assumed to be zero.

Another factor that affects the results of the analysis is the assumed level of saturation within the embankment. For normal operating conditions, the saturation level will be less than 1 foot high. However, if the outlet channel was to become plugged or there was an extreme inflow event, the saturation level could become somewhat higher. The higher the saturation level, the flatter the side slopes need to be to maintain an adequate safety factor. In order to maintain a conservative design that will be considered to be permanent, a saturation level of 2 feet was used for the stability analysis. Although this level is likely to be higher than what will actually occur, the analysis did not assume any erosion of the toe and therefore should be considered as reasonable. It is possible through a combination of outlet channel plugging and high inflows that the saturation level of the embankment could rise above 1 foot. Therefore, a 2 foot high saturation level is not overly conservative. Based on the assumptions given above, the recommended slope configuration for the outlet channel is 2.5 horizontal to 1 vertical.

Because the main criteria for sizing the outlet channel width is to prevent snow, ice and debris from building up and blocking or plugging the channel, the recommended width of the channel is much greater than necessary to pass normal outlet channel outflows. Therefore, a low flow channel that will generally contain all outflows is incorporated into the design, if possible unless on bedrock. Details of the low flow channel are shown on the drawings in Appendix B.

The outlet channel elevation was set to match the new reservoir level at the upstream and to tie into the existing outlet channel on the downstream to provide as smooth and even of a transition as possible. However, in order to keep channel velocities to less than 5 or 6 feet per second, the maximum grade within the outlet channel was limited to approximately 5 percent. In order to prevent erosion at the toe of the outlet channel slopes, channel velocities need to be minimized. In some cases this will require additional riprap armoring at the downstream end of the new outlet channel and existing outlet works channel transition due to several feet of drop required. Field crews will take care to minimize this drop by lengthening the downstream transition as much as possible.

The Storm Spillway Hydraulics table in Appendix C provides 100 year storm hydraulic data for the outlet channel flows for each of the dams.

As shown on the drawings, wire and gabion baskets lining the existing spillway outlet and channel will be removed and the side slopes laid back to a more stable angle. The wire and baskets will be removed from the HUWA at the end of the project.

Stream reconnection below Superior Lake

In addition to dam stabilization, an excellent restoration opportunity exists in the stream channel below Superior Lake. When these reservoirs were constructed, the flow below Superior Lake was diverted via a canal into the Five Point drainage. Since that time, the natural stream channel below the canal diversion to the confluence with Garfield Creek has been dewatered. A cross drainage channel has formed between the canal diversion and Five Point Lake (~ 0.40 miles). This cross drainage diversion has augmented flows out of Five Point Lake above natural levels. This additional flow has no doubt contributed to over-widened channels and gullies that are actively eroding below Five Point Lake (~ 1.25 miles). The degraded channel conditions below Five Point Lake are very unusual for the stream types expected in this drainage, and have not been observed in similar areas of the Uinta Mountains that have natural flow regimes.

By restoring the natural flow path below Superior Lake, the formerly de-watered channel would be restored along with the associated wetland and riparian habitats. The channel created from the cross drainage diversion between Superior and Five Point lakes would no longer receive perennial flow, which could affect a meadow area that has developed in a low gradient reach, but would also prevent further channel braiding and scouring to bedrock that has developed in higher gradient reaches. The flow regime below Five Point Lake would be restored to natural levels, which would prevent further flood damage from augmented flows in the channels below.

Recommendations for Stream Reconnection

It is recommended that a design-build approach be taken to restore the flow to the natural channel below Superior Lake. Based on field reviews to date, we propose breeching three berms that were constructed to divert water into the canal. The first berm to be breeched is directly below where a side channel re-enters the main channel and all the flow is combined in a single channel. This is the most critical berm to breech, and should restore all but the highest of flows to the natural drainage. Approximately 18 cubic yards (15’x 8’x4’) of material need to be removed from the natural drainage channel (see Appendix B for plan view drawing).

The second and third breech points are along the canal where berms have been constructed to keep flow in the canal, and out of natural drainage pathways. In order to fully restore flows to the natural drainage and to prevent flows from entering the canal, all three berms should be breeched (particularly for high flows). Material removed from the berms should be placed in the canal to direct flow down the natural channels. On site material could be utilized to perform this work, particularly the large boulders and cobble in the existing berms. The second and third breech points have approximately 8 cubic yards (12’x6’x3’) and 4 cubic yards (8’x3’x2’) of material that is currently blocking the natural drainage channel.

Five Point Lake

Many of the design considerations and much of the logic and approach to this project is applicable for each of the dams. As such, the narratives described for Superior Lake are not fully repeated for each of the other three. Although there is some repetition, it is avoided to the extent possible to maintain a readable report.

Five Point Lake is located near the top of Garfield Creek. It has a surface area of about 87 acres at the existing spillway and holds approximately 627 acre-feet of water. The dam is a homogeneous earthfill embankment with stone riprap facing. The dam is 15 feet high and has a 24-inch diameter low-level outlet pipe (62 feet long) located at the maximum section. There is a concrete-walled vertical shaft located on top of the dam; it extends from the top of the dam, down through the dam to the outlet pipe.

Inflow Hydrology

The Five Point Lake drainage basin is 1.9 square miles in area and is comprised of partially wooded slopes, interspersed with brush and grassy areas. Significant areas of rock and talus slopes are also present. The outlet channel of Superior Lake has been diverted to flow into Five Point Lake. The 100-year, 6-hour storm estimate of 2.75 inches has a peak runoff of 719 cfs. However, when routed through the reservoir, the peak runoff is attenuated to a maximum flow of 178 cfs through the spillway.

Dam Break Analysis

The dam break scenario table in Appendix C tabulates the results of various reservoir elevations and the corresponding dam break maximum flow.

A 15-foot-wide breach was used with a 300 minute time-to-breach, corresponding to half of the inflow hydrograph. A sunny day break of Five Point Lake Dam with the outlet channel at elevation 10,997 produces a maximum flow of 450 cubic feet per second and a water depth in the downstream channel averaging about 3.9 feet. By the time the breach flow reaches the confluence with Yellowstone River in 5.7 hours it is 3.1 feet deep. Stream cross sections were determined by WMS from the DEM data and verified by cross-sectional surveys obtained by Reclamation survey crews.

Several Forest Service campgrounds are located downstream of the subject lakes, including Riverview Campground which is approximately 12.5 miles from Five Point Lake and is estimated to be 0.5 to 2 feet above average river flows, depending on the time of year. Due to the proximity of the campground to the river, this campground is considered to be most at risk of damage/danger due to breach flow flooding.

A cross-sectional profile of the river near the campground was extracted from the DEM. Using the river profile and assuming the average river flow elevations range from 0.5 and 2 feet below the campground elevation, an available "flow area" was interpreted and tabulated below. Based on the "flow area" calculated by SMPDBK for Five Point Lake at the confluence of Garfield Creek and Yellowstone River, comparisons of available flows at the campground and demand flows from the Five Point breach were made, as tabulated below.

Base Flow Surface Below Campground Elevation	Available Flow Area Before Overtopping Stream Banks	Breach Flow Area at Confluence
(ft)	(ft^2)	(ft^2)
0.5	58.76	55.07
1.0	103.6	
1.5	137.24	
2.0	157.29	

The tabulated values show that Five Point Lake breach failure flows at the confluence of Garfield and Yellowstone Creeks is 55.07 ft^2 which is less than the available flow area for the idealized cross-section and range of base flows at the campground. This estimation indicates that breach failure flows would not exceed the river flow capacity; however, it should be noted that flow areas are a function of flow velocity, and this comparison assumes equal flow velocities. Additionally the comparison is based on the river channel having a width of approximately 140 feet and the river bank elevation. Satellite images show a relatively braided river channel that is wide in some sections and narrower in others. We recommend that the critical river cross-section be found and the profile verified to ensure more accurate capacity estimations are made. Furthermore it should be recognized that the breach failure flow area at the confluence is significantly higher than it would be, in reality, at the campground due to attenuation affects of breach flows traveling approximately 9.2 miles between the confluence and the campground which have not been considered here.

Outlet Works

Leaving the outlet pipe in place and plugging the pipe with cement is the proposed alternative. The outlet pipe at Five Point Lake is 62 feet in length. It would require about 6 CY of cement to seal completely with grout.

As shown on the drawings and as described thoroughly for Superior Lake, the plugged outlet pipe will be protected on the upstream and downstream ends with a grouted rock gabion basket cutoff wall and the plugged outlet pipe will have additional protection at the downstream end in the form of a filter material that will prevent migration of fines in the event that some water is able to flow through the grouted pipe.

The concrete-walled shaft from the top of Five Point Dam down into the outlet works will be broken off to a height of 4 feet below the existing dam surface. The broken concrete rubble will be used to partially fill the shaft. The remainder of the hole will be filled with 3 CY of cement grout. A light covering about 1 foot in depth of locally-available soils will be added on top to become flush with the embankment surface.

Outlet Channel

The constructed outlet channel will be located to the right side of the existing outlet pipe. The design drawings in Appendix B show the location of the channel. Based on the results of the dam break analysis and as shown on the drawings, the maximum recommended outlet channel invert elevation is 10,997 feet. A grouted rock gabion basket cutoff wall will be constructed at the upstream end of the outlet channel to insure a stabilized elevation. The top of gabion elevation will be 10,997. A second grouted gabion cutoff wall will be constructed at approximately halfway through the channel, and another at the downstream end of the outlet channel. A boulder-pool channel will be constructed to transition the new channel slope into the existing downstream grade.

The recommended width at the invert is 15 feet. Keeping the outlet channel a minimum width of 15 feet will help reduce plugging due to ice, snow, and debris. The outlet channel will be armored with a 24-inch layer of 12” D_{50} riprap along the invert and for a vertical height of 4 feet on the side slopes. The remainder of the outlet channel side slopes will consist of smaller riprap armoring.

A slope stability analysis was performed on the side slopes of the outlet channel. Based on the assumptions given above, the recommended slope configuration for the outlet channel is 2.5 horizontal to 1 vertical.

Because the main criteria for sizing the outlet channel width is to prevent snow, ice and debris from building up and blocking or plugging the channel, the recommended width of the channel is much greater than necessary to pass normal outlet channel outflows. Therefore, a low flow channel that will generally contain all outflows is incorporated into the design. Details of the low flow channel are shown on the drawings in Appendix B.

In order to prevent erosion at the toe of the outlet channel slopes, in some cases this will require additional riprap armoring at the downstream end of the new outlet channel and existing outlet works channel transition due to several feet of drop required. Field crews will take care to minimize this drop by lengthening the downstream transition as much as possible.

The Storm Spillway Hydraulics table in Appendix C provides 100 year storm hydraulic data for the outlet channel flows for each of the dams.

The old spillway channel for the reservoir contains several areas where wire gabions and other materials were incorporated in efforts to stabilize the spillway channel. This debris will be removed from the channel and packaged up to be removed as waste at the end of the project.

Drift Lake

Drift Lake is also located near the top of Garfield Creek. It has a surface area of about 31 acres at the existing spillway and holds approximately 158 acre-feet of water. The dam is a homogeneous earthfill embankment with stone riprap facing. The dam is 12 feet high and has 24-inch diameter low-level outlet pipe (44 feet long) located at the maximum section. The outlet pipe was slip-lined in late 1980s with a smaller diameter high-density polyethylene (HDPE) pipe. The void between the 24" diameter pipe and the inner HDPE pipe was filled with grout.

Inflow Hydrology

The Drift Lake drainage basin is 0.5 square miles in area and is comprised of partially wooded slopes, interspersed with brush and grassy areas. Significant areas of rock and talus slopes are also present. The 100-year, 6-hour storm estimate of 2.75 inches has a peak runoff of 1,070 cfs. However, when routed through the reservoir, the peak runoff is attenuated to a maximum flow of 62 cfs through the spillway.

Dam Break Analysis

The dam break scenario table in Appendix C tabulates the results of various reservoir elevations and the corresponding dam break maximum flow.

A 10-foot-wide breach was used with a 300 minute time-to-breach, corresponding to half of the inflow hydrograph. A sunny day break of Drift Lake Dam with the outlet channel at elevation 11,054.5 produces a maximum flow of 44 cubic feet per second and a water depth in the downstream channel averaging about 1.7 feet. By the time the breach flow reaches the confluence with Yellowstone River in 5.7 hours, the model predicts it is still 1.7 feet deep. Stream cross sections were determined by WMS from the DEM data and verified by cross-sectional surveys obtained by Reclamation survey crews.

Outlet Works

The proposed approach for Drift Lake Dam is to remove the outlet pipe. Historic design drawings and evidence from the site suggest that the outlet pipe for Drift Lake lies in a notch excavated through bedrock outcroppings. The proposed approach is to remove the pipe and then construct three loose rock check-dams in the outlet trench. Spaces between and among the rock dams will be filled with local fines. The fines should be compacted to the maximum density achievable under the field conditions. Filling of the channel will be performed in no more than 6-inch lifts, so that compaction protocols can be developed that will achieve good compaction.

Outlet Channel

Based on the results of the dam break analysis and as shown on the drawings, the maximum recommended outlet channel invert elevation is 11,054.55 feet. The recommended width at the invert is 10 feet. Keeping the outlet channel a minimum width of 10 feet will help reduce plugging due to ice, snow, and debris.

When the outlet pipe is removed, the trench is expected to be on bedrock. The channel should be stabilized with three or more loose rock check-dams in the outlet trench, at about 15-foot spacing. Spaces between and among the rock check-dams will be filled with local fines. The fines should be compacted to the maximum density achievable under the field conditions. Rock for the check-dams will be a mix of sizes, but include rocks between 24 and 36 inches. If large rocks cannot be incorporated into the check-dams due to limitations of traditional methods, then grouted rock-filled gabions would be acceptable alternatives.

If the outlet channel is not in bedrock outcroppings, the outlet channel will be armored with a 16-inch layer of 8” D_{50} riprap along the invert and for a vertical height of 4 feet on the side slopes. The remainder of the outlet channel side slopes will consist of smaller riprap armoring. The recommended slope configuration for the outlet channel is 2.5 horizontal to 1 vertical.

Because the main criteria for sizing the outlet channel width is to prevent snow, ice and debris from building up and blocking or plugging the channel, the recommended width of the channel is much greater than necessary to pass normal outlet channel outflows. Therefore, a low flow channel that will generally contain all outflows is incorporated into the design. Details of the low flow channel are shown on the drawings in Appendix B.

In order to prevent erosion at the toe of the outlet channel slopes, in some cases this will require additional riprap armoring at the downstream end of the new outlet channel and existing outlet works channel transition due to several feet of drop required. Field crews will take care to minimize this drop by lengthening the downstream transition as much as possible.

The Storm Spillway Hydraulics table in Appendix C provides 100 year storm hydraulic data for the outlet channel flows for each of the dams.

Bluebell Lake

Bluebell Lake is also located near the top of Garfield Creek. It has a surface area of about 48 acres at the existing spillway and holds approximately 235 acre-feet of water. The dam is a homogeneous earthfill embankment with stone riprap facing. The dam is 8 feet high and has a 24-inch diameter low-level outlet pipe (22 feet long) located at the maximum section. The outlet pipe was slip-lined in the late 1980s with a smaller diameter HDPE pipe. The void between the 24” diameter pipe and the inner HDPE pipe was filled with grout.

Inflow Hydrology

The Bluebell Lake drainage basin is 0.6 square miles in area and is comprised of partially wooded slopes, interspersed with brush and grassy areas. Significant areas of rock and talus slopes are also present. The 100-year, 6-hour storm estimate of 2.74 inches has a peak runoff of 1,255 cfs. However, when routed through the reservoir, the peak runoff is attenuated to a maximum flow of 75 cfs through the spillway.

Dam Break Analysis

The dam break scenario table in Appendix C tabulates the results of various reservoir elevations and the corresponding dam break maximum flow.

A 10-foot-wide breach was used with a 300 minute time-to-breach, corresponding to half of the inflow hydrograph. A sunny day break of Bluebell Lake Dam with the outlet channel at elevation 10,892 produces a maximum flow of 102 cubic feet per second and a water depth in the downstream channel averaging about 2.4 feet. By the time the breach flow reaches the confluence with Yellowstone River in 5.8 hours it is 2.1 feet deep. Stream cross sections were determined by WMS from the DEM data and verified by cross-sectional surveys obtained by Reclamation survey crews.

Outlet Works

In order to have a no hazard classification there can be no operable outlet works. The existing outlet pipe could either be left in place and plugged, or the entire outlet works could be removed. In either case the existing outlet works gate would be removed.

The proposed approach for Bluebell Lake Dam is to remove the outlet pipe and build the new outlet channel over top of the trench, with adequate protection to prevent erosion and down cutting. The proposed approach is to remove the pipe and then construct three loose rock check-dams in the trench, stabilizing the outlet channel. Spaces between and among the rock dams will be filled with local fines. The outlet channel's excavated side slopes would be flat enough to ensure a good bond between the new compacted backfill and the undisturbed existing ground. This is critical to address to ensure that a seepage path is not created at the interface. The backfill would be compacted as tightly as possible based on the tools allowed to be used.

Although this approach is not being recommended for Bluebell Lake, if for some reason the outlet pipe were to be grouted in place, the plugged outlet pipe would be protected on the upstream and downstream ends with a grouted rock gabion basket cutoff wall and the plugged outlet pipe would have additional protection at the downstream end in the form of a filter material that would prevent migration of fines in the event that some water is able to flow through the grouted pipe.

Outlet Channel

Based on the results of the dam break analysis and as shown on the drawings, the maximum recommended outlet channel invert elevation is 10,891.5 feet. Three or more rock-filled check dams would be placed in the outlet channel to establish elevation control. The outlet channel will be extended upstream of the dam cut to include the excavated trench upstream of the old dam. This "inlet trench" was originally excavated through native material. Spaces between and among the rock dams will be filled with local fines and compacted. The recommended width at the invert is 10 feet. Keeping the outlet channel a minimum width of 10 feet will help reduce plugging due to ice, snow, and debris. The outlet channel will be armored with a 16-inch layer of 8" D_{50} riprap along the invert and for a vertical height of 4 feet on the side slopes. The remainder of the outlet channel side slopes will consist of smaller riprap armoring.

A slope stability analysis was performed on the side slopes of the outlet channel. Based on the assumptions given above, the recommended slope configuration for the outlet channel is 2.5 horizontal to 1 vertical.

Because the main criteria for sizing the outlet channel width is to prevent snow, ice and debris from building up and blocking or plugging the channel, the recommended width of the channel is much greater than necessary to pass normal outlet channel outflows. Therefore, a low flow channel that will generally contain all outflows is incorporated into the design. Details of the low flow channel are shown on the drawings in Appendix B.

In order to prevent erosion at the toe of the outlet channel slopes, in some cases this will require additional riprap armoring at the downstream end of the new outlet channel and existing outlet works channel transition due to several feet of drop required. Field crews will take care to minimize this drop by lengthening the downstream transition as much as possible.

Appendix A - Memorandum of Understanding between State of Utah and U.S. Forest Service

MEMORANDUM OF UNDERSTANDING

Intermountain Region
Forest Service
U. S. Department of Agriculture

Division of Water Rights
Department of Natural Resources
State of Utah

THIS MEMORANDUM OF UNDERSTANDING is entered into by the Division of Water Rights, Department of Natural Resources, State of Utah, hereafter called the Division, and the Intermountain Region, Forest Service, Department of Agriculture, hereafter referred to as the Forest Service.

WHEREAS, the Forest Service and the Division have certain responsibilities for the safety of dams by virtue of land status or public safety, and

WHEREAS, the Division has been created under Utah Statutes 73-5-5, 6, 7, 12, and 13, to provide public safety and resource protection by supervision and administration of a system to safeguard dams in the State of Utah, and

WHEREAS, the Forest Service under Acts of June 4, 1897 (16 U.S.C. 551), February 1, 1905 (16 U.S.C. 473), July 22, 1937 (16 U.S.C. 1010), June 12, 1960 (16 U.S.C. 528), as amended, is directed to regulate the occupancy and use of the National Forests and National Grasslands, and

WHEREAS, the Forest Service under administrative Manual requirements is directed to supervise and administer a system of inspections to safeguard dams located on National Forest lands, and

WHEREAS, the Forest Service and the Division mutually desire:

1. To periodically inspect dams located on National Forest lands.

2. To develop and document procedural methods to minimize duplication of effort and facilitate complementary inspections of dams.

NOW THEREFORE, the parties agree as follows:

1. The Forest Service agrees:

a. To coordinate with the Division at the local and state levels in developing an annual inspection schedule for dams.

b. To provide the Division copies of dam inspection reports made by Forest Service engineers.

c. To notify the Division of suspected safety hazards of dams located on National Forest lands.

2. The Division agrees:

a. To provide notification to the appropriate Forest Supervisor of the dams scheduled for Division inspection each calendar year.

b. To provide the Forest Service copies of dam inspection reports made by Division engineers.

c. To notify the Forest Service of suspected safety hazards of dams located on, or affecting, National Forest lands.

3. It is mutually agreed:

a. To cooperate in the periodic inspection of dams located on National Forest lands in the State of Utah.

b. To develop and seek application of safety measures required to protect public safety and resources.

c. That nothing herein shall be construed in any way as limiting the authority of the Division in carrying out its legal responsibilities for management or regulation of dam safety.

d. That nothing herein shall be construed as limiting or affecting in any way the legal authority of the Forest Service in connection with the proper administration and protection of National Forest System lands, in accordance with Federal laws and regulations.

e. That nothing in the Memorandum of Understanding shall be construed as obligating the Forest Service or the Division to expend funds in any contract or other obligation for future payment of funds or services in excess of those available or authorized for expenditure.

f. That amendments to this Memorandum of Understanding may be proposed by either party and shall become effective after written approval by both parties.

g. That this Memorandum of Understanding shall continue in force unless terminated by either party upon thirty (30) days notice in writing to the other of intention to terminate upon a date indicated.

h. Forest Service and local Division inspection personnel[1] will coordinate their annual inspection schedules to avoid duplication of effort.

[1] See Exhibit 1 attached hereto.

i. That agreements between Forest Supervisors and local dam inspection personnel of the Division can be made as amendments to this document if such agreements are deemed necessary.

j. That no member of or delegate to Congress, or Resident Commissioner of the United States shall be admitted to any share or part of this agreement, or to any benefit that may arise therefrom.

k. That each and every provision of this Memorandum is subject to the laws of the State of Utah, the laws of the United States, the regulations of the Secretary of Agriculture, and the regulations of the Division.

IN WITNESS THEREOF, the parties hereto have caused this Memorandum of Understanding to be executed as of the last date signed below.

Jeff M. Sirmon
JEFF M. SIRMON
Acting Regional Forester
Intermountain Region
USDA Forest Service

Date 4/4/80

Dee C. Hansen
DEE C. HANSEN
State Engineer
Division of Water Rights
Department of Natural Resources
State of Utah

Date April 14, 1980

This Memorandum of Understanding is applicable to the following National Forests:

Ashley National Forest
437 East Main
Vernal, Utah 84078

Dixie National Forest
Federal Building
82 North 100 East
P.O. Box 580
Cedar City, Utah 84720

Fishlake National Forest
P.O. Box 628
170 North Main Street
Richfield, Utah 84701

Manti-LaSal National Forest
350 East Main Street
Price, Utah 84501

Uinta National Forest
P.O. Box 1428
88 West 100 North
Provo, Utah 84601

Wasatch National Forest
8226 Federal Building
125 South State Street
Salt Lake City, Utah 84138

USDA United States Department of Agriculture | Forest Service | Intermountain Region | 324 25th Street
Ogden, UT 84401
801-625-5605

File Code: 2320/7520 **Date:** February 22, 2007
Route To:

Subject: High Lakes Dam Stabilization

To: Forest Supervisor, Ashley NF

The High Lakes Dam Stabilization project represents a significant milestone in restoring watersheds of the High Uintas Wilderness that were affected by dam construction. We have significant concerns about multi-year phasing of these dam stabilization projects. This letter documents these concerns so you may adequately continue to plan successful stabilization projects.

Multi-year construction projects to stabilize a single dam have serious potential problems, which include, but are not limited to:

- Increased vulnerability to failure from hydraulic overloading when partial breaches may not be adequately stabilized
- High potential for erosion and soil disruption from over-wintering and unexpected weather events
- Additional required work and disturbance to reconstruct and stabilize the dam at the end of each construction season
- Increased mobilization and demobilization costs from additional work cycles
- Increased site disturbance from multi-year operations at camps, travel routes, and on-site activity
- The Forest Service does not allow riprap spillways on moderate-hazard earthfill dams, therefore any intermediate "spillway" or outlet channel on a partially stabilized dam would be required to be hardened, probably with concrete
- High potential for unexpected, early adverse weather which could close the construction project prior to adequate stabilization

In addition, because these dams were constructed at the turn of the century, there is no guarantee that plans are accurate. Once breached, there may be unexpected, inappropriate materials in the dam that would not adequately resist scour and potential failure. Partial breaches may also create unanticipated new flow regimes.

Other considerations with multi-year projects include:

- Uncertainty of weather from year to year which may require additional measures to ensure partially breached dams are secure
- Longer exposure of crews to accident factors during the multi-seasons
- Increased risk of personnel changes leading to loss of skills and experience
- Loss of availability of equipment

Based on past experience, success with multi-year staged construction projects has been low. We do not recommend planning for a multi-year project to stabilize individual dams. Consider the above concerns when planning for the High Lakes Stabilization projects. It is our understanding that the State of Utah also shares these concerns. Should you consider a multi-year staged approach to any of these dams, be advised that at the completion of each season of activity, the partially completed dam must meet State of Utah and Forest Service dam safety specifications. Due to the existing condition of many of the dams, we expect that achieving this requirement could entail even more extensive work and could be more difficult to achieve than completing the stabilization to its final proposed configuration in a single season.

Questions may be addressed to Bill Self, Dam Safety Engineer, at 801-625-5227, or Randy Welsh, Wilderness Program Leader, at 801-625-5250.

/s/ Liz Close
ELIZABETH G. CLOSE
Director of Recreation

/s/ Merv Eriksson (for)
KEITH SIMILA
Director, Engineering

cc: Mark Holden
Mitigation Commission

High Lakes Stabilization
CUP Mitigation Commission
Uinta Basin Replacement Project

Technical Memo
June 1, 2006

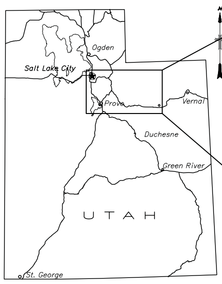
Matt Lindon, PE
Dam Safety Engineer
Utah DNR, State Engineer's Office
Dam Safety Section

Because of the breach potential of the High Lakes Dams, and the difficulty in monitoring and maintaining these dams in the Wilderness area, the CUP Mitigation Commission is undertaking the stabilization of 13 of these dam structures and replacing the storage water rights downstream in the expanded Big Sand Wash dam where maintenance and monitoring is practical. These wilderness dams vary in size, hazard rating and condition and have peak breach flow potential ranging from hundreds to several thousand CFS. Breach flows of this magnitude far exceed the carrying capacity of existing streams and they would cause extensive damage to the downstream forest resource, campgrounds, trails, roads, dams and in some cases, private property and residents. Because of this fact the "Do Nothing" option was not considered appropriate because of the eventuality of the deterioration and catastrophic failure of these dams.

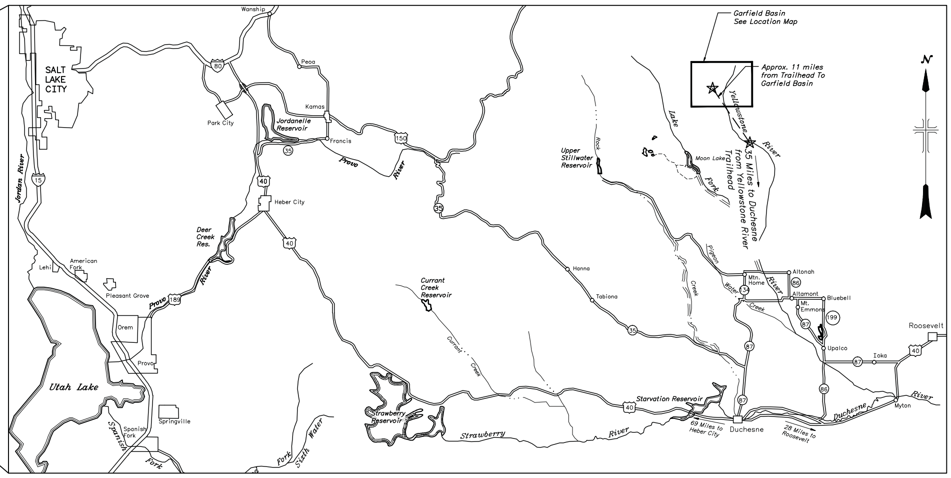
The stabilization of these dams will require the excavation of a spillway notch, with stable side slopes, through the middle of the embankment and the removal of the low level outlet. An armored, stabilized low level channel would then be constructed in the notch to pass normal runoff as well as large storm events without jeopardizing the remaining structure by impounding excess water. In some cases the embankment may be removed or rolled over on itself to decrease the height and increase the stability and ability of the remaining embankment to withstand any seismic event or overtopping during extreme events. This work is the minimum necessary to stabilize these dam structures and restore natural hydrologic flows to the greatest extent possible, while still meeting a "No Hazard" dam safety rating.

It was determined that each individual dam stabilization would need to be completed in one construction season because of the vulnerability of a partially removed embankment. These partially completed dams could easily overtop and fail from snow melt runoff or storm events, even if the outlet was still in place and open. Breach flow potential would be extensive even from the reduced lake storage volumes. Existing spillways would be too high to assist in flood routing under these circumstances and it would be prohibitive to build auxiliary or temporary spillways over the partially excavated embankment or on bedrock at the proper level, even if it could be located. It was determined that this risk possibility was inconsistent with the project's goals of safety and stabilization as well as minimum impact and the preservation of the Wilderness resources and values.

Appendix B – Drawings

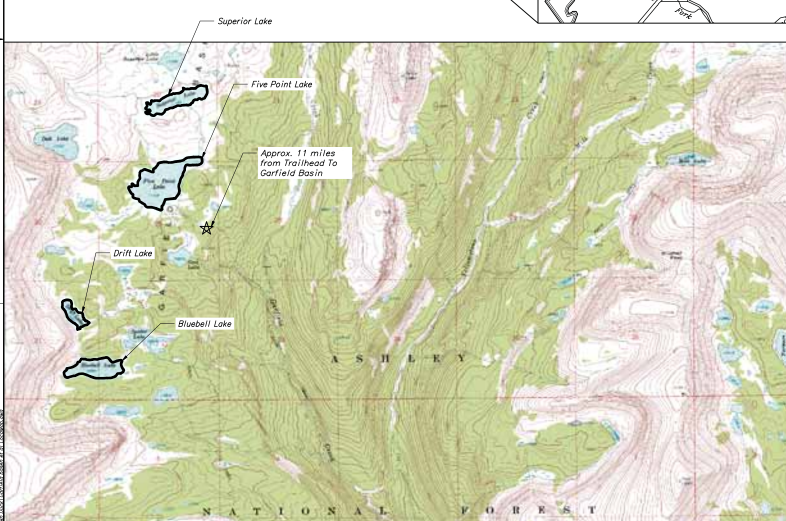


KEY MAP



VICINITY MAP

SCALE OF MILES



LOCATION MAP

NOT TO SCALE

SHEET	TITLE	DRAWING NUMBER
1	KEY MAP, VICINITY MAP, LOCATION MAP AND SHEET INDEX	OA58-418-86
2	SUPERIOR LAKE SITE PLAN	OA58-418-87
3	SUPERIOR LAKE BEACH PROFILE, ELEVATION AND SECTIONS	OA58-418-88
4	SUPERIOR LAKE EXISTING OUTLET PROFILE	OA58-418-89
5	FIVE POINT LAKE SITE PLAN	OA58-418-90
6	FIVE POINT LAKE PROFILE, ELEVATION AND SECTIONS	OA58-418-91
7	FIVE POINT LAKE EAST OUTLET PROFILE	OA58-418-92
8	DRIFT LAKE SITE PLAN	OA58-418-93
9	DRIFT LAKE PROFILE	OA58-418-94
10	DRIFT LAKE SECTIONS AND DETAILS	OA58-418-95
11	BLUEBELL LAKE SITE PLAN	OA58-418-96
12	BLUEBELL LAKE PROFILE	OA58-418-97
13	BLUEBELL LAKE SECTIONS AND DETAILS	OA58-418-98

ALWAYS THINK SAFETY

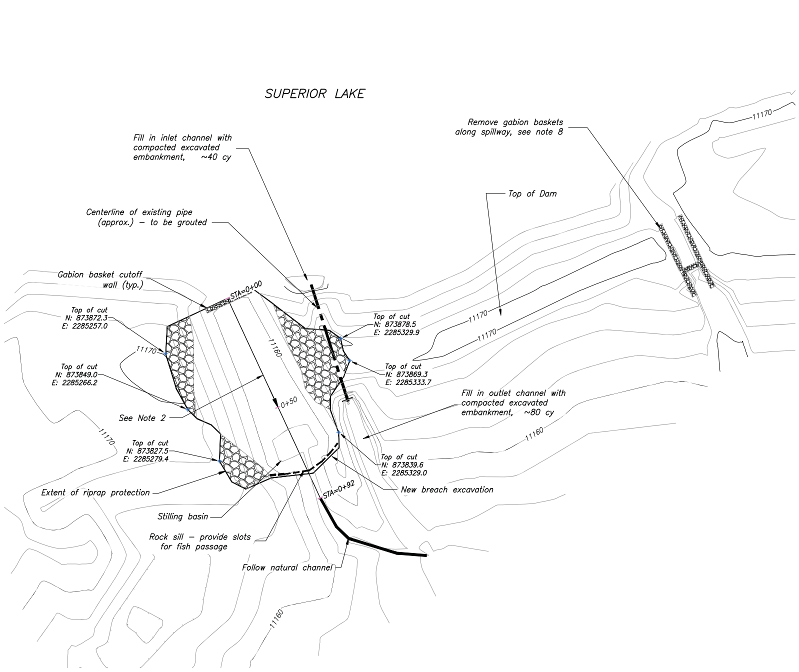
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
PROVO AREA OFFICE
PROVO, UTAH

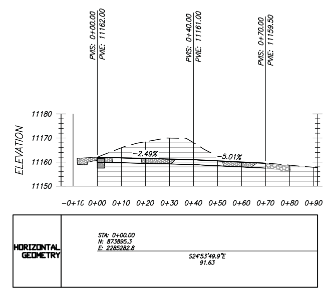
GARFIELD BASIN LAKES
DAM STABILIZATION

SUPERIOR, FIVE POINT, DRIFT AND BLUEBELL LAKES

VICINITY, LOCATION MAP AND SHEET INDEX

DESIGNED SCOTT WINTERTON, P.E. CHECKED MIKE TALBOT, P.E.
DRAWN MICHAEL DRAPER TECH. APPR. CARY SOUTHWORTH, P.E.
APPROVED /S/ SCOTT RICH, P.E. (SCOTT RICH, P.E. - PEER REVIEWER)
PROVO, UTAH 2009-02-23 OA58-418-86



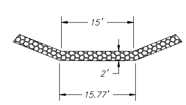


PROFILE: SUPERIOR BREACH

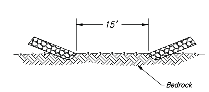
SEE OA58–418–88 FOR ADDITIONAL DETAIL

NOTES

1. Contour interval is 2 foot.
2. Vary centerline alignment along breach to create resting pools.
3. Breach El. 11,162.0
4. Cut vol. = 650 c.y.
5. Contours shown through the breach represent excavated grade below final riprap placement.
6. Grid factor = 0.99949466
7. Gabion basket may not be required due to underlying bedrock.
8. Reuse or scatter rock from existing gabions found on site and flatten side slopes along spillway.



Breach – 24" Riprap Thickness
15 ft. bottom width
2.5:1 Cut slopes



Breach – excavated to bedrock
15 ft. bottom width
2.5:1 Cut slopes

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BUREAU OF RECLAMATION

PROVO AREA OFFICE
PROVO, UTAH

GARFIELD BASIN LAKES DAM STABILIZATION

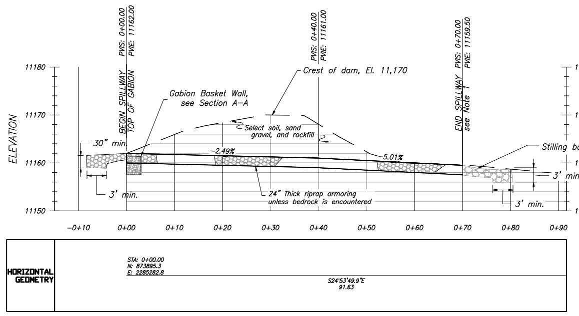
SUPERIOR LAKE BREACH

SITE PLAN

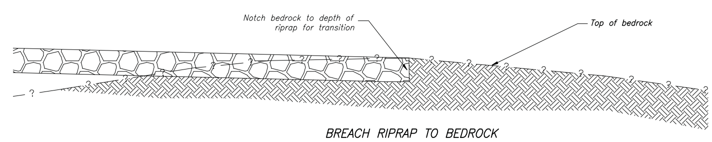
DESIGNED SCOTT WINTERTON, P.E. CHECKED MIKE TALBOT, P.E.
DRAWN MICHAEL DRAPER TECH. APPR. CARY SOUTHWORTH, P.E.
CARY SOUTHWORTH, P.E.
APPROVED /S/ SCOTT RICH, P.E.
SCOTT RICH, P.E. – PEER REVIEWER

PROVO, UTAH 2009–02–20 OA58–418–87

OA58-418-88

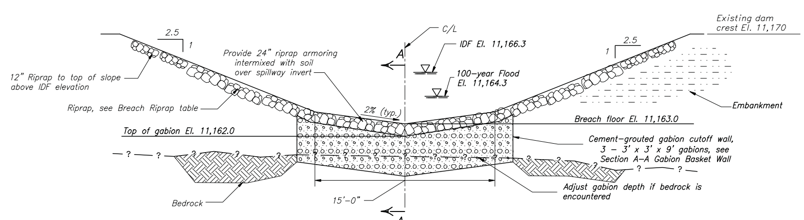


PROFILE: SUPERIOR BREACH

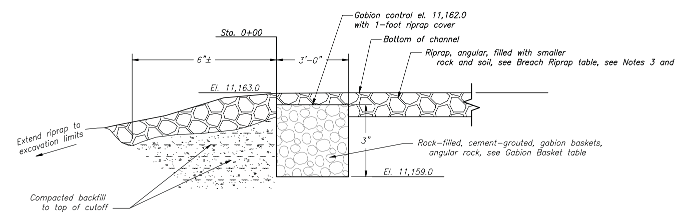


BREACH RIPRAP TO BEDROCK
TRANSITION DETAIL

SCALE OF FEET



BREACH CHANNEL SECTION AT STA. 0+00



SECTION A–A
GABION BASKET WALL

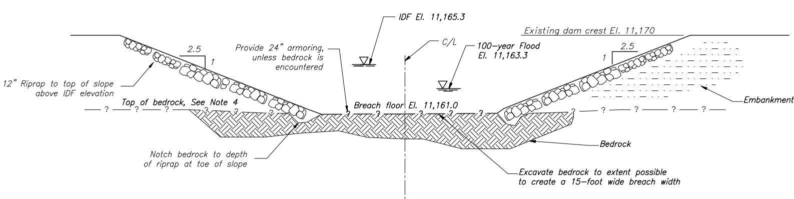
SCALE OF FEET

NOTES

1. Provide riprap armoring from end of breach to existing ground to prevent headcutting and erosion.
2. Flood elevations through the breach represent elevations as if the existing spillway does not operate.
3. Place riprap through breach in layers to maintain correct gradations.
4. Bedrock may be encountered at design elevations. Riprap is not required when bedrock is encountered.

GABION BASKET			
GABION BASKET	PREDOMINATE ROCK SIZE (INCHES)	MINIMUM ROCK SIZE (INCHES)	MAXIMUM ROCK SIZE (INCHES)
36	6 to 10	4	12

BREACH RIPRAP				
D MIN.	D15	D50	D MAX.	THICKNESS MIN.
6"	8"	12"	16"	24"



BREACH CHANNEL SECTION AT STA. 0+40

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BUREAU OF RECLAMATION

PROVO AREA OFFICE
PROVO, UTAH

GARFIELD BASIN LAKES DAM STABILIZATION

SUPERIOR LAKE SPILLWAY MODIFICATION
BREACH PROFILE AND SECTION

DESIGNED SCOTT WINTERTON, P.E. CHECKED MIKE TALBOT, P.E.
DRAWN MICHAEL DRAPER TECH. APPR. CARY SOUTHWORTH, P.E.
CARY SOUTHWORTH, P.E.
APPROVED /S/ SCOTT RICH, P.E.
SCOTT RICH, P.E. – PEER REVIEWER

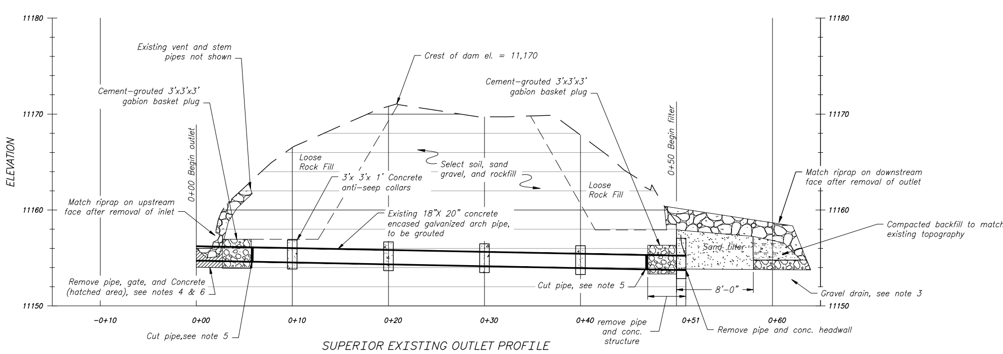
PROVO, UTAH 2009-02-20 OA58-418-88

D

C

B

A



SUPERIOR EXISTING OUTLET PROFILE

NOTES

1. Provide compacted filter material over last 8' of pipe removal trench.
2. Trench walls shall be sloped to allow adequate compaction between fill and natural ground. Actual slope will depend on compaction method used.
3. Extend gravel drain through compacted sloped material to discharge under riprap.
4. Fill inlet area with embankment material compacted to 95% maximum density.
5. Do not remove outlet cutoff callar.
6. Upstream end of outlet is approximated. Field verify actual length of outlet pipe.

SAND FILTER MATERIAL GRADATION REQUIREMENTS	
SIEVE SIZE	% PASSING BY WEIGHT
1/2 inch	100
3/8 inch	100
No. 4	95–100
No. 8	80–100
No. 16	50–85
No. 30	25–60
No. 50	10–30
No. 100	2–10
No. 200	0–3

GRAVEL DRAIN MATERIAL GRADATION REQUIREMENTS	
SIZE	% PASSING BY WEIGHT
1 1/2 inch	90–100
3/4 inch	55–100
3/8 inch	19–75
No. 4	0–40
No. 8	0–10
No. 16	0

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UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

PROVO AREA OFFICE
PROVO, UTAH

GARFIELD BASIN LAKES DAM STABILIZATION

SUPERIOR LAKE

EXISTING OUTLET PROFILE

DESIGNED SCOTT WINTERTON, P.E. CHECKED MIKE TALBOT, P.E.
DRAWN MICHAEL DRAPER TECH. APPR. CARY SOUTHWORTH, P.E.
CARY SOUTHWORTH, P.E.
APPROVED /S/ SCOTT RICH, P.E.
SCOTT RICH, P.E. – PEER REVIEWER

PROVO, UTAH 2009–02–23 0A58–418–89

Figure B-5. <u>Color image of stream channels and canal below Superior Lake.</u> Canal flow direction marked with red arrows, natural flow direction marked with yellow arrows, and breech points for the stream reconnect labeled 1, 2 and 3 (upstream to downstream). Photos 1-3 are taken at breech point 1, photo 3 at breech point 2, and photos 4-5 at breech point 3. Superior dam and lake are visible in the upper left corner. (from report by Mark Muir, Ashley National Forest hydrologist)

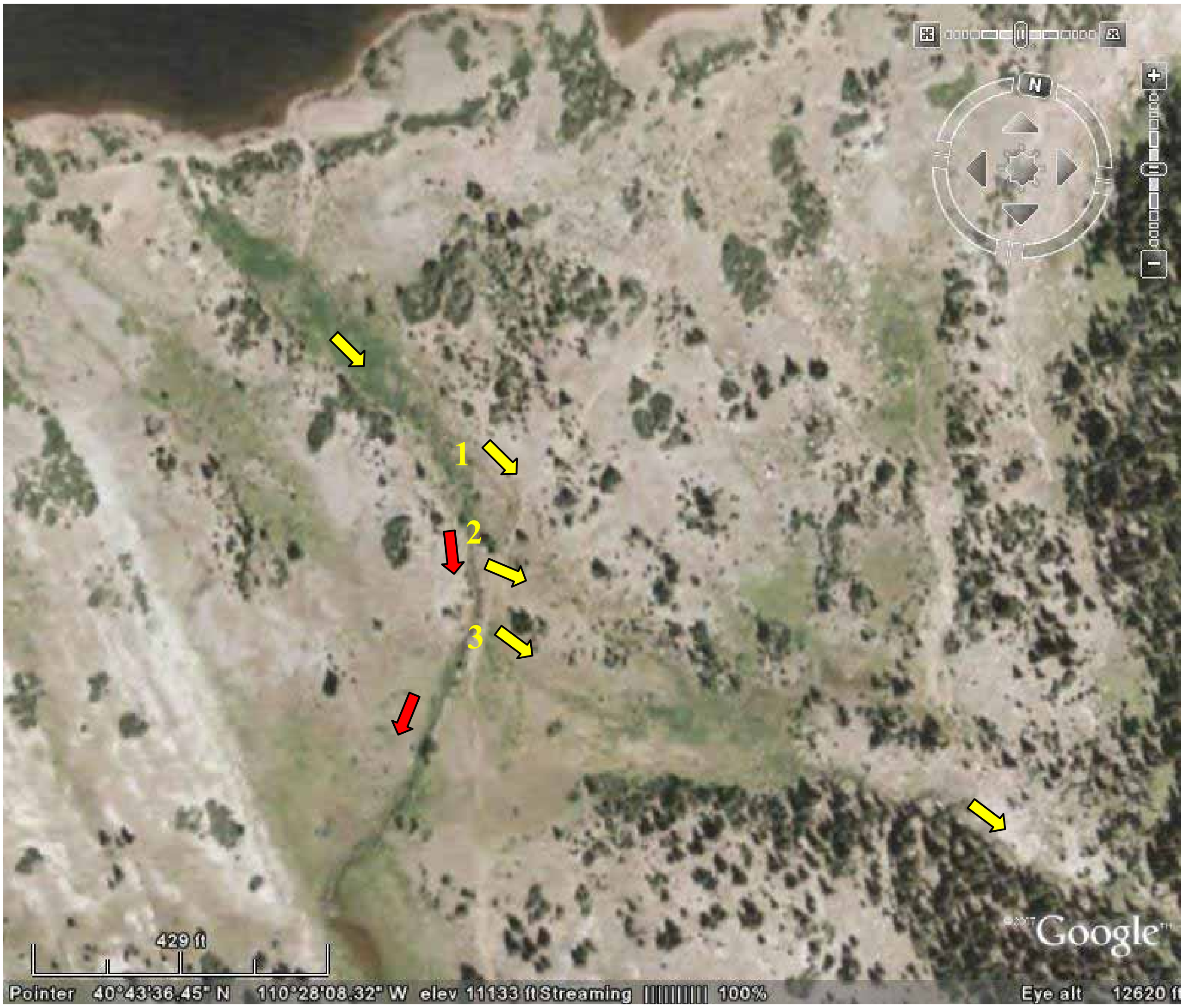
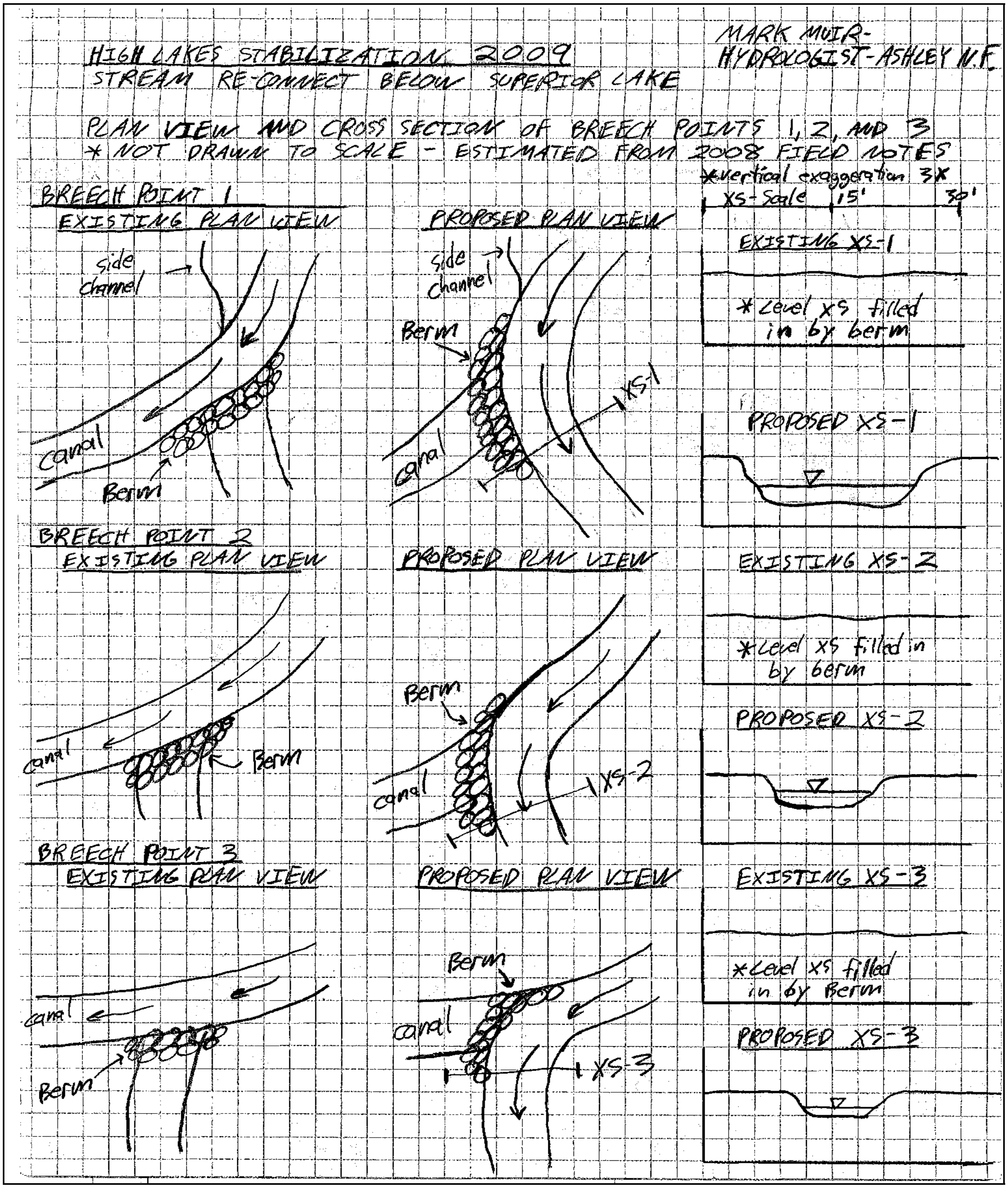
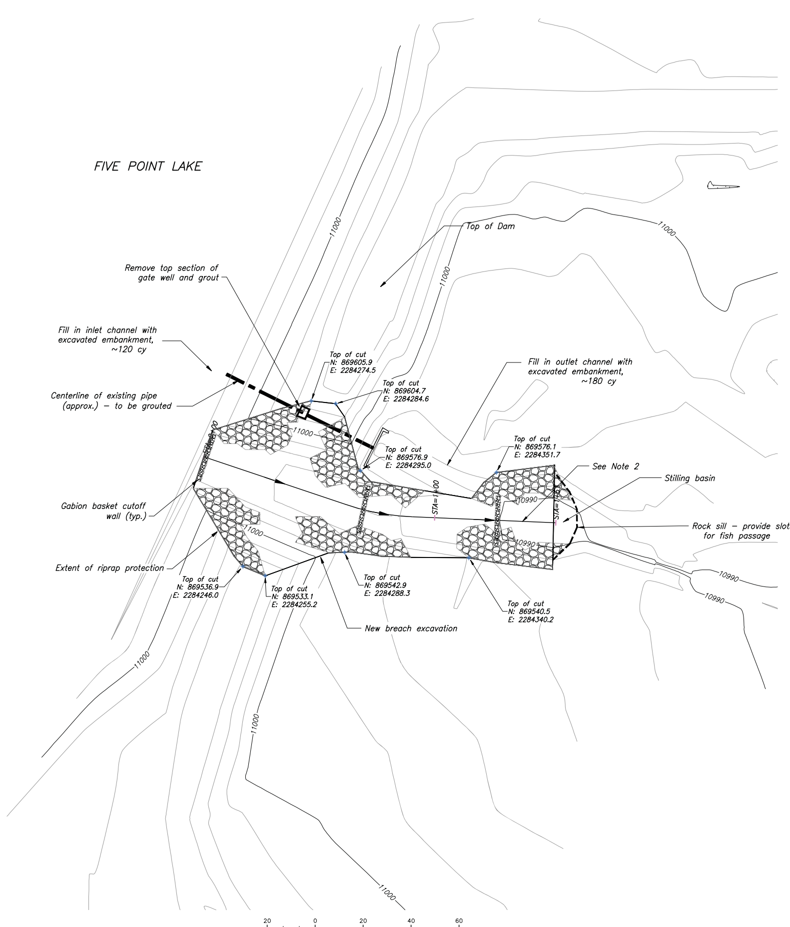
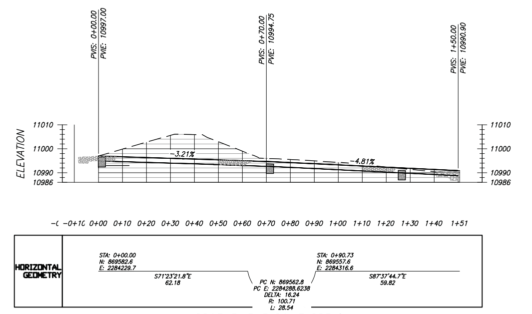


Figure B-6. Plan view and cross section drawings of the proposed breech points below Superior Lake. Survey equipment was not available during the September 9, 2008 field review, so these drawings are from field notes. Breech points 1, 2, and 3 are labeled in Figure B-1 of this report, which provides a larger plan view of the area.





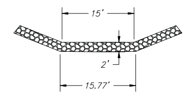


PROFILE: FIVE POINT BREACH

SEE OA58-418-91 FOR ADDITIONAL DETAIL

NOTES

1. Contour interval is 2 foot.
2. Vary centerline alignment along ramp to create resting pools.
3. Breach El. 10,997.00
4. Cut vol. = 1,000 c.y.
5. Contours shown through the breach represent excavated grade below final riprap placement.
6. Grid factor = 0.99949466
7. Remove exposed wire and debris from existing spillway.
8. Remove exposed rebar from existing spillway crest.



Breach – 24" Riprap Thickness
15 ft. bottom width
2.5:1 Cut slopes

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BUREAU OF RECLAMATION

PROVO AREA OFFICE
PROVO, UTAH

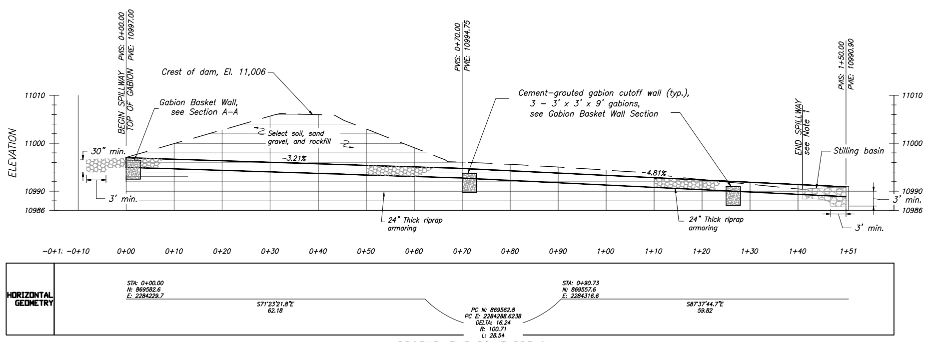
GARFIELD BASIN LAKES DAM STABILIZATION

FIVE POINT LAKE BREACH

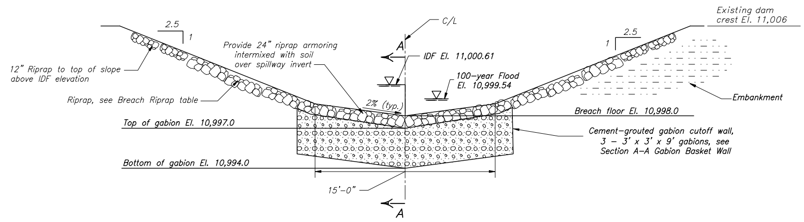
SITE PLAN

DESIGNED SCOTT WINTERTON, P.E. CHECKED MIKE TALBOT, P.E.
DRAWN MICHAEL DRAPER TECH. APPR. CARY SOUTHWORTH, P.E. (CARY SOUTHWORTH, P.E.)
APPROVED /S/ SCOTT RICH, P.E. (SCOTT RICH, P.E. – PEER REVIEWER)

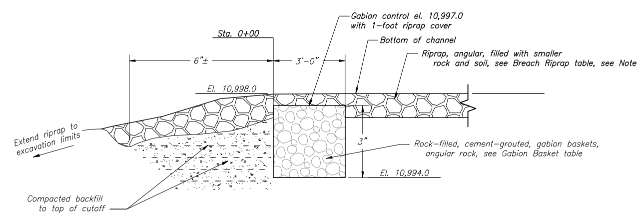
PROVO, UTAH 2009-03-03 OA58-418-90



PROFILE: FIVE POINT BREACH



BREACH CHANNEL SECTION AT STA. 0+00
(FOR STA 0+70 AND 1+25, SEE TABLE)



SECTION A–A
GABION BASKET WALL

BREACH RIPRAP				
D MIN.	D15	D50	D MAX.	THICKNESS MIN.
6"	8"	12"	16"	24"

GABION BASKET ROCK GRADATIONS			
GABION BASKET	PREDOMINATE ROCK SIZE (INCHES)	MINIMUM ROCK SIZE (INCHES)	MAXIMUM ROCK SIZE (INCHES)
36	6 to 10	4	12

GABION CUTOFF WALL ELEVATIONS					
STATION	BREACH FLOOR	TOP OF GABION	BOTTOM OF GABION	100 YEAR FLOOD ELEVATION	IDF ELEVATION
0+00	10,998.0	10,997.0	10,994.0	10,999.54	11,000.61
0+70	10,995.75	10,994.75	10,991.75	10,997.29	10,998.36
1+25	10,993.10	10,992.10	10,989.10	10,994.64	10,995.71

NOTES

1. Provide riprap armoring from end of breach to existing ground to prevent headcutting and erosion.
2. Flood elevations through the breach represent elevations as if the existing spillway does not operate.
3. Place riprap through breach in layers to maintain correct gradations.

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PROVO AREA OFFICE
PROVO, UTAH

GARFIELD BASIN LAKES DAM STABILIZATION

FIVE POINT LAKE SPILLWAY MODIFICATION

BREACH PROFILE AND SECTIONS

DESIGNED SCOTT WINTERTON, P.E. CHECKED MIKE TALBOT, P.E.
DRAWN MICHAEL DRAPER TECH. APPR. CARY SOUTHWORTH, P.E. (CARY SOUTHWORTH, P.E.)
APPROVED /S/ SCOTT RICH, P.E. (SCOTT RICH, P.E. – PEER REVIEWER)

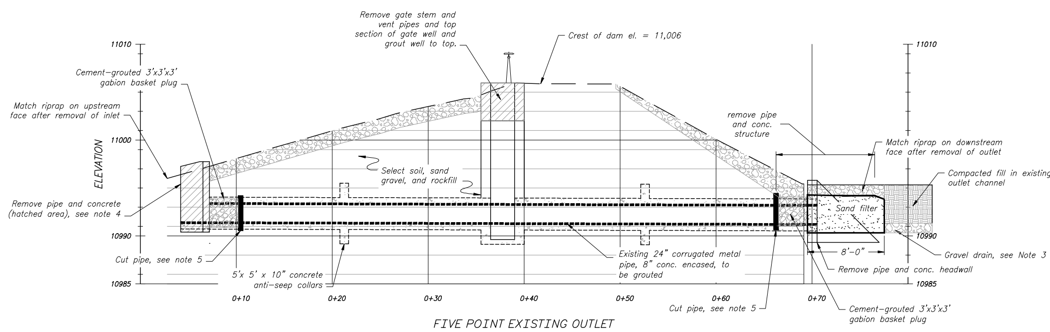
PROVO, UTAH 2009–03–02 0A58–418–91

D

C

B

A



FIVE POINT EXISTING OUTLET

NOTES

1. Provide compacted filter material over last 8' of pipe removal trench.
2. Trench walls shall be sloped to allow adequate compaction between fill and natural ground. Actual slope will depend on compaction method used.
3. Extend gravel drain through compacted sloped material to discharge under riprap.
4. Fill inlet area with embankment material compacted to 95% maximum density.
5. Do not remove outlet cutoff collar.

SAND FILTER MATERIAL GRADATION REQUIREMENTS

SIEVE SIZE	% PASSING BY WEIGHT
1/2 inch	100
3/8 inch	100
No. 4	95–100
No. 8	80–100
No. 16	50–85
No. 30	25–60
No. 50	10–30
No. 100	2–10
No. 200	0–3

GRAVEL DRAIN MATERIAL GRADATION REQUIREMENTS

SIZE	% PASSING BY WEIGHT
1 1/2 inch	90–100
3/4 inch	55–100
3/8 inch	19–75
No. 4	0–40
No. 8	0–10
No. 16	0

5 0 5 10 15
SCALE OF FEET

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PROVO AREA OFFICE
PROVO, UTAH

GARFIELD BASIN LAKES
DAM STABILIZATION

FIVE POINT LAKE

EXISTING OUTLET PROFILE

DESIGNED SCOTT WINTERTON, P.E. CHECKED MIKE TALBOT, P.E.
DRAWN MICHAEL DRAPER TECH. APPR. CARY SOUTHWORTH, P.E.
CARY SOUTHWORTH, P.E.
APPROVED /S/ SCOTT RICH, P.E.
SCOTT RICH, P.E. – PEER REVIEWER

PROVO, UTAH 2009-02-23 0A58-418-92

DATE AND TIME PLOTTED
27-Mar-09 3:30 PM
PLOTTED BY
MDRAPER

CAD SYSTEM
AUTOCAD 2005
CAD FILENAME
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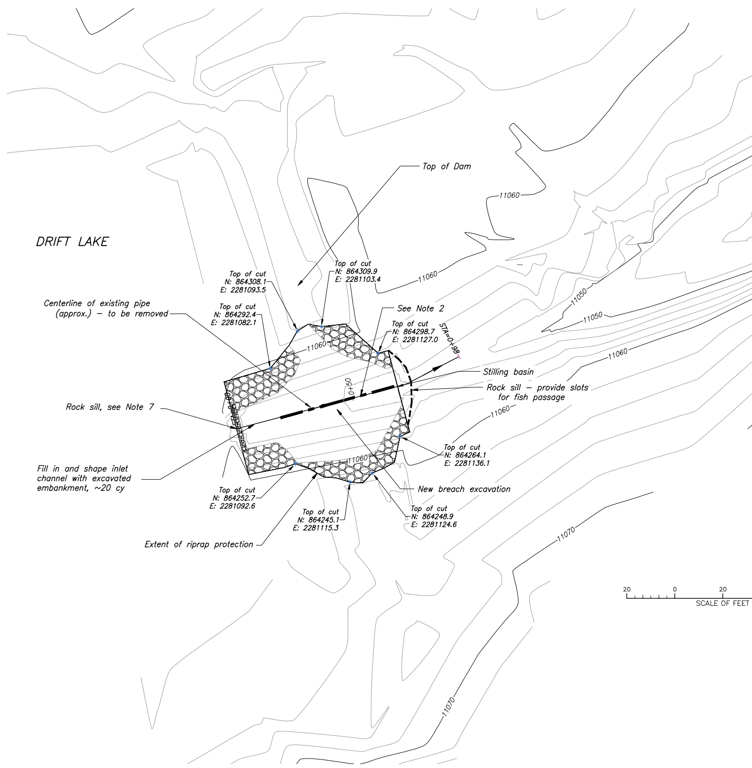
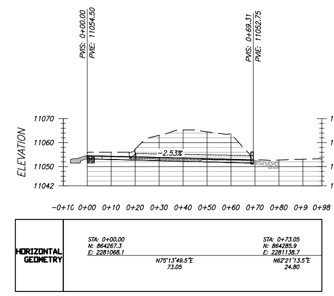


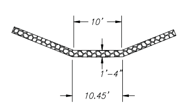


PROFILE: DRIFT BREACH

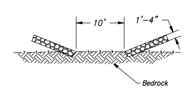
SEE 0A58–418–94 FOR ADDITIONAL DETAIL

NOTES

1. Contour interval is 2 feet.
2. Vary centerline alignment along breach to create resting pools.
3. Breach El. 11,054.50
4. Cut vol. = 850 c.y.
5. Contours shown through the breach represent excavated grade below final riprap placement.
6. Grid factor = 0.99949466
7. Rock sill shall be 12"–24" riprap. Upstream end of outlet is approximated. Field verify actual elevations to extend breach cutoff point as far upstream as possible.



Breach – 16 inch riprap depth
10 ft. bottom width
1.33 ft. riprap thickness
2.5:1 Cut slopes



Breach – excavated to bedrock
10 ft. bottom width
1.33 ft. riprap thickness on side slopes
2.5:1 Cut slopes

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BUREAU OF RECLAMATION

PROVO AREA OFFICE
PROVO, UTAH

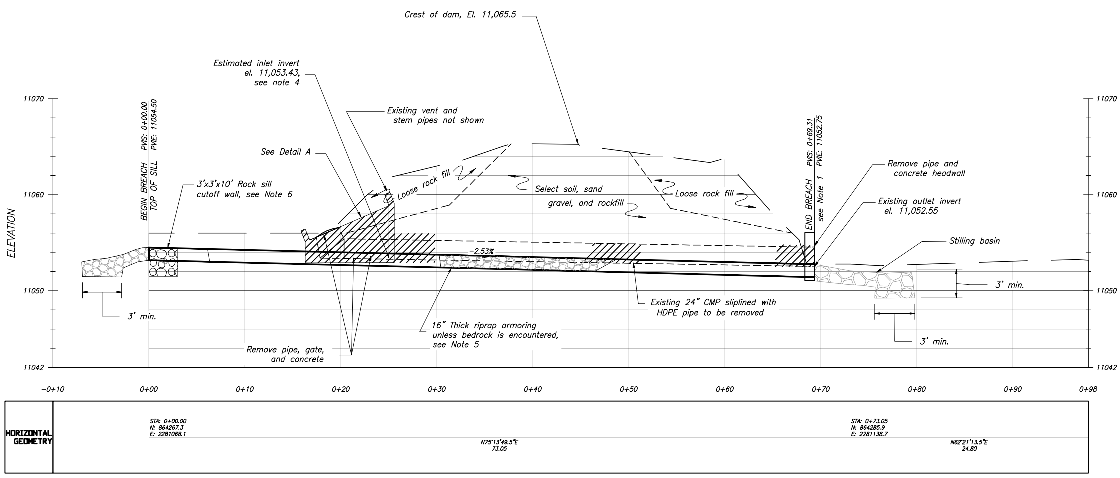
GARFIELD BASIN LAKES DAM STABILIZATION

DRIFT LAKE BREACH

SITE PLAN

DESIGNED SCOTT WINTERTON, P.E. CHECKED MIKE TALBOT, P.E.
DRAWN MICHAEL DRAPER TECH. APPR. CARY SOUTHWORTH, P.E. (CARY SOUTHWORTH, P.E.)
APPROVED /S/ SCOTT RICH, P.E. (SCOTT RICH, P.E. – PEER REVIEWER)

PROVO, UTAH 2009–02–20 0A58–418–93



PROFILE: DRIFT BREACH

5 0 5 10 15
SCALE OF FEET

BREACH RIPRAP				
D MIN.	D15	D50	D MAX.	THICKNESS MIN.
4"	6"	8"	12"	16"

NOTES

1. Provide riprap armoring from end of breach to existing ground to prevent headcutting and erosion.
2. Place riprap through breach in layers to maintain correct gradations.
3. Bedrock may be encountered at design elevations. Riprap is not required when bedrock is encountered.
4. Existing outlet pipe was assumed to rise at a 2% slope from the known outlet invert to the inlet invert.
5. Mix locally-available fines into riprap through breach and compact as conditions allow.
6. Place additional rock cutoff walls as field conditions permit where bedrock is not encountered through breach at 15 foot intervals minimum.

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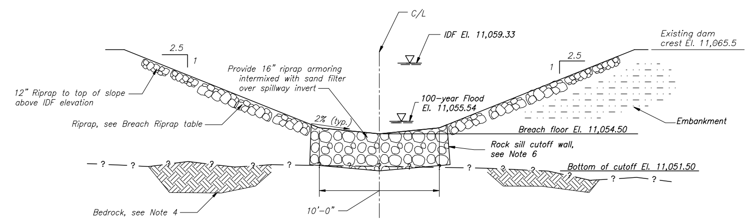
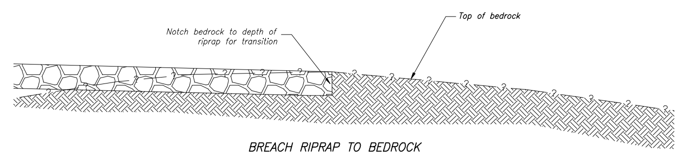
PROVO, UTAH

GARFIELD BASIN LAKES
DAM STABILIZATION
DRIFT LAKE SPILLWAY MODIFICATION
BREACH PROFILE

DESIGNED SCOTT WINTERTON, P.E. CHECKED MIKE TALBOT, P.E.
DRAWN MICHAEL DRAPER TECH. APPR. CARY SOUTHWORTH, P.E.
CARY SOUTHWORTH, P.E.
APPROVED /S/ SCOTT RICH, P.E.
SCOTT RICH, P.E. – PEER REVIEWER
PROVO, UTAH 2009-02-24 0A58–418–94

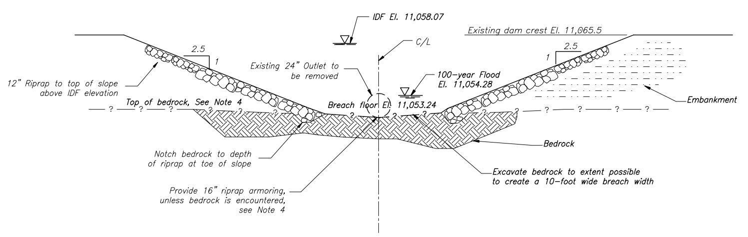


BREACH CHANNEL SECTION AT STA. 0+00



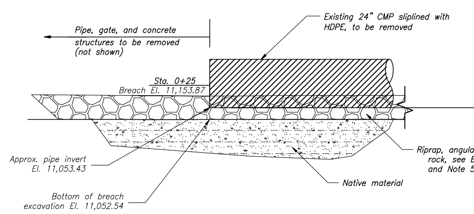
BREACH RIPRAP TO BEDROCK TRANSITION DETAIL

SCALE OF FEET



BREACH CHANNEL SECTION AT STA. 0+50

SCALE OF FEET



DETAIL A
OUTLET REMOVAL

SCALE OF FEET

BREACH RIPRAP				
D MIN.	D15	D50	D MAX.	THICKNESS MIN.
4"	6"	8"	12"	16"

NOTES

1. Flood elevations through the breach represent elevations as if the existing spillway does not operate.
2. Place riprap through breach in layers to maintain correct gradations.
3. Bedrock may be encountered at design elevations. Riprap is not required when bedrock is encountered.
4. Bedrock elevations are unknown. Adjustments will be required in the field to determine riprap requirements. Where riprap is utilized, a min. 16" thick layer shall be required.
5. Mix locally-available fines into riprap through breach and compact as conditions allow.
6. Rock sill shall be 18"-24"ø riprap intermixed with smaller rock to lock riprap together. Place additional rock cutoff walls as field conditions permit where bedrock is not encountered through breach at 15 foot intervals minimum.

SCALE OF FEET

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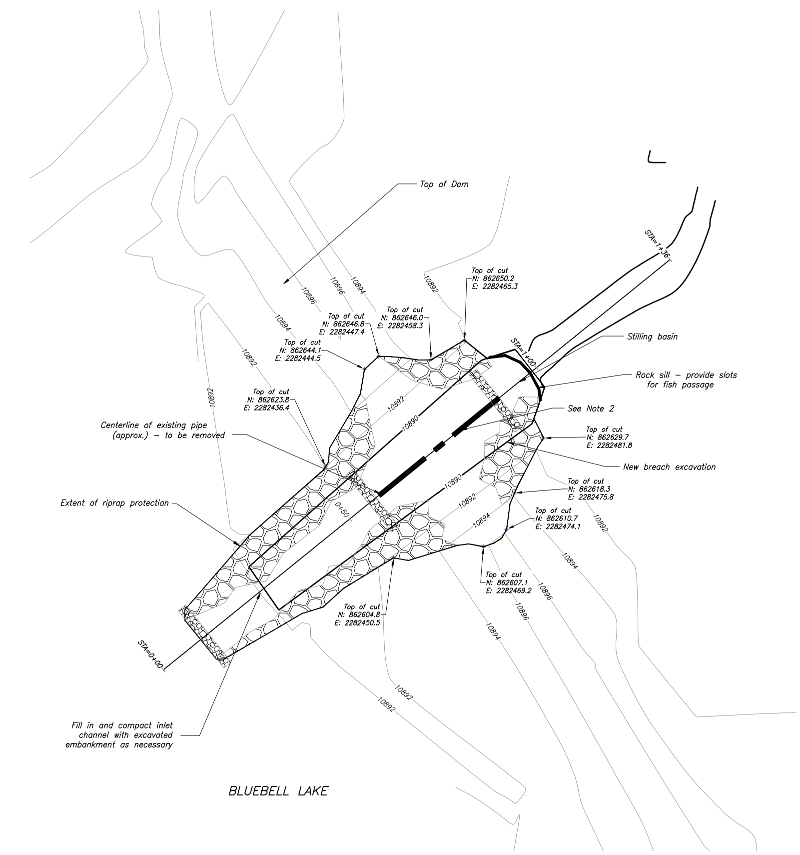
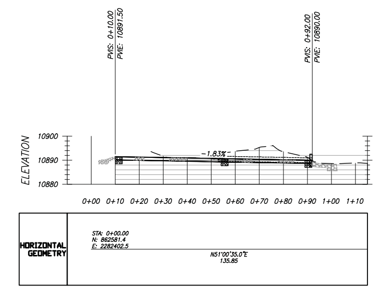
PROVO AREA OFFICE
PROVO, UTAH

GARFIELD BASIN LAKES
DAM STABILIZATION
DRIFT LAKE SPILLWAY MODIFICATION
BREACH ELEVATIONS AND DETAILS

DESIGNED SCOTT WINTERTON, P.E. CHECKED MIKE TALBOT, P.E.
DRAWN MICHAEL DRAPER TECH. APPR. CARY SOUTHWORTH, P.E.
APPROVED /S/ SCOTT RICH, P.E. — SCOTT RICH, P.E. – PEER REVIEWER
PROVO, UTAH 2009-02-24 0A58-418-95



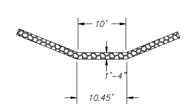


PROFILE: BLUEBELL BREACH

SEE OA58-418-97 FOR ADDITIONAL DETAIL

NOTES

1. Contour interval is 2 feet.
2. Vary centerline alignment along breach to create resting pools.
3. Breach El. 10,891.50
4. Cut vol. = 200 c.y.
5. Contours shown through the breach represent excavated grade below final riprap placement.
6. Grid factor = 0.99949466



Breach - 16 inch riprap depth
10 ft. bottom width
1.33 ft. riprap thickness
2.5:1 Cut slopes

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BUREAU OF RECLAMATION

PROVO AREA OFFICE
PROVO, UTAH

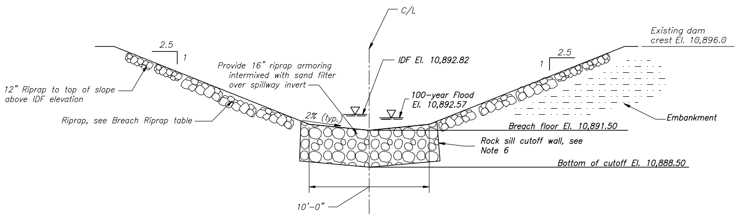
GARFIELD BASIN LAKES DAM STABILIZATION

BLUEBELL LAKE BREACH

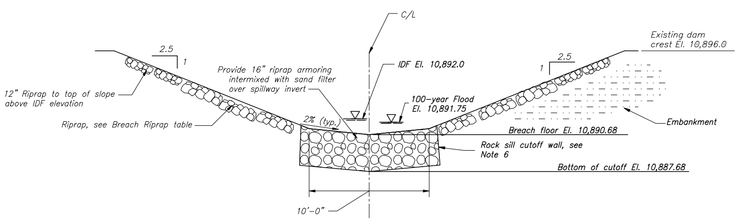
SITE PLAN

DESIGNED SCOTT WINTERTON, P.E. CHECKED MIKE TALBOT, P.E.
DRAWN MICHAEL DRAPER TECH. APPR. CARY SOUTHWORTH, P.E.
CARY SOUTHWORTH, P.E.
APPROVED /S/ SCOTT RICH, P.E.
SCOTT RICH, P.E. - PEER REVIEWER

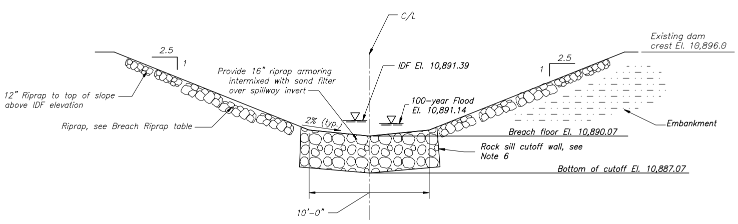
PROVO, UTAH 2009-02-20 OA58-418-96



BREACH CHANNEL SECTION AT STA. 0+10

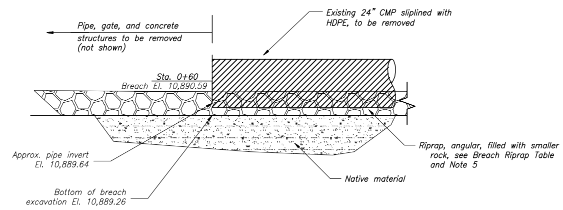


BREACH CHANNEL SECTION AT STA. 0+55



BREACH CHANNEL SECTION AT STA. 0+88

SCALE OF FEET (4 0 4 8 12)



DETAIL A
OUTLET REMOVAL

SCALE OF FEET (2 0 2 4 6)

BREACH RIPRAP				
D MIN.	D15	D50	D MAX.	THICKNESS MIN.
4"	6"	8"	12"	16"

NOTES

1. Flood elevations through the breach represent elevations as if the existing spillway does not operate.
2. Place riprap through breach in layers to maintain correct gradations.
3. Bedrock may be encountered at design elevations. Riprap is not required when bedrock is encountered.
4. Existing outlet pipe was assumed to rise at a 2% slope from the known outlet invert to the inlet invert.
5. Mix locally-available fines into riprap through breach and compact as conditions allow.
6. Rock sill shall be 18"-24"ø riprap intermixed with smaller rock to lock riprap together.

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PROVO AREA OFFICE
PROVO, UTAH

GARFIELD BASIN LAKES
DAM STABILIZATION
BLUEBELL LAKE SPILLWAY MODIFICATION
BREACH SECTIONS AND DETAIL

DESIGNED SCOTT WINTERTON, P.E. CHECKED MIKE TALBOT, P.E.
DRAWN MICHAEL DRAPER TECH. APPR. CARY SOUTHWORTH, P.E. (CARY SOUTHWORTH, P.E.)
APPROVED /S/ SCOTT RICH, P.E. (SCOTT RICH, P.E. – PEER REVIEWER)
PROVO, UTAH 2009-02-24 0A58-418-98

Appendix C - Inflow Hydrology Output Files

Dam Break Analysis Summary

	Spillway Floor Elev.	Bottom of Breach Elev.	Time to Breach (min.)	Dam Break Max. Flow (cfs)	Max. Depth in Channel (ft.)	Max. Depth @ confluence with Yellowstone River (ft.)
Superior	11,162	11,162	300	0	0	0
Five Point	10,997	10,991	300	450	3.89	3.14
Drift	11,054.5	11,052.5	300	44	1.66	1.66
Bluebell	10,891.5	10,888	300	102	2.38	2.12

100 yr. Storm Spillway Hydraulics

	AMC III Composite CN	Routed Flow in Spillway (cfs)**	Depth in Spillway (ft.)	Velocity in Spillway (ft.)
Superior	82.4	320	2.28	6.8
Five Point	74.9	178	1.54	6.1
Drift	90.5	62	1.04	4.7
Bluebell	77.5	75	1.07	5.5
* *100-year, 6-hour, SCS Type II event routed through the reservoir				

Appendix D – Construction Quantities

Construction quantities are approximate

Lake	Outlet channel Width*	Outlet channel Elevation	Outlet channel Excavation (cy)	Outlet Grout Backfill (cy)	Gabion Basket Grout (cy)	Riprap removed from Dam Volume (cy)	Inlet/Outlet Channel Fill (cy)	Riprap Placed In Breach (cy)	Riprap Volume Stilling Pool Sill (cy)	Filter Material (cy)
Superior	15'	11,162.0	650	3	15	150	120	306	15	5
Five Point	15'	10,997.0	1,000	10	15	120	300	501	15	5
Drift	10'	11,054.5	850	na	Na; but 12 (if needed)	200	20 (inlet only)	210	10	0 (5 CY if needed)
Bluebell	10'	10,891.5	200	na	Na; but 12 (if needed)	80	na	100	10	0 (5 CY if needed)
* 2.5:1 sideslopes, both sides, finished width										

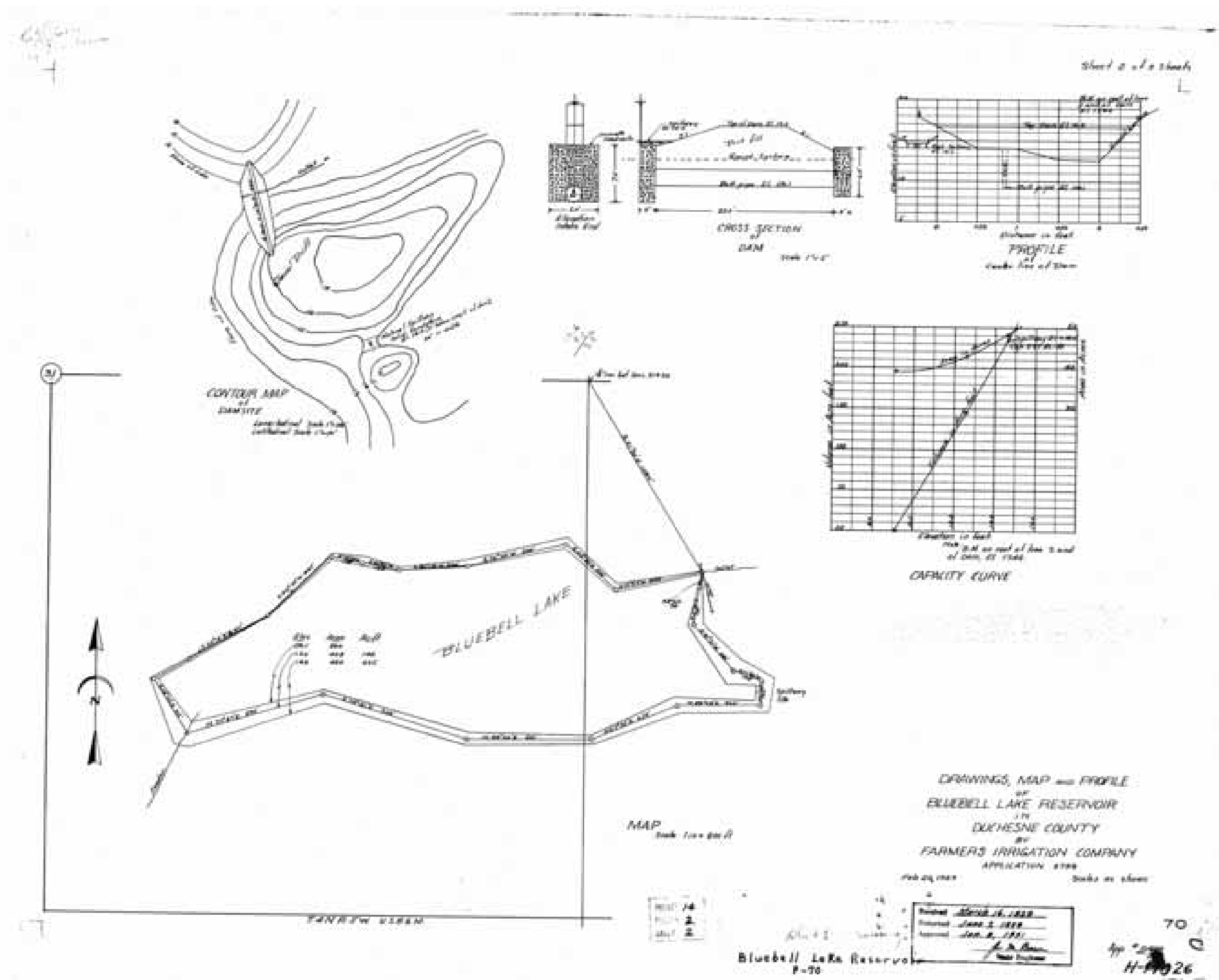
Lake	Total Bulk Amount of Material Handled **
Superior	1,246 CY
Five Point	1,941 CY
Drift	1,290 CY
Bluebell	390 CY

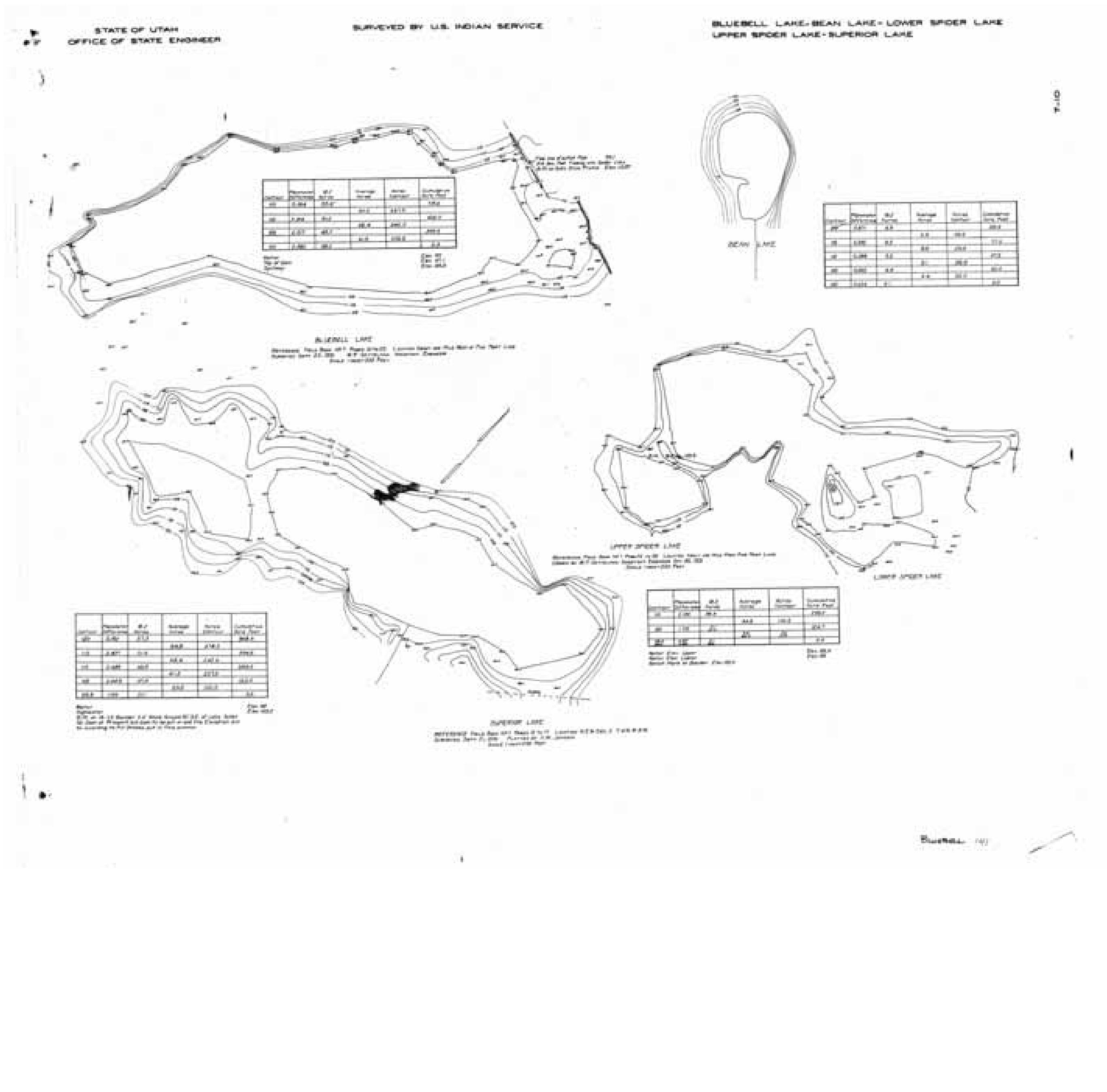
**** The sum of 'Outlet Channel Excavation' + 'Riprap Removed from Dam' + 'Riprap Placed in Breach' + 'Riprap Volume, Sill' + 'Inlet/Outlet Channel Fill' + 'Filter Material'**

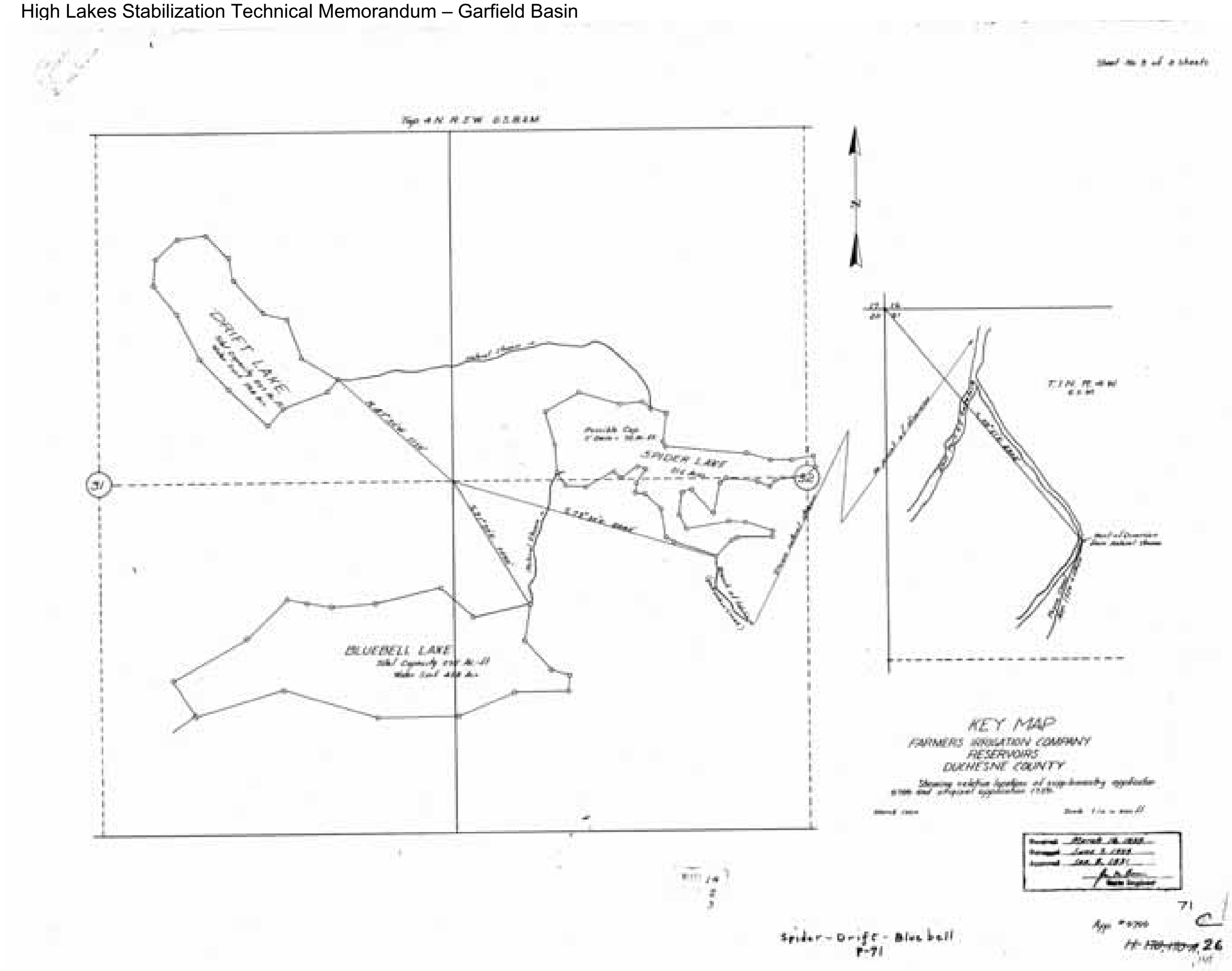
Appendix E – Dam Break Output Files

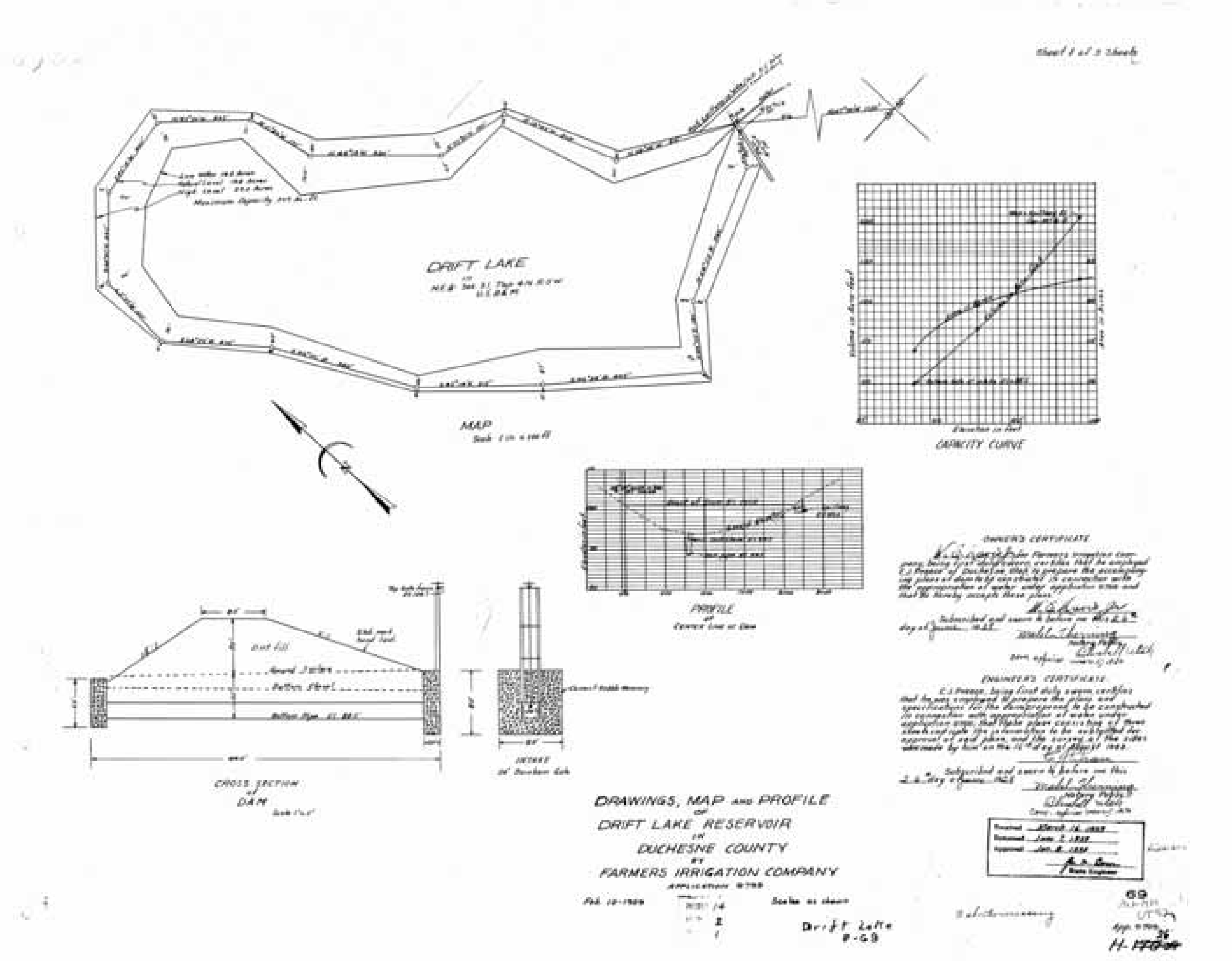
Dam Break Scenarios				
	Outlet Elevation	Dam Break Breach Elevation	Height to Breach (Hydraulic Head)	Dam Break Maximum Flow (cfs)
Superior	11,162.0	11,162.0	0	0
	11,163.0	11,162.0	1	28
	11,164.0	11,162.0	2	71
Five Point	10,994.0	10,991.0	3	155
	10,995.0	10,991.0	4	240
	10,996.0	10,991.0	5	339
	10,997.0	10,991.0	6	450
	10,998.0	10,991.0	7	566
Drift	11,053.0	11,052.5	0.5	2
	11,054.0	11,052.5	1.5	27
	11,054.5	11,052.5	2	44
	11,055.0	11,052.5	2.5	73
	11,056.0	11,052.5	3.5	112
Bluebell	10,890.0	10,888.0	2	62
	10,891.0	10,888.0	3	133
	10,891.5	10,888.0	3.5	102
	10,892.0	10,888.0	4	200
	10,893.0	10,888.0	5	279
	10,894.0	10,888.0	6	379

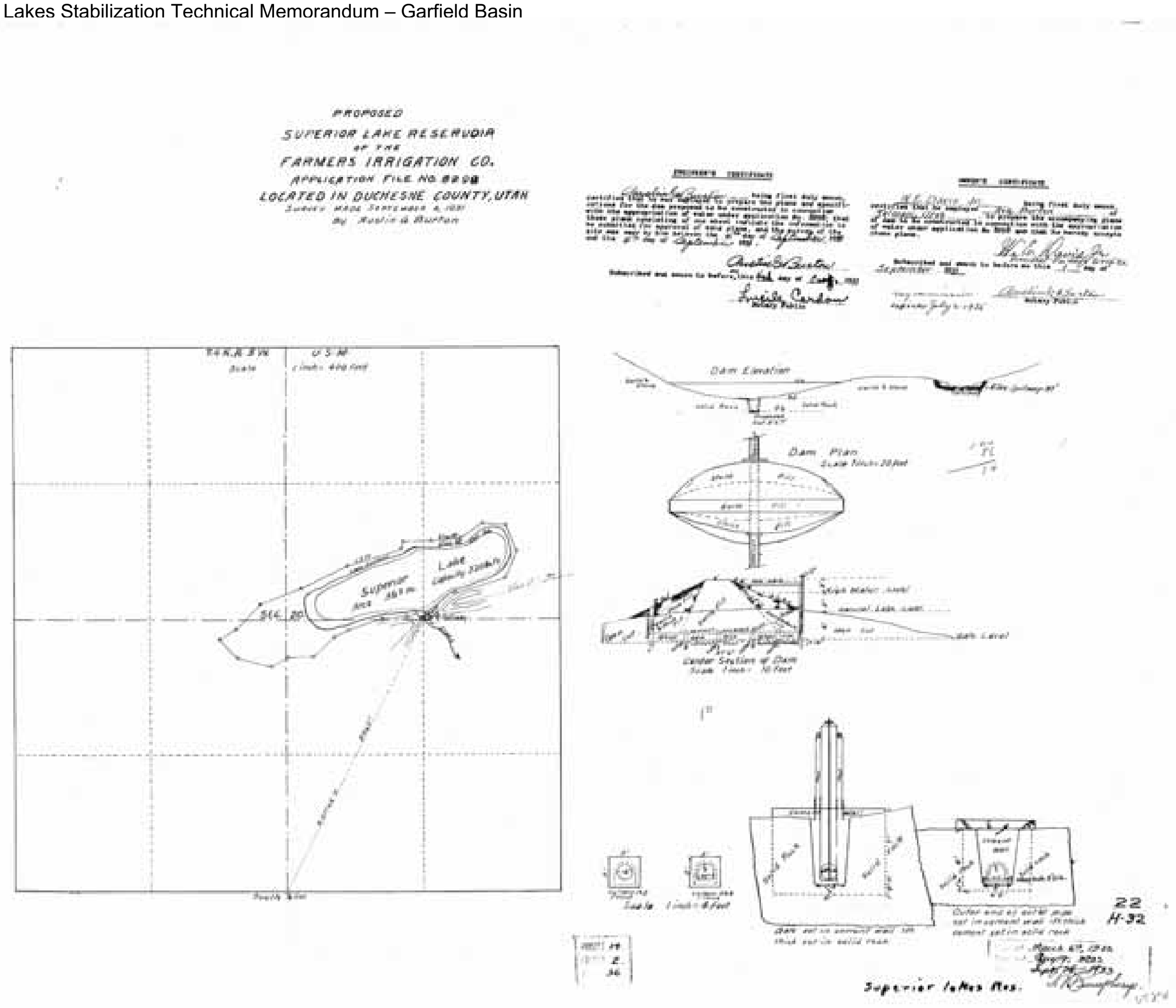
Appendix F – Historical Drawings

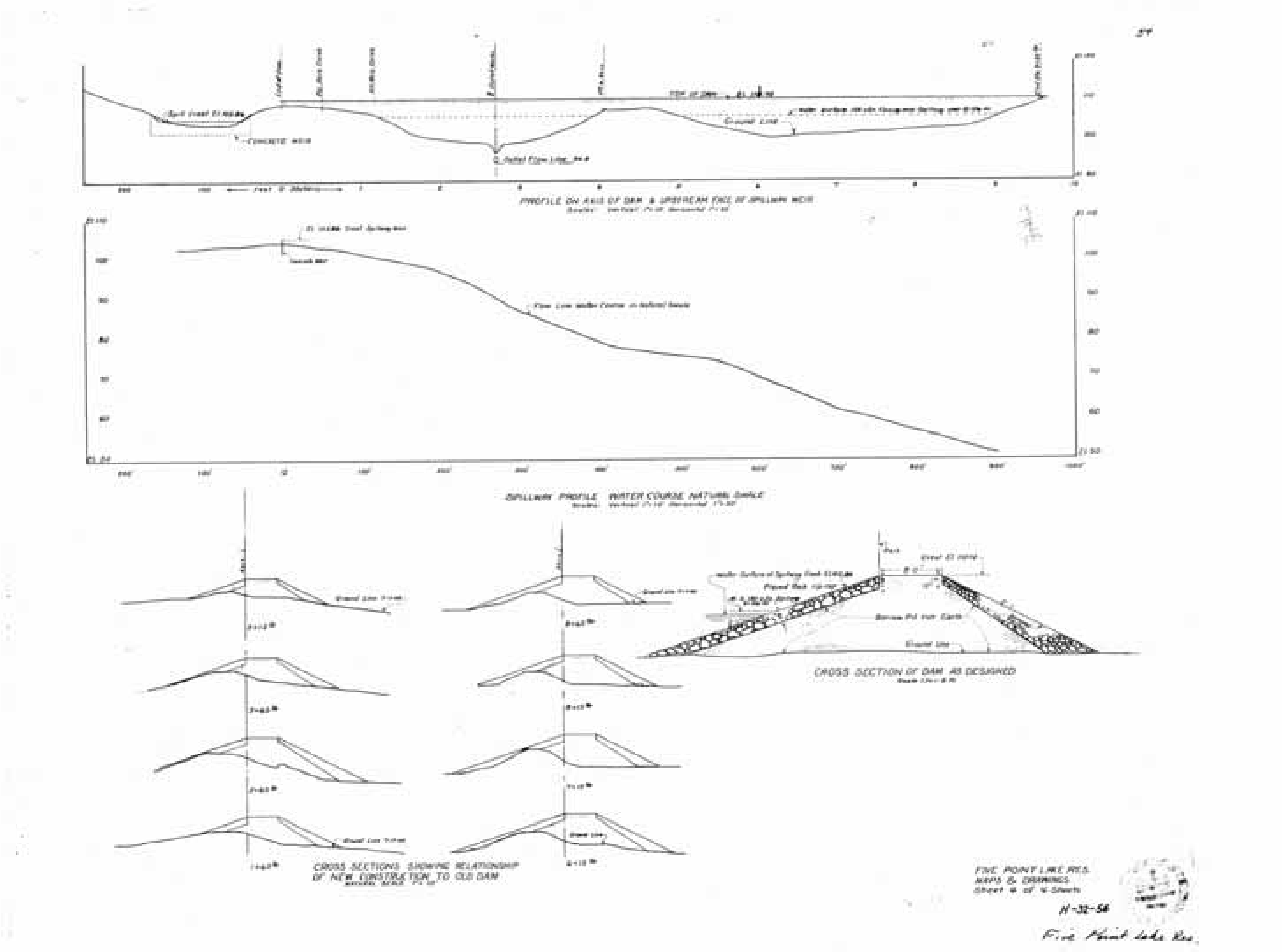

CONTOUR MAP
DAMSITE
CROSS SECTION
DAM
PROFILE
CAPACITY CURVE
BLUEBELL LAKE
MAP
DRAWINGS, MAP AND PROFILE
BLUEBELL LAKE RESERVOIR
DUCHESNE COUNTY
FARMERS IRRIGATION COMPANY
Bluebell Lake Reservo
70

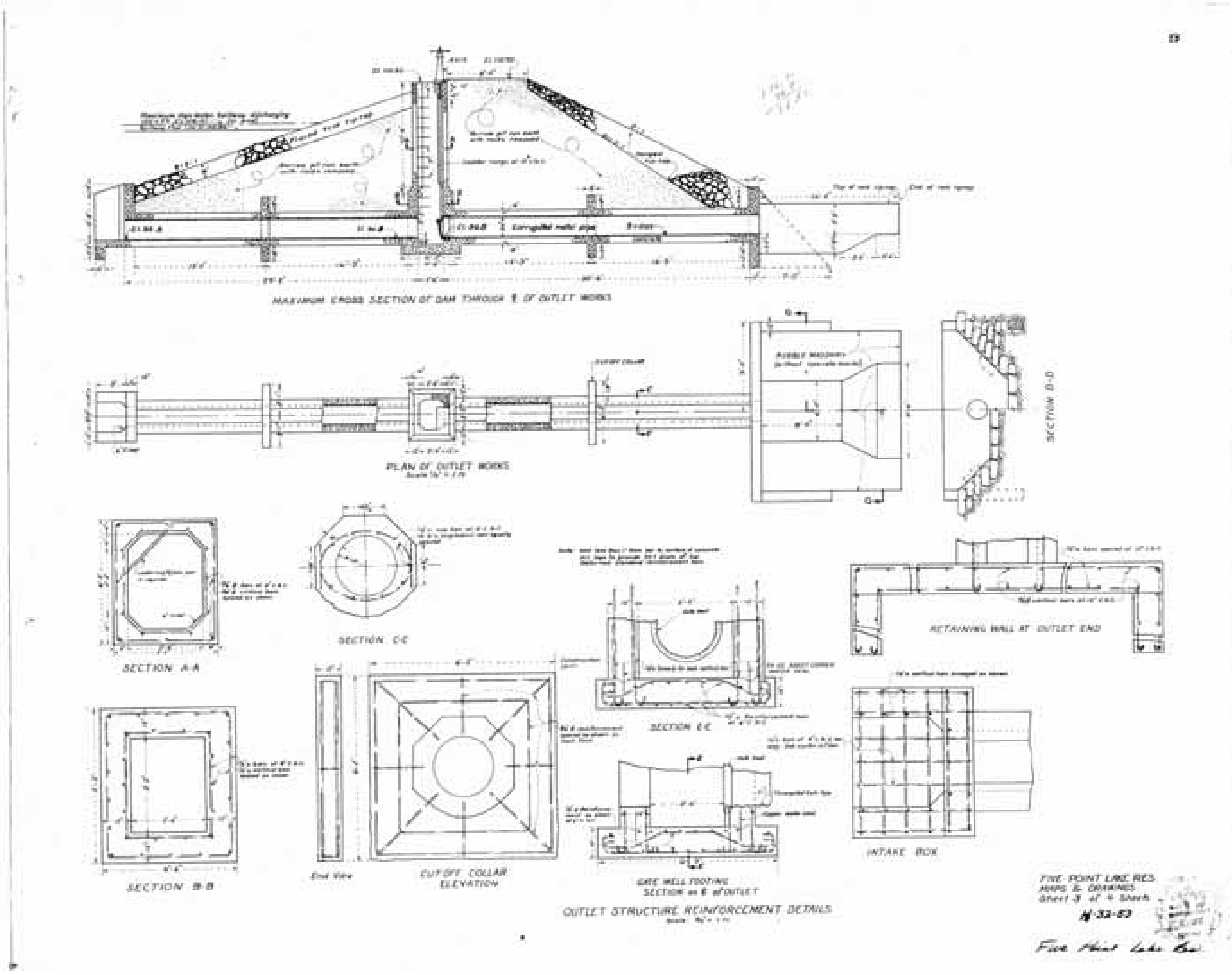

STATE OF UTAH
OFFICE OF STATE ENGINEER
SURVEYED BY U.S. INDIAN SERVICE
BLUEBELL LAKE-BEAN LAKE-LOWER SPIDER LAKE
UPPER SPIDER LAKE-SUPERIOR LAKE
BEAN LAKE
BLUEBELL LAKE
UPPER SPIDER LAKE
LOWER SPIDER LAKE
SUPERIOR LAKE

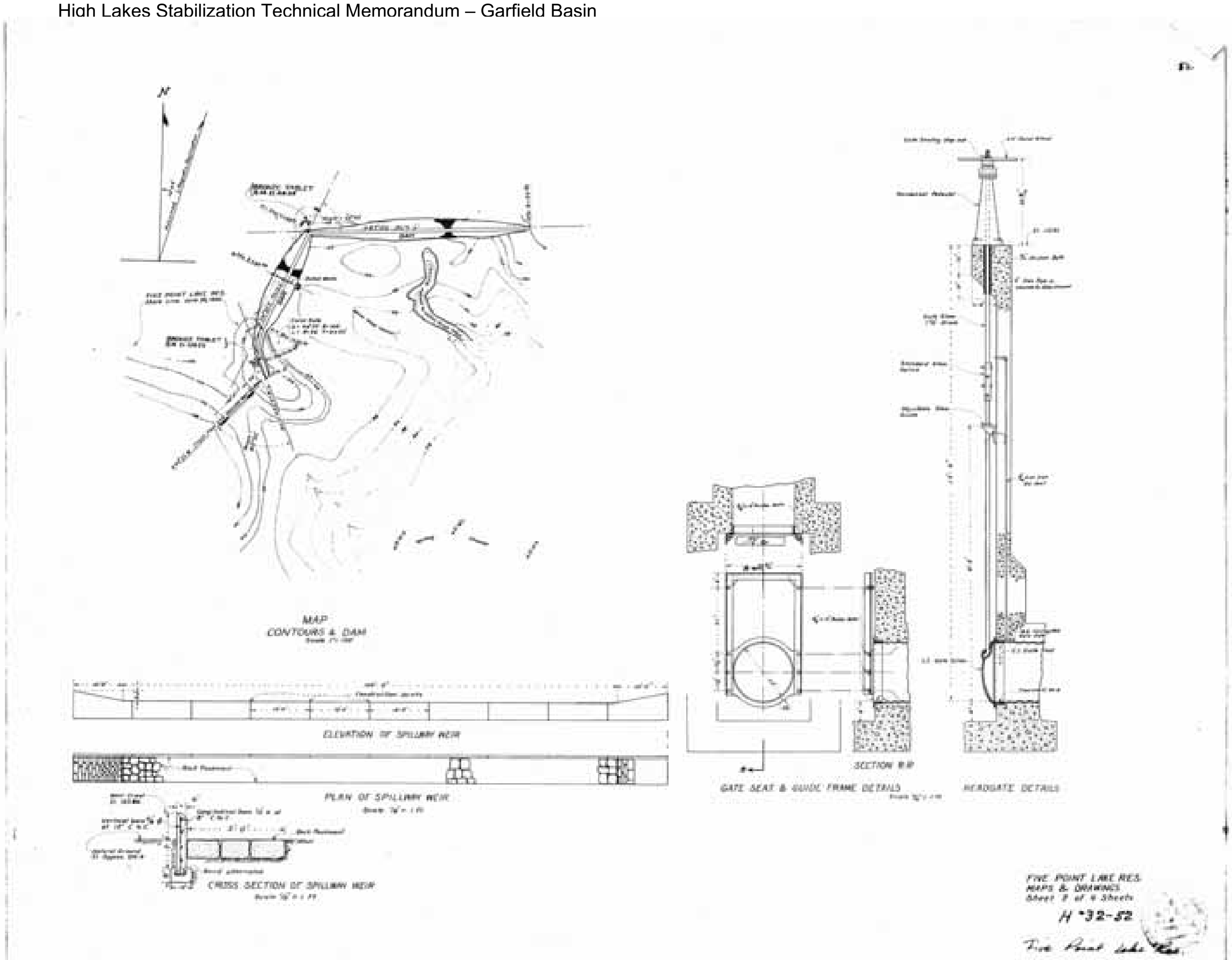

DRIFT LAKE
SPIDER LAKE
BLUEBELL LAKE
KEY MAP
FARMERS IRRIGATION COMPANY
RESERVOIRS
DUCHESNE COUNTY
Spider - Drift - Blue bell
P-71
71
26

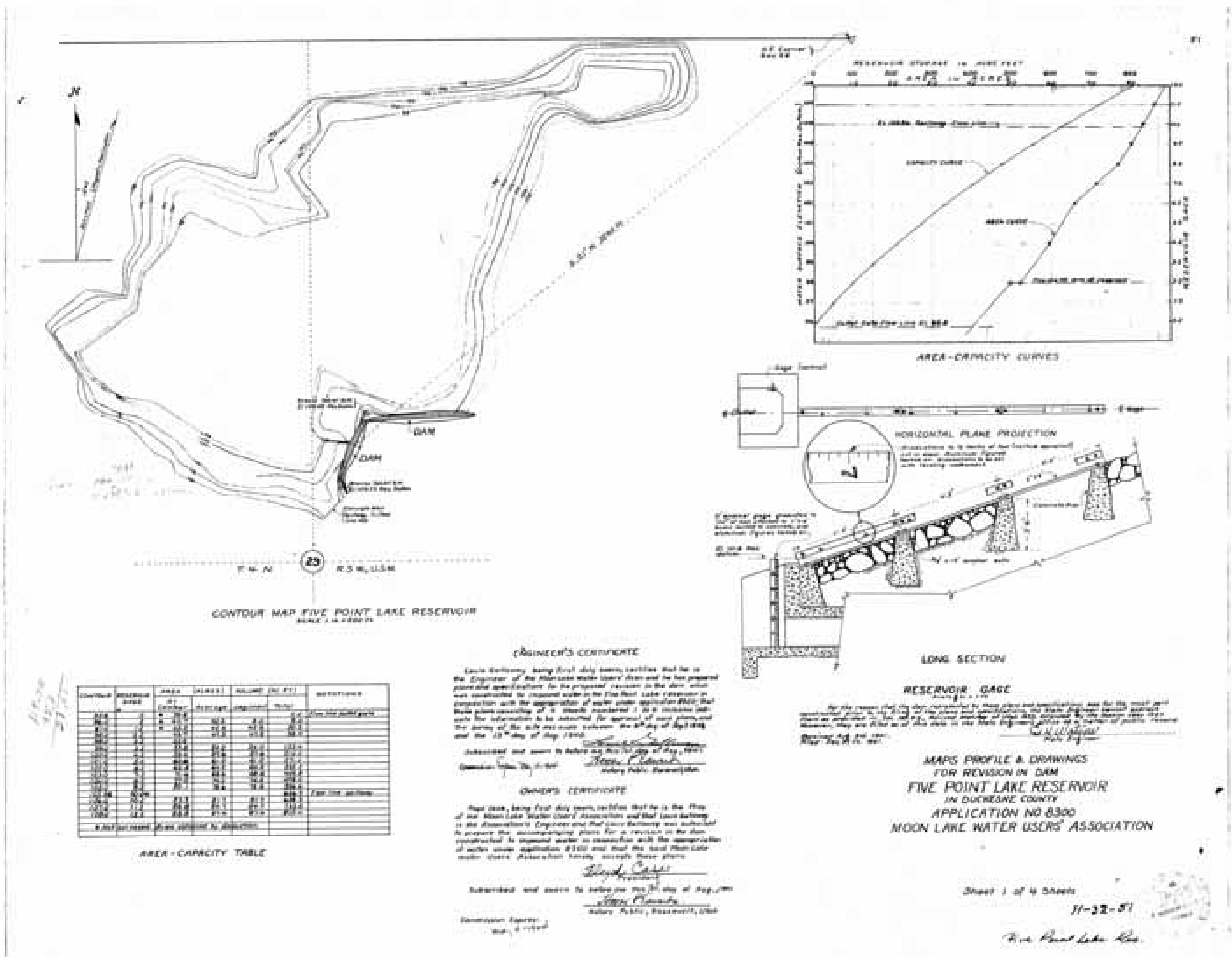

DRIFT LAKE
MAP
CAPACITY CURVE
PROFILE
CROSS SECTION OF DAM
INTAKE
OWNER'S CERTIFICATE
ENGINEER'S CERTIFICATE
DRAWINGS, MAP AND PROFILE
OF
DRIFT LAKE RESERVOIR
IN
DUCHESNE COUNTY
BY
FARMERS IRRIGATION COMPANY
Scales as shown
Drift Lake
69

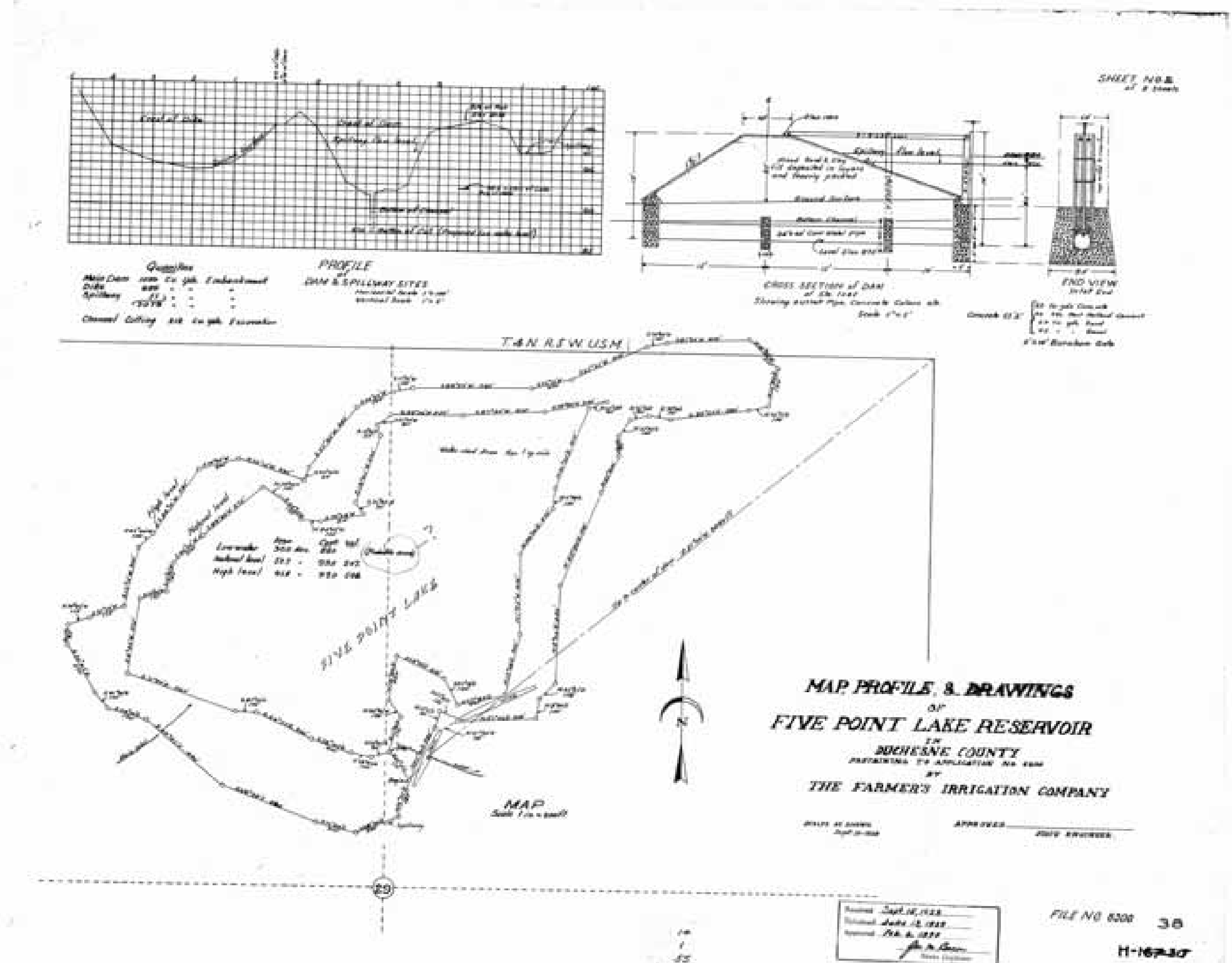

PROPOSED
SUPERIOR LAKE RESERVOIR
OF THE
FARMERS IRRIGATION CO.
LOCATED IN DUCHESNE COUNTY, UTAH
Dam Elevation
Dam Plan
Superior Lake
Center Section of Dam
22
H-32
Superior lakes Res.


PROFILE ON AXIS OF DAM & UPSTREAM FACE OF SPILLWAY WEIR
CONCRETE WEIR
Ground Line
SPILLWAY PROFILE WATER COURSE NATURAL SWALE
CROSS SECTION OF DAM AS DESIGNED
CROSS SECTIONS SHOWING RELATIONSHIP OF NEW CONSTRUCTION TO OLD DAM
FIVE POINT LAKE RES.
MAPS & DRAWINGS
Sheet 4 of 4 Sheets
H-32-56
Five Point Lake Res.


MAXIMUM CROSS SECTION OF DAM THROUGH ℄ OF OUTLET WORKS
PLAN OF OUTLET WORKS
SECTION D-D
RUBBLE MASONRY
SECTION A-A
SECTION C-C
SECTION E-E
RETAINING WALL AT OUTLET END
SECTION B-B
End View
CUT OFF COLLAR ELEVATION
GATE WELL FOOTING SECTION on ℄ of OUTLET
INTAKE BOX
OUTLET STRUCTURE REINFORCEMENT DETAILS
FIVE POINT LAKE RES.
MAPS & DRAWINGS
Sheet 3 of 4 Sheets


MAP
CONTOURS & DAM
ELEVATION OF SPILLWAY WEIR
PLAN OF SPILLWAY WEIR
CROSS SECTION OF SPILLWAY WEIR
SECTION B-B
GATE SEAT & GUIDE FRAME DETAILS
HEADGATE DETAILS
FIVE POINT LAKE RES.
MAPS & DRAWINGS
H *32-52


CONTOUR MAP FIVE POINT LAKE RESERVOIR
DAM
DAM
T. 4 N.
25
R. 5 W., U.S.M.
AREA-CAPACITY CURVES
CAPACITY CURVE
AREA CURVE
HORIZONTAL PLANE PROJECTION
LONG SECTION
RESERVOIR GAGE
AREA-CAPACITY TABLE
ENGINEER'S CERTIFICATE
OWNER'S CERTIFICATE
MAPS PROFILE & DRAWINGS
FOR REVISION IN DAM
FIVE POINT LAKE RESERVOIR
IN DUCHESNE COUNTY
APPLICATION NO 8300
MOON LAKE WATER USERS' ASSOCIATION
Sheet 1 of 4 Sheets


SHEET NO.2
PROFILE
DAM & SPILLWAY SITES
CROSS SECTION of DAM
END VIEW
T.4N R.5W U.S.M.
FIVE POINT LAKE
MAP
MAP, PROFILE, & DRAWINGS
OF
FIVE POINT LAKE RESERVOIR
IN
DUCHESNE COUNTY
BY
THE FARMER'S IRRIGATION COMPANY
29
FILE NO 5200
38