

Memorandum

To: City of Flandreau
From: Tom MacDonald and Ron Koth
Subject: Flandreau Dam Alternatives Analysis – 10% Design
Date: September 28, 2020
Project: Flandreau Dam Modifications

Purpose:

The purpose of this Flandreau Dam Alternatives Analysis is to review four modification options for the existing Flandreau Dam, allowing the City of Flandreau (City) the opportunity to select the preferred alternative to develop to a 30 percent design level and seek funding support. Each of the four modifications have been developed to address dam safety concerns and the City's primary project objectives.

Background:

The Flandreau Dam (Dam) is located on the Big Sioux River in the City of Flandreau, Moody County, South Dakota. The Dam was originally built for the purpose of powering the Flandreau Mill in 1881, but the Dam has become a safety hazard and an impediment to fish migration. The structure is entirely constructed of concrete and is approximately 11.5 feet tall. The Dam does not have a control mechanism. The principal spillway is an approximately 175-foot wide overflow weir. The Dam crest elevation is at 1526.8' (NAVD88). The Dam is located approximately 1,300 feet downstream of the Highway 13 Bridge and 450 feet upstream of the North Crescent Street Bridge.

The dam has experienced significant deterioration over the years, including partial loss of the concrete overlay, and erosion and loss of material at the abutments. Due to safety hazards associated with low-head dams, the City has requested that Barr develop four alternatives to remove or modify the existing structure.

Objectives:

In addition to stabilizing the existing structure and dam site, it is our understanding that each alternative must meet the following criteria:

- Mitigate the drowning hazard associated with the hydraulic roller caused by the Dam
- Be compatible with the upstream Highway 13 bridge
- Maximize the ability to secure public funding to design and construct the modification

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Project Approach:

Four alternatives were developed to meet the primary objectives described in the section above. The alternatives developed will meet the primary objectives; however, each of the alternatives also provide ancillary benefits to the City with respect to upstream pool elevations, construction costs, maintenance, aesthetics, and erosion control. The following approach was generally followed for each alternative developed:

1. Topographic and bathymetric surveys were completed to develop a base map of existing conditions to be used for development of each alternative.
2. An existing Army Corps HEC-RAS hydraulic model (Larsen 2009) was modified to include survey data collected at the Flandreau Dam site. The model was used to evaluate flow conditions upstream and downstream of the dam, and determine how water surface elevations might be affected by each of the alternatives considered.
3. The existing conditions model was modified to reflect removal of the dam; the extent of upstream water surface lowering was then estimated to understand the maximum impact to upstream areas.
4. Potentially impacted features were identified using Google Earth.
5. For each of the four alternatives plan and profile drawings were prepared using AutoCAD Civil 3D. These drawings were used to estimate the quantity of materials needed for construction.
6. A Class 4 Cost Estimate was developed for each alternative based upon the quantities developed during this 10 percent design phase.
7. Pros and cons were considered for each alternative.

Potentially Affected Upstream Features:

Several important features exist upstream of the dam that could potentially be impacted by modification or removal of the dam. It does not appear there are any active utility crossings upstream of the dam, at least as far as the Highway 13 bridge. There are several crossings in the vicinity of the Crescent Street bridge but this area should not be impacted by removal or modification of the dam. The identified features to date are as follows, in order of proximity to the dam:

- Avera Flandreau Hospital
- Highway 13 Bridge
- Flandreau Park
- River's Bend Country Club Golf Course
- Tribal Land

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Those features that are closest to the dam are most likely to be affected by lowered river levels – i.e. the hospital and the Highway 13 bridge. It may be necessary to provide stabilization countermeasures at these sites depending on the selected alternative and refined analysis.

Preliminary Hydraulic Summary:

Survey of the bathymetry was conducted by Barr Engineering in July 2020. This data, in combination with updated LiDAR, was used to update the existing Army Corps of Engineer’s hydraulic model for this segment of the Big Sioux River. The model was run for event flows ranging from 2-year to 100-year recurrence interval, as well as an assumed base flow of 200 cfs, in order to compare the estimated upstream elevations for each alternative with existing conditions. Table 1 below presents a summary of estimated water surface elevations for selected events upstream of the dam (between the dam and Highway 13 bridge). Water surface elevations downstream of the dam would not be affected by implementation of any of the alternatives.

Table 1 - Estimated upstream water surface elevations 1,000’ upstream of dam

Alternative	200 CFS (est. base flow) Water Surface Elevation (NAVD88 feet)	3,810 CFS (2-Year Event) Water Surface Elevation (NAVD88 feet)	10,500 CFS (10-Year Event) Water Surface Elevation (NAVD88 feet)	44,000 CFS (100-Year Event) Water Surface Elevation (NAVD88 feet)
Existing Conditions	1527.4	1530.9	1532.9	1537.0
Alternative 1: Full Removal	1521.2	1526.6	1531.0	1537.0
Alternative 2: Full Height Rapids	1527.4	1530.9	1532.9	1537.0
Alternative 3: Rapids 3.2-ft. Lower	1524.5	1528.8	1532.4	1536.9
Alternative 4: Rock Ramp (Full-Height)	1527.4	1530.9	1532.9	1537.0

Alternatives:

Four alternatives have been reviewed, and completed to an approximate 10 percent design level. These alternatives include:

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1. Remove the low-head dam and abutments;
2. Replace the low-head dam with a rock-rapids structure, maintaining a similar crest elevation as existing conditions;
3. Replace the low-head dam with a rock-rapids structure, with a crest elevation approximately 3.2-feet lower than existing conditions;
4. Remove a portion of the low-head dam, entirely remove the abutments, and construct full height rock-rapids structure over the partially removed dam structure.

A detailed description of each alternative is presented in the following sections. Figures of each alternative are presented in Appendix A.

Alternative 1: Complete Removal of the Existing Structure

For this alternative, the entire dam structure would be removed to the natural river bed. It is assumed that the existing structure would be removed and disposed of off-site. At each abutment, the existing dam embankment would be sloped back from the river's edge, and the excavated material would be placed along left riverbank upstream of the existing fish ladder. The existing fish ladder would be removed, sediment upstream of the dam would be removed and hauled offsite, and the newly exposed riverbanks (due to the lowered upstream pool) would be restored. A plan and profile figure for Alternative 1 is provided in Appendix A.

Table 2 presents Pros and Cons for Alternative 1. These items have been developed based upon Barr's past experience with similar low-head dam structures, and our understanding of the City's primary project objectives.

Table 2 - Pros and Cons of Alternative No. 1 – Full Dam Removal

Pros	Cons
Elimination of hydraulic roller and dam safety liability	Eliminates upstream pool
Lowest construction cost	May cause temporary instability of upstream shoreline
Removes aquatic barrier	Slope stabilization required adjacent to the existing dam structure
Provides canoe/kayak passage	Bank stabilization may be required adjacent to hospital
Eliminates future maintenance cost	Temporary increase in sediment transport from upstream of dam
Reduces upstream flooding for certain flow conditions up to at least the 10-year event	Potential scour impacts at the Highway 13 Bridge due to lower water levels
Water management during construction is minimal	Potential impact to nearby wells
Provides upstream fish and aquatic species passage and habitat	

Assumptions

For this alternative, we have assumed the following:

- The existing dam would be removed and disposed of offsite.
- Upstream sediment for a distance of 220-feet would be removed and hauled offsite.

Alternative 2: Construction of Rock Arch Rapids Maintaining the Existing Crest

This option includes construction of a rock-rapids spillway within the channel upstream of the existing dam. The current dam would be removed, allowing the rock rapids to be placed upstream to allow for a shallow slope without interfering with the downstream bridge. Sediment within the footprint of the rock rapids would be removed and disposed of offsite. A sheetpile wall would be placed at the upstream edge of the rock rapids to minimize seepage through the rocks and maximize the upstream pool elevation during low flow events. The new dam crest elevation would be similar to the existing structure. A plan and profile figure for Alternative 2 is provided in Appendix A. An example of a rock-rapids spillway is shown in **Figure 1** below.



Figure 1 - Rock-Rapids Spillway Example

Table 3 presents Pros and Cons for Alternative 2. These items have been developed based upon Barr’s past experience with similar low-head dam structures, and our understanding of the City’s primary project objectives.

Table 3 - Pros and Cons of Alternative No. 2 – Full-height Rock Arch Rapids

Pros	Cons
Elimination of hydraulic roller	Rock mass may be visible in low-flow conditions
Provides canoe/kayak passage during higher flows	Slight lowering of crest (compared to existing dam) will be necessary to maintain existing flood levels
Provides upstream fish and aquatic species passage and habitat	Requires diversion of river flows and dewatering of work area to properly install rock
Provides “aesthetic” feature	Highest-cost option
Rock helps stabilize newly exposed riverbank slopes	
Minimal maintenance associated with rock-rapids	
Existing upstream pool elevation is maintained	

Assumptions

For this alternative, we have assumed the following:

- The existing dam would be removed and disposed of offsite

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- Upstream sediment within the footprint of the rock ramp would be removed and hauled offsite.
- Rock rapids ramp will be constructed with a slope of 4% with boulder weirs spaced approximately 20-feet.
- Base rock (riprap) rock thickness assumed is 2.5 feet. Final thickness will be determined after completion of a hydraulic analysis to estimate expected flow and velocities.
- An upstream sheetpile wall was included to prevent leakage through the rocks and help maintain the upstream pool elevation. Sheetpile assumed to be a lightweight flat steel sheet.

Alternative 3: Construction of Rock Arch Rapids with a Lowered Crest Elevation

This option includes construction of a rock-rapids spillway within the channel upstream of the existing dam. The current dam would be removed, allowing the rock rapids to be placed upstream and allowing for a shallower slope without interfering with the downstream bridge. Sediment within the footprint of the rock rapids would be removed and hauled and disposed offsite. A sheetpile wall would be placed at the upstream edge of the rock rapids to minimize seepage through the rocks and maximize the upstream pool elevation during low flow events. This option is similar to Alternative 2, however, the crest elevation is lowered by approximately 3.2 feet which reduces rock volumes (and construction cost) and lowers upstream flood levels. A plan and profile figure for Alternative 3 is provided in Appendix A.

Table 4 presents Pros and Cons for Alternative 3. These items have been developed based upon Barr's past experience with similar low-head dam structures, and our understanding of the City's primary project objectives.

Table 4 - Pros and Cons of Alternative No. 3 – Partial-height Rock Arch Rapids

Pros	Cons
Elimination of hydraulic roller	Rock mass may be visible in low-flow conditions
Provides canoe/kayak passage during higher flows	Upstream pool elevation will be decreased approximately 3-feet from existing conditions
Provides upstream fish and aquatic species passage and habitat	Requires diversion of river flows and dewatering of work area to properly install rock
Provides “aesthetic” feature	Potential scour impacts at the Highway 13 Bridge due to lower water levels (less so than full removal alternative)
Rock helps stabilize newly exposed riverbank slopes	May cause some instability of upstream shoreline (less so than full removal alternative)
Minimal maintenance associated with rock-rapids	High-cost option compared to full removal
Upstream flood elevations lowered for some events	
A pool is maintained upstream of the existing dam site	

Assumptions

For this alternative, we have assumed the following:

- The existing dam would be removed and disposed of offsite.
- Upstream sediment within the footprint of the rock ramp would be removed and hauled offsite.
- Rock rapids spillway will be constructed with a slope of 4% with boulder weirs spaced approximately 20-feet.
- Base rock (riprap) thickness is assumed to be 2.5 feet. Final thickness will be developed after completion of a hydraulic analysis to estimate expected flow and velocities.
- Crest elevation would be reduced by 3.2 feet from existing conditions.
- An upstream sheetpile wall was included to prevent leakage through the rocks and help maintain the upstream pool elevation. Sheetpile assumed to be a lightweight flat steel sheet.

Alternative 4: Construction of Rock Arch Ramp Maintaining the Existing Crest

This option includes placement of a rock arch ramp within the channel upstream of the existing dam. The current dam would be partially removed, allowing the remaining structure to provide upstream stability and a seepage barrier for the rock arch ramp. The rock ramp slope in this alternative will be steeper to lower construction costs and avoid interfering with the downstream bridge. The new rock rapids crest elevation would be similar to the existing dam structure. A plan and profile figure for Alternative 4 is provided in Appendix A.

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Table 5 presents Pros and Cons for Alternative 4. These items have been developed based upon Barr’s past experience with similar low-head dam structures, and our understanding of the City’s primary project objectives.

Table 5 - Pros and Cons of Alternative No. 4 – Full-height Rock Arch Ramp

Pros	Cons
Elimination of hydraulic roller	Rock mass may be visible in low-flow conditions
Provides canoe/kayak passage during higher flows	May have small impact on upstream flood levels unless crest elevation is lowered slightly
Provides “aesthetic” feature	Likely would not provide upstream fish passage in river channel due to steeper slopes; existing fish ladder on right bank would be improved
Minimal maintenance associated with rock ramp	May require larger rock due to greater turbulence associated with steeper slope
Existing upstream pool elevation is maintained	
Lower cost than Alternatives 2 and 3	
Water control during construction simpler than for Alternatives 2 and 3 since a portion of dam will remain in place	
Upstream sediment removal likely not necessary	

Assumptions

For this alternative, we have assumed the following:

- The existing dam would be partially removed and disposed of offsite.
- Rock ramp will be constructed with a slope of 10% with boulder weirs spaced approximately 10-feet.
- The existing fish ladder would remain to allow for fish passage due to the steeper rock ramp slope. It is assumed the existing fish ladder will need to be repaired/improved as part of the project to providing upstream fish passage.
- Base rock (riprap) thickness assumed is 2.5 feet. Final thickness will be developed after completion of a hydraulic analysis to estimate expected flow and velocities.

Cost Estimate:

An opinion of probable cost has been developed to a Class 4 level, as defined by the AACE Accuracy Matrix for Estimating Classes for each of the four alternatives. The cost estimates are provided in **Attachment B**. A summary of the cost estimates, which include anticipated construction, engineering and permitting costs, is provided below in Table 6.

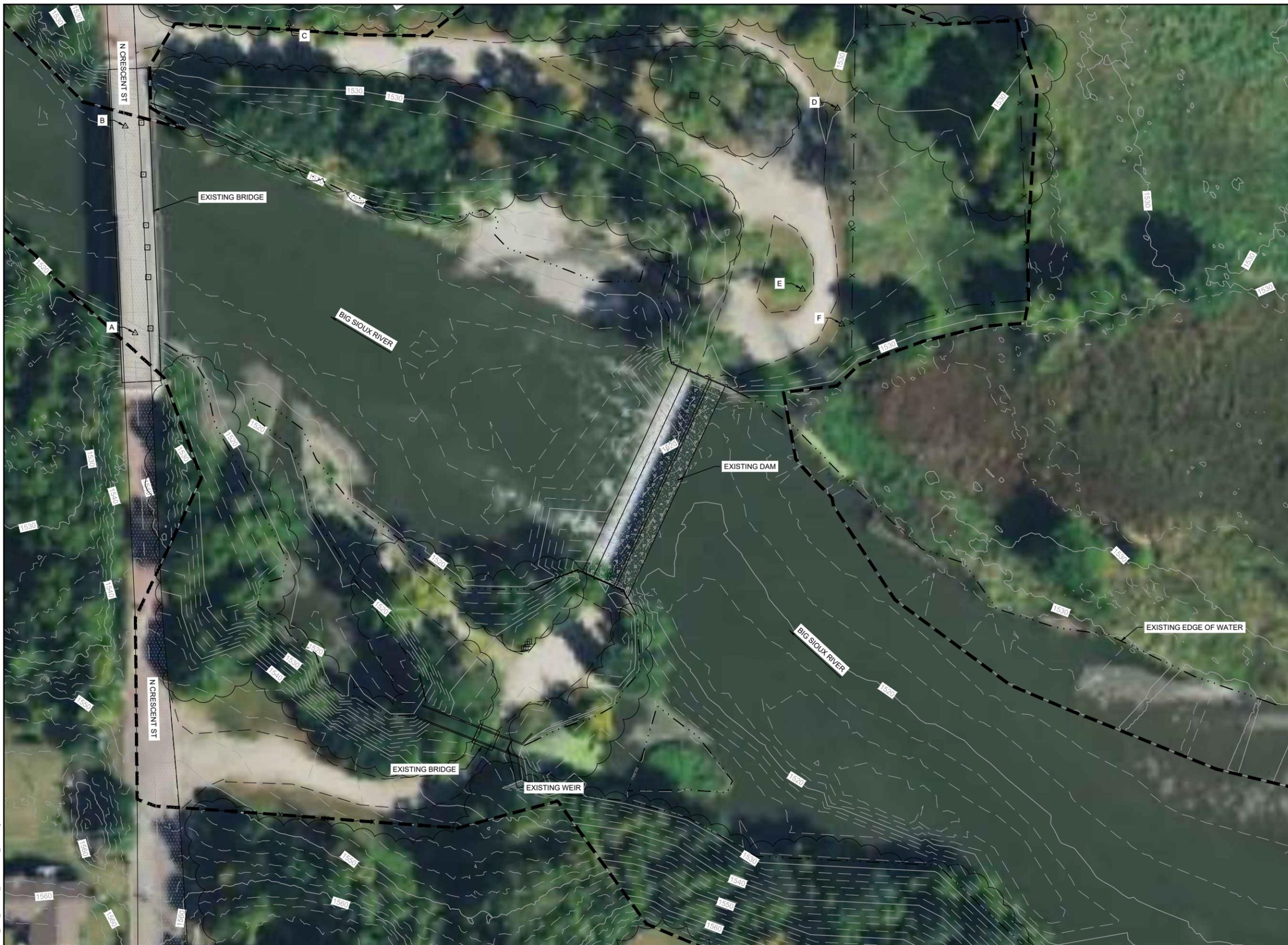
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Table 6 - Estimated Cost Summary

Alternative	Mid-Range Estimated Cost
Alternative 1 – Complete Removal of Existing Structure	\$778,000
Alternative 2 – Construction of Rock Arch Rapids Maintaining the Existing Crest	\$2,625,000
Alternative 3 – Construction of Rock Arch Rapids with a Lowered Crest Elevation	\$2,017,000
Alternative 4 – Partial Removal of Existing Structure and Construction of Steeper Rock Arch Ramp to Existing Crest Elevation	\$1,438,000

Recommendations for Next Steps:

After reviewing pros, cons, and associated costs for the four alternatives presented above, and after seeking public input, it is recommended that the City identify their preferred option and use the 10% design cost estimate for budget planning and early applications for cost-share funding. This project may qualify for cost-share assistance from entities such as the South Dakota Water Plan, East Dakota Water Development District, South Dakota Department of Game, Fish and Parks, US Fish and Wildlife Service and others. Cost estimates for the preferred alternative developed at 30% design level will refine the early 10% cost estimates used for initial cost-share funding requests from the potential cost-share partners.



LEGEND

	EXISTING TEN-FOOT CONTOUR
	EXISTING TWO-FOOT CONTOUR
	BORDER OF LIDAR SURVEY AND TOPOGRAPHIC SURVEY
	EXISTING EDGE OF WATER
	EXISTING FENCE
	EXISTING TREELINE
	EXISTING STRUCTURE
	EXISTING BITUMINOUS PAVEMENT
	EXISTING GRAVEL PAVEMENT
	EXISTING SIGN
	EXISTING GATE
	EXISTING BRIDGE PIER
	CONTROL POINT
	EXISTING CONCRETE

CONTROL POINTS

ID	EASTING	NORTHING	ELEVATION
A	2951348.4730	648942.5700	1538.85
B	2951340.8290	649102.1800	1536.37
C	2951467.1840	649181.2555	1533.03
D	2951892.1070	649116.0705	1530.47
E	2951864.9000	648976.3000	1530.93
F	2951895.4030	648949.3902	1531.51

- NOTES:**
- HORIZONTAL DATUM AND COORDINATE SYSTEM: SOUTH DAKOTA STATE PLANE SOUTH, NAD83/2011 NAVD88
VERTICAL DATUM: NAVD88
 - TOPOGRAPHIC SURVEY WAS COMPLETED ON 06/11/2020 AND 06/12/2020.
 - TOPOGRAPHIC SURVEY DATA WAS SUPPLEMENTED WITH LIDAR DATA COLLECTED BETWEEN 04/03/2012-05/16/2012.
 - HYDROGRAPHIC SURVEY WAS DONE USING Z-BOAT WITH CEE ECHO HYDROGRAPHIC SOFTWARE.

1 PLAN: EXISTING CONDITIONS

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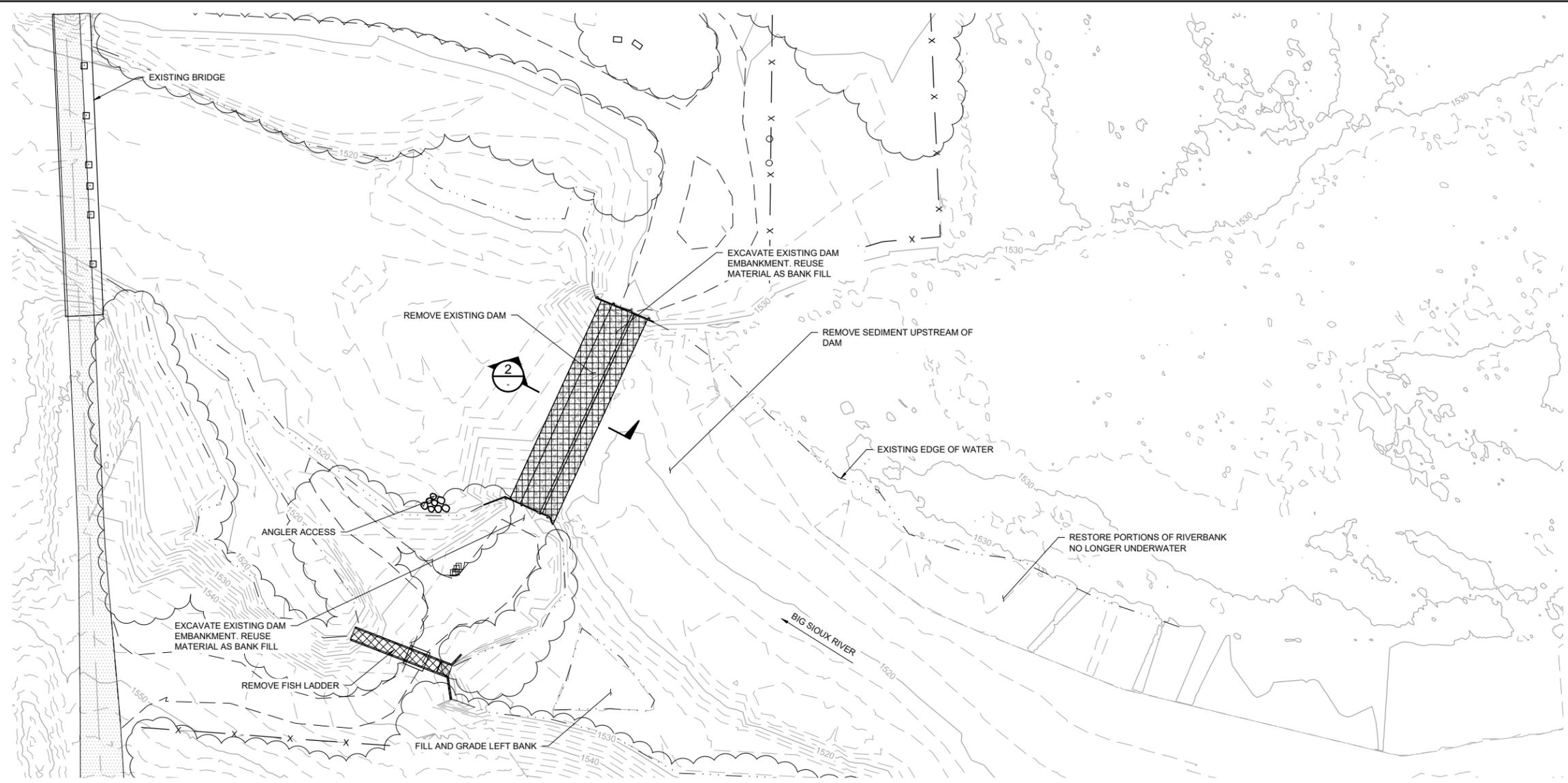
BARR

Project Office:
BARR ENGINEERING CO.
4300 MARKETPOINTE DRIVE
Suite 200
MINNEAPOLIS, MN 55435
Ph: 1-800-632-2277
Fax: (952) 832-2601
www.barr.com

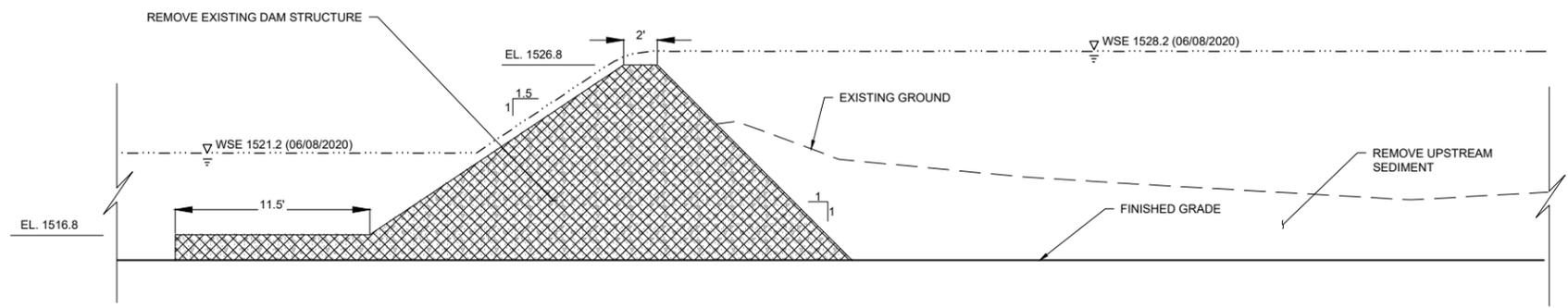
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CITY OF FLANDREAU
FLANDREAU, SOUTH DAKOTA

FLANDREAU DAM MODIFICATIONS FLANDREAU, SOUTH DAKOTA		BARR PROJECT No. 41/50-1001.00
EXISTING CONDITIONS DAM SITE PLAN		CLIENT PROJECT No.
DWG. No. FIGURE 1	REV. No. A	



1 PLAN: FULL DAM REMOVAL
SCALE IN FEET



2 PROFILE: FULL DAM REMOVAL
SCALE IN FEET

LEGEND

— 1520 —	EXISTING TEN-FOOT CONTOUR
- - - - -	EXISTING TWO-FOOT CONTOUR
· · · · ·	EXISTING EDGE OF WATER
X X X X	EXISTING FENCE
~ ~ ~ ~ ~	EXISTING TREELINE
W W W W	PROPOSED WATERLINE
▭	EXISTING STRUCTURE
▨	EXISTING BITUMINOUS PAVEMENT
▧	EXISTING GRAVEL PAVEMENT
□	EXISTING SIGN
○	EXISTING GATE
◻	EXISTING BRIDGE PIER
▩	EXISTING CONCRETE
▩	PROPOSED DAM REMOVAL

NOTES:
1. EXISTING DAM ELEVATIONS AND DIMENSIONS SHOWN ARE APPROXIMATE AND BASED ON SURVEY DATA, SITE PHOTOGRAPHS AND HISTORIC PERMIT APPLICATIONS.

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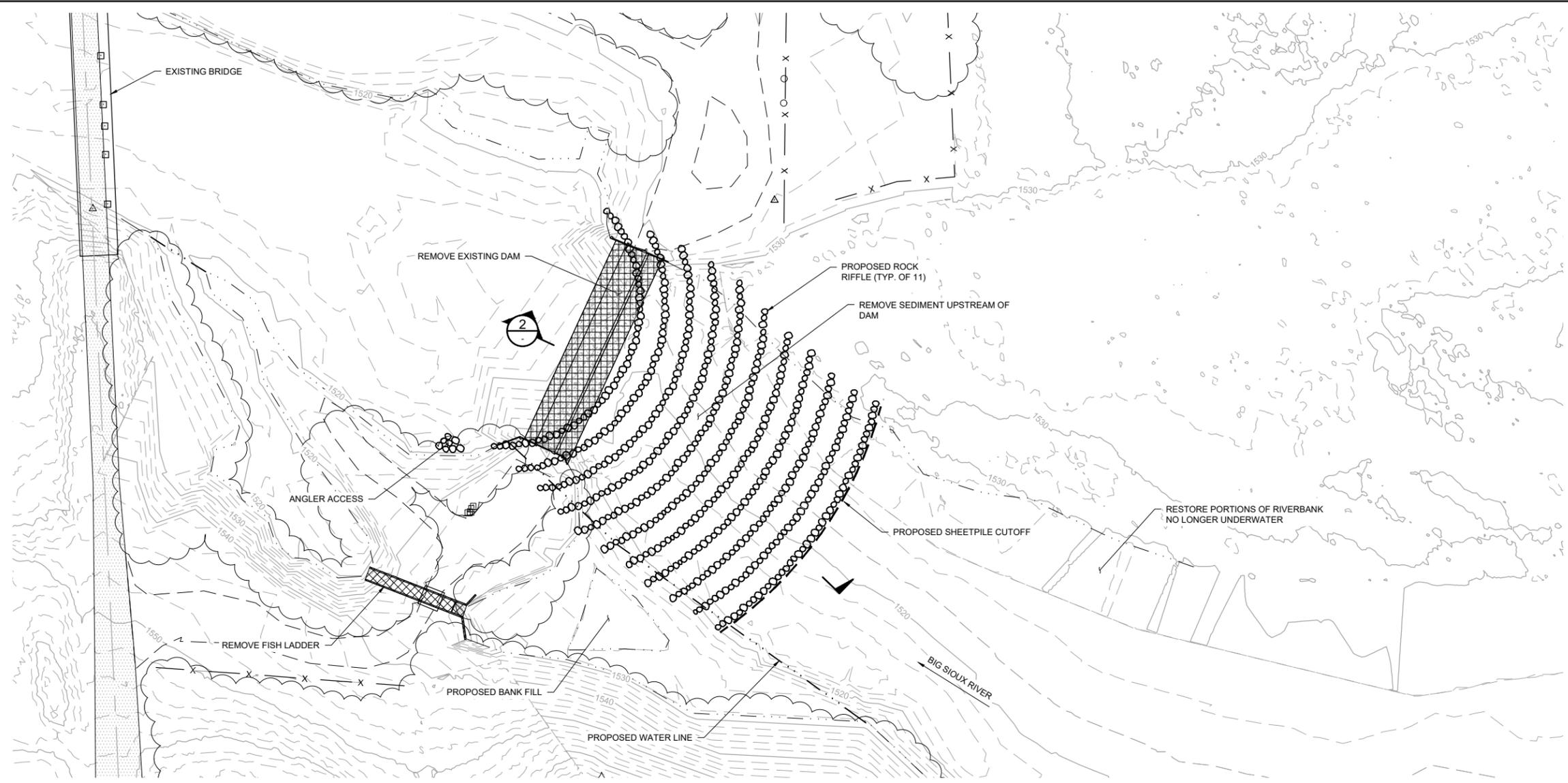
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 FLANDREAU, SOUTH DAKOTA

FLANDREAU DAM MODIFICATIONS
 FLANDREAU, SOUTH DAKOTA
 ALTERNATIVE 1 - FULL DAM REMOVAL
 PLAN AND PROFILE

BARR PROJECT No.	41/50-1001.00
CLIENT PROJECT No.	
DWG. No.	FIGURE 2
REV. No.	A



LEGEND

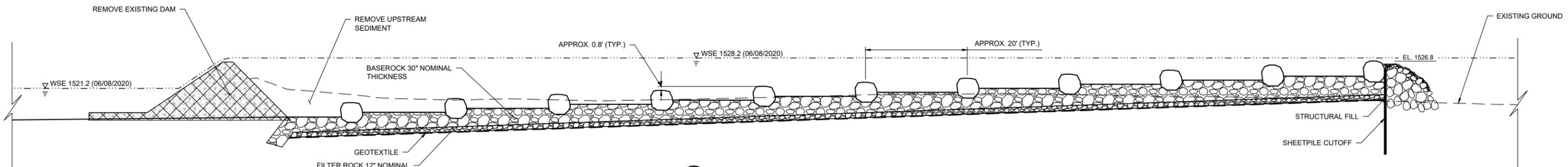
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- - - - -	EXISTING TWO-FOOT CONTOUR
· · · · ·	EXISTING EDGE OF WATER
X X X X	EXISTING FENCE
~ ~ ~ ~ ~	EXISTING TREELINE
- - - - -	PROPOSED SHEETPILE CUTOFF
· · · · ·	PROPOSED WATERLINE
[Hatched Box]	EXISTING STRUCTURE
[Dotted Box]	EXISTING BITUMINOUS PAVEMENT
[Cross-hatched Box]	EXISTING GRAVEL PAVEMENT
[Square with X]	EXISTING SIGN
[Circle with X]	EXISTING GATE
[Square with Circle]	EXISTING BRIDGE PIER
[Dotted Box]	EXISTING CONCRETE
[Cross-hatched Box]	PROPOSED DAM REMOVAL
[Circle]	4'-5" NOMINAL DIMENSION BOULDER

NOTES:

- EXISTING DAM ELEVATIONS AND DIMENSIONS SHOWN ARE APPROXIMATE AND BASED ON SURVEY DATA, SITE PHOTOGRAPHS AND HISTORIC PERMIT APPLICATIONS.

1 PLAN: FULL ROCK RIFFLES TO 1526.8'

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SCALE IN FEET



2 PROFILE: FULL ROCK RIFFLES TO 1526.8'

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SCALE IN FEET

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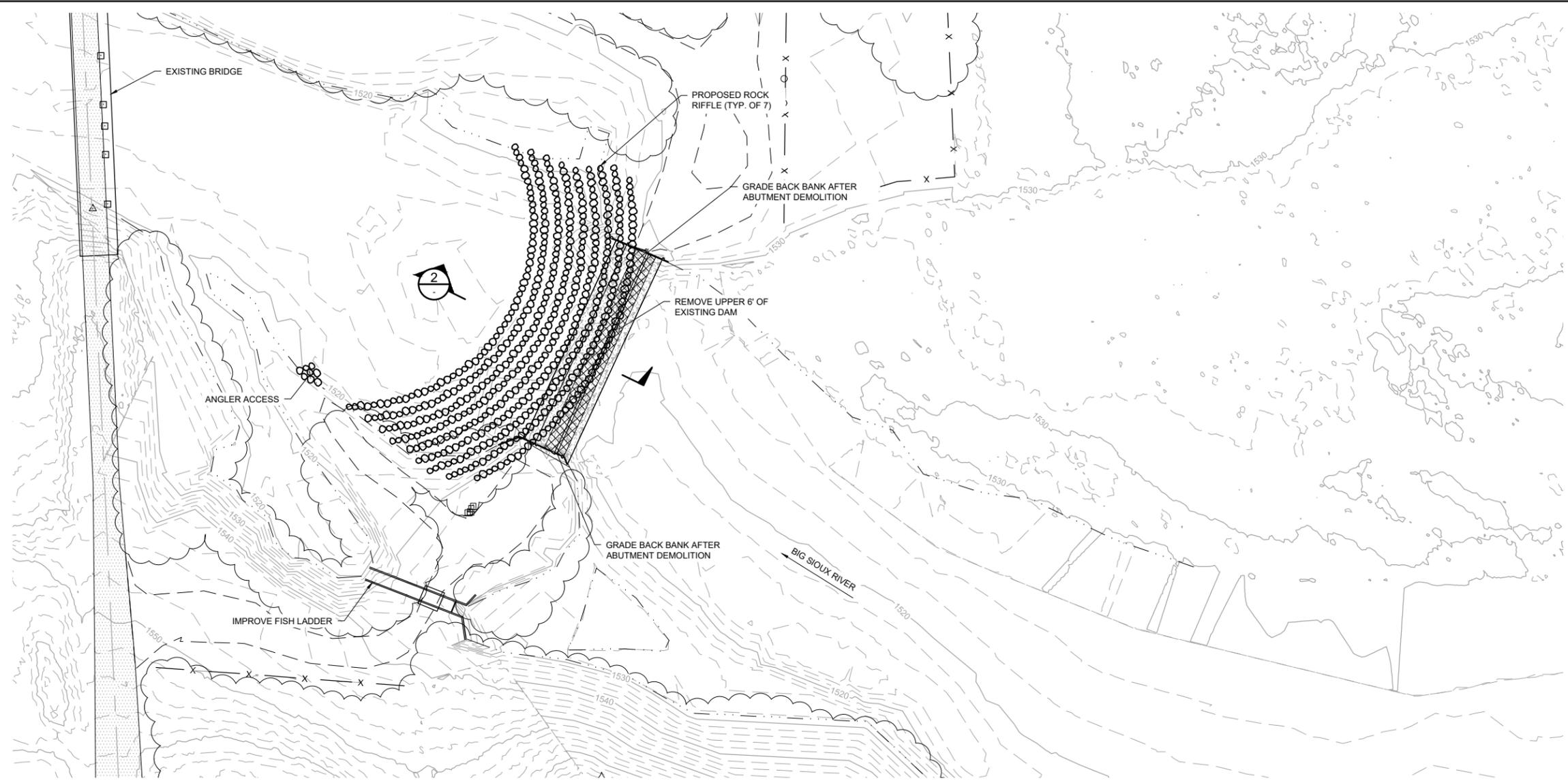
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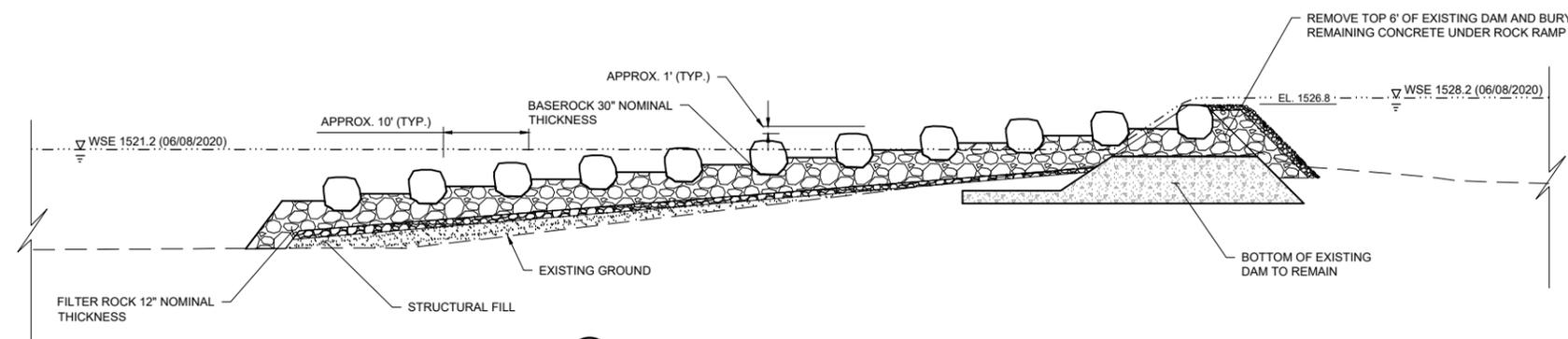
FLANDREAU DAM MODIFICATIONS
 FLANDREAU, SOUTH DAKOTA
 ALTERNATIVE 2 - FULL ROCK RIFFLES
 PLAN AND PROFILE

BARR PROJECT No.	41/50-1001.00
CLIENT PROJECT No.	
DWG. No.	FIGURE 3
REV. No.	A



LEGEND	
	EXISTING TEN-FOOT CONTOUR
	EXISTING TWO-FOOT CONTOUR
	EXISTING EDGE OF WATER
	EXISTING FENCE
	EXISTING TREELINE
	PROPOSED SHEETPILE CUTOFF
	PROPOSED WATERLINE
	EXISTING STRUCTURE
	EXISTING BITUMINOUS PAVEMENT
	EXISTING GRAVEL PAVEMENT
	EXISTING SIGN
	EXISTING GATE
	EXISTING BRIDGE PIER
	EXISTING CONCRETE
	PROPOSED DAM REMOVAL
	4'-5" NOMINAL DIMENSION BOULDER

1 PLAN: FULL ROCK RAMP TO 1526.8' WITH FISH LADDER



2 PROFILE: FULL ROCK RAMP TO 1526.8' WITH FISH LADDER

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CLIENT	BID	CONSTRUCTION	RELEASED TO/FOR	A	B	C	0	1	2	3

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 FLANDREAU, SOUTH DAKOTA

FLANDREAU DAM MODIFICATIONS
 FLANDREAU, SOUTH DAKOTA
 ALTERNATIVE 4 - FULL ROCK RAMP
 PLAN AND PROFILE

BARR PROJECT No.	41/50-1001.00
CLIENT PROJECT No.	
DWG. No.	FIGURE 5
REV. No.	A

Alternative 1 - Full Dam Removal

10% Concept Design Level

ENGINEER'S OPINION OF PROBABLE COST

PROJECT: Flandreau Dam Modifications

LOCATION: Flandreau, SD

PROJECT #: 41501001.00

September 2020

ESTIMATED COSTS

Item No:	Item Description	Units	Quantity	Unit Cost	Total Cost
1	Mobilization	LS	1	\$50,000	\$50,000
2	Water Control	LS	1	\$80,000	\$80,000
3	Remove Existing Dam	LS	1	\$100,000	\$100,000
4	Remove Fish Ladder	LS	1	\$15,000	\$15,000
5	Sediment Removal	CY	6500	\$20	\$130,000
6	Bank Regrading	CY	2570	\$15	\$38,550
7	Improved Angler Access	LS	1	\$15,000	\$15,000
8	Temporary Erosion Control	LS	1	\$15,000	\$15,000
9	Scour Protection at Hwy 13 Bridge (Allowance)	LS	1	\$50,000	\$50,000
10	Site Restoration	LS	1	\$25,000	\$25,000
	Construction Cost Subtotal				\$518,550
	Construction Cost Contingency (20%)				\$103,700
	Engineering and Permitting (25%)				\$155,600
	TOTAL PROJECT COST (Mid Range Estimate)				\$777,850
	Low Range Estimate (-20%)				\$622,000
	High Range Estimate (+40%)				\$1,089,000

Notes:

¹ Limited Design Work Completed (10% concept level).

² This concept-level (Class 4, 10% design completion per ASTM E 2516-11) cost estimate is based on concept-level designs, quantities and unit prices. Costs will change with further design. Time value-of-money escalation costs are not included. Contingency is an allowance for the net sum of costs that will be in the Final Total Project Cost at the time of the completion of design, but are not included at this level of project definition. The estimated accuracy range for the Total Project Cost as the project is defined is -20% to +40%. The accuracy range is based on professional judgement considering the level of design completed, the complexity of the project and the uncertainties in the project as scoped. The contingency and the accuracy range are not intended to include costs for future scope changes that are not part of the project as currently scoped or costs for risk contingency. Operation and Maintenance and Construction Administration costs are not included.

Alternative 2 - Full Height Rock Riffles

10% Concept Design Level

ENGINEER'S OPINION OF PROBABLE COST

PROJECT: Flandreau Dam Modifications

LOCATION: Flandreau, SD

PROJECT #: 41501001.00

September 2020

ESTIMATED COSTS

Item No:	Item Description	Units	Quantity	Unit Cost	Total Cost
1	Mobilization	LS	1	\$170,000	\$170,000
2	Water Control	LS	1	\$150,000	\$150,000
3	Remove Existing Dam	LS	1	\$100,000	\$100,000
4	Remove Fish Ladder	LS	1	\$15,000	\$15,000
5	Sediment Removal	CY	6500	\$20	\$130,000
6	Bank Regrading	CY	2570	\$15	\$38,550
7	Geotextile Fabric	SY	6750	\$3	\$20,250
8	Filter Rock	Ton	3590	\$55	\$197,450
9	Base Rock	Ton	8975	\$55	\$493,625
10	Boulders	EA	525	\$320	\$168,000
11	Upstream Chinking Rock	Ton	180	\$70	\$12,600
13	Install Sheetpile Cutoff	SF	4440	\$45	\$199,800
14	Improved Angler Access	EA	1	\$15,000	\$15,000
15	Temporary Erosion Control	LS	1	\$15,000	\$15,000
16	Site Restoration	LS	1	\$25,000	\$25,000
	Construction Cost Subtotal				\$1,750,275
	Construction Cost Contingency (20%)				\$350,100
	Engineering and Permitting (25%)				\$525,100
	TOTAL PROJECT COST (Mid Range Estimate)				\$2,625,475
	Low Range Estimate (-20%)				\$2,100,000
	High Range Estimate (+40%)				\$3,676,000

Notes:

¹ Limited Design Work Completed (10% concept level).

² This concept-level (Class 4, 10% design completion per ASTM E 2516-11) cost estimate is based on concept-level designs, quantities and unit prices. Costs will change with further design. Time value-of-money escalation costs are not included. Contingency is an allowance for the net sum of costs that will be in the Final Total Project Cost at the time of the completion of design, but are not included at this level of project definition. The estimated accuracy range for the Total Project Cost as the project is defined is -20% to +40%. The accuracy range is based on professional judgement considering the level of design completed, the complexity of the project and the uncertainties in the project as scoped. The contingency and the accuracy range are not intended to include costs for future scope changes that are not part of the project as currently scoped or costs for risk contingency. Operation and Maintenance and Construction Administration costs are not included.

Alternative 3 - Lowered Crest Rock Riffles

10% Concept Design Level

ENGINEER'S OPINION OF PROBABLE COST

PROJECT: Flandreau Dam Modifications

LOCATION: Flandreau, SD

PROJECT #: 41501001.00

September 2020

ESTIMATED COSTS

Item No:	Item Description	Units	Quantity	Unit Cost	Total Cost
1	Mobilization	LS	1	\$130,000	\$130,000
2	Water Control	LS	1	\$140,000	\$140,000
3	Remove Existing Dam	LS	1	\$100,000	\$100,000
4	Remove Fish Ladder	LS	1	\$15,000	\$15,000
5	Sediment Removal	CY	3230	\$20	\$64,600
6	Bank Regrading	CY	2570	\$15	\$38,550
7	Geotextile Fabric	SY	4340	\$3	\$13,020
8	Filter Rock	Ton	2290	\$55	\$125,950
9	Base Rock	Ton	5800	\$55	\$319,000
10	Boulders	EA	350	\$320	\$112,000
11	Upstream Chinking Rock	Ton	180	\$70	\$12,600
12	Install Sheetpile Cutoff	SF	4530	\$45	\$203,850
13	Improved Angler Access	EA	1	\$15,000	\$15,000
14	Temporary Erosion Control	LS	1	\$15,000	\$15,000
15	Scour Protection at Hwy 13 Bridge (Allowance)	LS	1	\$15,000	\$15,000
16	Site Restoration	LS	1	\$25,000	\$25,000
	Construction Cost Subtotal				\$1,344,570
	Construction Cost Contingency (20%)				\$269,000
	Engineering and Permitting (25%)				\$403,000
	TOTAL PROJECT COST (Mid Range Estimate)				\$2,016,570
	Low Range Estimate (-20%)				\$1,613,000
	High Range Estimate (+40%)				\$2,823,000

Notes:

¹ Limited Design Work Completed (10% concept level).

² This concept-level (Class 4, 10% design completion per ASTM E 2516-11) cost estimate is based on concept-level designs, quantities and unit prices. Costs will change with further design. Time value-of-money escalation costs are not included. Contingency is an allowance for the net sum of costs that will be in the Final Total Project Cost at the time of the completion of design, but are not included at this level of project definition. The estimated accuracy range for the Total Project Cost as the project is defined is -20% to +40%. The accuracy range is based on professional judgement considering the level of design completed, the complexity of the project and the uncertainties in the project as scoped. The contingency and the accuracy range are not intended to include costs for future scope changes that are not part of the project as currently scoped or costs for risk contingency. Operation and Maintenance and Construction Administration costs are not included.

Alternative 4 - Full Height Rock Ramp

10% Concept Design Level

ENGINEER'S OPINION OF PROBABLE COST

PROJECT: Flandreau Dam Modifications

LOCATION: Flandreau, SD

PROJECT #: 41501001.00

September 2020

ESTIMATED COSTS

Item No:	Item Description	Units	Quantity	Unit Cost	Total Cost
1	Mobilization	LS	1	\$90,000	\$90,000
2	Water Control	LS	1	\$100,000	\$100,000
3	Select Demolition of Existing Dam	LS	1	\$80,000	\$80,000
4	Improve Fish Ladder	LS	1	\$40,000	\$40,000
5	Bank Excavation	CY	2570	\$12	\$30,840
6	Structural Fill	CY	920	\$20	\$18,400
7	Filter Rock	Ton	1110	\$55	\$61,050
8	Base Rock	Ton	5500	\$55	\$302,500
9	Boulders	EA	525	\$320	\$168,000
10	Upstream Chinking Rock	Ton	180	\$70	\$12,600
11	Improved Angler Access	EA	1	\$15,000	\$15,000
12	Temporary Erosion Control	LS	1	\$15,000	\$15,000
13	Site Restoration	LS	1	\$25,000	\$25,000
	Construction Cost Subtotal				\$958,390
	Construction Cost Contingency (20%)				\$192,000
	Engineering and Permitting (25%)				\$288,000
	TOTAL PROJECT COST (Mid Range Estimate)				\$1,438,390
	Low Range Estimate (-20%)				\$1,151,000
	High Range Estimate (+40%)				\$2,014,000

Notes:

¹ Limited Design Work Completed (10% concept level).

² This concept-level (Class 4, 10% design completion per ASTM E 2516-11) cost estimate is based on concept-level designs, quantities and unit prices. Costs will change with further design. Time value-of-money escalation costs are not included. Contingency is an allowance for the net sum of costs that will be in the Final Total Project Cost at the time of the completion of design, but are not included at this level of project definition. The estimated accuracy range for the Total Project Cost as the project is defined is -20% to +40%. The accuracy range is based on professional judgement considering the level of design completed, the complexity of the project and the uncertainties in the project as scoped. The contingency and the accuracy range are not intended to include costs for future scope changes that are not part of the project as currently scoped or costs for risk contingency. Operation and Maintenance and Construction Administration costs are not included.