BLE

BUNNELL-LAMMONS ENGINEERING, INC.

GEOTECHNICAL, ENVIRONMENTAL AND CONSTRUCTION MATERIALS CONSULTANTS

LAKE JUNALUSKA DAM

BRIDGE EVALUATION

LAKE JUNALUSKA, NORTH CAROLINA

Prepared for:

Mr. Jack Carlisle
Lake Junaluska Assembly
Director of Public Works

Prepared by:

Chris Sluder, PE

John Garner, PE

of
Bunnell-Lammons Engineering, Inc.
Arden, North Carolina

October 3, 2016

BLE Project Number J16-9263-02

EXECUTIVE SUMMARY

Based on our observations and our limited structural analyses, it is the opinion of BLE that the bridge remain closed to vehicle traffic until repairs have been completed. The main factors contributing to our belief that the bridge structure is currently sub-standard for vehicular traffic are as follows:

- The absence of, or severe damage to the intermediate bridge abutments in (4) of the bays that result in one of the 8” deep steel bridge girders spanning the full 32’-0” as opposed to the 16’-0” span as the design intended.

- The missing or severe corrosion and degradation of several of the bolted connections between the top flange of the bridge girders and the wooden bridge deck, which result in the inability to consider the bridge girders as rigidly braced in compression, thereby greatly reducing their structural capacity.

- The corrosion of the steel bridge girders at multiple locations has resulted in the degradation and loss of the effective cross-sectional area of the girders, thereby reducing the structural capacity.

- The understanding that the corrosion of the steel components will continue to worsen until rehabilitative and corrosion inhibiting measures have been taken, or can no longer be effective.

- The damage to the concrete abutments at many of the bridge girder bearing locations, largely due to the fact that there are no bearing plates installed at any of these locations.

PROJECT BACKGROUND

BLE has been involved in several projects involving the dam in recent years. Upon the recommendation of Mr. Brian Aldridge of the LJA, Mr. John Garner, P.E. and Mr. Chris Sluder, P.E. of BLE conducted a preliminary visual inspection of the structural components of the bridge on August 10, 2016, during which, significant deterioration of the steel bridge girders and the concrete bridge abutments was observed, along with visually evident excessive deflection of a bridge girder under the load of a passing vehicle.

Based on these observations, BLE submitted a proposal to the LJA on August 31, 2016, proposing to conduct a more thorough evaluation of the current condition of the existing bridge, including a limited structural analysis and a hydrological study. Upon receipt of the proposal, the LJA decided to immediately close the bridge to vehicular traffic, and retained BLE to perform the proposed bridge evaluation.

HISTORY

Based on archived information provided by The Lake Junaluska Assembly (LJA), and archived information obtained from The Mountaineer and the Waynesville branch of the Haywood County Public Library, we have constructed the following timeline:

- **1913:** Construction of the dam was completed, including a wooden bridge that spanned the length of the dam.

- **1920:** Following an inspection by the original design engineer J. W. Seaver, the wooden bridge was removed and replaced with a steel girder and concrete abutment bridge constructed by the Atlantic Bridge Co. of Charlotte and completed in 1921.

- **1946:** Plans were being considered including a "re-flooring" of the bridge and the installation of a new sewer system.

  - **Nov. 5:** In a letter from Mr. F.S. Love of the LJA to Mr. Edwin L. Jones of J. A. Jones Construction Company, Dr. Love states: *"Mr. Liner suggests that the present I-beams are sufficient to support any weight that we would have on the bridge. This would save us 1100 feet of running steel."*

  - **Nov. 15:** In a letter from Mr. Edwin L. Jones of J. A. Jones Construction Company to Dr. F.S. Love of the LJA, Mr. Jones states: *"Both the bridge and the sewer are of prime importance. We can get into the Assembly grounds without the use of the bridge. We cannot operate the Assembly much longer without a main sewer line."*

- **1949:** An article in the Mountaineer dated March 8th states that the sewer project is close to being completed, along with several other projects including the west gate and the memorial chapel; however, no mention was made of any repairs to the bridge.

- **1970:** Mr. Hallett J. Bowen, P.E. was contracted to structurally assess the existing bridge to determine if a new concrete roadway slab could be placed. In a letter from Mr. Bowen to Dr. Edgar H. Nease, Jr. of the LJA dated December 14 Mr. Bowen States: *"In any event, a preliminary analysis, based on the information furnished, indicates that a new concrete slab can be placed on the existing beams. However, I do not believe the bridge now meets published standards for this type of structure, nor will the mere addition of a new slab bring the structure within these standards."*

- **1976:** Bigger and Agnew Engineers, Inc. issued a set of construction drawings dated August 6th for a large scale rehabilitation to the dam. The drawings included repairs to the buttresses, the dam face, as well as the bridge. The repairs to the bridge included the repair of the concrete abutments at several beam bearing locations, patching the asphalt wearing surface, and the removal and replacement of railing and posts.

- **~1990:** Mr. Mackey McKay installed supplemental structural steel beams directly adjacent to several existing beams that had sustained severe corrosion damage. We assume that the asphalt bridge deck was removed at this time or before, and replaced with the wooden bridge deck.

OBSERVATIONS

BLE representatives made several visits to the site to visually assess the existing condition of the bridge structure, and to confirm the member sizes, member spacing, and overall dimensions from earlier drawings. Member size and spacing, and the overall dimensions appeared to be in conformance with the set of Rehabilitation and Repair drawings issued by Bigger & Agnew in 1976. During our visual assessments BLE noted the following:

1. The intermediate concrete abutments that support the (3)-downstream bridge girders were severely damaged or missing altogether in Bay A, Bay B, Bay K, and Bay M. Refer to Photographs 1 – 7.

2. The steel bridge girders do not appear to be properly attached to the bridge deck at multiple locations. At some locations the bolts were missing entirely, and at other locations, the bolts, nuts, and top flange of the girders were severely corroded. Refer to Photographs 9 – 22.

3. The steel bridge girders are severely corroded at multiple locations throughout the bridge. In Bay Q, Bay O, and Bay G, supplemental steel girders have been added on either side of girders that have sustained extreme corrosion damage. Refer to Photographs 23 – 25.

4. The supplemental steel girders mentioned above, appear to be connected to the bridge deck with a wooden 3x8 stringer that is off-center with respect to the girder, and with bolts on only one side of the girder web. Refer to Photograph 8.

5. The top flange of the 12" deep steel bridge girder that supports the lamp posts and the rail between the pedestrian walkway and the roadway has been severely corroded and is delaminating in all of the bays, with the exception of Bay Q, where it appears to have been replaced. It appears that this particular line of girders has sustained more damage as a result of water intrusion from the posts above and ponding of the water on the top flange. Refer to Photographs 26 and 27.

6. Corrosion is evident at field weld locations, including the bridge girder splice locations where the splice plate is welded to the webs of the girders, and at the locations where lateral bracing frames into the web. The damage can be seen from the back side of the girders and generally follow the pattern of the weld. Refer to Photographs 28 and 29.

7. At the girder splice locations, a splice plate is only present and welded on one side of the web. There is no continuity of the top or bottom flanges across the splice. Refer to Photograph 30.

8. There does not appear to be bearing plates at any of the locations where the steel girders are supported by the concrete abutments. As a result, it appears that the concrete has sustained damage at multiple bearing locations. Refer to Photographs 31 – 35.

9. At several of the bridge abutments, concrete degradation and wear is evident at what appears to be the normal pool elevation. Refer to Photographs 36 – 38.

10. The base of the bridge abutment between Bay J and Bay K, appears to be spalling and cracking at the interface with the spillway slab. Refer to Photograph 39.

LIMITED STRUCTURAL ANALYSES

Resources

The following resources were utilized for the purpose of this limited analysis:

- The American Association of State Highway and Transportation Officials (AASHTO) 2012 Bridge Design Specifications
- American Institute of Steel Construction (AISC) Historical Record of Dimensions and Properties of Rolled Shapes, Steel and Wrought Iron Beams and Columns as Rolled in U.S.A., Period 1873 to 1952
- Enercalc-Version 6 Structural Engineering Library structural analysis software

Assumptions

The following assumptions were made for the purpose of this limited analysis:

- The section properties were determined by selecting the shapes from the AISC Historical Record that were produced closest to the year of construction (1920) and that best matched the dimensions of the shapes as measured in the field.
- The yield stress of the steel is assumed to be 27.5 KSI, per the AISC Historical Record.
- The girders are simply supported at each abutment due to the fact that no flange splices are present thereby providing a break in continuity across the support.
- The weight of the wood decking is assumed to be 50 pounds per cubic foot, per AASHTO.
- The full cross-sectional area (no loss due to corrosion) was used in the stress and deflection calculations of the girders.
- The steel behaves elastically under loading.
- The top (compression) flange is considered un-braced against lateral-torsional buckling due to corrosion and the lack of effective connectivity to the bridge deck diaphragm.

Based on the current condition of the existing bridge, and in accordance with our proposal dated 8/31/2016, BLE has performed a simple analysis of the structural steel members of the vehicular portion of the bridge. The members were analyzed for bending stress, shear stress, and deflection.

We applied the AASHTO Tandem and Lane Loads to the bridge in accordance with AASHTO 3.6.1.2.3 and 3.6.1.2.4, in order to establish a baseline of what the authority having jurisdiction typically expects, from a bridge performance standpoint. We also applied a "Standard Utility Truck Load" to more closely model the typical everyday traffic that the bridge is subjected to. The Standard Utility Truck Load was modeled after the truck that the LJA provided for the load test on 9/8/2016. It weighs 8000 pounds with an axle spacing of approximately 11’-0” and a wheel base of 6’-0”. For simplicity, we split the 8000 pounds evenly between the four tires.

These loads were applied to both the 12” and the 8” I-shaped bridge girders and evaluated as simply supported beams, both as fully-braced and completely unbraced, for the afore-mentioned limit states. We also ran an analysis of the 8” girder with a clear span of 14’-0” with fixed-pined end conditions to illustrate the difference in stress between the current condition and the design span as intended.

RESULTS

The results of our limited structural analyses are summarized in the table below:

Depth (in.)	Span (ft.)	Load Type	Bracing	Allowable Moment (k-ft)	Max Moment (k-ft)	% Stressed in Bending	Allowable Shear (kips)	Max Shear (kips)	% Stressed in Shear	Max. Deflection (in.)	Defl./Span	Max Reaction (kips)
12"	30	AASHTO	Fully	78.58	276.17	351.45%	66.33	22.16	33.41%	3.64	99	14.18
12"	30	Utility	None	41.91	42.25	100.81%	66.33	4.78	7.21%	0.49	742	3.38
12"	30	Utility	Fully	78.58	42.25	53.77%	66.33	4.78	7.21%	0.49	742	3.38
8"	14	Utility	None	27.31	10.57	38.70%	35.64	2.975	8.35%	0.05	3111	4.02
8"	30	AASHTO	Fully	29.29	274.34	936.62%	35.64	21.91	61.48%	14.40	25	14
8"	30	Utility	Fully	29.29	40.63	138.72%	35.64	4.53	12.71%	1.95	185	3.11
8"	30	Utility	None	27	40.36	149.48%	35.64	4.53	12.71%	1.95	185	3.11

As shown in the table above, the 8” girder is extremely overstressed even when fully braced with the utility truck. Also, note the magnitude of the difference in moment capacity of the girders when fully braced as opposed to unbraced.
The deflection of the 8” beam with the 30’ span is what BLE witnessed during our preliminary site visit on 8/10/2016.
The deflections of the 12” beam are more in line with what we saw during the load test on 9/8/2016.

For further information pertaining to the analysis, please refer to the calculation sheets for each instance in Appendix C.

SPILLWAY CAPACITY ANALYSES

Spillway capacity is governed by the selection of the appropriate design storm for the dam. Design storm selection is based on dam size and hazard classification. The Lake Junaluska Dam is classified as a High Hazard structure by the North Carolina Department of Environmental Quality, because impacts during a breach scenario create a probable loss of human life condition. Therefore, the design storm is selected based on hazard classification and the size of the structure.

Structure size is determined by the height of the structure or the storage capacity, depending on the factor that results in the largest size classification. The Lake Junaluska Dam has a height of approximately 44 feet from the roadway elevation to the stream channel at the downstream toe. We calculated the storage volume to be approximately 4,764 acre-feet. Therefore, in accordance with the North Carolina Dam Safety Act of 1967, the dam's size classification is Medium and the design storm is half of the Probable Maximum Precipitation storm event (1/2 PMP).

BLE has performed preliminary hydrologic and hydraulic analyses to evaluate the existing spillway capacity for the design storm and other lesser storm events over the Lake Junaluska Dam watershed. BLE used various data sources to develop the watershed characterization, the rainfall distribution, and the runoff routing for the spillway design. The lake flood storage (volume above normal pool), combined with the proposed spillway capacity must be adequate to pass the design storm. Additionally, BLE performed limited hydrologic and hydraulic analyses for the watershed above the Allen Creek Reservoir, to account for the detention of floodwaters by this impoundment. The following table summarizes the hydrologic input parameter values for the watersheds.

Table 1: Lake Junaluska Dam – Hydrologic and Hydraulic Input Data Summary

Analysis Parameter	**Allen Creek Reservoir**	**Lake Junaluska Dam**
Drainage Basin Area (sq-mi)	13	50.4
• Curve Number	33.5	59.3
• Basin Lag time (hours)	1.9	2.6
• Basin Snyders Peaking Coeff.	0.5	0.4
½ PMP Rainfall Depth (inches in 6 hours)	13.87	13.87
100-year Rainfall Depth (inches in 24 hours)	6.15	6.15

The hydrologic and hydraulic analyses were facilitated by the use of the HEC-HMS computer model developed by the US Army Corps of Engineers. Watershed hydrology and dam hydraulics are modeled within the software using user-developed input parameters, as summarized above, as well as user-developed site characterization inputs. These site characterization inputs include:

- A rainfall hyetograph (time-distribution of rainfall)
- a flood storage volume rating curve
- a spillway hydraulic rating curve.

The computer model develops a runoff hydrograph which is then routed through the reservoirs and spillways using the storage and hydraulic rating curves. The most critical of these rating curves is the hydraulic rating curve because this quantifies the hydraulic capacity of the dam. The hydraulic rating curve we developed assumes that the existing bridge acts to constrict flow over the main spillway section. We also modeled excess flows overtopping the roadway crest in areas beyond the main spillway section. The results of the hydrologic and hydraulic routing for various storm events are shown in Table 2 below.

Table 2: Lake Junaluska Dam – Spillway Capacity Modeling Results			
Analysis Parameter	**½ PMP**	**100-Year**	**50-Year**
Inflow to Impoundment (CFS)	38,952	8,188	6,654
Peak Water Surface Elev. (feet)	2,576.2	2,565.3	2,564.8
Overtopping Depth over El. 2568.0 (feet)	8.2	n/a	n/a
Peak outflow (CFS)	38,949	7,223	6,019

CONCLUSIONS (SPILLWAY CAPACITY)

The results presented above provide a preliminary consideration of the hydraulic capacity of the existing spillway structure at the Lake Junaluska Dam. These results were compared with published data for anticipated peak outflows from the associated watershed developed by the US Geological Survey (USGS). 100-year storm peak flows calculated here are within the limits of the USGS calculation flows (5,710 CFS to 21,500 CFS). These results provide a basis for the watershed parameters we developed.

Calculated inflows for the ½ PMP design storm event vary significantly from previous evaluations by others. While these calculations were not available for review, we believe that a measure of conservatism was applied to account for development within the watershed and other factors. The previously calculated value for the full PMP inflow was roughly double the result shown above. The BLE analyses indicate that the spillway capacity, relative to the design storm, is more than previously anticipated.

It is our understanding that the current bridge section over the spillway is designed to be removed by flood flows. BLE was not able to find documentation of this intent within the available historical documents. However, it is our opinion that counting on the bridge to be dislodged by excess flood flows is risk inherent, and should not be counted. The previous analysis demonstrates that the current configuration of the bridge relative to the spillway function may provide the same level of spillway capacity as previously thought required with a bridge failure function. Additional, detailed analyses are required to verify this condition and/or the function of the bridge and spillway under a repaired condition scenario.

RECOMMENDATIONS

Based on our visual assessments, the results of our limited structural analysis, our experience with similar projects, and the understanding that the conditions of the structure will continue to worsen, it is the opinion of BLE that the bridge remains closed until repairs have been completed to bring the bridge up to a safe standard.

If it is the wish of the owner to re-open the bridge to vehicular traffic, BLE suggests the following to be completed prior to doing so:

- Conduct further exploration into the integrity of the concrete bridge abutments, including a visual inspection of the bottom of the concrete posts, and obtaining core samples to check for compressive strength.
- Remove the existing wooden bridge deck to expose the top flange of all of the steel girders.
- Conduct a full-scale qualitative visual assessment of each girder to determine which members are worth saving.
- Replace/repair the damaged or missing intermediate concrete abutments.
- Complete concrete abutment remediation, as required by results of additional explorations.
- Install bearing plates at all bearing locations
- Sandblast the girders that are retained
- Paint all the steel with a corrosion inhibiting paint.
- Install flashing or provide some other method of preventing the water intrusion as noted in Observation No. 5.
- Properly fasten the new deck to the girders with galvanized bolts, in a manner as to achieve a fully-braced condition of the girders.

If it is the wish of the owner to close the bridge indefinitely to vehicular traffic, and maintain it for pedestrian and bicycle use, BLE suggests the following:

- Remove the existing pedestrian walkway, including the built-up section of the abutment and the severely corroded beam noted in Observation 5.
- Remove the existing wooden deck to expose the girders below.
- Clean, patch, repair, and paint the existing girders, under the guidance of a registered design professional.
- Attach the new deck with galvanized bolts in a manner that achieves the fully-braced condition of the girders.
- Replace the decking with a compliant material.

SUMMARY

The bridge over the Lake Junaluska Dam provides a central amenity feature for pedestrians and a convenient vehicular access for the community. Based on engineering analysis, the bridge can no longer function as a vehicle avenue, with an acceptable factor of safety. The value of the bridge and the role it plays in the community must be evaluated in the context of the safe operation of the dam as well as the safe access it provides. Our analyses indicate that the bridge will need maintenance, repairs, and/or rehabilitation based on the selected course of action.

APPENDIX A:

Photographs

Photograph 1: Missing intermediate concrete abutment for 8" bridge girder support at Bay M.

Photograph 2: Missing intermediate concrete abutment for 8" bridge girder support at Bay M.

Photograph 3: Damaged intermediate concrete abutment for 8" bridge girder support at Bay K.

Photograph 4: Damaged intermediate concrete abutment for 8" bridge girder support at Bay K.

Photograph 5: Damaged intermediate concrete abutment for 8" bridge girder support at Bay B.

Photograph 6: Damaged intermediate concrete abutment for 8" bridge girder support at Bay B.

Photograph 7: Damaged intermediate concrete abutment for 8" bridge girder support at Bay A.

Photograph 8: Insufficient connection of supplemental bridge girder to bridge deck.

Photograph 9: Severely corroded bolted connection and top flange of bridge girder in Bay N.

Photograph 10: Severely corroded bolted connection and top flange of bridge girder in Bay M.

Photograph 11: Severely corroded bolted connection and top flange of bridge girder in Bay Q.

Photograph 12: Severely corroded bolted connection and top flange of bridge girder in Bay K.

Photograph 13: Severely corroded bolted connection and top flange of bridge girder in Bay M.

Photograph 14: Missing bolted connection and corroded top flange of bridge girder in Bay F.

Photograph 15: Missing bolted connection and corroded top flange of bridge girder.

Photograph 16: Missing/Corroded bolted connection and corroded top flange of bridge girder.

Photograph 17: Corrosion of bolted connection, top flange, and web of bridge girder in Bay B.

Photograph 18: Missing bolted connection and corrosion of top flange of bridge girder in Bay D.

Photograph 19: Corrosion of bolted connection and top flange of bridge girder in Bay K.

Photograph 20: Severe corrosion of web and bottom flange of bridge girder at Bay K – Bay L bearing location.

Photograph 21: Corrosion of top flange of bridge girder at Bay N.

Photograph 22: Corrosion of bolted connections and top flanges of bridge girder at Bay M.

Photograph 23: Severe corrosion of web of bridge girder at Bay G-Bay H bearing. Supplemental girders added on either side in early 1990's. Supplemental girder shown in foreground.

Photograph 24: Severe corrosion of web and bottom flange at mid-span of bridge girder in Bay O. Supplemental girders added on either side in early 1990's.

Photograph 25: Severe corrosion of web and bottom flange at mid-span of bridge girder in Bay Q. Supplemental girders added on either side in early 1990's.

Photograph 26: Severe corrosion and delamination of top flange of bridge girder/post support beam in Bay C.

Photograph 27: Severe corrosion and delamination of top flange of bridge girder/post support beam in Bay M.

Photograph 28: Damage and corrosion at back side of weld for bridge girder connection plate typical at bridge girder connection plates.

Photograph 29: Damage and corrosion at back side of weld for the lateral bracing member.

Photograph 30: Back side of typical bridge girder to bridge girder connection.

Photograph 31: No bearing plates at bridge girder bearing locations.

Photograph 32: Damage to concrete bridge abutment at Bay M – Bay L bridge girder bearing location.

Photograph 33: Damage to built-up section of the concrete bridge abutment at bridge girder bearing location.

Photograph 34: Damage to the concrete bridge abutment at bridge girder bearing location.

Photograph 35: Damage to built-up section of the concrete bridge abutment at bridge girder bearing location.

Photograph 36: Wearing of the concrete bridge abutment at the water level.

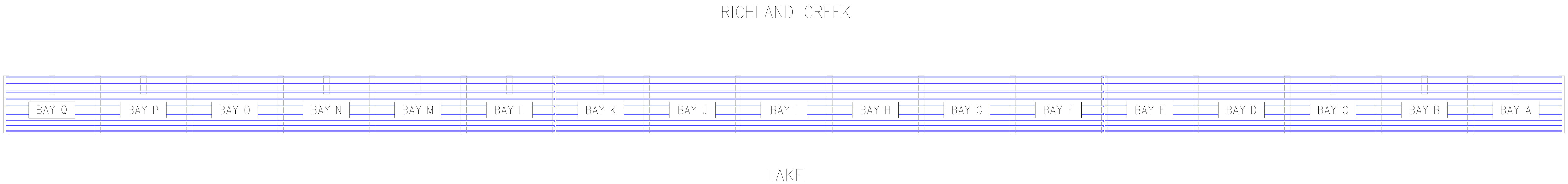
Photograph 37: Wearing of the concrete bridge abutment at the water level.

Photograph 38: Wearing of the concrete bridge abutment at the water level.

Photograph 39: Damage and spalling to the concrete bridge abutment between Bay J and Bay K at the interface with the spillway surface.

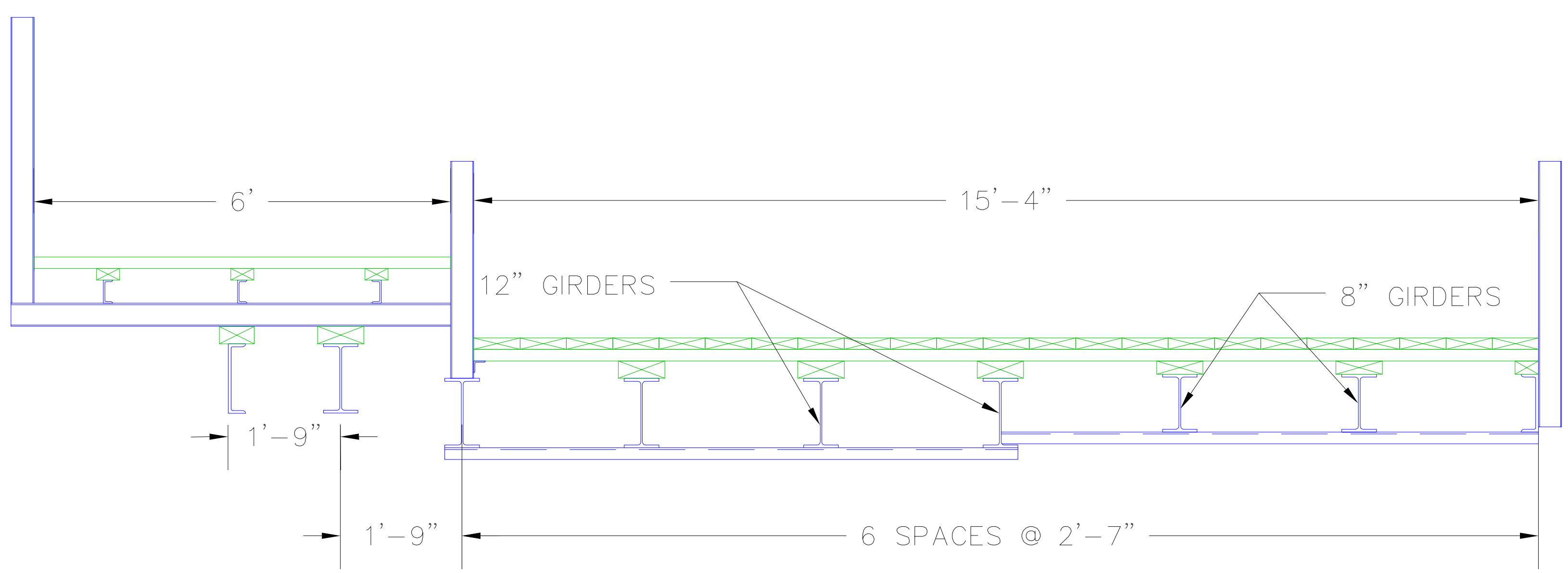
APPENDIX B:

Figures



BAY LAYOUT

N.T.S.



TYPICAL BRIDGE SECTION

N.T.S.

NOTE: ALL DIMENSIONS ARE APPROXIMATE

DRAWN BY: CWS	DATE: 10-03-2016	BLE INC. BUNNELL-LAMMONS ENGINEERING, INC. 130 OVAL ROAD, SUITE 200 ARDEN, NORTH CAROLINA 28704 PHONE: (828)277-0100 FAX: (828)277-0110	DAM BRIDGE EVALUATION LAKE JUNALUSKA LAKE JUNALUSKA, NORTH CAROLINA
CHECKED BY:	SCALE: VARIES		
APPROVED BY:	JOB NO: 9263-02		SHEET 01

BUNNELL-LAMMONS ENGINEERING, INC.
GEOTECHNICAL, ENVIRONMENTAL AND CONSTRUCTION MATERIALS CONSULTANTS

APPENDIX C:

Calculations

Steel Beam

File = c:\Users\SLUDES~1\DOCUME~1\ENERCA~1\TYPGIR~1.EC6
ENERCALC, INC. 1983-2016, Build:6.16.7.21, Ver:6.16.8.31

Lic. # : KW-06011232

Description : 12" Fully Braced Bridge Girder w/ AASHTO Tandem Load

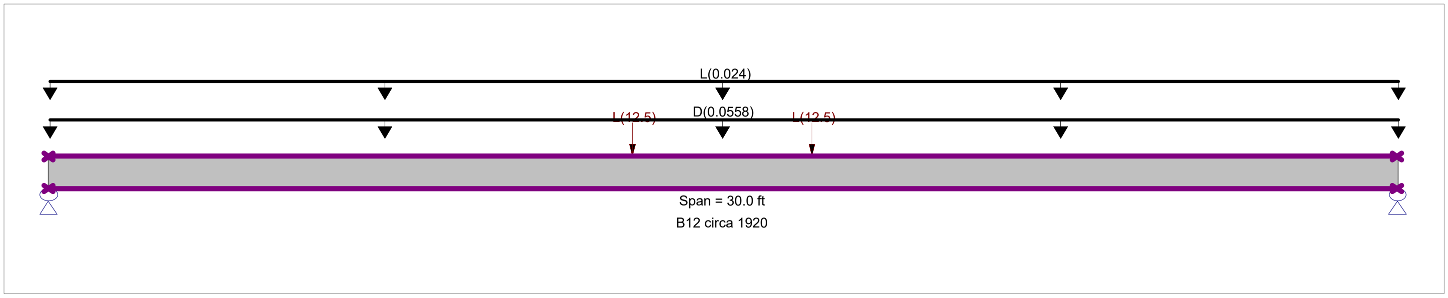
CODE REFERENCES

Calculations per AISC 360-10, IBC 2012, ASCE 7-10
Load Combination Set : ASCE 7-05

Material Properties

Analysis Method : Load Resistance Factor Design
Beam Bracing : Beam is Fully Braced against lateral-torsional buckling
Bending Axis : Major Axis Bending

Fy : Steel Yield : 27.50 ksi
E: Modulus : 29,000.0 ksi



Applied Loads

Service loads entered. Load Factors will be applied for calculations.

Beam self weight calculated and added to loading
Uniform Load : D = 0.05580 k/ft, Tributary Width = 1.0 ft, (Dead)
Point Load : L = 12.50 k @ 17.0 ft, (AASHTO Tandem)
Point Load : L = 12.50 k @ 13.0 ft, (AASHTO Tandem)
Uniform Load : L = 0.0240 k/ft, Tributary Width = 1.0 ft, (AASHTO Lane Load)

DESIGN SUMMARY

Design N.G.

Maximum Bending Stress Ratio =	3.514 : 1	Maximum Shear Stress Ratio =	0.334 : 1
Section used for this span	B12 circa 1920	Section used for this span	B12 circa 1920
Mu : Applied	276.173 k-ft	Vu : Applied	22.156 k
Mn * Phi : Allowable	78.581 k-ft	Vn * Phi : Allowable	66.330 k
Load Combination	+1.20D+1.60L	Load Combination	+1.20D+1.60L
Location of maximum on span	15.000 ft	Location of maximum on span	0.000 ft
Span # where maximum occurs	Span # 1	Span # where maximum occurs	Span # 1

Maximum Deflection

Max Downward Transient Deflection	3.638 in	Ratio =	98 <800.0
Max Upward Transient Deflection	0.000 in	Ratio =	0 <800.0
Max Downward Total Deflection	0.000 in	Ratio =	0 <180
Max Upward Total Deflection	0.000 in	Ratio =	0 <180

Maximum Forces & Stresses for Load Combinations

Load Combination / Segment Length	Span #	Max Stress Ratios M	Max Stress Ratios V	max Mu +	max Mu -	Mu Max	Mnx	Phi*Mnx	Cb	Rm	VuMax	Vnx	Phi*Vnx
+1.40D													
Dsgn. L = 30.00 ft	1	0.176	0.028	13.83		13.83	87.31	78.58	1.00	1.00	1.84	66.33	66.33
+1.20D+1.60L													
Dsgn. L = 30.00 ft	1	3.514	0.334	276.17		276.17	87.31	78.58	1.00	1.00	22.16	66.33	66.33
+D+L													
Dsgn. L = 30.00 ft	1	2.228	0.214	175.08		175.08	87.31	78.58	1.00	1.00	14.18	66.33	66.33
+1.20D+0.50L													
Dsgn. L = 30.00 ft	1	1.202	0.121	94.45		94.45	87.31	78.58	1.00	1.00	8.01	66.33	66.33
+1.20D													
Dsgn. L = 30.00 ft	1	0.151	0.024	11.85		11.85	87.31	78.58	1.00	1.00	1.58	66.33	66.33
+0.90D													
Dsgn. L = 30.00 ft	1	0.113	0.018	8.89		8.89	87.31	78.58	1.00	1.00	1.19	66.33	66.33

Overall Maximum Deflections

Load Combination	Span	Max. "-" Defl	Location in Span	Load Combination	Max. "+" Defl	Location in Span
L Only	1	3.6554	15.086		0.0000	0.000

Vertical Reactions

Support notation : Far left is #1 Values in KIPS

Load Combination	Support 1	Support 2
Overall MAXimum	14.177	14.177
Overall MINimum	0.790	0.790
D Only	1.317	1.317

Steel Beam

File = c:\Users\SLUDES~1\DOCUME~1\ENERCA~1\TYPGIR~1.EC6
ENERCALC, INC. 1983-2016, Build:6.16.7.21, Ver:6.16.8.31

Lic. # : KW-06011232

Description : 12" Fully Braced Bridge Girder w/ AASHTO Tandem Load

Vertical Reactions

Support notation : Far left is #1 Values in KIPS

Load Combination	Support 1	Support 2
+D+L	14.177	14.177
+D+0.750L	10.962	10.962
+0.60D	0.790	0.790
L Only	12.860	12.860

Steel Section Properties : B12 circa 1920

Depth	=	12.000	in	I xx	=	228.50	in^4	J	=	0.553	in^4
Web Thick	=	0.335	in	S xx		38.10	in^3	Cw	=	729.76	in^6
Flange Width	=	6.205	in	R xx	=	4.920	in				
Flange Thick	=	0.462	in	Zx	=	38.100	in^3				
Area	=	9.130	in^2	I yy	=	16.000	in^4				
Weight	=	32.000	plf	S yy	=	5.160	in^3	Wno	=	18.963	in^2
Kdesign	=	0.740	in	R yy	=	1.300	in	Sw	=	14.384	in^4
K1	=	0.750	in	Zy	=	5.160	in^3	Qf	=	8.460	in^3
rts	=	1.782	in	rT	=	1.750	in	Qw	=	21.761	in^3
Ycg	=	6.045	in								

Lake Junaluska
Dam Bridge Evaluation

BLE Project No. 9263-02

Steel Beam

File = c:\Users\SLUDES~1\DOCUME~1\ENERCA~1\TYPGIR~1.EC6
ENERCALC, INC. 1983-2016, Build:6.16.7.21, Ver:6.16.8.31

Lic. # : KW-06011232

Description : 12" Unbraced Bridge Girder w/ Standard Utility Truck Load

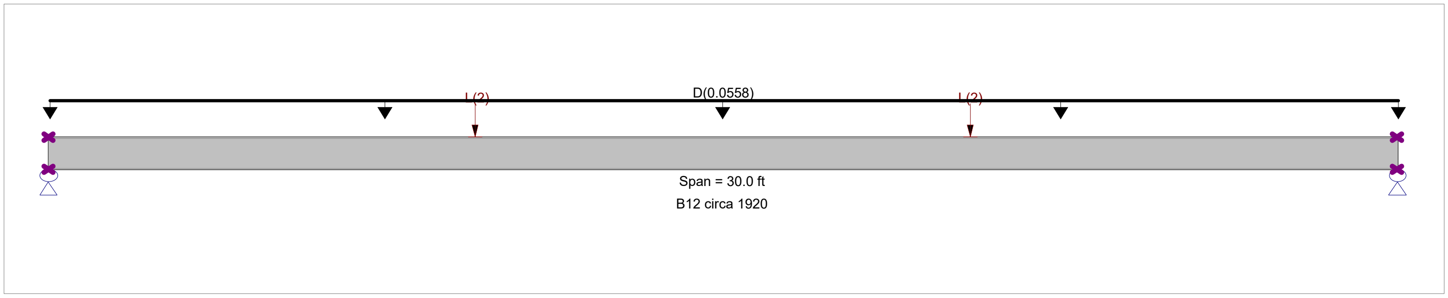
CODE REFERENCES

Calculations per AISC 360-10, IBC 2012, ASCE 7-10
Load Combination Set : ASCE 7-05

Material Properties

Analysis Method : Load Resistance Factor Design
Beam Bracing : Completely Unbraced
Bending Axis : Major Axis Bending

Fy : Steel Yield : 27.50 ksi
E: Modulus : 29,000.0 ksi



Applied Loads

Service loads entered. Load Factors will be applied for calculations.

Beam self weight calculated and added to loading
Uniform Load : D = 0.05580 k/ft, Tributary Width = 1.0 ft, (Dead)
Point Load : L = 2.0 k @ 20.50 ft, (Utility Truck)
Point Load : L = 2.0 k @ 9.50 ft, (Utility Truck)

DESIGN SUMMARY

Design N.G.

Maximum Bending Stress Ratio =	1.008 : 1	Maximum Shear Stress Ratio =	0.072 : 1
Section used for this span	B12 circa 1920	Section used for this span	B12 circa 1920
Mu : Applied	42.253 k-ft	Vu : Applied	4.780 k
Mn * Phi : Allowable	41.910 k-ft	Vn * Phi : Allowable	66.330 k
Load Combination	+1.20D+1.60L	Load Combination	+1.20D+1.60L
Location of maximum on span	15.000ft	Location of maximum on span	0.000 ft
Span # where maximum occurs	Span # 1	Span # where maximum occurs	Span # 1

Maximum Deflection

Max Downward Transient Deflection	0.485 in	Ratio =	742 >=360.
Max Upward Transient Deflection	0.000 in	Ratio =	0 <360.0
Max Downward Total Deflection	0.000 in	Ratio =	0 <180
Max Upward Total Deflection	0.000 in	Ratio =	0 <180

Maximum Forces & Stresses for Load Combinations

Load Combination		Max Stress Ratios		Summary of Moment Values							Summary of Shear Values		
Segment Length	Span #	M	V	max Mu +	max Mu -	Mu Max	Mnx	Phi*Mnx	Cb	Rm	VuMax	Vnx	Phi*Vnx
+1.40D													
Dsgn. L = 30.00 ft	1	0.330	0.028	13.83		13.83	46.57	41.91	1.00	1.00	1.84	66.33	66.33
+1.20D+1.60L													
Dsgn. L = 30.00 ft	1	1.008	0.072	42.25		42.25	46.57	41.91	1.00	1.00	4.78	66.33	66.33
+D+L													
Dsgn. L = 30.00 ft	1	0.689	0.050	28.88		28.88	46.57	41.91	1.00	1.00	3.32	66.33	66.33
+1.20D+0.50L													
Dsgn. L = 30.00 ft	1	0.509	0.039	21.35		21.35	46.57	41.91	1.00	1.00	2.58	66.33	66.33
+1.20D													
Dsgn. L = 30.00 ft	1	0.283	0.024	11.85		11.85	46.57	41.91	1.00	1.00	1.58	66.33	66.33
+0.90D													
Dsgn. L = 30.00 ft	1	0.212	0.018	8.89		8.89	46.57	41.91	1.00	1.00	1.19	66.33	66.33

Overall Maximum Deflections

Load Combination	Span	Max. "-" Defl	Location in Span	Load Combination	Max. "+" Defl	Location in Span
L Only	1	0.4850	15.086		0.0000	0.000

Vertical Reactions

Support notation : Far left is #1 Values in KIPS

Load Combination	Support 1	Support 2
Overall MAXimum	3.317	3.317
Overall MINimum	0.790	0.790
D Only	1.317	1.317
+D+L	3.317	3.317

Steel Beam

Description : 12" Unbraced Bridge Girder w/ Standard Utility Truck Load

Vertical Reactions

Support notation : Far left is #1 Values in KIPS

Load Combination	Support 1	Support 2
+D+0.750L	2.817	2.817
+0.60D	0.790	0.790
L Only	2.000	2.000

Steel Section Properties : B12 circa 1920

Depth	=	12.000	in	I xx	=	228.50	in^4	J	=	0.553	in^4
Web Thick	=	0.335	in	S xx		38.10	in^3	Cw	=	729.76	in^6
Flange Width	=	6.205	in	R xx	=	4.920	in				
Flange Thick	=	0.462	in	Zx	=	38.100	in^3				
Area	=	9.130	in^2	I yy	=	16.000	in^4				
Weight	=	32.000	plf	S yy	=	5.160	in^3	Wno	=	18.963	in^2
Kdesign	=	0.740	in	R yy	=	1.300	in	Sw	=	14.384	in^4
K1	=	0.750	in	Zy	=	5.160	in^3	Qf	=	8.460	in^3
rts	=	1.782	in	rT	=	1.750	in	Qw	=	21.761	in^3
Ycg	=	6.045	in								

Steel Beam

File = c:\Users\SLUDES~1\DOCUME~1\ENERCA~1\TYPGIR~1.EC6
ENERCALC, INC. 1983-2016, Build:6.16.7.21, Ver:6.16.8.31

Lic. # : KW-06011232

Description : 12" Fully Braced Bridge Girder w/ Standard Utility Truck Load

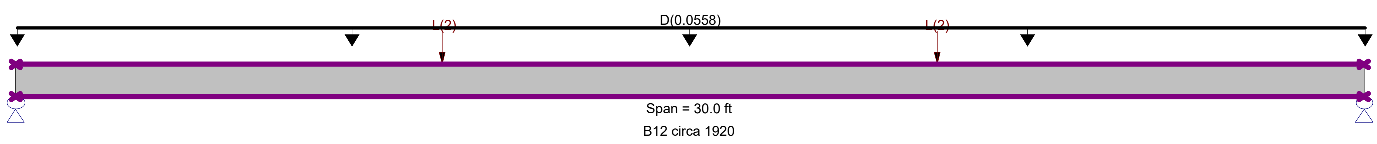
CODE REFERENCES

Calculations per AISC 360-10, IBC 2012, ASCE 7-10
Load Combination Set : ASCE 7-05

Material Properties

Analysis Method : Load Resistance Factor Design
Beam Bracing : Beam is Fully Braced against lateral-torsional buckling
Bending Axis : Major Axis Bending

Fy : Steel Yield : 27.50 ksi
E: Modulus : 29,000.0 ksi



Applied Loads

Service loads entered. Load Factors will be applied for calculations.

Beam self weight calculated and added to loading
Uniform Load : D = 0.05580 k/ft, Tributary Width = 1.0 ft, (Dead)
Point Load : L = 2.0 k @ 9.50 ft, (Utility Truck)
Point Load : L = 2.0 k @ 20.50 ft, (Utility Truck)

DESIGN SUMMARY

Design OK

Maximum Bending Stress Ratio =	**0.538** : 1	Maximum Shear Stress Ratio =	**0.072** : 1
Section used for this span	**B12 circa 1920**	Section used for this span	**B12 circa 1920**
Mu : Applied	42.253 k-ft	Vu : Applied	4.780 k
Mn * Phi : Allowable	78.581 k-ft	Vn * Phi : Allowable	66.330 k
Load Combination	+1.20D+1.60L	Load Combination	+1.20D+1.60L
Location of maximum on span	15.000ft	Location of maximum on span	0.000 ft
Span # where maximum occurs	Span # 1	Span # where maximum occurs	Span # 1

Maximum Deflection

Max Downward Transient Deflection	0.485 in	Ratio =	742 >=360.
Max Upward Transient Deflection	0.000 in	Ratio =	0 <360.0
Max Downward Total Deflection	0.000 in	Ratio =	0 <180
Max Upward Total Deflection	0.000 in	Ratio =	0 <180

Maximum Forces & Stresses for Load Combinations

Load Combination		Max Stress Ratios		Summary of Moment Values							Summary of Shear Values		
Segment Length	Span #	M	V	max Mu +	max Mu -	Mu Max	Mnx	Phi*Mnx	Cb	Rm	VuMax	Vnx	Phi*Vnx
+1.40D													
Dsgn. L = 30.00 ft	1	0.176	0.028	13.83		13.83	87.31	78.58	1.00	1.00	1.84	66.33	66.33
+1.20D+1.60L													
Dsgn. L = 30.00 ft	1	0.538	0.072	42.25		42.25	87.31	78.58	1.00	1.00	4.78	66.33	66.33
+D+L													
Dsgn. L = 30.00 ft	1	0.367	0.050	28.88		28.88	87.31	78.58	1.00	1.00	3.32	66.33	66.33
+1.20D+0.50L													
Dsgn. L = 30.00 ft	1	0.272	0.039	21.35		21.35	87.31	78.58	1.00	1.00	2.58	66.33	66.33
+1.20D													
Dsgn. L = 30.00 ft	1	0.151	0.024	11.85		11.85	87.31	78.58	1.00	1.00	1.58	66.33	66.33
+0.90D													
Dsgn. L = 30.00 ft	1	0.113	0.018	8.89		8.89	87.31	78.58	1.00	1.00	1.19	66.33	66.33

Overall Maximum Deflections

Load Combination	Span	Max. "-" Defl	Location in Span	Load Combination	Max. "+" Defl	Location in Span
L Only	1	0.4850	15.086		0.0000	0.000

Vertical Reactions

Support notation : Far left is #1 Values in KIPS

Load Combination	Support 1	Support 2
Overall MAXimum	3.317	3.317
Overall MINimum	0.790	0.790
D Only	1.317	1.317
+D+L	3.317	3.317

Steel Beam

File = c:\Users\SLUDES~1\DOCUME~1\ENERCA~1\TYPGIR~1.EC6
ENERCALC, INC. 1983-2016, Build:6.16.7.21, Ver:6.16.8.31

Lic. # : KW-06011232

Description : 12" Fully Braced Bridge Girder w/ Standard Utility Truck Load

Vertical Reactions

Support notation : Far left is #1 Values in KIPS

Load Combination	Support 1	Support 2
+D+0.750L	2.817	2.817
+0.60D	0.790	0.790
L Only	2.000	2.000

Steel Section Properties : B12 circa 1920

Depth	=	12.000	in	I xx	=	228.50	in^4	J	=	0.553	in^4
Web Thick	=	0.335	in	S xx		38.10	in^3	Cw	=	729.76	in^6
Flange Width	=	6.205	in	R xx	=	4.920	in				
Flange Thick	=	0.462	in	Zx	=	38.100	in^3				
Area	=	9.130	in^2	I yy	=	16.000	in^4				
Weight	=	32.000	plf	S yy	=	5.160	in^3	Wno	=	18.963	in^2
Kdesign	=	0.740	in	R yy	=	1.300	in	Sw	=	14.384	in^4
K1	=	0.750	in	Zy	=	5.160	in^3	Qf	=	8.460	in^3
rts	=	1.782	in	rT	=	1.750	in	Qw	=	21.761	in^3
Ycg	=	6.045	in								

Lake Junaluska
Dam Bridge Evaluation

BLE Project No. 9263-02

Steel Beam

File = c:\Users\SLUDES~1\DOCUME~1\ENERCA~1\TYPGIR~1.EC6
ENERCALC, INC. 1983-2016, Build:6.16.7.21, Ver:6.16.8.31

Lic. # : KW-06011232

Description : 8" Unbraced Bridge Girder w/ Standard Utility Truck Load for 14' Span

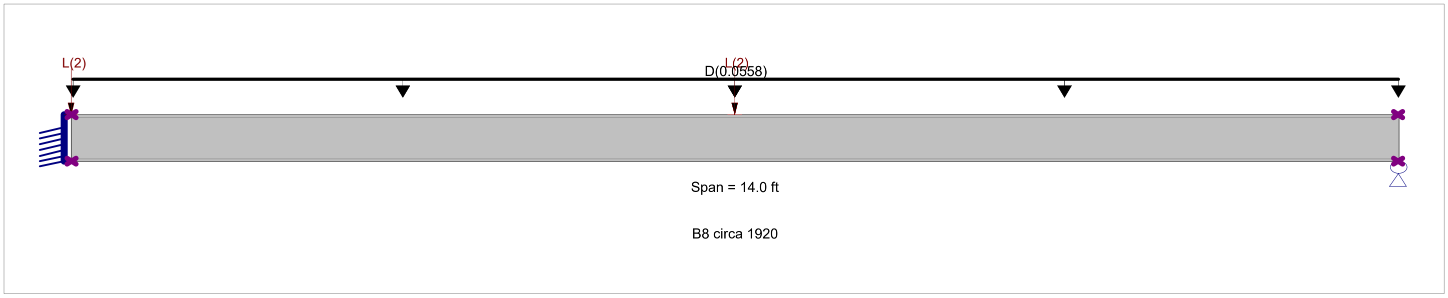
CODE REFERENCES

Calculations per AISC 360-10, IBC 2012, ASCE 7-10
Load Combination Set : ASCE 7-05

Material Properties

Analysis Method : Load Resistance Factor Design
Beam Bracing : Completely Unbraced
Bending Axis : Major Axis Bending

Fy : Steel Yield : 27.50 ksi
E: Modulus : 29,000.0 ksi



Applied Loads

Service loads entered. Load Factors will be applied for calculations.

Beam self weight calculated and added to loading
Uniform Load : D = 0.05580 k/ft, Tributary Width = 1.0 ft, (Dead)
Point Load : L = 2.0 k @ 7.0 ft, (Utility Truck)
Point Load : L = 2.0 k @ 0.0 ft, (Utility Truck)

DESIGN SUMMARY

Design OK

Maximum Bending Stress Ratio =	**0.387** : 1	Maximum Shear Stress Ratio =	**0.083** : 1
Section used for this span	**B8 circa 1920**	Section used for this span	**B8 circa 1920**
Mu : Applied	10.570 k-ft	Vu : Applied	2.975 k
Mn * Phi : Allowable	27.313 k-ft	Vn * Phi : Allowable	35.640 k
Load Combination	+1.20D+1.60L	Load Combination	+1.20D+1.60L
Location of maximum on span	0.000 ft	Location of maximum on span	0.000 ft
Span # where maximum occurs	Span # 1	Span # where maximum occurs	Span # 1

Maximum Deflection

Max Downward Transient Deflection	0.054 in	Ratio =	3,137 >=360.
Max Upward Transient Deflection	0.000 in	Ratio =	0 <360.0
Max Downward Total Deflection	0.000 in	Ratio =	0 <180
Max Upward Total Deflection	0.000 in	Ratio =	0 <180

Maximum Forces & Stresses for Load Combinations

Load Combination		Max Stress Ratios		Summary of Moment Values							Summary of Shear Values		
Segment Length	Span #	M	V	max Mu +	max Mu -	Mu Max	Mnx	Phi*Mnx	Cb	Rm	VuMax	Vnx	Phi*Vnx
+1.40D													
Dsgn. L = 14.00 ft	1	0.093	0.025	1.42	-2.53	2.53	30.35	27.31	1.00	1.00	0.90	35.64	35.64
+1.20D+1.60L													
Dsgn. L = 14.00 ft	1	0.387	0.083	8.08	-10.57	10.57	30.35	27.31	1.00	1.00	2.97	35.64	35.64
+D+L													
Dsgn. L = 14.00 ft	1	0.258	0.057	5.28	-7.06	7.06	30.35	27.31	1.00	1.00	2.02	35.64	35.64
+1.20D+0.50L													
Dsgn. L = 14.00 ft	1	0.176	0.041	3.27	-4.79	4.79	30.35	27.31	1.00	1.00	1.46	35.64	35.64
+1.20D													
Dsgn. L = 14.00 ft	1	0.079	0.022	1.22	-2.17	2.17	30.35	27.31	1.00	1.00	0.77	35.64	35.64
+0.90D													
Dsgn. L = 14.00 ft	1	0.060	0.016	0.92	-1.63	1.63	30.35	27.31	1.00	1.00	0.58	35.64	35.64

Overall Maximum Deflections

Load Combination	Span	Max. "-" Defl	Location in Span	Load Combination	Max. "+" Defl	Location in Span
L Only	1	0.0535	7.760		0.0000	0.000

Vertical Reactions

Support notation : Far left is #1 Values in KIPS

Load Combination	Support 1	Support 2
Overall MAXimum	4.021	1.012
Overall MINimum	0.387	0.232
D Only	0.646	0.387
+D+L	4.021	1.012

Steel Beam

File = c:\Users\SLUDES~1\DOCUME~1\ENERCA~1\TYPGIR~1.EC6
ENERCALC, INC. 1983-2016, Build:6.16.7.21, Ver:6.16.8.31

Lic. # : KW-06011232

Description : 8" Unbraced Bridge Girder w/ Standard Utility Truck Load for 14' Span

Vertical Reactions

Support notation : Far left is #1 Values in KIPS

Load Combination	Support 1	Support 2
+D+0.750L	3.177	0.856
+0.60D	0.387	0.232
L Only	3.375	0.625

Steel Section Properties : B8 circa 1920

Depth	=	8.000 in	I xx	=	56.90 in^4	J	=	0.553 in^4
Web Thick	=	0.270 in	S xx		14.20 in^3	Cw	=	729.76 in^6
Flange Width	=	4.000 in	R xx	=	3.270 in			
Flange Thick	=	0.462 in	Zx	=	14.200 in^3			
Area	=	5.330 in^2	I yy	=	3.780 in^4			
Weight	=	18.000 plf	S yy	=	1.900 in^3	Wno	=	18.963 in^2
Kdesign	=	0.740 in	R yy	=	0.840 in	Sw	=	14.384 in^4
K1	=	0.750 in	Zy	=	1.900 in^3	Qf	=	8.460 in^3
rts	=	1.782 in	rT	=	1.750 in	Qw	=	21.761 in^3
Ycg	=	6.045 in						

Steel Beam

File = c:\Users\SLUDES~1\DOCUME~1\ENERCA~1\TYPGIR~1.EC6
ENERCALC, INC. 1983-2016, Build:6.16.7.21, Ver:6.16.8.31

Lic. # : KW-06011232

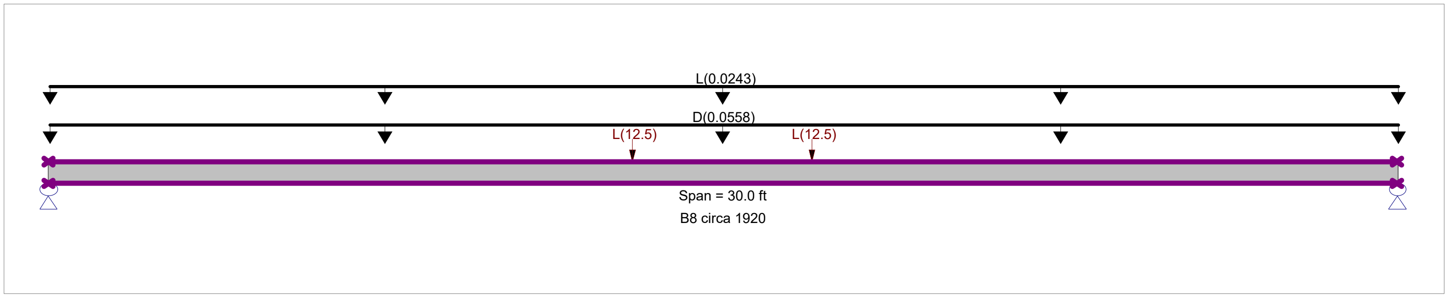
Description : 8" Fully Braced Bridge Girder w/ AASHTO Tandem Loads

CODE REFERENCES

Calculations per AISC 360-10, IBC 2012, ASCE 7-10
Load Combination Set : ASCE 7-05

Material Properties

Analysis Method :	Load Resistance Factor Design	Fy : Steel Yield :	27.50 ksi
Beam Bracing :	Beam is Fully Braced against lateral-torsional buckling	E: Modulus :	29,000.0 ksi
Bending Axis :	Major Axis Bending		



Applied Loads

Service loads entered. Load Factors will be applied for calculations.

Beam self weight calculated and added to loading
Uniform Load : D = 0.05580 k/ft, Tributary Width = 1.0 ft, (Dead)
Point Load : L = 12.50 k @ 17.0 ft, (AASHTO Tandem)
Point Load : L = 12.50 k @ 13.0 ft, (AASHTO Tandem)
Uniform Load : L = 0.02430 k/ft, Tributary Width = 1.0 ft, (AASHTO Lane)

DESIGN SUMMARY

Design N.G.

Maximum Bending Stress Ratio =	**9.367** : 1	Maximum Shear Stress Ratio =	**0.615** : 1
Section used for this span	**B8 circa 1920**	Section used for this span	**B8 circa 1920**
Mu : Applied	274.337 k-ft	Vu : Applied	21.912 k
Mn * Phi : Allowable	29.288 k-ft	Vn * Phi : Allowable	35.640 k
Load Combination	+1.20D+1.60L	Load Combination	+1.20D+1.60L
Location of maximum on span	15.000 ft	Location of maximum on span	0.000 ft
Span # where maximum occurs	Span # 1	Span # where maximum occurs	Span # 1

Maximum Deflection

Max Downward Transient Deflection	14.416 in	Ratio =	24 <360.0
Max Upward Transient Deflection	0.000 in	Ratio =	0 <360.0
Max Downward Total Deflection	0.000 in	Ratio =	0 <180
Max Upward Total Deflection	0.000 in	Ratio =	0 <180

Maximum Forces & Stresses for Load Combinations

Load Combination		Max Stress Ratios		Summary of Moment Values							Summary of Shear Values		
Segment Length	Span #	M	V	max Mu +	max Mu -	Mu Max	Mnx	Phi*Mnx	Cb	Rm	VuMax	Vnx	Phi*Vnx
+1.40D													
Dsgn. L = 30.00 ft	1	0.397	0.043	11.62		11.62	32.54	29.29	1.00	1.00	1.55	35.64	35.64
+1.20D+1.60L													
Dsgn. L = 30.00 ft	1	9.367	0.615	274.34		274.34	32.54	29.29	1.00	1.00	21.91	35.64	35.64
+D+L													
Dsgn. L = 30.00 ft	1	5.925	0.392	173.54		173.54	32.54	29.29	1.00	1.00	13.97	35.64	35.64
+1.20D+0.50L													
Dsgn. L = 30.00 ft	1	3.161	0.218	92.58		92.58	32.54	29.29	1.00	1.00	7.76	35.64	35.64
+1.20D													
Dsgn. L = 30.00 ft	1	0.340	0.037	9.96		9.96	32.54	29.29	1.00	1.00	1.33	35.64	35.64
+0.90D													
Dsgn. L = 30.00 ft	1	0.255	0.028	7.47		7.47	32.54	29.29	1.00	1.00	1.00	35.64	35.64

Overall Maximum Deflections

Load Combination	Span	Max. "-" Defl	Location in Span	Load Combination	Max. "+" Defl	Location in Span
L Only	1	14.6827	15.086		0.0000	0.000

Vertical Reactions

Support notation : Far left is #1 Values in KIPS

Load Combination	Support 1	Support 2
Overall MAXimum	13.972	13.972
Overall MINimum	0.664	0.664
D Only	1.107	1.107

Steel Beam

File = c:\Users\SLUDES~1\DOCUME~1\ENERCA~1\TYPGIR~1.EC6
ENERCALC, INC. 1983-2016, Build:6.16.7.21, Ver:6.16.8.31

Lic. # : KW-06011232

Description : 8" Fully Braced Bridge Girder w/ AASHTO Tandem Loads

Vertical Reactions

Support notation : Far left is #1   Values in KIPS

Load Combination	Support 1	Support 2
+D+L	13.972	13.972
+D+0.750L	10.755	10.755
+0.60D	0.664	0.664
L Only	12.865	12.865

Steel Section Properties : B8 circa 1920

Depth	=	8.000	in	I xx	=	56.90	in^4	J	=	0.553	in^4
Web Thick	=	0.270	in	S xx		14.20	in^3	Cw	=	729.76	in^6
Flange Width	=	4.000	in	R xx	=	3.270	in				
Flange Thick	=	0.462	in	Zx	=	14.200	in^3				
Area	=	5.330	in^2	I yy	=	3.780	in^4				
Weight	=	18.000	plf	S yy	=	1.900	in^3	Wno	=	18.963	in^2
Kdesign	=	0.740	in	R yy	=	0.840	in	Sw	=	14.384	in^4
K1	=	0.750	in	Zy	=	1.900	in^3	Qf	=	8.460	in^3
rts	=	1.782	in	rT	=	1.750	in	Qw	=	21.761	in^3
Ycg	=	6.045	in								

Lake Junaluska
Dam Bridge Evaluation

BLE Project No. 9263-02

File = c:\Users\SLUDES~1\DOCUME~1\ENERCA~1\TYPGIR~1.EC6
ENERCALC, INC. 1983-2016, Build:6.16.7.21, Ver:6.16.8.31

Steel Beam

Lic. # : KW-06011232

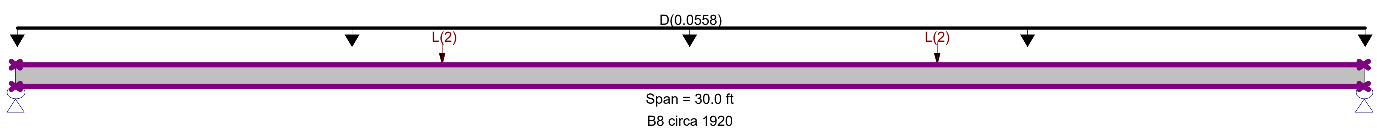
Description : 8" Fully Braced Bridge Girder w/ Standard Utility Truck Load

CODE REFERENCES

Calculations per AISC 360-10, IBC 2012, ASCE 7-10
Load Combination Set : ASCE 7-05

Material Properties

Analysis Method :	Load Resistance Factor Design	Fy : Steel Yield :	27.50 ksi
Beam Bracing :	Beam is Fully Braced against lateral-torsional buckling	E: Modulus :	29,000.0 ksi
Bending Axis :	Major Axis Bending		



Applied Loads

Service loads entered. Load Factors will be applied for calculations.

Beam self weight calculated and added to loading
Uniform Load : D = 0.05580 k/ft, Tributary Width = 1.0 ft, (Dead)
Point Load : L = 2.0 k @ 20.50 ft, (Utility Truck)
Point Load : L = 2.0 k @ 9.50 ft, (Utility Truck)

DESIGN SUMMARY

Design N.G.

Maximum Bending Stress Ratio =	**1.378** : 1	Maximum Shear Stress Ratio =	**0.127** : 1
Section used for this span	**B8 circa 1920**	Section used for this span	**B8 circa 1920**
Mu : Applied	40.363 k-ft	Vu : Applied	4.528 k
Mn * Phi : Allowable	29.288 k-ft	Vn * Phi : Allowable	35.640 k
Load Combination	+1.20D+1.60L	Load Combination	+1.20D+1.60L
Location of maximum on span	15.000 ft	Location of maximum on span	0.000 ft
Span # where maximum occurs	Span # 1	Span # where maximum occurs	Span # 1

Maximum Deflection

Max Downward Transient Deflection	1.946 in	Ratio =	184 <360.0
Max Upward Transient Deflection	0.000 in	Ratio =	0 <360.0
Max Downward Total Deflection	0.000 in	Ratio =	0 <180
Max Upward Total Deflection	0.000 in	Ratio =	0 <180

Maximum Forces & Stresses for Load Combinations

Load Combination		Max Stress Ratios		Summary of Moment Values							Summary of Shear Values		
Segment Length	Span #	M	V	max Mu +	max Mu -	Mu Max	Mnx	Phi*Mnx	Cb	Rm	VuMax	Vnx	Phi*Vnx
+1.40D													
Dsgn. L = 30.00 ft	1	0.397	0.043	11.62		11.62	32.54	29.29	1.00	1.00	1.55	35.64	35.64
+1.20D+1.60L													
Dsgn. L = 30.00 ft	1	1.378	0.127	40.36		40.36	32.54	29.29	1.00	1.00	4.53	35.64	35.64
+D+L													
Dsgn. L = 30.00 ft	1	0.932	0.087	27.30		27.30	32.54	29.29	1.00	1.00	3.11	35.64	35.64
+1.20D+0.50L													
Dsgn. L = 30.00 ft	1	0.665	0.065	19.46		19.46	32.54	29.29	1.00	1.00	2.33	35.64	35.64
+1.20D													
Dsgn. L = 30.00 ft	1	0.340	0.037	9.96		9.96	32.54	29.29	1.00	1.00	1.33	35.64	35.64
+0.90D													
Dsgn. L = 30.00 ft	1	0.255	0.028	7.47		7.47	32.54	29.29	1.00	1.00	1.00	35.64	35.64

Overall Maximum Deflections

Load Combination	Span	Max. "-" Defl	Location in Span	Load Combination	Max. "+" Defl	Location in Span
L Only	1	1.9479	15.086		0.0000	0.000

Vertical Reactions

Support notation : Far left is #1 Values in KIPS

Load Combination	Support 1	Support 2
Overall MAXimum	3.107	3.107
Overall MINimum	0.664	0.664
D Only	1.107	1.107
+D+L	3.107	3.107

Steel Beam

File = c:\Users\SLUDES~1\DOCUME~1\ENERCA~1\TYPGIR~1.EC6
ENERCALC, INC. 1983-2016, Build:6.16.7.21, Ver:6.16.8.31

Lic. # : KW-06011232

Description : 8" Fully Braced Bridge Girder w/ Standard Utility Truck Load

Vertical Reactions

Support notation : Far left is #1 Values in KIPS

Load Combination	Support 1	Support 2
+D+0.750L	2.607	2.607
+0.60D	0.664	0.664
L Only	2.000	2.000

Steel Section Properties : B8 circa 1920

Depth	=	8.000	in	I xx	=	56.90	in^4	J	=	0.553	in^4
Web Thick	=	0.270	in	S xx		14.20	in^3	Cw	=	729.76	in^6
Flange Width	=	4.000	in	R xx	=	3.270	in				
Flange Thick	=	0.462	in	Zx	=	14.200	in^3				
Area	=	5.330	in^2	I yy	=	3.780	in^4				
Weight	=	18.000	plf	S yy	=	1.900	in^3	Wno	=	18.963	in^2
Kdesign	=	0.740	in	R yy	=	0.840	in	Sw	=	14.384	in^4
K1	=	0.750	in	Zy	=	1.900	in^3	Qf	=	8.460	in^3
rts	=	1.782	in	rT	=	1.750	in	Qw	=	21.761	in^3
Ycg	=	6.045	in								

Steel Beam

File = c:\Users\SLUDES~1\DOCUME~1\ENERCA~1\TYPGIR~1.EC6
ENERCALC, INC. 1983-2016, Build:6.16.7.21, Ver:6.16.8.31

Lic. # : KW-06011232

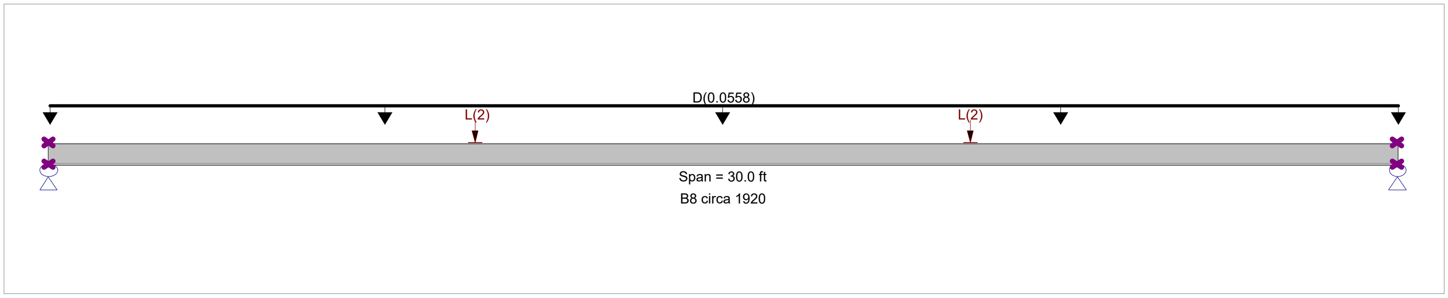
Description : 8" Unbraced Bridge Girder w/ Standard Utility Truck Load

CODE REFERENCES

Calculations per AISC 360-10, IBC 2012, ASCE 7-10
Load Combination Set : ASCE 7-05

Material Properties

Analysis Method :	Load Resistance Factor Design	Fy : Steel Yield :	27.50 ksi
Beam Bracing :	Completely Unbraced	E: Modulus :	29,000.0 ksi
Bending Axis :	Major Axis Bending		



Applied Loads

Service loads entered. Load Factors will be applied for calculations.

Beam self weight calculated and added to loading
Uniform Load : D = 0.05580 k/ft, Tributary Width = 1.0 ft, (Dead)
Point Load : L = 2.0 k @ 20.50 ft, (Utility Truck)
Point Load : L = 2.0 k @ 9.50 ft, (Utility Truck)

DESIGN SUMMARY

Design N.G.

Maximum Bending Stress Ratio =	**1.495** : 1	Maximum Shear Stress Ratio =	**0.127** : 1
Section used for this span	**B8 circa 1920**	Section used for this span	**B8 circa 1920**
Mu : Applied	40.363 k-ft	Vu : Applied	4.528 k
Mn * Phi : Allowable	27.005 k-ft	Vn * Phi : Allowable	35.640 k
Load Combination	+1.20D+1.60L	Load Combination	+1.20D+1.60L
Location of maximum on span	15.000ft	Location of maximum on span	0.000 ft
Span # where maximum occurs	Span # 1	Span # where maximum occurs	Span # 1

Maximum Deflection

Max Downward Transient Deflection	1.946 in	Ratio =	184 <360.0
Max Upward Transient Deflection	0.000 in	Ratio =	0 <360.0
Max Downward Total Deflection	0.000 in	Ratio =	0 <180
Max Upward Total Deflection	0.000 in	Ratio =	0 <180

Maximum Forces & Stresses for Load Combinations

Load Combination		Max Stress Ratios		Summary of Moment Values							Summary of Shear Values		
Segment Length	Span #	M	V	max Mu +	max Mu -	Mu Max	Mnx	Phi*Mnx	Cb	Rm	VuMax	Vnx	Phi*Vnx
+1.40D													
Dsgn. L = 30.00 ft	1	0.424	0.043	11.62		11.62	30.49	27.44	1.14	1.00	1.55	35.64	35.64
+1.20D+1.60L													
Dsgn. L = 30.00 ft	1	1.495	0.127	40.36		40.36	30.01	27.00	1.12	1.00	4.53	35.64	35.64
+D+L													
Dsgn. L = 30.00 ft	1	1.009	0.087	27.30		27.30	30.06	27.05	1.12	1.00	3.11	35.64	35.64
+1.20D+0.50L													
Dsgn. L = 30.00 ft	1	0.716	0.065	19.46		19.46	30.19	27.17	1.13	1.00	2.33	35.64	35.64
+1.20D													
Dsgn. L = 30.00 ft	1	0.363	0.037	9.96		9.96	30.49	27.44	1.14	1.00	1.33	35.64	35.64
+0.90D													
Dsgn. L = 30.00 ft	1	0.272	0.028	7.47		7.47	30.49	27.44	1.14	1.00	1.00	35.64	35.64

Overall Maximum Deflections

Load Combination	Span	Max. "-" Defl	Location in Span	Load Combination	Max. "+" Defl	Location in Span
L Only	1	1.9479	15.086		0.0000	0.000

Vertical Reactions

Support notation : Far left is #1 Values in KIPS

Load Combination	Support 1	Support 2
Overall MAXimum	3.107	3.107
Overall MINimum	0.664	0.664
D Only	1.107	1.107
+D+L	3.107	3.107

Steel Beam

File = c:\Users\SLUDES~1\DOCUME~1\ENERCA~1\TYPGIR~1.EC6
ENERCALC, INC. 1983-2016, Build:6.16.7.21, Ver:6.16.8.31

Lic. # : KW-06011232

Description : 8" Unbraced Bridge Girder w/ Standard Utility Truck Load

Vertical Reactions

Support notation : Far left is #1 Values in KIPS

Load Combination	Support 1	Support 2
+D+0.750L	2.607	2.607
+0.60D	0.664	0.664
L Only	2.000	2.000

Steel Section Properties : B8 circa 1920

Depth	=	8.000	in	I xx	=	56.90	in^4	J	=	0.553	in^4
Web Thick	=	0.270	in	S xx		14.20	in^3	Cw	=	729.76	in^6
Flange Width	=	4.000	in	R xx	=	3.270	in				
Flange Thick	=	0.462	in	Zx	=	14.200	in^3				
Area	=	5.330	in^2	I yy	=	3.780	in^4				
Weight	=	18.000	plf	S yy	=	1.900	in^3	Wno	=	18.963	in^2
Kdesign	=	0.740	in	R yy	=	0.840	in	Sw	=	14.384	in^4
K1	=	0.750	in	Zy	=	1.900	in^3	Qf	=	8.460	in^3
rts	=	1.782	in	rT	=	1.750	in	Qw	=	21.761	in^3
Ycg	=	6.045	in								

BUNNELL-LAMMONS ENGINEERING, INC.
GEOTECHNICAL, ENVIRONMENTAL AND CONSTRUCTION MATERIALS CONSULTANTS

APPENDIX D:

Supporting Documents

Point No.	Northing	Easting	Elevation	Description	
	Bay E Beam 1				
4	4910.527	5123.867	2565.390	BAY E BASE 1	
20	4910.522	5123.864	2565.391	BAY E BASECHK 1	
12	4910.521	5123.860	2565.388	BAY E TRUCK 1	0.036 in
21	4910.529	5123.862	2565.388	BAY E 2TRUCK 1	0.036 in
13	4910.519	5123.863	2565.382	BAY E CLTRUCK 1	0.108 in
28	4910.531	5123.863	2565.390	BAY E 2CLTRUCK 1	0.012 in
	Bay E Beam 2				
5	4912.411	5122.090	2565.410	BAY E BASE 2	
19	4912.411	5122.086	2565.412	BAY E BASECHK 2	
11	4912.405	5122.084	2565.401	BAY E TRUCK 2	0.132 in
22	4912.415	5122.090	2565.406	BAY E 2TRUCK 2	0.072 in
14	4912.409	5122.084	2565.400	BAY E CLTRUCK 2	0.144 in
27	4912.414	5122.087	2565.404	BAY E 2CLTRUCK 2	0.096 in
	Bay E Beam 3				
6	4914.62	5120.697	2565.401	BAY E BASE 3	
18	4914.619	5120.694	2565.400	BAY E BASECHK 3	
10	4914.613	5120.694	2565.388	BAY E TRUCK 3	0.156 in
23	4914.623	5120.697	2565.389	BAY E 2TRUCK 3	0.144 in
15	4914.613	5120.691	2565.385	BAY E CLTRUCK 3	0.192 in
26	4914.619	5120.695	2565.387	BAY E 2CLTRUCK 3	0.168 in
	Bay E Beam 4				
7	4917.015	5119.630	2565.434	BAY E BASE 4	
17	4917.016	5119.626	2565.431	BAY E BASECHK 4	
9	4917.012	5119.630	2565.422	BAY E TRUCK 4	0.144 in
24	4917.021	5119.631	2565.421	BAY E 2TRUCK 4	0.156 in
16	4917.016	5119.628	2565.421	BAY E CLTRUCK 4	0.156 in
25	4917.022	5119.629	2565.421	BAY E 2CLTRUCK 4	0.156 in
	Bay B Beam 1				
33	4967.608	5200.433	2564.985	BAY B BASE 1	
45	4967.61	5200.436	2564.989	BAY B BASECHK 1	
39	4967.61	5200.433	2564.977	BAY B TRUCK 1	0.144 in
40	4967.611	5200.430	2564.981	BAY B CLTRUCK 1	0.096 in
	Bay B Beam 2				
34	4969.561	5198.751	2564.970	BAY B BASE 2	
44	4969.555	5198.747	2564.970	BAY B BASECHK 2	
46	4969.545	5198.743	2564.973	BAY B BASECHK 2 REDO	
38	4969.552	5198.748	2564.962	BAY B TRUCK 2	0.132
41	4969.551	5198.743	2564.960	BAY B CLTRUCK 2	0.156
	Bay B Beam 3				
36	4972.124	5197.815	2564.972	BAY B BASE 3	
43	4972.117	5197.809	2564.971	BAY B BASECHK 3	
37	4972.127	5197.810	2564.963	BAY B TRUCK 3	0.108
42	4972.117	5197.809	2564.957	BAY B CLTRUCK 3	0.18
47	4986.342	5246.956	2565.230	BM IN BRDG NAVD88G12B	

NORTH CAROLINA PROFESSIONAL SEAL L-4881 LAND SURVEYOR J. DANIEL HENRY

9/9/2016

December 14, 1970

Dr. Edgar H. Nease, Jr.
Lake Junaluska Assembly, Inc.
Box 67
Lake Junaluska, N.C. 28745

Re: Bridge over lake dam.

Dear Dr. Nease:

I am in receipt of Mrs. Campbell's letter of December 8, 1970, and the accompanying information prepared by Mr. Charlie Green.

In general, the information received is as requested. However, I will need a more exact measurement of width for the 12 inch deep beams. These beams should not be exactly 6 inches wide but should be approximately 5½ or 6½ inches. It is important to know the more exact dimension because the physical properties depend upon the width of the flanges and material thickness as well as depth.

Secondly, I should like verification of the 32 ft. spans indicated by Mr. Green. I had estimated the piers to be 15 to 16 ft. on centers which seems to be more correct for the sizes of beams shown in Mr. Green's sketch. It may be, of course, that the end spans are as I estimated with the intermediate spans being 32 ft. If so, the beam sizes may also vary between long and short spans.

In any event, a preliminary analysis, based on the information furnished, indicates that a new concrete slab can be placed on the existing beams. However, I do not believe the bridge now meets published standards for this type of structure, nor will the mere addition of a new slab bring the structure within these standards. It will, in my opinion, be safe for automobile traffic provided car velocities can be kept within reasonably low values. Upon the completion of final designs, limits and vehicle speeds can be posted.

For preparing construction drawings, it will be most helpful if mr. Green would furnish me with the width of road bed, and walkway, the height of the walk above the roadbed, and the thickness of the existing wood deck of the walk.

I appreciate this opportunity to be of service to you.

Respectfully,

Hallett J. Bowen, P.E.

November 5, 1946

Mr. Edwin L. Jones
The J. A. Jones Construction Company
Charlotte 1, North Carolina

My dear Mr. Jones:

I have just had some sketches and a bid from A. S. Wickstrom, Construction Company, for the work on the bridge. I am enclosing this letter to you and need not repeat the detailed information it conveys. I think it will impress you, as it does me, that the figure is unreasonable and impossible. I have Mr. Liner working on a proposition now and I think we will get a vastly different figure from him. Mr. Liner suggest that the present I-beams are sufficient to support any weight that we would have on the bridge. This would save us 1100 feet of running steel. I am asking Mr. Kelker for an approval of this. I would appreciate very much having your appraisal of the above, and, of course, would like to have the Wickstrom letter returned for our files.

Is there a possibility of having your organisation do this work?

I hope you and Judge Littleton will keep me informed as to any conclusions you may have relative to financing the hotel.

With warm personal regards, I am

Sincerely,

F. S. Love

FSL:L

copy to Bishop Clare Purcell

J. A. JONES CONSTRUCTION COMPANY

ORGANIZED 1894 — INCORPORATED 1920

Contractors and Builders

CHARLOTTE, 1, N. C.

November 15, 1946

Dr. F. S. Love
Lake Junaluska Assembly
Lake Junaluska, North Carolina

Dear Dr. Love:

Answering your letter of the 13th, I am returning the estimate of Mr. Liner for rebuilding the bridge. This estimate is $22,575. This is more than double the $10,000 figure you suggested in our Atlanta meeting. I do not believe we have this much money to put into the bridge, and if this is the best price we can get, we should replace the planks that Mr. Ivey put down and use the bridge another season.

We ought to put up several more signs calling for the public to slow down to ten miles an hour. I strongly recommend that we close the bridge completely during the off season and divert all necessary traffic around to the other end. If some truck or some tourist goes off the bridge, we may be in for a nasty suit.

You will note that Mr. Liner's quotation does not even include the cost of asphalt topping or wearing surface. You will recall in our Atlanta meeting, the writer was appointed on a committee to make suggestions about financing and handling the installation of a trunk sewer line. I hope you can send me the plans you have so we can make up our own estimate of the cost.

I would also like to have a copy of the last audit left by Dr. Lambeth and copies of all subsequent audits, so as to be able to make some recommendations about the money we can and should take out of our surplus to use on the sewer line. If you do not have extra copies that I could retain, I will return the audits to you immediately.

Both the bridge and sewer are of prime importance. We can get into the Assembly grounds without the use of the bridge. We cannot operate the Assembly much longer without a main sewer line.

With best wishes, I am

Sincerely yours,

Edwin

Edwin L. Jones

ELJ:cs
cc - Bishop Purcell
cc - Bishop Kern, Bishop Peele, Bishop Moore

THE MOUNTAINEER
PUBLISHED EVERY MONDAY, WEDNESDAY and FRIDAY
WAYNESVILLE, NORTH CAROLINA FRIDAY, MARCH 12, 1976 15c Per Copy

Junaluska Dam

It's Safe But Needs Some Repairs

Two governmental agency engineers and a private engineering concern have told trustees of Lake Junaluska Assembly that the lake dam, which backs up water to cover 250 acres "is safe, and meets engineering standards, but needs some repairs."

Based on recommendations of the three specialists, the trustees have authorized W. Hugh Massie, board chairman, the building and grounds committee, and other officials of the assembly to get specifications and let a contract for major modernization of the dam with work to begin early September.

The three engineers said there was no need to drain the lake prior to September, and that there is no danger. Work will begin at the end of the current season and will require several months to complete.

Recommendations for a new four-inch concrete surface on the water side of the dam, new concrete plaster on the back side, and some work on abutments.

The project will cost several hundred thousand dollars, Massie said this morning.

"While we hate to have to make this expenditure, we want to be more than sure about the dam. We offered to close the dam to traffic and drain the lake if engineers thought it was needed, but they said to wait until September to start the project.

"Our plans are to get the details worked out and the contract let so the contractor can start work immediately after the close of the season in late August," the chairman added.

The dam was inspected two years ago by engineers and given a "clean bill of health."

The dam has been maintained since it was constructed in 1913.

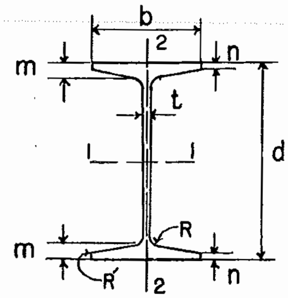
The engineers recently checking the dam included representatives from the U.S. Environmental Protective Agency, N. C. safety engineers, and the private concern.

8" AMERICAN STANDARD BEAMS

REFERENCES; SEE COLUMN (1) AND PAGE 4

31
PE 1896

1,2,3,4,5,6,7,8,9,10, 11,12,13,14,15,16,17, 18,19,20,21,22,23, 24,25,26,27,28, 29,30,32,33,34, 35,36,37,38,39
See Page 26



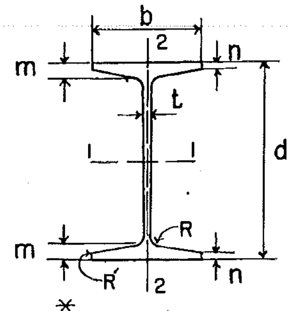
*Computed

COL. (1)	WEIGHT PER FOOT	AREA	DEPTH d	FLANGE WIDTH b	WEB THICK t	DIMENSIONS m	DIMENSIONS n	DIMENSIONS R	DIMENSIONS R′	SLOPE INSIDE FLANGE	AXIS 1—1 I	AXIS 1—1 S	AXIS 1—1 r	AXIS 2—2 I	AXIS 2—2 S	AXIS 2—2 r
	Lb.	Sq.In.	In.	In.	In.	In.	In.	In.	In.	%	In.⁴	In.³	In.	In.⁴	In.³	In.
2	21.7	6.4*	8.0	4.387*	.387*	.56	.26	.37	—	15.0*	63.65*	15.9*	3.15*	4.88*	2.22*	.87*
31	21.2	6.24	8.0	4.14*	.40*	.53	.25	—	—	15.0*	60.28	15.07	3.11	3.96	1.91	.80
36,37	21.0	6.18	8.0	5.40	.38	.409	.20	.30	.03	8 1/3*	62.3	15.6	3.18	6.80	2.52	1.05
23	20.5	6.07*	8.0	4.092	.362	.581	.27	.37	—	16 2/3*	60.83*	15.21*	3.17*	4.09*	2.00*	.82*
21	20.5	6.06*	8.0	4.090	.360	.581	.27	.37	—	16 2/3*	60.74*	15.19*	3.17*	4.08*	2.00*	.82*
34,35	20.5	6.03	8.0	4.092	.362	.581	.27	.37	.162	16 2/3*	60.6	15.1	3.17	4.07	1.99*	.82
4,9,11,17,18, 22,24,26	20.5	6.03	8.0	4.087	.357	.581	.27	.37	.162	16 2/3*	60.6	15.1	3.17	4.07	2.0	.82
36,	20.5	6.03	8.0	4.08	.35	.581	.27	.37	.16	16 2/3*	60.6	15.2	3.17	4.04	1.98	.82
32	20.5	6.03	8.0	4.07	.34	.58	.27	—	—	16 2/3*	61.29	15.3	3.19	4.02	1.98*	.82
7,10,12,16,25, 37	20.5	5.97	8.0	4.079	.349	.581	.27	.37	.16	16 2/3*	60.2	15.1	3.18	4.0	2.0	.82
20	20.25	6.06*	8.0	4.090	.360	.581	.27	.37	—	16 2/3*	60.74*	15.19*	3.17*	4.08*	2.00*	.82*
14,15	20.25	5.96	8.0	4.08	.35	.581	.27	.37	.16	16 2/3*	60.2	15.0	3.18	4.04	1.98*	.82
29	20.0	5.9	8.0	4.20	.32	.56	.27	.37	—	14.9*	59.9	15.0	3.22	4.33	2.06*	.86
36,37	19.0	5.59	8.0	5.32	.31	.409	.20	.30	.03	8 1/3*	59.2	14.8	3.26	6.45	2.42	1.08
36	18.4	5.41	8.0	4.00	.270	.581	.27	.37	.16	16 2/3*	57.3	14.3	3.25	3.78	1.89	.84
7,8,10,12,13, 16,18,25,35, 37,38,39	18.4	5.34	8.0	4.00	.270	.581	.27	.37	.16	16 2/3	56.9	14.2	3.26	3.8	1.9	.84
21,	18.0	5.34*	8.0	4.000	.270	.581	.27	.37	—	16 2/3*	56.90*	14.23*	3.26*	3.79*	1.90*	.84*
4,9,11,15,17, 18,22,23, 24,26,31	18.0	5.33	8.0	4.000	.270	.581	.27	.37	.162	16 2/3*	56.9	14.2	3.27	3.78	1.9	.84
1,2,3,27,33	18.0	5.3	8.0	4.25	.25	.56	.26	.37	—	15.0*	57.8	14.4	3.30	4.35	2.05*	.91
19	18.0	5.3	8.0	4.250	.250	.563	.25	.375	—	15.7*	57.3	14.3	3.28	4.27	2.01*	.89
32	18.0	5.29	8.0	4.00	.27	.58	.27	—	—	16 2/3*	57.36	14.3	3.29	3.72	1.86*	.84
34	18.0	5.29	8.0	4.000	.270	.581	.27	.37	.162	16 2/3*	56.9	14.2	3.27	3.78	1.89*	.84
28	18.0	5.2	8.0	4.13	.25	.56	.27	.37	—	14.9*	56.8	14.2	3.30	3.95	1.91*	.87
14	17.75	5.33	8.0	4.00	.27	.581	.27	.37	.16	16 2/3*	56.9	14.2	3.27	3.78	1.89*	.84
20	17.75	5.22	8.0	4.000	.270	.581	.27	.37	—	16 2/3*	56.87	14.2	3.31	3.78	1.89*	.84
5	17.5	5.15	8.0	4.330	.210	.583	.24	.33	—	16 2/3*	58.3	14.6	3.37	4.5	2.1	.93
6	17.5	5.12	8.0	5.000	.220	.457	.24	.18	—	9.0*	58.4	14.6	3.38	6.2	2.5	1.10
31	17.4	5.12	8.0	4.00	.26	.53	.25	—	—	15.0*	54.31	13.58	3.26	3.52	1.76*	.83
30	17.23	5.07	8.0	4.00	.26	.52	.26	.40	.20	13.9*	53.22	13.31	3.24	3.52	1.76*	.83
36,37	17.0	5.00	8.0	5.25	.24	.409	.20	.30	.03	8 1/3*	56.0	14.0	3.35	6.16	2.35	1.11

12" BEAMS

REFERENCES; SEE COLUMN (1) AND PAGE 4

3	6	1,7,11,19,21
S3-1909	S24-1927	See Page 71
S4-1911	8	9,10,17,20
S12-1922	812	See Page 72
S15-1924	S27-1928	
5	S35-1930	24
S16-1925	812, 12X6½	K1950
S18-1926	S40,-1931	K1952



*Computed

SECT. NO. OR NOM. SIZE	COL. (1)	WEIGHT PER FOOT Lb.	AREA Sq.In.	DEPTH d In.	FLANGE WIDTH b In.	WEB THICK t In.	DIMENSIONS m In.	n In.	R In.	R' In.	SLOPE INSIDE FLANGE %	AXIS 1—1 I In.⁴	S In.³	r In.	AXIS 2—2 I In.⁴	S In.³	r In.	
12WF B12a 12X8	11	45.0	13.24	12.060	8.042	.336	.576	.576	.60	0	0	350.8	58.2	5.15	50.0	12.4	1.94	
12WF CB122 12X8	21	45.0	13.24	12.060	8.042	.336	.576	.576	.60	0	0	350.8	58.2	5.15	50.0	12.4	1.94	
CB123 12X8	17	45.0	13.23	12.130	8.036	.326	.591	.591	.50	0	0	356.9	58.8	5.19	51.2	12.7	1.97	
CB123N 12X8	19	45.0	13.21	12.060	8.042	.340	.576	.576	.60	0	0	349.3	57.9	5.14	50.0	12.4	1.95	
B12a	6	44.5	13.10	12.250	6.445	.375	.818	.565	.40	0	8⅓*	340.9	55.7	5.10	28.3	8.77	1.47	
B12a	7	44.0	12.97	12.120	6.780	.360	.795	.528	.40	0	8⅓*	335.1	55.3	5.08	31.1	9.18	1.55	
B12a	6	40.0	11.84	12.120	6.410	.340	.753	.500	.40	0	8⅓*	304.6	50.3	5.07	24.9	7.78	1.45	
B12a	7	40.0	11.80	12.000	6.750	.330	.735	.468	.35	0	8⅓*	301.2	50.2	5.05	27.6	8.18	1.53	
12WF B12a 12X8	11	40.0	11.77	11.940	8.000	.294	.516	.516	.60	0	0	310.1	51.9	5.13	44.1	11.0	1.94	
12WF CB122 12X8	21	40.0	11.77	11.940	8.000	.294	.516	.516	.60	0	0	310.1	51.9	5.13	44.1	11.0	1.94	
CB123 12X8	17	40.0	11.76	12.000	8.000	.290	.526	.526	.50	0	0	313.7	52.3	5.17	44.9	11.2	1.95	
CB123N 12X8	19	40.0	11.75	11.940	8.000	.298	.516	.516	.60	0	0	308.6	51.7	5.13	44.1	11.0	1.94	
B12a	5	36.5	10.60	12.000	6.380	.310	.693	.440	.40	0	8⅓*	269.2	44.9	5.04	21.9	6.88	1.44	
B12a	1	36.0	10.63	12.000	6.300	.310	.764	.390	.41	0	12.5*	270.2	45.0	5.04	20.4	6.48*	1.38	
B12a	3	36.0	10.61	12.000	6.300	.310	.710	.440	.40	0	9.0*	269.2	44.9	5.04	21.3	6.76*	1.42	
CB122 12X6½	17	36.0	10.59	12.236	6.568	.308	.538	.538	.35	0	0	280.1	45.8	5.14	25.4	7.7	1.55	
12WF B12 12X6½	11	36.0	10.59	12.240	6.565	.305	.540†		.35	0	5.0	280.8	45.9	5.15	23.7	7.2	1.50	
12WF CB121 12X6½	21	36.0	10.59	12.240	6.565	.305	.540	.540	.37	0	0	280.8	45.9	5.15	23.7	7.2	1.50	
CB122N 12X6½	19	36.0	10.58	12.250	6.560	.300	.545	.545	.35	0	0	282.3	46.1	5.17	25.7	7.8	1.56	
B12 12X6½	8	36.0	10.58	12.250	6.555	.300	.675	.415	.35	0	8⅓*	281.8	46.0	5.16	22.7	6.93	1.46	
CB122 12X6½	17	34.0	9.99	12.022	6.635	.375	.431	.431	.35	0	0	238.1	39.6	4.88	21.0	6.3	1.45	
12WF 12X6½	24	32.5	9.54	12.000	6.570	.310	.456†		—	—	10.5	238.1	39.7	5.00	17.8	5.4	1.37	
B12	3	32.0	9.44	12.000	6.205	.335	.594	.330	.35	0	9.0*	228.5	38.1	4.92	16.0	5.16*	1.30	(highlighted)
CB122N 12X6½	19	32.0	9.42	12.120	6.535	.275	.480	.480	.35	0	0	247.0	40.8	5.12	22.3	6.8	1.54	
B12 12X6½	9	32.0	9.42	12.120	6.530	.275	.610	.350	.35	0	8⅓*	246.4	40.7	5.11	19.4	5.94	1.44	
12WF B12 12X6½	10	32.0	9.41	12.120	6.533	.273	.480†		.35	0	5.0	246.8	40.7	5.12	20.6	6.3	1.48	
12WF CB121 12X6½	20	32.0	9.41	12.120	6.533	.273	.480	.480	.37	0	0	246.8	40.7	5.12	20.6	6.3	1.48	
CB122 12X6½	17	32.0	9.40	12.118	6.534	.274	.479	.479	.35	0	0	246.3	40.7	5.12	22.3	6.8	1.54	

†Average thickness

HISTORY OF A.S.T.M. AND A.I.S.C.
STRUCTURAL STEEL SPECIFICATION STRESSES

Date	Specification	Remarks	ASTM Requirement Tensile Strength psi	ASTM Requirement Minimum Yield Point psi
1900	ASTM, A7	Rivet Steel	50,000 to 60,000	30,000
	Bridges	Soft Steel	52,000 to 62,000	32,000
		Medium Steel	60,000 to 70,000	35,000
	ASTM, A9	Rivet Steel	50,000 to 60,000	30,000
	Buildings	Medium Steel	60,000 to 70,000	35,000
1901–1904	ASTM, A7	Rivet Steel	50,000 to 60,000	1/2 T.S.
	Bridges	Soft Steel	52,000 to 62,000	1/2 T.S.
		Medium Steel	60,000 to 70,000	1/2 T.S.
	ASTM, A9	Rivet Steel	50,000 to 60,000	1/2 T.S.
	Buildings	Medium Steel	60,000 to 70,000	1/2 T.S.
1905–1908	ASTM, A7	Structual Steel	Desired 60,000	– – – –(1)
	Bridges	Rivet Steel	Desired 50,000	– – – –(1)
		Steel Castings not less than	65,000	– – – –(1)
	ASTM, A9	Rivet Steel	50,000 to 60,000	1/2 T.S.
	Buildings	Medium Steel	60,000 to 70,000	1/2 T.S.
1909–1912	ASTM, A7	Structurol Steel	Desired 60,000	– – – –(1)
	Bridges	Rivet Steel	Desired 50,000	– – – –(1)
		Steel Costings not less thon	65,000	– – – –(1)
	ASTM, A9	Structurol Steel	55,000 to 65,000	1/2 T.S.
	Buildings	Rivet Steel	48,000 to 58,000	1/2 T.S.
1913	ASTM, A7	Structural Steel	Desired 60,000	– – – –(1)
	Bridges	Rivet Steel	Desired 50,000	– – – –(1)
		Steel Costings were deleted from A7		
	ASTM, A9	Structurol Steel	55,000 to 65,000	1/2 T.S.
	Buildings	Rivet Steel	48,000 to 58,000	1/2 T.S.
1914–1923	ASTM, A7	Structurol Steel	55,000 to 65,000	1/2 T.S.
	Bridges	Rivet Steel	46,000 to 56,000	1/2 T.S.
	ASTM, A9	Structurol Steel	55,000 to 65,000	1/2 T.S.
	Buildings	Rivet Steel	46,000 to 56,000	1/2 T.S.
1923	AISC	Allowoble basic working stress 18,000 psi		

(1) No definite requirements for yield point other than it be recorded in test reports.

December 22, 2016

Lake Junaluska Assembly
91 Lakeshore Drive
Lake Junaluska, North Carolina 28745

Attention: Mr. Jack Ewing
Executive Director

Subject: **ADDITIONAL BRIDGE EVALUATION**
Lake Junaluska Dam (NC Dam Safety ID No. HAYWO-001)
Lake Junaluska, North Carolina
BLE Project No. P14-9263-05

Dear Mr. Ewing,

Bunnell-Lammons Engineering, Inc. (BLE) has completed Phase II of the Lake Junaluska Dam Bridge Evaluation. The work was performed in general conformance with our proposal number P16-0753B, executed on November 10, 2016. The scope of services generally included concrete sampling and compressive strength testing; bridge beam inventory; development of remediation alternatives and construction cost estimating.

BACKGROUND

On October 20, 2016, BLE engineers John Garner, PE and Chris Sluder, PE presented the results of our preliminary bridge structural analysis and spillway capacity analysis to the Lake Junaluska Board of Trustees. Based on our report, the Board authorized BLE to evaluate two alternatives for the bridge over the dam: restore the bridge to pedestrian-only traffic standard, and restore the bridge to limited vehicular traffic standards. Additionally, the Board directed BLE to prepare a preliminary engineer's construction cost estimate for both alternatives.

CONCRETE SAMPLING AND TESTING

On November 17, 2016 representatives of BLE obtained eight usable concrete cores from the concrete supports located between: Bays O and N, Bays K and J, Bays C and B. The cores were obtained from the upstream side of the bridge supports at the approximate locations shown on the attached Coring Location Plan, Figure 3. The cores were obtained and tested in general accordance with ASTM procedure C-42 *"Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete"*. The exact date of concrete abutment construction is not known, but we understand the dam was construction in the early 1900's. The concrete mixture utilized for construction of the subject concrete supports is unknown.

The cores were obtained using a diamond-tipped, water-cooled, 4-inch diameter core barrel driven by an electric drill. Cores were advanced to a depth of approximately 10 inches. After the coring was completed, the cores were transported to BLE's laboratory where the cores were photo-documented, measured, and prepared for testing. Pictures of the cores are attached.

After air drying for 5 days, the cores were trimmed, measured, and prepared for compressive strength testing. Due to the length of the core obtained from core location #1, it was possible to obtain two samples (1 and 1A) for compressive testing. The cores were tested by applying a continuous load on the plane perpendicular to the longitudinal axis of the cores.

The exposed surface of the obtained cores was generally rough and had a surface growth of algae. In general, the concrete paste was light grey in color and had an even appearance. The coarse aggregate was angular in shape and ranged in size from ¾ of an inch to approximately 6 inches in average diameter. Steel reinforcing was not encountered at the locations the cores were taken. Visual observations of exposed reinforcing steel in other portions of the spillway indicate that cold-twisted square stock steel was used as the original reinforcement.

The compressive strength results of the cores ranged from 1,490 to 3,090 pounds per square inch (psi), with an average of 2,140 psi. The individual results of the compressive strength testing are shown on the attached Summary of Core Compressive Strength Tests. The cores tested on November 21, 2016 exhibited a failure mode through the cement and aggregate with failure characteristics noted to be non-typical due to failure caused by exposed large aggregate within the concrete cores obtained at multiple locations.

The average concrete compressive strength results indicate that the concrete supports appear to be suitable for pedestrian travel on the bridge. The results do present potential concerns with regards to bridge support for vehicular traffic. The range of the compressive strengths may be the result of the interaction of the observed larger aggregate with the concrete paste in a relatively small core size. If the concrete can be shown to have strength consistently near the high range, the supports may be adequate for vehicular traffic. Therefore, further evaluation of the concrete supports is necessary to determine the suitability of the concrete supports for vehicular traffic loads. Additional evaluation may include:

- additional, large diameter core samples
- detailed observations of the supports' connections to the buttresses below each support
- detailed measurements of the concrete supports

BRIDGE GIRDER ASSESSMENT

Representatives of BLE investigated the condition of the structural members for the Lake Junaluska Dam bridge. Observations of the steel structural members were made utilizing photographs obtained during recent site visits in conjunction with onsite observations from underneath the bridge from a boat, and from the downstream side of the dam at the bottom of the spillway using binoculars.

Observations confirmed corrosion previously observed within the steel members supporting the timber bridge. Levels of corrosion range from minor to severe. The level of corrosion was apparent from the observed loss of cross section within the web and/or flanges of the steel members. Steel members that appeared to have corrosion are marked on Girder Assessment, Figures 1 and 2.

The year that the steel members were installed for the Lake Junaluska Dam bridge is unknown, but we understand that additional and/or replacement steel members were installed in the 1990's. The location of these added steel members is noted by hatching on Girder Assessment, Figure 1.

The girder assessment indicates that approximately 45% of the girders appear to be re-usable steel members. Further evaluation of the individual steel members is necessary to determine the exact number of re-usable steel members. For cost estimating purposes, we have assumed that 56 of the presently used beams will not be usable in a vehicle-ready bridge structure.

COST ESTIMATES

BLE prepared preliminary engineer's construction cost estimates to provide a basis for decisions on the remediation of the bridge. We evaluated two scenarios: pedestrian-only access and vehicle access. Based on the results of the concrete testing, there is a possibility that the existing concrete supports can still be used in the vehicle access scenario. Therefore, we developed a second alternative under the vehicle access scenario to evaluate the difference between removal and replacement of the supports versus re-use of the existing supports. The three scenarios are discussed below.

Alternative 1 – Pedestrian-only Access

Alternative 1 stipulates that the bridge will be permanently closed to vehicular access. Therefore, the bridge loading would be limited to pedestrian and bicycle traffic. Furthermore, this loading condition would be limited to transient loading conditions. Scenarios that would involve a large group of pedestrians congregating on the bridge are not considered.

In Alternative 1, the existing bridge steel beams and concrete supports are adequate to support the anticipated loading conditions. We note that some degradation in steel beams and concrete supports should be remediated to address longevity concerns. The following recommendations are incorporated into the Engineer's Construction Cost Estimate for Alternative 1:

- Removal and recycling of existing pedestrian walkway
- Steel beam corrosion is removed by sandblasting
- Steel beams are repaired by patch welding where corrosion is severe
- Steel members are primed and painted
- The existing guardrails are re-used
- Concrete bridge supports are fitted with bearing plates at each steel beam contact area
- The existing wood decking is removed and replaced with an exterior-grade laminate lumber
- Structural bollards are erected to prevent vehicle access

The Preliminary Engineer's Construction Cost Estimate for Alternative 1 is attached to this report. This estimate provides information on our understanding of the required work items necessary to complete the scope of work identified above. We have developed construction material quantities based on our visual observations and sampling and testing. This estimate is not based on a set of engineering or construction plans. BLE consulted with an independent contractor to receive input on our approach and unit rates for cost estimate line items.

Alternative 2 – Vehicle Access – Reuse Existing Concrete Supports

Alternative 2 is an evaluation of the work required to restore vehicular access to the bridge while utilizing the existing concrete supports. In this alternative, the vehicle loading would require that some of the existing steel beams be replaced, due to the loss of structural section. BLE made a visual approximation of the number of beams that would potentially require replacement. These beams are identified on the attached Figure 1 and Figure 2. Other beams would require additional inspection, also identified on the Figures. All steel beams to be re-used would be sandblasted, primed and painted to inhibit further corrosion.

We note that this alternative assumes that the bridge is restored to its existing dimensions and that vehicular traffic is limited to one lane. Additionally, the weight limit for vehicular loading should be set at a practical limit that is within the structural tolerance of the proposed beam-works and the existing concrete supports. Finally, the degradation of concrete at the concrete supports appears to primarily be the result of two effects: freeze-thaw degradation around the normal water surface elevation and cyclic loading at the steel beam contact areas. We have included a line-item for repair of this area in the cost estimate for Alternative 2. Anticipated elements of Alternative 2 are presented below.

- Failing steel beams are removed and recycled
- Steel beam corrosion is removed by sandblasting
- Steel beams are repaired by patch welding where corrosion is not severe enough to warrant beam removal
- New steel beams are added
- Steel members are primed and painted
- The existing guardrails are removed and recycled
- New, vehicle-restraining guardrails are fabricated and installed
- Concrete bridge supports are cleaned and repaired in degraded areas
- Concrete bridge supports are fitted with bearing plates at each steel beam contact area
- The existing wood decking is removed and replaced with an exterior-grade laminate lumber

The Preliminary Engineer's Construction Cost Estimate for Alternative 2 is attached to this report. This estimate provides information on our understanding of the required work items to complete the scope of work identified above. We have developed construction material quantities based on our visual observations and sampling and testing. This estimate is not based on a set of engineering or construction plans. BLE consulted with an independent contractor to receive input on our approach and unit rates for cost estimate line items.

Alternative 3 – Vehicle Access – Remove and Replace Existing Concrete Supports
Alternative 3 is an evaluation of the work required to restore vehicular access to the bridge and replacing the existing concrete supports. In this alternative, the vehicle loading would require that some of the existing steel beams be replaced, due to the loss of structural section, similar to Alternative 2. BLE made a visual approximation of the number of beams that would potentially require replacement. These beams are identified on the attached Figure 1 and Figure 2. Other beams would require additional inspection, also identified on the Figures. All steel beams to be re-used would be sandblasted, primed and painted to inhibit further corrosion.

Based on the concrete testing results, some or all of the concrete bridge supports may not be suitable for long term service under continued vehicular loading. Confirmation of the interface between the concrete supports and the slab and buttress dam structure below the water surface is also required. This alternative considers the cost implications of complete removal of the concrete supports and replacement with new supports that are structurally integrated with the existing dam support structure. This alternative anticipates a significant effort in creating working access to the existing concrete support areas.

We note that this alternative assumes that the bridge is restored to its existing dimensions and that vehicular traffic is limited to one lane. Additionally, the weight limit for vehicular loading should be set at a practical limit that is within the structural tolerance of the proposed beam-works and the proposed new concrete supports. Anticipated elements of Alternative 3 are presented below.

- The existing guardrails are removed and recycled
- All beams are removed and failing steel beams are recycled. Re-usable steel beams are stockpiled
- Existing concrete bridge supports are demolished and disposed off site.
- New concrete bridge supports are constructed and fitted with bearing plates at each steel beam contact area
- Steel beam corrosion is removed by sandblasting
- Steel beams are repaired by patch welding where corrosion is not severe enough to warrant beam removal
- New steel beams are added
- Steel members are primed and painted
- Steel members are replaced on the new concrete supports
- New, vehicle-restraining guardrails are fabricated and installed
- New wood decking is installed with an exterior-grade laminate lumber

The Preliminary Engineer's Construction Cost Estimate for Alternative 3 is attached to this report. This estimate provides information on our understanding of the required work items to complete the scope of work identified above. We have developed construction material quantities based on our visual observations and sampling and testing. This estimate is not based on a set of engineering or construction plans. BLE consulted with an independent contractor to receive input on our approach and unit rates for cost estimate line items.

The information in each of these Preliminary Engineer's Construction Cost Estimate should be used to evaluate the subject alternative relative to the other presented alternatives. Budgeting discussions and decisions should be based on a more thorough development of plans and specifications for the selected alternative(s).

CONCLUSIONS

The development of Preliminary Engineer's Construction Cost Estimates provides a basis for decision-making and planning for the next actions to be taken on this project. A summary of these estimates and contingencies is presented in the table below. While we have worked to provide an accurate evaluation of the construction costs, these estimates are limited by the preliminary nature of our analyses, a limited view of the bridge structure, an under-developed scope of construction work, and other unknown factors relevant to actual construction costs.

Preliminary Cost Item	Alt. 1 – Ped.-only	Alt. 2 – Veh. w/ Existing Supports	Alt. 3 – Veh. w/ New Supports
Construction	$ 495,600.00	$ 894,096.00	$ 1,291,096.00
Engineering	$ 49,560.00	$ 223,524.00	$ 129,109.60
Construction Phase Engineering Services	$ 24,780.00	$ 89,409.60	$ 64,554.80
Project Contingency	$ 99,120.00	$ 178,819.20	$ 258,219.20
Total Estimate	**$ 669,060.00**	**$ 1,385,848.80**	**$ 1,742,979.60**

Through the process of developing these estimates, specific items appear to play a more significant role in the project, and may warrant more focused consideration:

- Integrity of Concrete Bridge Abutments – the testing results and observations from the sampled concrete cores provided valuable insight into the condition and make-up of the concrete bridge supports. We have indicated that these supports should be adequate for the Alternative 1 – Pedestrian-only Access. However, the amount of testing and engineering analysis that would be required to verify the condition of each concrete support (as shown in the cost estimate) is a reflection of the uncertainty associated with their continued use in a vehicle access alternative.
- Ultimate Use of the Structure – The ultimate use of the structure should be carefully considered. The unique location of the bridge presents challenges for construction. The association of the bridge with the high hazard dam adds a level of complexity to the project and the decision process. A comprehensive view of the proposed repairs may provide opportunities to address dam-related issues:
    - Gate repairs – notwithstanding the need for immediate repairs to the gate operating hardware, the bridge work may allow for a more comprehensive and detailed evaluation

of the gates, their operating mechanisms and associated structural supports. We note that previous observations have noted significant deterioration of the concrete thrust block at the gate operating platform.

  - Spillway capacity improvements – Previous analyses have indicated that the spillway capacity (while not as insufficient as previously thought) is constrained by the elevation of the bridge girders. Additional consideration could be given to raising the elevation of the bridge girders to improve the hydraulic capacity of the spillway. Based on our previous analysis, a 1 foot increase in the bridge girder elevation could potentially allow for passage of the 100-year storm without impacting the bridge. The current capacity is just less than the 50-year storm. This is significant from a dam safety perspective because it reduces the risk of spillway function complications due to bridge effects.

- Additional Evaluations – Any repair work on the bridge will require the development of a detailed set of construction plans with technical specifications for the work. We anticipate that permitting applications will be required for the US Army Corps of Engineers, North Carolina Dam Safety, and various other state and local agencies. Our estimates of additional engineering costs are based strictly on a percentage of total construction costs. A more detailed scope of work can be developed based on decisions of the Trustees and our further investigations into the permitting and engineering required.

Our work has been guided by generally accepted, present-day, engineering standards for dams in this region. The preliminary nature of our analyses is reflected in the contingencies placed on the preliminary cost estimates and our discussion of the proposed repair alternatives. Additional engineering analyses are required to develop a precise construction plan that can be used for permitting and bidding purposes.

BLE appreciates the opportunity to continue our association on this project. Please reach out to us with additional questions or comments on this report.

Sincerely,
BUNNELL-LAMMONS ENGINEERING, INC.

NORTH CAROLINA PROFESSIONAL SEAL 030821 ENGINEER JOHN F. GARNER 12.22.2016

John F. Garner, PE
Senior Engineer

for
Christopher W. Sluder, PE
Project Engineer

Attachments: Summary of Core Compressive Strength Test
Preliminary Engineer's Construction Cost Estimates (Alternatives 1 – 3)
Figures 1 – 3
Photos 1 - 12

B L E INC

Summary of Core Compressive Strength Tests
BLE Project: Lake Junaluska Dam Bridge Evaluation Phase II
Project Number: J16-9263-05
Date Cored: November 17, 2016
Date Tested: November 21, 2016

Sample Number	Location	Average Diameter (inches)	Capped Length (inches)	Length/ Diameter Ratio	Cross Sectional Area (in^2)	Correction Factor	Load (lbs)	Corrected Strength (psi)
1		3.72	6.00	1.61	10.87	0.9688	20,561	1840
1A		3.72	5.86	1.57	10.87	0.9656	27,580	2460
2		3.72	7.57	2.04	10.87	1	33,522	3090
3		3.72	7.73	2.08	10.87	1	20,893	1930
4		3.72	7.60	2.04	10.87	1	21,014	1940
5		3.72	6.56	1.76	10.87	0.9808	19,605	1770
6		3.72	7.57	2.03	10.87	1	28,870	2660
7		3.72	7.53	2.02	10.87	1	16,137	1490
8		3.72	6.82	1.83	10.87	0.9864	23,257	2120

Min 1490
Max 3090
Average 2140

Prepared By: SCI
Checked By: CWS

BLE INC.

BUNNELL-LAMMONS ENGINEERING, INC.
GEOTECHNICAL, ENVIRONMENTAL, AND CONSTRUCTION MATERIALS CONSULTANTS
GREENVILLE, SOUTH CAROLINA • ASHEVILLE, NORTH CAROLINA

PROJECT NO.:	9263	SHEET:	1 of 1
PHASE:	05	TASK:	CONST. COST EST.
PROJ. NAME:	LAKE JUNALUSKA DAM - BRIDGE EVALUATION		
BY:	J. Garner	DATE:	12/9/2016
CHECKED:	M. Ellum	DATE:	12/9/2016

Preliminary Engineer's Construction Cost Estimate

Alternative 1 - Restore Pedestrian-only Access - Repair Bridge Beams, Use Existing Concrete Piers

Item	Description of Work	Quantity	Unit		Unit Price	Amount
1.	Mobilization & Demobilization	1	Job		$ 20,000.00	$ 20,000.00
2.	Surveying	1	Job		$ 5,000.00	$ 5,000.00
3.	Erosion & Sediment Control	1	Job		$ 7,500.00	$ 7,500.00
4.	Control of Water (coordination with LJA)	1	Job		$ 5,000.00	$ 5,000.00
5.	Site Access (Staging area below dam)	1	Job		$ 10,000.00	$ 10,000.00
6.	Utilities (relocate - overhead power, below-deck water/sewer)	1	Job		$ 15,000.00	$ 15,000.00
7.	Demolition and Removal (entire pedestrian walkway steel beams)	1	Job		$ 17,000.00	$ 17,000.00
8.	Demolition and Removal (wood: decking)	11,000	sq-ft		$ 3.00	$ 33,000.00
9.	Demolition and Removal (concrete: existing bridge piers)	0	cu-yds		$ 500.00	$ -
10.	Structural Preparation (sandblasting, painting, concrete prep)	1	Job		$ 115,000.00	$ 115,000.00
11.	Cast-in-place concrete (fix new bridge piers @ beam contacts)	10	Cu-yd		$ 2,000.00	$ 20,000.00
12.	New Structural Steel Beams	0	Ton		$ 500.00	$ -
13.	New Wood Decking	11,000	sq-ft		$ 19.10	$ 210,100.00
14.	New Vehicle-rated Guardrail/Pedestrian guardrail (3 runs of 544 ft)	0	lin-ft		$ 120.00	$ -
15.	Vehicle Bollards at each end of dam	8	each		$ 1,000.00	$ 8,000.00
16.	Restore Utilities	1	Job		$ 30,000.00	$ 30,000.00
					$ -	$ -
					$ -	$ -
					Construction Subtotal	**$ 495,600.00**
	Engineering - investigation, design and permitting (10% const.)	1.0	Job	10%	$ 49,560.00	$ 49,560.00
	Construction - site visits, materials testing, consultations (5% const.)	1.0	Job	5%	$ 24,780.00	$ 24,780.00
	Contingency @ 20% of Construction subtotal	1.0	Job	20%	$ 99,120.00	$ 99,120.00
					Total	**$ 669,060.00**

BUNNELL-LAMMONS ENGINEERING, INC.
GEOTECHNICAL, ENVIRONMENTAL, AND CONSTRUCTION MATERIALS CONSULTANTS
GREENVILLE, SOUTH CAROLINA • ASHEVILLE, NORTH CAROLINA

PROJECT NO.:	9263	SHEET:	1 of 1
PHASE:	05	TASK:	CONST. COST EST.
PROJ. NAME:	LAKE JUNALUSKA DAM - BRIDGE EVALUATION		
BY:	J. Garner	DATE:	12/9/2016
CHECKED:	M. Ellum	DATE:	12/9/2016

Preliminary Engineer's Construction Cost Estimate

Alternative 2 - Restore Vehicle Access - Replace Selected Bridge Beams, Guardrail; Use Existing Concrete Piers

Item	Description of Work	Quantity	Unit		Unit Price	Amount
1.	Mobilization & Demobilization	1	Job		$ 40,000.00	$ 40,000.00
2.	Surveying	1	Job		$ 5,000.00	$ 5,000.00
3.	Erosion & Sediment Control	1	Job		$ 7,500.00	$ 7,500.00
4.	Control of Water (coordination with LJA)	1	Job		$ 5,000.00	$ 5,000.00
5.	Site Access (Staging area below dam)	1	Job		$ 20,000.00	$ 20,000.00
6.	Utilities (relocate - overhead power, below-deck water/sewer)	1	Job		$ 30,000.00	$ 30,000.00
7.	Demolition and Removal (steel: railing, rejected beams)	38	ton		$ 900.00	$ 34,200.00
8.	Demolition and Removal (wood: decking)	11,000	sq-ft		$ 3.00	$ 33,000.00
9.	Demolition and Removal (concrete: existing bridge piers)	0	cu-yds		$ 500.00	$ -
10.	Structural Preparation (sandblasting, painting, concrete prep)	1	Job		$ 125,000.00	$ 125,000.00
11.	Cast-in-place concrete (fix new bridge piers @ beam contacts)	10	Cu-yd		$ 6,500.00	$ 65,000.00
12.	New Structural Steel Beams	44	Ton		$ 2,124.00	$ 93,456.00
13.	New Wood Decking	11,000	sq-ft		$ 19.10	$ 210,100.00
14.	New Vehicle-rated Guardrail/Pedestrian guardrail (3 runs of 544 ft)	1,632	lin-ft		$ 120.00	$ 195,840.00
15.	Restore Utilities	1	Job		$ 30,000.00	$ 30,000.00
					$ -	$ -
					$ -	$ -
					$ -	$ -
					Construction Subtotal	**$ 894,096.00**
	Engineering - investigation, design and permitting (25% const.)	1.0	Job	25%	$ 223,524.00	$ 223,524.00
	Construction - site visits, materials testing, consultations (10% const.)	1.0	Job	10%	$ 89,409.60	$ 89,409.60
	Contingency @ 20% of Construction subtotal	1.0	Job	20%	$ 178,819.20	$ 178,819.20
					Total	**$ 1,385,848.80**

BLE INC.

BUNNELL-LAMMONS ENGINEERING, INC.

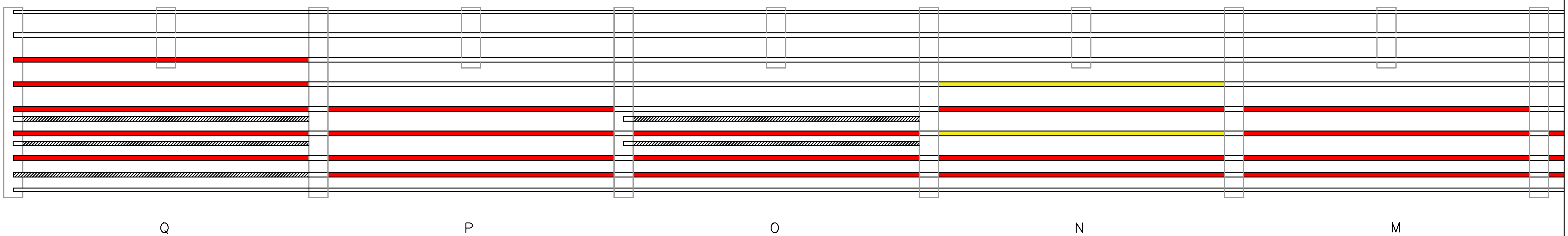
GEOTECHNICAL, ENVIRONMENTAL, AND CONSTRUCTION MATERIALS CONSULTANTS
GREENVILLE, SOUTH CAROLINA • ASHEVILLE, NORTH CAROLINA

PROJECT NO.:	9263	SHEET:	1 of 1
PHASE:	05	TASK:	CONST. COST EST.
PROJ. NAME:	LAKE JUNALUSKA DAM - BRIDGE EVALUATION		
BY:	J. Garner	DATE:	12/9/2016
CHECKED:	M. Ellum	DATE:	12/9/2016

Preliminary Engineer's Construction Cost Estimate

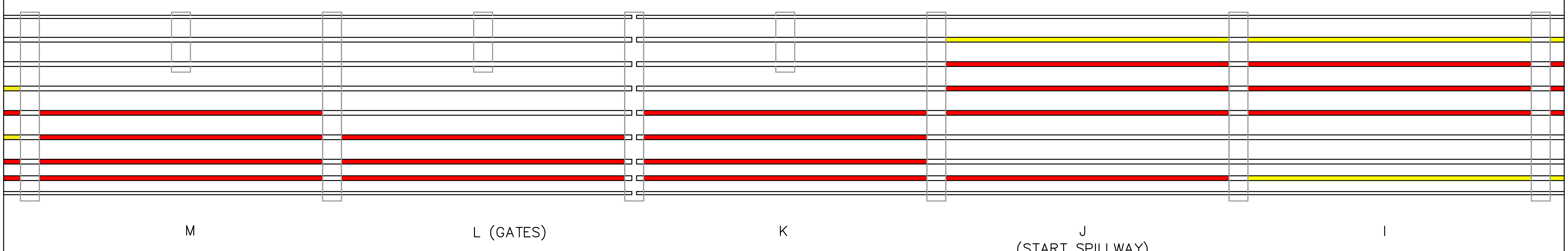
Alternative 3 - Restore Vehicle Access - Replace Selected Bridge Beams, Guardrail and Concrete Piers

Item	Description of Work	Quantity	Unit		Unit Price	Amount
1.	Mobilization & Demobilization	1	Job		$ 40,000.00	$ 40,000.00
2.	Surveying	1	Job		$ 5,000.00	$ 5,000.00
3.	Erosion & Sediment Control	1	Job		$ 7,500.00	$ 7,500.00
4.	Control of Water (coordination with LJA)	1	Job		$ 5,000.00	$ 5,000.00
5.	Site Access (Staging area below dam)	1	Job		$ 20,000.00	$ 20,000.00
6.	Utilities (relocate - overhead power, below-deck water/sewer)	1	Job		$ 30,000.00	$ 30,000.00
7.	Demolition and Removal (steel: railing, rejected beams)	38	ton		$ 900.00	$ 34,200.00
8.	Demolition and Removal (wood: decking)	11,000	sq-ft		$ 3.00	$ 33,000.00
9.	Demolition and Removal (concrete: existing bridge piers)	220	cu-yds		$ 550.00	$ 121,000.00
10.	Structural Preparation (sandblasting, painting, concrete prep)	1.0	Job		$ 125,000.00	$ 125,000.00
11.	Cast-in-place concrete (new bridge piers)	220	Cu-yd		$ 1,550.00	$ 341,000.00
12.	New Structural Steel Beams	44	Ton		$ 2,124.00	$ 93,456.00
13.	New Wood Decking	11,000	sq-ft		$ 19.10	$ 210,100.00
14.	New Vehicle-rated Guardrail/Pedestrian guardrail (3 runs of 544 ft)	1,632	lin-ft		$ 120.00	$ 195,840.00
15.	Restore Utilities	1	Job		$ 30,000.00	$ 30,000.00
					$ -	$ -
					$ -	$ -
					$ -	$ -
					Construction Subtotal	**$ 1,291,096.00**
	Engineering - investigation, design and permitting (10% const.)	1.0	Job	10%	$ 129,109.60	$ 129,109.60
	Construction - site visits, materials testing, consultations (5% const.)	1.0	Job	5%	$ 64,554.80	$ 64,554.80
	Contingency @ 20% of Construction subtotal	1.0	Job	20%	$ 258,219.20	$ 258,219.20
					Total	**$ 1,742,979.60**



LEGEND

- STEEL MEMBER TO BE REMOVED
- STEEL MEMBER TO BE RE-INSPECTED
- ADDITIONAL AND/OR REPLACED STEEL MEMBER

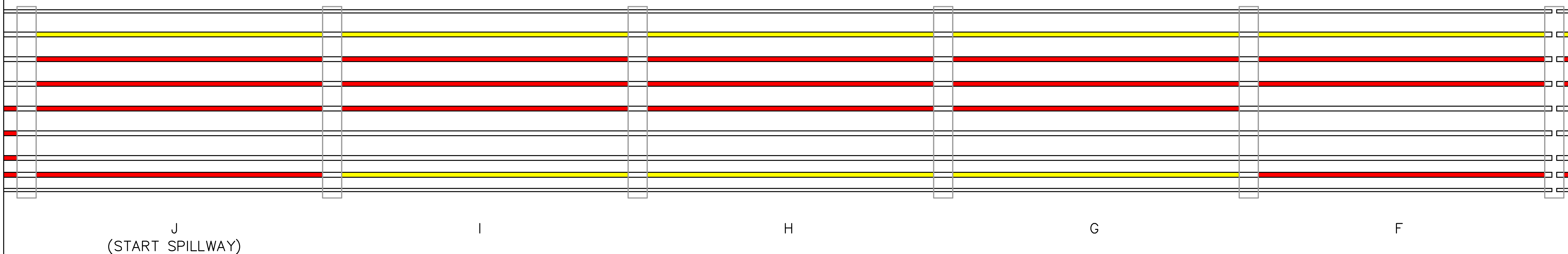


DRAWN BY: JWB	DATE: 12/9/2016	REVISIONS			
CHECKED BY: JFG	SCALE: 1"=10'	No.	DESCRIPTION	BY	
APPROVED BY:	JOB NO: J14-9263-05				

BLE INC.
BUNNELL-LAMMONS ENGINEERING, INC.
130 OVAL ROAD, SUITE 200
ARDEN, NORTH CAROLINA 28704
PHONE: (828)277-0100 FAX: (828)277-0110

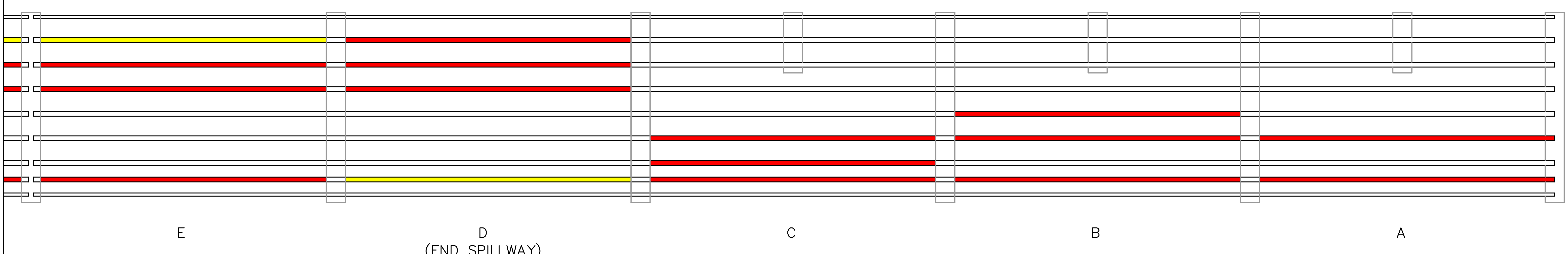
GIRDER ASSESSMENT
LAKE JUNALUSKA BRIDGE EVALUATION
HAYWOOD COUNTY, NORTH CAROLINA

FIGURE 1

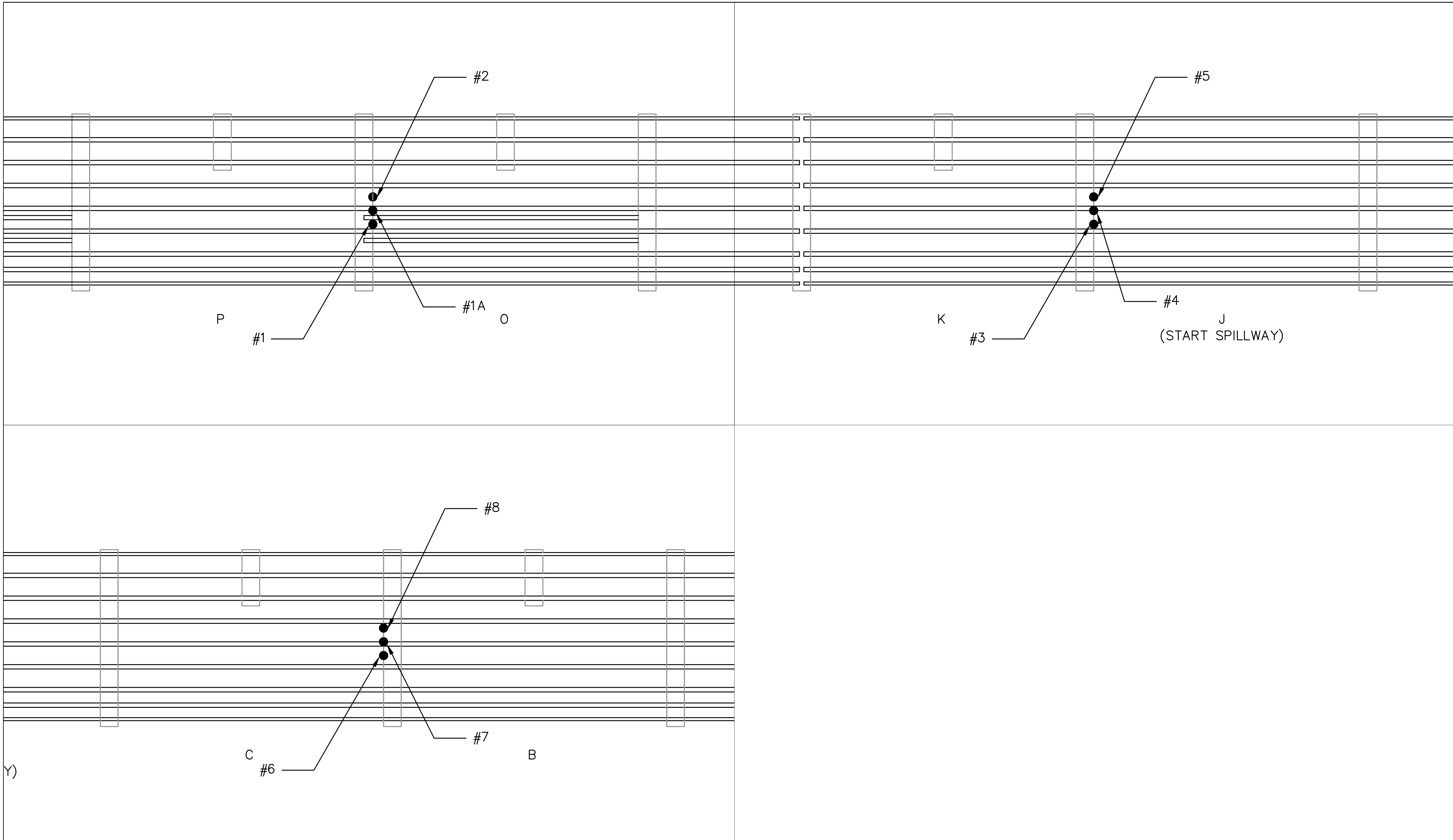


LEGEND

- STEEL MEMBER TO BE REMOVED
- STEEL MEMBER TO BE RE-INSPECTED
- ADDITIONAL AND/OR REPLACED STEEL MEMBER



DRAWN BY: JWB	DATE: 12/9/2016	REVISIONS			BUNNELL-LAMMONS ENGINEERING, INC. 130 OVAL ROAD, SUITE 200 ARDEN, NORTH CAROLINA 28704 PHONE: (828)277-0100 FAX: (828)277-0110	GIRDER ASSESSMENT LAKE JUNALUSKA BRIDGE EVALUATION HAYWOOD COUNTY, NORTH CAROLINA	FIGURE 2
CHECKED BY: JFG	SCALE: 1"=10'	No.	DESCRIPTION	BY			
APPROVED BY:	JOB NO: J14-9263-05						



DRAWN BY: JWB	DATE: 12/9/2016	REVISIONS			BUNNELL-LAMMONS ENGINEERING, INC.	FIGURE
CHECKED BY: JFG	SCALE: 1"=10'	No.	DESCRIPTION	BY	130 OVAL ROAD, SUITE 200 ARDEN, NORTH CAROLINA 28704 PHONE: (828)277-0100 FAX: (828)277-0110	3
APPROVED BY:	JOB NO: J14-9263-05				CONCRETE CORE LOCATION PLAN LAKE JUNALUSKA BRIDGE EVALUATION HAYWOOD COUNTY, NORTH CAROLINA	

130 Oval Road
Suite 200
Arden, North Carolina 28704

Date:09/07/16

Photographer: C. Sluder

1		
	Location / Orientation	Girder Assessment
	Remarks	Typical steel Member (on left) with severe corrosion at top flange.

Date: 09/07/16

Photographer: C. Sluder

2		
	Location / Orientation	Girder Assessment
	Remarks	Typical surface corrosion (bottom flange) re-usable after repairs.

130 Oval Road
Suite 200
Arden, North Carolina 28704

Date: 12/8/16

Photographer: C. Sluder

3		
	Location / Orientation	Concrete Core from Abutment
	Remarks	Large aggregate shown with separation at cement.

Date: 12/8/16

Photographer: C. Sluder

4		
	Location / Orientation	Concrete Core #1
	Remarks	Concrete failure at edge of large aggregate.

130 Oval Road
Suite 200
Arden, North Carolina 28704

Date: 12/8/16

Photographer: C. Sluder

5		
	Location / Orientation	Concrete Core #1A
	Remarks	Fracture along the aggregate.

Date: 12/8/16

Photographer: C. Sluder

6		
	Location / Orientation	Concrete Core #2
	Remarks	Concrete failure Type 2

130 Oval Road
Suite 200
Arden, North Carolina 28704

Date: 12/8/16

Photographer: C. Sluder

7		
	Location / Orientation	Concrete Core #3
	Remarks	Fractures along aggregate

Date: 12/8/16

Photographer: C. Sluder

8		
	Location / Orientation	Concrete Core #4
	Remarks	Concrete failure Type 1

130 Oval Road
Suite 200
Arden, North Carolina 28704

Date: 12/8/16

Photographer: C. Sluder

9		
	Location / Orientation	Concrete Core #5
	Remarks	Fractures along aggregate.

Date: 12/8/16

Photographer: C. Sluder

10		
	Location / Orientation	Concrete Core #6
	Remarks	Concrete failure Type 2

BLE
130 Oval Road
Suite 200
Arden, North Carolina 28704

Date: 12/8/16

Photographer: C. Sluder

11	**Location / Orientation**	Concrete Core #7
	Remarks	Concrete failure Type 1

Date: 12/8/16

Photographer: C. Sluder

12	**Location / Orientation**	Concrete Core #8
	Remarks	Fractures along aggregate

BUNNELL-LAMMONS ENGINEERING, INC.
GEOTECHNICAL, ENVIRONMENTAL AND CONSTRUCTION MATERIALS CONSULTANTS

March 17, 2017

Lake Junaluska Assembly
91 Lakeshore Drive
Lake Junaluska, North Carolina 28745

Attention: Mr. Jack Ewing
Executive Director

Subject: **ADDENDUM REPORT – Report of Structural Evaluation – Phase II**
Lake Junaluska Dam (NC Dam Safety ID No. HAYWO-001)
Lake Junaluska, North Carolina
BLE Project No. P14-9263-05

Dear Mr. Ewing,

Bunnell-Lammons Engineering, Inc. (BLE) completed Phase II of the Lake Junaluska Dam Bridge Evaluation and provided our report date December 22, 2016. Subsequent discussions with LJA staff, the Bridge Task Force and LJA Public Works lead to consideration of two additional alternatives:

- "Do Nothing" – closing the bridge to all access and securing the structure, "as-is."
- Restoring only the Pedestrian Walkway and securing the remainder of the bridge "as-is."

Discussions with LJA Public Works staff brought to light the operation and maintenance of the existing gate structures at the northern portion of the dam in the powerhouse area. Safe access to this area for equipment and materials is considered critical to the dam's safe operation going forward. Consideration of these additional alternatives is made more complex by the requirement to maintain safe access for maintenance equipment to the northern portion of the current roadway deck. We have also revised the cost estimate for the previous Alternative 1 to reflect equipment access to the northern end in addition to the pedestrian access.

REVISED COST ESTIMATES

BLE prepared preliminary engineer's construction cost estimates to provide a basis for decisions on the remediation of the bridge in our December 22, 2016 report. We evaluated two scenarios: pedestrian-only access to the main bridge deck area and vehicle access. Based on the results of the concrete testing, there is a possibility that the existing concrete supports can still be used in the vehicle access scenario. Therefore, we developed a second alternative under the vehicle access scenario to evaluate the difference between removal and replacement of the supports versus re-use of the existing supports.

In addition to these three scenarios, we have included in this addendum report three additional scenarios:

- Alternative 1A – This scenario adds the cost of restoring equipment access to the gates area of the bridge, with only pedestrian access to the remaining portion of the bridge.
- Alternative 4 – "Do Nothing" – This scenario includes the cost of restoring equipment access to the gates area and closing the remaining portion of the bridge as well as the pedestrian walkway to public access.
- Alternative 5 – This scenario includes the cost of restoring equipment access to the gates area and also restoring the existing pedestrian bridge.

The information in each of these Preliminary Engineer's Construction Cost Estimates should be used to evaluate the subject alternative relative to the other presented alternatives. Budgeting discussions and decisions should be based on a more thorough development of plans and specifications for the selected alternative(s).

CONCLUSIONS

The development of Preliminary Engineer's Construction Cost Estimates provides a basis for decision-making and planning for the next actions to be taken on this project. A summary of these estimates and contingencies is presented in the table below. While we have worked to provide an accurate evaluation of the construction costs, these estimates are limited by the preliminary nature of our analyses, a limited view of the bridge structure, an preliminary and conceptual scope of construction work, and other unknown factors relevant to actual construction costs.

Preliminary Cost Item	Alt. 1 Ped.-only	Alt. 1A Ped.-only (Mnt. Access)	Alt. 2 – Veh. w/ Existing Supports	Alt. 3 – Veh. w/ New Supports	Alt. 4 "Do Nothing"	Alt. 5 Restore Ped. Bridge
Construction	$ 495,600	$ 550,100	$ 894,096	$ 1,291,096	$ 213,210	$ 432,243
Engineering	$ 49,560	$ 55,010	$ 223,524	$ 129,110	$ 21,321	$ 43,224
Const. Phase Eng. Services	$ 24,780	$ 27,505	$ 89,410	$ 64,555	$ 10,661	$ 21,612
Project Contingency	$ 99,120	$ 110,020	$ 178,819	$ 258,219	$ 42,642	$ 86,449
Total Estimate	**$ 669,060**	**$ 742,635**	**$ 1,385,849**	**$ 1,742,980**	**$ 287,834**	**$ 583,527**

We reiterate that through the process of developing these estimates, specific items appear to play a more significant role in the project, and may warrant more focused consideration. These items are discussed in detail in our previous report, but we have listed them here, in summary:

- Integrity of Concrete Bridge Abutments –
- Ultimate Use of the Structure – The ultimate use of the structure should be carefully considered. The unique location of the bridge presents challenges for construction. The association of the bridge with the high hazard dam adds a level of complexity to the project and the decision process. A comprehensive view of the proposed repairs may provide opportunities to address dam-related issues:
    - Gate repairs
    - Spillway capacity improvements
- Additional Evaluations –
    - Construction plans with technical specifications
    - Permitting applications
    - More detailed engineering scope

Our work has been guided by generally accepted, present-day, engineering standards for dams in this region. The preliminary nature of our analyses is reflected in the contingencies placed on the preliminary cost estimates and our discussion of the proposed repair alternatives. Additional engineering analyses are required to develop a precise construction plan that can be used for permitting and bidding purposes.

BLE appreciates the opportunity to continue our association on this project. Please reach out to us with additional questions or comments on this report.

Sincerely,
BUNNELL-LAMMONS ENGINEERING, INC.

NORTH CAROLINA PROFESSIONAL ENGINEER SEAL 030821 JOHN F. GARNER 03-17-2017

John F. Garner, PE
Senior Engineer

FOR
Christopher W. Sluder, PE
Project Engineer

Attachments: Revised Calculation Narrative
Preliminary Engineer's Construction Cost Estimates (Alternatives 1, 1A, 2 – 5)

This narrative reflects modifications to the original Lake Junaluska Dam Bridge Evaluation provided to the Lake Junaluska Association (LJA) Board of Trustees on December 09, 2016. The modifications herein are based on requests from LJA for additional analysis by BLE after the December memo was received and reviewed. For clarity, the March 2017 revisions to the original narrative are shown in italics.

Objective

Due to concerns for the structural integrity of the bridge over the Lake Junaluska Dam, the bridge was closed to vehicle access. Based on discussions with the LJA Board of Trustees, BLE has been directed to assess restoring the bridge to vehicular use compared to limiting the future use of the bridge to pedestrians only. Based on our explorations, we have developed three alternatives that demonstrate the potential relative range and order-of-magnitude costs associated with restoring the bridge to either of the two final objective uses. Therefore, the objective of this calculation is to develop costs for three bridge remediation alternatives:

1. Restore pedestrian only access to the main area of the bridge.
2. Restore full vehicular access using existing concrete piers.
3. Restore full vehicular access with full replacement of concrete piers.

*Note – All *five* options assume the bridge configuration will remain similar to the existing configuration.

> *The three existing 2-foot x 5-foot sluice gates are the primary means for draining the impoundment. These gates, and the associated appurtenances, are located in bay #21, underneath the existing bridge structure. Gate stems extend from the top of each gate, through the concrete slab to geared control wheels on the downstream side of the slab. Currently these gates and their appurtenances are accessible for repairs and maintenance via the existing bridge structure. Additionally, though no longer in use, the powerhouse gates adjacent to these gates are also accessible via the existing bridge structure. Therefore, unless modifications are made as to how these are accessed, the existing bridge structure must be modified as necessary, and maintained as appropriate, to continue to provide this access. With this requirement in mind, LJA has requested that BLE considers two additional alternatives: #4 – "Do Nothing" Restore (restricted) equipment access to the gates and #5 – Restore the existing pedestrian walkway only and (restricted) equipment access.*

Pertinent Background Data and Assumptions

The bridge is generally described as follows:

- 17 spans of 32 feet each, between buttress structures associated with the dam sub-structure
- Total span is approximately 544 feet.
- Spans consist of a combination of W12 and W8 I-beams
- Deck consists of two layers of cross-lain 4"x8" dimension lumber
- Elevated pedestrian walkway cantilevered over the upstream side of the deck.

BLE performed the following tasks to collect data pertinent to the estimating of construction costs:

- multiple visual surveys;
- deflection measurements;
- concrete coring of existing piers.

Based on our measurements and observations, the following data were developed for the estimation of construction quantities.

Table 1: Lake Junaluska Dam Bridge Data Summary

ELEMENT	ASSUMED DATA
Span (typical)	32 ft – center-to-center
Number of spans	17
Principal Beam Sizes	W8, W12
Average Beam Unit Weight	32 lbs/lin-ft
# of Beams to be Replaced (for vehicle access)	56
Average Concrete Compressive Strength	2,140 psi*
Deck Length	544 feet
Deck Width (overall)	20 feet

*Concrete compressive strength is based on limited sampling of the existing piers and should be further assessed to confirm viability for continued use.

Calculations

Alternative 1 - Restore pedestrian only access to main bridge deck.

Construction scope items include:

- Demolition and disposal of
  - Wood decking (Area = 11,000 sq-ft)
- Sandblasting and re-painting of existing bridge beams and existing railing/guardrail members
- Repair of selected existing beams where corrosion is severe (56 beams distributed across the bridge)
- Repair of bridge piers at beam contact locations (18 piers)
- Replacement of double-layered wood decking with laminate exterior grade lumber (Area = 11,000 sq-ft)

Alternative 2 – Restore full vehicular access using existing concrete piers

Construction scope items include:

- Coordination/relocation of utilities
- Demolition and disposal of
  - Wood decking (Area = 11,000 sq-ft)
  - Steel guardrail (tonnage = 8 tons)
  - Rejected steel bridge beams (56 beams @ total tonnage = 30 tons)
- Replacement of rejected bridge beams with new beams (56 beams @ tonnage = 40 tons)
- Repair of selected existing beams where corrosion is severe
- Sandblasting and re-painting of remaining bridge beams
- Repair of bridge piers at beam contact locations (18 piers)
- Replacement of double-layered wood decking with laminate exterior grade lumber (Area = 11,000 sq-ft)
- Replacement of guardrail with vehicle-safe guardrail on roadway and pedestrian walkway (544 lin-ft)

Alternative 3 - Restore full vehicular access with full replacement of concrete piers

Construction scope items include:

- Coordination/relocation of utilities
- Demolition and disposal of
    - Wood decking (Area = 11,000 sq-ft)
    - Steel guardrail (tonnage = 8 tons)
    - Rejected steel bridge beams (56 beams @ total tonnage = 30 tons)
    - Existing concrete piers (concrete volume = 220 cu-yds)
- Removal, storage, sandblasting and re-painting of re-usable bridge beams.
- Repair of selected existing beams where corrosion is severe.
- Replacement of concrete bridge piers. (concrete volume = 220 cu-yds)
- Replacement of rejected bridge steel beams (56 beams @ tonnage = 40 tons)
- Replacement of double-layered wood decking with laminate exterior grade lumber. (Area = 11,000 sq-ft)
- Replacement of guardrail with vehicle-safe guardrail on roadway and pedestrian walkway. (544 lin-ft)

Alternative 4 – "Do Nothing" Restore equipment only access to gates using existing concrete piers, access Provided Only to Bay L

Construction scope items include:

- *Demolition and disposal of*
    - *Wood decking (~2,600 sq-ft)*
    - *Steel beams associated with pedestrian walkway*
- *Sandblasting and re-painting 25% of existing bridge beams and existing railing/guardrail members*
- *Repair of selected existing beams where corrosion is severe*
- *Replacement of a portion of double-layered wood decking with laminate exterior grade lumber (Area = ~2,600 sq-ft)*

Alternative 5 - Restore existing pedestrian walkway only access and restore equipment only access using existing concrete piers access provided only to bay L

Construction scope items include:

- *Demolition and disposal of*
    - *Wood decking and pedestrian walkway (~5,325 sq-ft)*
    - *Steel beams associated with pedestrian walkway*
- *Sandblasting and re-painting 80% of existing bridge beams and existing railing/guardrail members*
- *Repair of selected existing beams where corrosion is severe*
- *Replacement of a portion of double-layered wood decking with laminate exterior grade lumber (~5,325 sq-ft)*

Conclusions

Preliminary cost estimates for each of the listed alternatives are attached. These cost estimates are based on limited information and our experience with similar projects. Factors affecting these estimates include changing material and construction costs, unknown conditions at the existing structure, limitations due to site access, environmental, economic, bidding and weather conditions. These estimates are preliminary and are provided for order-of-magnitude comparison and decision-making purposes and should not be relied upon to establish budgets.

![BLE INC.]

BUNNELL-LAMMONS ENGINEERING, INC.

GEOTECHNICAL, ENVIRONMENTAL, AND CONSTRUCTION MATERIALS CONSULTANTS

GREENVILLE, SOUTH CAROLINA • ASHEVILLE, NORTH CAROLINA

PROJECT NO.:	9263	SHEET:	1 of 1
PHASE:	05	TASK:	CONST. COST EST.
PROJ. NAME:	LAKE JUNALUSKA DAM - BRIDGE EVALUATION		
BY:	J. Garner	DATE:	3/17/2017
CHECKED:	J. Burrell	DATE:	3/17/2017

Preliminary Engineer's Construction Cost Estimate

Alternative 1A - Restore Pedestrian-only Access - Repair Bridge Beams, Use Existing Concrete Piers

Item	Description of Work	Quantity	Unit		Unit Price	Amount
1.	Mobilization & Demobilization	1	Job		$ 20,000.00	$ 20,000.00
2.	Surveying	1	Job		$ 5,000.00	$ 5,000.00
3.	Erosion & Sediment Control	1	Job		$ 7,500.00	$ 7,500.00
4.	Control of Water (coordination with LJA)	1	Job		$ 5,000.00	$ 5,000.00
5.	Site Access (Staging area below dam)	1	Job		$ 10,000.00	$ 10,000.00
6.	Utilities (relocate - overhead power, below-deck water/sewer)	1	Job		$ 15,000.00	$ 15,000.00
7.	Demolition and Removal (entire pedestrian walkway steel beams)	1	Job		$ 17,000.00	$ 17,000.00
8.	Demolition and Removal (wood: decking)	11,000	sq-ft		$ 3.00	$ 33,000.00
9.	Demolition and Removal (concrete: existing bridge piers)	0	cu-yds		$ 500.00	$ -
10.	Structural Preparation (sandblasting, painting, concrete prep)	1	Job		$ 115,000.00	$ 115,000.00
11.	Cast-in-place concrete (fix new bridge piers @ beam contacts)	10	Cu-yd		$ 2,000.00	$ 20,000.00
12.	New Structural Steel Beams	13	Ton		$ 500.00	$ 6,500.00
13.	New Wood Decking	11,000	sq-ft		$ 19.10	$ 210,100.00
14.	New Vehicle-rated Guardrail/Pedestrian guardrail (3 runs of 544 ft)	400	lin-ft		$ 120.00	$ 48,000.00
15.	Vehicle Bollards at each end of dam	8	each		$ 1,000.00	$ 8,000.00
16.	Restore Utilities	1	Job		$ 30,000.00	$ 30,000.00
					$ -	$ -
					$ -	$ -
					Construction Subtotal	**$ 550,100.00**
	Engineering - investigation, design and permitting (10% const.)	1.0	Job	10%	$ 55,010.00	$ 55,010.00
	Construction - site visits, materials testing, consultations (5% const.)	1.0	Job	5%	$ 27,505.00	$ 27,505.00
	Contingency @ 20% of Construction subtotal	1.0	Job	20%	$ 110,020.00	$ 110,020.00
					Total	**$ 742,635.00**

BUNNELL-LAMMONS ENGINEERING, INC.
GEOTECHNICAL, ENVIRONMENTAL, AND CONSTRUCTION MATERIALS CONSULTANTS
GREENVILLE, SOUTH CAROLINA • ASHEVILLE, NORTH CAROLINA

PROJECT NO.: 9263 SHEET: 1 of 1
PHASE: 05 TASK: CONST. COST EST.
PROJ. NAME: LAKE JUNALUSKA DAM - BRIDGE EVALUATION
BY: J. Garner DATE: 12/9/2016
CHECKED: M. Ellum DATE: 12/9/2016

Preliminary Engineer's Construction Cost Estimate

Alternative 1 - Restore Pedestrian-only Access - Repair Bridge Beams, Use Existing Concrete Piers

Item	Description of Work	Quantity	Unit		Unit Price	Amount
1.	Mobilization & Demobilization	1	Job		$ 20,000.00	$ 20,000.00
2.	Surveying	1	Job		$ 5,000.00	$ 5,000.00
3.	Erosion & Sediment Control	1	Job		$ 7,500.00	$ 7,500.00
4.	Control of Water (coordination with LJA)	1	Job		$ 5,000.00	$ 5,000.00
5.	Site Access (Staging area below dam)	1	Job		$ 10,000.00	$ 10,000.00
6.	Utilities (relocate - overhead power, below-deck water/sewer)	1	Job		$ 15,000.00	$ 15,000.00
7.	Demolition and Removal (entire pedestrian walkway steel beams)	1	Job		$ 17,000.00	$ 17,000.00
8.	Demolition and Removal (wood: decking)	11,000	sq-ft		$ 3.00	$ 33,000.00
9.	Demolition and Removal (concrete: existing bridge piers)	0	cu-yds		$ 500.00	$ -
10.	Structural Preparation (sandblasting, painting, concrete prep)	1	Job		$ 115,000.00	$ 115,000.00
11.	Cast-in-place concrete (fix new bridge piers @ beam contacts)	10	Cu-yd		$ 2,000.00	$ 20,000.00
12.	New Structural Steel Beams	0	Ton		$ 500.00	$ -
13.	New Wood Decking	11,000	sq-ft		$ 19.10	$ 210,100.00
14.	New Vehicle-rated Guardrail/Pedestrian guardrail (3 runs of 544 ft)	0	lin-ft		$ 120.00	$ -
15.	Vehicle Bollards at each end of dam	8	each		$ 1,000.00	$ 8,000.00
16.	Restore Utilities	1	Job		$ 30,000.00	$ 30,000.00
					$ -	$ -
					$ -	$ -
					Construction Subtotal	**$ 495,600.00**
	Engineering - investigation, design and permitting (10% const.)	1.0	Job	10%	$ 49,560.00	$ 49,560.00
	Construction - site visits, materials testing, consultations (5% const.)	1.0	Job	5%	$ 24,780.00	$ 24,780.00
	Contingency @ 20% of Construction subtotal	1.0	Job	20%	$ 99,120.00	$ 99,120.00
					Total	**$ 669,060.00**

BLE INC.

BUNNELL-LAMMONS ENGINEERING, INC.

GEOTECHNICAL, ENVIRONMENTAL, AND CONSTRUCTION MATERIALS CONSULTANTS
GREENVILLE, SOUTH CAROLINA • ASHEVILLE, NORTH CAROLINA

PROJECT NO.:	9263	SHEET:	1 of 1
PHASE:	05	TASK:	CONST. COST EST.
PROJ. NAME:	LAKE JUNALUSKA DAM - BRIDGE EVALUATION		
BY:	J. Garner	DATE:	12/9/2016
CHECKED:	M. Ellum	DATE:	12/9/2016

Preliminary Engineer's Construction Cost Estimate

Alternative 2 - Restore Vehicle Access - Replace Selected Bridge Beams, Guardrail; Use Existing Concrete Piers

Item	Description of Work	Quantity	Unit		Unit Price	Amount
1.	Mobilization & Demobilization	1	Job		$ 40,000.00	$ 40,000.00
2.	Surveying	1	Job		$ 5,000.00	$ 5,000.00
3.	Erosion & Sediment Control	1	Job		$ 7,500.00	$ 7,500.00
4.	Control of Water (coordination with LJA)	1	Job		$ 5,000.00	$ 5,000.00
5.	Site Access (Staging area below dam)	1	Job		$ 20,000.00	$ 20,000.00
6.	Utilities (relocate - overhead power, below-deck water/sewer)	1	Job		$ 30,000.00	$ 30,000.00
7.	Demolition and Removal (steel: railing, rejected beams)	38	ton		$ 900.00	$ 34,200.00
8.	Demolition and Removal (wood: decking)	11,000	sq-ft		$ 3.00	$ 33,000.00
9.	Demolition and Removal (concrete: existing bridge piers)	0	cu-yds		$ 500.00	$ -
10.	Structural Preparation (sandblasting, painting, concrete prep)	1	Job		$ 125,000.00	$ 125,000.00
11.	Cast-in-place concrete (fix new bridge piers @ beam contacts)	10	Cu-yd		$ 6,500.00	$ 65,000.00
12.	New Structural Steel Beams	44	Ton		$ 2,124.00	$ 93,456.00
13.	New Wood Decking	11,000	sq-ft		$ 19.10	$ 210,100.00
14.	New Vehicle-rated Guardrail/Pedestrian guardrail (3 runs of 544 ft)	1,632	lin-ft		$ 120.00	$ 195,840.00
15.	Restore Utilities	1	Job		$ 30,000.00	$ 30,000.00
					$ -	$ -
					$ -	$ -
					$ -	$ -
					Construction Subtotal	**$ 894,096.00**
	Engineering - investigation, design and permitting (25% const.)	1.0	Job	25%	$ 223,524.00	$ 223,524.00
	Construction - site visits, materials testing, consultations (10% const.)	1.0	Job	10%	$ 89,409.60	$ 89,409.60
	Contingency @ 20% of Construction subtotal	1.0	Job	20%	$ 178,819.20	$ 178,819.20
					Total	**$ 1,385,848.80**

BLE INC.

BUNNELL-LAMMONS ENGINEERING, INC.

GEOTECHNICAL, ENVIRONMENTAL, AND CONSTRUCTION MATERIALS CONSULTANTS
GREENVILLE, SOUTH CAROLINA • ASHEVILLE, NORTH CAROLINA

PROJECT NO.: 9263 SHEET: 1 of 1
PHASE: 05 TASK: CONST. COST EST.
PROJ. NAME: LAKE JUNALUSKA DAM - BRIDGE EVALUATION
BY: J. Garner DATE: 12/9/2016
CHECKED: M. Ellum DATE: 12/9/2016

Preliminary Engineer's Construction Cost Estimate

Alternative 3 - Restore Vehicle Access - Replace Selected Bridge Beams, Guardrail and Concrete Piers

Item	Description of Work	Quantity	Unit		Unit Price	Amount
1.	Mobilization & Demobilization	1	Job		$ 40,000.00	$ 40,000.00
2.	Surveying	1	Job		$ 5,000.00	$ 5,000.00
3.	Erosion & Sediment Control	1	Job		$ 7,500.00	$ 7,500.00
4.	Control of Water (coordination with LJA)	1	Job		$ 5,000.00	$ 5,000.00
5.	Site Access (Staging area below dam)	1	Job		$ 20,000.00	$ 20,000.00
6.	Utilities (relocate - overhead power, below-deck water/sewer)	1	Job		$ 30,000.00	$ 30,000.00
7.	Demolition and Removal (steel: railing, rejected beams)	38	ton		$ 900.00	$ 34,200.00
8.	Demolition and Removal (wood: decking)	11,000	sq-ft		$ 3.00	$ 33,000.00
9.	Demolition and Removal (concrete: existing bridge piers)	220	cu-yds		$ 550.00	$ 121,000.00
10.	Structural Preparation (sandblasting, painting, concrete prep)	1.0	Job		$ 125,000.00	$ 125,000.00
11.	Cast-in-place concrete (new bridge piers)	220	Cu-yd		$ 1,550.00	$ 341,000.00
12.	New Structural Steel Beams	44	Ton		$ 2,124.00	$ 93,456.00
13.	New Wood Decking	11,000	sq-ft		$ 19.10	$ 210,100.00
14.	New Vehicle-rated Guardrail/Pedestrian guardrail (3 runs of 544 ft)	1,632	lin-ft		$ 120.00	$ 195,840.00
15.	Restore Utilities	1	Job		$ 30,000.00	$ 30,000.00
					$ -	$ -
					$ -	$ -
					$ -	$ -
					Construction Subtotal	**$ 1,291,096.00**
	Engineering - investigation, design and permitting (10% const.)	1.0	Job	10%	$ 129,109.60	$ 129,109.60
	Construction - site visits, materials testing, consultations (5% const.)	1.0	Job	5%	$ 64,554.80	$ 64,554.80
	Contingency @ 20% of Construction subtotal	1.0	Job	20%	$ 258,219.20	$ 258,219.20
					Total	**$ 1,742,979.60**

BLE INC.

BUNNELL-LAMMONS ENGINEERING, INC.

GEOTECHNICAL, ENVIRONMENTAL, AND CONSTRUCTION MATERIALS CONSULTANTS
GREENVILLE, SOUTH CAROLINA • ASHEVILLE, NORTH CAROLINA

PROJECT NO.:	9263	SHEET:	1 of 1
PHASE:	05	TASK:	CONST. COST EST.
PROJ. NAME:	LAKE JUNALUSKA DAM - BRIDGE EVALUATION		
BY:	J. Garner	DATE:	3/8/2017
CHECKED:	M. Ellum	DATE:	3/17/2017

Preliminary Engineer's Construction Cost Estimate

Alternative 4 - Restore Equipment Access Only to Bay L - Repair Bridge Beams, Use Existing Concrete Piers

Item	Description of Work	Quantity	Unit		Unit Price	Amount
1.	Mobilization & Demobilization	1	Job		$ 20,000.00	$ 20,000.00
2.	Surveying	1	Job		$ 5,000.00	$ 5,000.00
3.	Erosion & Sediment Control	1	Job		$ 7,500.00	$ 7,500.00
4.	Control of Water (coordination with LJA)	1	Job		$ 5,000.00	$ 5,000.00
5.	Site Access (Staging area below dam)	1	Job		$ 10,000.00	$ 10,000.00
6.	Utilities (relocate - overhead power, below-deck water/sewer)	1	Job		$ 15,000.00	$ 15,000.00
7.	Demolition and Removal (wood: decking)	2,600	sq-ft		$ 3.00	$ 7,800.00
8.	Demolition and Removal (concrete: existing bridge piers)	0	cu-yds		$ 500.00	$ -
9.	Structural Preparation (sandblasting, painting, concrete prep)	1	Job		$ 28,750.00	$ 28,750.00
10.	Cast-in-place concrete (fix new bridge piers @ beam contacts)	0	Cu-yd		$ 2,000.00	$ -
11.	New Structural Steel Beams	13	Ton		$ 500.00	$ 6,500.00
12.	New Wood Decking	2,600	sq-ft		$ 19.10	$ 49,660.00
13.	New Vehicle-rated Guardrail/Pedestrian guardrail (2 runs of 200 ft)	400	lin-ft		$ 120.00	$ 48,000.00
14.	Vehicle Bollards at each end of dam and close pedestrian walkway	10	each		$ 1,000.00	$ 10,000.00
15.	Restore Utilities	0	Job		$ 30,000.00	$ -
					$ -	$ -
					$ -	$ -
					Construction Subtotal	**$ 213,210.00**
	Engineering - investigation, design and permitting (10% const.)	1.0	Job	10%	$ 21,321.00	$ 21,321.00
	Construction - site visits, materials testing, consultations (5% const.)	1.0	Job	5%	$ 10,660.50	$ 10,660.50
	Contingency @ 20% of Construction subtotal	1.0	Job	20%	$ 42,642.00	$ 42,642.00
					Total	**$ 287,833.50**

BUNNELL-LAMMONS ENGINEERING, INC.	
BLE INC.	PROJECT NO.: 9263 SHEET: 1 of 1
BUNNELL-LAMMONS ENGINEERING, INC.	PHASE: 05 TASK: CONST. COST EST.
GEOTECHNICAL, ENVIRONMENTAL, AND CONSTRUCTION MATERIALS CONSULTANTS	PROJ. NAME: LAKE JUNALUSKA DAM - BRIDGE EVALUATION
GREENVILLE, SOUTH CAROLINA • ASHEVILLE, NORTH CAROLINA	BY: J. Garner DATE: 3/8/2017
	CHECKED: M. Ellum DATE: 3/17/2017

Preliminary Engineer's Construction Cost Estimate

Alternative 5 - Restore Existing Pedestrian Walkway Only Access and Equipment Access from Bay Q to Bay L - Repair Bridge Beams, Use Existing Concrete Piers

Item	Description of Work	Quantity	Unit		Unit Price	Amount
1.	Mobilization & Demobilization	1	Job		$ 20,000.00	$ 20,000.00
2.	Surveying	1	Job		$ 5,000.00	$ 5,000.00
3.	Erosion & Sediment Control	1	Job		$ 7,500.00	$ 7,500.00
4.	Control of Water (coordination with LJA)	1	Job		$ 5,000.00	$ 5,000.00
5.	Site Access (Staging area below dam)	1	Job		$ 10,000.00	$ 10,000.00
6.	Utilities (relocate - overhead power, below-deck water/sewer)	1	Job		$ 15,000.00	$ 15,000.00
7.	Demolition and Removal (entire pedestrian walkway steel beams)	1	Job		$ 17,000.00	$ 17,000.00
8.	Demolition and Removal (wood: decking, including pedestrain walkway)	5,325	sq-ft		$ 3.00	$ 15,975.00
9.	Demolition and Removal (concrete: existing bridge piers)	0	cu-yds		$ 500.00	$ -
10.	Structural Preparation (sandblasting, painting, concrete prep)	1	Job		$ 57,500.00	$ 57,500.00
11.	Cast-in-place concrete (fix new bridge piers @ beam contacts)	0	Cu-yd		$ 2,000.00	$ -
12.	New Structural Steel Beams	18	Ton		$ 500.00	$ 9,000.00
13.	New Wood Decking (Equipment Access and Pedestrain Walkway	5,325	sq-ft		$ 19.10	$ 101,707.50
14.	New Vehicle-rated Guardrail/Pedestrian guardrail (2 runs of 544 ft)	1,088	lin-ft		$ 120.00	$ 130,560.00
15.	Vehicle Bollards at each end of dam	8	each		$ 1,000.00	$ 8,000.00
16.	Restore Utilities	1	Job		$ 30,000.00	$ 30,000.00
					$ -	$ -
					$ -	$ -
					Construction Subtotal	**$ 432,242.50**
	Engineering - investigation, design and permitting (10% const.)	1.0	Job	10%	$ 43,224.25	$ 43,224.25
	Construction - site visits, materials testing, consultations (5% const.)	1.0	Job	5%	$ 21,612.13	$ 21,612.13
	Contingency @ 20% of Construction subtotal	1.0	Job	20%	$ 86,448.50	$ 86,448.50
					Total	**$ 583,527.38**