Structure Type Feasibility Study
Part 1
Caleb's Creek Road (T-850)
Eldred Township

Lycoming County Bridge Bundling

September 18, 2020

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Chapter I

Feasibility Study

I. Feasibility Study

A. Purpose

The Lycoming County Bridge Bundling Project proposes to replace or repair 17 small bridges across Lycoming County as a coordinated effort between the County, local municipal bridge owners, all of whom serve on the Steering Committee, various local and state agencies, and the Bassett Engineering/WMA team. This Structure Type Feasibility Study will evaluate and present feasible structure types for each bridge replacement and recommend a structure type for each location. Local municipal bridge owners will then review and comment on the recommended structure type for their bridge prior to structure selection by the County.

The Structure Type Feasibility Study is divided into two parts; Part 1 evaluates the bridges that are considered to be the most straightforward structure selections and replacements while Part 2 will evaluate the more difficult replacements and all of the structures to be repaired. The division of the Study serves to enable the simpler bridges to proceed to design and construction more rapidly with the intent to construct the first of four bundles while designing the bridges included in Part 2 of the study.

B. Involved Bridges

Phase 1 of the Structure Type Feasibility Study focuses on the bridges which one would consider the simplest and most straightforward replacements. The bridges selected for Phase 1 are those. with minimal site complications, low traffic roadways, ease of construction, shorter spans, and quickest anticipated project delivery.

1.	Calebs Creek Road	(T-850)	Eldred Township
2.	Smith Road	(T-469)	Franklin Township
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8.	Logue Hill Road	(T-571)	Penn Township
9.	Valley Road	(T-392)	Susquehanna Township

C. Exclusions

All structures excluded from Phase 1 of the Structure Type Feasibility Study will be addressed under Phase 2. These bridges were excluded from Phase 1 due to their status as a repair or apparent complex nature due to urban settings, adjacent structures, foreseen construction difficulties which would require a more highly qualified contractor, and the potential for a bridge currently listed as a repair to be replaced. The excluded bridges are listed below:

1.	Old Cement Road	(T-541)	Fairfield Township
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8.	Penn Drive	(T-250)	Wolf Township

D. Study Approach

Bassett Engineering has become intimately familiar with the strong majority of these bridge sites as a part of the Lycoming County Small Bridge Inspections program. In the six years of the program, many of these structures experienced extreme flood events such as Hurricane Lee in 2011, and since then the flooding in October 2016 and throughout the late summer and fall of 2018. Given this deep background, we were able to quickly evaluate each site for the most suitable structures.

1. Site

The structure type alternatives for each site were selected based on multiple criteria including geometric constraints, road use, stream quality, streambed movement, and stream velocity. The bridge sites are located across Lycoming County in several geologic regions including the Allegheny Plateau on the northern half of the county, the Ridge and Valley region south and west of the West Branch, and the rolling hills which lie between the two. The streams spanned by the bridges in this study vary from winding farm brooks to roaring mountain streams, all of which experience the floods which the County routinely sees.

2. Hydrology and Hydraulics

All stream flows for this study were estimated using USGS Streamstats, a hydrologic tool used to delineate drainage areas and prepare flow statistics estimates. In BE's experience with small bridges, Streamstats accurately predicts stream flows for the drainage areas typical of these streams. The only exception we have seen is where karst topography causes sinkholes which capture and attenuate the peak flow events of a given stream. We believe that Streamstats is the ideal method to predict flows for each stream.

3. General Considerations

While this study focuses on the structure types for each location, there are a plethora of other factors that affect the structure that is recommended. In all cases, structures were sized such that they could carry the full width of the existing road surface (cartway) and shoulders on each side between the face of the guiderails. For many sites this would make the structures several feet longer than the existing, but it will make the bridges far safer. All bridge sites will require at least minimal road surfacing at the excavation itself. Some of the bridge sites warrant more extensive changes to correct deficiencies such as improper road horizontal or vertical geometry. Additional heed was given to factors such as utilities, adjacent structures, and nearby homes.

4. Opinion of Probable Costs

We developed our opinion of the costs for the structure alternatives proposed at each location using a combination of manufacturer's estimates, BE's cost history of small bridge replacements, and PennDOT guidance on GRS-IBS bridge installations. The opinions prepared for each site are not final quotations, which is why they are presented as a range. A multitude of factors will affect the final cost including paving, guiderail type, site-specific constraints, utility coordination, maintenance & protection of traffic. Some are completely independent of the structure type while others are only minorly dependent.

Pre-engineered structure manufacturers provided estimates for their structures specific for the bridge sites being used. Bassett Engineering has tracked the history of costs for actual bridge and culvert projects completed by independent contractors (as opposed to municipal crews). Bassett calculates an installation factor for every bridge it completes and has established a range of installation factors which varies based on local site conditions. Cost opinions were developed based on the manufacturer-provided estimate multiplied by an installation factor.

5. Structure Type Recommendation

A structure type recommendation was made for each site based on several considerations including capital cost, structure suitability, road closure duration, and life cycle considerations. All structures presented have the same economic life as they should not see significant deterioration for decades. Structures that were not suitable for the site were not analyzed as feasible alternatives. Of the analyzed alternatives, each structure was evaluated for its fit with hydraulic conditions, site geometry and stream velocity (critical to GRS). While many of the sites were flexible, hydraulic conditions proved to be the primary constraint.

Capital costs were the most heavily considered factor in structure type recommendation. For small bridges such as those included in Part 1 of the Study, costs vary dramatically depending on the selected structure type as there are few shared components between alternatives. Compare this to a traditional beam bridge having an average span, where almost all components of the bridge are similar regardless of alternative, with the only major variation being the beam types themselves. Low-cost structures were favored in this study as most of these bridges are situated on rural, low-traffic roadways with simple geometries. More expensive alternatives were also evaluated at each site, but only recommended where conditions dictated the need for a specific structure type.

Road closure duration was considered as most of the structures within the Study are in rural settings with long detours, and in some cases no detour is available. In these cases, structures that minimize road closure time through use of prefabricated components were selected. A road only needs to be closed a few weeks to remove the old bridge, install the culvert/construct the bridge, backfill, rebuild the road, and set guiderail. Aluminum culverts can be completely assembled alongside the road without interrupting traffic. Concrete arch boxes and rigid frames come in complete sections and can be assembled in a week. GRS abutments can be fully built on site typically in a week's time and the superstructure in a similar timeframe. All recommended structures offer road closure time savings over traditional beam bridges and cast-in-place culverts, which require extensive time for multiple successive concrete pours.

All structures recommended within Part 1 of the Study will have similar life cycle considerations. The largest factor considered here was minimizing the required structure maintenance. All selected components utilize materials that require no significant upkeep, eliminating the need for beam painting and other repairs. Aluminum box culverts and concrete arches are buried structures that do not have bridge decks. The same roadbed and surfacing are used over these structures as the approach road has. This eliminates bridge deck rehabilitation and replacement, which can be a significant cost over the structure's life cycle. GRS bridges have conventional superstructures. Concrete rigid frames can either be buried or have composite decks, depending on the location.

The service life and expected maintenance for each structure type are listed on the Structure Type pages in Chapter 2. It should be noted that service life is a prediction of the life of the structure under normal conditions but damage because of impacts or other unexpected instances can drastically reduce service life. Additionally, expected maintenance refers to the the predicted major maintenance items for each structure, such as deck replacements, beam repainting, etc. All bridges require general upkeep, can be damaged by accidents, and always should be inspected after flood events.

6. Bundle Selections

Several criteria were evaluated for bundle selections including recommended structure type, opinion of probable cost, location (mainly proximity to other structures), stream restrictions, seasonal use of the bridge, and detour considerations. Ultimately recommended structure type was the determining factor for bundle selections. Bundling similar structure types will maximize contractor inclusion, as compared to bundling based on location which may result in putting complicated structures all bundles that only a handful of contractors could bid on. Additionally, if the structures were to be prepurchased, bundling by structure type would allow for a single prepurchase for each bundle.

While Lycoming County is the largest county in Pennsylvania, structure location (proximity to other structures) was not used as a determining factor in bundle selection as our survey of contractors yielded that location was far less important to them than the economy of scale offered by similar structure types. When a contractor installs four or five of the same kind of structure, it enables them to buy that specialized necessary piece of equipment and devote the time to train a dedicated crew to work on the project. The lessons learned on the first structure in the bundle can be applied to the following structures, offering a significant economy of scale.

Within the bundles, considerations were made to ensure that stream restrictions and seasonal use of bridges would allow the contractor flexibility in scheduling. Each bundle will include a bridge with no stream or seasonal use restrictions, providing the contractor with some cushion to their schedule. The only detour considerations for Part 1 of the Study are the two dead-end roads, Zinck Road and Calebs Creek Road, which will require phased construction or a bypass road regardless of what bundle they are placed in or the time of year.

7. Bundle Cost Evaluation

Bundle costs are calculated as a simple sum of the opinion of probable cost of each structure in the bundle. We expect that costs would be on the low end of this range as we anticipate significant savings from bundling these structures based on extensive past experience. There should be savings offered by contractor for repeated tasks, reduced mobilization, and optimization of time on site. However, this savings is hard to accurately quantify and is likely to vary widely. To assume a uniform savings during the study phase of this project was deemed to be potentially inaccurate and therefore it was not incorporated into the total bundle cost evaluation.

Chapter II

Structure Types

II A - Structure Type: Aluminum Box Culvert

Cost:	Low	**Level of Difficulty:**	Low
Service Life:	50 years	**Expected Maintenance:**	General Upkeep

Manufacturers: Contech, Lane

Substructure: Invert Plate or Concrete Footers (Precast or Cast-in-Place)

Headwalls: Aluminum or Cast-in-Place Concrete

Wingwalls: Aluminum, Precast Concrete (Bin) Blocks, or Cast-in-Place (CIP) Concrete

Deck Type: N/A – Fill over structure to conventional road surfacing

Natural Stream Bed Yes (Invert plate with fish baffles or footers outside stream channel)

Span:	8.75	foot minimum	35.25	foot maximum
Rise:	2.5	foot minimum	13.58	foot maximum
Hydraulic Opening	18.4	sq. foot minimum	400	sq. foot maximum

Considerations: Guiderail sleeper slabs needed, debris flow hazards, bedrock presence

Notes: Aluminum Box Culverts (ALBCs) are a low-cost option for small bridge replacements offering a low profile, near-optimal hydraulic shape, ease-of-construction, and the shortest road closure duration. Most local excavators and municipal crews can assemble and install an ALBC in a month without the need for a crane. The total cost is largely influenced by the selection of headwall and wingwall materials. Boxes can be fully assembled before lowering into place, allowing the road to remain open during assembly. Invert plates (if used) are set a minimum of one foot below the natural stream bottom. The addition of low-cost fish baffles holds the stream bed material in place, or the use of concrete footers enables a truly natural stream bottom.

Photos:

II F - Structure Type: Concrete Rigid Frame

Cost:	High	**Level of Difficulty:**	Medium
Service Life:	50 years	**Expected Maintenance:**	General Upkeep

Manufacturers: Terre Hill, Oldcastle, AC Miller, Keystone Precast, Mack Industries

Substructure: Precast or Cast-in-Place Concrete Footers

Headwalls: Precast Concrete or Cast-in-Place Concrete

Wingwalls: Precast Concrete or Cast-in-Place Concrete

Deck Type: Integral, concrete, asphalt or fill over structure to conventional road surfacing

Natural Stream Bed Yes

Span:	6	foot minimum	28	foot maximum
Rise:	2	foot minimum	10	foot maximum
Hydraulic Opening	12	sq. foot minimum	280	sq. foot maximum

Considerations: Scour depth, soil bearing capacity, small spans

Notes: The rigid frame (3-sided box culvert) is very similar to the concrete box culvert (4-sided), utilizing a 3-sided bridge with independent footers that must be set well below the streambed. These bridges are a popular small bridge selection as they can fit very low underclearances, host a natural streambed, are optimal for streams with bed movement, and can be installed without having to pump the stream around the bridge during installation. Like CBC's they are one of the highest-costing small bridge replacement alternatives, ideal for low-underclearace and urban bridge replacements.

Photos:

Chapter III

Structure Alternatives Analysis

Structure Alternatives Form

Municipality	Eldred
Road Number	T-850
Road Name	Calebs Creek Road
	over
Stream Name	Calebs Run

Key Selection Criteria
Exceptional Value Stream
Streambed Movement
No Available Detour
Only Route to Rider Park

Existing Structure Info

Existing Structure	Double RR Tanker	
Clear Span	4.8,4.8	Feet
Structure Length	9	Feet
Rise	4.5,4.5	Feet
Width	32	Feet
Skew	70	Deg.
Hyd. Open	36.2	Sq. Ft.
TB - TB	22, 23	Feet
BB - BB	12, 13	Feet
Inv.- Road Crown	5.5, 6.5	Feet
Roadway Width	18	Feet
Roadway Surface	HMA	

Stream Info

Existing Use	EV	
Designated Use	Stocked Trout	
Trout Information	Natural Reproduction	
NWI Mapper	N/A	
Basin Area	2.31	Sq. Mi.
Basin Slope	15.3	%
Bed Material	Med Cobbles	
Mean Flow	4.03	cfs
10-Year Storm Flow	351	cfs
50-Year Storm Flow	598	cfs
100-Year Storm Flov	722	cfs
500-Year Storm Flov	1060	cfs

Potential Structure

Type	Aluminum Box Culvert with Concrete Footers
Description	Corrugated aluminum structure fully assembled then set onto independent footers
Considerations	Lowest cost low-profile structure for low-ADT road. Assembling aluminum box outside stream channel minimizes road closure duration. Rounded shoulders reduce hydraulic opening. Open natural bottom allows moderate streambed movement for EV stream.

Potential Structure

Type	Concrete Rigid Frame
Description	Three-sided precast concrete frame installed on independent concrete footers
Considerations	Higher cost low-profile structure. Precast sections can be rapidly assembeld in-stream to minimize road closure duration. Square shoulders provide maximum hydraulic opening. Open natural bottom allows moderate streambed movement for EV stream.

Photograph 1: Inlet Elevation

Photograph 2: Outlet Elevation

Photograph 3: Near Approach

Photograph 4: Far Approach

Photograph 5: Upstream View

Photograph 6: Downstream View

1. **Site Characteristics**

   a. **Existing Conditions:** The culvert is situated where Calebs Creek Road, the sole access to Rider Park, crosses Calebs Run at a 70-degree skew. The paved road provides minimal cover over the culvert, the ends of which sit directly on the road shoulder, protected only by I-beam headwalls. The near approach features a horizontal curve while the far approach directly climbs the Allegheny Ridge to Rider Park, often featuring high-speed traffic. There is a very low rise from the streambed to the roadway, which limits the practical structure alternatives to an aluminum box culvert or a concrete rigid frame. While GRS-IBS can fit this configuration, stream velocities are far too high for the application. The road is not planned to be realigned and the road grade is not expected to change significantly.

      Overhead electric and communications lines are present just upstream of the structure at Calebs Creek Road. The utility owners will need to be notified of the project, but the lines are not expected to need relocation for construction. Assuming a 33-foot wide road right-of way, additional ROW will need to be obtained for the structure footprint and a temporary construction easement will need to be obtained for the potential bypass road.

   b. **Stream Hydrology:** Calebs Run has a 2.3 square mile drainage area tributary to this site. The stream experiences some of the higher flows seen in the bundle, producing a steep profile with moderate bed movement. The stream is classified as exceptional value with both stocked and naturally reproducing trout. Only open-bottomed structures were considered to retain the natural streambed and allow aquatic organisms free movement. Floodwater velocities will be high on this stream, which is a factor for structure selection.

   c. **Existing Structure Hydraulics:** The existing twin barrel steel pipe culvert is arguably the most hydraulically challenged structure in this study. Hydraulic analysis of the structure indicated that it was unable to pass the 5-year storm. Featuring one of the smallest hydraulic openings coupled with the obstruction created by the space between the culverts, this culvert frequently overtops. Additionally, the culvert is set at a flatter slope than the overall stream, causing deposition upstream of the culvert and a large scour hole immediately downstream.

   d. **Proposed Structure Hydraulics:** The proposed structure type alternatives for Calebs Creek Road were sized to be able to pass the 50-year storm, a dramatic improvement over the existing culvert. This increase in flow capacity was due to removing the obstruction caused by twin pipes and roughly doubling the hydraulic opening. The proposed open bottom structures will allow the natural streambed profile to form, eliminating deposition upstream and scour downstream.

2. **Structure Alternative: Aluminum Box Culvert with Concrete Footers**

   a. **Size:** 19'-9" Span x 4'-5" Clear Rise x 40'-6" Long

   b. **Structure Details:** The Aluminum Box Culvert with Concrete Footers offers a low profile at a low cost, and approximately double the hydraulic opening of the existing structure. Concrete footers were selected to accommodate both streambed movement and the exceptional value trout stream status.

c. **Cost:** $202,000 - $269,000 Costs are based on prices from the two manufacturers who have supplied all of the ALBC's that BE has installed and are therefore reliable.

3. **Structure Alternative: Concrete Rigid Frame**

a. **Size:** 18'-0" Span x 4'-0" Clear Rise x 40'-0" Long

b. **Structure Details:** The Concrete Rigid Frame offers a very low profile and approximately double the hydraulic opening of the existing structure, but at a cost. When considering what concrete structure alternative to evaluate, a rigid frame was selected over a concrete box culvert to accommodate both streambed movement and the exceptional value trout stream status.

c. **Cost:** $471,000 - $628,000 Costs are based on prices from two PennDOT-approved manufacturers. A third major supplier was contacted several times, but they never offered prices. The costs are over twice those for the aluminum box.

4. **Recommended Alternative: Aluminum Box Culvert**

a. **Discussion:** An Aluminum Box Culvert will reliably serve Caleb's Creek Road at a dramatically lower cost than a concrete rigid frame. Because the road offers the sole access to the very popular Ryder Park it is anticipated that traffic could not be interrupted for any extended period. A temporary drive-around is feasible and may prove necessary, but it would add considerable costs. Temporary road closure in certain months may also be acceptable. Bundling bridges allows the opportunity to optimize what time of year this structure is replaced. An aluminum box culvert can be completely assembled alongside the road without interrupting traffic. The road would need to be closed only a few weeks to remove the twin pipes, install the assembled culvert, backfill, rebuild the road, and set guiderail. If road closure is acceptable but the duration needs minimized, extended construction hours would accomplish that. Any approach will raise costs over a conventional install without these complications.

b. **Final Opinion of Probable Cost: $202,000 - $269,000**

Structure Type Feasibility Study
Part 1
Klump Road (T-489)
Hepburn Township

Lycoming County Bridge Bundling

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Chapter II

Structure Types

II A - Structure Type: Aluminum Box Culvert

Cost:	Low	**Level of Difficulty:**	Low
Service Life:	50 years	**Expected Maintenance:**	General Upkeep

Manufacturers: Contech, Lane

Substructure: Invert Plate or Concrete Footers (Precast or Cast-in-Place)

Headwalls: Aluminum or Cast-in-Place Concrete

Wingwalls: Aluminum, Precast Concrete (Bin) Blocks, or Cast-in-Place (CIP) Concrete

Deck Type: N/A – Fill over structure to conventional road surfacing

Natural Stream Bed Yes (Invert plate with fish baffles or footers outside stream channel)

Span:	8.75	foot minimum	35.25	foot maximum
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Hydraulic Opening	18.4	sq. foot minimum	400	sq. foot maximum

Considerations: Guiderail sleeper slabs needed, debris flow hazards, bedrock presence

Notes: Aluminum Box Culverts (ALBCs) are a low-cost option for small bridge replacements offering a low profile, near-optimal hydraulic shape, ease-of-construction, and the shortest road closure duration. Most local excavators and municipal crews can assemble and install an ALBC in a month without the need for a crane. The total cost is largely influenced by the selection of headwall and wingwall materials. Boxes can be fully assembled before lowering into place, allowing the road to remain open during assembly. Invert plates (if used) are set a minimum of one foot below the natural stream bottom. The addition of low-cost fish baffles holds the stream bed material in place, or the use of concrete footers enables a truly natural stream bottom.

Photos:

II B - Structure Type: GRS-IBS (Geosyntetic Reinforced Soils - Integrated Bridge System)

Cost:	Low	**Level of Difficulty:**	Low-Medium
Service Life:	50-100 years	**Expected Maintenance:**	Replace Deck (Est. 25-years)

Manufacturers: Allan Block, Keystone Retaining Wall Systems, Oldcastle, Redi-Rock

Substructure: GRS Abutments

Parapets: Cast-in-Place Concrete (full-height or structure-mounted guiderail)

Wingwalls: GRS Wingwalls

Deck Type: Cast-in-Place Concrete

Natural Stream Bed Yes

Span:	20	foot minimum	70	foot maximum
Rise:	N/A	foot minimum	30	foot maximum
Hydraulic Opening	N/A	sq. foot minimum	2,100	sq. foot maximum

Considerations: Not cost-effective under 20-foot span, low stream velocity critical

Notes: GRS-IBS bridges are a low-cost alternative to traditional beam bridges, using abutments constructed with alternating layers of geosynthetic material and granular backfill rather than concrete. These bridges are most cost effective for spans greater than 20-feet as their economy of scale lies in the span of the bridge (to a certain point) and the simple low-cost abutment construction. GRS-IBS bridges are not applicable where stream velocities exceed 12 ft/s as the abutments are vulnerable to scour conditions.

Photos:

II F - Structure Type: Concrete Rigid Frame

Cost:	High		**Level of Difficulty:**	Medium
Service Life:	50 years		**Expected Maintenance:**	General Upkeep

Manufacturers: Terre Hill, Oldcastle, AC Miller, Keystone Precast, Mack Industries

Substructure: Precast or Cast-in-Place Concrete Footers

Headwalls: Precast Concrete or Cast-in-Place Concrete

Wingwalls: Precast Concrete or Cast-in-Place Concrete

Deck Type: Integral, concrete, asphalt or fill over structure to conventional road surfacing

Natural Stream Bed Yes

Span:	6	foot minimum	28	foot maximum
Rise:	2	foot minimum	10	foot maximum
Hydraulic Opening	12	sq. foot minimum	280	sq. foot maximum

Considerations: Scour depth, soil bearing capacity, small spans

Notes: The rigid frame (3-sided box culvert) is very similar to the concrete box culvert (4-sided), utilizing a 3-sided bridge with independent footers that must be set well below the streambed. These bridges are a popular small bridge selection as they can fit very low underclearances, host a natural streambed, are optimal for streams with bed movement, and can be installed without having to pump the stream around the bridge during installation. Like CBC's they are one of the highest-costing small bridge replacement alternatives, ideal for low-underclearace and urban bridge replacements.

Photos:

Chapter III

Structure Alternatives Analysis

Structure Alternatives Form

Municipality	Hepburn
Road Number	T-489
Road Name	Klump Road
	over
Stream Name	Mill Creek

Key Selection Criteria

- Low Stream Velocities
- Low-ADT Road
- Low Rise
- Roadway Geometry

Existing Structure Info

Existing Structure	Steel Multi-Beam	
Clear Span	13.9	Feet
Structure Length	17	Feet
Rise	5	Feet
Width	21.3	Feet
Skew	85	Deg.
Hyd. Open	69.5	Sq. Ft.
TB - TB	23, 25	Feet
BB - BB	14, 11.5	Feet
Inv.- Road Crown	7.5, 6	Feet
Roadway Width	18	Feet
Roadway Surface	HMA	

Stream Info

Existing Use	N/A	
Designated Use	WWF	
Trout Information	N/A	
NWI Mapper	N/A	
Basin Area	1.57	Sq. Mi.
Basin Slope	19.44	%
Bed Material	Sm-Med Cobbles	
Mean Flow	2.58	cfs
10-Year Storm Flow	255	cfs
50-Year Storm Flow	436	cfs
100-Year Storm Flov	527	cfs
500-Year Storm Flov	777	cfs

Potential Structure

Type	GRS-IBS
Description	Beam bridge featuring low-cost geosynthetic reinforced soil abutments
Considerations	Low-cost low-profile structure for low-ADT road. Low rise. Low stream velocities and proposed span >20' enable the use of GRS. Deck will need to be configured to improve roadway geomentry (existing harsh superelevation transition). Open Bottom.

Potential Structure

Type	Aluminum Box Culvert with Invert Plate and Fish Baffles
Description	Corrugated aluminum structure fully assembled with invert plate and baffles set monoliti
Considerations	Lowest cost low-profile structure for low-ADT road. Assembling aluminum box outside stream channel minimizes road closure duration. Fill over culvert to improve roadway geomentry (existing harsh superelevation transition) Invert plate with fish baffles.

Potential Structure

Type	Concrete Rigid Frame
Description	Three-sided precast concrete frame installed on independent concrete footers
Considerations	Higher cost low-profile structure. Precast sections can be rapidly assembled in-stream to minimize road closure duration. Square shoulders maximize hydraulic opening. Open natural bottom: moderate bed movement. Reconfigure deck, roadway superelevation.

Photograph 1: Inlet Elevation

Photograph 2: Outlet Elevation

Photograph 3: Near Approach

Photograph 4: Far Approach

Photograph 5: Upstream View

Photograph 6: Downstream View

1. **Site Characteristics**

   a. **Existing Conditions:** The bridge is situated just south of the Allegheny Ridge where Klump Road crosses an unnamed tributary to Mill Creek at an 85-degree skew. The area is rolling farm county with steep open hillsides. The existing structure is oriented with the railings tight to the roadway and the slippery open steel grate deck having a heavy superelevation. There is a harsh superelevation transition at the far abutment. The road and bridge grades are complicated and not at all desirable. This site has the greatest need for road regrading, and perhaps a modest realignment. The existing structure is oriented with the railings tight to the roadway and the deck having a heavy superelevation. The rise from streambed to the road surface is low enough that arch-type structures will not fit, only flatter box-type structures.

      Overhead electric lines are present just upstream of the structure on Klump Road. The utility owners will need to be notified of the project and the lines will need to be temporarily relocated for construction. Assuming a 33-foot wide road right-of way, additional ROW will need to be obtained for the structure footprint and the potential realignment of the road.

   b. **Stream Hydrology:** The unnamed tributary to Mill Creek has a 1.6 square mile drainage area tributary to this site, much of the area being the side of the Allegheny Ridge. The stream experiences moderate to high flows in valley terrain, producing a flat profile with slight bed movement.

   c. **Existing Structure Hydraulics:** The existing steel beam bridge has no apparent hydraulic issues, likely aided by the deck superelevation which yields a larger hydraulic opening on the upstream end. Hydraulic analysis of the structure indicate that it is able to pass the 100-year storm, an ideal fit hydraulically.

   d. **Proposed Structure Hydraulics:** The proposed structure type alternatives for Klump Road were sized to increase the hydraulic opening slightly, which was already able to pass the 100-year storm. DEP requires that the replacement of a structure does not reduce the hydraulic opening, even if the flow capacity is increased. The low velocities through the structure enable the potential use of GRS.

2. **Structure Alternative: GRS-IBS**

   a. **Size:** 15'-0" Span x 5'-0" Clear Rise x 24'-0" Wide

   b. **Structure Details:** The GRS-IBS offers a low profile at a low cost, and the flexibility to fit the geometric constraints of the site, namely the ability to orient the superstructure with the roadway superelevation. The GRS-IBS was selected for its low cost and the low stream velocities at the site. This open bottom structure will allow the natural streambed profile to form, eliminating deposition upstream and scour downstream.

   c. **Cost:** $131,000 - $174,000 Costs are based on PennDOT experience and the database they maintain. The GRS would cost roughly 10% more than an aluminum box culvert. Aluminum box culverts are normally more cost effective for spans below 20 feet, while the longer the span, the more cost-effective GRS is, to the point where they generally are more cost effective at 30 feet.

3. **Structure Alternative: Aluminum Box Culvert with Invert Plate and Fish Baffles**

    a. **Size:** 15'-4" Span x 5'-5" Clear Rise x 27'-0" Wide

    b. **Structure Details:** The Aluminum Box Culvert with Invert Plate and Fish Baffles offers a low-profile, low cost and a slightly larger hydraulic opening than that of the existing structure. The invert plate with fish baffles was selected for the lowest cost in a situation with no significant bed movement and no fish restrictions. Fish baffles would retain the natural streambed inside the structure and allow aquatic organisms free movement. An ALBC would be set to match the slope of the stream channel, which is necessary to avoid streambed material deposition upstream and a scour hole downstream of the culvert.

    c. **Cost**: \$119,000 - \$158,000 Costs are based on prices from the two manufacturers who have supplied all of the ALBC's that BE has installed and are therefore reliable.

4. **Structure Alternative: Concrete Rigid Frame**

    a. **Size:** 15'-0" Span x 5'-0" Clear Rise x 24'-0" Wide

    b. **Structure Details:** The Concrete Rigid Frame offers a low-profile and a slightly larger hydraulic opening than that the existing structure. When considering what concrete structure alternative to evaluate, a rigid frame was selected for its flexibility to fit the geometric constraints of the site, namely the ability to orient the superstructure with the superelevation of the roadway.

    c. **Cost:** \$313,000 - \$418,000 Costs are based on prices from two PennDOT-approved manufacturers. A third major supplier was contacted several times, but they never offered prices. Costs are over double those of the GRS-IBS bridge and 2½ times those of the aluminum box.

5. **Recommended Alternative: Aluminum Box Culvert**

    a. Discussion: An Aluminum Box Culvert would reliably serve Klump Road at a significantly lower cost than a concrete rigid frame and the cost is lower than that of a GRS-IBS. The road does not receive heavy traffic. The structure does not receive heavy damaging storm flows and the culvert is generously sized. Temporary road closure should be acceptable, and detours are short. No complicating factor is apparent that would warrant a more expensive structure. An ALBC was selected for this site over a GRS for being better suited to work under the likely roadway geometry changes.

    b. Final Opinion of Probable Cost \$119,000 - \$158,000

Structure Type Feasibility Study
Part 1
Mill Road (T-305)
Limestone Township

Lycoming County Bridge Bundling

September 18, 2020

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Chapter I

Feasibility Study

I. Feasibility Study

A. Purpose

The Lycoming County Bridge Bundling Project proposes to replace or repair 17 small bridges across Lycoming County as a coordinated effort between the County, local municipal bridge owners, all of whom serve on the Steering Committee, various local and state agencies, and the Bassett Engineering/WMA team. This Structure Type Feasibility Study will evaluate and present feasible structure types for each bridge replacement and recommend a structure type for each location. Local municipal bridge owners will then review and comment on the recommended structure type for their bridge prior to structure selection by the County.

The Structure Type Feasibility Study is divided into two parts; Part 1 evaluates the bridges that are considered to be the most straightforward structure selections and replacements while Part 2 will evaluate the more difficult replacements and all of the structures to be repaired. The division of the Study serves to enable the simpler bridges to proceed to design and construction more rapidly with the intent to construct the first of four bundles while designing the bridges included in Part 2 of the study.

B. Involved Bridges

Phase 1 of the Structure Type Feasibility Study focuses on the bridges which one would consider the simplest and most straightforward replacements. The bridges selected for Phase 1 are those. with minimal site complications, low traffic roadways, ease of construction, shorter spans, and quickest anticipated project delivery.

1.	Calebs Creek Road	(T-850)	Eldred Township
2.	Smith Road	(T-469)	Franklin Township
3.	Winner Lane	(T-625)	Gamble Township
4.	Klump Road	(T-489)	Hepburn Township
5.	Mill Road	(T-305)	Limestone Township
6.	Zinck Road	(T-358)	Mifflin Township
7.	Auchmuty Road	(T-516)	Muncy Township
8.	Logue Hill Road	(T-571)	Penn Township
9.	Valley Road	(T-392)	Susquehanna Township

C. Exclusions

All structures excluded from Phase 1 of the Structure Type Feasibility Study will be addressed under Phase 2. These bridges were excluded from Phase 1 due to their status as a repair or apparent complex nature due to urban settings, adjacent structures, foreseen construction difficulties which would require a more highly qualified contractor, and the potential for a bridge currently listed as a repair to be replaced. The excluded bridges are listed below:

1.	Old Cement Road	(T-541)	Fairfield Township
2.	Wilson Street		Jersey Shore Borough
3.	Upper Bodines Road	(T-857)	Lewis Township
4.	Sheridan Street	(T-616)	Loyalsock Township
5.	Montgomery Park Road		Montgomery Borough
6.	Bill Sones Road	(T-638)	Moreland Township
7.	Gap Road	(T-384)	Washington Township
8.	Penn Drive	(T-250)	Wolf Township

D. Study Approach

Bassett Engineering has become intimately familiar with the strong majority of these bridge sites as a part of the Lycoming County Small Bridge Inspections program. In the six years of the program, many of these structures experienced extreme flood events such as Hurricane Lee in 2011, and since then the flooding in October 2016 and throughout the late summer and fall of 2018. Given this deep background, we were able to quickly evaluate each site for the most suitable structures.

1. Site

The structure type alternatives for each site were selected based on multiple criteria including geometric constraints, road use, stream quality, streambed movement, and stream velocity. The bridge sites are located across Lycoming County in several geologic regions including the Allegheny Plateau on the northern half of the county, the Ridge and Valley region south and west of the West Branch, and the rolling hills which lie between the two. The streams spanned by the bridges in this study vary from winding farm brooks to roaring mountain streams, all of which experience the floods which the County routinely sees.

2. Hydrology and Hydraulics

All stream flows for this study were estimated using USGS Streamstats, a hydrologic tool used to delineate drainage areas and prepare flow statistics estimates. In BE's experience with small bridges, Streamstats accurately predicts stream flows for the drainage areas typical of these streams. The only exception we have seen is where karst topography causes sinkholes which capture and attenuate the peak flow events of a given stream. We believe that Streamstats is the ideal method to predict flows for each stream.

3. General Considerations

While this study focuses on the structure types for each location, there are a plethora of other factors that affect the structure that is recommended. In all cases, structures were sized such that they could carry the full width of the existing road surface (cartway) and shoulders on each side between the face of the guiderails. For many sites this would make the structures several feet longer than the existing, but it will make the bridges far safer. All bridge sites will require at least minimal road surfacing at the excavation itself. Some of the bridge sites warrant more extensive changes to correct deficiencies such as improper road horizontal or vertical geometry. Additional heed was given to factors such as utilities, adjacent structures, and nearby homes.

4. Opinion of Probable Costs

We developed our opinion of the costs for the structure alternatives proposed at each location using a combination of manufacturer's estimates, BE's cost history of small bridge replacements, and PennDOT guidance on GRS-IBS bridge installations. The opinions prepared for each site are not final quotations, which is why they are presented as a range. A multitude of factors will affect the final cost including paving, guiderail type, site-specific constraints, utility coordination, maintenance & protection of traffic. Some are completely independent of the structure type while others are only minorly dependent.

Pre-engineered structure manufacturers provided estimates for their structures specific for the bridge sites being used. Bassett Engineering has tracked the history of costs for actual bridge and culvert projects completed by independent contractors (as opposed to municipal crews). Bassett calculates an installation factor for every bridge it completes and has established a range of installation factors which varies based on local site conditions. Cost opinions were developed based on the manufacturer-provided estimate multiplied by an installation factor.

5. Structure Type Recommendation

A structure type recommendation was made for each site based on several considerations including capital cost, structure suitability, road closure duration, and life cycle considerations. All structures presented have the same economic life as they should not see significant deterioration for decades. Structures that were not suitable for the site were not analyzed as feasible alternatives. Of the analyzed alternatives, each structure was evaluated for its fit with hydraulic conditions, site geometry and stream velocity (critical to GRS). While many of the sites were flexible, hydraulic conditions proved to be the primary constraint.

Capital costs were the most heavily considered factor in structure type recommendation. For small bridges such as those included in Part 1 of the Study, costs vary dramatically depending on the selected structure type as there are few shared components between alternatives. Compare this to a traditional beam bridge having an average span, where almost all components of the bridge are similar regardless of alternative, with the only major variation being the beam types themselves. Low-cost structures were favored in this study as most of these bridges are situated on rural, low-traffic roadways with simple geometries. More expensive alternatives were also evaluated at each site, but only recommended where conditions dictated the need for a specific structure type.

Road closure duration was considered as most of the structures within the Study are in rural settings with long detours, and in some cases no detour is available. In these cases, structures that minimize road closure time through use of prefabricated components were selected. A road only needs to be closed a few weeks to remove the old bridge, install the culvert/construct the bridge, backfill, rebuild the road, and set guiderail. Aluminum culverts can be completely assembled alongside the road without interrupting traffic. Concrete arch boxes and rigid frames come in complete sections and can be assembled in a week. GRS abutments can be fully built on site typically in a week’s time and the superstructure in a similar timeframe. All recommended structures offer road closure time savings over traditional beam bridges and cast-in-place culverts, which require extensive time for multiple successive concrete pours.

All structures recommended within Part 1 of the Study will have similar life cycle considerations. The largest factor considered here was minimizing the required structure maintenance. All selected components utilize materials that require no significant upkeep, eliminating the need for beam painting and other repairs. Aluminum box culverts and concrete arches are buried structures that do not have bridge decks. The same roadbed and surfacing are used over these structures as the approach road has. This eliminates bridge deck rehabilitation and replacement, which can be a significant cost over the structure’s life cycle. GRS bridges have conventional superstructures. Concrete rigid frames can either be buried or have composite decks, depending on the location.

The service life and expected maintenance for each structure type are listed on the Structure Type pages in Chapter 2. It should be noted that service life is a prediction of the life of the structure under normal conditions but damage because of impacts or other unexpected instances can drastically reduce service life. Additionally, expected maintenance refers to the the predicted major maintenance items for each structure, such as deck replacements, beam repainting, etc. All bridges require general upkeep, can be damaged by accidents, and always should be inspected after flood events.

6. Bundle Selections

Several criteria were evaluated for bundle selections including recommended structure type, opinion of probable cost, location (mainly proximity to other structures), stream restrictions, seasonal use of the bridge, and detour considerations. Ultimately recommended structure type was the determining factor for bundle selections. Bundling similar structure types will maximize contractor inclusion, as compared to bundling based on location which may result in putting complicated structures all bundles that only a handful of contractors could bid on. Additionally, if the structures were to be prepurchased, bundling by structure type would allow for a single prepurchase for each bundle.

While Lycoming County is the largest county in Pennsylvania, structure location (proximity to other structures) was not used as a determining factor in bundle selection as our survey of contractors yielded that location was far less important to them than the economy of scale offered by similar structure types. When a contractor installs four or five of the same kind of structure, it enables them to buy that specialized necessary piece of equipment and devote the time to train a dedicated crew to work on the project. The lessons learned on the first structure in the bundle can be applied to the following structures, offering a significant economy of scale.

Within the bundles, considerations were made to ensure that stream restrictions and seasonal use of bridges would allow the contractor flexibility in scheduling. Each bundle will include a bridge with no stream or seasonal use restrictions, providing the contractor with some cushion to their schedule. The only detour considerations for Part 1 of the Study are the two dead-end roads, Zinck Road and Calebs Creek Road, which will require phased construction or a bypass road regardless of what bundle they are placed in or the time of year.

7. Bundle Cost Evaluation

Bundle costs are calculated as a simple sum of the opinion of probable cost of each structure in the bundle. We expect that costs would be on the low end of this range as we anticipate significant savings from bundling these structures based on extensive past experience. There should be savings offered by contractor for repeated tasks, reduced mobilization, and optimization of time on site. However, this savings is hard to accurately quantify and is likely to vary widely. To assume a uniform savings during the study phase of this project was deemed to be potentially inaccurate and therefore it was not incorporated into the total bundle cost evaluation.

Chapter II

Structure Types

II A - Structure Type: Aluminum Box Culvert

Cost:	Low	**Level of Difficulty:**	Low
Service Life:	50 years	**Expected Maintenance:**	General Upkeep

Manufacturers: Contech, Lane

Substructure: Invert Plate or Concrete Footers (Precast or Cast-in-Place)

Headwalls: Aluminum or Cast-in-Place Concrete

Wingwalls: Aluminum, Precast Concrete (Bin) Blocks, or Cast-in-Place (CIP) Concrete

Deck Type: N/A – Fill over structure to conventional road surfacing

Natural Stream Bed Yes (Invert plate with fish baffles or footers outside stream channel)

Span:	8.75	foot minimum	35.25	foot maximum
Rise:	2.5	foot minimum	13.58	foot maximum
Hydraulic Opening	18.4	sq. foot minimum	400	sq. foot maximum

Considerations: Guiderail sleeper slabs needed, debris flow hazards, bedrock presence

Notes: Aluminum Box Culverts (ALBCs) are a low-cost option for small bridge replacements offering a low profile, near-optimal hydraulic shape, ease-of-construction, and the shortest road closure duration. Most local excavators and municipal crews can assemble and install an ALBC in a month without the need for a crane. The total cost is largely influenced by the selection of headwall and wingwall materials. Boxes can be fully assembled before lowering into place, allowing the road to remain open during assembly. Invert plates (if used) are set a minimum of one foot below the natural stream bottom. The addition of low-cost fish baffles holds the stream bed material in place, or the use of concrete footers enables a truly natural stream bottom.

Photos:

II C - Structure Type: Concrete Arch Box Culvert

Cost:	Medium	**Level of Difficulty:**	Low-Medium
Service Life:	50 years	**Expected Maintenance:**	General Upkeep

Manufacturers: Contech, Ecospan, Tindall, Michie, Tricon

Substructure: Precast or Express Footings (Precast Form with Rebar, fill with Cast-in-Place)

Headwalls: Attached or Detached Precast Concrete, Cast-in-Place (CIP) Concrete

Wingwalls: Precast Concrete or Cast-in-Place Concrete

Deck Type: N/A – Fill over structure to conventional road surfacing

Natural Stream Bed Yes

Span:	12 (13) foot minimum	48 (87) foot maximum
Rise:	4 (3.2) foot minimum	14 (21) foot maximum
Hydraulic Opening	42 (33) sq. foot minimum	502 (1440) sq. foot maximum

**All dimensions listed in parentheses are for two-piece arches, joined at center span*

Considerations: Guiderail sleeper slabs sometimes needed, bedrock excavation, low-rises

Notes: Arch box culverts are the most common precast concrete arch and while Contech is the most prevalent supplier, many precast manufacturers can produce these structures. Arch boxes are a mid-cost structure alternative with a wide applicability range only limited by the arch shape, which does not always work in low-rise situations. Precast concrete arches balance the quality of a concrete product with the cost-effectiveness of a pre-manufactured structure. The natural stream bottom provided by the structure is important in streams with environmental restrictions such as HQ, EV, CWF, native trout, etc.

Photos:

II D - Structure Type: Concrete BEBO Arch

Cost:	Medium-High		**Level of Difficulty:**	Medium-High
Service Life:	50 years		**Expected Maintenance:**	General Upkeep

Manufacturers: Contech, Tindall

Substructure: Precast or Express Footings (Precast Form with Rebar, Set and Cast-in-Place)

Headwalls: Precast Concrete or Cast-in-Place Concrete

Wingwalls: Precast Concrete or Cast-in-Place Concrete

Deck Type: N/A – Fill over structure to conventional road surfacing

Natural Stream Bed Yes

Span:	11.17	foot minimum	84	foot maximum
Rise:	3.5	foot minimum	30	foot maximum
Hydraulic Opening	28	sq. foot minimum	2,080	sq. foot maximum

Considerations: Guiderail sleeper slabs sometimes needed, bedrock excavation

Notes: BEBO arches are an alternative arch style to the common concrete arch which features vertical walls and a simple arch shape. BEBO arches are manufactured in three distinct shapes optimized for longer spans, high fill depths, and extreme applications. Contech is the only licensed US manufacturer of BEBO brand arches, although many precasters can produce an identical product. While they are a medium-high cost structure selection, they offer a cost savings with longer spans where a traditional beam bridge would be needed, and under high fill depths where other structures are infeasible.

Photos:

Chapter III

Structure Alternatives Analysis

Structure Alternatives Form

Municipality	Limestone
Road Number	T-305
Road Name	Mill Road
	over
Stream Name	Antes Creek

Key Selection Criteria

Streambed Movement
Cold Water Fish Stream
High Rise
N/A

Existing Structure Info

Existing Structure	SPP RR Tanker	
Clear Span	8.5	Feet
Structure Length	9	Feet
Rise	7.3	Feet
Width	40	Feet
Skew	70	Deg.
Hyd. Open	48.7	Sq. Ft.
TB - TB	32, 30	Feet
BB - BB	18, 16	Feet
Inv.- Road Crown	10, 10.5	Feet
Roadway Width	18	Feet
Roadway Surface	HMA	

Stream Info

Existing Use	N/A	
Designated Use	CWF	
Trout Information	N/A	
NWI Mapper	N/A	
Basin Area	1.75	Sq. Mi.
Basin Slope	17.99	%
Bed Material	Med-Lg Cobbles	
Mean Flow	3.07	cfs
10-Year Storm Flow	279	cfs
50-Year Storm Flow	476	cfs
100-Year Storm Flov	576	cfs
500-Year Storm Flov	849	cfs

Potential Structure

Type	Aluminum Box Culvert with Concrete Footers
Description	Corrugated aluminum structure fully assembled then set onto independent footers
Considerations	Lowest cost low-profile structure for low-ADT road. Assembling aluminum box outside stream channel minimizes road closure duration. Rounded shoulders reduce hydraulic opening. Open natural bottom allows moderate streambed movement for EV stream.

Potential Structure

Type	Concrete Arch Box Culvert
Description	Precast concrete arch installed in monolithic segments on independent concrete footers
Considerations	Most efficient precast concrete structure type. Medium cost. Precast: rapid assembly in-stream, minimize road closure. High rise enables use of arch. Rounded arch shape: lower hydraulic opening for any given height. Open natural bottom for CWF stream.

Potential Structure

Type	BEBO Arch
Description	Precast arch with optimized shape installed in monolithic segments on independent foote
Considerations	High rise enables the use of an arch, open natural bottom allows moderate streambed movement for CWF stream. BEBO arch offers hydraulically optimized shape superior to that of the standard CON/SPAN Arch.

Photograph 1: Inlet Elevation

Photograph 2: Outlet Elevation

Photograph 3: Near Approach

Photograph 4: Far Approach

Photograph 5: Upstream View

Photograph 6: Downstream View

1. **Site Characteristics**

    a. **Existing Conditions:** The culvert is situated in the Nippenose Valley where Mill Road crosses an unnamed tributary to Antes Creek at a 70-degree skew. The site is in the ridge and valley region and the area is well known for its karst topography. The existing structure is oriented with its tall headwalls (the downstream being a large mass of concrete) tight to the roadway. The structure sits in the middle of an S-bend on Mill Road where it also meets with Buffington Road, creating an asymmetric intersection. The road is not planned to be realigned and the road grade is not expected to change.

    Overhead electric and communications lines are present at the structure on Mill Road. The utility owners will need to be notified of the project, and the communication lines directly over the structure are expected to need temporary relocation for construction. Assuming a 33-foot wide road right-of way, additional ROW will need to be obtained for the structure footprint.

    b. **Stream Hydrology:** The unnamed tributary to Antes Creek has a very steep 1.8 square mile drainage area tributary to the site, paralleling Route 44 and Rattling Run. The stream experiences moderate to high flows in mountainous terrain, producing a steep profile with constant streambed movement. The stream has a designated use as a cold-water fishery and it disappears into a sinkhole a quarter mile downstream of the structure. Only open-bottomed structures were considered to retain the natural streambed and allow aquatic organisms free movement.

    c. **Existing Structure Hydraulics:** The existing steel railroad tanker culvert is hydraulically acceptable, although it is set at a lower slope than the overall stream, causing deposition upstream of the culvert and a large scour hole immediately downstream. Hydraulic analysis of the structure indicated that it was able to pass flows between the 50-year and the 100-year storms, an acceptable fit hydraulically that could be improved with an open-bottomed structure.

    d. **Proposed Structure Hydraulics:** The proposed structure type alternatives for Mill Road were sized to increase the hydraulic opening, which was already able to pass flows between the 50-year and the 100-year storms. DEP requires that the replacement of a structure does not reduce the hydraulic opening, even if the flow capacity is increased. The proposed structure alternatives were all able to pass flows greater than the 100-year storm by offering better hydraulic configurations than the existing round pipe.

2. **Structure Alternative: Aluminum Box Culvert with Concrete Footers**

    a. **Size:** 16'-2" Span x 5'-1" Clear Rise x 40'-6" Long

    b. **Structure Details:** The Aluminum Box Culvert with Concrete Footers offers a low-profile, low cost, and a hydraulic opening somewhat larger than that of the existing structure. Concrete footers were selected to allow for streambed movement.

    c. **Cost:** $173,000 - $230,000 Costs are based on prices from the two manufacturers who have supplied all of the ALBC’s that BE has installed and are therefore reliable.

3. **Structure Alternative: Concrete Arch Box**

    a. **Size:** 16'-0" Span x 4'-0" Clear Rise x 42'-0" Long

    b. **Structure Details:** The concrete arch box offers an optimal structural shape at a medium cost and a hydraulic opening just a bit larger than that of the existing structure. The arch box was selected given the higher clearance and to allow for streambed movement.

    c. **Cost:** $269,000 - $359,000 Costs are based on prices from two manufacturers, one of which who has supplied all of the concrete arches that BE has installed and are therefore reliable. Costs are 60% higher than those for the aluminum box.

1. **Recommended Alternative: Aluminum Box Culvert**

    a. **Discussion:** An Aluminum Box Culvert will reliably serve Mill Road at a significantly lower cost than a concrete arch box. An aluminum box culvert built in 1996 is located directly upstream and is in like-new condition. The road does not receive heavy traffic. The structure does not receive heavy damaging storm flows and the culvert is generously sized. Temporary road closure should be acceptable and detours are short. No complicating factor is apparent that would warrant a more expensive structure.

    b. **Final Opinion of Probable Cost $173,000 - $230,000**

Structure Type Feasibility Study
Part 1
Auchmuty Road (T-516)
Muncy Township

Lycoming County Bridge Bundling

September 18, 2020

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Chapter I

Feasibility Study

I. Feasibility Study

A. Purpose

The Lycoming County Bridge Bundling Project proposes to replace or repair 17 small bridges across Lycoming County as a coordinated effort between the County, local municipal bridge owners, all of whom serve on the Steering Committee, various local and state agencies, and the Bassett Engineering/WMA team. This Structure Type Feasibility Study will evaluate and present feasible structure types for each bridge replacement and recommend a structure type for each location. Local municipal bridge owners will then review and comment on the recommended structure type for their bridge prior to structure selection by the County.

The Structure Type Feasibility Study is divided into two parts; Part 1 evaluates the bridges that are considered to be the most straightforward structure selections and replacements while Part 2 will evaluate the more difficult replacements and all of the structures to be repaired. The division of the Study serves to enable the simpler bridges to proceed to design and construction more rapidly with the intent to construct the first of four bundles while designing the bridges included in Part 2 of the study.

B. Involved Bridges

Phase 1 of the Structure Type Feasibility Study focuses on the bridges which one would consider the simplest and most straightforward replacements. The bridges selected for Phase 1 are those. with minimal site complications, low traffic roadways, ease of construction, shorter spans, and quickest anticipated project delivery.

1.	Calebs Creek Road	(T-850)	Eldred Township
2.	Smith Road	(T-469)	Franklin Township
3.	Winner Lane	(T-625)	Gamble Township
4.	Klump Road	(T-489)	Hepburn Township
5.	Mill Road	(T-305)	Limestone Township
6.	Zinck Road	(T-358)	Mifflin Township
7.	Auchmuty Road	(T-516)	Muncy Township
8.	Logue Hill Road	(T-571)	Penn Township
9.	Valley Road	(T-392)	Susquehanna Township

C. Exclusions

All structures excluded from Phase 1 of the Structure Type Feasibility Study will be addressed under Phase 2. These bridges were excluded from Phase 1 due to their status as a repair or apparent complex nature due to urban settings, adjacent structures, foreseen construction difficulties which would require a more highly qualified contractor, and the potential for a bridge currently listed as a repair to be replaced. The excluded bridges are listed below:

1.	Old Cement Road	(T-541)	Fairfield Township
2.	Wilson Street		Jersey Shore Borough
3.	Upper Bodines Road	(T-857)	Lewis Township
4.	Sheridan Street	(T-616)	Loyalsock Township
5.	Montgomery Park Road		Montgomery Borough
6.	Bill Sones Road	(T-638)	Moreland Township
7.	Gap Road	(T-384)	Washington Township
8.	Penn Drive	(T-250)	Wolf Township

D. Study Approach

Bassett Engineering has become intimately familiar with the strong majority of these bridge sites as a part of the Lycoming County Small Bridge Inspections program. In the six years of the program, many of these structures experienced extreme flood events such as Hurricane Lee in 2011, and since then the flooding in October 2016 and throughout the late summer and fall of 2018. Given this deep background, we were able to quickly evaluate each site for the most suitable structures.

1. Site

The structure type alternatives for each site were selected based on multiple criteria including geometric constraints, road use, stream quality, streambed movement, and stream velocity. The bridge sites are located across Lycoming County in several geologic regions including the Allegheny Plateau on the northern half of the county, the Ridge and Valley region south and west of the West Branch, and the rolling hills which lie between the two. The streams spanned by the bridges in this study vary from winding farm brooks to roaring mountain streams, all of which experience the floods which the County routinely sees.

2. Hydrology and Hydraulics

All stream flows for this study were estimated using USGS Streamstats, a hydrologic tool used to delineate drainage areas and prepare flow statistics estimates. In BE's experience with small bridges, Streamstats accurately predicts stream flows for the drainage areas typical of these streams. The only exception we have seen is where karst topography causes sinkholes which capture and attenuate the peak flow events of a given stream. We believe that Streamstats is the ideal method to predict flows for each stream.

3. General Considerations

While this study focuses on the structure types for each location, there are a plethora of other factors that affect the structure that is recommended. In all cases, structures were sized such that they could carry the full width of the existing road surface (cartway) and shoulders on each side between the face of the guiderails. For many sites this would make the structures several feet longer than the existing, but it will make the bridges far safer. All bridge sites will require at least minimal road surfacing at the excavation itself. Some of the bridge sites warrant more extensive changes to correct deficiencies such as improper road horizontal or vertical geometry. Additional heed was given to factors such as utilities, adjacent structures, and nearby homes.

4. Opinion of Probable Costs

We developed our opinion of the costs for the structure alternatives proposed at each location using a combination of manufacturer's estimates, BE's cost history of small bridge replacements, and PennDOT guidance on GRS-IBS bridge installations. The opinions prepared for each site are not final quotations, which is why they are presented as a range. A multitude of factors will affect the final cost including paving, guiderail type, site-specific constraints, utility coordination, maintenance & protection of traffic. Some are completely independent of the structure type while others are only minorly dependent.

Pre-engineered structure manufacturers provided estimates for their structures specific for the bridge sites being used. Bassett Engineering has tracked the history of costs for actual bridge and culvert projects completed by independent contractors (as opposed to municipal crews). Bassett calculates an installation factor for every bridge it completes and has established a range of installation factors which varies based on local site conditions. Cost opinions were developed based on the manufacturer-provided estimate multiplied by an installation factor.

5. Structure Type Recommendation

A structure type recommendation was made for each site based on several considerations including capital cost, structure suitability, road closure duration, and life cycle considerations. All structures presented have the same economic life as they should not see significant deterioration for decades. Structures that were not suitable for the site were not analyzed as feasible alternatives. Of the analyzed alternatives, each structure was evaluated for its fit with hydraulic conditions, site geometry and stream velocity (critical to GRS). While many of the sites were flexible, hydraulic conditions proved to be the primary constraint.

Capital costs were the most heavily considered factor in structure type recommendation. For small bridges such as those included in Part 1 of the Study, costs vary dramatically depending on the selected structure type as there are few shared components between alternatives. Compare this to a traditional beam bridge having an average span, where almost all components of the bridge are similar regardless of alternative, with the only major variation being the beam types themselves. Low-cost structures were favored in this study as most of these bridges are situated on rural, low-traffic roadways with simple geometries. More expensive alternatives were also evaluated at each site, but only recommended where conditions dictated the need for a specific structure type.

Road closure duration was considered as most of the structures within the Study are in rural settings with long detours, and in some cases no detour is available. In these cases, structures that minimize road closure time through use of prefabricated components were selected. A road only needs to be closed a few weeks to remove the old bridge, install the culvert/construct the bridge, backfill, rebuild the road, and set guiderail. Aluminum culverts can be completely assembled alongside the road without interrupting traffic. Concrete arch boxes and rigid frames come in complete sections and can be assembled in a week. GRS abutments can be fully built on site typically in a week's time and the superstructure in a similar timeframe. All recommended structures offer road closure time savings over traditional beam bridges and cast-in-place culverts, which require extensive time for multiple successive concrete pours.

All structures recommended within Part 1 of the Study will have similar life cycle considerations. The largest factor considered here was minimizing the required structure maintenance. All selected components utilize materials that require no significant upkeep, eliminating the need for beam painting and other repairs. Aluminum box culverts and concrete arches are buried structures that do not have bridge decks. The same roadbed and surfacing are used over these structures as the approach road has. This eliminates bridge deck rehabilitation and replacement, which can be a significant cost over the structure's life cycle. GRS bridges have conventional superstructures. Concrete rigid frames can either be buried or have composite decks, depending on the location.

The service life and expected maintenance for each structure type are listed on the Structure Type pages in Chapter 2. It should be noted that service life is a prediction of the life of the structure under normal conditions but damage because of impacts or other unexpected instances can drastically reduce service life. Additionally, expected maintenance refers to the the predicted major maintenance items for each structure, such as deck replacements, beam repainting, etc. All bridges require general upkeep, can be damaged by accidents, and always should be inspected after flood events.

6. Bundle Selections

Several criteria were evaluated for bundle selections including recommended structure type, opinion of probable cost, location (mainly proximity to other structures), stream restrictions, seasonal use of the bridge, and detour considerations. Ultimately recommended structure type was the determining factor for bundle selections. Bundling similar structure types will maximize contractor inclusion, as compared to bundling based on location which may result in putting complicated structures all bundles that only a handful of contractors could bid on. Additionally, if the structures were to be prepurchased, bundling by structure type would allow for a single prepurchase for each bundle.

While Lycoming County is the largest county in Pennsylvania, structure location (proximity to other structures) was not used as a determining factor in bundle selection as our survey of contractors yielded that location was far less important to them than the economy of scale offered by similar structure types. When a contractor installs four or five of the same kind of structure, it enables them to buy that specialized necessary piece of equipment and devote the time to train a dedicated crew to work on the project. The lessons learned on the first structure in the bundle can be applied to the following structures, offering a significant economy of scale.

Within the bundles, considerations were made to ensure that stream restrictions and seasonal use of bridges would allow the contractor flexibility in scheduling. Each bundle will include a bridge with no stream or seasonal use restrictions, providing the contractor with some cushion to their schedule. The only detour considerations for Part 1 of the Study are the two dead-end roads, Zinck Road and Calebs Creek Road, which will require phased construction or a bypass road regardless of what bundle they are placed in or the time of year.

7. Bundle Cost Evaluation

Bundle costs are calculated as a simple sum of the opinion of probable cost of each structure in the bundle. We expect that costs would be on the low end of this range as we anticipate significant savings from bundling these structures based on extensive past experience. There should be savings offered by contractor for repeated tasks, reduced mobilization, and optimization of time on site. However, this savings is hard to accurately quantify and is likely to vary widely. To assume a uniform savings during the study phase of this project was deemed to be potentially inaccurate and therefore it was not incorporated into the total bundle cost evaluation.

Chapter II

Structure Types

II A - Structure Type: Aluminum Box Culvert

Cost:	Low	**Level of Difficulty:**	Low
Service Life:	50 years	**Expected Maintenance:**	General Upkeep

Manufacturers: Contech, Lane

Substructure: Invert Plate or Concrete Footers (Precast or Cast-in-Place)

Headwalls: Aluminum or Cast-in-Place Concrete

Wingwalls: Aluminum, Precast Concrete (Bin) Blocks, or Cast-in-Place (CIP) Concrete

Deck Type: N/A – Fill over structure to conventional road surfacing

Natural Stream Bed Yes (Invert plate with fish baffles or footers outside stream channel)

Span:	8.75	foot minimum	35.25	foot maximum
Rise:	2.5	foot minimum	13.58	foot maximum
Hydraulic Opening	18.4	sq. foot minimum	400	sq. foot maximum

Considerations: Guiderail sleeper slabs needed, debris flow hazards, bedrock presence

Notes: Aluminum Box Culverts (ALBCs) are a low-cost option for small bridge replacements offering a low profile, near-optimal hydraulic shape, ease-of-construction, and the shortest road closure duration. Most local excavators and municipal crews can assemble and install an ALBC in a month without the need for a crane. The total cost is largely influenced by the selection of headwall and wingwall materials. Boxes can be fully assembled before lowering into place, allowing the road to remain open during assembly. Invert plates (if used) are set a minimum of one foot below the natural stream bottom. The addition of low-cost fish baffles holds the stream bed material in place, or the use of concrete footers enables a truly natural stream bottom.

Photos:

II C - Structure Type: Concrete Arch Box Culvert

Cost:	Medium	**Level of Difficulty:**	Low-Medium
Service Life:	50 years	**Expected Maintenance:**	General Upkeep

Manufacturers: Contech, Ecospan, Tindall, Michie, Tricon

Substructure: Precast or Express Footings (Precast Form with Rebar, fill with Cast-in-Place)

Headwalls: Attached or Detached Precast Concrete, Cast-in-Place (CIP) Concrete

Wingwalls: Precast Concrete or Cast-in-Place Concrete

Deck Type: N/A – Fill over structure to conventional road surfacing

Natural Stream Bed Yes

Span:	12 (13) foot minimum	48 (87) foot maximum
Rise:	4 (3.2) foot minimum	14 (21) foot maximum
Hydraulic Opening	42 (33) sq. foot minimum	502 (1440) sq. foot maximum

**All dimensions listed in parentheses are for two-piece arches, joined at center span*

Considerations: Guiderail sleeper slabs sometimes needed, bedrock excavation, low-rises

Notes: Arch box culverts are the most common precast concrete arch and while Contech is the most prevalent supplier, many precast manufacturers can produce these structures. Arch boxes are a mid-cost structure alternative with a wide applicability range only limited by the arch shape, which does not always work in low-rise situations. Precast concrete arches balance the quality of a concrete product with the cost-effectiveness of a pre-manufactured structure. The natural stream bottom provided by the structure is important in streams with environmental restrictions such as HQ, EV, CWF, native trout, etc.

Photos:

II F - Structure Type: Concrete Rigid Frame

Cost:	High		**Level of Difficulty:**	Medium
Service Life:	50 years		**Expected Maintenance:**	General Upkeep

Manufacturers: Terre Hill, Oldcastle, AC Miller, Keystone Precast, Mack Industries

Substructure: Precast or Cast-in-Place Concrete Footers

Headwalls: Precast Concrete or Cast-in-Place Concrete

Wingwalls: Precast Concrete or Cast-in-Place Concrete

Deck Type: Integral, concrete, asphalt or fill over structure to conventional road surfacing

Natural Stream Bed Yes

Span:	6	foot minimum	28	foot maximum
Rise:	2	foot minimum	10	foot maximum
Hydraulic Opening	12	sq. foot minimum	280	sq. foot maximum

Considerations: Scour depth, soil bearing capacity, small spans

Notes: The rigid frame (3-sided box culvert) is very similar to the concrete box culvert (4-sided), utilizing a 3-sided bridge with independent footers that must be set well below the streambed. These bridges are a popular small bridge selection as they can fit very low underclearances, host a natural streambed, are optimal for streams with bed movement, and can be installed without having to pump the stream around the bridge during installation. Like CBC's they are one of the highest-costing small bridge replacement alternatives, ideal for low-underclearace and urban bridge replacements.

Photos:

Chapter III

Structure Alternatives Analysis

Structure Alternatives Form

Municipality	Muncy
Road Number	T-516
Road Name	Auchmuty Road
	over
Stream Name	Oak Run

Key Selection Criteria

Low Rise
Cold Water Fish Stream
Moderate ADT Road
N/A

Existing Structure Info

Existing Structure	Concrete Arch	
Clear Span	11.5	Feet
Structure Length	12	Feet
Rise	4.5	Feet
Width	31	Feet
Skew	90	Deg.
Hyd. Open	38.4	Sq. Ft.
TB - TB	26, 27	Feet
BB - BB	11, 11	Feet
Inv.- Road Crown	6.5, 6.75	Feet
Roadway Width	20	Feet
Roadway Surface	HMA	

Stream Info

Existing Use	N/A	
Designated Use	CWF	
Trout Information	N/A	
NWI Mapper	N/A	
Basin Area	1.37	Sq. Mi.
Basin Slope	19.8	%
Bed Material	Small Cobbles	
Mean Flow	1.87	cfs
10-Year Storm Flow	227	cfs
50-Year Storm Flow	390	cfs
100-Year Storm Flov	471	cfs
500-Year Storm Flov	696	cfs

Potential Structure

Type	Aluminum Box Culvert with Invert Plate and Fish Baffles
Description	Corrugated aluminum structure fully assembled with invert plate and baffles set monoliti
Considerations	Lowest cost low-profile structure for low-ADT road. Assembling aluminum box outside stream channel minimizes road closure duration. Rounded shoulders reduce hydraulic opening. Invert plate with fish baffles retains native streambed material.

Potential Structure

Type	Concrete Arch Box Culvert
Description	Precast concrete arch installed in monolithic segments on independent concrete footers
Considerations	Most efficient precast concrete structure type. Medium cost. Precast: rapid assembly in-stream, minimize road closure. High rise enables use of arch. Rounded arch shape: lower hydraulic opening for any given height. Open natural bottom for CWF stream.

Potential Structure

Type	Concrete Rigid Frame
Description	Three-sided precast concrete frame installed on independent concrete footers
Considerations	Higher cost low-profile structure. Precast sections can be rapidly assembled in-stream to minimize road closure duration. Square shoulders maximize hydraulic opening. Open natural bottom allows moderate streambed movement for CWF stream.

Photograph 1: Inlet Elevation

Photograph 2: Outlet Elevation

Photograph 3: Near Approach

Photograph 4: Far Approach

Photograph 5: Upstream View

Photograph 6: Downstream View

1. **Site Characteristics**

   a. **Existing Conditions:** The bridge is situated parallel to Route 220 where Auchmuty Road crosses Oak Run at a 90-degree skew. The site is in rolling farm country with moderate open hillsides. The existing structure is oriented with the downsteam headwall tight to the roadway and the upstream headwall extending beyond the shoulder. The structure sits in a sag curve on Auchmuty Road, just downhill of Fry's Plastic.

      Overhead electric lines are present just downstream of the structure on Auchmuty Road. The utility owners will need to be notified of the project, but the lines are not expected to need relocation for construction. Assuming a 33-foot wide road right-of way, additional ROW will need to be obtained for the structure footprint.

   b. **Stream Hydrology:** Oak Run has a somewhat steep 1.4 square mile drainage area tributary to the site, which begins steep in the hills and flattens out prior to reaching the culvert site. The stream experiences moderate flows in hilly terrain, creating a wide channel with little bed movement. The stream has a designated use as a cold water fishery.

   c. **Existing Structure Hydraulics:** The two-piece steel plate and concrete arch is hydraulically acceptable, showing no signs of scour. Hydraulic analysis of the structure indicated that it was able to pass flows just under the 100-year storm, which could easily be improved with a more optimal structure.

   d. **Proposed Structure Hydraulics:** The proposed structure type alternatives for Auchmuty Road were sized to be able to pass the 100-year storm, a slight improvement over the existing culvert. This increase in flow capacity was due to roughly doubling the hydraulic opening in all cases as the single radius arch has the minimal opening for its span and is the most inefficient hydraulically.

2. **Structure Alternative: Aluminum Box Culvert with Invert Plate and Fish Baffles**

   a. **Size:** 15'-1" Span x 4'-8" Clear Rise x 31'-6" Long

   b. **Structure Details:** The Aluminum Box Culvert with Invert Plate and Fish Baffles offers a low-profile, low cost, and a hydraulic opening approximately double that of the existing structure. The invert plate was selected for the lowest cost in a situation with no bed movement and no fish restrictions. Fish baffles would retain the natural streambed and allow aquatic organisms free movement. An ALBC would be set to match the slope of the stream channel, which is necessary to avoid streambed material deposition upstream and a scour hole downstream of the culvert.

   c. **Cost:** $111,000 - $148,000 Costs are based on prices from the two manufacturers who have supplied all of the ALBC's that BE has installed and are therefore reliable.

3. **Structure Alternative: Concrete Arch Box Culvert**

    a. **Size:** 14'-0" Span x 5'-0" Clear Rise x 32'-0” Long

    b. **Structure Details:** The concrete arch box culvert offers an optimal structural shape at a moderate cost and approximately double the hydraulic opening of the existing structure. The arch box was selected given the moderate clearance and to allow for streambed movement.

    c. **Cost:** 203,000 - $270,000 Costs are based on prices from two manufacturers, one of which who has supplied all of the concrete arches that BE has installed and are therefore reliable. Costs are 80% higher than those for the aluminum box.

4. **Structure Alternative: Concrete Rigid Frame**

    a. **Size:** 14'-1" Span x 4'-6" Clear Rise x 32'-0” Long

    b. **Structure Details:** The Concrete Rigid Frame offers a very low-profile and approximately double the hydraulic opening of the existing structure, but at a higher cost. When considering what concrete structure alternative to evaluate, a rigid frame was selected over a concrete box culvert to provide a natural bottom for the cold water fishery.

    c. **Cost:** $321,000 - $428,000 Costs are based on prices from two PennDOT-approved manufacturers. A third major supplier was contacted several times, but they never offered prices. Costs are 60% more than the concrete arch box culvert and nearly 3 times those of the aluminum box.

5. **Recommended Alternative: Aluminum Box Culvert**

    a. **Discussion:** An Aluminum Box Culvert will reliably serve Auchmuty Road at a much lower cost than a concrete arch box culvert and a concrete rigid frame. The primary advantage an aluminum box offers is the culvert can be completely assembled alongside the road without interrupting traffic. No complicating factor is apparent that would warrant a more expensive structure. The road does not receive high-speed traffic. The structure does not receive heavy damaging storm flows and the culvert is generously sized. Temporary road closure should be acceptable, and detours are short.

    b. **Final Opinion of Probable Cost: $111,000 - $148,000**