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August 25, 2021

Chuck Fuller, Selectman Chair
Town of Effingham
68 School Street
Effingham, NH 03882

Re: Project Report -
Province Lake Drainage Improvements Analysis for Bailey Rd
CMA # 1183

Dear Mr. Fuller and Board:

We are pleased to transmit herewith our report on drainage improvements at the Bailey Road culvert at the outlet of Province Lake in Effingham. The report summarizes and presents the evaluations, recommendation of alternatives, conceptual designs, and cost estimates for a replacement of this important part of Town infrastructure. The project team included CMA Engineers, Streamworks PLLC for hydrology and hydraulic evaluations, DK Water Resources Consulting LLC for lake water quality assessments, and T.F. Bernier, Inc. for survey and wetlands delineation.

As the report describes, the hydrologic and hydraulic settings and conditions at the culvert, which is also the outlet control structure to Province Lake under high flow conditions, are interesting and unique. The replacement structures perform more as a dam outlet rather than a conventional culvert. As presented, the recommended replacement is a 12-foot span precast rigid frame structure, with an estimated capital cost of $383,000. Additionally, a lakeshore stabilization project has been conceptually described for 350-400 feet east of the site.

It has been our pleasure to have developed this interesting and important project with you and others in Effingham and at NHDES. If you or NHDES has any questions or comments, please do not hesitate to call.

Very truly yours,
CMA ENGINEERS, INC.

William A. Straub, P.E., P.G.
Principal and Project Manager

WAS/kao

Enc.

*1183-Effingham-DL-210823-Province Lake Oulet Culverts -WAS*

# Town of Effingham, NH

## Province Lake Drainage Improvements Analysis for Bailey Road

Project Report August 2021


Chuck Fuller, Chairman
Board of Selectman
Town of Effingham
68 School Street
Effingham, NH 03822

CMA ENGINEERS

**Submitted by:**
CMA Engineers, Inc.
35 Bow Street
Portsmouth, NH 03801

Streamworks
Tom Ballestero, P.E., PhD

# Table of Contents

# 1. Background and Objectives

Province Lake is an important, natural feature in Effingham, NH. It is a scenic and popular natural water body with lakefront properties and recreational resources. The lake has been the focus of environmental studies and evaluations for decades. The NH Department of Environmental Services (NHDES), and other agencies/organizations, have partnered with the Town of Effingham and the Province Lake Association in these efforts. Much of the work is associated with managing nutrient loading to the lake, particularly phosphorous which contributes to algal growth and cyanobacteria blooms.

The objectives of the current study are to evaluate and plan future culvert and road improvements for Bailey Road. Bailey Road is a public road maintained by the Town of Effingham. The culvert is at the outlet to Province Lake as it flows north into the South River. The project is a priority to alleviate local flooding at the outlet of Province Lake, improve aging and inadequate infrastructure, and address potential water quality concerns for the lake.

To complete the study, the Town of Effingham received funding under the NHDES State Revolving Fund (SRF) program administered by the Water Division (CS-330036-01). The study and report provide information to assist in understanding current conditions at the site and evaluate potential infrastructure improvements. Objectives for the project include:

- Evaluate the existing infrastructure including general condition of the structures, stormwater impacts at the site, and other related concerns.
- Assess potential impacts of the existing structure relative to flooding, aquatic organism passage, and sediment transport.
- Complete a hydraulic and hydrologic analysis of the culvert crossing to provide a working understanding of flow regimes at the site and develop relationships of culverts to the lake.
- Assess erosion from unmanaged stormwater and address associated potential water quality concerns for Province Lake.
- Prepare alternatives for improvements/replacement of the current infrastructure, including a description of how the alternatives would address the stated concern
- Development of conceptual designs and costs estimates for further project development.

The engineering team for the project is led by CMA Engineers, Inc. with support from Streamworks, PLLC for hydrologic and hydraulic evaluations; DK Water Resource Consulting, LLC for lake water quality evaluation; and T.F. Bernier, Inc. for survey and wetlands delineation.

## 2. Existing Conditions

The existing Bailey Road crossing of South River consists of two 4-foot corrugated metal pipe culverts, and it is in poor condition. Headwalls are a combination of stone and old concrete and are failing and is evidenced falling/missing stones and sinkholes between the headwall and roadway. The guardrail is substandard for vehicle protection. Baily Road is paved across the culverts. Pictures of the culvert's conditions are presented below.

Culvert inlet

Culvert Outlet

Culvert Outlet, Guardrail, and Sinkhole

South River Downstream of Bailey Road Culvert

There is a low-level control structure at the end of the lake, and at the beginning of the channel leading to Bailey Road and South River. This short and low dam is operated seasonally to maintain lake levels, during periods of normal or low flow. As described in both Section 3 and Attachment A, during high flow/ high lake elevations, the lake level is not controlled by the dam; it is controlled by the Bailey Road culvert crossing. Bailey Road effectively becomes a dam with the culvert crossing the dam outlet structure.

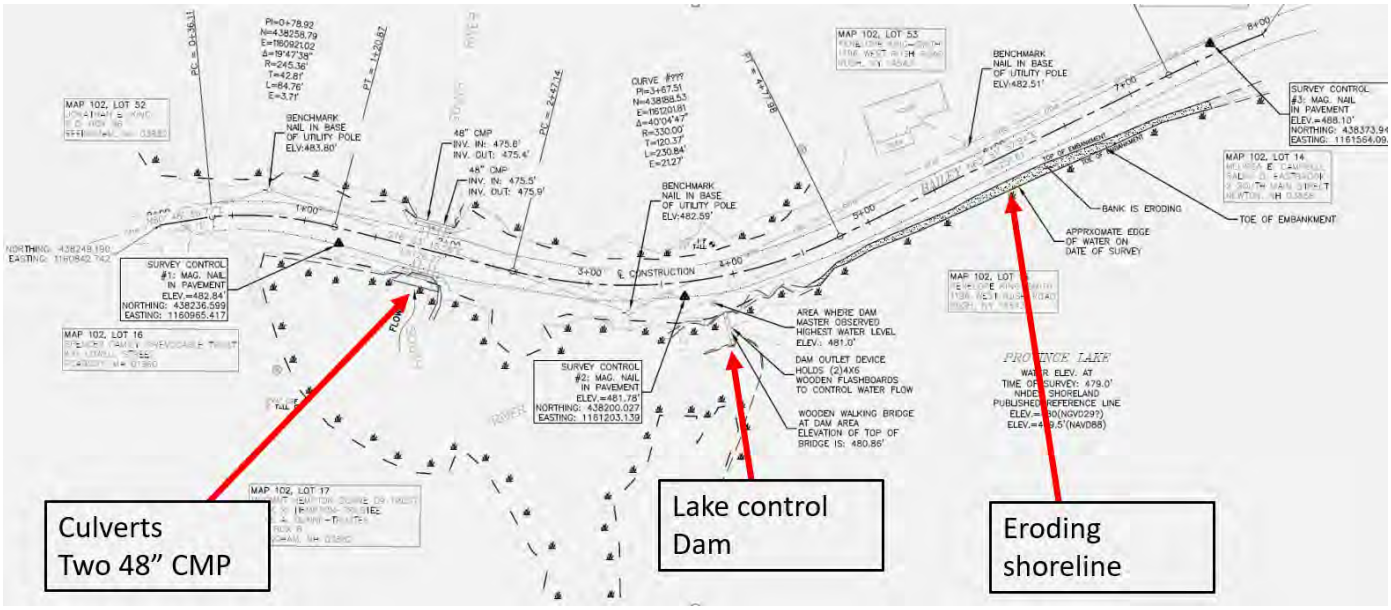
Low-Flow Control Dam and Footbridge

Another significant feature of the area is the Province Lake shoreline to the east of the dam/footbridge is narrow between Province Lake and Bailey Road. The shore is sandy, significantly eroded for approximately 350-400 feet, and it is not stable to resist future and ongoing erosion.

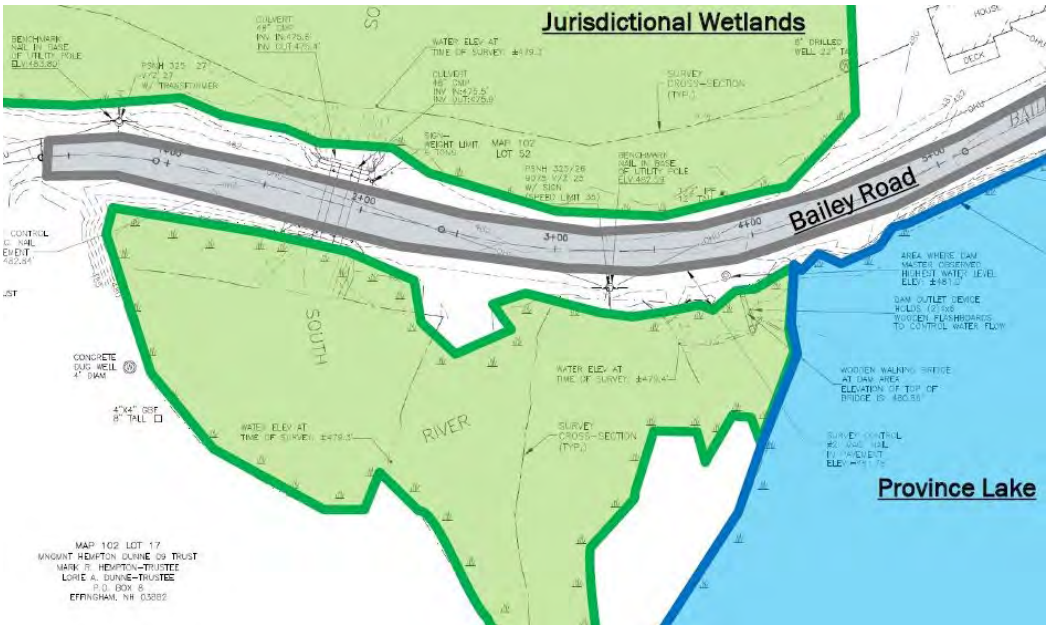
Shoreline east of Dam/Footbridge

The existing conditions at the Bailey Road culvert, and the surrounding areas, were identified to support the hydrology and hydraulic evaluations, and the preliminary design and permitting requirements of this project. An aerial depiction of the area is as follows:

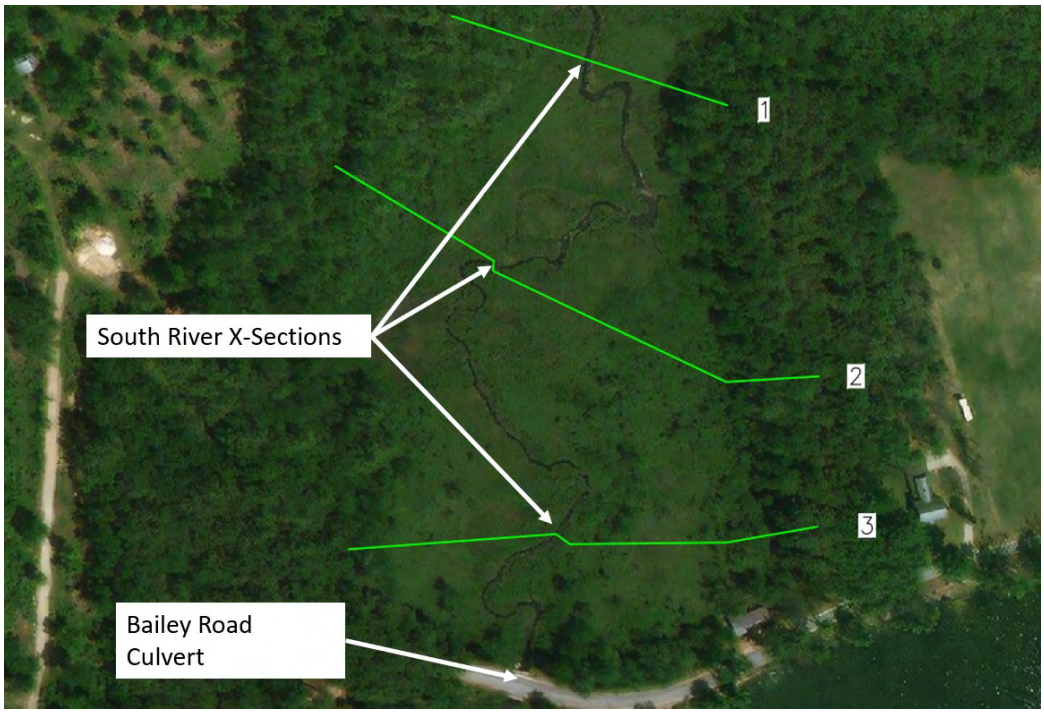

T.F. Bernier, Inc. was retained for field survey and wetlands delineation. Survey work included detailed site/topographic survey of the Bailey Road culvert and surroundings. The existing conditions plan is included in Attachment C – Design Drawings. A figure indicating the extent and limits of the field survey is provided below.



T.F. Bernier delineated the jurisdictional wetlands surrounding the culvert, which are included on the existing conditions plan. These wetlands limits are graphically depicted in the following figure.




Also included in the survey are three channel cross-sections showing ground/marsh elevations on the South River extending 4,000 feet north from the Bailey Road culvert crossing. The field survey was integrated into LiDAR topographic coverage available on NH Granit. The locations of the South River cross sections and marsh elevations are depicted on the following figure.




Additionally, Streamworks obtained samples of the sediments at the existing culvert for evaluation of the geomorphic characteristics of the channel.

The detailed existing conditions survey provided information required to complete the hydrologic/hydraulic evaluations of the study, and it supported the conceptual engineering and cost estimate for the recommended culvert replacement.

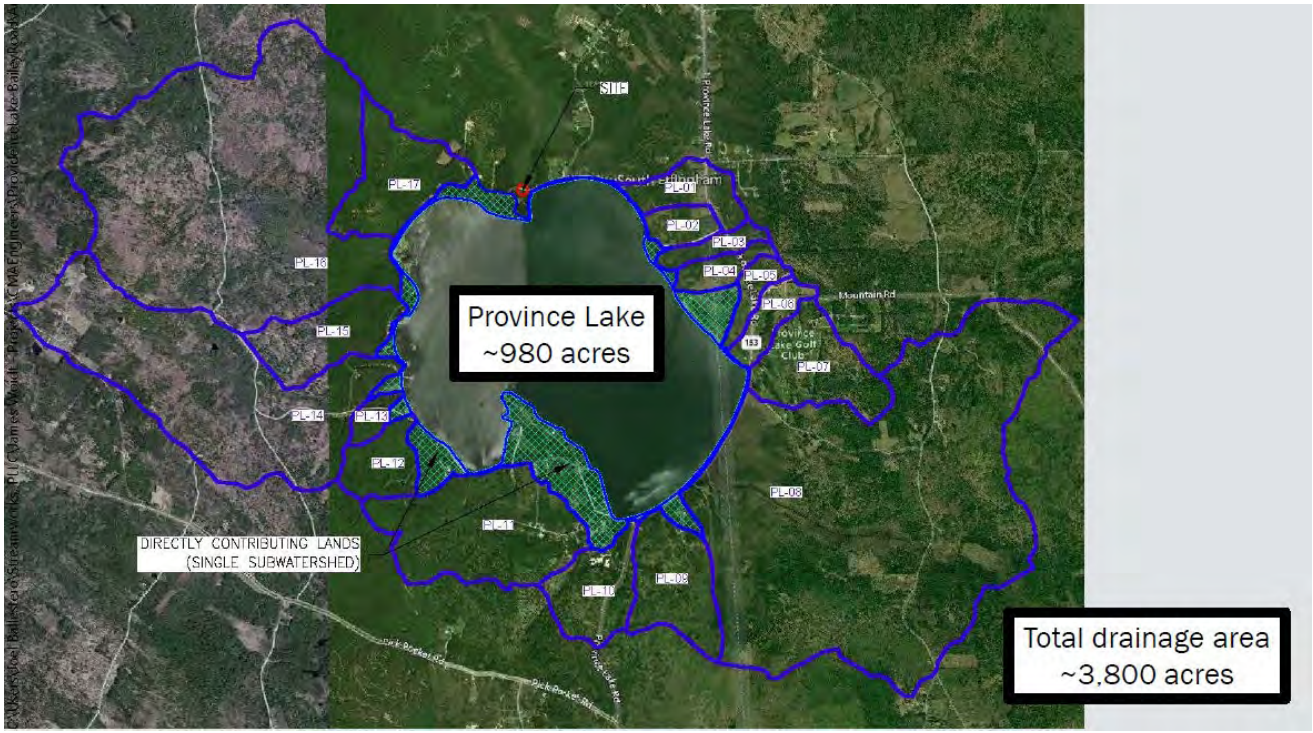
# 3. Hydrology and Hydraulics

The Streamworks report is included as Attachment A and includes a comprehensive presentation of the hydrologic and hydraulic (H/H) evaluations completed as part of this report. The application of HEC-RAS modeling evaluated the hydraulics of the outlet system including the dam structure and the culverts under Bailey Road.

Attachment A should be reviewed for details of the H/H evaliuations. Below are presented some of the key findings.

## Hydrology

- Province Lake Watershed. The entire watershed encompasses 3,800 acres contributing to Province Lake, which itself occupying another 980 acres (about 25% of the total). It is somewhat unique for a water body to occupy such a large percentage of its watershed, and because of this, there is relatively low flow from the surrounding watershed replacing the volume of lake water (aka low "flushing" rate).




- Existing Dam/Culvert. The low-level lake control dam maintains the lake levels during normal and low flow periods. It is classified by NHDES as a "non-menace" dam, with 12" or less of head across the structure. Stop logs are seasonally added in the summer and removed from October through May. The dam controls the flow to the South River during low flow periods. During periods of high flow, control of lake elevation shifts to the Bailey Road culvert crossing, and the dam is "flooded". Existing beaver activity downstream in the South River affects the low flow water elevation of the South River.

## Key Points of the System Hydraulics

- Modeled hydraulics were consistent with observed conditions, verifying accuracy of models.

- During high lake levels/high flows, Bailey Road, with the existing and proposed alternative culvert replacements, acts as a dam with outlet control. During periods of peak flow and lake elevation, as the size/span of the culvert increases, there is a corresponding increase in flow leaving the lake and flowing down the South River.

- The Bailey Road culvert crossing acts as a dam outlet, and this is a unique circumstance compared with conventional culvert/bridge designs, where culvert size does not affect total flow passing through the culvert/bridge.

- During modelled high flow events, increased outlet opening size essentially "drains the lake", resulting in slightly lower lake elevations (fractions of an inch). This also results in increased flows in the South River. For example, for the 50-year modeled storm frequency, the existing culverts are modeled to flow at 107 cubic feet/second (cfs). A 10-foot span replacement culvert's modeled flow is 30% higher than existing; a 12-foot span replacement culvert is 36% higher; an 18-foot span replacement culvert is 50% higher. If there were no culvert or road, the Bailey Road crossing is modeled to flow 68% higher than existing. At 100-yr or greater recurrence intervals, the percentage increases for the larger openings are greater.

- In accordance with the NH stream crossing regulations, replacement culvert size must not significantly increase resulting peak downstream flows.

- All modeled replacement spans (10, 12, and 18-foot) result in improved, and satisfactory, aquatic organism passage (AOP, including fish).

- All modeled replacement spans (10, 12, and 18-foot) result in reduced, and satisfactory, sediment transport characteristics.

The hydrologic and hydraulic modeling support the culvert replacement alternatives with respect to the NH stream crossing regulations.

# 4. Evaluation of Culvert Size Alternatives

Replacement of the Bailey Road culvert over the outlet to Province Lake and the beginning of the South River is necessary. The evaluation of size alternatives for replacement have considered the unique characteristics and setting of the culvert, as well as the NH stream crossing regulations (included in Env-Wt 900) and the NH Stream Crossing Guidelines.

The combined opening of the existing 4-foot metal culverts is approximately 25 square feet. The existing culvert opening might be considered to be 8 ft wide (two 4-ft culverts). The estimated bankfull width is somewhat variable based on the channel leaving the lake but has been identified as a nominal 15 feet.

The NH Stream Crossing Guidelines provides guidance for the relationship (multiplier) of bankfull width to the culvert or bridge width spanning the stream. These range from a historic multiplier of 1.2 to up to 2.2+ (from Rosgen, 1996). These factors consider stream slope, channel materials, stream entrenchment, width/depth, and stream sinuosity.

These factors assume that a culvert is located along a reach of stream that has reasonably uniform flow conditions both upstream and downstream. Application of these factors at Bailey Road, without consideration of the actual setting, might lead to a conclusion of a structure width of 2.2 times bankfull width (over 30 feet of culvert span/width). This condition may apply if the crossing was surrounded by marshes upstream and downstream that flooded periodically.

These general conditions do not apply to this crossing. As described in the previous section, during high flow periods, the structure functions as a dam outlet structure, not a culvert crossing. The crossing is located between separate hydrologic regimes: the lake and the downstream river. Accordingly, the Rosgen characteristics for evaluating structure widths are not applicable.

Accordingly, three nominal widths were considered: 10-ft, 12-ft, and 18 -ft. (The 18-ft alternative is 1.2 times bankfull width). Other criteria in the stream crossing regulations are appropriately considered with these alternatives.

The crossing is a Tier 3 crossing (watershed greater than 640 acres). For Tier 3 crossings, per Env-Wt 904.07, all crossing widths:

- Pass the 100-yr, 24-hour storm
- Do not affect flows and sediment transport adversely affecting channel stability
- Can have streambed characteristics with water depths and velocities comparable to upstream and downstream conditions.
- Allow terrestrial passage in most flow conditions. During high flows, the vertical distance between land and the road surface is small. Bailey Road is a very low traffic road providing infrequent potential conflicts.
- Simulated natural stream channels can readily be constructed

We note this *excludes* Env-Wt (2) b .1. which requires that flows prevent flooding of upstream or downstream properties. As noted in the previous section, the characteristic of the crossing as a dam outlet results in greater flows with increasing structure widths. These increased flows are associated with release of lake water, not hydrologic flows directly from runoff/precipitation.

Accordingly, the width should be minimized to reduce downstream flooding while meeting other steam crossing regulations and guidance. The effective "width" of the existing culvert is approximately 8 feet. The 10-foot width is the smallest that approximates existing conditions. The increase in downstream flow under peak flows is approximately 30% at a 10-ft width. For a 12-ft alternative, it is increased by only 4%, to 34%. At greater widths, flows are increased more significantly (48% with an 18-ft span).

While aquatic organism passage (AOP) and sediment/scour characteristics are satisfactory with the 10-ft or 12-ft alternatives, these are slightly improved with the 12-ft alternative. Accordingly, the 12-ft span is recommended.

It is noted that in the NHDES permitting process, the 12-ft width may require an Alternative Design process under Env-W 904.10. For the reasons outlined above, such a determination is appropriate, reasonable, and supportable.

# 5. Lake Phosphorous

Historically, Province Lake has had an issue with phosphorous levels resulting in algal blooms and elevated cyanobacteria levels during the summer. Evaluation of current phosphorous levels, and the potential effect of replacing the Bailey Road culvert crossing has in improving overall phosphorous levels, was completed by Don Kretchmer, CLM of DK Water Resource Consulting (DK), LLC. Using the LLRM Model of Province Lake developed by DK in 2019, the model was updated with culvert alternatives included in this current study, and lake phosphorous levels were reevaluated.

The DK memo dated April 23, 2021, is included as Attachment B.

Mr. Kretchmer concluded that negligible differences in phosphorous loadings of in-lake phosphorus concentrations would result in the different culvert alternatives being considered, based on very small differences in disturbed soil adjacent to the lake due to varying lake levels with the different culvert sizes.

Mr. Kretchmer further concluded that if an operating scenario were to be developed that varied lake levels to “flush out” phosphorous, it would not lower phosphorus levels because the groundwater replacing the lake water is relatively higher in phosphorous due to the numerous septic systems surrounding the lake.

East of the Bailey Road culvert crossing, there is approximately 400 feet of shoreline eroding into Province Lake. Using the referenced USEPA models, Streamworks considered the effect that stabilizing this shoreline might have on phosphorous loadings due to decreasing sediment transport into the lake. Streamworks predicted that implementing a shoreline stabilization treatment may reduce phosphorous loading by over 90%.

# 6. Description and Conceptual Design of Preferred Alternative

Based on the recommended 12-foot replacement culvert span, several types of structures were considered and evaluated. These included:

- Precast concrete rigid frame culvert
- Large metal arch pipe with buried floor
- Precast bridge beam, with abutments

The precast concrete rigid frame culvert is the recommended type of structure. The primary reasons for the recommendation include:

- Dimensionally favorable, with flexibility in span and height, minimizing roadway impacts
- Material is resilient and long lasting (75-year service life)
- Readily available and established manufacturers/fabricators in the region, which will respond favorably to performance specifications for installations.
- Cost effective for long service life
- Relatively short construction period with installation of precast concrete elements

The other alternatives were not recommended. Reasons included:

Large metal arch pipe: *Arch section has larger vertical profile, requiring significant roadway impacts*

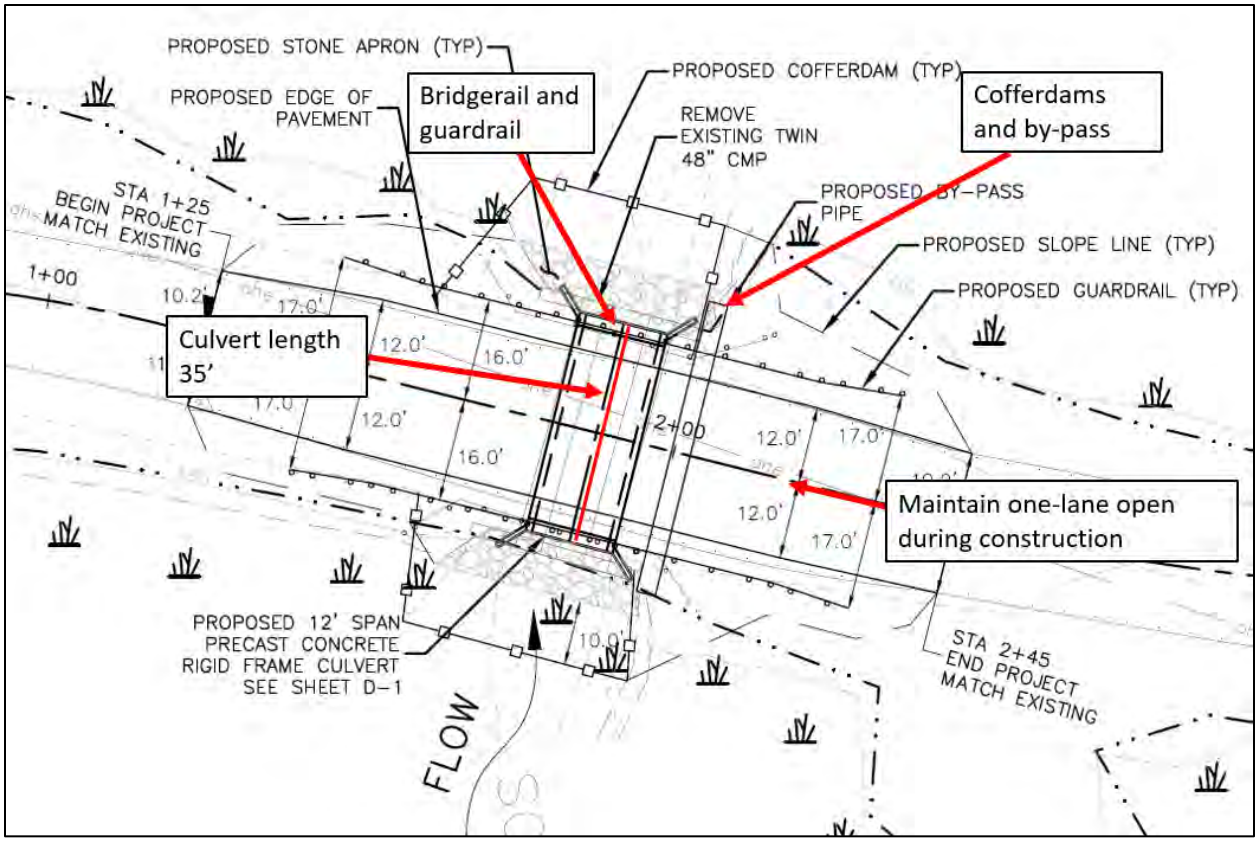
Precast bridge beams with new abutments: *No advantage over precast; higher cost.*

Below is summarized some of the design features of the installation.

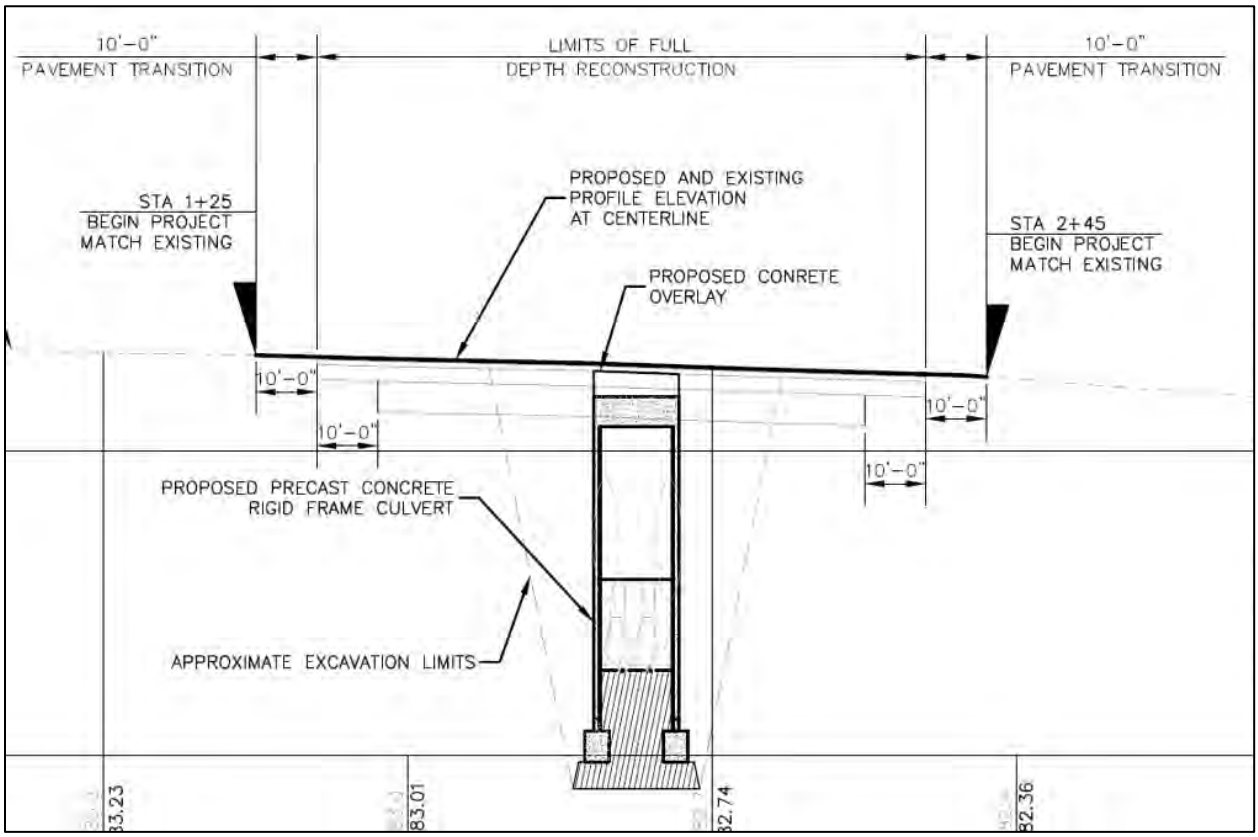
- 12-ft span, 3-sided precast rigid frame "box"
- Precast concrete footings: below 5-ft frost depth
- Opening height: 5 feet
- Culvert length: 35 feet.
    - Sized to plow snow each lane with no crowding of other lane
    - Sized to maintain 1 lane open during construction to access western side
    - Existing pavement/roadway is 24' wide
- Precast Headwalls, and Wingwalls on all four corners of culvert
- Dewatering during construction; During low-flow conditions.
- New guardrail approximately 32 feet either side of culvert, both sides of road integrating with 14 feet of bridge rail
- No significant changes to roadway profile

Figures of conceptual plan and profile of the culvert are depicted below. Attachment C includes a set of conceptual design drawings of the recommended culvert system and installation.

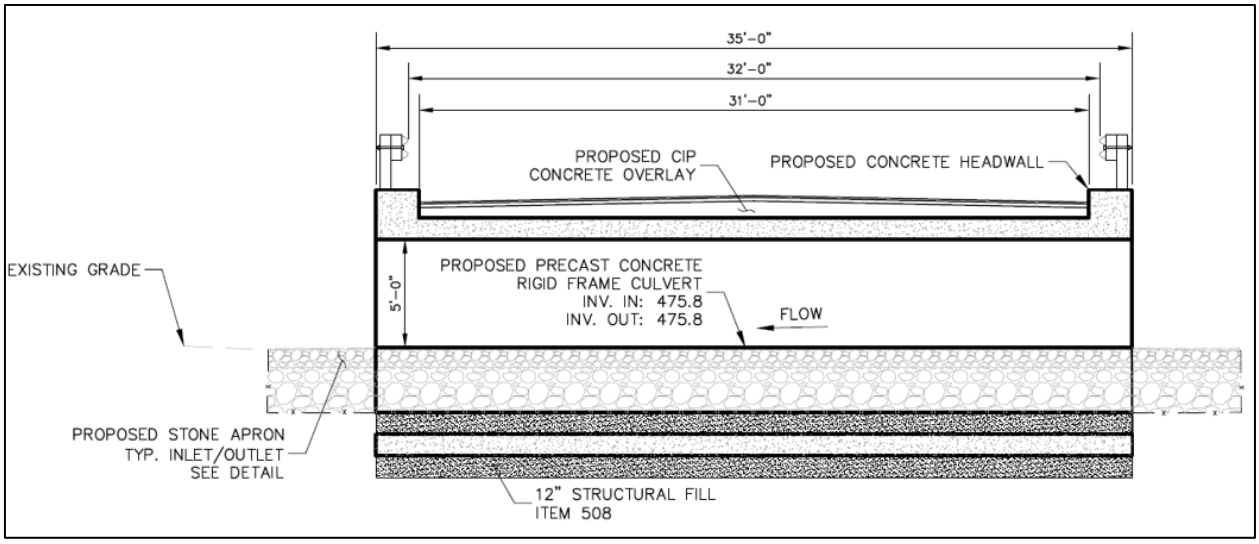
## Plan View




## Expanded Scale Vertical Profile



Longitudinal Section




In addition, alternatives were considered for stabilization of approximately 350-400 feet of the unstable shoreline to the east of the dam/footbridge. These are more completely described in Streamworks' report in Attachment A. General alternatives included:

- Stabilization of shoreland using coconut fiber filled rolls ("coir logs") in combination with seedings, loam, and erosion resistant plantings. Configuration to conform with shoreline and elevations, slopes between lake and roadway.
- Regrading of road away from lake
- Construction of swales on each side of roadway.

Use of the "coir log" stabilization technique is the preferred option, due to its flexibility to conform with actual conditions of the shoreline, their anticipated effectiveness, and overall cost.

Province Lake unstable shoreline

Example of Coir log stabilization project

# 7. Cost estimate of Preferred Alternative

A cost estimate was developed for the culvert replacement. The estimate is based on the conceptual design included as Attachment C using estimated probable quantities of materials and lump sum items. Costs of work were based on recent similar projects, NHDOT cost data, and CMA Engineers' experience.

*A detailed summary of the cost estimate is included as Attachment D.*

A summary is presented below.

| | |
|---|---|
| *Permitting:* | *$ 15,000* |
| *Final Design, contract documents, bidding:* | *$ 40,000* |
| *Construction Subtotal:* | *$225,000* |
| *Construction contingency (20%):* | *$ 45,000* |
| *Construction period engineering (15%):* | *$ 34,000* |
| *Grant administration:* | *$ 10,000* |
| *2023 Construction inflation escalator:* | *$ 14,000* |
| *Project Total* | *$383,000* |

Separately, the preliminary cost estimate for 400 feet of unstable shoreline is about $150,000. This is based on $100,000 of direct construction cost and 50% development cost including permitting, design, resolution of property easements/ROW, and construction period engineering.

# Attachment A

## Streamworks PLLC Report on Hydraulics/Hydrology

# Hydrologic and Hydraulic Modeling Memorandum

**Project:** Province Lake Drainage Improvements Analysis for Bailey Road
**Prepared For:** William Straub, PE / CMA Engineers, Inc.
Town of Effingham Selectmen
**Prepared By:** Joel Ballestero, EIT / Streamworks, PLLC
James Woidt, PE / Streamworks, PLLC
**Reviewed By:** Thomas Ballestero, PhD, PE / Streamworks, PLLC
**Date:** August 24, 2021

## Background

Bailey Road is a public road maintained by the Town of Effingham, New Hampshire (Town) that crosses the South River, the outlet of Province Lake. With the goal to alleviate local flooding, improve aging infrastructure, and address potential water quality concerns in Province Lake, the Town of Effingham, New Hampshire (Town) procured CMA Engineers, Inc. (CMA) to study the existing crossing of Bailey Road over the South River, the outlet of Province Lake, and plan improvements for the crossing and adjacent roadway. CMA subcontracted Streamworks, PLLC (Streamworks) to lead the hydrologic, hydraulic, geomorphic, and water quality aspects of the project.

## Memorandum Purpose

Streamworks prepared this memorandum to summarize the hydrologic, hydraulic, geomorphic, and water quality analyses for the development of alternatives to replace the existing Bailey Road South River crossing. Additionally, this memorandum documents the conceptual design and anticipated water quality benefits of stormwater and shoreline improvements along the adjacent reach of Bailey Road.

## Geomorphic Assessment

The New Hampshire Department of Environmental Services' (NHDES) "New Hampshire Rules for Stream Crossings" (Env-Wt 900) references the *New Hampshire Stream Crossing Guidelines* (University of New Hampshire, 2009) which recommends the width of crossings over perennial streams be sized as a function of the bankfull width of the natural channel. To estimate the bankfull width of the natural channel at the Bailey Road crossing, Streamworks identified the South River downstream of Bailey Road as a reference reach and performed a limited geomorphic assessment by analyzing three reference sections surveyed by TF Bernier (Exhibit 1) and conducting particle size distribution analyses of streambed material (Exhibit 2). Table 1 summarizes key geomorphic parameters for the three surveyed South River sections in comparison to New Hampshire regional curves as well as Streamworks' assessment of the channel type.

Based on Streamworks' geomorphic assessment, Streamworks recommends a bankfull width of 13.5 feet. Per the NHDES Wetland Bureau's "Stream Crossing Worksheet", the recommended minimum width of a geomorphically-compatible stream crossing over a Type E stream is 2.2 times the bankfull width or 2.2 x 13.5 ~ 30 feet. Providing this width via a wider crossing and/or floodplain culverts would be more geomorphically compatible for Type E streams which have a relatively wide floodplain (quantified by the large entrenchment ratio) that conveys a significant portion of flood flows that, compared to a similar stream with narrower floodplain, would reduce the flow and sediment conveyed by the channel itself. However, at this site located at the outlet of a lake, provision of a wider crossing may also increase outflows from Province Lake in comparison to the outflows of the past several decades that the South River's morphology and ecosystem have adapted to; this potential is evaluated later in the memorandum.

**Table 1: Summary of Geomorphic Metrics**

| Parameter | XS1 | XS2 | XS3 | Regional Curve |
|---|---|---|---|---|
| **Bankfull Width (ft)** | 13.5 | 13.5 | 9 | 33.3 |
| **Mean Bankfull Depth (ft)** | 2.44 | 1.41 | 1.83 | N/A |
| **Max Bankfull Depth (ft)** | 2.96 | 2.05 | 2.28 | 2.20 |
| **Width-to-Depth Ratio (ft/ft)** | 5.5 | 9.5 | 5.0 | 15.1 = 33.3 / 2.20 |
| **Floodprone Width (ft)** | 460 | 730 | 660 | N/A |
| **Entrenchment Ratio** | 34 | 54 | 73 | N/A |
| **Slope (ft/ft)** | 0.000274 (reach average) | | | N/A |
| **Median Grain Size** | 1.1 mm (very coarse sand) | | | N/A |
| **Rosgen Stream Type** | E5 | E5 | E5 | N/A |

## Existing Conditions Hydrologic Assessment

### Watershed Description

The Bailey Road crossing is located on the South River, the outlet of the 976-acre Province Lake. Province Lake comprises approximately 20 percent of the nearly 4,800-acre contributing watershed at Bailey Road and therefore provides significant attenuation of watershed runoff. Excluding Province Lake, the majority (84 percent) of the remaining watershed is forested (Province Lake Association [PLA], 2014). Of the 12 percent of the watershed that is developed, principal uses are low-density residential lots or camps, open space, and agriculture.

Water levels of Province Lake are partly managed by the low head Province Lake Dam located at the outlet of Province Lake, approximately 350 feet upstream of the Bailey Road crossing (Figure 1). The dam is classified as a “non-menace” dam by the New Hampshire Department of Environment Services (NHDES). The dam was reportedly constructed to restore water levels of Province Lake that were lowered following installation of the existing Bailey Road crossing which replaced one or more culverts that were presumably set at higher elevation (personal communication, Town Selectmen). The degree to which the existing Bailey Road crossing influences the levels of Province Lake, if at all, are unknown and a subject of this study.

The Province Lake Dam spillway is composed of two concrete abutments with a 15-foot clear span between them. Each abutment has insets which, along with a centered, vertical I-beam driven in the channel bed, are used to set up to two rows of nominal 2x6 wooden stoplogs. The wooden stoplogs are used to seasonally raise water levels of Province Lake and are secured vertically by steel pins seen near the center handrail posts in Figure 1. Atop the concrete abutments is a wooden pedestrian bridge that has approximately two feet of vertical clearance above the natural channel bed when the stoplogs are removed.

When the stoplogs are removed, discharge from the lake is controlled by open channel flow through the natural channel beneath the bridge. Per interviews with the Dam Master and review of the Provisional Operating Plan (Stern, 1995) for the dam filed with NHDES, stoplogs are generally placed between Memorial Day and Columbus Day to maintain a lake elevation 12 inches below the top of the concrete abutments, or elevation 479.00 ft, North American Vertical Datum of 1988 (NAVD88). Individual stoplogs may be removed or replaced to maintain the lake level at approximately elevation 479.00 ft, NAVD88. The Provisional Operating Plan specifies that the stoplogs be removed in response to predicted storms or rises in the lake level.

**Figure 1 –** Province Lake Dam Spillway (without stoplogs)

## Hydrologic Model Development – Rainfall-Runoff

Considering the expected attenuation of inflows through Province Lake and the unknown effect of the existing Bailey Road crossing on Province Lake levels, Streamworks modeled watershed hydrology using a rainfall-runoff model, HydroCAD®, version 10.1. To represent the varying runoff characteristics of subbasins contributing to Province Lake, Streamworks divided the watershed into 28 subbasins, including one for Province Lake itself and ten small watersheds, reported as a single subbasin, which model direct hillslope runoff to Province Lake (i.e., no defined channel). Table 2 on the following page summarizes the methodologies and assumptions used to develop the HydroCAD® model; Exhibit 3 illustrates the limits and parameters of the discretized subbasins.

**Table 2: Rainfall-Runoff Parameters for Study Watersheds**

| Parameter | Value / Methodology | Comments |
|---|---|---|
| **Subbasin Area** | See Exhibit 1 | Derived from 10m Digital Elevation Model |
| **Design Hyetograph** | NRCS Type III | 24-hour and 48-hour storms evaluated; see Note |
| **Runoff Approach** | NRCS (2004) | Traditional Curve Number methodology |
| **Runoff Curve Number (CN)** | See Exhibit 1 | Weighted CN for contributing subbasin |
| **Initial Abstraction (Ia)** | 0.2 * Storage (S) | Default for methodology |
| **Hydrograph Transform** | SCS Unit Hydrograph | Standard $q_p$ = 484 |
| **Time of Concentration (Tc)** | See Exhibit 1 | NRCS (2010) Segment Method except for direct hillslopes which used Kirpich (1940) methodology |

Note: For the 24-hour storm, a 5% difference in peak discharges was modeled between the NRCS Type III and site-specific Northeast Regional Climate Center (NRCC) hyetographs; however, the NRCC Extreme Precipitation web tool does not produce a 48-hour hyetograph so the NRCS Type III hyetograph was adopted for the study.

To estimate CN for each subbasin, Streamworks used QGIS to delineate subbasins based on unique combinations of hydrologic soil group classifications from the US Department of Agriculture's Soil Survey Geographic Database and land cover based on the Multi-Resolution Land Characteristics Consortium's 2016 National Land Cover Database (NLCD). The resultant attributes were exported to Microsoft Excel and aggregated by unique combination of hydrologic soil group and land cover. Aerial imagery was used to confirm the dominant land cover for each NLCD land cover classification and standard NRCS (2004) CN values were assigned to each combination of assigned land cover and hydrologic soil group. The total area contributing to each unique combination of land cover and hydrological soil group was then input to HydroCAD®. Runoff was calculated for each individual CN value then weighted by area (in contrast to weighting CN by area then calculating runoff) to better represent runoff characteristics of varying land uses and hydrologic soil groups.

## Hydrologic Model Development – Province Lake and Bailey Road

To account for potential backwater effects from the Bailey Road crossing that may restrict outflows from Province Lake, Province Lake and the Bailey Road crossing were represented with separate pond nodes in HydroCAD®. Dynamic routing routines in HydroCAD® were used so that the computed water surface elevation upstream of the Bailey Road crossing was used as the tailwater condition for Province Lake. In this way, outflows from Province Lake would be hydraulically controlled by Bailey Road or the Province Lake outlet, whichever was more limiting.

Stage-storage curves were developed for both of the pond nodes representing Province Lake and Bailey Road; stage-storage curves were developed using bathymetric mapping from the NH Lake Bathymetry layer and lidar downloaded from NHGranit. Modeled outflows from Province Lake were controlled with parallel hydraulic controls representing a small side-channel 350 feet south of the dam (Figure 2) as a weir and the dam itself which also had two parallel weirs: one for the portion of the dam below the pedestrian bridge (with orifice flow when surcharged) and one weir for flow atop the pedestrian bridge. Outflows through the Bailey Road crossing were controlled with parallel hydraulic controls representing the culverts beneath Bailey Road and an overflow weir representing the crest of Bailey Road. Unless noted otherwise, the starting water surface elevation for Province Lake was assumed as 479.00 ft, NAVD88.

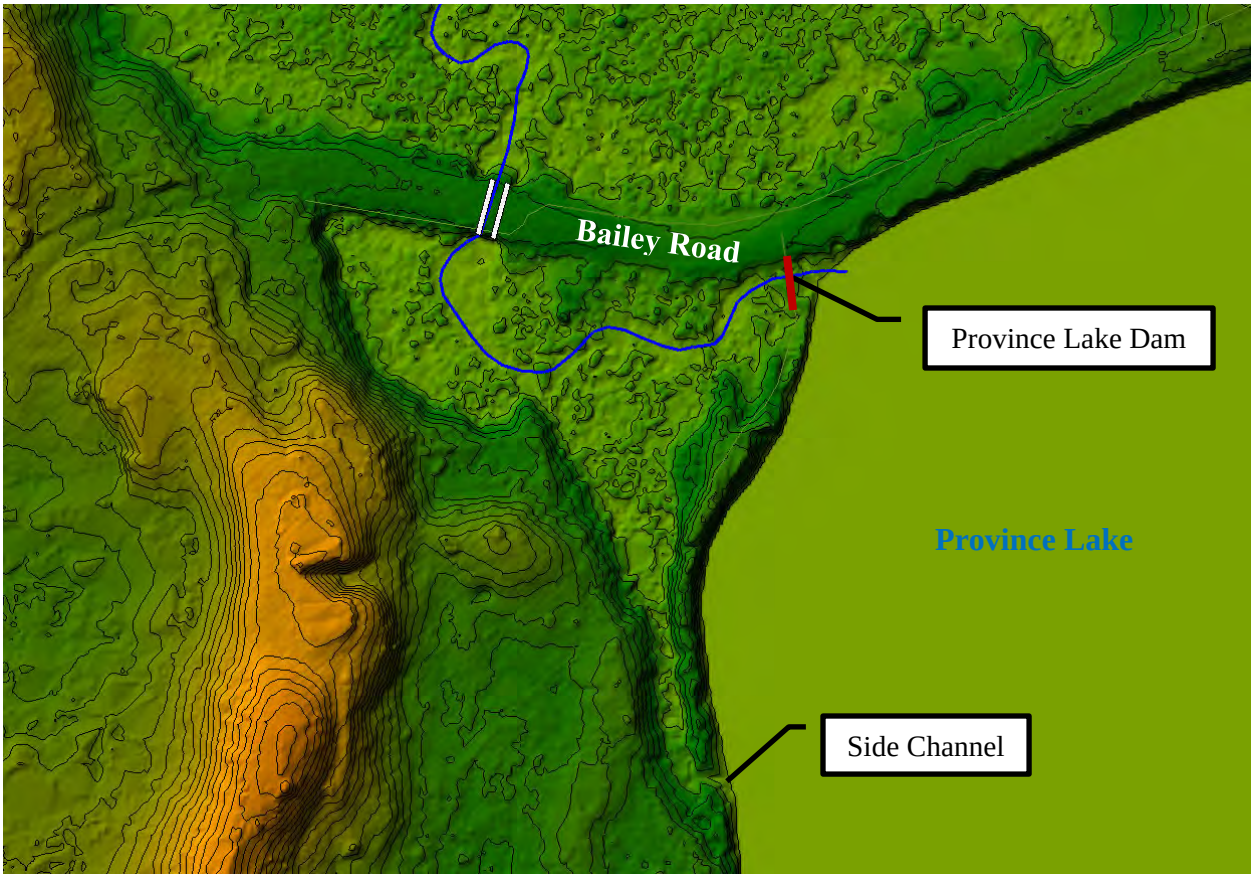



**Figure 2 –** One-foot contours from lidar mapping from NH Granit

## Precipitation Data and Selected Recurrence Intervals

Streamworks used the Northeast Regional Climate Center (NRCC)'s Extreme Precipitation in New York and New England interactive web tool (http://precip.eas.cornell.edu/) to quantify precipitation depths for selected annual chance hydrologic events. Given the potential sensitivity of Province Lake outflows to total *volume* of runoff (versus intensity), Streamworks also analyzed the 48-hour duration storm. The 1-in-50 chance event and 1-in-100 chance event were selected for consistency with NHDOT design standards and NHDES Tier 3 stream crossing permitting standards, respectively. The 1-in-2, 10, and 25 chance events were selected to represent the range of more frequent annual peak discharges. Table 3 summarizes the precipitation depths for the recurrence intervals selected for analysis.

**Table 3:** Precipitation-Frequency Summary

| Annual Chance Occurrence | Recurrence Interval (Years) | Precipitation Depth (in) | |
|---|---|---|---|
| | | 24-hour | 48-hour |
| **1-in-2 Chance** | 2 | 2.99 | 3.35 |
| **1-in-10 Chance** | 10 | 4.38 | 5.05 |
| **1-in-25 Chance** | 25 | 5.46 | 6.39 |
| **1-in-50 Chance** | 50 | 6.45 | 7.63 |
| **1-in-100 Chance** | 100 | 7.62 | 9.13 |

## Existing Conditions Model Sensitivity and Validation

Using the developed hydrologic model, Streamworks assessed the hydrology of Province Lake and the Bailey Road crossing under existing conditions as well as the sensitivity of the hydrologic model results to various parameters, including Bailey Road. Table 4 presents the calculated peak discharge rates and peak water surface levels of Province Lake for a baseline scenario as well as various scenarios where a single model parameter is varied to assess the sensitivity of model results to each parameter. The baseline scenario assumed a starting water surface elevation of 479.00, ft NAVD88, no stoplogs (consistent with the Provisional Operation Plan), and a 24-hour storm event.

**Table 4:** Summary of Existing Conditions Hydrology and Hydrologic Model Sensitivity

| Scenario | Peak Discharge (cfs) | | | Province Lake Peak WSE (ft, NAVD88) | | |
|---|---|---|---|---|---|---|
| | 1-in-2 | 1-in-50 | 1-in-100 | 1-in-2 | 1-in-50 | 1-in-100 |
| **Baseline** | 35 | 92 | 113 | 479.32 | 480.17 | 480.50 |
| **Starting WSE = 479.50** | 62 | 116 | 132 | 479.74 | 480.56 | 480.89 |
| **Stoplogs Left In** | 18 | 86 | 112 | 479.37 | 480.21 | 480.53 |
| **48-hour Storm** | 36 | 107 | 130 | 479.35 | 480.41 | 480.83 |
| **Three above scenarios** | 46 | 127 | 147 | 479.80 | 480.80 | 481.21 |
| **48-hr Storm but without Bailey Road** | 44 | 180 | 281 | 479.33 | 480.30 | 480.63 |

cfs = cubic feet per second; WSE = Water Surface Elevation

As summarized in Table 4, modeled peak water surface elevations of Province Lake have a ±7-inch sensitivity to model parameters that may vary due to natural causes or variable operation of the dam. Sensitivity of modeled outflows to the same parameters range from ±50 percent at frequent recurrence intervals to ±20 percent at less frequent recurrence intervals. However, the deviation of model results from the baseline scenario are generally consistent between the various sensitivity scenarios. Considering this and the likelihood of a 48-hour storm (nor'easters, tropical storms, etc.), Streamworks elected to use the hydrologic model results for the 48-hour storms for all subsequent modeling and also added a "1-in-100 chance plus" event that assumed a 48-hour storm, a higher-than-normal starting water surface elevation of 479.50 ft, NAVD88, and that the stoplogs were left in place. This 1-in-100 chance plus scenario is recommended as a factor-of-safety check for future hydraulic design of erosion control measures and scour potential analyses.

The final row of Table 4 provides evidence that the existence of the Bailey Road crossing restricts outflows from Province Lake. This infers that discharge rates are not independent of the Bailey Road crossing as is assumed for most stream crossings. Instead, the Bailey Road crossing acts as an additional hydraulic control and the size and construction of the crossing affects the flows released from Province Lake and conveyed through the crossing. This requires an atypical design approach where the hydrologic and hydraulic models must be developed in parallel: each proposed alternative will require separate hydrologic models to determine outflows from Province Lake which are then transferred to the hydraulic model to model water surface elevations between Bailey Road and Province Lake.

Finally, Table 4 was used to perform a limited validation of the hydrologic model based on the following anecdotal evidence of high water marks conveyed to Streamworks:

- Per the Province Lake dam master, the highest lake level that he recalled in the approximately 25 years he has managed the dam occurred in the late 1990s when lake levels were approximately 6 to 12 inches below the crest of Bailey Road (surveyed 481.4 ft, NAVD88) for an estimated high water mark elevation of 480.75±
- Per Steve Craig, who has conducted annual water sampling at Province Lake since 2004, the highest lake level he recalled was approximately ten years ago when water elevations reached the top of the Bailey Road culverts which were surveyed as 479.60 ft, NAVD88.

Review of US Geological Survey (USGS) stream gage records in the area and associated Flood Insurance Studies identified that an event in June 1998 caused annual peak discharges on the order of the 1-in-50 chance annual event at the Winnipesaukee River at Tilton, NH gage (USGS 01081000). The anecdotal high water mark of 480.75± is similar to the modeled range of 1-in-50 chance Province Lake water surface elevation of 480.17 to 480.80 ft, NAVD88.

Review of USGS stream gage records were less definitive in identifying the recurrence interval of a high-flow event in the last decade: Tropical Storm Irene in 2011 appeared to be the most likely cause of the high flows and measured annual peak discharges varied from more frequent than a 1-in-10 chance event at the Winnipesaukee River at Tilton, NH gage to possibly a 1-in-50 chance event at the Bearcamp River at South Tamworth, NH gage (USGS 01064801). Despite the uncertainty, the modeled water surface elevations of 479.24 and 480.01 ft, NAVD88 at Bailey Road for the 1-in-10 chance event and 1-in-50 chance event are within five inches of the anecdotal high water mark of 479.60 ft, NAVD88.

While the comparison of modeled water surface elevations to anecdotal high-water marks provides a limited validation of the hydrologic model, Streamworks deemed there to be insufficient rationale to calibrate the model to this high-water mark given the uncertainty in the anecdotal high-water mark, uncertainty in the recurrence interval of this storm at Bailey Road, and the sensitivity of the hydrologic model.

## Base and Aquatic Organism Passage Flows

To assess the hydraulic effect of project alternatives on normal water levels in Province Lake and aquatic organism passage, Streamworks used the USGS's StreamStats software to quantify baseflows at Bailey Road. The equations embedded within StreamStats are derived from regional regressions reported in Flynn and Tasker (2002). Table 5 summarizes the discharges selected to represent baseflows and aquatic organism passage flows. Note that as no aquatic organisms were identified as target species to provide passage for, and the seasonality of StreamStats-derived baseflows were not aligned with migratory fish periods, Streamworks assumed the 95% exceedance discharge for the summer (June to October) and the two-year annual peak discharge as a conservative range that exceeded the typical recommendation to provide aquatic organism passage for 90 percent of the duration of migratory season (USFWS, 2019). Streamworks assumed that the Bailey Road crossing had no effect on Province Lake at these flows and that baseflows reported in Table 5 on the following page would be unchanged by the proposed alternatives.

**Table 5: Base and Aquatic Organism Passage Flows**

| Event | Hydrologic Metric | Discharge (cfs) |
|---|---|---|
| **Low AOP Flow** | 95% summer exceedance (June to October) | 0.32 |
| **Typical Summer** | 60% summer exceedance (June to October) | 1.42 |
| **Typical Annual** | 60% annual exceedance | 4.27 |
| **Typical Spring** | 60% spring exceedance (March 16 to May) | 14.8 |
| **High AOP Flow** | 1-in-2 annual peak discharge | 36 |

AOP = Aquatic Organism Passage

## Existing Conditions Hydraulic Model

Streamworks used the steady-state capabilities of the US Army Corps of Engineers' Hydrologic Engineering Center's River Analysis System (HEC-RAS), v5.0.7 to model the hydraulics of the Bailey Road stream crossing. Surveyed cross-sections from Province Lake to approximately 1,500 feet downstream of Bailey Road were integrated into the hydraulic model. Surveyed cross-sections were supplemented with lidar downloaded from NH Granit to laterally extend cross-sections downstream of the crossing to contain the entirety of modeled annual peak discharges. The existing Bailey Road crossing was parameterized using survey data and modeled using culvert analysis (HY-8) algorithms embedded within HEC-RAS. Manning's n-values were delineated using aerial imagery and assigned values based on professional judgment and technical references.

For high flows derived from the hydrologic model, Streamworks assumed a downstream normal depth boundary condition with energy slope calculated from water surface elevations surveyed as part of the project survey. The level of Province Lake was approximately six inches higher than normal at the time of the survey – without stoplogs in place – and outflows were elevated and causing some overbank flooding downstream of Bailey Road such that the surveyed water surface slope was assumed to be representative of typical flood conditions.

For the downstream boundary condition for baseflows, Streamworks assumed a constant water surface elevation of 476.50 ft, NAVD88 to account for the backwatering effect of downstream beaver dams that, based on historical imagery, are a recurrent hydraulic control within the South River. The elevation of 476.50 ft, NAVD88 was selected as the lower end of lidar elevations across 1.5 miles of the South River downstream of the model boundary. Whereas available lidar mapping shows a distinct drop in elevation across a beaver dam approximately 300 feet downstream of the hydraulic model boundary that would justify a higher water surface elevation, lower water surface elevations would be conservative for the analysis of aquatic organism passage. Therefore, the lower elevation of 476.50 ft, NAVD88 was selected as a conservative, but reasonable, water surface elevation downstream of the crossing. However, it should be noted that water surface elevations will vary with continued beaver activity.

# Alternatives Analysis for Bailey Road Crossings

## Alternatives Development

To develop alternatives for the replacement of the Bailey Road stream crossing, Streamworks and CMA considered design criteria using NHDES's "New Hampshire Rules for Stream Crossings" (Env-Wt 900) and New Hampshire Department of Transportation's (NHDOT; 2018) *Bridge Design Manual*. Considering the unique conditions at the site – specifically that the Bailey Road crossing partially controls Province Lake levels and outflows and downstream beaver dam activity increases water levels and reduces velocities at the crossing – Streamworks and CMA deemed that an alternative design per NHDES's "New Hampshire Rules for Stream Crossings" may also be appropriate at this site. For the alternative designs, CMA recommended a minimum width of 10 feet to meet NHDOT definition of a bridge which may qualify the replacement crossing for future NHDOT funding. CMA also recommended concrete structures for longevity and resiliency. Considering these design criteria, Streamworks and CMA developed the following alternatives for the proposed Bailey Road crossing:

- Alternative 1: A 10-foot wide, three-sided box, constructed of precast concrete with a natural streambed that is intended to meet NHDES's "alternative design" criteria for a stream crossing;
- Alternative 2: A 12-foot wide, proprietary "Conspan" arch, constructed of precast concrete with a natural streambed that may be more cost-effective than a precast box and is intended to meet NHDES's "alternative design" criteria for a stream crossing;
- Alternative 3: An 18-foot wide, three-sided box, constructed of precast concrete with a bankfull channel and floodplain bench designed using reference reach data that is intended to be fully compliant with the *New Hampshire Stream Crossing Guidelines* (which recommend a minimum crossing width of 1.2 times bankfull width, less than NHDES Wetland Bureau).
- Alternative 4: A 30-foot wide, three-sided box, constructed of precast concrete with a bankfull channel and floodplain bench designed using reference reach data that is intended to be fully compliant with NHDES's stream crossing criteria (which recommend a minimum crossing width of 2.2 times bankfull width).

## Hydrologic Modeling of Proposed Alternatives

Given the sensitivity of the hydrologic model to the existing Bailey Road crossing, Streamworks modified the hydrologic model for each of the proposed Bailey Road crossing alternatives to quantify the effect the proposed culverts would have on outflows from Province Lake. Streamworks modeled Alternative 1 and Alternative 2 by modifying the Bailey Road culvert parameters to represent the proposed alternative; no other model parameters were modified. Due to the inability to use HydroCAD culvert routines to model a natural stream section and floodplain bench within a culvert, Streamworks modeled Alternative 3 and Alternative 4 by replacing the Bailey Road culvert with a custom weir/orifice that represented the natural channel shape that would be provided through the proposed crossings while also accounting for surcharging caused by the low chord of the crossing. For efficiency, hydrologic model results for the proposed alternative have been consolidated with the hydraulic model results presented later this memorandum.

## Hydraulic Modeling of Proposed Alternatives

To model proposed alternatives, Streamworks started with the Existing Conditions model and modified it to reflect proposed alternatives. Specifically, each alternative crossing was modeled as a bridge using the energy equation. Ineffective flow areas were adjusted accordingly given the increased effective width of each proposed alternative. For Alternative 1 and Alternative 2, the channel bed was modeled as a "zero-slope" culvert with channel bed elevations matching the bounding cross-sections. Given that both Alternative 1 and Alternative 2 are less than the bankfull width, and that the steep streambanks of the downstream South River are stable as the result of dense vegetation that is not anticipated to exist beneath the crossing, the bed was assumed to span the entirety of Alternative 1 and Alternative 2 crossing width (i.e., constant bed elevation between the abutments with no streambanks).

For Alternative 3 and Alternative 4, which spanned the bankfull channel, Streamworks assumed that a bankfull channel would be graded through the culvert and the downstream scour pool that has formed. Given the steep streambanks of the downstream reference reach that are stabilized by vegetation, Streamworks assumed that the constructed streambanks (which would take time to vegetate after construction) would be shallower than the downstream reference reach and thus increased the bankfull width of the channel to maintain a bankfull area similar to that calculated for the reference cross sections summarized in Table 1.

## Modeled Impacts to Province Lake Levels and Outflow

To assess the impact of the Bailey Road crossings on Province Lake levels and outflows under flood conditions, Streamworks used the hydrologic model to estimate the peak Province Lake water surface elevation and resultant peak outflow for the 1-in-2, 1-in-50, 1-in-100, and "1-in-100 plus" chance events. The 1-in-2 chance event was selected to represent the peak annual flood that would be expected to be equaled or exceeded every other year and is empirically most similar to a bankfull discharge which is often assumed to be the dominant discharge of a stream, or the discharge which conveys the most sediment over time, that is important to assessing the long-term stability of a channel. The 1-in-50 chance event and 1-in-100 chance event were selected for consistency with NHDOT bridge design standards for local roads and NHDES Tier 3 stream crossing permitting standards, respectively. The 1-in-100 chance plus event was selected as a conservative estimate of the 1-in-100 chance event considering natural variability in lake levels and uncertainty in future lake level management.

**Table 6:** Modeled Effect of Alternatives on Province Lake Levels and Outflow

| Scenario | Peak Discharge (cfs) | | | | Province Lake WSE (ft, NAVD88) | | | |
|---|---|---|---|---|---|---|---|---|
| | 1-in-2 | 1-in-50 | 1-in-100 | 1-in-100 plus | 1-in-2 | 1-in-50 | 1-in-100 | 1-in-100 plus |
| **Existing** | 36 | 107 | 130 | 147 | 479.35 | 480.41 | 480.83 | 481.21 |
| **Alt. 1 – 10ft Box** | 40 | 140 | 189 | 230 | 479.34 | 480.36 | 480.74 | 481.11 |
| **Alt. 2 – 12ft Conspan** | 41 | 146 | 196 | 235 | 479.34 | 480.35 | 480.72 | 481.10 |
| **Alt. 3 – 18ft Box** | 42 | 160 | 228 | 290 | 479.33 | 480.33 | 480.68 | 481.05 |
| **Alt. 4 – 30ft Bridge span** | 43 | 167 | 247 | 323 | 479.33 | 480.31 | 480.66 | 481.02 |

cfs = cubic feet per second; WSE = Water Surface Elevation

As summarized in Table 6, each of the proposed alternatives was modeled to provide a modest reduction in peak flood levels of Province Lake. This finding confirms that the Bailey Road crossing does have an effect on Province Lake water levels at flood flows. The modeled reduction in peak Province Lake flood levels as a result of the proposed alternatives is interpreted to be the result of improving the hydraulic efficiency of the Bailey Road crossing which allows flood waters to drain from Province Lake more quickly in comparison to existing conditions. This interpretation is supported by Table 6 which also summarizes that peak outflows from Province Lake were modeled to increase as a result of the proposed alternatives. Depending on the timing of Province Lake outflow in relation to runoff from downstream watersheds, this increased outflow could potentially increase the frequency and magnitude of flood damage downstream. However, Streamworks notes that the expansive and low-gradient floodplain downstream of Bailey Road is anticipated to mitigate most of the downstream impacts of increased flow.

Table 6 also summarizes model results that demonstrate the relative hydraulic effect of the proposed alternatives increases with increasing storm magnitude; that is, the proposed alternatives yield a greater percent increase in downstream discharges at larger, rarer flood events than at smaller, more frequent floods. This also infers that the impact of the Bailey Road culvert on Province Lake levels decreases with smaller flows. Table 7 summarizes hydraulic model results for Province Lake water levels at baseflow conditions. The lack of difference between the modeled water surface elevations for existing conditions and all four alternatives demonstrates that baseflows from Province Lake are controlled by the Province Lake dam and that the Bailey Road crossing would not impact Province Lake levels except at flood conditions. This also validates Streamworks' assumption that Province Lake baseflow hydrology is unaffected by Bailey Road.

**Table 7:** Modeled Effect of Alternatives and Province Lake Normal Levels

| Scenario | Province Lake WSE (ft, NAVD88) | | | |
|---|---|---|---|---|
| | 95% Summer (0.32 cfs) | 60% Summer (1.42 cfs) | 60% Annual (4.27 cfs) | 60% Spring (14.8 cfs) |
| **Existing Conditions** | 478.98 | 479.04 | 479.13 | 478.58* |
| **Alt. 1 – 10ft Box** | 478.98 | 479.04 | 479.13 | 478.58* |
| **Alt. 2 – 12ft Conspan** | 478.98 | 479.04 | 479.13 | 478.58* |
| **Alt. 3 – 18ft Box** | 478.98 | 479.04 | 479.13 | 478.58* |
| **Alt. 4 – 30ft Bridge** | 478.98 | 479.04 | 479.13 | 478.58* |

cfs = cubic feet per second; WSE = Water Surface Elevation

* Assuming flash boards are removed (more critical condition for influencing Province Lake levels)

## South River Water Levels and Downstream Impacts

Exhibit 4 provides modeled water surface elevations for existing conditions and each of the four alternatives for the 1-in-2 chance and 1-in-50 chance flood events. Exhibit 4 demonstrates an interesting outcome: that increasing the size of the Bailey Road crossing increases flood levels of the South River approximately three to five inches downstream of the crossing and approximately one to three inches between Bailey Road and Province Lake. Such results are counterintuitive to expectations for most stream crossing replacements where an increased culvert size is expected to reduce upstream water levels and have negligible impact on downstream water levels. However, the results presented in Exhibit 4 are reasonable in this situation when considering that the increased culvert sizes increase the amount of flow released from Province Lake.

Of note in Exhibit 4 is that the relative increase in water surface elevations along the South River increases with the size of the proposed crossing: the 30-foot bridge crossing yields the highest increase in water levels whereas the 10-foot bridge crossing yields the lowest. This result is of note as the New Hampshire Rules for Stream Crossings require that replacement crossings "not cause an increase in the frequency of flooding or overtopping of banks." However, the results presented in Exhibit 4 demonstrates that geomorphically-sized crossings would cause the greatest increase in the frequency of flooding or overtopping of the banks. Therefore, a geomorphically-sized crossing would not satisfy all of the conditions of the New Hampshire Rules for Stream Crossings such that an Alternative Design may be appropriate for this site.

Considering that the increased outflow from Province Lake could perpetuate downstream further than the limits of the hydraulic model, Streamworks also performed a limited assessment of the potential hydraulic impacts to downstream crossings of the South River at State Route 153 (Province Lake Road) and Snow Road; the Granite Road crossing was not analyzed as the Town noted it is currently closed to traffic and due to be replaced in the next three years. Impacts to residential properties downstream of Bailey Road may also occur but this analysis was beyond the scope of this memorandum and not evaluated.

To analyze the potential increase in water levels at the two downstream crossings, Streamworks utilized the Federal Highway Administration's HY-8, v7.60 software. Crossing geometry was developed using measurements at each crossing reported in the New Hampshire Geological Survey's (NHGS) Stream Crossing Survey Database. To assess the impact of increased outflows from the proposed Bailey Road alternatives, Streamworks varied the discharge at each crossing. For existing conditions, Streamworks utilized the US Geological Survey's StreamStats to estimate peak discharges. For each of the proposed alternatives, StreamStats discharges were increased by an amount equal to the increase in peak discharge modeled at Bailey Road (Table 6). This approach is likely conservative as some of the increased peak discharge is expected to attenuate along the South River and its broad floodplain. In addition, the timing of outflows from Province Lake may lag runoff from downstream portions of the watershed that may cause peak discharges downstream of Bailey Road. Table 8 summarizes the results of Streamworks' analysis.

**Table 8:** Screening Assessment of Hydraulic Impact to Downstream Bridges

| Scenario | 1-in-100 Chance Peak Discharge ($ft^3/s$) | 1-in-100 Chance Water Level (ft*) | Deck Elevation (ft*) | Freeboard (ft) |
|---|---|---|---|---|
| ***State Route 153 (Province Lake Road)*** | | | | |
| **Existing** | 614 | 16.39 | 20.00 | 3.61 |
| **Alt. 1 – 10ft Box** | 673 | 16.78 | | 3.22 |
| **Alt. 2 – 12ft Conspan** | 680 | 16.83 | | 3.17 |
| **Alt. 3 – 18ft Box** | 712 | 17.03 | | 2.97 |
| **Alt. 4 – 30ft Bridge** | 730 | 17.15 | | 2.85 |
| ***Snow Road*** | | | | |
| **Existing** | 766 | 18.30 | 17.00 | -1.30 |
| **Alt. 1 – 10ft Box** | 825 | 18.59 | | -1.59 |
| **Alt. 2 – 12ft Conspan** | 832 | 18.63 | | -1.63 |
| **Alt. 3 – 18ft Box** | 864 | 18.77 | | -1.77 |
| **Alt. 4 – 30ft Bridge** | 883 | 18.86 | | -1.86 |

* NHGS Stream Crossing Survey Database elevations are relative and not tied to NAVD88.

Reviewing Table 8, the increase in peak discharge of the South River is anticipated to increase water levels at the newly replaced State Route 153 but the modeling demonstrates the crossing to have sufficient capacity to convey the increased discharges without inundating the road surface. The driving surface of the Snow Road crossing was modeled to be inundated at the 1-in-100 chance peak discharge under existing conditions such that the increased discharge resulting from the proposed Bailey Road crossings was modeled to increase the depth of road inundation by up to approximately seven inches. Expecting a similar increase in water levels associated with smaller discharges the Snow Road crossing would be expected to overtop more frequently than under existing conditions. However, the Town informed Streamworks that this crossing is anticipated to be replaced soon and Streamworks recommends a new bridge at this located be designed to accommodate the increase in discharge.

## Sediment Impacts

The New Hampshire Rules for Stream Crossings (Env-Wt 900) requires that replacement culverts "not cause erosion, aggradation, or scouring upstream or downstream of the crossing." As a simplified sediment impact assessment, Streamworks used channel velocities, shear stresses, and sediment competence calculations at the 1-in-2 chance event and 1-in-50 chance event as a surrogate for erosion potential: where velocities or shear stresses increase, additional erosion would be expected; where velocities or shear stresses decrease, less erosion would be expected. Streamworks selected the 1-in-2 chance flood event as it is most similar in magnitude to a bankfull discharge (previously discussed) that empirically has a recurrence interval of 1 to 2 years. The 1-in-50 chance flood was selected as an event that may disrupt bed armor layers and convey a significant amount of sediment over the course of the event (albeit infrequently) and was used to understand the potential for rapid sediment deposition or erosion during large but infrequent flood events. To quantify sediment competence, Streamworks used modeled shear stresses and Shields' equation to back-calculate a mobile grain size with Shields Parameter calculated as a function of dimensionless particle diameter using Julien's (2010) equations. Table 9 presents the calculated results at two representative sections of the South River upstream and downstream of Bailey Road.

**Table 9:** Modeled Erosive Forces and Sediment Competence of South River

| Scenario | Velocity (ft/s) | | Shear Stress ($lb/ft^2$) | | Mobile Grain Size (mm) | | Sampled $D_{50}$ (mm) |
|---|---|---|---|---|---|---|---|
| | 1-in-2 | 1-in-50 | 1-in-2 | 1-in-50 | 1-in-2 | 1-in-50 | |
| ***Upstream Bailey Road (HEC-RAS STA 2445)*** | | | | | | | |
| **Existing** | 0.98 | 1.06 | 0.056 | 0.052 | 4.1 | 3.8 | 60 |
| **Alt. 1 – 10ft Box** | 1.04 | 1.37 | 0.063 | 0.087 | 4.6 | 6.4 | |
| **Alt. 2 – 12ft Conspan** | 1.07 | 1.45 | 0.065 | 0.098 | 4.8 | 7.2 | |
| **Alt. 3 – 18ft Box** | 0.99 | 1.43 | 0.055 | 0.092 | 4.1 | 6.7 | |
| **Alt. 4 – 30ft Bridge** | 1.00 | 1.48 | 0.056 | 0.100 | 4.1 | 7.3 | |
| ***Downstream Bailey Road (HEC-RAS STA 1861)*** | | | | | | | |
| **Existing** | 1.00 | 1.13 | 0.049 | 0.057 | 3.6 | 4.2 | 0.85 |
| **Alt. 1 – 10ft Box** | 1.00 | 1.19 | 0.048 | 0.062 | 3.6 | 4.6 | |
| **Alt. 2 – 12ft Conspan** | 1.00 | 1.20 | 0.049 | 0.063 | 3.6 | 4.6 | |
| **Alt. 3 – 18ft Box** | 1.01 | 1.23 | 0.049 | 0.065 | 3.6 | 4.8 | |
| **Alt. 4 – 30ft Bridge** | 1.01 | 1.22 | 0.048 | 0.065 | 3.6 | 4.8 | |

Reviewing Table 9, proposed alternatives were modeled to increase velocities and shear stresses of the South River upstream of Bailey Road on the order of 10 percent for the 1-in-2 chance peak discharge in comparison to existing conditions; more significant increases on the order of 30 to 100 percent were modeled for the 1-in-50 chance peak discharge. Again, these increases result from larger crossings allowing larger flows to leave Province Lake during flood events. However, the stream channel from the Province Lake Dam spillway and approximately 100 feet downstream has been naturally armored over time as large flows removed the smaller sediments. As the computed mobile grain size (6 mm to 8 mm) for the increased flows expected for the alternatives is significantly smaller than the median grain size (60 mm) of the armored streambed at the dam's spillway, the South River was modeled to have insufficient capacity to mobilize the armored gravel bed along this reach of the South River. From a geomorphic perspective, such a result is not unexpected as if the outlet of a lake was readily erodible at frequent floods, downcutting and draining of the lake would occur. Based on this limited analysis, no significant erosion or deposition along the South River upstream of Bailey Road is expected.

Downstream of Bailey Road, Table 9 summarizes modeled shear stresses to be sufficient to mobilize the sand bed of the South River for existing and all proposed conditions (evidenced by the scour hole just downstream of the culvert today.) In addition, the computed mobile grain size is well in excess of the measured median particle size composing the streambed and suggests that the sand bed of the South River downstream of Bailey Road is mobile at more moderate and frequent discharges. At the 1-in-2 chance peak discharge, Table 9 demonstrates that a negligible change in channel velocity and shear stresses was modeled for the proposed alternatives (likely due to downstream beaver dams) such that no long-term aggradation or degradation is expected. At the 1-in-50 chance peak discharge, the proposed alternatives were modeled to increase channel velocities and shear stresses of the South River downstream of Bailey Road approximately 10 percent, although such increase is within the range of variability across the South River under existing conditions. While some minor degradation may occur during occurrence of rarer events such as the 1-in-50 chance event, Streamworks anticipates that such degradation would be minor and short-term considering the negligible changes at the 1-in-2 chance event and smaller events that, over time, are expected to convey the most sediment.

## Aquatic Organism Passage

The New Hampshire Rules for Stream Crossings (Env-Wt 900) require that replacement culverts "not obstruct or otherwise substantially disrupt the movement of aquatic organisms." To assess the effect of the proposed alternatives on aquatic organism passage, Streamworks compared hydraulic model results for the low- and high-range of aquatic organism passage flows (discussed previously) to MaineDOT (2008) fish passage criteria for "resident fish" which is a category that includes non-trout fish species that live the entirety of their life in freshwater. Aquatic organism passage would be expected for these resident species where modeled depth is greater than the minimum depth criteria AND velocity is less than the maximum velocity criteria. Table 10 summarizes the results which demonstrate that aquatic organism passage is expected for each of the four proposed alternatives across the range of aquatic organism passage flows. Table 10 also shows that while the existing culvert provides aquatic organism passage at the low end of aquatic organism passage flows, it was modeled to not provide passage at the higher end of this range. In contrast, each of the proposed alternatives was modeled to provide aquatic organism passage at the lower and high range of flows. Therefore, the proposed alternatives are expected to improve aquatic organism passage.

**Table 10: Aquatic Organism Passage Metrics**

| Alternative | Depth (ft) | | Velocity (feet/second) | |
|---|---|---|---|---|
| | Low AOP | High AOP | Low AOP | High AOP |
| **MaineDOT (2008) Criteria** | Min. 0.5 | | Max. 1.8 feet per second | |
| **Existing / In-kind Replacement** | 0.91 | 3.05 | < 0.1 | 1.9 |
| **Alternative 1 – 10ft Box** | 0.71 | 2.86 | < 0.1 | 1.4 |
| **Alternative 2 – 12ft Conspan** | 0.71 | 2.88 | < 0.1 | 1.2 |
| **Alternative 3 – 18ft Box** | 0.71 | 2.93 | < 0.1 | 1.3 |
| **Alternative 4 – 30ft Bridge** | 0.71 | 2.97 | < 0.1 | 1.2 |

AOP = Aquatic Organism Passage

### Terrestrial Passage

In addition to requiring aquatic organism passage, the New Hampshire Rules for Stream Crossings (Env-Wt 900) require that replacement culverts provide a vegetated bank on both sides of the watercourse or a wildlife shelf to facilitate passage of terrestrial species. Of the four proposed alternatives, only Alternative 3 and Alternative 4 span the bankfull channel and could provide a vegetated bank on one or both sides of the watercourse to facilitate terrestrial passage. Considering the low height of Bailey Road and the potential to affect flow releases from Province Lake, provisions for terrestrial passage for Alternative 1 and Alternative 2 are somewhat limited but could be considered as part of detailed design of the structure (for example a shelf). However, considering the frequent inundation of the floodplain surfaces due to downstream beaver activity, low height of Bailey Road, and the road's low and seasonal traffic volume as a dead-end road, provision of dedicated terrestrial passage facilities for Alternative 1 and Alternative 2 may provide negligible additional terrestrial passage.

### Water Quality

DK Water Resource Consulting, LLC (DK) was procured by CMA to assess the impact of the proposed alternatives on water quality of Province Lake. To quantify the water quality impacts of the proposed alternatives, DK assumed that the 1-in-2 chance flood level defined the limit of vegetated shoreline around Province Lake such that a reduction in the peak flood level would increase the vegetated area contributing to the lake and decrease the area of unvegetated shorelines which had higher erosion potential. Based on this calculation, DK concluded that the proposed culvert replacement would reduce in-lake phosphorous levels less than 0.1 percent and not have an appreciable effect on algae growth in the lake.

## Province Lake Water Quality Improvements near Bailey Road

In addition to analyzing alternatives to replace the existing Bailey Road crossing, Streamworks also assessed opportunities near Bailey Road to reduce pollutant loading to Province Lake. Based on field reconnaissance and professional judgment, Streamworks identified three opportunities near Bailey Road to improve the water quality of Province Lake: 1) temporary drawdowns to flush Province Lake, 2) stormwater management along Bailey Road, and 3) stabilization of the Province Lake shoreline near Bailey Road. Each of these alternatives is further described in the following sections.

## Temporary Drawdowns to Flush Province Lake

Streamworks and DK identified temporary drawdowns of Province Lake as a low-cost opportunity to improve water quality of Province Lake. The temporary drawdowns would occur by removing the flashboards from Province Lake dam during periods of poor water quality (usually summer months when flashboards are in place) to flush a portion of the poor-quality water from the Lake. The flashboards would then be replaced to raise water levels and replace the flushed volume of water with new water from the lake's tributaries. However, DK concluded this option is infeasible as the water quality of tributary runoff is usually poorer than the flushed water it would replace. Additionally, Province Lake does not stratify so there is not an opportunity to dilute in-lake pollutant levels by promoting lake mixing through temporary flushing as could occur in stratified lakes. Therefore, this alternative was not considered further.

## Bailey Road Stormwater Management

Bailey Road in the vicinity of the crossing of the South River is a paved local road with a normal crown such that stormwater runs off south towards Province Lake and north towards the South River. Between Bailey Road and Province Lake is a thin band of poorly vegetated, steep, sandy soils that exhibits signs of erosion and provides negligible filtering of stormwater runoff such that stormwater runoff, and its associated pollutants, from Bailey Road effectively runs off directly into Province Lake. Therefore, Streamworks identified two opportunities to manage stormwater runoff from Bailey Road to reduce nutrient loading to Province Lake: 1) re-crowning Bailey Road to redirect all stormwater runoff towards the South River and 2) intercepting and treating stormwater runoff from Bailey Road prior to discharging to Province Lake.

Through discussions with CMA, Streamworks understands that the Town recently re-paved Bailey Road and re-crowning of Bailey Road in the medium-term is not feasible. In addition, this option would not reduce the net pollutant export from Bailey Road but would only redirect the pollutants from Province Lake to the South River – although the floodplain wetlands along the South River provide some opportunity for pollutant uptake and retention. While this option was not considered further, Streamworks recommends the Town consider re-crowning Bailey Road away from Province Lake the next time Bailey Road is re-paved.

Reviewing the existing site, Bailey Road has an average grade of approximately 1.5% towards the South River and the soils underlying Bailey Road are relatively sandy and provide an opportunity for infiltration. To take advantage of these site conditions, Streamworks developed a concept for stormwater management presented in Exhibit 5. The developed concept includes vegetated swales that will intercept and filter runoff from Bailey Road and convey stormwater runoff to infiltration trenches located near the South River. In addition to infiltrating stormwater runoff the infiltration trenches are located downstream of the Province Lake dam such that any surface or subsurface outflow would discharge to the South River, not Province Lake.

Based on the cost estimates provided in the University of New Hampshire's Stormwater BMP Factsheets and New York State Department of Environmental Conservation's *Standards and Specifications for Erosion and Sediment Control Practices*, Streamworks' opinion of the probable construction cost of the Province Lake stormwater management option is approximately $34,000 to $73,000. Regular maintenance of the stormwater management option would be expected but were not estimated.

## Province Lake Shoreline Stabilization

In addition to soil rilling from concentration of stormwater runoff from Bailey Road onto the Province Lake shoreline, approximately 350 linear feet of shoreline along Bailey Road exhibits signs of erosion from wave action and ice shoving. To mitigate the sediment and pollutant loading from the gradual erosion of the Bailey Road shoreline due to these forces, Streamworks developed a concept to stabilize 350 linear feet of poorly vegetated Province Lake shoreline along Bailey Road.

Streamworks' concept design for shoreline stabilization is presented in Exhibit 6 and is dependent on establishing a vegetated shoreline toe. This will be accomplished by re-grading the toe to a shallower slope that can be planted; the combination of shallower toe slope and vegetation will attenuate some of the wave energy and reduce the energy available to erode the shoreline. Coir logs and erosion control blankets will be used to temporarily protect the toe until planted vegetation establishes and provides long-term stabilization of the toe. To reduce ice shoving, large boulders will be installed waterward of the toe to function similar to a breakwater to intercept and break up ice sheets before they raft against the shoreline and cause erosion.

Based on comparison to past projects, Streamworks' opinion of the probable construction cost of the Province Lake shoreline stabilization is approximately $87,500 to $122,500. After vegetation is established, minimal maintenance would be expected such that lifecycle maintenance costs would be expected to be significantly less than that of the stormwater management option.

## Pollutant Loads and Potential Reductions

To inform the recommendation to consider the developed Bailey Road improvements further, Streamworks calculated the potential pollutant reduction provided for both alternatives. For the stormwater management alternative, Streamworks calculated the pollutant reduction using the Simple Method and accompanying DES worksheet recommended in DES's (2008) *New Hampshire Stormwater Manual*. The Simple method is a pollutant loading methodology that calculates annual pollutant loading as a simple multiplicative equation with factors accounting for catchment area, annual runoff, land cover, and best management practices. The catchment area for the proposed swales along Bailey Road were delineated using project survey and included only the paved surfaces of Bailey Road; areas adjacent to the proposed swale would drain away from the proposed swale. No road regrading or realignment was assumed and the potential pollutant reduction provided by treating runoff from that existing area that would be occupied by the swales was excluded from the calculations. The pollutant loading for "residential streets" was selected to be representative of the pollutant loading from Bailey Road. For post-project conditions, the pollutant removal efficiency was selected as the maximum of pollutant removal efficiencies for the swale or infiltration trench, as recommended in the *New Hampshire Stormwater Manual.* Reviewers should note that as swales would treat stormwater runoff discharging to both the South River and Province Lake, only a portion of the calculated pollutant load reduction would benefit Province Lake.

For the shoreline stabilization method, Streamworks calculated the pollutant reduction used the "Bank Stabilization" component of the US Environmental Protection Agency's (EPA) "Region 5 Model for Estimating Pollutant Load Reductions" which calculates pollutant loads as a function of the bank height, bank length, and lateral erosion rate. Based on qualitative descriptions of bank conditions associated with various lateral erosion rates provided in the Region 5 Model, Streamworks estimated the lateral erosion rate as 0.1 ft/year, or moderate. Streamworks adopted the Region 5 Model pollutant loading defaults for sands and assumed the bank stabilization would yield a 99 percent reduction in pollutant loading.

In addition to the abatement of shoreline erosion, Streamworks also used the Simple Method to estimate the magnitude of pollutant loading that would be reduced by the shoreline stabilization acting as a buffer for stormwater runoff from Bailey Road. Specifically, Streamworks delineated the portion of Bailey Road and adjacent pervious ground that would drain towards the proposed bank stabilization and assumed pollutant removal efficiencies for a vegetated buffer. However, Streamworks notes that the proposed width and slope of the proposed shoreline stabilization do not meet the guidelines for a vegetated buffer in DES's (2008) *New Hampshire Stormwater Manual*, so Streamworks' calculations are best considered an estimate of the upper range of potential pollutant load reduction.

Table 9 summarizes the nutrient loadings for pre- and post-project conditions for the two proposed alternatives. As summarized in Table 9, both alternatives were modeled to reduce pollutant loading to Province Lake. Of the two alternatives, the shoreline stabilization alternative was modeled to provide a significantly greater reduction in pollutant loading than the stormwater improvement. In addition, all of this modeled reduction would benefit Province Lake whereas the majority of the stormwater management alternative would benefit the South River downstream of Province Lake. Of note is that the buffering of stormwater runoff from Bailey Road is anticipated to be near-negligible: the upper estimate summarized in Table 9 is approximately one percent of the calculated pollutant load reduction for stabilizing the shoreline. However, it should be noted that the calculation of pollutant load reduction is highly sensitive to the lateral erosion rate which could be further refined by monitoring the shoreline over time.

**Table 9: Summary of Nutrient Loading**

| Alt. | Metric | Unit | Suspended Solids (TSS) | Phosphorous (TP) | Nitrogen (TN) |
|---|---|---|---|---|---|
| Stormwater Management[1] | **Pre-Project Loading** | lb/yr | 497 | 1.6 | 4.0 |
| | **Post-Project Loading** | lb/yr | 50 | 1.3 | 1.6 |
| | **Difference** | lb/yr | -447 | -0.3 | -2.4 |
| | **Percent Reduction** | pct | 90% | -20% | -60% |
| Shoreline Stabilization | **Pre-Project Loading** | lb/yr | 19,250 | 8.2 | 16.4 |
| | **Post-Project Loading** | lb/yr | 193 | 0.1 | 0.2 |
| | **Difference** | lb/yr | -19,057 | -8.1 | -16.2 |
| | **Percent Reduction** | pct | 99% | 99% | 99% |
| … Buffering of Bailey Rd[2] | **Pre-Project Loading** | lb/yr | 78 | 0.2 | 0.7 |
| | **Post-Project Loading** | lb/yr | 21 | 0.1 | 0.3 |
| | **Difference** | lb/yr | -57 | -0.1 | -0.3 |
| | **Percent Reduction** | pct | 73% | 40% | 45% |

[1] Approximately 30% of the load reduction would benefit Province Lake, the rest would benefit South River
[2] Upper estimate; actual reduction anticipated to be less

# Summary and Recommendations

## Bailey Road Crossing Replacement

Under subcontract to CMA, Streamworks was tasked by the Town of Effingham to investigate the geomorphic, hydrologic, hydraulic, and water quality impacts of alternatives to replace the existing Bailey Road crossing of the South River. With these goals, Streamworks completed hydrologic and hydraulic modeling of the existing Bailey Road crossing and four alternatives: two stream crossing alternatives that spanned the full bankfull width of the South River and varying portions of its floodplain and two alternative designs that were smaller but satisfied the intent of NHDES stream crossing rules.

Prior to analyzing proposed alternatives, Streamworks developed hydrologic and hydraulic models to assess the degree to which the Bailey Road crossing may impact the levels of Province Lake and its releases. Based on Streamworks modeling, Streamworks concluded that the Bailey Road crossing has no impact on Province Lake levels or outflows under normal conditions but that the Bailey Road crossing does restrict outflows from Province Lake at flood conditions. As such, Streamworks concluded that the Bailey Road stream crossing functions not only as a riverine crossing but also similar to a dam spillway that restricts outflows from Province Lake: larger crossings would drain Province Lake faster and result in larger downstream flows during floods. In contrast, downstream flow regimes are usually insensitive to stream crossing sizes for most common riverine crossings. Considering the unique impact of the Bailey Road crossing on Province Lake, Streamworks identified the potential that replacement of the Bailey Road crossing with a geomorphically-sized crossing may yield adverse impacts not typically expected for riverine crossings.

To inform the selection of a preferred stream crossing alternative, Streamworks used the hydrologic and hydraulic models to assess the impact of proposed stream crossing alternatives on upstream and downstream water levels, aquatic organism passage, sediment transport, and water quality of Province Lake. At baseflow conditions, each of the proposed alternatives were modeled to not have any impact on Province Lake water levels at baseflow conditions. In addition, each of the proposed Bailey Road crossing alternatives was modeled to provide favorable conditions for passage of aquatic organisms required by the New Hampshire Rules for Stream Crossings.

As a result of the Bailey Road crossing acting similar to a dam spillway, Streamworks' modeling demonstrated that each of the proposed alternatives would increase the magnitude of flood releases from Province Lake and, in turn, water levels downstream of Province Lake. This result conflicts with the New Hampshire Rules for Stream Crossings that require no increase in the frequency of flooding or streambank overtopping and thus will necessitate some form of alternative design. In general, water levels were modeled to increase up to nine inches along the South River, including at downstream municipal and state crossings at Snow Road and State Route 153, respectively. Of particular note is the Snow Road crossing, which was modeled to overtop at the 1-in-100 chance event under current conditions, would be expected to overtop more frequently for each of the alternatives. Although Streamworks' analyses demonstrated that the proposed alternatives would be expected to increase the frequency of downstream flooding and streambank overtopping, Streamworks' analyses demonstrate that the increase in flood discharges expected for the proposed alternatives would have negligible impacts on erosion and deposition in the South River.

As none of the Bailey Road crossing alternatives fully satisfy the New Hampshire Rules for Stream Crossings an Alternative Design will need to be permitted with NHDES. Considering that most of the alternatives satisfied the environmental criteria for the New Hampshire Rules for Stream Crossings and that the most significant adverse impact associated was an increase in downstream flows and flooding resulting

from increased crossing sizes, Streamworks recommends the Town select the less expensive of the two smaller crossing sizes – Alternative 1 or Alternative 2, the 10-ft concrete box or 12-ft Conspan arch, respectively. Both alternatives provide aquatic organism passage and will not adversely impact the geomorphic equilibrium of the South River while also limiting adverse impacts to downstream flooding that increase with larger crossing sizes. Should Alternative 1 and Alternative 2 be comparable in cost and all other considerations, Streamworks recommends the 12-ft Conspan arch given that the Conspan shape, in comparison to the 10-ft box, provides for greater flow area at low depths but comparable hydraulic performance at flood flows due to the arch shape obstructing some portion of higher flow depths.

## Province Lake Water Quality Improvements

In addition to investigating alternatives to replace the Bailey Road crossing, Streamworks also investigated opportunities to implement actions near Bailey Road that would improve the water quality of Bailey Road. After DK Water Resource Consulting concluded that temporary drawdown of Province Lake was not anticipated to improve water quality, Streamworks investigated options to manage stormwater runoff from Bailey Road and reduce shoreline erosion near Bailey Road. Considering that the stabilization of approximately 350 linear feet of Province Lake near Bailey Road was estimated to cost two to four times as much as the stormwater management alternative but would reduce 25 to 50 times as much sediment and nutrients to Province Lake, while also requiring less long-term maintenance, Streamworks recommends advancement of the shoreline stabilization project. However, Streamworks also recommends that the Town consider re-crowning Bailey Road to drain towards the north, diverting stormwater runoff away from Province Lake and towards the South River, the next time the road is re-paved.

## Funding Opportunities

To assist funding the replacement of the Bailey Road crossing, Streamworks recommends that the Town monitor Aquatic Resource Mitigation (ARM) funds available through NHDES Wetlands Bureau and consider a grant application when funds are next available for the Saco River ARM region which includes Province Lake area; no funds for this area are available in 2021. To assist funding the stabilization of Province Lake alongside Bailey Road, Streamworks recommends that the Town consider applying for a Section 319 Watershed Assistance grant through NHDES. Section 319 grants are specifically intended for projects to improve water quality for lakes and watercourses which have a watershed management plan (like Province Lake); 2021 pre-proposal applications are due September 17, 2021.

# Exhibits

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SCALE: 1" = 100'

0 50 100 150

N

SHEET ID: EXHIBIT 1

SHEET NUMBER: 01 OF 01

SHEET TITLE: GEOMORPHIC REFERENCE REACH SECTIONS

SHEET SET: HYDROLOGIC & HYDRAULIC MODELING MEMO

PROJECT NAME: PROVINCE LAKE DRAINAGE IMPROVEMENTS ANALYSIS FOR BAILEY RD

PROJECT LOCATION: PROVINCE LAKE & BAILEY RD, EFFINGHAM NH

streamworks

DESIGNED BY: JCB, JLW

DRAWN BY: JCB

CHECKED BY: TPB

DATE: 27 JUL 2021

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**Exhibit 2A: Particle Size Distribution Results at South River downstream of Bailey Road**

| US Sieve Number | Sieve Opening (mm) | Mass Retained (g) | Mass Passing (g) | Percent Finer, by Weight |
|---|---|---|---|---|
| **3/8”** | 9.51 | 1.14 | 1150.49 | 99.90% |
| **4** | 4.76 | 2.68 | 1147.81 | 99.67% |
| **10** | 2.00 | 149.04 | 998.77 | 86.73% |
| **20** | 0.85 | 515.31 | 483.46 | 41.98% |
| **40** | 0.43 | 268.29 | 215.17 | 18.68% |
| **60** | 0.25 | 131.88 | 83.29 | 7.23% |
| **100** | 0.15 | 39.73 | 43.56 | 3.78% |
| **200** | 0.075 | 36.15 | 7.41 | 0.64% |
| **Pan** | n/a | 7.41 | 0.00 | 0.00% |

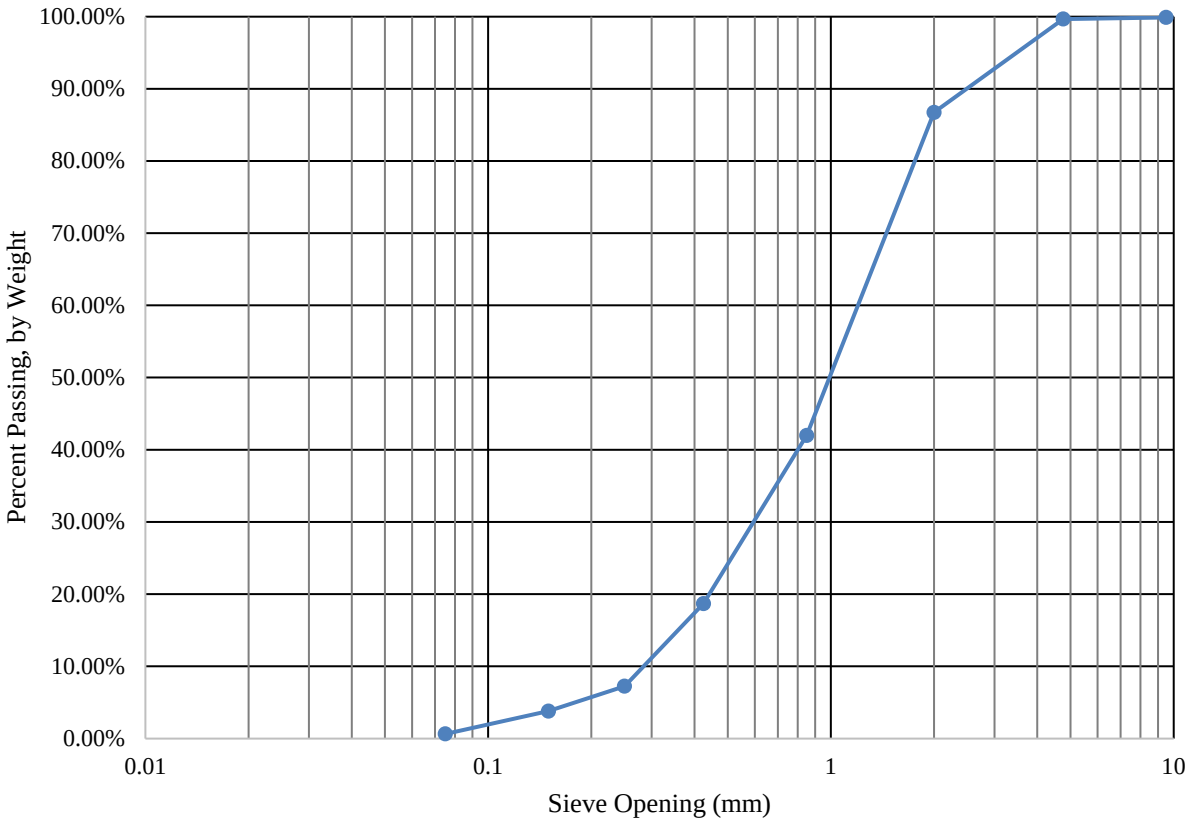



**Exhibit 2B: Particle Size Distribution Graph at South River downstream of Bailey Road**

**Exhibit 2C: Particle Size Distribution Results at South River downstream of dam**

| US Sieve Number | Sieve Opening (mm) | Mass Retained (g) | Mass Passing (g) | Percent Finer, by Weight |
|---|---|---|---|---|
| | 75 | 463.9 | 1541.56 | 76.87% |
| | 65 | 362.22 | 1179.34 | 58.81% |
| | 58 | 417.07 | 762.27 | 38.01% |
| | 50 | 288.18 | 474.09 | 23.64% |
| | 50 | 188.04 | 286.05 | 14.26% |
| | 45 | 94.41 | 191.64 | 9.56% |
| | 42 | 136.51 | 55.13 | 2.75% |
| | 35 | 32.42 | 22.71 | 1.13% |
| | 30 | 7.37 | 15.34 | 0.76% |
| **3/8"** | 9.51 | 11.99 | 3.35 | 0.17% |
| **4** | 4.76 | 2.57 | 0.78 | 0.04% |
| **200** | 0.075 | 0.61 | 0.17 | 0.10% |
| **Pan** | 75 | 0 | 0.17 | 0.01% |

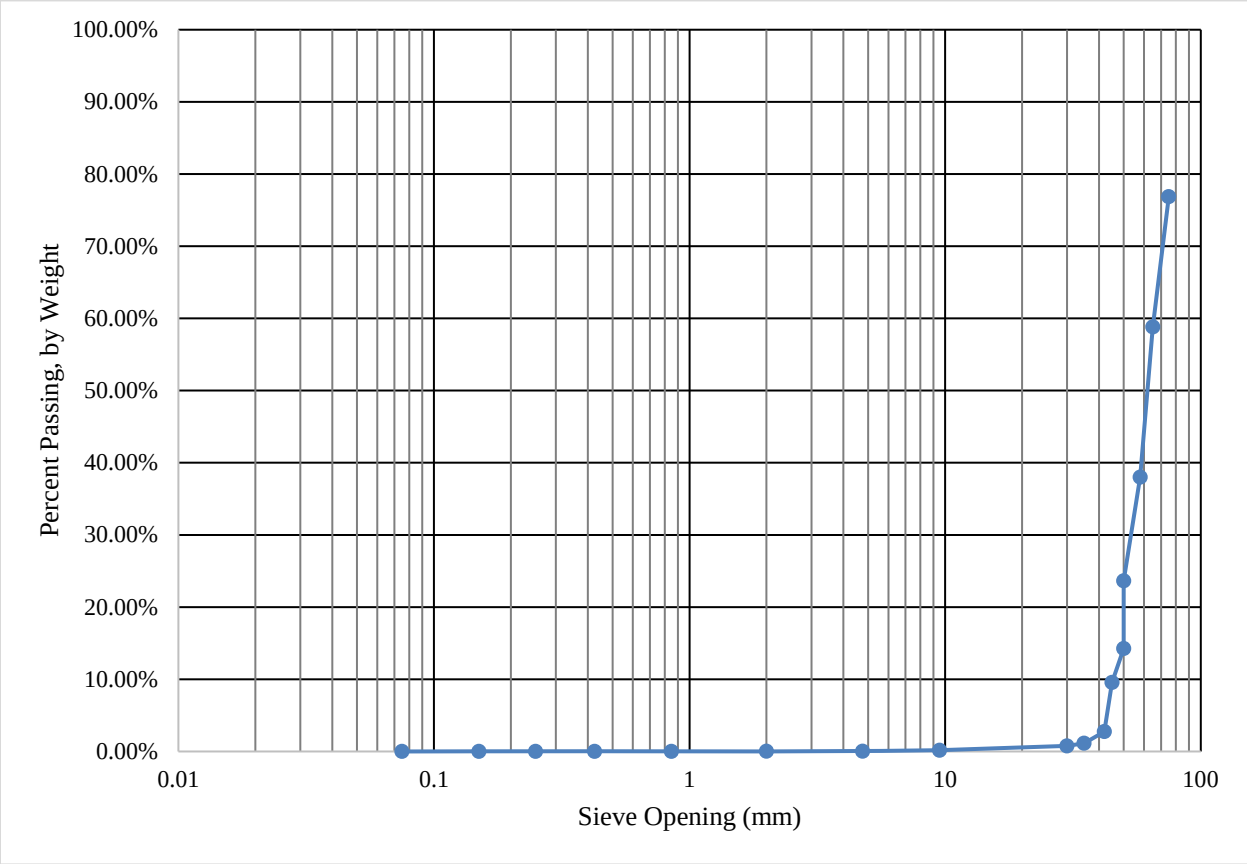
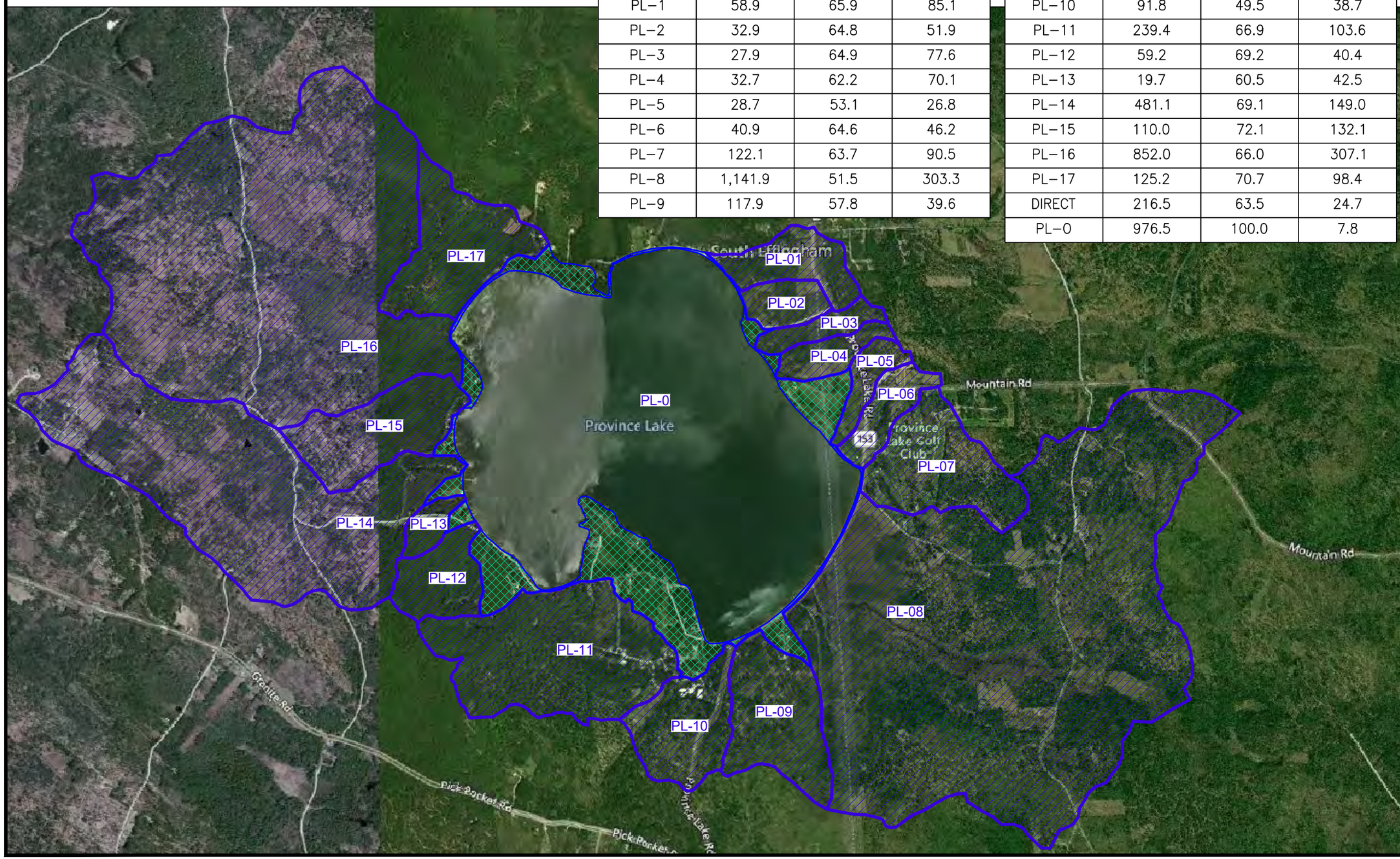



**Exhibit 2D: Particle Size Distribution Graph at South River downstream of dam**

| HYDROLOGIC SUMMARY | | | |
|---|---|---|---|
| ID | AREA (ac) | CN | Tc (min) |
| PL-1 | 58.9 | 65.9 | 85.1 |
| PL-2 | 32.9 | 64.8 | 51.9 |
| PL-3 | 27.9 | 64.9 | 77.6 |
| PL-4 | 32.7 | 62.2 | 70.1 |
| PL-5 | 28.7 | 53.1 | 26.8 |
| PL-6 | 40.9 | 64.6 | 46.2 |
| PL-7 | 122.1 | 63.7 | 90.5 |
| PL-8 | 1,141.9 | 51.5 | 303.3 |
| PL-9 | 117.9 | 57.8 | 39.6 |

| HYDROLOGIC SUMMARY | | | |
|---|---|---|---|
| ID | AREA (ac) | CN | Tc (min) |
| PL-10 | 91.8 | 49.5 | 38.7 |
| PL-11 | 239.4 | 66.9 | 103.6 |
| PL-12 | 59.2 | 69.2 | 40.4 |
| PL-13 | 19.7 | 60.5 | 42.5 |
| PL-14 | 481.1 | 69.1 | 149.0 |
| PL-15 | 110.0 | 72.1 | 132.1 |
| PL-16 | 852.0 | 66.0 | 307.1 |
| PL-17 | 125.2 | 70.7 | 98.4 |
| DIRECT | 216.5 | 63.5 | 24.7 |
| PL-0 | 976.5 | 100.0 | 7.8 |




DESIGNED BY: JCB, JLW
DRAWN BY: JCB
CHECKED BY: TPB
DATE: 27 JUL 2021

Streamworks

SHEET TITLE: HYDROLOGIC SUMMARY

SHEET SET: HYDROLOGIC & HYDRAULIC MODELING MEMO

PROJECT NAME: PROVINCE LAKE DRAINAGE IMPROVEMENTS ANALYSIS FOR BAILEY RD

PROJECT LOCATION: PROVINCE LAKE & BAILEY RD, EFFINGHAM NH

N

SCALE: 1" = 2,000'

0 1000 2000 3000

SHEET ID: EXHIBIT 3

SHEET NUMBER: 01 OF 01

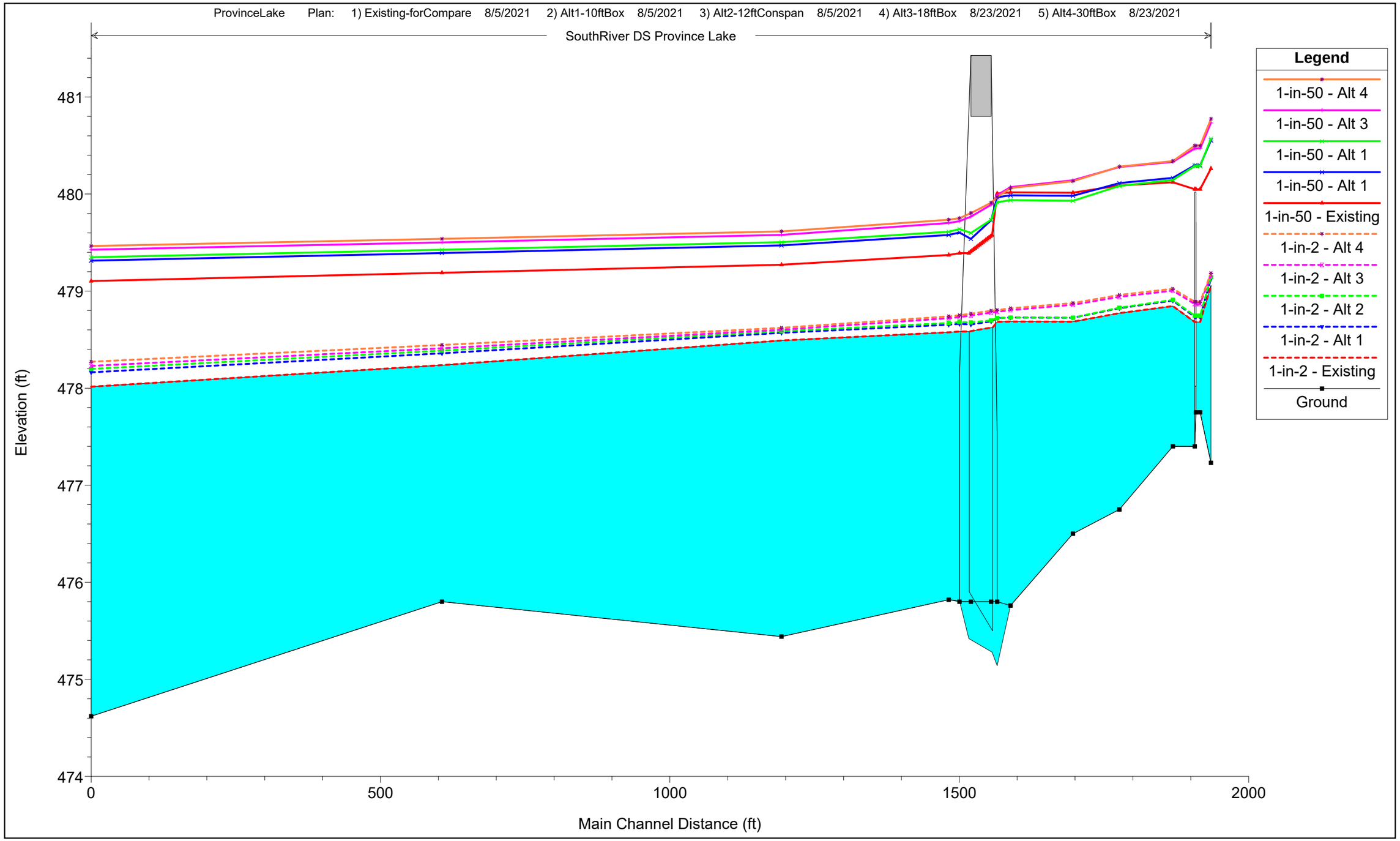
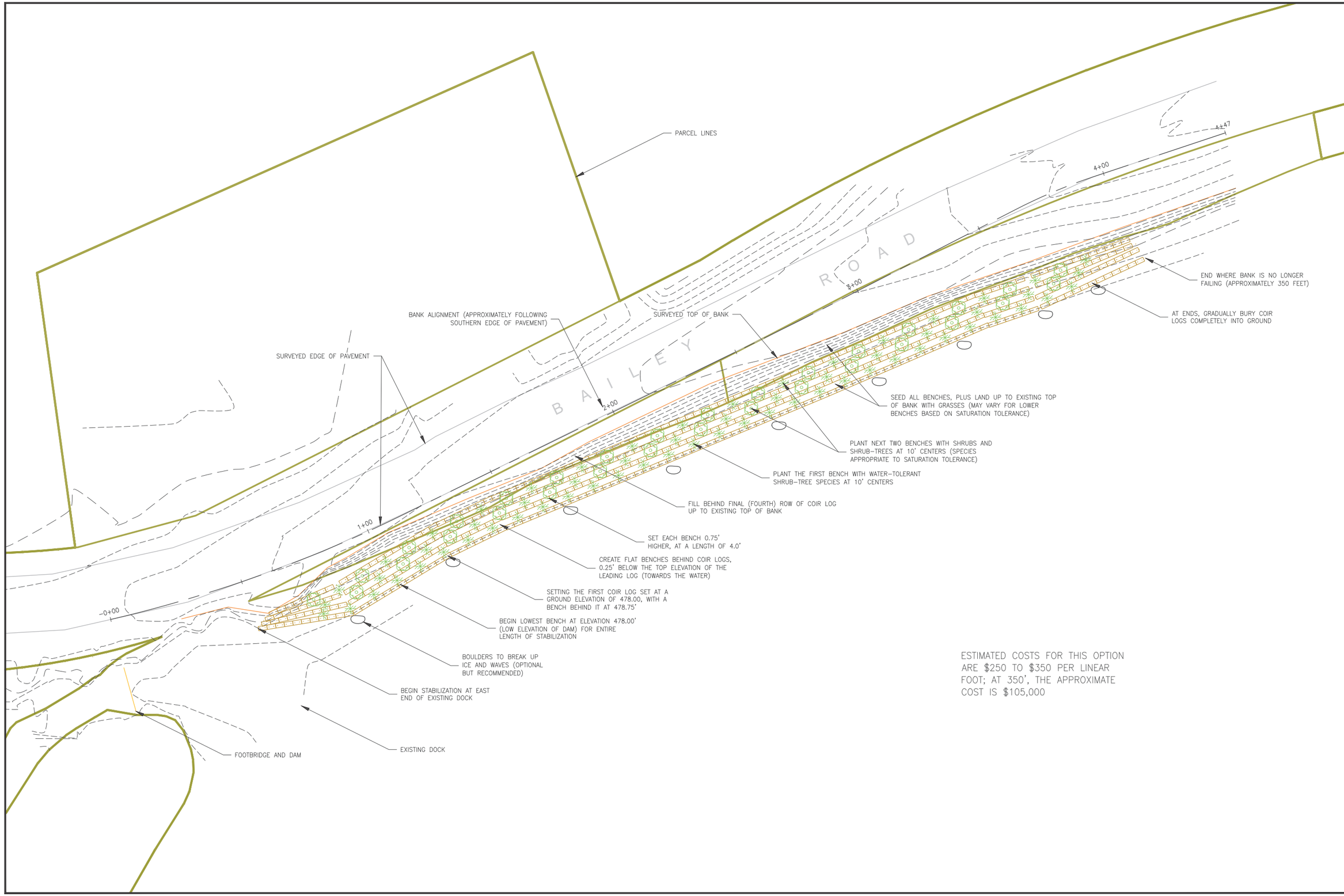

ProvinceLake Plan: 1) Existing-forCompare 8/5/2021 2) Alt1-10ftBox 8/5/2021 3) Alt2-12ftConspan 8/5/2021 4) Alt3-18ftBox 8/23/2021 5) Alt4-30ftBox 8/23/2021
SouthRiver DS Province Lake
Elevation (ft)
481
480
479
478
477
476
475
474
0
500
1000
1500
2000
Main Channel Distance (ft)
Legend
1-in-50 - Alt 4
1-in-50 - Alt 3
1-in-50 - Alt 1
1-in-50 - Alt 1
1-in-50 - Existing
1-in-2 - Alt 4
1-in-2 - Alt 3
1-in-2 - Alt 2
1-in-2 - Alt 1
1-in-2 - Existing
Ground


**Exhibit 5 - Stormwater Management Alternative along Bailey Road**

Province Lake Drainage Improvements Analysis for Bailey Road

*Hydrologic and Hydraulic Modeling Memorandum*




ESTIMATED COSTS FOR THIS OPTION ARE $250 TO $350 PER LINEAR FOOT; AT 350', THE APPROXIMATE COST IS $105,000

| | |
|---|---|
| Designed By: | JCB, JMW |
| Drawn By: | JCB |
| Checked By: | TPB |
| Date: | 14 JUN 2021 |

Streamworks

Notes:

| Revision # | Date: |
|---|---|
| | |

Sheet Title: ERODING BANK, ALIGNMENT, SECTIONS

Sheet Set: CONCEPTUAL SHORELINE STABILIZATION DESIGN

Project Name: BAILEY RD SHORELINE STABILIZATION

Project Location: BAILEY RD & PROVINCE LAKE IN EFFINGHAM, NH

N

SCALE: 1" = 16'

0 8 16 24

Sheet ID: EXHIBIT 6A

Sheet Number: 01 of 03


| | |
|---|---|
| Designed By: | JCB, JMW |
| Drawn By: | JCB |
| Checked By: | TPB |
| Date: | 14 JUN 2021 |

Notes:

| Revision # | Date: |
|---|---|
| | |

Sheet Title: ERODING BANK OVER AERIAL

Sheet Set: CONCEPTUAL SHORELINE STABILIZATION DESIGN

Project Name: BAILEY RD SHORELINE STABILIZATION

Project Location: BAILEY RD & PROVINCE LAKE IN EFFINGHAM, NH

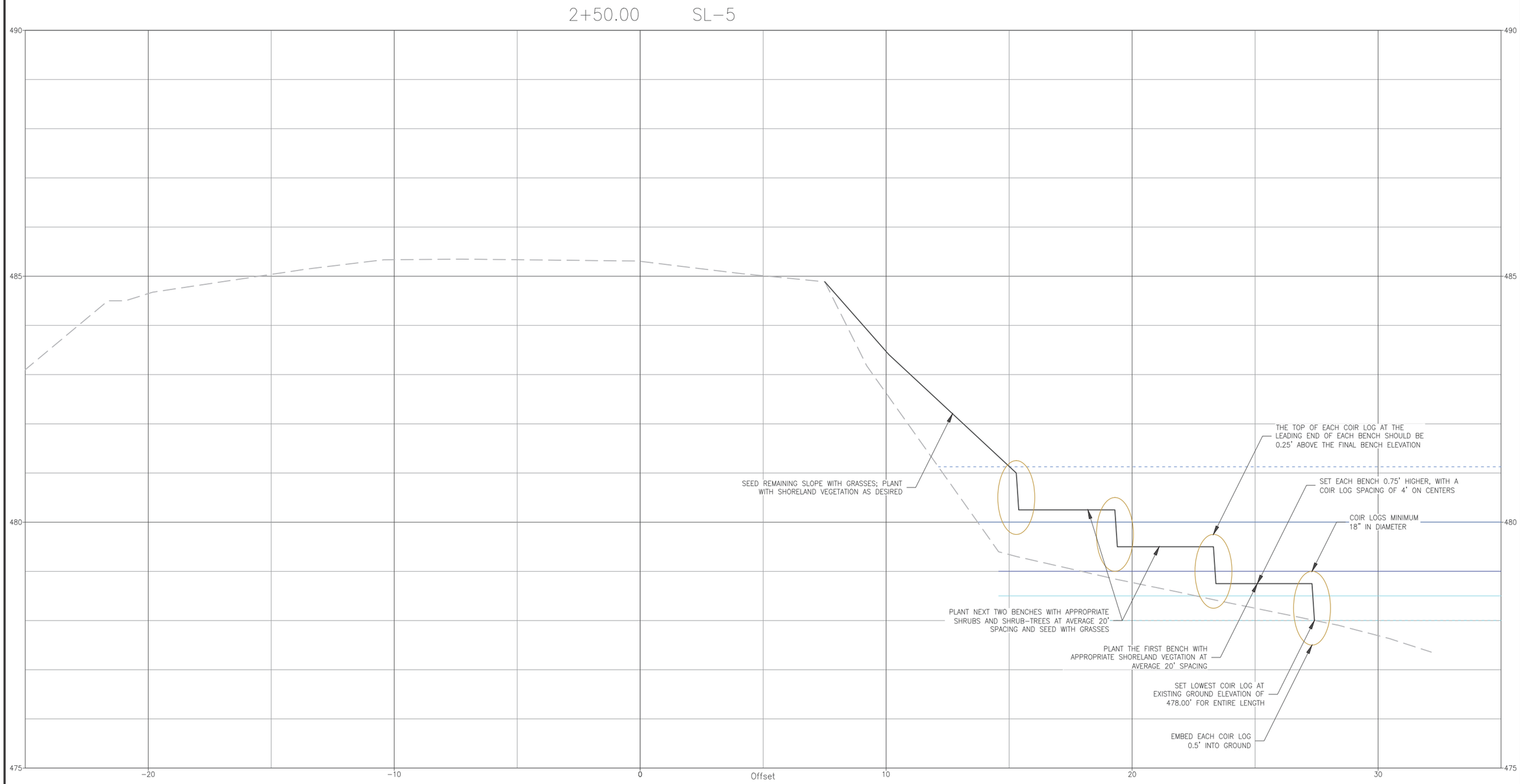
N

SCALE: 1" = 16'

0 8 16 24

Sheet ID: EXHIBIT 6B

Sheet Number: 02 of 03




Lowest Possible Elevation; 478.00

Typical Minimum Elevation; 478.50'

Target Summer Elevation; 479.00'

Typical Maximum Elevation; 480.00'

Highest Reported Elevation; 481.25'

Designed By: JCB, JMW
Drawn By: JCB
Checked By: TPB
Date: 14 JUN 2021

Streamworks

Notes:

Date:

Revision #

Sheet Title: CROSS SECTIONS

Sheet Set: CONCEPTUAL SHORELINE STABILIZATION DESIGN

Project Name: BAILEY RD SHORELINE STABILIZATION

Project Location: BAILEY RD & PROVINCE LAKE IN EFFINGHAM, NH

2:1 VERTICAL EXAGGERATION

VERTICAL SCALE: 1" = 1'

HORIZONTAL SCALE: 1" = 2'

0 2 4 6

Sheet ID: EXHIBIT 6C

Sheet Number: 03 of 03

# Attachment B

## DK Water Resources Consulting LLC Letter/Report

DK Water Resource Consulting LLC

**Don Kretchmer CLM**
DK Water Resource Consulting LLC
45 Red Brook Circle
Wolfeboro, NH 03894

April 23, 2021

William Straub
CMA Engineers, Inc.
35 Bow Street
Portsmouth, NH 03801

***RE: Evaluation of proposed culvert and BMP project on Province Lake with LLRM model.***

Dear Mr. Straub:

DK Water Resource Consulting LLC was contracted to provide assessment of the recently designed culvert replacement downstream of the outlet structure on Province Lake using the LLRM model (AECOM 2009) of Province Lake (FB Environmental 2013). The model was developed as a part of the watershed planning effort for Province Lake in Wakefield, NH and was updated by DK Water Resource Consulting in 2019 (DKWRC 2019).
Using the LLRM model update prepared as a part of the 2019 evaluation of the Province Lake, the influence of potential phosphorus loading changes associated with the project proposed by CMA were evaluated. A discussion of the implications of other short term operational changes follows the modeling discussion.

## 1. EVALUATION OF POTENTIAL CHANGES IN LAKE WATER QUALITY AFTER IMPLEMENTATION OF CULVERT PROJECT

This evaluation included four different culvert replacement scenarios. Each of these scenarios has the potential to reduce the peak level of the lake under a variety of return frequencies from 2 years to 100 years. The 2-year return frequency levels were chosen for this analysis because it was assumed that the high water experienced during these events had the potential to permanently disrupt the shoreline and the shoreline vegetation. Storms of longer return frequency were more likely to revert to a stable and vegetated environment before the next storm of similar magnitude occurred. Other than water level and associated lake area and volume changes as well as assumed land cover from the exposed areas under the new culvert scenarios, the model remained unchanged from the 2019 model update. The existing scenario is the same as the current condition scenario from the 2019 model update.

The culvert replacement project will result in a reduction in the peak annual lake level on the return interval of 2 years by less than ¼ inch depending on the culvert configuration. The calculation of the potential change in in-lake phosphorus concentrations related to the change was made under the assumption that the water level of the 2-year storm permanently disturbs the shoreline. Lowering that level results in a small band around the shoreline revegetating and stabilizing. The shoreline is assumed to have a 1:2 slope. This means that a 1-inch change in water level would result in a 2-inch horizontal band around the lake. For these scenarios, it was assumed that the 2-year

frequency peak currently experienced by the lake results in a zone of bare soil. In the future condition, it is assumed that this band would be vegetated and resemble meadow land cover and export less phosphorus. There is not expected to be any appreciable change in septic performance from these small, short-term changes in water level. Selected relevant modeling estimates from these scenarios are presented in Table 1.

The total area encompassed by this band of disturbed soil around the lake under different culvert scenarios is estimated at 0.006 to 0.011 ha. As a result of eliminating this band. phosphorus loading to the lake would be reduced by 0.001 to 0.002 kg/yr depending on the culvert configuration. This would result in a less than 0.01 µg/l reduction in-lake phosphorus from current loading. A loading reduction of this magnitude would not appreciably change the amount of biological productivity (algal growth) in the lake. Changes in these peak flows will not change the annual flushing rate of the lake as the peaks only represent a short-term reversable change in storage.

Table 1: Estimates of selected annual average characteristics under different outlet operating scenarios as predicted by LLRM.

| Scenario | Watershed phosphorus load | In-lake phosphorus | land use change |
|---|---|---|---|
| | kg/yr | µg/l | |
| Current Conditions | 143.189 | 16.46 | none |
| No culverts | 143.191 | 16.46 | 0.011 ha meadow added |
| 10 ft box | 143.190 | 16.46 | 0.006 ha meadow added |
| 12 foot Conspan | 143.190 | 16.46 | 0.006 ha meadow added |
| 18 ft box | 143.191 | 16.46 | 0.011 ha meadow added |

[1]Note that in-lake phosphorus predictions did vary between scenarios however were all essentially the same after rounding.

## 2. EVALUATION OF POTENTIAL FLUSHING BY TEMPORARILY LOWERING THE LAKE TO FLUSH NUTRIENTS.

Discussions between Streamworks PLCC and DKWRC suggested that the possibility of flushing the lake through periodic short-term drawdowns during episodes of poor lake water quality may improve lake condition. However, this technique is only helpful if better quality water replaces the poor-quality water removed from the lake (typically in the deep layers). Currently, tributary water quality is commonly much poorer than in-lake water quality, the lake does not typically stratify because it is so shallow and the outlet structure is at the surface, so this option is not considered feasible, nor would it be effective in improving lake water quality.

## 3. EVALUATION OF ACTIVE MANAGEMENT OF LAKE LEVEL TO AVOID HIGH WATER EVENTS.

There is some possibility that the frequency of high-water events in the lake can be reduced and the magnitude of these events can be minimized through active management of the outlet structure. While anecdotal evidence suggests the lake level drops very slowly through the small outlet structure, it still may be possible to drop the lake level in anticipation of high rainfall and runoff events. Less frequent and lower lake levels should result in a more stable shoreline and less opportunity for low lying septic systems to perform poorly or fail.

## 4. REFERENCES

AECOM (2009). LLRM Lake Loading Response Model Users Guide and Quality Assurance Project Plan. AECOM, Willington, CT.

FB Environmental. 2013. Province Lake Nutrient Modeling: Estimating Phosphorus Loads using Lake Loading Response Modeling. Prepared for the Province Lake Association.

DKWRC. 2019. Province Lake Water Quality Model Update. Prepared for the Province Lake Association.

# Attachment C

## Design Drawings – Conceptual Design of Preferred Alternative

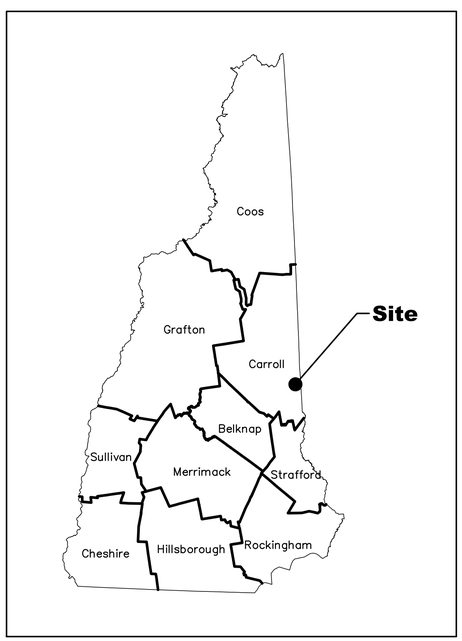
# Town Of Effingham
# Province Lake Drainage Improvements
# For Bailey Road

## Conceptual Design
### August 2021

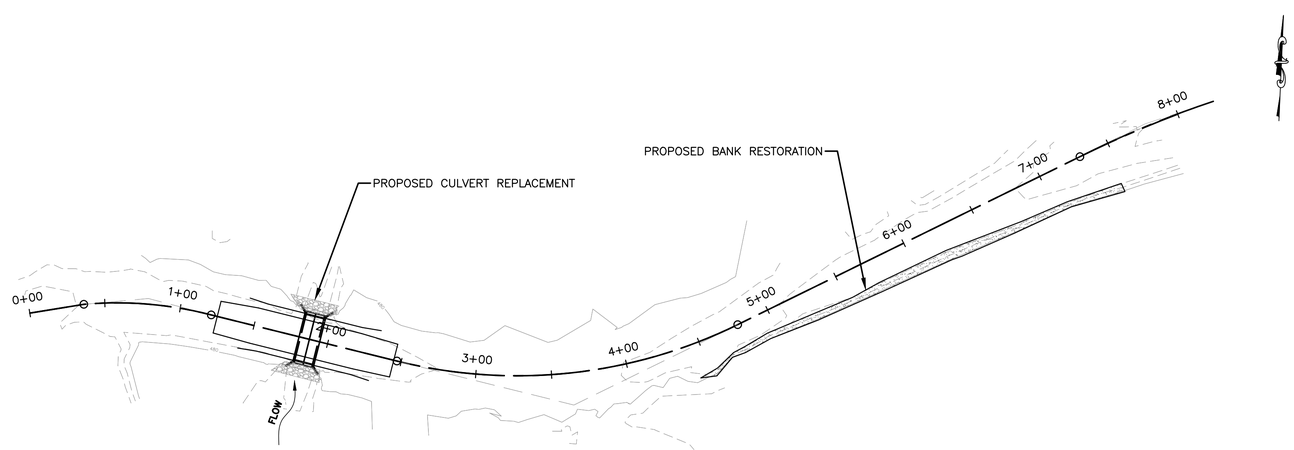
| Sheet List Table | |
|---|---|
| Sheet Number | Sheet Title |
| C | |
| 1 | Cover |
| EX | |
| 2 | ECP |
| G | |
| 3 | Culvert Replacement Plan and Profile |
| 4 | Slope Restoration Plan and Profile |
| 5 | Eroding Bank, Alignment, Sections |
| 6 | Eroding Bank Overall Aerial |
| 7 | Cross Sections |

NOT FOR CONSTRUCTION

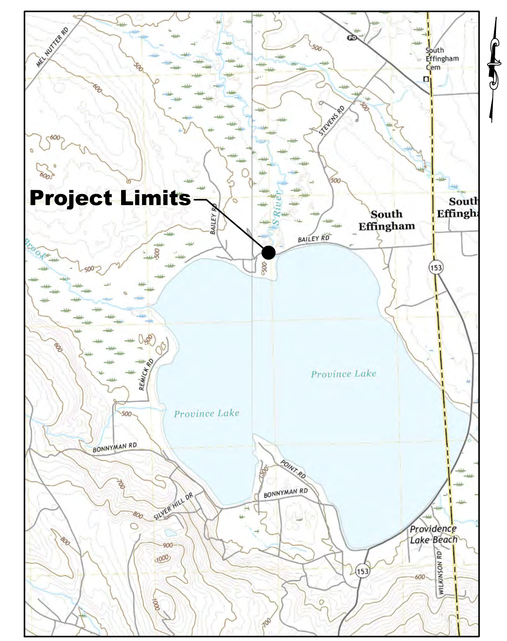
STATE OF NEW HAMPSHIRE
JOSHUA W. BOUCHARD
No. 12150
LICENSED
PROFESSIONAL ENGINEER




**Locus Plan**




SITE OVERVIEW
SCALE: 1" = 50'




**Project Locations**

*Prepared By:*

CMA ENGINEERS
CIVIL/ENVIRONMENTAL/STRUCTURAL
Portsmouth, NH 603/431-6196 • Manchester, NH 603/627-0708 • Portland, ME 207/541-4223
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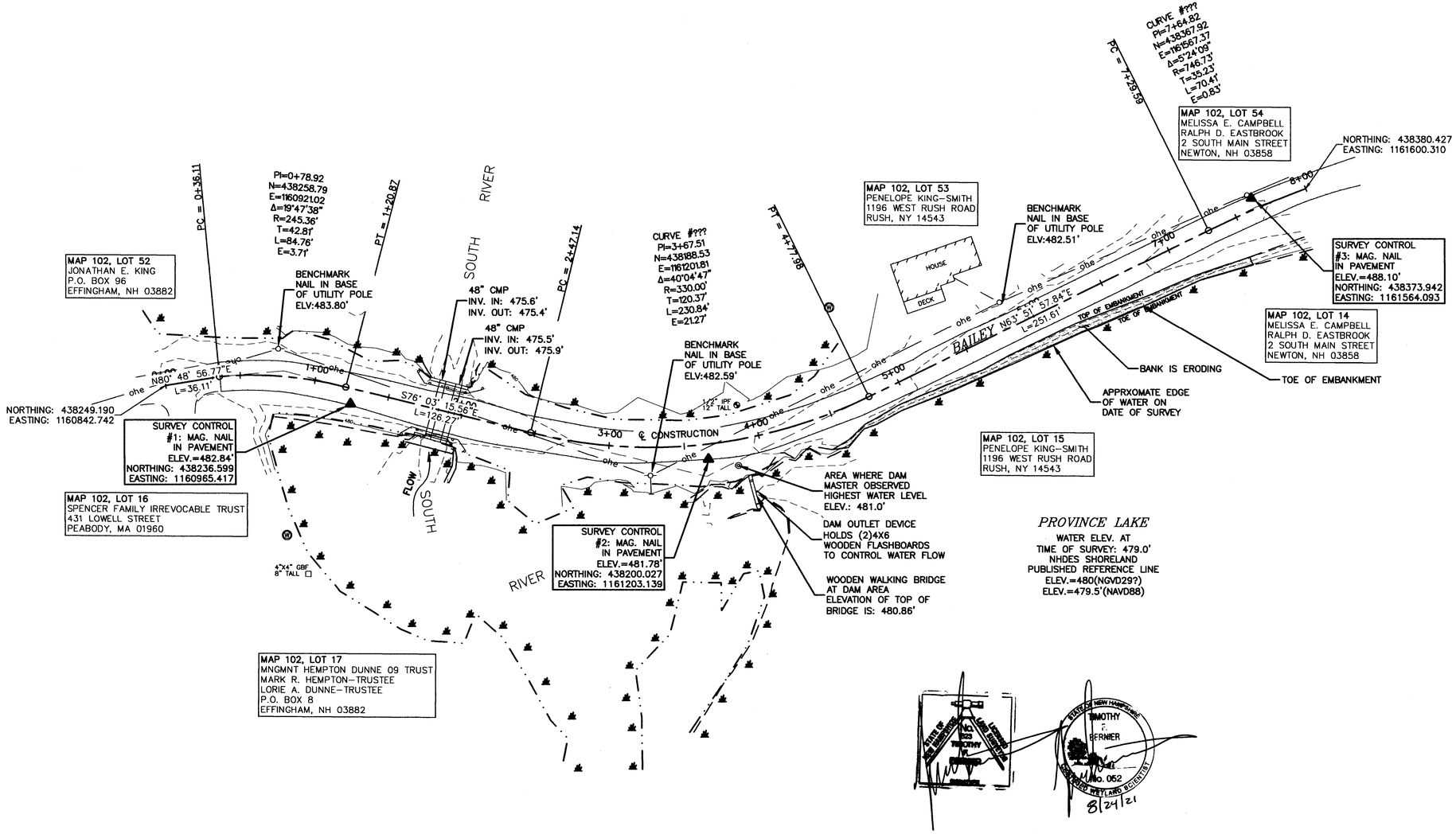
F:\CADD\PROJECTS\1183 Effingham Province Lake Outlet Culverts\Production\1183-Cover.dwg Date Plotted: Aug 24, 2021 - 1:02pm Plotted By: NMESSINA




NOTES:

1. THE INFORMATION SHOWN HEREON IS FROM A FIELD SURVEY PERFORMED BY T.F. BERNIER, INC. IN JANUARY 2021.
2. THE BEARINGS SHOWN HEREON ARE REFERENCED TO NH STATE PLANE NAD 83/11, AND THE VERTICAL DATUM IS NAVD88 BASED ON GPS OBSERVATIONS PERFORMED BY T.F. BERNIER, INC. IN JANUARY 2021, CORRECTED TO UNH CORS BASE STATION, GEOID GRAVITY MODEL 12B. ALL DISTANCES ARE GROUND IN US SURVEY FEET.
3. THE WETLANDS SHOWN HEREON WERE DELINEATED IN THE FIELD BY TIMOTHY F. BERNIER, CWS #052, IN JANUARY 2021 AND FIELD LOCATED BY T.F. BERNIER, INC. THE WETLAND DELINEATION WAS PERFORMED TO THE STANDARDS OF THE CORPS OF ENGINEERS WETLANDS DELINEATION MANUAL, TECHNICAL REPORT Y-87-1, JANUARY 1987). DOMINANT HYDRIC SOIL CONDITIONS WITHIN THE WETLANDS WERE IDENTIFIED USING THE CRITERIA OF "FIELD INDICATORS FOR IDENTIFYING HYDRIC SOILS IN NEW ENGLAND", VERSION 3, DOMINANCE OF WETLAND VEGETATION WAS ASSESSED UTILIZING THE "SPECIES THAT OCCUR IN WETLANDS: 1988 NORTHEAST" (BY PORTER B. REED JR.).

| no. | revision | date | by |
|---|---|---|---|
| 1 | Issued with Final Report | 8/21 | JWB |

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designed by: JWB
drawn by: NJM
approved by: JWB
date: August 2021
project no: 1183
checked by: JWB
scale: 0 40' 80' Scale: 1" = 40'

Town of Effingham
New Hampshire

Province Lake Drainage Improvements for Bailey Road

Existing Conditions Plan

drawing no. EX-1



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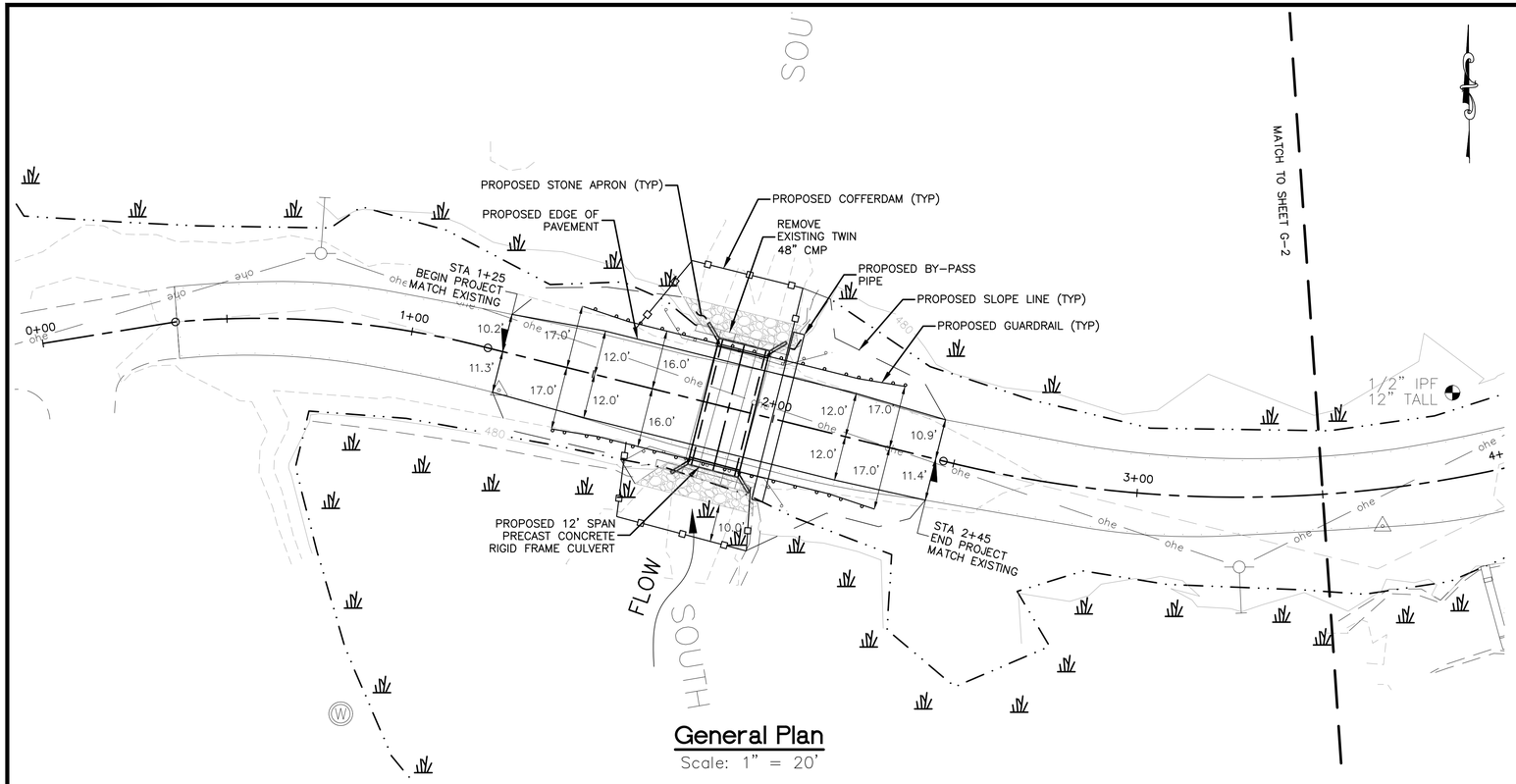
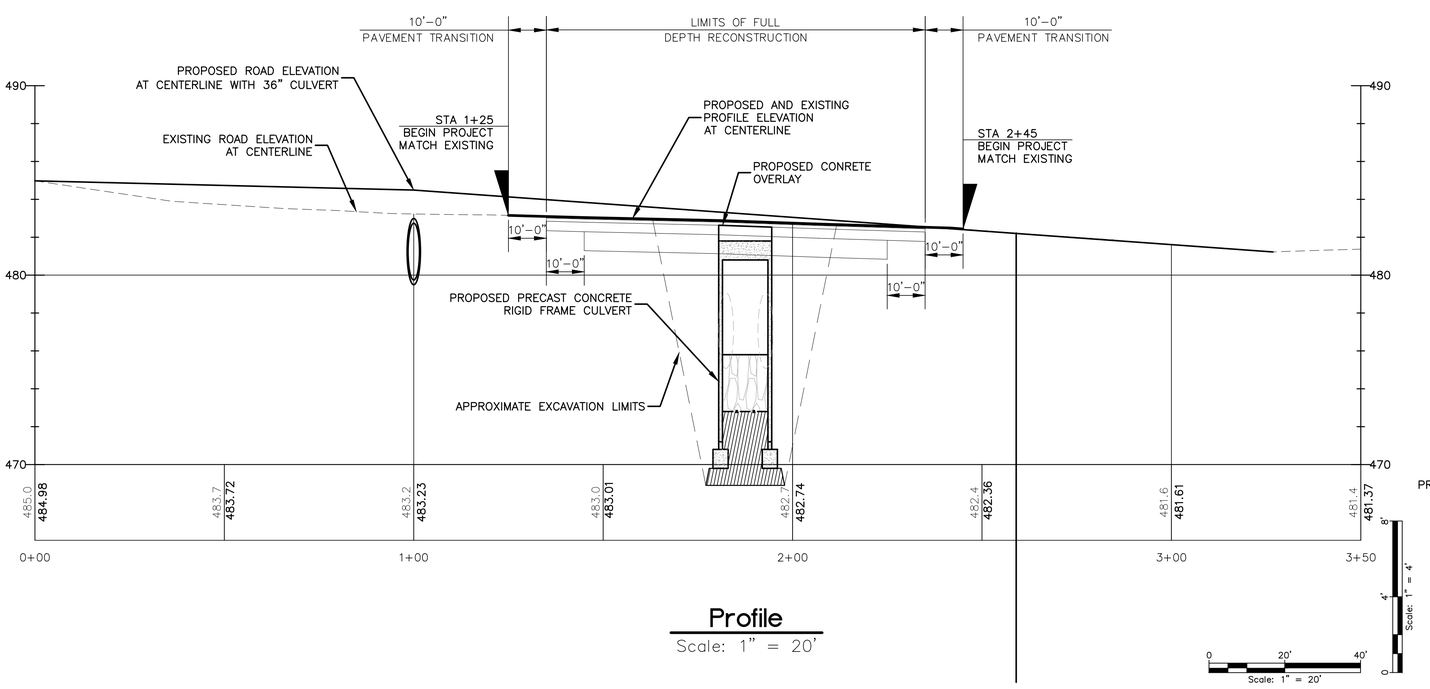


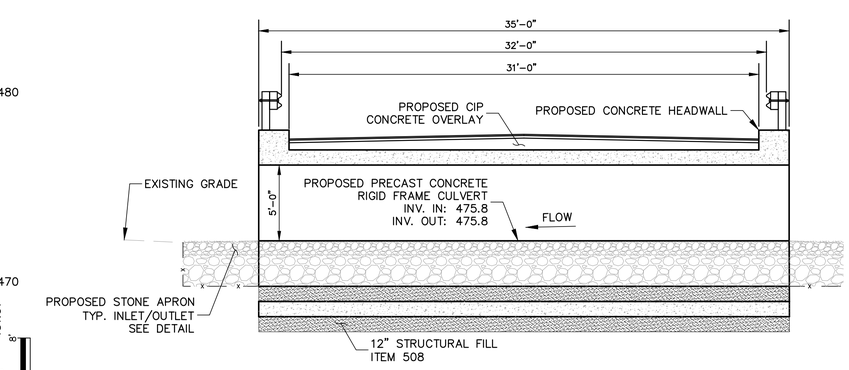

## General Plan

Scale: 1" = 20'




## Profile

Scale: 1" = 20'




## Bailey Road Culvert Longitudinal Section

Scale: 1" = 2'

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STATE OF NEW HAMPSHIRE JOSHUA W. BURPEE 15784 LICENSED PROFESSIONAL ENGINEER

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drawn by: NJM
approved by: JWB
date: August 2021
project no: 1183
checked by: JWB
scale: 0 20' 40' Scale: 1" = 20'

Town of Effingham
New Hampshire
Province Lake Drainage Improvements for Bailey Road
Culvert Replacement Plan and Profile

drawing no. G-1

sheet: 3 of 11

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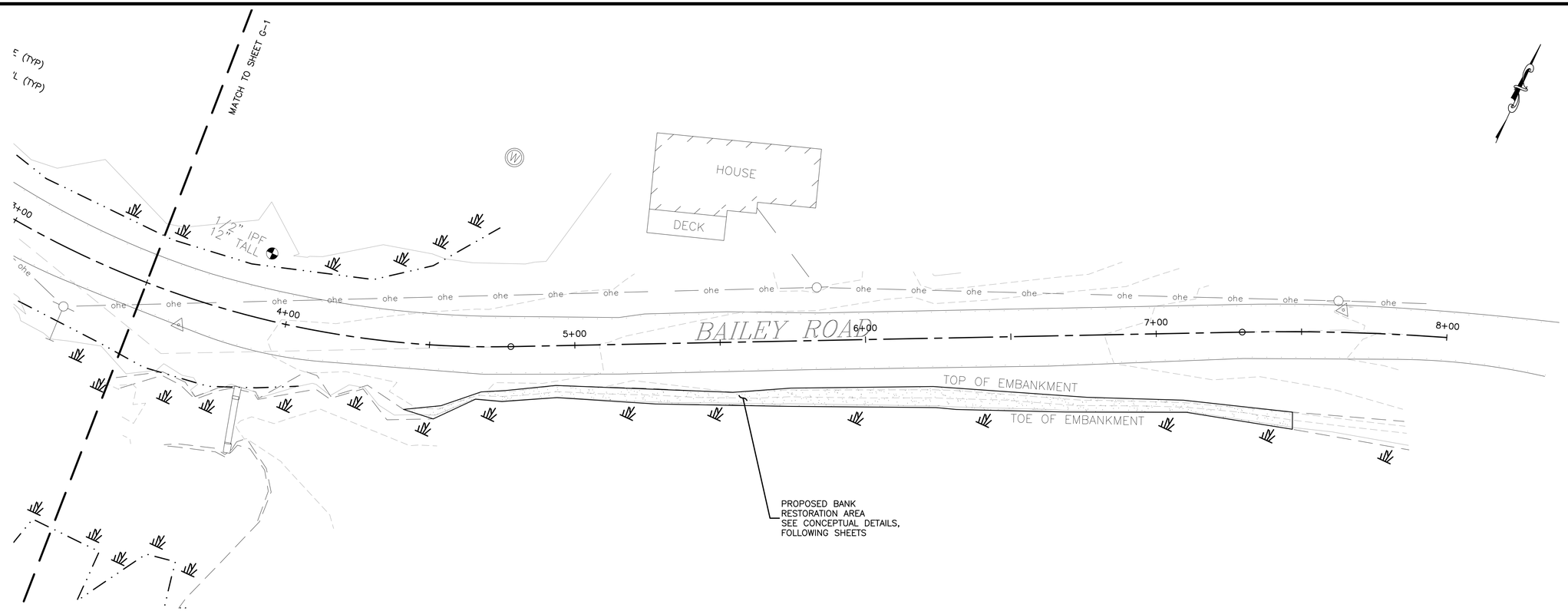
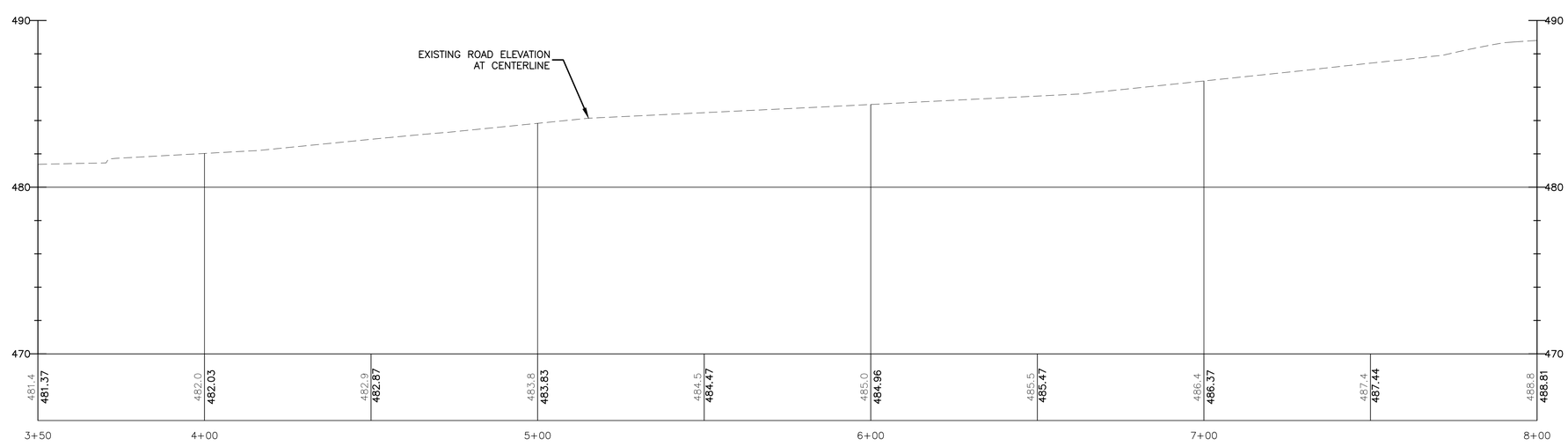



## General Plan

Scale: 1" = 20'




## Profile

Scale: 1" = 20'

0 20' 40'
Scale: 1" = 20'

0 4' 8'
Scale: 1" = 4'

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|---|---|---|---|
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STATE OF NEW HAMPSHIRE JOSHUA W. BOUCHARD NO. 12180 LICENSED PROFESSIONAL ENGINEER

designed by: JWB
drawn by: NJM
approved by: JWB
date: August 2021
project no: 1183
checked by: JWB
scale: 0 20' 40' Scale: 1" = 20'

Town of Effingham
New Hampshire

Province Lake Drainage Improvements for Bailey Road

Bank Restoration Plan and Profile

drawing no. G-2

sheet: 4 of 11

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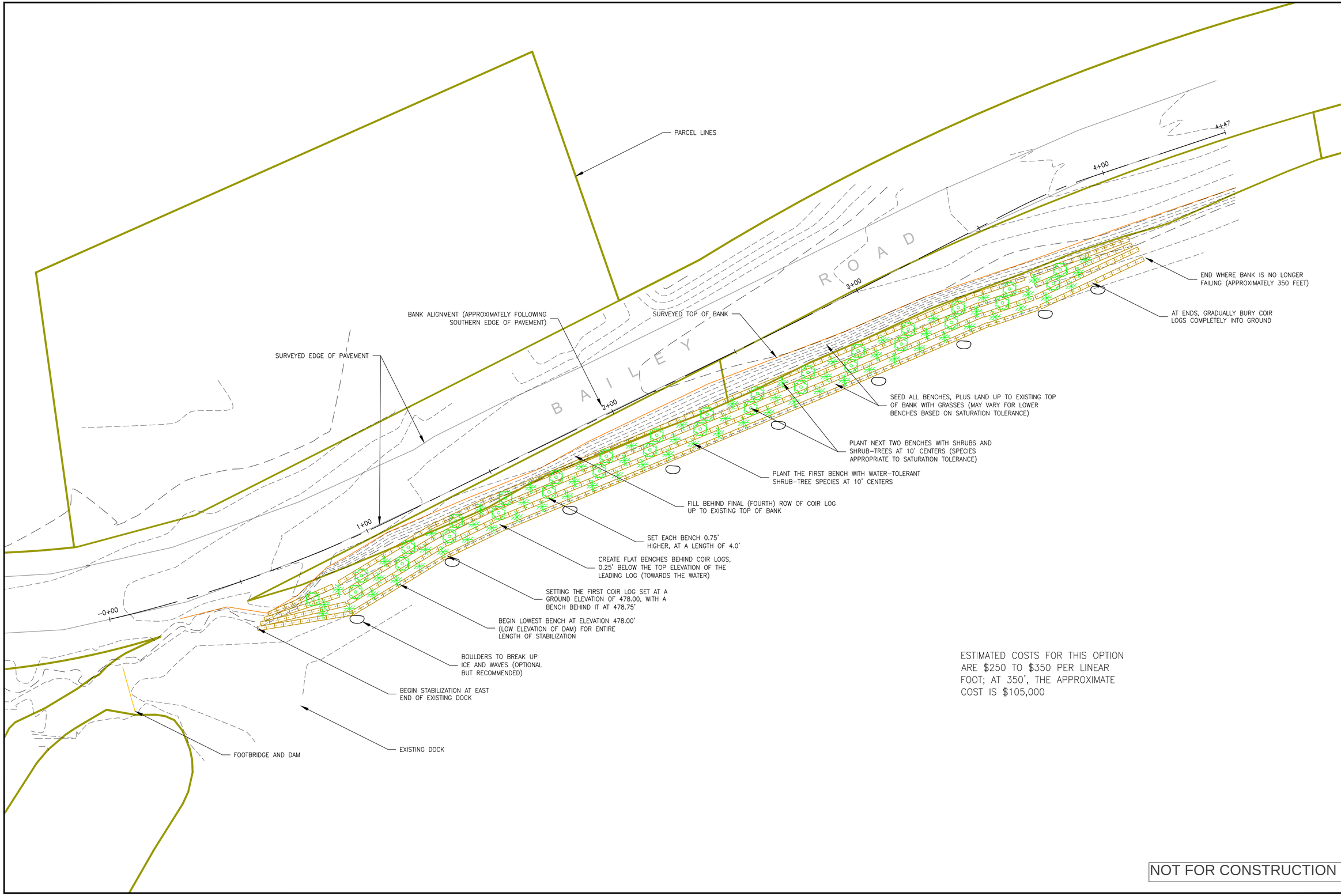



ESTIMATED COSTS FOR THIS OPTION ARE $250 TO $350 PER LINEAR FOOT; AT 350', THE APPROXIMATE COST IS $105,000

NOT FOR CONSTRUCTION

Designed By: JCB, JMW
Drawn By: JCB
Checked By: TPB
Date: 14 JUN 2021

STREAMWORKS, PLLC

Notes:

| Revision # | Date: |
|---|---|
| | |

Sheet Title: ERODING BANK, ALIGNMENT, SECTIONS

Sheet Set: CONCEPTUAL SHORELINE STABILIZATION DESIGN

Project Name: BAILEY RD SHORELINE STABILIZATION

Project Location: BAILEY RD & PROVINCE LAKE IN EFFINGHAM, NH

N

SCALE: 1" = 16'

0 8 16 24

Sheet ID: X-BANK

Sheet Number: 01 of 03


Designed By: JCB, JMW
Drawn By: JCB
Checked By: TPB
Date: 14 JUN 2021

STREAMWORKS, PLLC

Notes:

| Revision # | Date: |
|---|---|
| | |

Sheet Title: ERODING BANK OVER AERIAL

Sheet Set: CONCEPTUAL SHORELINE STABILIZATION DESIGN

Project Name: BAILEY RD SHORELINE STABILIZATION

Project Location: BAILEY RD & PROVINCE LAKE IN EFFINGHAM, NH

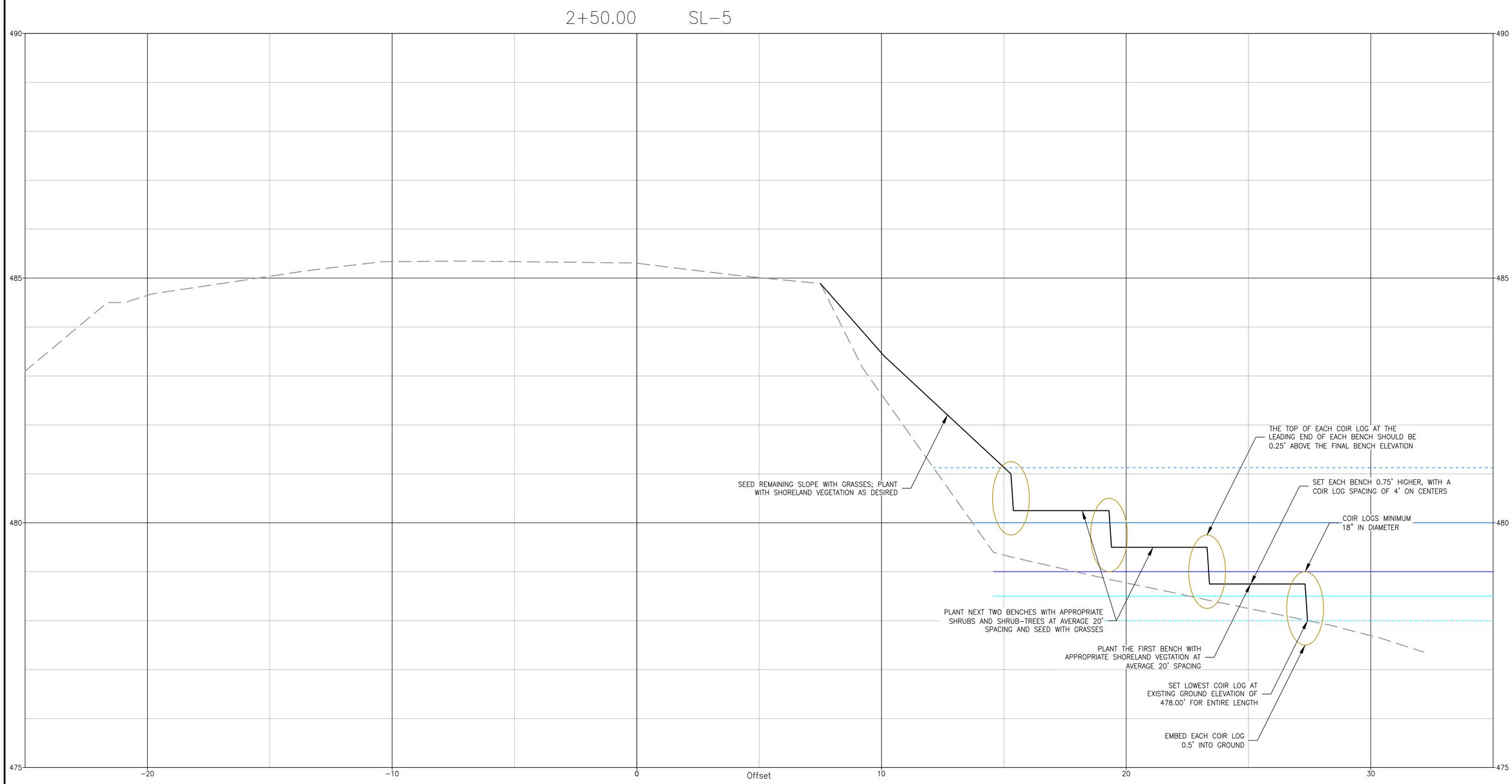
N

SCALE: 1" = 16'

0 8 16 24

Sheet ID: AERIAL

Sheet Number: 02 of 03




Lowest Possible Elevation; 478.00

Typical Minimum Elevation; 478.50'

Target Summer Elevation; 479.00'

Typical Maximum Elevation; 480.00'

Highest Reported Elevation; 481.25'

NOT FOR CONSTRUCTION

Designed By: JCB, JMW
Drawn By: JCB
Checked By: TPB
Date: 14 JUN 2021

STREAMWORKS, PLLC

Notes:

Date:

Revision #:

Sheet Title: CROSS SECTIONS

Sheet Set: CONCEPTUAL SHORELINE STABILIZATION DESIGN

Project Name: BAILEY RD SHORELINE STABILIZATION

Project Location: BAILEY RD & PROVINCE LAKE IN EFFINGHAM, NH

2:1 VERTICAL EXAGGERATION

VERTICAL SCALE: 1" = 1'

HORIZONTAL SCALE: 1" = 2'

0 2 4 6

Sheet ID: XSECS

Sheet Number: 03 of 03

# Attachment D

## Cost Estimate Breakdown

| | | | |
|---|---|---|---|
| PROJECT NAME: | Effingham Province Lake Outlet Culverts | | |
| PROJECT NO.: | 1183 | | |
| SHEET NO.: | 1 | CITY/TOWN | Effingham, NH |
| CALCULATED BY: | NJM | DATE: | 6/9/2021 |
| CHECKED BY: | JWB | DATE: | 6/11/2021 |

**Engineers Opinion of Probable Construction Cost (PS&E Submission)**

| Item # | Item Description | Unit | Quantity | Unit Price | Cost |
|---|---|---|---|---|---|
| | **Earthwork** | | | | |
| 203.6 | EMBANKMENT-IN-PLACE (F) | CY | 320.00 | $ 12.00 | $ 3,840 |
| 207.1 | COMMON CHANNEL EXCAVATION | CY | 300 | $ 22.00 | $ 6,600 |
| 214 | FINE GRADING | U | 1 | $ 6,000.00 | $ 6,000 |
| 645.531 | SILT FENCE | LF | 220 | $ 4.15 | $ 913 |
| | | | | **Earthwork Subtotal** | **$ 17,353** |
| | **Structure** | | | | |
| 503.1 | WATER DIVERSION STRUCTURES | U | 1 | $ 30,000.00 | $ 30,000 |
| 508 | STRUCTURAL FILL | CY | 20 | $ 52.50 | $ 1,050 |
| 529.00101 | PRECAST CONCRETE RIGID FRAME CULVERT | U | 1 | $ 70,000.00 | $ 70,000 |
| 585.2 | STONE FILL, CLASS B | CY | 460 | $ 45.00 | $ 20,700 |
| 593.411 | GEOTEXTILE; PERM CONTROL CL.1, NON-WOVEN | SY | 460 | $ 3.25 | $ 1,495 |
| | | | | **Structure Subtotal** | **$ 123,245** |
| | **Roadway** | | | | |
| 202.7 | REMOVAL OF GUARDRAIL | LF | 105 | $ 5.00 | $ 525 |
| 203.1 | COMMON EXCAVATION | CY | 150 | $ 10.00 | $ 1,500 |
| 304.2 | GRAVEL (F) | CY | 35 | $ 29.00 | $ 1,015 |
| 304.3 | CRUSHED GRAVEL (F) | CY | 50 | $ 35.00 | $ 1,750 |
| 403.11 | HOT BITUMINOUS PAVEMENT, MACHINE METHOD | TON | 55 | $ 120.00 | $ 6,600 |
| 403.6 | PAVEMENT JOINT ADHESIVE | LF | 240 | $ 0.50 | $ 120 |
| 417 | COLD PLANING BITUMINOUS SURFACES | SY | 50 | $ 10.00 | $ 500 |
| 563.3 | BRIDGE RAIL T101 | LF | 30 | $ 150.00 | $ 4,500 |
| 606.1285 | BEAM GUARDRAIL (BRIDGE APPROACH UNIT) | U | 4 | $ 5,000.00 | $ 20,000 |
| 606.147 | BEAM GUARDRAIL (TERMINAL UNIT TYPE G-2) | U | 4 | $ 1,100.00 | $ 4,400 |
| 628.2 | SAWED BITUMINOUS PAVEMENT | LF | 45 | $ 5.00 | $ 225 |
| | | | | **Roadway Subtotal** | **$ 41,135** |
| | **Incidentals** | | | | |
| 619.1 | MAINTENANCE OF TRAFFIC | U | 1 | $ 10,000.00 | $ 10,000 |
| 645.7 | STORM WATER POLLUTION PREVENTION PLAN | U | 1 | $ 3,000.00 | $ 3,000 |
| 645.71 | MONITORING SWPPP AND EROSION AND SEDIMENT CONTROLS | HR | 50 | $ 80.00 | $ 4,000 |
| 692 | MOBILIZATION | U | 1 | $ 21,000.00 | $ 21,000 |
| 1008.9 | ALTERATIONS AND ADDITIONS AS NEEDED - TESTING OF MATERIALS | $ | 1 | $ 5,000.00 | $ 5,000 |
| | | | | **Incidentals Subtotal** | **$ 43,000** |
| | | | | **Project Subtotal (2021)** | **$ 224,733** |

| | |
|---|---|
| Permitting | **$ 15,000.00** |
| Contingency (20%) | **$ 45,000** |
| Geotechnical Investigation, Final Design, and Bidding | **$ 40,000** |
| Construction Administration/Resident Inspection (15%) | **$ 34,000** |
| Local Grant Administration | **$ 10,000** |
| 2023 Construction Escalator (3%/yr) | **$ 14,000** |
| **Project Total** | **$ 383,000** |

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