



RESTORATION MASTER PLAN FOR THE COLD RIVER, WARREN BROOK, AND BOWERS BROOK

ACWORTH, ALSTEAD, LANGDON, AND WALPOLE, NH

March 2007



Project Sponsored by:



**RESTORATION MASTER PLAN
FOR
THE COLD RIVER, WARREN BROOK, AND BOWERS BROOK
ACWORTH, ALSTEAD, LANGDON, AND WALPOLE, NH**

Prepared for:

**NH Department of Environmental Services
NH Department of Transportation
NH Fish and Game Department
USDA Natural Resources Conservation Service**



Prepared by:

**Sean Sweeney, P.E., CWS
Horizons Engineering, PLLC**

March 2007

**Project No. 06093
Horizons Engineering, P.L.L.C.**

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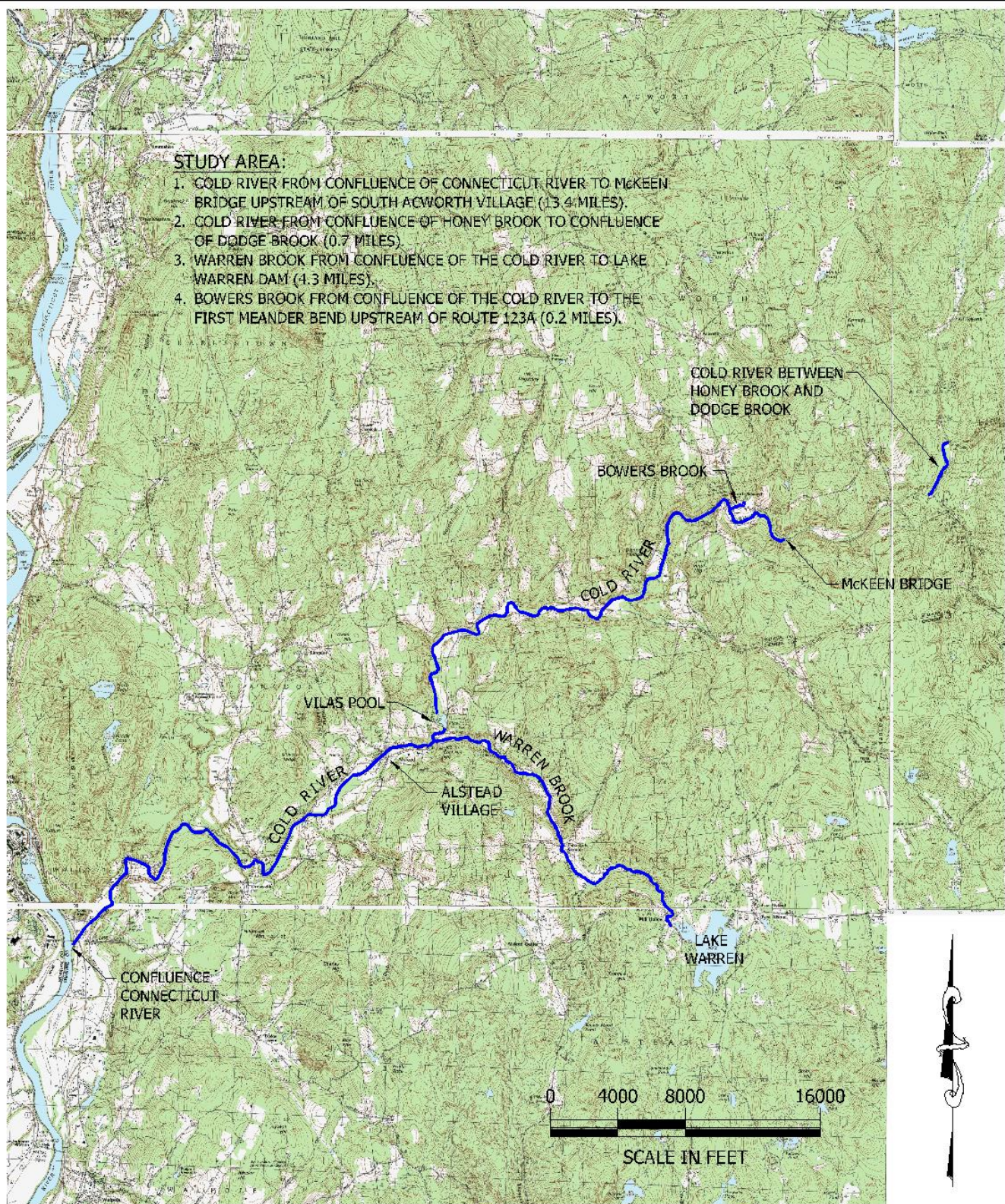
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Restoration Master Plan Narrative

The intent of this document is to provide an overall Master Plan for restoring channel stability to reaches of the Cold River, Warren Brook, and Bowers Brook affected by the devastating flood of October 9, 2005. The channel improvements depicted on the site plans are based upon substantial data collection and analyses completed in support of the fluvial geomorphic assessment performed in 2006¹. The assessment report should be referenced for documentation in support of the proposed channel improvements.

The restoration site plans are not intended for use as construction documents. Although the proposed channel improvements shown on the plans are based on field surveys, sediment transport calculations, and other data and analyses, they should be considered preliminary. Final designs will be required prior to construction and should be based upon additional data collection and analyses, including reference reach surveys, and consultation with the affected landowners.

¹ Horizons Engineering, PLLC. *Fluvial Geomorphic Assessment, Cold River, Warren Brook, and Bowers Brook, Acworth, Alstead, Langdon, and Walpole, New Hampshire*. October 2006.



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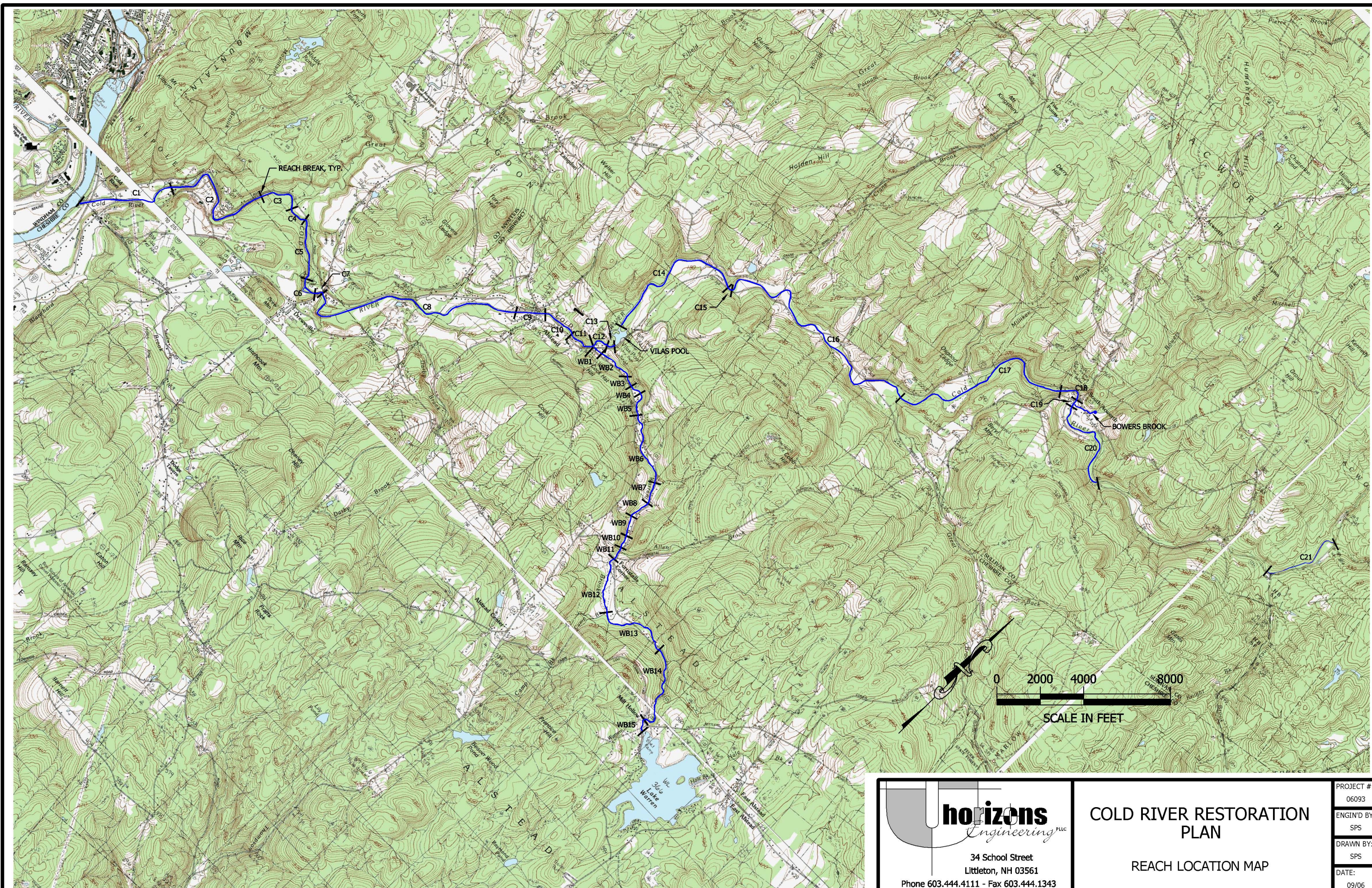
34 School Street
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**COLD RIVER RESTORATION
PLAN**

STUDY AREA EXHIBIT

PROJECT #:	06093
ENGIN'D BY:	SPS
DRAWN BY:	SPS
DATE:	09/06

Stream Reach Location Map



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COLD RIVER RESTORATION PLAN

REACH LOCATION MAP

PROJECT #:	06093
ENGIN'D BY:	SPS
DRAWN BY:	SPS
DATE:	09/06

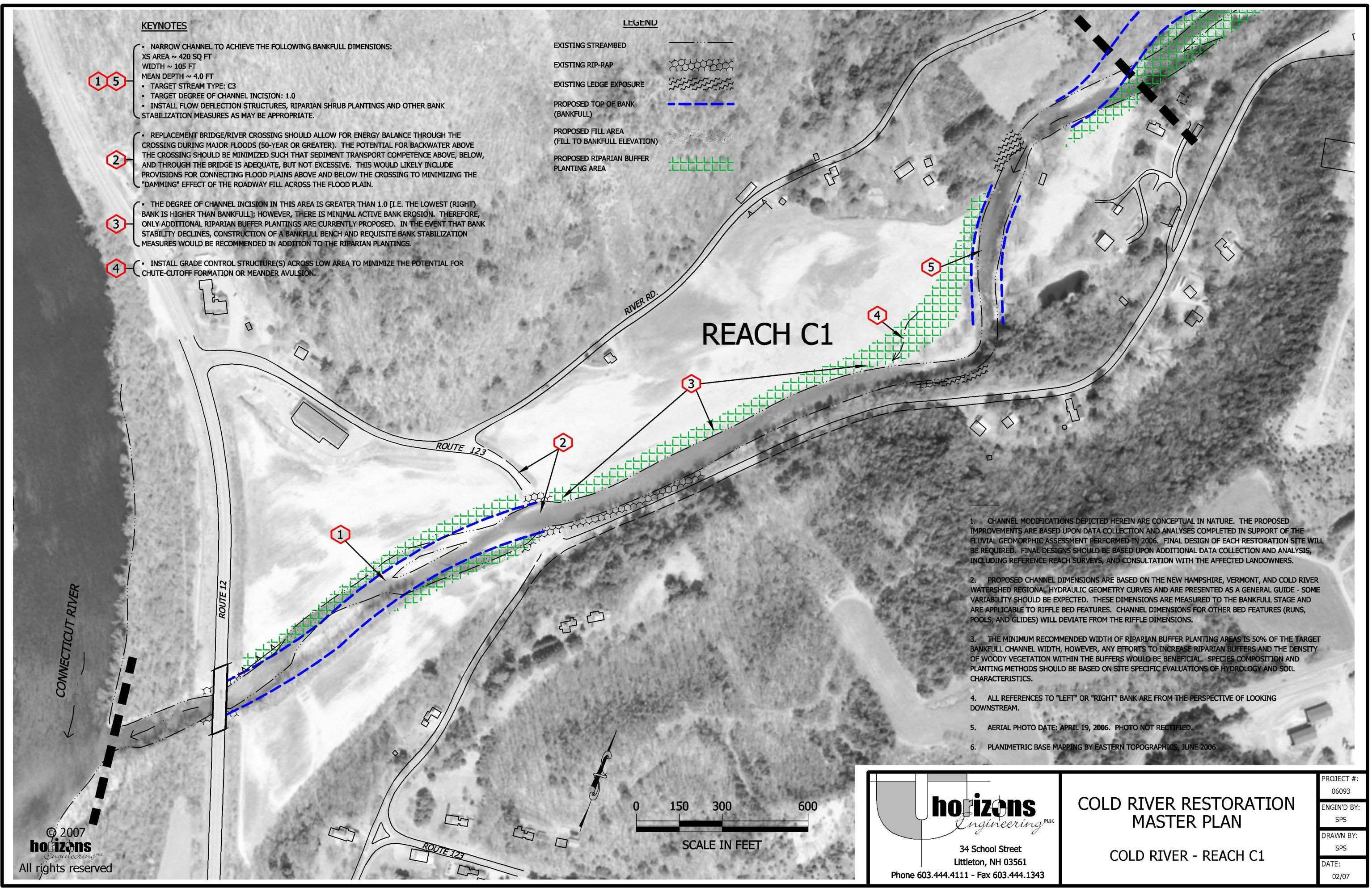
Cold River Restoration Site Plans

KEYNOTES

- 1 5 • NARROW CHANNEL TO ACHIEVE THE FOLLOWING BANKFULL DIMENSIONS:
XS AREA ~ 420 SQ FT
WIDTH ~ 105 FT
MEAN DEPTH ~ 4.0 FT
• TARGET STREAM TYPE: C3
• TARGET DEGREE OF CHANNEL INCISION: 1.0
• INSTALL FLOW DEFLECTION STRUCTURES, RIPARIAN SHRUB PLANTINGS AND OTHER BANK STABILIZATION MEASURES AS MAY BE APPROPRIATE.
- 2 • REPLACEMENT BRIDGE/RIVER CROSSING SHOULD ALLOW FOR ENERGY BALANCE THROUGH THE CROSSING DURING MAJOR FLOODS (50-YEAR OR GREATER). THE POTENTIAL FOR BACKWATER ABOVE THE CROSSING SHOULD BE MINIMIZED SUCH THAT SEDIMENT TRANSPORT COMPETENCE ABOVE, BELOW, AND THROUGH THE BRIDGE IS ADEQUATE, BUT NOT EXCESSIVE. THIS WOULD LIKELY INCLUDE PROVISIONS FOR CONNECTING FLOOD PLAINS ABOVE AND BELOW THE CROSSING TO MINIMIZING THE "DAMMING" EFFECT OF THE ROADWAY FILL ACROSS THE FLOOD PLAIN.
- 3 • THE DEGREE OF CHANNEL INCISION IN THIS AREA IS GREATER THAN 1.0 [I.E. THE LOWEST (RIGHT) BANK IS HIGHER THAN BANKFULL]; HOWEVER, THERE IS MINIMAL ACTIVE BANK EROSION. THEREFORE, ONLY ADDITIONAL RIPARIAN BUFFER PLANTINGS ARE CURRENTLY PROPOSED. IN THE EVENT THAT BANK STABILITY DECLINES, CONSTRUCTION OF A BANKFULL BENCH AND REQUISITE BANK STABILIZATION MEASURES WOULD BE RECOMMENDED IN ADDITION TO THE RIPARIAN PLANTINGS.
- 4 • INSTALL GRADE CONTROL STRUCTURE(S) ACROSS LOW AREA TO MINIMIZE THE POTENTIAL FOR CHUTE-CUTOFF FORMATION OR MEANDER AVULSION.

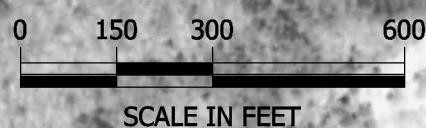
LEGEND

- EXISTING STREAMBED
- EXISTING RIP-RAP
- EXISTING LEDGE EXPOSURE
- PROPOSED TOP OF BANK (BANKFULL)
- PROPOSED FILL AREA (FILL TO BANKFULL ELEVATION)
- PROPOSED RIPARIAN BUFFER PLANTING AREA



1. CHANNEL MODIFICATIONS DEPICTED HEREIN ARE CONCEPTUAL IN NATURE. THE PROPOSED IMPROVEMENTS ARE BASED UPON DATA COLLECTION AND ANALYSES COMPLETED IN SUPPORT OF THE FLUVIAL GEOMORPHIC ASSESSMENT PERFORMED IN 2006. FINAL DESIGN OF EACH RESTORATION SITE WILL BE REQUIRED. FINAL DESIGNS SHOULD BE BASED UPON ADDITIONAL DATA COLLECTION AND ANALYSIS, INCLUDING REFERENCE REACH SURVEYS, AND CONSULTATION WITH THE AFFECTED LANDOWNERS.
2. PROPOSED CHANNEL DIMENSIONS ARE BASED ON THE NEW HAMPSHIRE, VERMONT, AND COLD RIVER WATERSHED REGIONAL HYDRAULIC GEOMETRY CURVES AND ARE PRESENTED AS A GENERAL GUIDE - SOME VARIABILITY SHOULD BE EXPECTED. THESE DIMENSIONS ARE MEASURED TO THE BANKFULL STAGE AND ARE APPLICABLE TO RIFFLE BED FEATURES. CHANNEL DIMENSIONS FOR OTHER BED FEATURES (RUNS, POOLS, AND GLIDES) WILL DEVIATE FROM THE RIFFLE DIMENSIONS.
3. THE MINIMUM RECOMMENDED WIDTH OF RIPARIAN BUFFER PLANTING AREAS IS 50% OF THE TARGET BANKFULL CHANNEL WIDTH, HOWEVER, ANY EFFORTS TO INCREASE RIPARIAN BUFFERS AND THE DENSITY OF WOODY VEGETATION WITHIN THE BUFFERS WOULD BE BENEFICIAL. SPECIES COMPOSITION AND PLANTING METHODS SHOULD BE BASED ON SITE SPECIFIC EVALUATIONS OF HYDROLOGY AND SOIL CHARACTERISTICS.
4. ALL REFERENCES TO "LEFT" OR "RIGHT" BANK ARE FROM THE PERSPECTIVE OF LOOKING DOWNSTREAM.
5. AERIAL PHOTO DATE: APRIL 19, 2006. PHOTO NOT RECTIFIED.
6. PLANIMETRIC BASE MAPPING BY EASTERN TOPOGRAPHICS, JUNE 2006

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**COLD RIVER RESTORATION
MASTER PLAN**

COLD RIVER - REACH C1

PROJECT #:	06093
ENGIN'D BY:	SPS
DRAWN BY:	SPS
DATE:	02/07

REACH C3

REACH C4

REACH C5

NOTES:

1. CHANNEL MODIFICATIONS DEPICTED HEREIN ARE CONCEPTUAL IN NATURE. THE PROPOSED IMPROVEMENTS ARE BASED UPON DATA COLLECTION AND ANALYSES COMPLETED IN SUPPORT OF THE FLUVIAL GEOMORPHIC ASSESSMENT PERFORMED IN 2006. FINAL DESIGN OF EACH RESTORATION SITE WILL BE REQUIRED. FINAL DESIGNS SHOULD BE BASED UPON ADDITIONAL DATA COLLECTION AND ANALYSIS, INCLUDING REFERENCE REACH SURVEYS, AND CONSULTATION WITH THE AFFECTED LANDOWNERS.
2. PROPOSED CHANNEL DIMENSIONS ARE BASED ON THE NEW HAMPSHIRE, VERMONT, AND COLD RIVER WATERSHED REGIONAL HYDRAULIC GEOMETRY CURVES AND ARE PRESENTED AS A GENERAL GUIDE - SOME VARIABILITY SHOULD BE EXPECTED. THESE DIMENSIONS ARE MEASURED TO THE BANKFULL STAGE AND ARE APPLICABLE TO RIFFLE BED FEATURES. CHANNEL DIMENSIONS FOR OTHER BED FEATURES (RUNS, POOLS, AND GLIDES) WILL DEVIATE FROM THE RIFFLE DIMENSIONS.
3. THE MINIMUM RECOMMENDED WIDTH OF RIPARIAN BUFFER PLANTING AREAS IS 50% OF THE TARGET BANKFULL CHANNEL WIDTH, HOWEVER, ANY EFFORTS TO INCREASE RIPARIAN BUFFERS AND THE DENSITY OF WOODY VEGETATION WITHIN THE BUFFERS WOULD BE BENEFICIAL. SPECIES COMPOSITION AND PLANTING METHODS SHOULD BE BASED ON SITE SPECIFIC EVALUATIONS OF HYDROLOGY AND SOIL CHARACTERISTICS.
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6. PLANIMETRIC BASE MAPPING BY EASTERN TOPOGRAPHICS, JUNE 2006

KEYNOTES

- 1**
 - INCREASE THE DENSITY OF RIPARIAN VEGETATION WHERE RIVER ROAD PARALLELS THE RIVER BY INSTALLING ADDITIONAL WOODY PLANTINGS ON THE RIVERBANK. THESE SHOULD BE SHADE TOLERANT SPECIES SUCH AS NORTHERN ARROWWOOD.
 - CONSIDER ROADWAY DRAINAGE MODIFICATIONS WHICH MINIMIZE THE AMOUNT OF SURFACE RUNOFF FLOWING DIRECTLY OVER THE BANK.
- 2**
 - NARROW CHANNEL, PRIMARILY THROUGH FILLING ALONG THE LEFT BANK, TO ACHIEVE THE FOLLOWING BANKFULL CHANNEL DIMENSIONS:
XS AREA ~ 390 SQ FT
WIDTH ~ 100 FT
MEAN DEPTH ~ 3.9 FT
 - TARGET STREAM TYPE: C3
 - TARGET DEGREE OF CHANNEL INCISION: 1.0
 - INSTALL FLOW DEFLECTION STRUCTURES, EMBEDDED WOODY DEBRIS, RIPARIAN SHRUB PLANTINGS, AND OTHER BANK STABILIZATION MEASURES AS MAY BE NECESSARY ALONG THE LEFT BANK. A BROAD RIPARIAN BUFFER IS WARRANTED IN THIS AREA AS IT IS THE PRIMARY FLOW PATH FOR OVERBANK FLOODWATERS.
 - CONSTRUCT A 20-FOOT WIDE BANKFULL BENCH ALONG THE RIGHT BANK DOWNSTREAM FROM GREAT BROOK TO THE EXISTING FORESTED AREA ALONG WITH FLOW DEFLECTION STRUCTURES, EMBEDDED WOODY DEBRIS, RIPARIAN SHRUB PLANTINGS, AND OTHER BANK STABILIZATION MEASURES AS MAY BE APPROPRIATE.
- 3**
 - NARROW CHANNEL, PRIMARILY THROUGH FILLING ALONG THE RIGHT BANK, TO ACHIEVE THE FOLLOWING BANKFULL CHANNEL DIMENSIONS:
XS AREA ~ 350 SQ FT
WIDTH ~ 92 FT
MEAN DEPTH ~ 3.8 FT
 - TARGET STREAM TYPE: C3
 - TARGET DEGREE OF CHANNEL INCISION: 1.0
- 4**
 - CONSTRUCT A MINIMUM 20-FOOT WIDE BANKFULL BENCH ALONG THE RIGHT BANK BETWEEN THE DOWNSTREAM OF EXPOSED LEDGE TO THE UPSTREAM END OF EXISTING RIP-RAP. INSTALL FLOW DEFLECTION STRUCTURES, EMBEDDED WOODY DEBRIS, RIPARIAN SHRUB PLANTINGS, AND OTHER BANK STABILIZATION MEASURES AS MAY BE APPROPRIATE.



LEGEND

- EXISTING STREAMBED
- EXISTING RIP-RAP
- EXISTING LEDGE EXPOSURE
- PROPOSED TOP OF BANK (BANKFULL)
- PROPOSED FILL AREA (FILL TO BANKFULL ELEVATION)
- PROPOSED RIPARIAN BUFFER PLANTING AREA

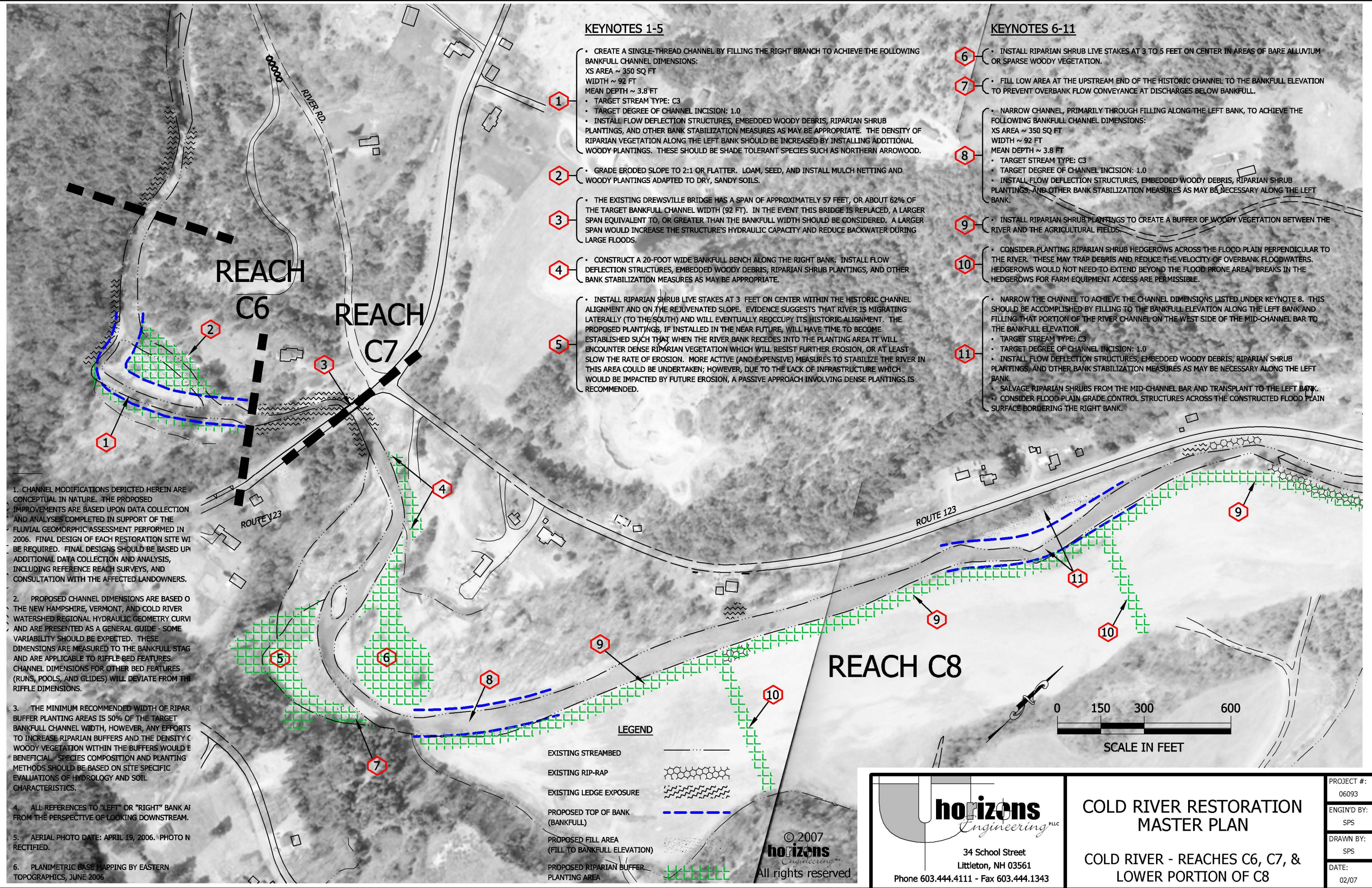
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COLD RIVER RESTORATION MASTER PLAN

COLD RIVER - REACHES C3 - C5

PROJECT #:	06093
ENGIN'D BY:	SPS
DRAWN BY:	SPS
DATE:	02/07



KEYNOTES 1-5

- 1. CREATE A SINGLE-THREAD CHANNEL BY FILLING THE RIGHT BRANCH TO ACHIEVE THE FOLLOWING BANKFULL CHANNEL DIMENSIONS:
 XS AREA ~ 350 SQ FT
 WIDTH ~ 92 FT
 MEAN DEPTH ~ 3.8 FT
 • TARGET STREAM TYPE: C3
 • TARGET DEGREE OF CHANNEL INCISION: 1.0
 • INSTALL FLOW DEFLECTION STRUCTURES, EMBEDDED WOODY DEBRIS, RIPARIAN SHRUB PLANTINGS, AND OTHER BANK STABILIZATION MEASURES AS MAY BE APPROPRIATE. THE DENSITY OF RIPARIAN VEGETATION ALONG THE LEFT BANK SHOULD BE INCREASED BY INSTALLING ADDITIONAL WOODY PLANTINGS. THESE SHOULD BE SHADE TOLERANT SPECIES SUCH AS NORTHERN ARROWOOD.
- 2. GRADE ERODED SLOPE TO 2:1 OR FLATTER. LOAM, SEED, AND INSTALL MULCH NETTING AND WOODY PLANTINGS ADAPTED TO DRY, SANDY SOILS.
- 3. THE EXISTING DREWSVILLE BRIDGE HAS A SPAN OF APPROXIMATELY 57 FEET, OR ABOUT 62% OF THE TARGET BANKFULL CHANNEL WIDTH (92 FT). IN THE EVENT THIS BRIDGE IS REPLACED, A LARGER SPAN EQUIVALENT TO, OR GREATER THAN THE BANKFULL WIDTH SHOULD BE CONSIDERED. A LARGER SPAN WOULD INCREASE THE STRUCTURE'S HYDRAULIC CAPACITY AND REDUCE BACKWATER DURING LARGE FLOODS.
- 4. CONSTRUCT A 20-FOOT WIDE BANKFULL BENCH ALONG THE RIGHT BANK. INSTALL FLOW DEFLECTION STRUCTURES, EMBEDDED WOODY DEBRIS, RIPARIAN SHRUB PLANTINGS, AND OTHER BANK STABILIZATION MEASURES AS MAY BE APPROPRIATE.
- 5. INSTALL RIPARIAN SHRUB LIVE STAKES AT 3 FEET ON CENTER WITHIN THE HISTORIC CHANNEL ALIGNMENT AND ON THE REJUVENATED SLOPE. EVIDENCE SUGGESTS THAT RIVER IS MIGRATING LATERALLY (TO THE SOUTH) AND WILL EVENTUALLY REOCCUPY ITS HISTORIC ALIGNMENT. THE PROPOSED PLANTINGS, IF INSTALLED IN THE NEAR FUTURE, WILL HAVE TIME TO BECOME ESTABLISHED SUCH THAT WHEN THE RIVER BANK RECEDES INTO THE PLANTING AREA IT WILL ENCOUNTER DENSE RIPARIAN VEGETATION WHICH WILL RESIST FURTHER EROSION, OR AT LEAST SLOW THE RATE OF EROSION. MORE ACTIVE (AND EXPENSIVE) MEASURES TO STABILIZE THE RIVER IN THIS AREA COULD BE UNDERTAKEN; HOWEVER, DUE TO THE LACK OF INFRASTRUCTURE WHICH WOULD BE IMPACTED BY FUTURE EROSION, A PASSIVE APPROACH INVOLVING DENSE PLANTINGS IS RECOMMENDED.

KEYNOTES 6-11

- 6. INSTALL RIPARIAN SHRUB LIVE STAKES AT 3 TO 5 FEET ON CENTER IN AREAS OF BARE ALLUVIUM OR SPARSE WOODY VEGETATION.
- 7. FILL LOW AREA AT THE UPSTREAM END OF THE HISTORIC CHANNEL TO THE BANKFULL ELEVATION TO PREVENT OVERBANK FLOW CONVEYANCE AT DISCHARGES BELOW BANKFULL.
- 8. NARROW CHANNEL, PRIMARILY THROUGH FILLING ALONG THE LEFT BANK, TO ACHIEVE THE FOLLOWING BANKFULL CHANNEL DIMENSIONS:
 XS AREA ~ 350 SQ FT
 WIDTH ~ 92 FT
 MEAN DEPTH ~ 3.8 FT
 • TARGET STREAM TYPE: C3
 • TARGET DEGREE OF CHANNEL INCISION: 1.0
 • INSTALL FLOW DEFLECTION STRUCTURES, EMBEDDED WOODY DEBRIS, RIPARIAN SHRUB PLANTINGS, AND OTHER BANK STABILIZATION MEASURES AS MAY BE NECESSARY ALONG THE LEFT BANK.
- 9. INSTALL RIPARIAN SHRUB PLANTINGS TO CREATE A BUFFER OF WOODY VEGETATION BETWEEN THE RIVER AND THE AGRICULTURAL FIELDS.
- 10. CONSIDER PLANTING RIPARIAN SHRUB HEDGEROWS ACROSS THE FLOOD PLAIN PERPENDICULAR TO THE RIVER. THESE MAY TRAP DEBRIS AND REDUCE THE VELOCITY OF OVERBANK FLOODWATERS. HEDGEROWS WOULD NOT NEED TO EXTEND BEYOND THE FLOOD PRONE AREA. BREAKS IN THE HEDGEROWS FOR FARM EQUIPMENT ACCESS ARE PERMISSIBLE.
- 11. NARROW THE CHANNEL TO ACHIEVE THE CHANNEL DIMENSIONS LISTED UNDER KEYNOTE 8. THIS SHOULD BE ACCOMPLISHED BY FILLING TO THE BANKFULL ELEVATION ALONG THE LEFT BANK AND FILLING THAT PORTION OF THE RIVER CHANNEL ON THE WEST SIDE OF THE MID-CHANNEL BAR TO THE BANKFULL ELEVATION.
 • TARGET STREAM TYPE: C3
 • TARGET DEGREE OF CHANNEL INCISION: 1.0
 • INSTALL FLOW DEFLECTION STRUCTURES, EMBEDDED WOODY DEBRIS, RIPARIAN SHRUB PLANTINGS, AND OTHER BANK STABILIZATION MEASURES AS MAY BE NECESSARY ALONG THE LEFT BANK.
 • SALVAGE RIPARIAN SHRUBS FROM THE MID-CHANNEL BAR AND TRANSPLANT TO THE LEFT BANK.
 • CONSIDER FLOOD PLAIN GRADE CONTROL STRUCTURES ACROSS THE CONSTRUCTED FLOOD PLAIN SURFACE BORDERING THE RIGHT BANK.

1. CHANNEL MODIFICATIONS DEPICTED HEREIN ARE CONCEPTUAL IN NATURE. THE PROPOSED IMPROVEMENTS ARE BASED UPON DATA COLLECTION AND ANALYSES COMPLETED IN SUPPORT OF THE FLUVIAL GEOMORPHIC ASSESSMENT PERFORMED IN 2006. FINAL DESIGN OF EACH RESTORATION SITE WILL BE REQUIRED. FINAL DESIGNS SHOULD BE BASED UPON ADDITIONAL DATA COLLECTION AND ANALYSIS, INCLUDING REFERENCE REACH SURVEYS, AND CONSULTATION WITH THE AFFECTED LANDOWNERS.

2. PROPOSED CHANNEL DIMENSIONS ARE BASED ON THE NEW HAMPSHIRE, VERMONT, AND COLD RIVER WATERSHED REGIONAL HYDRAULIC GEOMETRY CURVE AND ARE PRESENTED AS A GENERAL GUIDE - SOME VARIABILITY SHOULD BE EXPECTED. THESE DIMENSIONS ARE MEASURED TO THE BANKFULL STAG AND ARE APPLICABLE TO RIFFLE BED FEATURES. CHANNEL DIMENSIONS FOR OTHER BED FEATURES (RUNS, POOLS, AND GLIDES) WILL DEVIATE FROM THE RIFFLE DIMENSIONS.

3. THE MINIMUM RECOMMENDED WIDTH OF RIPARIAN BUFFER PLANTING AREAS IS 50% OF THE TARGET BANKFULL CHANNEL WIDTH, HOWEVER, ANY EFFORTS TO INCREASE RIPARIAN BUFFERS AND THE DENSITY OF WOODY VEGETATION WITHIN THE BUFFERS WOULD BE BENEFICIAL. SPECIES COMPOSITION AND PLANTING METHODS SHOULD BE BASED ON SITE SPECIFIC EVALUATIONS OF HYDROLOGY AND SOIL CHARACTERISTICS.

4. ALL REFERENCES TO "LEFT" OR "RIGHT" BANK ARE FROM THE PERSPECTIVE OF LOOKING DOWNSTREAM.

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6. PLANIMETRIC BASE MAPPING BY EASTERN TOPOGRAPHICS, JUNE 2006

LEGEND

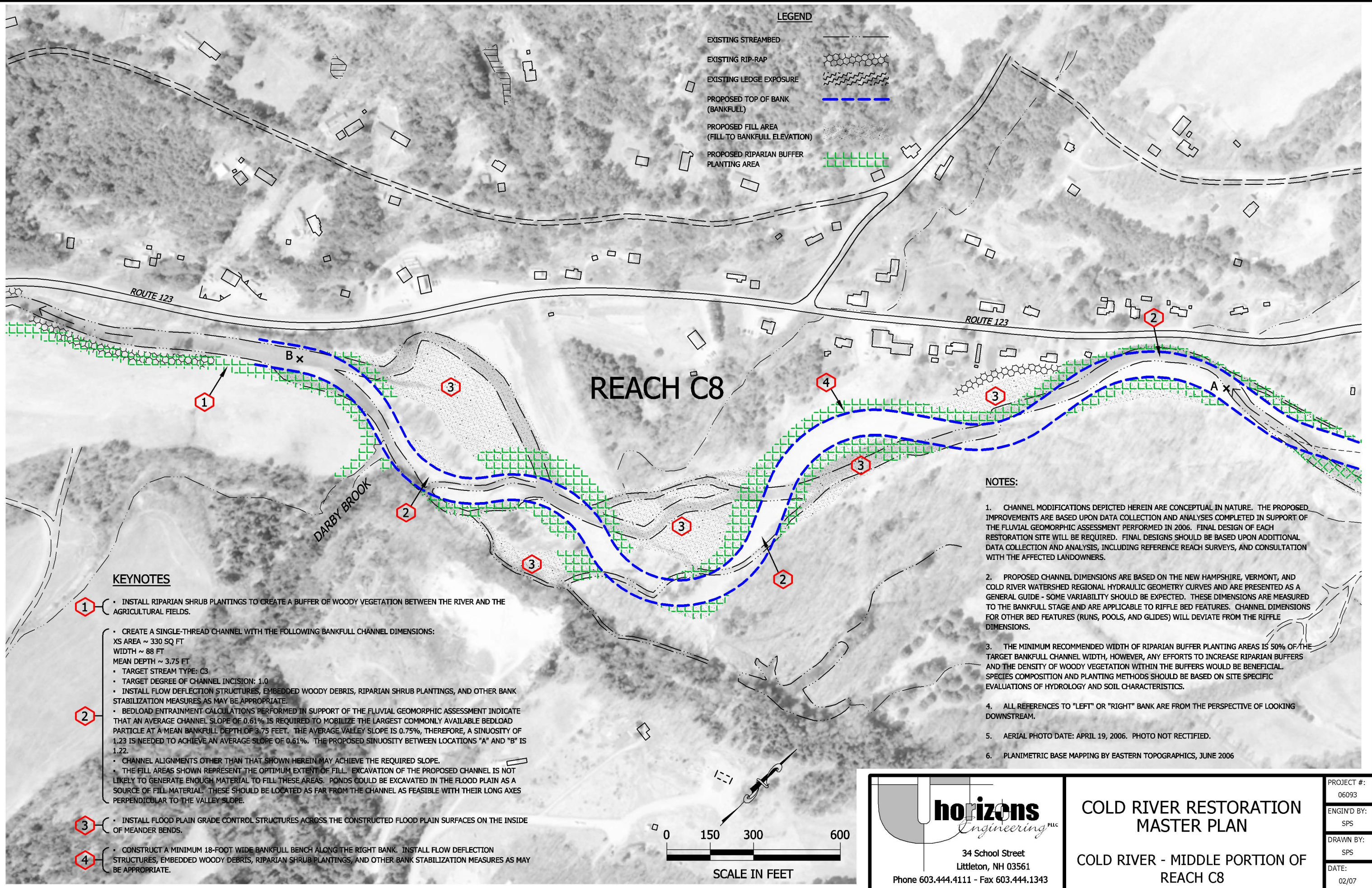
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PROPOSED TOP OF BANK (BANKFULL)	
PROPOSED FILL AREA (FILL TO BANKFULL ELEVATION)	
PROPOSED RIPARIAN BUFFER PLANTING AREA	

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**COLD RIVER RESTORATION
 MASTER PLAN**
 COLD RIVER - REACHES C6, C7, &
 LOWER PORTION OF C8

PROJECT #:	06093
ENGIN'D BY:	SPS
DRAWN BY:	SPS
DATE:	02/07



LEGEND

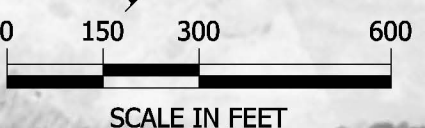
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- EXISTING LEDGE EXPOSURE
- PROPOSED TOP OF BANK (BANKFULL)
- PROPOSED FILL AREA (FILL TO BANKFULL ELEVATION)
- PROPOSED RIPARIAN BUFFER PLANTING AREA

KEYNOTES

- 1. INSTALL RIPARIAN SHRUB PLANTINGS TO CREATE A BUFFER OF WOODY VEGETATION BETWEEN THE RIVER AND THE AGRICULTURAL FIELDS.
- 2. CREATE A SINGLE-THREAD CHANNEL WITH THE FOLLOWING BANKFULL CHANNEL DIMENSIONS:
 XS AREA ~ 330 SQ FT
 WIDTH ~ 88 FT
 MEAN DEPTH ~ 3.75 FT
 TARGET STREAM TYPE: C3
 TARGET DEGREE OF CHANNEL INCISION: 1.0
 INSTALL FLOW DEFLECTION STRUCTURES, EMBEDDED WOODY DEBRIS, RIPARIAN SHRUB PLANTINGS, AND OTHER BANK STABILIZATION MEASURES AS MAY BE APPROPRIATE.
 BEDLOAD ENTRAINMENT CALCULATIONS PERFORMED IN SUPPORT OF THE FLUVIAL GEOMORPHIC ASSESSMENT INDICATE THAT AN AVERAGE CHANNEL SLOPE OF 0.61% IS REQUIRED TO MOBILIZE THE LARGEST COMMONLY AVAILABLE BEDLOAD PARTICLE AT A MEAN BANKFULL DEPTH OF 3.75 FEET. THE AVERAGE VALLEY SLOPE IS 0.75%, THEREFORE, A SINUOSITY OF 1.23 IS NEEDED TO ACHIEVE AN AVERAGE SLOPE OF 0.61%. THE PROPOSED SINUOSITY BETWEEN LOCATIONS "A" AND "B" IS 1.22.
 CHANNEL ALIGNMENTS OTHER THAN THAT SHOWN HEREIN MAY ACHIEVE THE REQUIRED SLOPE.
 THE FILL AREAS SHOWN REPRESENT THE OPTIMUM EXTENT OF FILL. EXCAVATION OF THE PROPOSED CHANNEL IS NOT LIKELY TO GENERATE ENOUGH MATERIAL TO FILL THESE AREAS. PONDS COULD BE EXCAVATED IN THE FLOOD PLAIN AS A SOURCE OF FILL MATERIAL. THESE SHOULD BE LOCATED AS FAR FROM THE CHANNEL AS FEASIBLE WITH THEIR LONG AXES PERPENDICULAR TO THE VALLEY SLOPE.
- 3. INSTALL FLOOD PLAIN GRADE CONTROL STRUCTURES ACROSS THE CONSTRUCTED FLOOD PLAIN SURFACES ON THE INSIDE OF MEANDER BENDS.
- 4. CONSTRUCT A MINIMUM 18-FOOT WIDE BANKFULL BENCH ALONG THE RIGHT BANK. INSTALL FLOW DEFLECTION STRUCTURES, EMBEDDED WOODY DEBRIS, RIPARIAN SHRUB PLANTINGS, AND OTHER BANK STABILIZATION MEASURES AS MAY BE APPROPRIATE.

NOTES:

1. CHANNEL MODIFICATIONS DEPICTED HEREIN ARE CONCEPTUAL IN NATURE. THE PROPOSED IMPROVEMENTS ARE BASED UPON DATA COLLECTION AND ANALYSES COMPLETED IN SUPPORT OF THE FLUVIAL GEOMORPHIC ASSESSMENT PERFORMED IN 2006. FINAL DESIGN OF EACH RESTORATION SITE WILL BE REQUIRED. FINAL DESIGNS SHOULD BE BASED UPON ADDITIONAL DATA COLLECTION AND ANALYSIS, INCLUDING REFERENCE REACH SURVEYS, AND CONSULTATION WITH THE AFFECTED LANDOWNERS.
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**COLD RIVER RESTORATION
MASTER PLAN**

COLD RIVER - MIDDLE PORTION OF
REACH C8

PROJECT #:	06093
ENGIN'D BY:	SPS
DRAWN BY:	SPS
DATE:	02/07

NOTES:

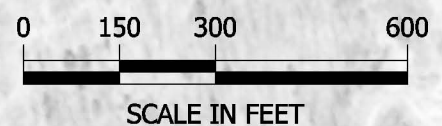
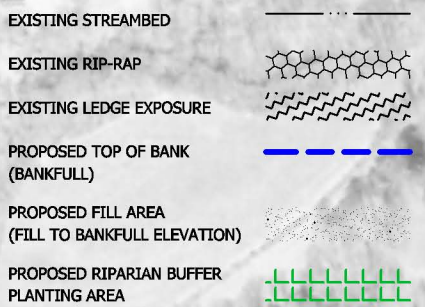
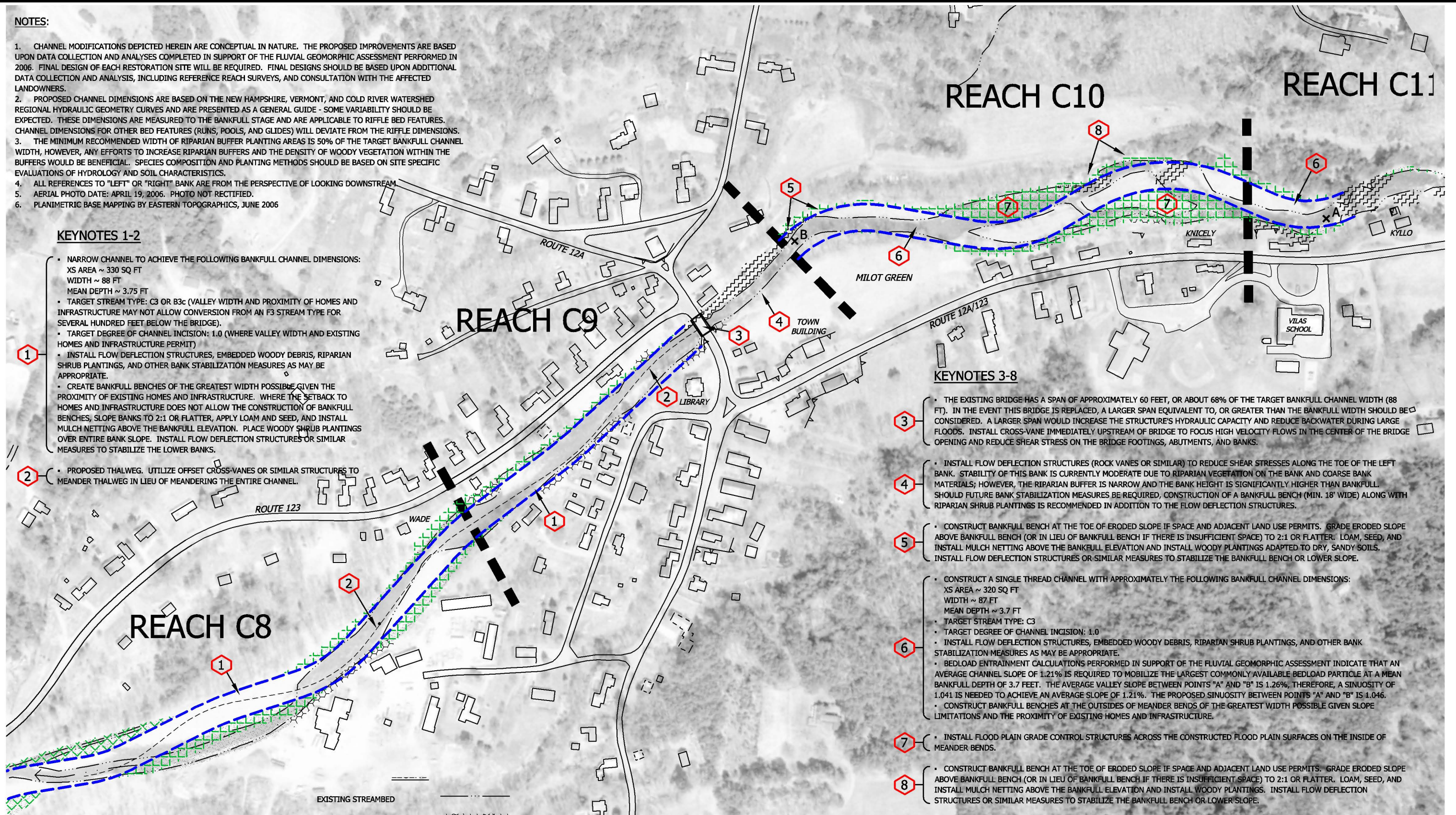
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2. PROPOSED CHANNEL DIMENSIONS ARE BASED ON THE NEW HAMPSHIRE, VERMONT, AND COLD RIVER WATERSHED REGIONAL HYDRAULIC GEOMETRY CURVES AND ARE PRESENTED AS A GENERAL GUIDE - SOME VARIABILITY SHOULD BE EXPECTED. THESE DIMENSIONS ARE MEASURED TO THE BANKFULL STAGE AND ARE APPLICABLE TO RIFFLE BED FEATURES. CHANNEL DIMENSIONS FOR OTHER BED FEATURES (RUNS, POOLS, AND GLIDES) WILL DEVIATE FROM THE RIFFLE DIMENSIONS.
3. THE MINIMUM RECOMMENDED WIDTH OF RIPARIAN BUFFER PLANTING AREAS IS 50% OF THE TARGET BANKFULL CHANNEL WIDTH, HOWEVER, ANY EFFORTS TO INCREASE RIPARIAN BUFFERS AND THE DENSITY OF WOODY VEGETATION WITHIN THE BUFFERS WOULD BE BENEFICIAL. SPECIES COMPOSITION AND PLANTING METHODS SHOULD BE BASED ON SITE SPECIFIC EVALUATIONS OF HYDROLOGY AND SOIL CHARACTERISTICS.
4. ALL REFERENCES TO "LEFT" OR "RIGHT" BANK ARE FROM THE PERSPECTIVE OF LOOKING DOWNSTREAM.
5. AERIAL PHOTO DATE: APRIL 19, 2006. PHOTO NOT RECTIFIED.
6. PLANIMETRIC BASE MAPPING BY EASTERN TOPOGRAPHICS, JUNE 2006

KEYNOTES 1-2

- 1. NARROW CHANNEL TO ACHIEVE THE FOLLOWING BANKFULL CHANNEL DIMENSIONS:
XS AREA ~ 330 SQ FT
WIDTH ~ 88 FT
MEAN DEPTH ~ 3.75 FT
- 2. TARGET STREAM TYPE: C3 OR B3c (VALLEY WIDTH AND PROXIMITY OF HOMES AND INFRASTRUCTURE MAY NOT ALLOW CONVERSION FROM AN F3 STREAM TYPE FOR SEVERAL HUNDRED FEET BELOW THE BRIDGE).
- 3. TARGET DEGREE OF CHANNEL INCISION: 1.0 (WHERE VALLEY WIDTH AND EXISTING HOMES AND INFRASTRUCTURE PERMIT)
- 4. INSTALL FLOW DEFLECTION STRUCTURES, EMBEDDED WOODY DEBRIS, RIPARIAN SHRUB PLANTINGS, AND OTHER BANK STABILIZATION MEASURES AS MAY BE APPROPRIATE.
- 5. CREATE BANKFULL BENCHES OF THE GREATEST WIDTH POSSIBLE GIVEN THE PROXIMITY OF EXISTING HOMES AND INFRASTRUCTURE. WHERE THE SETBACK TO HOMES AND INFRASTRUCTURE DOES NOT ALLOW THE CONSTRUCTION OF BANKFULL BENCHES, SLOPE BANKS TO 2:1 OR FLATTER, APPLY LOAM AND SEED, AND INSTALL MULCH NETTING ABOVE THE BANKFULL ELEVATION. PLACE WOODY SHRUB PLANTINGS OVER ENTIRE BANK SLOPE. INSTALL FLOW DEFLECTION STRUCTURES OR SIMILAR MEASURES TO STABILIZE THE LOWER BANKS.
- 6. PROPOSED THALWEG. UTILIZE OFFSET CROSS-VANES OR SIMILAR STRUCTURES TO MEANDER THALWEG IN LIEU OF MEANDERING THE ENTIRE CHANNEL.

KEYNOTES 3-8

- 3. THE EXISTING BRIDGE HAS A SPAN OF APPROXIMATELY 60 FEET, OR ABOUT 68% OF THE TARGET BANKFULL CHANNEL WIDTH (88 FT). IN THE EVENT THIS BRIDGE IS REPLACED, A LARGER SPAN EQUIVALENT TO, OR GREATER THAN THE BANKFULL WIDTH SHOULD BE CONSIDERED. A LARGER SPAN WOULD INCREASE THE STRUCTURE'S HYDRAULIC CAPACITY AND REDUCE BACKWATER DURING LARGE FLOODS. INSTALL CROSS-VANE IMMEDIATELY UPSTREAM OF BRIDGE TO FOCUS HIGH VELOCITY FLOWS IN THE CENTER OF THE BRIDGE OPENING AND REDUCE SHEAR STRESS ON THE BRIDGE FOOTINGS, ABUTMENTS, AND BANKS.
- 4. INSTALL FLOW DEFLECTION STRUCTURES (ROCK VANES OR SIMILAR) TO REDUCE SHEAR STRESSES ALONG THE TOE OF THE LEFT BANK. STABILITY OF THIS BANK IS CURRENTLY MODERATE DUE TO RIPARIAN VEGETATION ON THE BANK AND COARSE BANK MATERIALS; HOWEVER, THE RIPARIAN BUFFER IS NARROW AND THE BANK HEIGHT IS SIGNIFICANTLY HIGHER THAN BANKFULL. SHOULD FUTURE BANK STABILIZATION MEASURES BE REQUIRED, CONSTRUCTION OF A BANKFULL BENCH (MIN. 18' WIDE) ALONG WITH RIPARIAN SHRUB PLANTINGS IS RECOMMENDED IN ADDITION TO THE FLOW DEFLECTION STRUCTURES.
- 5. CONSTRUCT BANKFULL BENCH AT THE TOE OF ERODED SLOPE IF SPACE AND ADJACENT LAND USE PERMITS. GRADE ERODED SLOPE ABOVE BANKFULL BENCH (OR IN LIEU OF BANKFULL BENCH IF THERE IS INSUFFICIENT SPACE) TO 2:1 OR FLATTER. LOAM, SEED, AND INSTALL MULCH NETTING ABOVE THE BANKFULL ELEVATION AND INSTALL WOODY PLANTINGS ADAPTED TO DRY, SANDY SOILS. INSTALL FLOW DEFLECTION STRUCTURES OR SIMILAR MEASURES TO STABILIZE THE BANKFULL BENCH OR LOWER SLOPE.
- 6. CONSTRUCT A SINGLE THREAD CHANNEL WITH APPROXIMATELY THE FOLLOWING BANKFULL CHANNEL DIMENSIONS:
XS AREA ~ 320 SQ FT
WIDTH ~ 87 FT
MEAN DEPTH ~ 3.7 FT
TARGET STREAM TYPE: C3
TARGET DEGREE OF CHANNEL INCISION: 1.0
- 7. INSTALL FLOW DEFLECTION STRUCTURES, EMBEDDED WOODY DEBRIS, RIPARIAN SHRUB PLANTINGS, AND OTHER BANK STABILIZATION MEASURES AS MAY BE APPROPRIATE.
- 8. BEDLOAD ENTRAINMENT CALCULATIONS PERFORMED IN SUPPORT OF THE FLUVIAL GEOMORPHIC ASSESSMENT INDICATE THAT AN AVERAGE CHANNEL SLOPE OF 1.21% IS REQUIRED TO MOBILIZE THE LARGEST COMMONLY AVAILABLE BEDLOAD PARTICLE AT A MEAN BANKFULL DEPTH OF 3.7 FEET. THE AVERAGE VALLEY SLOPE BETWEEN POINTS "A" AND "B" IS 1.26%, THEREFORE, A SINUOSITY OF 1.041 IS NEEDED TO ACHIEVE AN AVERAGE SLOPE OF 1.21%. THE PROPOSED SINUOSITY BETWEEN POINTS "A" AND "B" IS 1.046.
- 9. CONSTRUCT BANKFULL BENCHES AT THE OUTSIDES OF MEANDER BENDS OF THE GREATEST WIDTH POSSIBLE GIVEN SLOPE LIMITATIONS AND THE PROXIMITY OF EXISTING HOMES AND INFRASTRUCTURE.
- 10. INSTALL FLOOD PLAIN GRADE CONTROL STRUCTURES ACROSS THE CONSTRUCTED FLOOD PLAIN SURFACES ON THE INSIDE OF MEANDER BENDS.
- 11. CONSTRUCT BANKFULL BENCH AT THE TOE OF ERODED SLOPE IF SPACE AND ADJACENT LAND USE PERMITS. GRADE ERODED SLOPE ABOVE BANKFULL BENCH (OR IN LIEU OF BANKFULL BENCH IF THERE IS INSUFFICIENT SPACE) TO 2:1 OR FLATTER. LOAM, SEED, AND INSTALL MULCH NETTING ABOVE THE BANKFULL ELEVATION AND INSTALL WOODY PLANTINGS. INSTALL FLOW DEFLECTION STRUCTURES OR SIMILAR MEASURES TO STABILIZE THE BANKFULL BENCH OR LOWER SLOPE.



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**COLD RIVER RESTORATION
MASTER PLAN**

COLD RIVER - UPPER PORTION OF
REACH C8 & REACHES C9 & C10

PROJECT #:	06093
ENGINE'D BY:	SPS
DRAWN BY:	SPS
DATE:	02/07

KEYNOTES

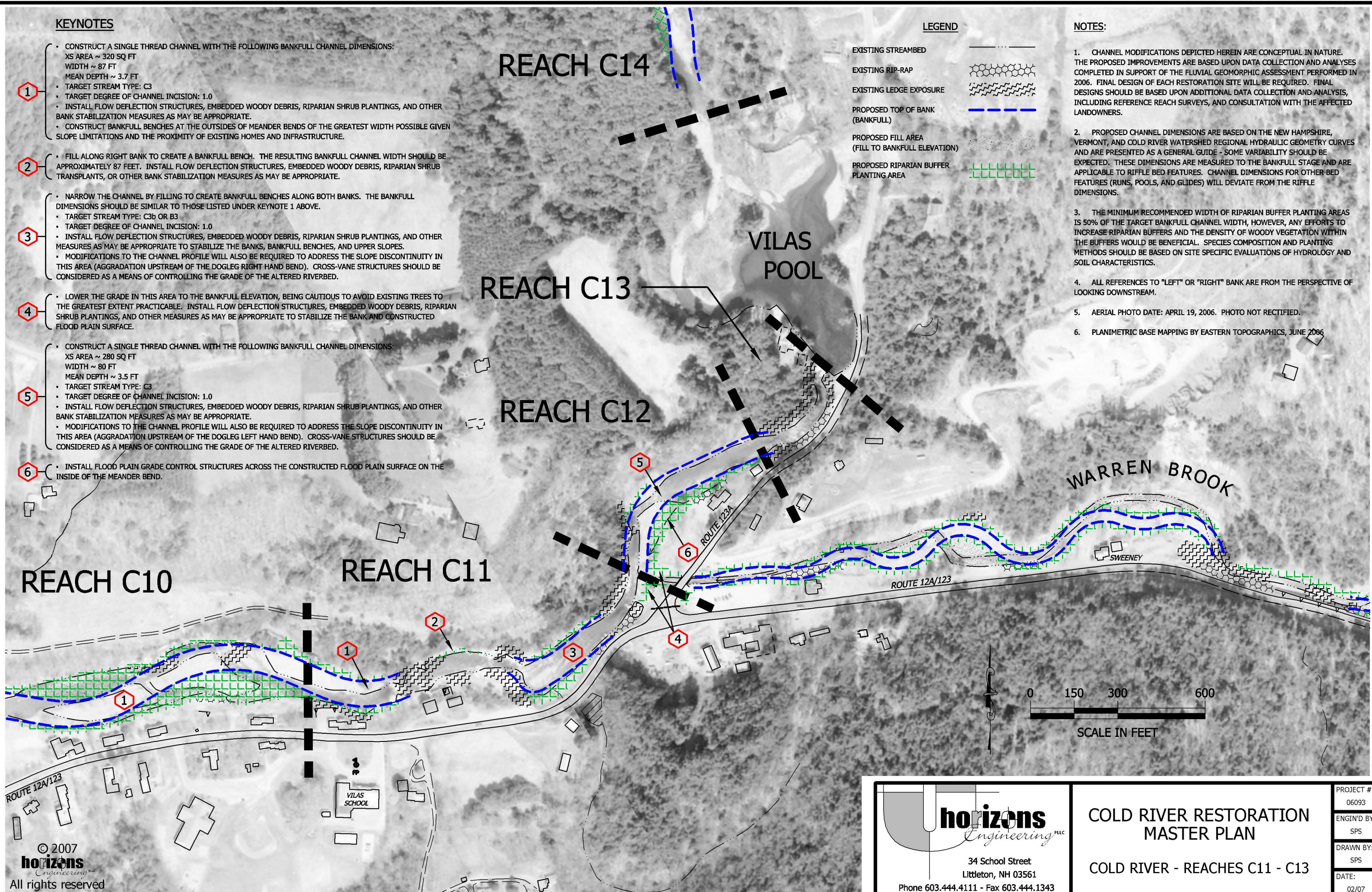
- 1. CONSTRUCT A SINGLE THREAD CHANNEL WITH THE FOLLOWING BANKFULL CHANNEL DIMENSIONS:
XS AREA ~ 320 SQ FT
WIDTH ~ 87 FT
MEAN DEPTH ~ 3.7 FT
TARGET STREAM TYPE: C3
TARGET DEGREE OF CHANNEL INCISION: 1.0
INSTALL FLOW DEFLECTION STRUCTURES, EMBEDDED WOODY DEBRIS, RIPARIAN SHRUB PLANTINGS, AND OTHER BANK STABILIZATION MEASURES AS MAY BE APPROPRIATE.
CONSTRUCT BANKFULL BENCHES AT THE OUTSIDES OF MEANDER BENDS OF THE GREATEST WIDTH POSSIBLE GIVEN SLOPE LIMITATIONS AND THE PROXIMITY OF EXISTING HOMES AND INFRASTRUCTURE.
- 2. FILL ALONG RIGHT BANK TO CREATE A BANKFULL BENCH. THE RESULTING BANKFULL CHANNEL WIDTH SHOULD BE APPROXIMATELY 87 FEET. INSTALL FLOW DEFLECTION STRUCTURES, EMBEDDED WOODY DEBRIS, RIPARIAN SHRUB TRANSPLANTS, OR OTHER BANK STABILIZATION MEASURES AS MAY BE APPROPRIATE.
- 3. NARROW THE CHANNEL BY FILLING TO CREATE BANKFULL BENCHES ALONG BOTH BANKS. THE BANKFULL DIMENSIONS SHOULD BE SIMILAR TO THOSE LISTED UNDER KEYNOTE 1 ABOVE.
TARGET STREAM TYPE: C3b OR B3
TARGET DEGREE OF CHANNEL INCISION: 1.0
INSTALL FLOW DEFLECTION STRUCTURES, EMBEDDED WOODY DEBRIS, RIPARIAN SHRUB PLANTINGS, AND OTHER MEASURES AS MAY BE APPROPRIATE TO STABILIZE THE BANKS, BANKFULL BENCHES, AND UPPER SLOPES.
MODIFICATIONS TO THE CHANNEL PROFILE WILL ALSO BE REQUIRED TO ADDRESS THE SLOPE DISCONTINUITY IN THIS AREA (AGGRADATION UPSTREAM OF THE DOGLEG RIGHT HAND BEND). CROSS-VANE STRUCTURES SHOULD BE CONSIDERED AS A MEANS OF CONTROLLING THE GRADE OF THE ALTERED RIVERBED.
- 4. LOWER THE GRADE IN THIS AREA TO THE BANKFULL ELEVATION, BEING CAUTIOUS TO AVOID EXISTING TREES TO THE GREATEST EXTENT PRACTICABLE. INSTALL FLOW DEFLECTION STRUCTURES, EMBEDDED WOODY DEBRIS, RIPARIAN SHRUB PLANTINGS, AND OTHER MEASURES AS MAY BE APPROPRIATE TO STABILIZE THE BANK AND CONSTRUCTED FLOOD PLAIN SURFACE.
- 5. CONSTRUCT A SINGLE THREAD CHANNEL WITH THE FOLLOWING BANKFULL CHANNEL DIMENSIONS:
XS AREA ~ 280 SQ FT
WIDTH ~ 80 FT
MEAN DEPTH ~ 3.5 FT
TARGET STREAM TYPE: C3
TARGET DEGREE OF CHANNEL INCISION: 1.0
INSTALL FLOW DEFLECTION STRUCTURES, EMBEDDED WOODY DEBRIS, RIPARIAN SHRUB PLANTINGS, AND OTHER BANK STABILIZATION MEASURES AS MAY BE APPROPRIATE.
MODIFICATIONS TO THE CHANNEL PROFILE WILL ALSO BE REQUIRED TO ADDRESS THE SLOPE DISCONTINUITY IN THIS AREA (AGGRADATION UPSTREAM OF THE DOGLEG LEFT HAND BEND). CROSS-VANE STRUCTURES SHOULD BE CONSIDERED AS A MEANS OF CONTROLLING THE GRADE OF THE ALTERED RIVERBED.
- 6. INSTALL FLOOD PLAIN GRADE CONTROL STRUCTURES ACROSS THE CONSTRUCTED FLOOD PLAIN SURFACE ON THE INSIDE OF THE MEANDER BEND.

LEGEND

- EXISTING STREAMBED
- EXISTING RIP-RAP
- EXISTING LEDGE EXPOSURE
- PROPOSED TOP OF BANK (BANKFULL)
- PROPOSED FILL AREA (FILL TO BANKFULL ELEVATION)
- PROPOSED RIPARIAN BUFFER PLANTING AREA

NOTES:

1. CHANNEL MODIFICATIONS DEPICTED HEREIN ARE CONCEPTUAL IN NATURE. THE PROPOSED IMPROVEMENTS ARE BASED UPON DATA COLLECTION AND ANALYSES COMPLETED IN SUPPORT OF THE FLUVIAL GEOMORPHIC ASSESSMENT PERFORMED IN 2006. FINAL DESIGN OF EACH RESTORATION SITE WILL BE REQUIRED. FINAL DESIGNS SHOULD BE BASED UPON ADDITIONAL DATA COLLECTION AND ANALYSIS, INCLUDING REFERENCE REACH SURVEYS, AND CONSULTATION WITH THE AFFECTED LANDOWNERS.
2. PROPOSED CHANNEL DIMENSIONS ARE BASED ON THE NEW HAMPSHIRE, VERMONT, AND COLD RIVER WATERSHED REGIONAL HYDRAULIC GEOMETRY CURVES AND ARE PRESENTED AS A GENERAL GUIDE - SOME VARIABILITY SHOULD BE EXPECTED. THESE DIMENSIONS ARE MEASURED TO THE BANKFULL STAGE AND ARE APPLICABLE TO RIFFLE BED FEATURES. CHANNEL DIMENSIONS FOR OTHER BED FEATURES (RUNS, POOLS, AND GLIDES) WILL DEVIATE FROM THE RIFFLE DIMENSIONS.
3. THE MINIMUM RECOMMENDED WIDTH OF RIPARIAN BUFFER PLANTING AREAS IS 50% OF THE TARGET BANKFULL CHANNEL WIDTH, HOWEVER, ANY EFFORTS TO INCREASE RIPARIAN BUFFERS AND THE DENSITY OF WOODY VEGETATION WITHIN THE BUFFERS WOULD BE BENEFICIAL. SPECIES COMPOSITION AND PLANTING METHODS SHOULD BE BASED ON SITE SPECIFIC EVALUATIONS OF HYDROLOGY AND SOIL CHARACTERISTICS.
4. ALL REFERENCES TO "LEFT" OR "RIGHT" BANK ARE FROM THE PERSPECTIVE OF LOOKING DOWNSTREAM.
5. AERIAL PHOTO DATE: APRIL 19, 2006. PHOTO NOT RECTIFIED.
6. PLANIMETRIC BASE MAPPING BY EASTERN TOPOGRAPHICS, JUNE 2006



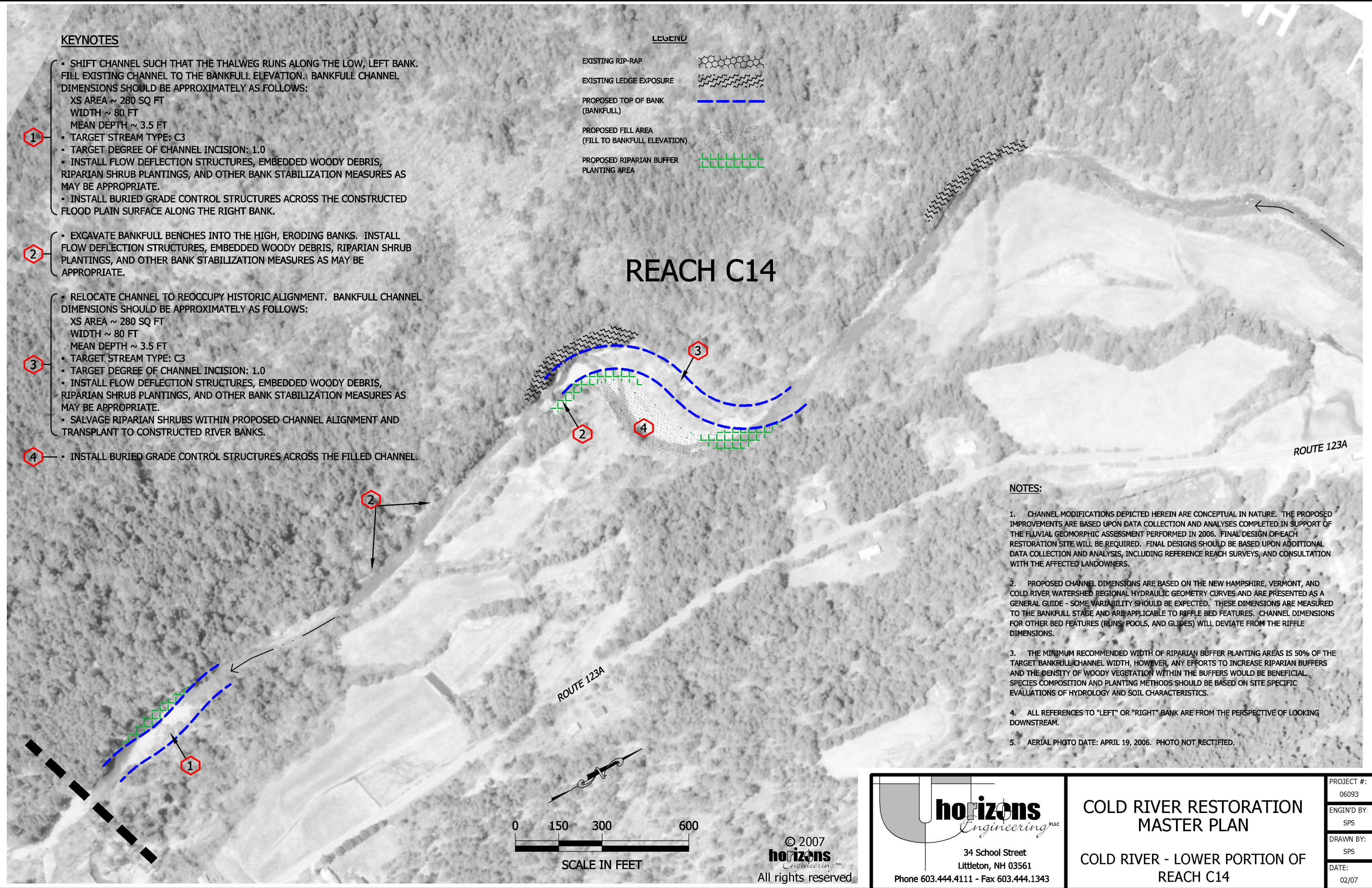
KEYNOTES

- 1. SHIFT CHANNEL SUCH THAT THE THALWEG RUNS ALONG THE LOW, LEFT BANK. FILL EXISTING CHANNEL TO THE BANKFULL ELEVATION. BANKFULL CHANNEL DIMENSIONS SHOULD BE APPROXIMATELY AS FOLLOWS:
 XS AREA ~ 280 SQ FT
 WIDTH ~ 80 FT
 MEAN DEPTH ~ 3.5 FT
 TARGET STREAM TYPE: C3
 TARGET DEGREE OF CHANNEL INCISION: 1.0
 INSTALL FLOW DEFLECTION STRUCTURES, EMBEDDED WOODY DEBRIS, RIPARIAN SHRUB PLANTINGS, AND OTHER BANK STABILIZATION MEASURES AS MAY BE APPROPRIATE.
 INSTALL BURIED GRADE CONTROL STRUCTURES ACROSS THE CONSTRUCTED FLOOD PLAIN SURFACE ALONG THE RIGHT BANK.
- 2. EXCAVATE BANKFULL BENCHES INTO THE HIGH, ERODING BANKS. INSTALL FLOW DEFLECTION STRUCTURES, EMBEDDED WOODY DEBRIS, RIPARIAN SHRUB PLANTINGS, AND OTHER BANK STABILIZATION MEASURES AS MAY BE APPROPRIATE.
- 3. RELOCATE CHANNEL TO REOCCUPY HISTORIC ALIGNMENT. BANKFULL CHANNEL DIMENSIONS SHOULD BE APPROXIMATELY AS FOLLOWS:
 XS AREA ~ 280 SQ FT
 WIDTH ~ 80 FT
 MEAN DEPTH ~ 3.5 FT
 TARGET STREAM TYPE: C3
 TARGET DEGREE OF CHANNEL INCISION: 1.0
 INSTALL FLOW DEFLECTION STRUCTURES, EMBEDDED WOODY DEBRIS, RIPARIAN SHRUB PLANTINGS, AND OTHER BANK STABILIZATION MEASURES AS MAY BE APPROPRIATE.
 SALVAGE RIPARIAN SHRUBS WITHIN PROPOSED CHANNEL ALIGNMENT AND TRANSPLANT TO CONSTRUCTED RIVER BANKS.
- 4. INSTALL BURIED GRADE CONTROL STRUCTURES ACROSS THE FILLED CHANNEL.

LEGEND

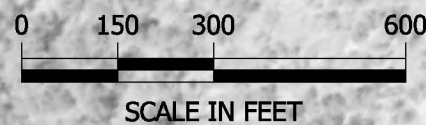
- EXISTING RIP-RAP
- EXISTING LEDGE EXPOSURE
- PROPOSED TOP OF BANK (BANKFULL)
- PROPOSED FILL AREA (FILL TO BANKFULL ELEVATION)
- PROPOSED RIPARIAN BUFFER PLANTING AREA

REACH C14



NOTES:

1. CHANNEL MODIFICATIONS DEPICTED HEREIN ARE CONCEPTUAL IN NATURE. THE PROPOSED IMPROVEMENTS ARE BASED UPON DATA COLLECTION AND ANALYSES COMPLETED IN SUPPORT OF THE FLUVIAL GEOMORPHIC ASSESSMENT PERFORMED IN 2006. FINAL DESIGN OF EACH RESTORATION SITE WILL BE REQUIRED. FINAL DESIGNS SHOULD BE BASED UPON ADDITIONAL DATA COLLECTION AND ANALYSIS, INCLUDING REFERENCE REACH SURVEYS, AND CONSULTATION WITH THE AFFECTED LANDOWNERS.
2. PROPOSED CHANNEL DIMENSIONS ARE BASED ON THE NEW HAMPSHIRE, VERMONT, AND COLD RIVER WATERSHED REGIONAL HYDRAULIC GEOMETRY CURVES AND ARE PRESENTED AS A GENERAL GUIDE - SOME VARIABILITY SHOULD BE EXPECTED. THESE DIMENSIONS ARE MEASURED TO THE BANKFULL STAGE AND ARE APPLICABLE TO RIFFLE BED FEATURES. CHANNEL DIMENSIONS FOR OTHER BED FEATURES (RUNS, POOLS, AND GLIDES) WILL DEVIATE FROM THE RIFFLE DIMENSIONS.
3. THE MINIMUM RECOMMENDED WIDTH OF RIPARIAN BUFFER PLANTING AREAS IS 50% OF THE TARGET BANKFULL CHANNEL WIDTH, HOWEVER, ANY EFFORTS TO INCREASE RIPARIAN BUFFERS AND THE DENSITY OF WOODY VEGETATION WITHIN THE BUFFERS WOULD BE BENEFICIAL. SPECIES COMPOSITION AND PLANTING METHODS SHOULD BE BASED ON SITE SPECIFIC EVALUATIONS OF HYDROLOGY AND SOIL CHARACTERISTICS.
4. ALL REFERENCES TO "LEFT" OR "RIGHT" BANK ARE FROM THE PERSPECTIVE OF LOOKING DOWNSTREAM.
5. AERIAL PHOTO DATE: APRIL 19, 2006. PHOTO NOT RECTIFIED.

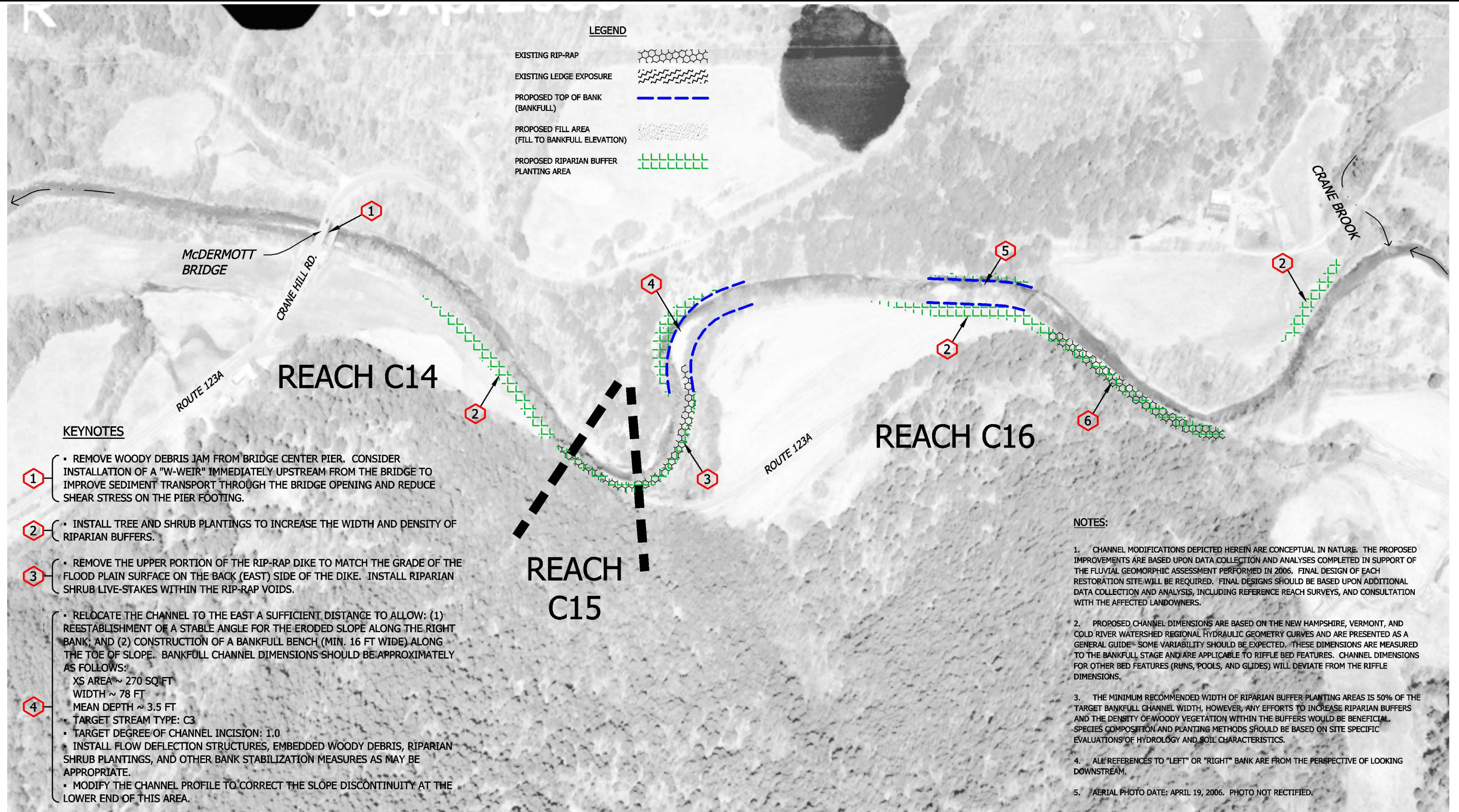


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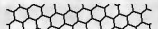


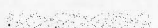
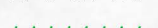
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**COLD RIVER RESTORATION
 MASTER PLAN**
 COLD RIVER - LOWER PORTION OF
 REACH C14

PROJECT #:	06093
ENGIN'D BY:	SPS
DRAWN BY:	SPS
DATE:	02/07



LEGEND

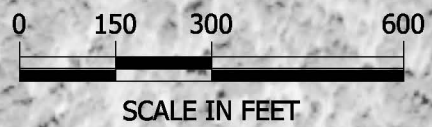
- EXISTING RIP-RAP 
- EXISTING LEDGE EXPOSURE 
- PROPOSED TOP OF BANK (BANKFULL) 
- PROPOSED FILL AREA (FILL TO BANKFULL ELEVATION) 
- PROPOSED RIPARIAN BUFFER PLANTING AREA 

KEYNOTES

- 1** - REMOVE WOODY DEBRIS JAM FROM BRIDGE CENTER PIER. CONSIDER INSTALLATION OF A "W-WEIR" IMMEDIATELY UPSTREAM FROM THE BRIDGE TO IMPROVE SEDIMENT TRANSPORT THROUGH THE BRIDGE OPENING AND REDUCE SHEAR STRESS ON THE PIER FOOTING.
- 2** - INSTALL TREE AND SHRUB PLANTINGS TO INCREASE THE WIDTH AND DENSITY OF RIPARIAN BUFFERS.
- 3** - REMOVE THE UPPER PORTION OF THE RIP-RAP DIKE TO MATCH THE GRADE OF THE FLOOD PLAIN SURFACE ON THE BACK (EAST) SIDE OF THE DIKE. INSTALL RIPARIAN SHRUB LIVE-STAKES WITHIN THE RIP-RAP VOIDS.
- 4** - RELOCATE THE CHANNEL TO THE EAST A SUFFICIENT DISTANCE TO ALLOW: (1) REESTABLISHMENT OF A STABLE ANGLE FOR THE ERODED SLOPE ALONG THE RIGHT BANK; AND (2) CONSTRUCTION OF A BANKFULL BENCH (MIN. 16 FT WIDE) ALONG THE TOE OF SLOPE. BANKFULL CHANNEL DIMENSIONS SHOULD BE APPROXIMATELY AS FOLLOWS:
 XS AREA ~ 270 SQ FT
 WIDTH ~ 78 FT
 MEAN DEPTH ~ 3.5 FT
 TARGET STREAM TYPE: C3
 TARGET DEGREE OF CHANNEL INCISION: 1.0
 INSTALL FLOW DEFLECTION STRUCTURES, EMBEDDED WOODY DEBRIS, RIPARIAN SHRUB PLANTINGS, AND OTHER BANK STABILIZATION MEASURES AS MAY BE APPROPRIATE.
 MODIFY THE CHANNEL PROFILE TO CORRECT THE SLOPE DISCONTINUITY AT THE LOWER END OF THIS AREA.
- 5** - RELOCATE THE CHANNEL TO THE SOUTH A SUFFICIENT DISTANCE TO ALLOW CONSTRUCTION OF A BANKFULL BENCH OF THE GREATEST WIDTH POSSIBLE ALONG THE TOE OF THE ERODED SLOPE ALONG THE RIGHT BANK. BANKFULL CHANNEL DIMENSIONS SHOULD BE SIMILAR TO THOSE LISTED UNDER KEYNOTE 4.
 INSTALL FLOW DEFLECTION STRUCTURES, EMBEDDED WOODY DEBRIS, RIPARIAN SHRUB PLANTINGS, AND OTHER BANK STABILIZATION MEASURES AS MAY BE APPROPRIATE TO STABILIZE THE BANK AND BANKFULL BENCH.
- 6** - INSTALL RIPARIAN SHRUB LIVE-STAKES WITHIN THE RIP-RAP VOIDS.

NOTES:

1. CHANNEL MODIFICATIONS DEPICTED HEREIN ARE CONCEPTUAL IN NATURE. THE PROPOSED IMPROVEMENTS ARE BASED UPON DATA COLLECTION AND ANALYSES COMPLETED IN SUPPORT OF THE FLUVIAL GEOMORPHIC ASSESSMENT PERFORMED IN 2006. FINAL DESIGN OF EACH RESTORATION SITE WILL BE REQUIRED. FINAL DESIGNS SHOULD BE BASED UPON ADDITIONAL DATA COLLECTION AND ANALYSIS, INCLUDING REFERENCE REACH SURVEYS, AND CONSULTATION WITH THE AFFECTED LANDOWNERS.
2. PROPOSED CHANNEL DIMENSIONS ARE BASED ON THE NEW HAMPSHIRE, VERMONT, AND COLD RIVER WATERSHED REGIONAL HYDRAULIC GEOMETRY CURVES AND ARE PRESENTED AS A GENERAL GUIDE- SOME VARIABILITY SHOULD BE EXPECTED. THESE DIMENSIONS ARE MEASURED TO THE BANKFULL STAGE AND ARE APPLICABLE TO RIFFLE BED FEATURES. CHANNEL DIMENSIONS FOR OTHER BED FEATURES (RUNS, POOLS, AND GLIDES) WILL DEVIATE FROM THE RIFFLE DIMENSIONS.
3. THE MINIMUM RECOMMENDED WIDTH OF RIPARIAN BUFFER PLANTING AREAS IS 50% OF THE TARGET BANKFULL CHANNEL WIDTH, HOWEVER, ANY EFFORTS TO INCREASE RIPARIAN BUFFERS AND THE DENSITY OF WOODY VEGETATION WITHIN THE BUFFERS WOULD BE BENEFICIAL. SPECIES COMPOSITION AND PLANTING METHODS SHOULD BE BASED ON SITE SPECIFIC EVALUATIONS OF HYDROLOGY AND SOIL CHARACTERISTICS.
4. ALL REFERENCES TO "LEFT" OR "RIGHT" BANK ARE FROM THE PERSPECTIVE OF LOOKING DOWNSTREAM.
5. AERIAL PHOTO DATE: APRIL 19, 2006. PHOTO NOT RECTIFIED.



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**COLD RIVER RESTORATION
MASTER PLAN**

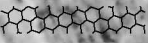




COLD RIVER - UPPER PORTION OF
REACH C14 THROUGH LOWER C16

PROJECT #:	06093
ENGIN'D BY:	SPS
DRAWN BY:	SPS
DATE:	02/07

NOTES:

1. CHANNEL MODIFICATIONS DEPICTED HEREIN ARE CONCEPTUAL IN NATURE. THE PROPOSED IMPROVEMENTS ARE BASED UPON DATA COLLECTION AND ANALYSES COMPLETED IN SUPPORT OF THE FLUVIAL GEOMORPHIC ASSESSMENT PERFORMED IN 2006. FINAL DESIGN OF EACH RESTORATION SITE WILL BE REQUIRED. FINAL DESIGNS SHOULD BE BASED UPON ADDITIONAL DATA COLLECTION AND ANALYSIS, INCLUDING REFERENCE REACH SURVEYS, AND CONSULTATION WITH THE AFFECTED LANDOWNERS.
2. PROPOSED CHANNEL DIMENSIONS ARE BASED ON THE NEW HAMPSHIRE, VERMONT, AND COLD RIVER WATERSHED REGIONAL HYDRAULIC GEOMETRY CURVES AND ARE PRESENTED AS A GENERAL GUIDE - SOME VARIABILITY SHOULD BE EXPECTED. THESE DIMENSIONS ARE MEASURED TO THE BANKFULL STAGE AND ARE APPLICABLE TO RIFFLE BED FEATURES. CHANNEL DIMENSIONS FOR OTHER BED FEATURES (RUNS, POOLS, AND GLIDES) WILL DEVIATE FROM THE RIFFLE DIMENSIONS.
3. THE MINIMUM RECOMMENDED WIDTH OF RIPARIAN BUFFER PLANTING AREAS IS 50% OF THE TARGET BANKFULL CHANNEL WIDTH, HOWEVER, ANY EFFORTS TO INCREASE RIPARIAN BUFFERS AND THE DENSITY OF WOODY VEGETATION WITHIN THE BUFFERS WOULD BE BENEFICIAL. SPECIES COMPOSITION AND PLANTING METHODS SHOULD BE BASED ON SITE SPECIFIC EVALUATIONS OF HYDROLOGY AND SOIL CHARACTERISTICS.
4. ALL REFERENCES TO "LEFT" OR "RIGHT" BANK ARE FROM THE PERSPECTIVE OF LOOKING DOWNSTREAM.
5. BASE MAP IS A MOSAIC OF AERIAL PHOTOS FROM APRIL 2006 AND APRIL 1998. PHOTOS NOT RECTIFIED.

LEGEND

- EXISTING RIP-RAP 
- EXISTING LEDGE EXPOSURE 
- PROPOSED TOP OF BANK (BANKFULL) 
- PROPOSED FILL AREA (FILL TO BANKFULL ELEVATION) 
- PROPOSED RIPARIAN BUFFER PLANTING AREA 

APRIL 1998
AERIAL PHOTO

APRIL 2006
AERIAL PHOTO

REACH C16

ROUTE 123A

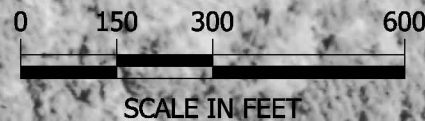
RTE. 123A
BRIDGE

KEYNOTES

- 1. CONSTRUCT A SINGLE-THREAD CHANNEL WITH APPROXIMATELY THE FOLLOWING BANKFULL CHANNEL DIMENSIONS:
 XS AREA ~ 260 SQ FT
 WIDTH ~ 76 FT
 MEAN DEPTH ~ 3.4 FT
- 2. TARGET STREAM TYPE: C3
- 3. TARGET DEGREE OF CHANNEL INCISION: 1.0
- 4. INSTALL FLOW DEFLECTION STRUCTURES, EMBEDDED WOODY DEBRIS, RIPARIAN SHRUB PLANTINGS, AND OTHER BANK STABILIZATION MEASURES AS MAY BE APPROPRIATE.
- 5. SALVAGE RIPARIAN SHRUBS WITHIN PROPOSED CHANNEL ALIGNMENT AND TRANSPLANT TO CONSTRUCTED RIVER BANKS.
- 6. FILL CHANNEL SEGMENTS TO BE ABANDONED AND INSTALL BURIED GRADE CONTROL STRUCTURES ACROSS THE FILLED CHANNELS.
- 7. INSTALL RIPARIAN SHRUB LIVE-STAKES WITHIN THE RIP-RAP VOIDS.
- 8. INSTALL FLOW DEFLECTION STRUCTURES ALONG THE RIGHT BANK BELOW THE BRIDGE.
- 9. CONSIDER INSTALLATION OF A "W-WEIR" IMMEDIATELY UPSTREAM FROM THE BRIDGE TO IMPROVE SEDIMENT TRANSPORT THROUGH THE BRIDGE OPENING AND REDUCE SHEAR STRESSES ON THE PIER FOOTINGS.
- 10. INSTALL TREE AND SHRUB PLANTINGS TO INCREASE THE WIDTH AND DENSITY OF RIPARIAN BUFFERS.

E BROOK

ROUTE 123A



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**COLD RIVER RESTORATION
MASTER PLAN**

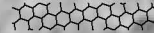




COLD RIVER - MIDDLE PORTION OF
REACH C16

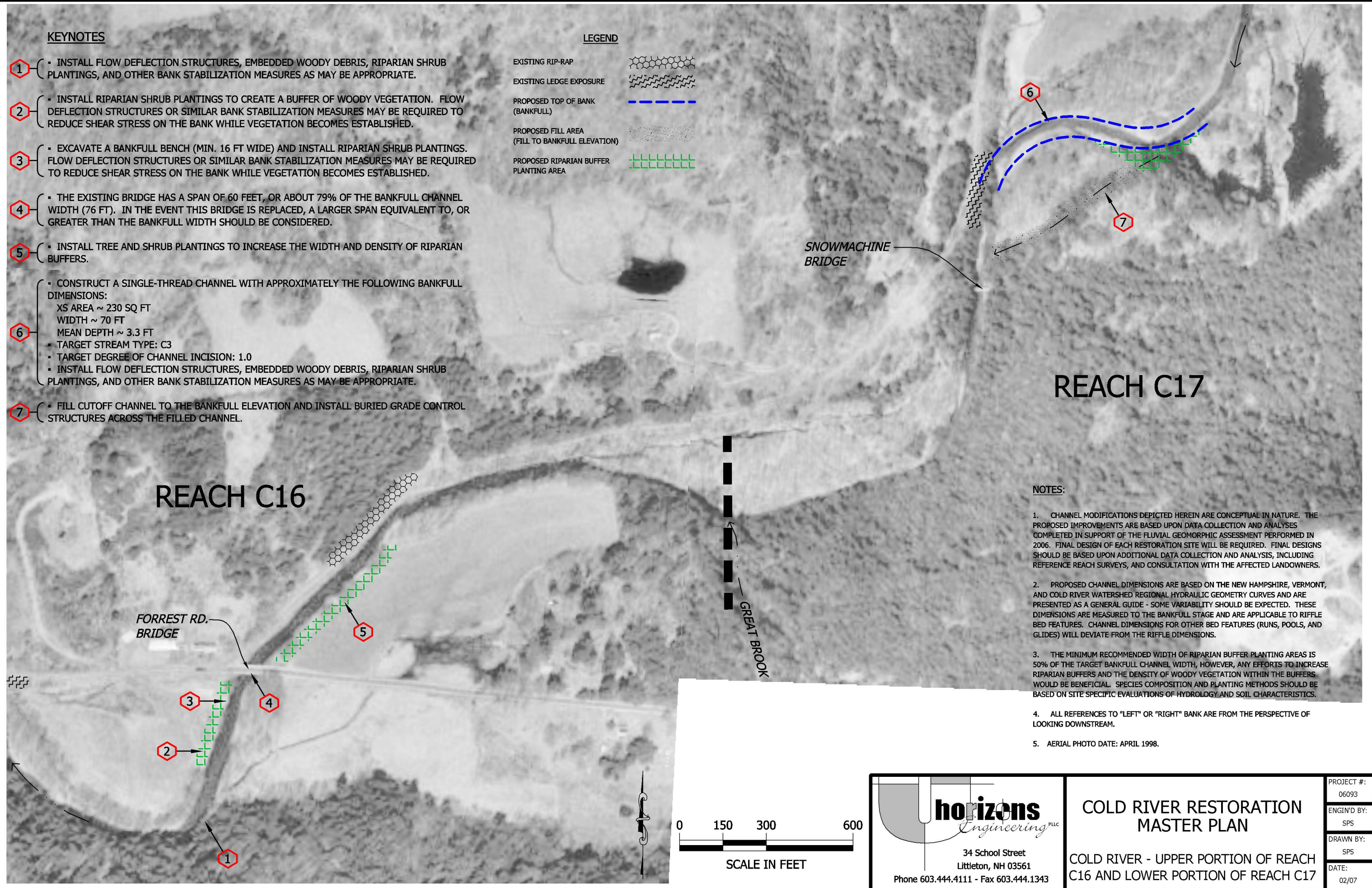
PROJECT #:	06093
ENGIN'D BY:	SPS
DRAWN BY:	SPS
DATE:	02/07

KEYNOTES

- 1 • INSTALL FLOW DEFLECTION STRUCTURES, EMBEDDED WOODY DEBRIS, RIPARIAN SHRUB PLANTINGS, AND OTHER BANK STABILIZATION MEASURES AS MAY BE APPROPRIATE.
- 2 • INSTALL RIPARIAN SHRUB PLANTINGS TO CREATE A BUFFER OF WOODY VEGETATION. FLOW DEFLECTION STRUCTURES OR SIMILAR BANK STABILIZATION MEASURES MAY BE REQUIRED TO REDUCE SHEAR STRESS ON THE BANK WHILE VEGETATION BECOMES ESTABLISHED.
- 3 • EXCAVATE A BANKFULL BENCH (MIN. 16 FT WIDE) AND INSTALL RIPARIAN SHRUB PLANTINGS. FLOW DEFLECTION STRUCTURES OR SIMILAR BANK STABILIZATION MEASURES MAY BE REQUIRED TO REDUCE SHEAR STRESS ON THE BANK WHILE VEGETATION BECOMES ESTABLISHED.
- 4 • THE EXISTING BRIDGE HAS A SPAN OF 60 FEET, OR ABOUT 79% OF THE BANKFULL CHANNEL WIDTH (76 FT). IN THE EVENT THIS BRIDGE IS REPLACED, A LARGER SPAN EQUIVALENT TO, OR GREATER THAN THE BANKFULL WIDTH SHOULD BE CONSIDERED.
- 5 • INSTALL TREE AND SHRUB PLANTINGS TO INCREASE THE WIDTH AND DENSITY OF RIPARIAN BUFFERS.
- 6 • CONSTRUCT A SINGLE-THREAD CHANNEL WITH APPROXIMATELY THE FOLLOWING BANKFULL DIMENSIONS:
 XS AREA ~ 230 SQ FT
 WIDTH ~ 70 FT
 MEAN DEPTH ~ 3.3 FT
 TARGET STREAM TYPE: C3
 TARGET DEGREE OF CHANNEL INCISION: 1.0
 • INSTALL FLOW DEFLECTION STRUCTURES, EMBEDDED WOODY DEBRIS, RIPARIAN SHRUB PLANTINGS, AND OTHER BANK STABILIZATION MEASURES AS MAY BE APPROPRIATE.
- 7 • FILL CUTOFF CHANNEL TO THE BANKFULL ELEVATION AND INSTALL BURIED GRADE CONTROL STRUCTURES ACROSS THE FILLED CHANNEL.

LEGEND

- EXISTING RIP-RAP 
- EXISTING LEDGE EXPOSURE 
- PROPOSED TOP OF BANK (BANKFULL) 
- PROPOSED FILL AREA (FILL TO BANKFULL ELEVATION) 
- PROPOSED RIPARIAN BUFFER PLANTING AREA 

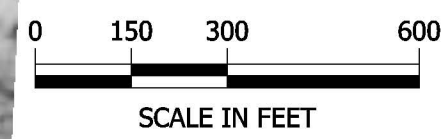


REACH C17

REACH C16

NOTES:

1. CHANNEL MODIFICATIONS DEPICTED HEREIN ARE CONCEPTUAL IN NATURE. THE PROPOSED IMPROVEMENTS ARE BASED UPON DATA COLLECTION AND ANALYSES COMPLETED IN SUPPORT OF THE FLUVIAL GEOMORPHIC ASSESSMENT PERFORMED IN 2006. FINAL DESIGN OF EACH RESTORATION SITE WILL BE REQUIRED. FINAL DESIGNS SHOULD BE BASED UPON ADDITIONAL DATA COLLECTION AND ANALYSIS, INCLUDING REFERENCE REACH SURVEYS, AND CONSULTATION WITH THE AFFECTED LANDOWNERS.
2. PROPOSED CHANNEL DIMENSIONS ARE BASED ON THE NEW HAMPSHIRE, VERMONT, AND COLD RIVER WATERSHED REGIONAL HYDRAULIC GEOMETRY CURVES AND ARE PRESENTED AS A GENERAL GUIDE - SOME VARIABILITY SHOULD BE EXPECTED. THESE DIMENSIONS ARE MEASURED TO THE BANKFULL STAGE AND ARE APPLICABLE TO RIFFLE BED FEATURES. CHANNEL DIMENSIONS FOR OTHER BED FEATURES (RUNS, POOLS, AND GLIDES) WILL DEVIATE FROM THE RIFFLE DIMENSIONS.
3. THE MINIMUM RECOMMENDED WIDTH OF RIPARIAN BUFFER PLANTING AREAS IS 50% OF THE TARGET BANKFULL CHANNEL WIDTH, HOWEVER, ANY EFFORTS TO INCREASE RIPARIAN BUFFERS AND THE DENSITY OF WOODY VEGETATION WITHIN THE BUFFERS WOULD BE BENEFICIAL. SPECIES COMPOSITION AND PLANTING METHODS SHOULD BE BASED ON SITE SPECIFIC EVALUATIONS OF HYDROLOGY AND SOIL CHARACTERISTICS.
4. ALL REFERENCES TO "LEFT" OR "RIGHT" BANK ARE FROM THE PERSPECTIVE OF LOOKING DOWNSTREAM.
5. AERIAL PHOTO DATE: APRIL 1998.



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COLD RIVER RESTORATION MASTER PLAN

COLD RIVER - UPPER PORTION OF REACH C16 AND LOWER PORTION OF REACH C17

PROJECT #:	06093
ENGIN'D BY:	SPS
DRAWN BY:	SPS
DATE:	02/07

KEYNOTES 1-3

1 • INSTALL TREE AND SHRUB PLANTINGS TO INCREASE THE WIDTH AND DENSITY OF RIPARIAN BUFFERS.

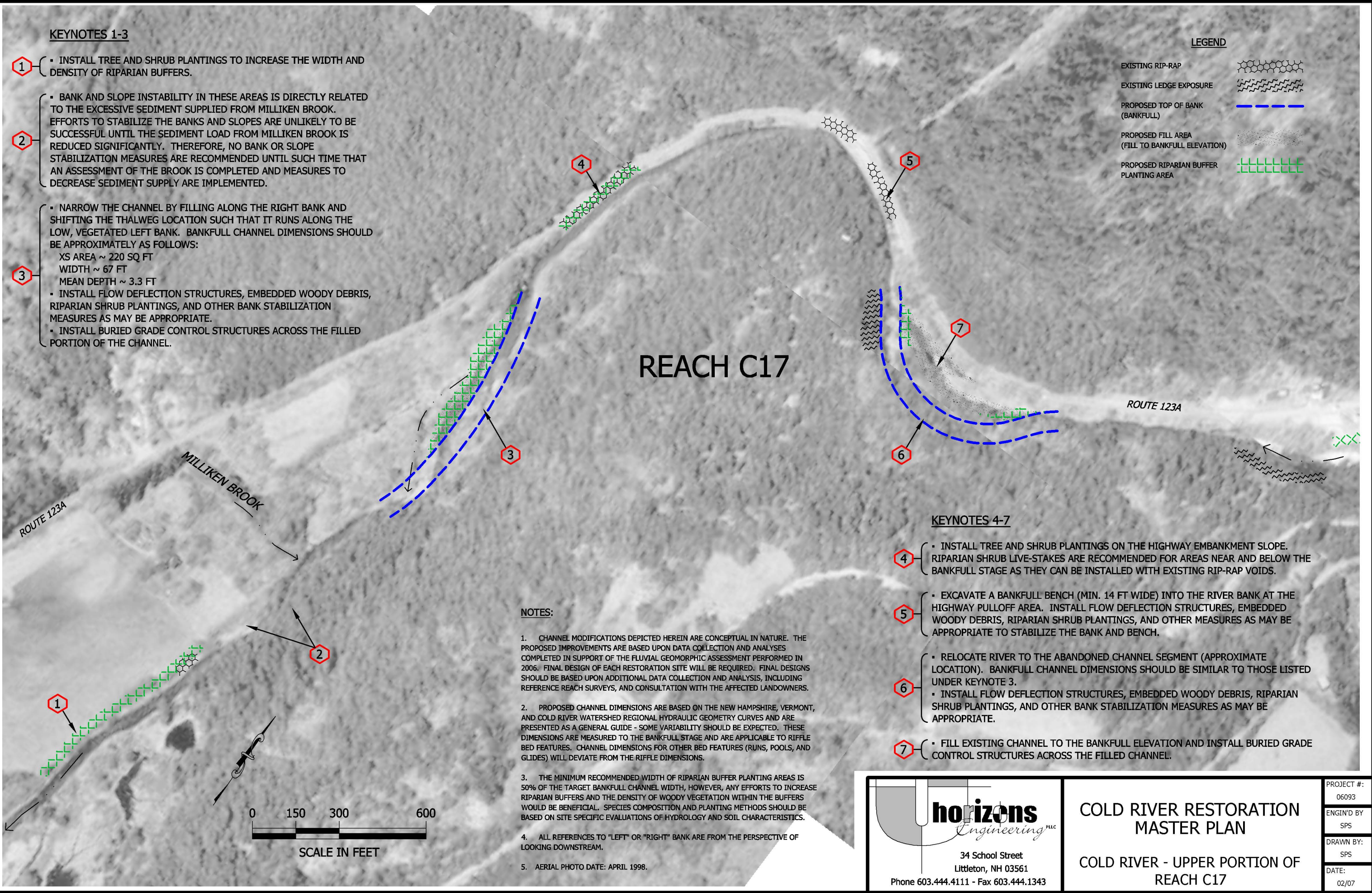
2 • BANK AND SLOPE INSTABILITY IN THESE AREAS IS DIRECTLY RELATED TO THE EXCESSIVE SEDIMENT SUPPLIED FROM MILLIKEN BROOK. EFFORTS TO STABILIZE THE BANKS AND SLOPES ARE UNLIKELY TO BE SUCCESSFUL UNTIL THE SEDIMENT LOAD FROM MILLIKEN BROOK IS REDUCED SIGNIFICANTLY. THEREFORE, NO BANK OR SLOPE STABILIZATION MEASURES ARE RECOMMENDED UNTIL SUCH TIME THAT AN ASSESSMENT OF THE BROOK IS COMPLETED AND MEASURES TO DECREASE SEDIMENT SUPPLY ARE IMPLEMENTED.

3 • NARROW THE CHANNEL BY FILLING ALONG THE RIGHT BANK AND SHIFTING THE THALWEG LOCATION SUCH THAT IT RUNS ALONG THE LOW, VEGETATED LEFT BANK. BANKFULL CHANNEL DIMENSIONS SHOULD BE APPROXIMATELY AS FOLLOWS:
 XS AREA ~ 220 SQ FT
 WIDTH ~ 67 FT
 MEAN DEPTH ~ 3.3 FT
 • INSTALL FLOW DEFLECTION STRUCTURES, EMBEDDED WOODY DEBRIS, RIPARIAN SHRUB PLANTINGS, AND OTHER BANK STABILIZATION MEASURES AS MAY BE APPROPRIATE.
 • INSTALL BURIED GRADE CONTROL STRUCTURES ACROSS THE FILLED PORTION OF THE CHANNEL.

LEGEND

- EXISTING RIP-RAP
- EXISTING LEDGE EXPOSURE
- PROPOSED TOP OF BANK (BANKFULL)
- PROPOSED FILL AREA (FILL TO BANKFULL ELEVATION)
- PROPOSED RIPARIAN BUFFER PLANTING AREA

REACH C17



KEYNOTES 4-7

4 • INSTALL TREE AND SHRUB PLANTINGS ON THE HIGHWAY EMBANKMENT SLOPE. RIPARIAN SHRUB LIVE-STAKES ARE RECOMMENDED FOR AREAS NEAR AND BELOW THE BANKFULL STAGE AS THEY CAN BE INSTALLED WITH EXISTING RIP-RAP VOIDS.

5 • EXCAVATE A BANKFULL BENCH (MIN. 14 FT WIDE) INTO THE RIVER BANK AT THE HIGHWAY PULLOFF AREA. INSTALL FLOW DEFLECTION STRUCTURES, EMBEDDED WOODY DEBRIS, RIPARIAN SHRUB PLANTINGS, AND OTHER MEASURES AS MAY BE APPROPRIATE TO STABILIZE THE BANK AND BENCH.

6 • RELOCATE RIVER TO THE ABANDONED CHANNEL SEGMENT (APPROXIMATE LOCATION). BANKFULL CHANNEL DIMENSIONS SHOULD BE SIMILAR TO THOSE LISTED UNDER KEYNOTE 3.

7 • INSTALL FLOW DEFLECTION STRUCTURES, EMBEDDED WOODY DEBRIS, RIPARIAN SHRUB PLANTINGS, AND OTHER BANK STABILIZATION MEASURES AS MAY BE APPROPRIATE.

7 • FILL EXISTING CHANNEL TO THE BANKFULL ELEVATION AND INSTALL BURIED GRADE CONTROL STRUCTURES ACROSS THE FILLED CHANNEL.

NOTES:

1. CHANNEL MODIFICATIONS DEPICTED HEREIN ARE CONCEPTUAL IN NATURE. THE PROPOSED IMPROVEMENTS ARE BASED UPON DATA COLLECTION AND ANALYSES COMPLETED IN SUPPORT OF THE FLUVIAL GEOMORPHIC ASSESSMENT PERFORMED IN 2006. FINAL DESIGN OF EACH RESTORATION SITE WILL BE REQUIRED. FINAL DESIGNS SHOULD BE BASED UPON ADDITIONAL DATA COLLECTION AND ANALYSIS, INCLUDING REFERENCE REACH SURVEYS, AND CONSULTATION WITH THE AFFECTED LANDOWNERS.

2. PROPOSED CHANNEL DIMENSIONS ARE BASED ON THE NEW HAMPSHIRE, VERMONT, AND COLD RIVER WATERSHED REGIONAL HYDRAULIC GEOMETRY CURVES AND ARE PRESENTED AS A GENERAL GUIDE - SOME VARIABILITY SHOULD BE EXPECTED. THESE DIMENSIONS ARE MEASURED TO THE BANKFULL STAGE AND ARE APPLICABLE TO RIFFLE BED FEATURES. CHANNEL DIMENSIONS FOR OTHER BED FEATURES (RUNS, POOLS, AND GLIDES) WILL DEVIATE FROM THE RIFFLE DIMENSIONS.

3. THE MINIMUM RECOMMENDED WIDTH OF RIPARIAN BUFFER PLANTING AREAS IS 50% OF THE TARGET BANKFULL CHANNEL WIDTH, HOWEVER, ANY EFFORTS TO INCREASE RIPARIAN BUFFERS AND THE DENSITY OF WOODY VEGETATION WITHIN THE BUFFERS WOULD BE BENEFICIAL. SPECIES COMPOSITION AND PLANTING METHODS SHOULD BE BASED ON SITE SPECIFIC EVALUATIONS OF HYDROLOGY AND SOIL CHARACTERISTICS.

4. ALL REFERENCES TO "LEFT" OR "RIGHT" BANK ARE FROM THE PERSPECTIVE OF LOOKING DOWNSTREAM.

5. AERIAL PHOTO DATE: APRIL 1998.

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**COLD RIVER RESTORATION
 MASTER PLAN**

**COLD RIVER - UPPER PORTION OF
 REACH C17**

PROJECT #:	06093
ENGIN'D BY:	SPS
DRAWN BY:	SPS
DATE:	02/07

REACH C18

BERYL MTN. ROAD BRIDGE

BOWERS BROOK

ROUTE 123A

REACH C19

SNOWMACHINE BRIDGE

REACH C20

ROUTE 123A

McKEEN BRIDGE

NOTES:

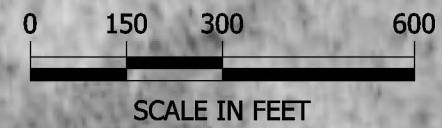
1. CHANNEL MODIFICATIONS DEPICTED HEREIN ARE CONCEPTUAL IN NATURE. THE PROPOSED IMPROVEMENTS ARE BASED UPON DATA COLLECTION AND ANALYSES COMPLETED IN SUPPORT OF THE FLUVIAL GEOMORPHIC ASSESSMENT PERFORMED IN 2006. FINAL DESIGN OF EACH RESTORATION SITE WILL BE REQUIRED. FINAL DESIGNS SHOULD BE BASED UPON ADDITIONAL DATA COLLECTION AND ANALYSIS, INCLUDING REFERENCE REACH SURVEYS, AND CONSULTATION WITH THE AFFECTED LANDOWNERS.
2. PROPOSED CHANNEL DIMENSIONS ARE BASED ON THE NEW HAMPSHIRE, VERMONT, AND COLD RIVER WATERSHED REGIONAL HYDRAULIC GEOMETRY CURVES AND ARE PRESENTED AS A GENERAL GUIDE - SOME VARIABILITY SHOULD BE EXPECTED. THESE DIMENSIONS ARE MEASURED TO THE BANKFULL STAGE AND ARE APPLICABLE TO RIFFLE BED FEATURES. CHANNEL DIMENSIONS FOR OTHER BED FEATURES (RUNS, POOLS, AND GLIDES) WILL DEVIATE FROM THE RIFFLE DIMENSIONS.
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4. ALL REFERENCES TO "LEFT" OR "RIGHT" BANK ARE FROM THE PERSPECTIVE OF LOOKING DOWNSTREAM.
5. AERIAL PHOTO DATE: APRIL 1998.

LEGEND

- EXISTING RIP-RAP
- EXISTING LEDGE EXPOSURE
- PROPOSED TOP OF BANK (BANKFULL)
- PROPOSED FILL AREA (FILL TO BANKFULL ELEVATION)
- PROPOSED RIPARIAN BUFFER PLANTING AREA

KEYNOTES

- 1. REMOVE EXISTING DIKE AND RELOCATE A MINIMUM OF 20 FEET BACK FROM TOP OF BANK (I.E. CREATE "OFFSET DIKE"). INSTALL RIPARIAN SHRUB PLANTINGS BETWEEN OFFSET DIKE AND TOP OF BANK.
- 2. INSTALL FLOW DEFLECTION STRUCTURES TO REDUCE SHEAR STRESSES ON THE ERODING RIGHT BANK AND RIPARIAN SHRUB PLANTINGS FOR LONG-TERM BANK STABILITY.
- 3. PARTIALLY REMOVE DAM REMNANTS. REFER TO PLANS BY HORIZONS ENGINEERING, PLLC, DATED MARCH 2005, FOR DETAILED INFORMATION.
- 4.
 - NARROW CHANNEL TO ACHIEVE THE FOLLOWING BANKFULL DIMENSIONS:
XS AREA ~ 200 SQ FT
WIDTH ~ 60 FT
MEAN DEPTH ~ 3.3 FT
 - CREATE A BANKFULL BENCH ALONG THE RIGHT BANK THROUGH A COMBINATION OF CUTS AND FILLS.
 - INSTALL FLOW DEFLECTION STRUCTURES, EMBEDDED WOODY DEBRIS, RIPARIAN SHRUB PLANTINGS, AND OTHER BANK STABILIZATION MEASURES AS MAY BE APPROPRIATE.
 - REFER TO PLANS BY HORIZONS ENGINEERING, PLLC, DATED MARCH 2005, FOR MORE DETAILED INFORMATION.
 - CHANNEL INSTABILITY IN THIS AREA IS PARTLY DUE TO THE EXCESSIVE SEDIMENT SUPPLIED FROM BOWERS BROOK. EFFORTS TO STABILIZE THE RIVER CHANNEL ARE UNLIKELY TO BE SUCCESSFUL UNTIL THE SEDIMENT LOAD FROM THE BROOK IS REDUCED SIGNIFICANTLY. THEREFORE, RIVER CHANNEL STABILIZATION SHOULD NOT PROCEED UNTIL SUCH TIME THAT MEASURES TO DECREASE THE BROOK'S SEDIMENT LOAD ARE IMPLEMENTED.
- 5. GRADE "ISLAND" TO THE BANKFULL ELEVATION. SALVAGE EXISTING RIPARIAN SHRUBS AND TRANSPLANT TO THE OUTSIDE BANK OF THE RELOCATED BOWERS BROOK CHANNEL AND THE REGRADED BANK OF THE COLD RIVER.
- 6. INSTALL TREE AND SHRUB PLANTINGS TO INCREASE THE WIDTH AND DENSITY OF RIPARIAN BUFFERS.



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COLD RIVER RESTORATION MASTER PLAN

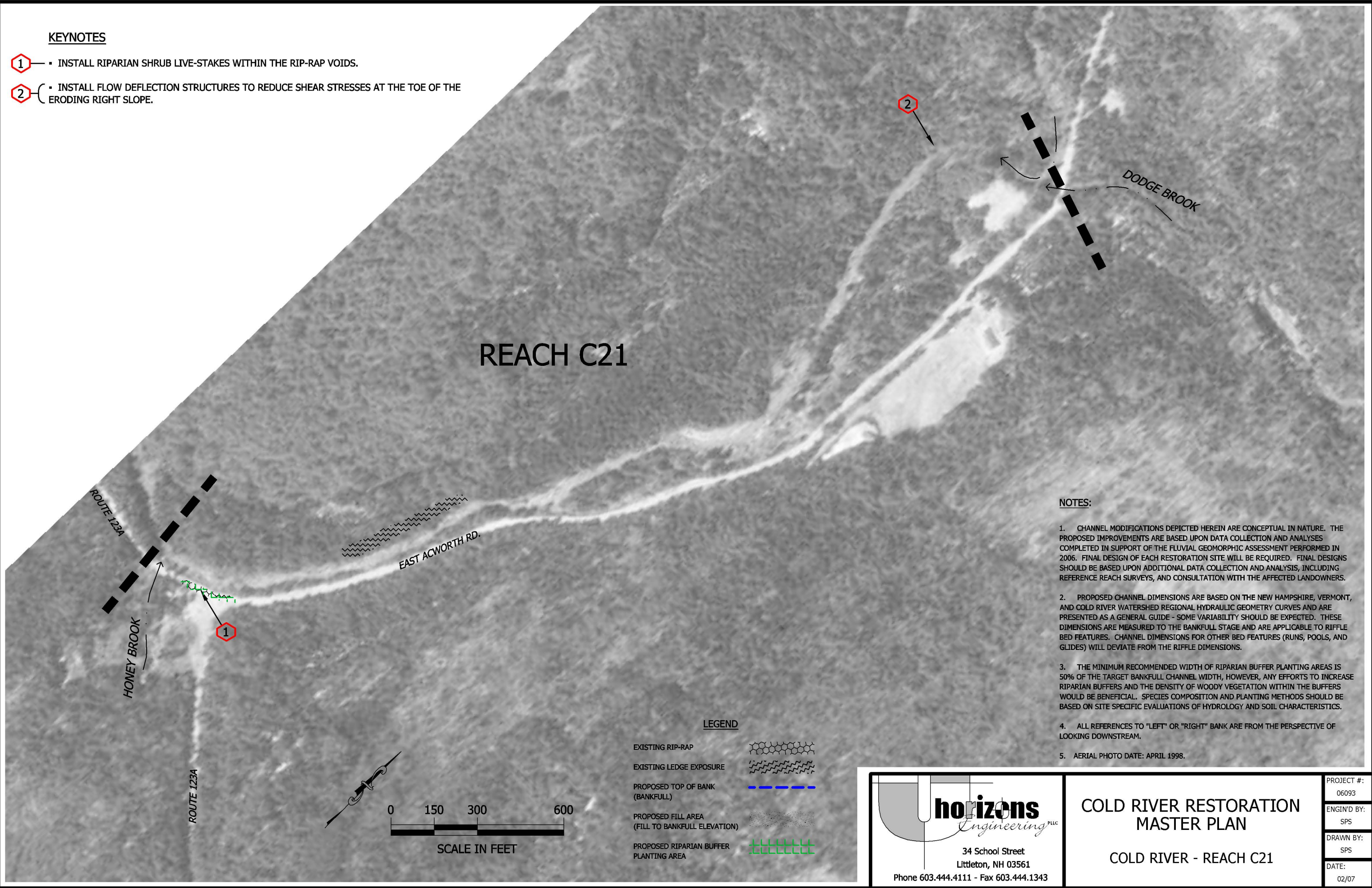
COLD RIVER - REACHES C18 - C20

PROJECT #:	06093
ENGIN'D BY:	SPS
DRAWN BY:	SPS
DATE:	02/07

KEYNOTES

- ① • INSTALL RIPARIAN SHRUB LIVE-STAKES WITHIN THE RIP-RAP VOIDS.
- ② • INSTALL FLOW DEFLECTION STRUCTURES TO REDUCE SHEAR STRESSES AT THE TOE OF THE ERODING RIGHT SLOPE.

REACH C21

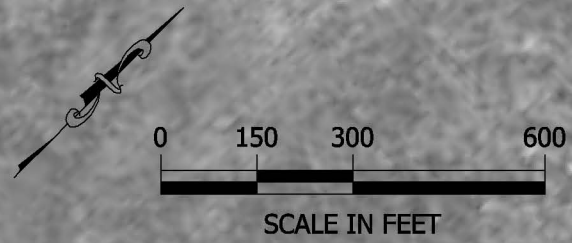


NOTES:

1. CHANNEL MODIFICATIONS DEPICTED HEREIN ARE CONCEPTUAL IN NATURE. THE PROPOSED IMPROVEMENTS ARE BASED UPON DATA COLLECTION AND ANALYSES COMPLETED IN SUPPORT OF THE FLUVIAL GEOMORPHIC ASSESSMENT PERFORMED IN 2006. FINAL DESIGN OF EACH RESTORATION SITE WILL BE REQUIRED. FINAL DESIGNS SHOULD BE BASED UPON ADDITIONAL DATA COLLECTION AND ANALYSIS, INCLUDING REFERENCE REACH SURVEYS, AND CONSULTATION WITH THE AFFECTED LANDOWNERS.
2. PROPOSED CHANNEL DIMENSIONS ARE BASED ON THE NEW HAMPSHIRE, VERMONT, AND COLD RIVER WATERSHED REGIONAL HYDRAULIC GEOMETRY CURVES AND ARE PRESENTED AS A GENERAL GUIDE - SOME VARIABILITY SHOULD BE EXPECTED. THESE DIMENSIONS ARE MEASURED TO THE BANKFULL STAGE AND ARE APPLICABLE TO RIFFLE BED FEATURES. CHANNEL DIMENSIONS FOR OTHER BED FEATURES (RUNS, POOLS, AND GLIDES) WILL DEVIATE FROM THE RIFFLE DIMENSIONS.
3. THE MINIMUM RECOMMENDED WIDTH OF RIPARIAN BUFFER PLANTING AREAS IS 50% OF THE TARGET BANKFULL CHANNEL WIDTH, HOWEVER, ANY EFFORTS TO INCREASE RIPARIAN BUFFERS AND THE DENSITY OF WOODY VEGETATION WITHIN THE BUFFERS WOULD BE BENEFICIAL. SPECIES COMPOSITION AND PLANTING METHODS SHOULD BE BASED ON SITE SPECIFIC EVALUATIONS OF HYDROLOGY AND SOIL CHARACTERISTICS.
4. ALL REFERENCES TO "LEFT" OR "RIGHT" BANK ARE FROM THE PERSPECTIVE OF LOOKING DOWNSTREAM.
5. AERIAL PHOTO DATE: APRIL 1998.

LEGEND

- EXISTING RIP-RAP
- EXISTING LEDGE EXPOSURE
- PROPOSED TOP OF BANK (BANKFULL)
- PROPOSED FILL AREA (FILL TO BANKFULL ELEVATION)
- PROPOSED RIPARIAN BUFFER PLANTING AREA



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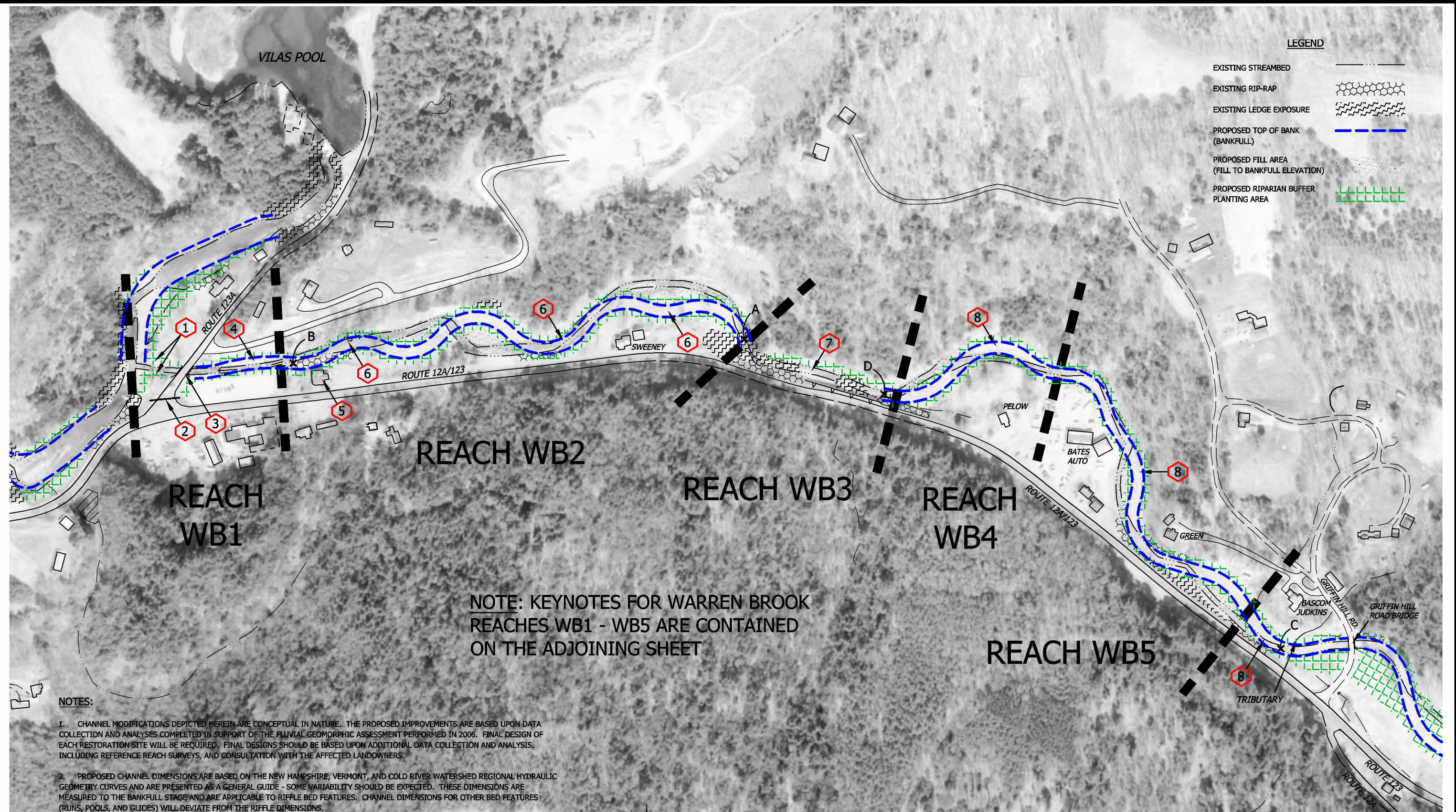
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**COLD RIVER RESTORATION
MASTER PLAN**

COLD RIVER - REACH C21

PROJECT #:	06093
ENGIN'D BY:	SPS
DRAWN BY:	SPS
DATE:	02/07

Warren Brook Restoration Site Plans



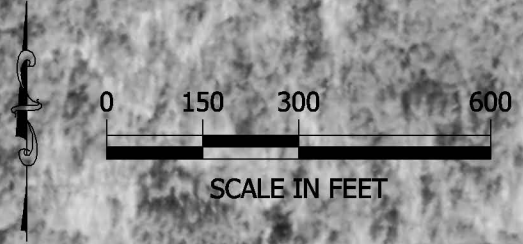
LEGEND

- EXISTING STREAMBED
- EXISTING RIP-RAP
- EXISTING LEDGE EXPOSURE
- PROPOSED TOP OF BANK (BANKFULL)
- PROPOSED FILL AREA (FILL TO BANKFULL ELEVATION)
- PROPOSED RIPARIAN BUFFER PLANTING AREA

NOTE: KEYNOTES FOR WARREN BROOK REACHES WB1 - WB5 ARE CONTAINED ON THE ADJOINING SHEET

NOTES:

1. CHANNEL MODIFICATIONS DEPICTED HEREIN ARE CONCEPTUAL IN NATURE. THE PROPOSED IMPROVEMENTS ARE BASED UPON DATA COLLECTION AND ANALYSES COMPLETED IN SUPPORT OF THE FLUVIAL GEOMORPHIC ASSESSMENT PERFORMED IN 2006. FINAL DESIGN OF EACH RESTORATION SITE WILL BE REQUIRED. FINAL DESIGNS SHOULD BE BASED UPON ADDITIONAL DATA COLLECTION AND ANALYSIS, INCLUDING REFERENCE REACH SURVEYS, AND CONSULTATION WITH THE AFFECTED LANDOWNERS.
2. PROPOSED CHANNEL DIMENSIONS ARE BASED ON THE NEW HAMPSHIRE, VERMONT, AND COLD RIVER WATERSHED REGIONAL HYDRAULIC GEOMETRY CURVES AND ARE PRESENTED AS A GENERAL GUIDE - SOME VARIABILITY SHOULD BE EXPECTED. THESE DIMENSIONS ARE MEASURED TO THE BANKFULL STAGE AND ARE APPLICABLE TO RIFFLE BED FEATURES. CHANNEL DIMENSIONS FOR OTHER BED FEATURES (RUNS, POOLS, AND GLIDES) WILL DEVIATE FROM THE RIFFLE DIMENSIONS.
3. THE MINIMUM RECOMMENDED WIDTH OF RIPARIAN BUFFER PLANTING AREAS IS 50% OF THE TARGET BANKFULL CHANNEL WIDTH, HOWEVER, ANY EFFORTS TO INCREASE RIPARIAN BUFFERS AND THE DENSITY OF WOODY VEGETATION WITHIN THE BUFFERS WOULD BE BENEFICIAL. SPECIES COMPOSITION AND PLANTING METHODS SHOULD BE BASED ON SITE SPECIFIC EVALUATIONS OF HYDROLOGY AND SOIL CHARACTERISTICS.
4. ALL REFERENCES TO "LEFT" OR "RIGHT" BANK ARE FROM THE PERSPECTIVE OF LOOKING DOWNSTREAM.
5. AERIAL PHOTO DATE: APRIL 19, 2006. PHOTO NOT RECTIFIED.
6. PLANIMETRIC BASE MAPPING BY EASTERN TOPOGRAPHICS, JUNE 2006



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COLD RIVER RESTORATION MASTER PLAN

WARREN BK - REACHES WB1 - WB5

PROJECT #:	06093
ENGIN'D BY:	SPS
DRAWN BY:	SPS
DATE:	02/07

KEYNOTES FOR WARREN BROOK REACHES WB1 - WB5

1 • LOWER THE GRADE IN THIS AREA TO THE BANKFULL ELEVATION, BEING CAUTIOUS TO AVOID EXISTING TREES TO THE GREATEST EXTENT PRACTICABLE. INSTALL FLOW DEFLECTION STRUCTURES, EMBEDDED WOODY DEBRIS, RIPARIAN SHRUB PLANTINGS, AND OTHER MEASURES AS MAY BE APPROPRIATE TO STABILIZE THE BANK AND CONSTRUCTED FLOOD PLAIN SURFACE.

2 • EXISTING CULVERT. GRADE AREA UPSTREAM FROM CULVERT INLET TO THE BANKFULL ELEVATION SUCH THAT THERE IS A CONTIGUOUS AREA AT THE BANKFULL ELEVATION BETWEEN THE LEFT STREAM BANK AND THE CULVERT INLET. THIS GRADING IS INTENDED TO UTILIZE THE EXISTING CULVERT TO CONVEY OVERBANK FLOODWATERS THROUGH THE HIGHWAY FILL AND REDUCE BACKWATER ABOVE THE ROUTE 123A BOX CULVERT.

3 • THE EXISTING BRIDGE (BOX CULVERT) HAS A SPAN OF APPROXIMATELY 24 FEET, OR ABOUT 63% OF THE TARGET BANKFULL CHANNEL WIDTH (38 FT). IN THE EVENT THIS BRIDGE IS REPLACED, A LARGER SPAN EQUIVALENT TO, OR GREATER THAN, THE BANKFULL WIDTH SHOULD BE CONSTRUCTED ALONG WITH PROVISIONS TO CONVEY OVERBANK FLOODWATERS. THE MOST PREFERABLE OPTION WOULD BE A STRUCTURE WHICH SPANS BOTH THE BANKFULL CHANNEL AND A SIGNIFICANT PORTION OF THE FLOOD PLAIN. AN ALTERNATIVE APPROACH WOULD INCLUDE A BRIDGE WITH A SPAN EQUIVALENT TO THE BANKFULL WIDTH ALONG WITH INSTALLATION OF LARGE SPAN, LOW RISE ELLIPTICAL OR BOX CULVERTS THROUGH THE ROUTE 123A HIGHWAY FILL. THE CULVERTS SHOULD BE SET WITH THEIR INVERTS AT THE BANKFULL ELEVATION AND THE AREA UPSTREAM FROM THE CULVERT INLETS SHOULD BE GRADED SUCH THAT THERE IS A CONTIGUOUS AREA AT THE BANKFULL ELEVATION BETWEEN THE STREAM BANKS AND THE CULVERT INLETS.

4 • **FOR REACH WB1** - MODIFY CHANNEL TO CREATE THE FOLLOWING BANKFULL CHANNEL DIMENSIONS:
 XS AREA ~ 90 SQ FT
 WIDTH ~ 38 FT
 MEAN DEPTH ~ 2.35 FT
 • TARGET STREAM TYPE: C3b OR B3
 • TARGET DEGREE OF CHANNEL INCISION: 1.0
 • CONSTRUCT BANKFULL BENCHES ALONG THE CHANNEL OF THE GREATEST WIDTH POSSIBLE GIVEN SLOPE LIMITATIONS AND THE PROXIMITY OF FUTURE BUILDINGS AND INFRASTRUCTURE.
 • INSTALL FLOW DEFLECTION STRUCTURES, EMBEDDED WOODY DEBRIS, RIPARIAN SHRUB PLANTINGS, AND OTHER BANK STABILIZATION MEASURES AS MAY BE APPROPRIATE.

5 • PROPOSED CHANNEL AND FLOOD PLAIN MODIFICATIONS ASSUME THAT THE FORMER KMI EC RESIDENCE, WHICH WAS SEVERELY DAMAGED BY THE OCTOBER 2005 FLOOD, WILL BE DEMOLISHED.

• **FOR REACH WB2** - CONSTRUCT A SINGLE-THREAD CHANNEL WITH THE FOLLOWING BANKFULL CHANNEL DIMENSIONS:

XS AREA ~ 90 SQ FT
 WIDTH ~ 38 FT
 MEAN DEPTH ~ 2.35 FT
 • TARGET STREAM TYPE: C3
 • TARGET DEGREE OF CHANNEL INCISION: 1.0

• INSTALL FLOW DEFLECTION STRUCTURES, EMBEDDED WOODY DEBRIS, RIPARIAN SHRUB PLANTINGS, AND OTHER BANK STABILIZATION MEASURES AS MAY BE APPROPRIATE.

• THE PROPOSED CHANNEL IS LOCATED SUCH THAT, TO THE GREATEST EXTENT POSSIBLE, IT DOES NOT FLOW DIRECTLY AGAINST THE ERODED, OVER-STEEPENED VALLEY WALLS. FLOOD PLAIN SURFACES SHOULD BE CREATED ALONG THE TOE OF THE VALLEY WALLS TO PROVIDE AN AREA FOR ACCUMULATION OF ERODED MATERIAL SUCH THAT, OVER TIME, DEPOSITION OF THIS MATERIAL WILL RESULT IN AN OVERALL DECREASE IN VALLEY WALL SLOPES UNTIL A STABLE SLOPE ANGLE IS ACHIEVED.

• CONSTRUCT BANKFULL BENCHES ALONG THE CHANNEL OF THE GREATEST WIDTH POSSIBLE GIVEN SLOPE LIMITATIONS AND THE PROXIMITY OF EXISTING AND FUTURE BUILDINGS AND INFRASTRUCTURE.

• BEDLOAD ENTRAINMENT CALCULATIONS PERFORMED IN SUPPORT OF THE FLUVIAL GEOMORPHIC ASSESSMENT INDICATE THAT AN AVERAGE CHANNEL SLOPE OF 2.35% IS REQUIRED TO MOBILIZE THE LARGEST COMMONLY AVAILABLE BEDLOAD PARTICLE AT A MEAN BANKFULL DEPTH OF 2.35 FEET. THE AVERAGE VALLEY SLOPE IS 2.69%, THEREFORE, A SINUOSITY OF 1.14 IS NEEDED TO ACHIEVE AN AVERAGE CHANNEL SLOPE OF 2.35%. THE PROPOSED SINUOSITY BETWEEN LOCATIONS "A" AND "B" IS 1.13.

• INSTALL FLOOD PLAIN GRADE CONTROL STRUCTURES ACROSS THE CONSTRUCTED FLOOD PLAIN SURFACES ON THE INSIDE OF MEANDER BENDS.

7 • **FOR REACH WB3** - RAISE CHANNEL BED UPSTREAM FROM THE BEDROCK CASCADES TO THE APPROXIMATE PRE-FLOOD LEVEL - ESTIMATED TO BE BETWEEN 3 AND 5 FEET ABOVE THE EXISTING STREAMBED. USE CROSS-VANES OR SIMILAR GRADE CONTROL/FLOW DEFLECTION STRUCTURES TO STABILIZE THE RAISED STREAMBED AND STREAM BANKS. BANKFULL CHANNEL DIMENSIONS SHOULD BE SIMILAR TO THOSE LISTED UNDER KEYNOTE 6. UTILIZE THE ADDITIONAL VALLEY BOTTOM WIDTH CREATED BY RAISING THE STREAM BED TO ACCOMMODATE BANKFULL BENCHES AND/OR FLATTER SLOPES ALONG THE RIGHT BANK. STREAM RESTORATION AND HIGHWAY RECONSTRUCTION SHOULD BE PLANNED CONCURRENTLY. INSTALLATION OF HARD ARMAMENTS ALONG THE LEFT BANK, AS NEEDED FOR HIGHWAY RECONSTRUCTION, ARE CONSIDERED ACCEPTABLE AS THE CHANNEL FLOWS THROUGH A NATURALLY CONFINED VALLEY IN THIS AREA.

8 • **FOR REACHES WB4, WB5, AND WB6** DOWNSTREAM FROM THE TRIBUTARY BELOW GRIFFIN HILL ROAD BRIDGE - RAISE CHANNEL BED TO THE APPROXIMATE PRE-FLOOD LEVEL - ESTIMATED TO BE BETWEEN 3 AND 5 FEET ABOVE THE EXISTING STREAMBED - AND RECONNECT REMNANT FLOOD PLAIN SURFACES. USE CROSS-VANES OR SIMILAR GRADE CONTROL/FLOW DEFLECTION STRUCTURES TO STABILIZE THE RAISED STREAMBED AND STREAM BANKS. BANKFULL CHANNEL DIMENSIONS SHOULD BE SIMILAR TO THOSE LISTED UNDER KEYNOTE 6. UTILIZE THE ADDITIONAL VALLEY BOTTOM WIDTH CREATED BY RAISING THE STREAM BED TO ACCOMMODATE BANKFULL BENCHES.

• TARGET STREAM TYPES: C3, C3b, OR B3 WHERE VALLEY WIDTH IS CONSTRICTED

• TARGET DEGREE OF CHANNEL INCISION: 1.0

• INSTALL FLOW DEFLECTION STRUCTURES, EMBEDDED WOODY DEBRIS, RIPARIAN SHRUB PLANTINGS, AND OTHER BANK STABILIZATION MEASURES AS MAY BE APPROPRIATE.

• THE PROPOSED CHANNEL IS LOCATED SUCH THAT, TO THE GREATEST EXTENT POSSIBLE, IT DOES NOT FLOW DIRECTLY AGAINST THE ERODED, OVER-STEEPENED VALLEY WALLS. FLOOD PLAIN SURFACES SHOULD BE CREATED ALONG THE TOE OF THE VALLEY WALLS TO PROVIDE AN AREA FOR ACCUMULATION OF ERODED MATERIAL SUCH THAT, OVER TIME, DEPOSITION OF THIS MATERIAL WILL RESULT IN AN OVERALL DECREASE IN VALLEY WALL SLOPES UNTIL A STABLE SLOPE ANGLE IS ACHIEVED.

• CONSTRUCT BANKFULL BENCHES ALONG THE CHANNEL OF THE GREATEST WIDTH POSSIBLE GIVEN SLOPE LIMITATIONS AND THE PROXIMITY OF EXISTING AND FUTURE BUILDINGS AND INFRASTRUCTURE.

• BEDLOAD ENTRAINMENT CALCULATIONS PERFORMED IN SUPPORT OF THE FLUVIAL GEOMORPHIC ASSESSMENT FOR REACH WB6 INDICATE THAT AN AVERAGE CHANNEL SLOPE OF 1.83% IS REQUIRED TO MOBILIZE THE LARGEST COMMONLY AVAILABLE BEDLOAD PARTICLE AT A MEAN BANKFULL DEPTH OF 2.35 FEET. THE AVERAGE VALLEY SLOPE OVER REACH WB6 IS 2.17%, THEREFORE, A SINUOSITY OF APPROXIMATELY 1.19 IS NEEDED TO ACHIEVE AN AVERAGE CHANNEL SLOPE OF 1.83%. THE PROPOSED SINUOSITY BETWEEN LOCATIONS "C" AND "D" IS APPROXIMATELY 1.16. FINAL DESIGN SHOULD INCLUDE ADDITIONAL DATA COLLECTION AND BEDLOAD ENTRAINMENT CALCULATIONS IN REACHES WB4 AND WB5.

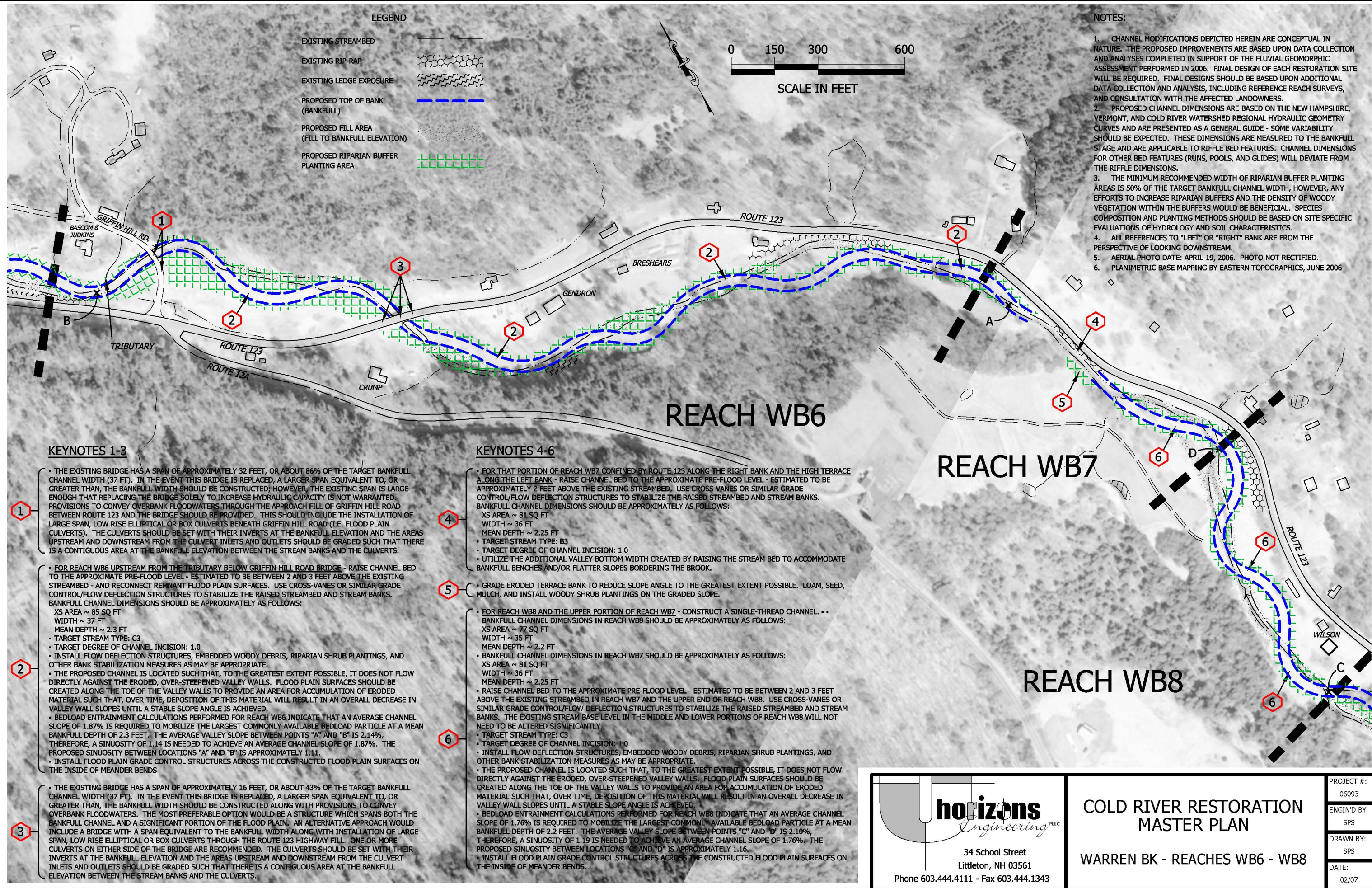
• INSTALL FLOOD PLAIN GRADE CONTROL STRUCTURES ACROSS THE CONSTRUCTED FLOOD PLAIN SURFACES ON THE INSIDE OF MEANDER BENDS.



COLD RIVER RESTORATION MASTER PLAN

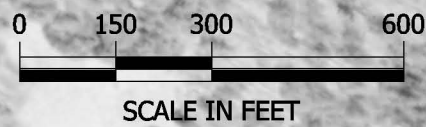
KEYNOTES FOR
WARREN BK - REACHES WB1 - WB5

PROJECT #: 06093
ENGIN'D BY: SPS
DRAWN BY: SPS
DATE: 02/07



LEGEND

- EXISTING STREAMBED
- EXISTING RIP-RAP
- EXISTING LEDGE EXPOSURE
- PROPOSED TOP OF BANK (BANKFULL)
- PROPOSED FILL AREA (FILL TO BANKFULL ELEVATION)
- PROPOSED RIPARIAN BUFFER PLANTING AREA



NOTES:

1. CHANNEL MODIFICATIONS DEPICTED HEREIN ARE CONCEPTUAL IN NATURE. THE PROPOSED IMPROVEMENTS ARE BASED UPON DATA COLLECTION AND ANALYSES COMPLETED IN SUPPORT OF THE FLUVIAL GEOMORPHIC ASSESSMENT PERFORMED IN 2006. FINAL DESIGN OF EACH RESTORATION SITE WILL BE REQUIRED. FINAL DESIGNS SHOULD BE BASED UPON ADDITIONAL DATA COLLECTION AND ANALYSIS, INCLUDING REFERENCE REACH SURVEYS, AND CONSULTATION WITH THE AFFECTED LANDOWNERS.
2. PROPOSED CHANNEL DIMENSIONS ARE BASED ON THE NEW HAMPSHIRE, VERMONT, AND COLD RIVER WATERSHED REGIONAL HYDRAULIC GEOMETRY CURVES AND ARE PRESENTED AS A GENERAL GUIDE - SOME VARIABILITY SHOULD BE EXPECTED. THESE DIMENSIONS ARE MEASURED TO THE BANKFULL STAGE AND ARE APPLICABLE TO RIFFLE BED FEATURES. CHANNEL DIMENSIONS FOR OTHER BED FEATURES (RUNS, POOLS, AND GLIDES) WILL DEVIATE FROM THE RIFFLE DIMENSIONS.
3. THE MINIMUM RECOMMENDED WIDTH OF RIPARIAN BUFFER PLANTING AREAS IS 50% OF THE TARGET BANKFULL CHANNEL WIDTH, HOWEVER, ANY EFFORTS TO INCREASE RIPARIAN BUFFERS AND THE DENSITY OF WOODY VEGETATION WITHIN THE BUFFERS WOULD BE BENEFICIAL. SPECIES COMPOSITION AND PLANTING METHODS SHOULD BE BASED ON SITE SPECIFIC EVALUATIONS OF HYDROLOGY AND SOIL CHARACTERISTICS.
4. ALL REFERENCES TO "LEFT" OR "RIGHT" BANK ARE FROM THE PERSPECTIVE OF LOOKING DOWNSTREAM.
5. AERIAL PHOTO DATE: APRIL 19, 2006. PHOTO NOT RECTIFIED.
6. PLANIMETRIC BASE MAPPING BY EASTERN TOPOGRAPHICS, JUNE 2006

KEYNOTES 1-3

- 1** • THE EXISTING BRIDGE HAS A SPAN OF APPROXIMATELY 32 FEET, OR ABOUT 86% OF THE TARGET BANKFULL CHANNEL WIDTH (37 FT). IN THE EVENT THIS BRIDGE IS REPLACED, A LARGER SPAN EQUIVALENT TO, OR GREATER THAN, THE BANKFULL WIDTH SHOULD BE CONSTRUCTED; HOWEVER, THE EXISTING SPAN IS LARGE ENOUGH THAT REPLACING THE BRIDGE SOLELY TO INCREASE HYDRAULIC CAPACITY IS NOT WARRANTED. PROVISIONS TO CONVEY OVERBANK FLOODWATERS THROUGH THE APPROACH FILL OF GRIFFIN HILL ROAD BETWEEN ROUTE 123 AND THE BRIDGE SHOULD BE PROVIDED. THIS SHOULD INCLUDE THE INSTALLATION OF LARGE SPAN, LOW RISE ELLIPTICAL OR BOX CULVERTS BENEATH GRIFFIN HILL ROAD (I.E. FLOOD PLAIN CULVERTS). THE CULVERTS SHOULD BE SET WITH THEIR INVERTS AT THE BANKFULL ELEVATION AND THE AREAS UPSTREAM AND DOWNSTREAM FROM THE CULVERT INLETS AND OUTLETS SHOULD BE GRADED SUCH THAT THERE IS A CONTIGUOUS AREA AT THE BANKFULL ELEVATION BETWEEN THE STREAM BANKS AND THE CULVERTS.
- 2** • FOR REACH WB6 UPSTREAM FROM THE TRIBUTARY BELOW GRIFFIN HILL ROAD BRIDGE - RAISE CHANNEL BED TO THE APPROXIMATE PRE-FLOOD LEVEL - ESTIMATED TO BE BETWEEN 2 AND 3 FEET ABOVE THE EXISTING STREAMBED - AND RECONNECT REMNANT FLOOD PLAIN SURFACES. USE CROSS-VANES OR SIMILAR GRADE CONTROL/FLOW DEFLECTION STRUCTURES TO STABILIZE THE RAISED STREAMBED AND STREAM BANKS. BANKFULL CHANNEL DIMENSIONS SHOULD BE APPROXIMATELY AS FOLLOWS:
 XS AREA ~ 85 SQ FT
 WIDTH ~ 37 FT
 MEAN DEPTH ~ 2.3 FT
 • TARGET STREAM TYPE: C3
 • TARGET DEGREE OF CHANNEL INCISION: 1.0
 • INSTALL FLOW DEFLECTION STRUCTURES, EMBEDDED WOODY DEBRIS, RIPARIAN SHRUB PLANTINGS, AND OTHER BANK STABILIZATION MEASURES AS MAY BE APPROPRIATE.
 • THE PROPOSED CHANNEL IS LOCATED SUCH THAT, TO THE GREATEST EXTENT POSSIBLE, IT DOES NOT FLOW DIRECTLY AGAINST THE ERODED, OVER-STEEPENED VALLEY WALLS. FLOOD PLAIN SURFACES SHOULD BE CREATED ALONG THE TOE OF THE VALLEY WALLS TO PROVIDE AN AREA FOR ACCUMULATION OF ERODED MATERIAL SUCH THAT, OVER TIME, DEPOSITION OF THIS MATERIAL WILL RESULT IN AN OVERALL DECREASE IN VALLEY WALL SLOPES UNTIL A STABLE SLOPE ANGLE IS ACHIEVED.
 • BEDLOAD ENTRAINMENT CALCULATIONS PERFORMED FOR REACH WB6 INDICATE THAT AN AVERAGE CHANNEL SLOPE OF 1.87% IS REQUIRED TO MOBILIZE THE LARGEST COMMONLY AVAILABLE BEDLOAD PARTICLE AT A MEAN BANKFULL DEPTH OF 2.3 FEET. THE AVERAGE VALLEY SLOPE BETWEEN POINTS "A" AND "B" IS 2.14%, THEREFORE, A SINUOSITY OF 1.14 IS NEEDED TO ACHIEVE AN AVERAGE CHANNEL SLOPE OF 1.87%. THE PROPOSED SINUOSITY BETWEEN LOCATIONS "A" AND "B" IS APPROXIMATELY 1.11.
 • INSTALL FLOOD PLAIN GRADE CONTROL STRUCTURES ACROSS THE CONSTRUCTED FLOOD PLAIN SURFACES ON THE INSIDE OF MEANDER BENDS
- 3** • THE EXISTING BRIDGE HAS A SPAN OF APPROXIMATELY 16 FEET, OR ABOUT 43% OF THE TARGET BANKFULL CHANNEL WIDTH (37 FT). IN THE EVENT THIS BRIDGE IS REPLACED, A LARGER SPAN EQUIVALENT TO, OR GREATER THAN, THE BANKFULL WIDTH SHOULD BE CONSTRUCTED ALONG WITH PROVISIONS TO CONVEY OVERBANK FLOODWATERS. THE MOST PREFERABLE OPTION WOULD BE A STRUCTURE WHICH SPANS BOTH THE BANKFULL CHANNEL AND A SIGNIFICANT PORTION OF THE FLOOD PLAIN. AN ALTERNATIVE APPROACH WOULD INCLUDE A BRIDGE WITH A SPAN EQUIVALENT TO THE BANKFULL WIDTH ALONG WITH INSTALLATION OF LARGE SPAN, LOW RISE ELLIPTICAL OR BOX CULVERTS THROUGH THE ROUTE 123 HIGHWAY FILL. ONE OR MORE CULVERTS ON EITHER SIDE OF THE BRIDGE ARE RECOMMENDED. THE CULVERTS SHOULD BE SET WITH THEIR INVERTS AT THE BANKFULL ELEVATION AND THE AREAS UPSTREAM AND DOWNSTREAM FROM THE CULVERT INLETS AND OUTLETS SHOULD BE GRADED SUCH THAT THERE IS A CONTIGUOUS AREA AT THE BANKFULL ELEVATION BETWEEN THE STREAM BANKS AND THE CULVERTS.

KEYNOTES 4-6

- 4** • FOR THAT PORTION OF REACH WB7 CONFINED BY ROUTE 123 ALONG THE RIGHT BANK AND THE HIGH TERRACE ALONG THE LEFT BANK - RAISE CHANNEL BED TO THE APPROXIMATE PRE-FLOOD LEVEL - ESTIMATED TO BE APPROXIMATELY 2 FEET ABOVE THE EXISTING STREAMBED. USE CROSS-VANES OR SIMILAR GRADE CONTROL/FLOW DEFLECTION STRUCTURES TO STABILIZE THE RAISED STREAMBED AND STREAM BANKS. BANKFULL CHANNEL DIMENSIONS SHOULD BE APPROXIMATELY AS FOLLOWS:
 XS AREA ~ 81 SQ FT
 WIDTH ~ 36 FT
 MEAN DEPTH ~ 2.25 FT
 • TARGET STREAM TYPE: B3
 • TARGET DEGREE OF CHANNEL INCISION: 1.0
 • UTILIZE THE ADDITIONAL VALLEY BOTTOM WIDTH CREATED BY RAISING THE STREAM BED TO ACCOMMODATE BANKFULL BENCHES AND/OR FLATTER SLOPES BORDERING THE BROOK.
- 5** • GRADE ERODED TERRACE BANK TO REDUCE SLOPE ANGLE TO THE GREATEST EXTENT POSSIBLE. LOAM, SEED, MULCH, AND INSTALL WOODY SHRUB PLANTINGS ON THE GRADED SLOPE.
- 6** • FOR REACH WB8 AND THE UPPER PORTION OF REACH WB7 - CONSTRUCT A SINGLE-THREAD CHANNEL. • • BANKFULL CHANNEL DIMENSIONS IN REACH WB8 SHOULD BE APPROXIMATELY AS FOLLOWS:
 XS AREA ~ 77 SQ FT
 WIDTH ~ 35 FT
 MEAN DEPTH ~ 2.2 FT
 • BANKFULL CHANNEL DIMENSIONS IN REACH WB7 SHOULD BE APPROXIMATELY AS FOLLOWS:
 XS AREA ~ 81 SQ FT
 WIDTH ~ 36 FT
 MEAN DEPTH ~ 2.25 FT
 • RAISE CHANNEL BED TO THE APPROXIMATE PRE-FLOOD LEVEL - ESTIMATED TO BE BETWEEN 2 AND 3 FEET ABOVE THE EXISTING STREAMBED IN REACH WB7 AND THE UPPER END OF REACH WB8. USE CROSS-VANES OR SIMILAR GRADE CONTROL/FLOW DEFLECTION STRUCTURES TO STABILIZE THE RAISED STREAMBED AND STREAM BANKS. THE EXISTING STREAM BASE LEVEL IN THE MIDDLE AND LOWER PORTIONS OF REACH WB8 WILL NOT NEED TO BE ALTERED SIGNIFICANTLY.
 • TARGET STREAM TYPE: C3
 • TARGET DEGREE OF CHANNEL INCISION: 1.0
 • INSTALL FLOW DEFLECTION STRUCTURES, EMBEDDED WOODY DEBRIS, RIPARIAN SHRUB PLANTINGS, AND OTHER BANK STABILIZATION MEASURES AS MAY BE APPROPRIATE.
 • THE PROPOSED CHANNEL IS LOCATED SUCH THAT, TO THE GREATEST EXTENT POSSIBLE, IT DOES NOT FLOW DIRECTLY AGAINST THE ERODED, OVER-STEEPENED VALLEY WALLS. FLOOD PLAIN SURFACES SHOULD BE CREATED ALONG THE TOE OF THE VALLEY WALLS TO PROVIDE AN AREA FOR ACCUMULATION OF ERODED MATERIAL SUCH THAT, OVER TIME, DEPOSITION OF THIS MATERIAL WILL RESULT IN AN OVERALL DECREASE IN VALLEY WALL SLOPES UNTIL A STABLE SLOPE ANGLE IS ACHIEVED.
 • BEDLOAD ENTRAINMENT CALCULATIONS PERFORMED FOR REACH WB8 INDICATE THAT AN AVERAGE CHANNEL SLOPE OF 1.76% IS REQUIRED TO MOBILIZE THE LARGEST COMMONLY AVAILABLE BEDLOAD PARTICLE AT A MEAN BANKFULL DEPTH OF 2.2 FEET. THE AVERAGE VALLEY SLOPE BETWEEN POINTS "C" AND "D" IS 2.10%, THEREFORE, A SINUOSITY OF 1.19 IS NEEDED TO ACHIEVE AN AVERAGE CHANNEL SLOPE OF 1.76%. THE PROPOSED SINUOSITY BETWEEN LOCATIONS "C" AND "D" IS APPROXIMATELY 1.16.
 • INSTALL FLOOD PLAIN GRADE CONTROL STRUCTURES ACROSS THE CONSTRUCTED FLOOD PLAIN SURFACES ON THE INSIDE OF MEANDER BENDS.

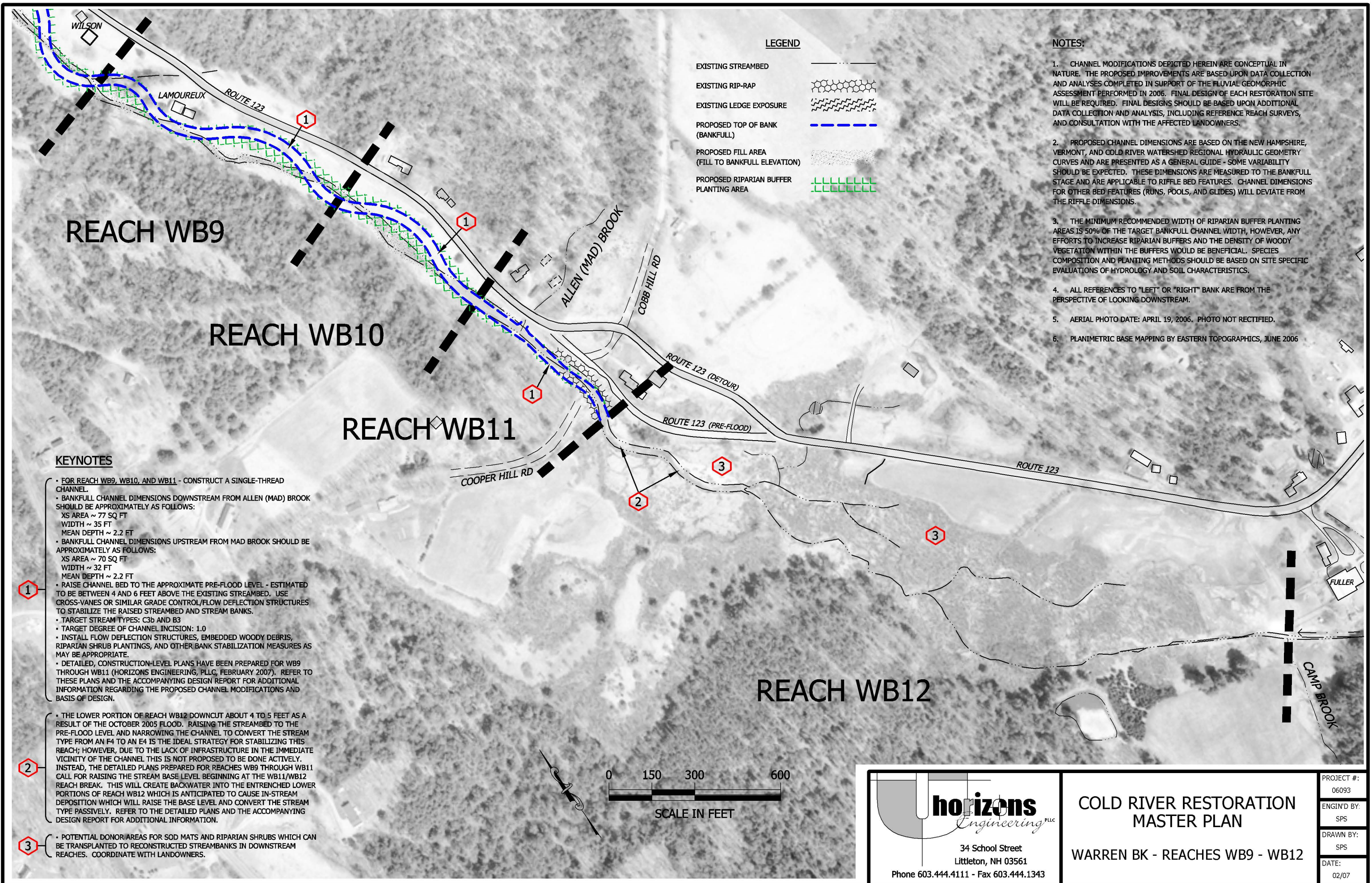
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**COLD RIVER RESTORATION
MASTER PLAN**

WARREN BK - REACHES WB6 - WB8

PROJECT #:	06093
ENGIN'D BY:	SPS
DRAWN BY:	SPS
DATE:	02/07



LEGEND

- EXISTING STREAMBED
- EXISTING RIP-RAP
- EXISTING LEDGE EXPOSURE
- PROPOSED TOP OF BANK (BANKFULL)
- PROPOSED FILL AREA (FILL TO BANKFULL ELEVATION)
- PROPOSED RIPARIAN BUFFER PLANTING AREA

NOTES:

1. CHANNEL MODIFICATIONS DEPICTED HEREIN ARE CONCEPTUAL IN NATURE. THE PROPOSED IMPROVEMENTS ARE BASED UPON DATA COLLECTION AND ANALYSES COMPLETED IN SUPPORT OF THE FLUVIAL GEOMORPHIC ASSESSMENT PERFORMED IN 2006. FINAL DESIGN OF EACH RESTORATION SITE WILL BE REQUIRED. FINAL DESIGNS SHOULD BE BASED UPON ADDITIONAL DATA COLLECTION AND ANALYSIS, INCLUDING REFERENCE REACH SURVEYS, AND CONSULTATION WITH THE AFFECTED LANDOWNERS.
2. PROPOSED CHANNEL DIMENSIONS ARE BASED ON THE NEW HAMPSHIRE, VERMONT, AND COLD RIVER WATERSHED REGIONAL HYDRAULIC GEOMETRY CURVES AND ARE PRESENTED AS A GENERAL GUIDE - SOME VARIABILITY SHOULD BE EXPECTED. THESE DIMENSIONS ARE MEASURED TO THE BANKFULL STAGE AND ARE APPLICABLE TO RIFFLE BED FEATURES. CHANNEL DIMENSIONS FOR OTHER BED FEATURES (RUNS, POOLS, AND GLIDES) WILL DEVIATE FROM THE RIFFLE DIMENSIONS.
3. THE MINIMUM RECOMMENDED WIDTH OF RIPARIAN BUFFER PLANTING AREAS IS 50% OF THE TARGET BANKFULL CHANNEL WIDTH, HOWEVER, ANY EFFORTS TO INCREASE RIPARIAN BUFFERS AND THE DENSITY OF WOODY VEGETATION WITHIN THE BUFFERS WOULD BE BENEFICIAL. SPECIES COMPOSITION AND PLANTING METHODS SHOULD BE BASED ON SITE SPECIFIC EVALUATIONS OF HYDROLOGY AND SOIL CHARACTERISTICS.
4. ALL REFERENCES TO "LEFT" OR "RIGHT" BANK ARE FROM THE PERSPECTIVE OF LOOKING DOWNSTREAM.
5. AERIAL PHOTO DATE: APRIL 19, 2006. PHOTO NOT RECTIFIED.
6. PLANIMETRIC BASE MAPPING BY EASTERN TOPOGRAPHICS, JUNE 2006

KEYNOTES

- FOR REACH WB9, WB10, AND WB11 - CONSTRUCT A SINGLE-THREAD CHANNEL.
- BANKFULL CHANNEL DIMENSIONS DOWNSTREAM FROM ALLEN (MAD) BROOK SHOULD BE APPROXIMATELY AS FOLLOWS:
XS AREA ~ 77 SQ FT
WIDTH ~ 35 FT
MEAN DEPTH ~ 2.2 FT
- BANKFULL CHANNEL DIMENSIONS UPSTREAM FROM MAD BROOK SHOULD BE APPROXIMATELY AS FOLLOWS:
XS AREA ~ 70 SQ FT
WIDTH ~ 32 FT
MEAN DEPTH ~ 2.2 FT
- RAISE CHANNEL BED TO THE APPROXIMATE PRE-FLOOD LEVEL - ESTIMATED TO BE BETWEEN 4 AND 6 FEET ABOVE THE EXISTING STREAMBED. USE CROSS-VANES OR SIMILAR GRADE CONTROL/FLOW DEFLECTION STRUCTURES TO STABILIZE THE RAISED STREAMBED AND STREAM BANKS.
- TARGET STREAM TYPES: C3b AND B3
- TARGET DEGREE OF CHANNEL INCISION: 1.0
- INSTALL FLOW DEFLECTION STRUCTURES, EMBEDDED WOODY DEBRIS, RIPARIAN SHRUB PLANTINGS, AND OTHER BANK STABILIZATION MEASURES AS MAY BE APPROPRIATE.
- DETAILED, CONSTRUCTION-LEVEL PLANS HAVE BEEN PREPARED FOR WB9 THROUGH WB11 (HORIZONS ENGINEERING, PLLC, FEBRUARY 2007). REFER TO THESE PLANS AND THE ACCOMPANYING DESIGN REPORT FOR ADDITIONAL INFORMATION REGARDING THE PROPOSED CHANNEL MODIFICATIONS AND BASIS OF DESIGN.
- THE LOWER PORTION OF REACH WB12 DOWNCUT ABOUT 4 TO 5 FEET AS A RESULT OF THE OCTOBER 2005 FLOOD. RAISING THE STREAMBED TO THE PRE-FLOOD LEVEL AND NARROWING THE CHANNEL TO CONVERT THE STREAM TYPE FROM AN F4 TO AN E4 IS THE IDEAL STRATEGY FOR STABILIZING THIS REACH; HOWEVER, DUE TO THE LACK OF INFRASTRUCTURE IN THE IMMEDIATE VICINITY OF THE CHANNEL THIS IS NOT PROPOSED TO BE DONE ACTIVELY. INSTEAD, THE DETAILED PLANS PREPARED FOR REACHES WB9 THROUGH WB11 CALL FOR RAISING THE STREAM BASE LEVEL BEGINNING AT THE WB11/WB12 REACH BREAK. THIS WILL CREATE BACKWATER INTO THE ENTRENCHED LOWER PORTIONS OF REACH WB12 WHICH IS ANTICIPATED TO CAUSE IN-STREAM DEPOSITION WHICH WILL RAISE THE BASE LEVEL AND CONVERT THE STREAM TYPE PASSIVELY. REFER TO THE DETAILED PLANS AND THE ACCOMPANYING DESIGN REPORT FOR ADDITIONAL INFORMATION.
- POTENTIAL DONOR AREAS FOR SOD MATS AND RIPARIAN SHRUBS WHICH CAN BE TRANSPLANTED TO RECONSTRUCTED STREAMBANKS IN DOWNSTREAM REACHES. COORDINATE WITH LANDOWNERS.



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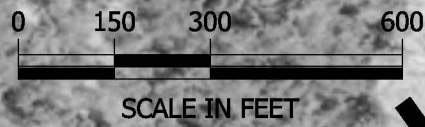
**COLD RIVER RESTORATION
MASTER PLAN**

WARREN BK - REACHES WB9 - WB12

PROJECT #:	06093
ENGIN'D BY:	SPS
DRAWN BY:	SPS
DATE:	02/07

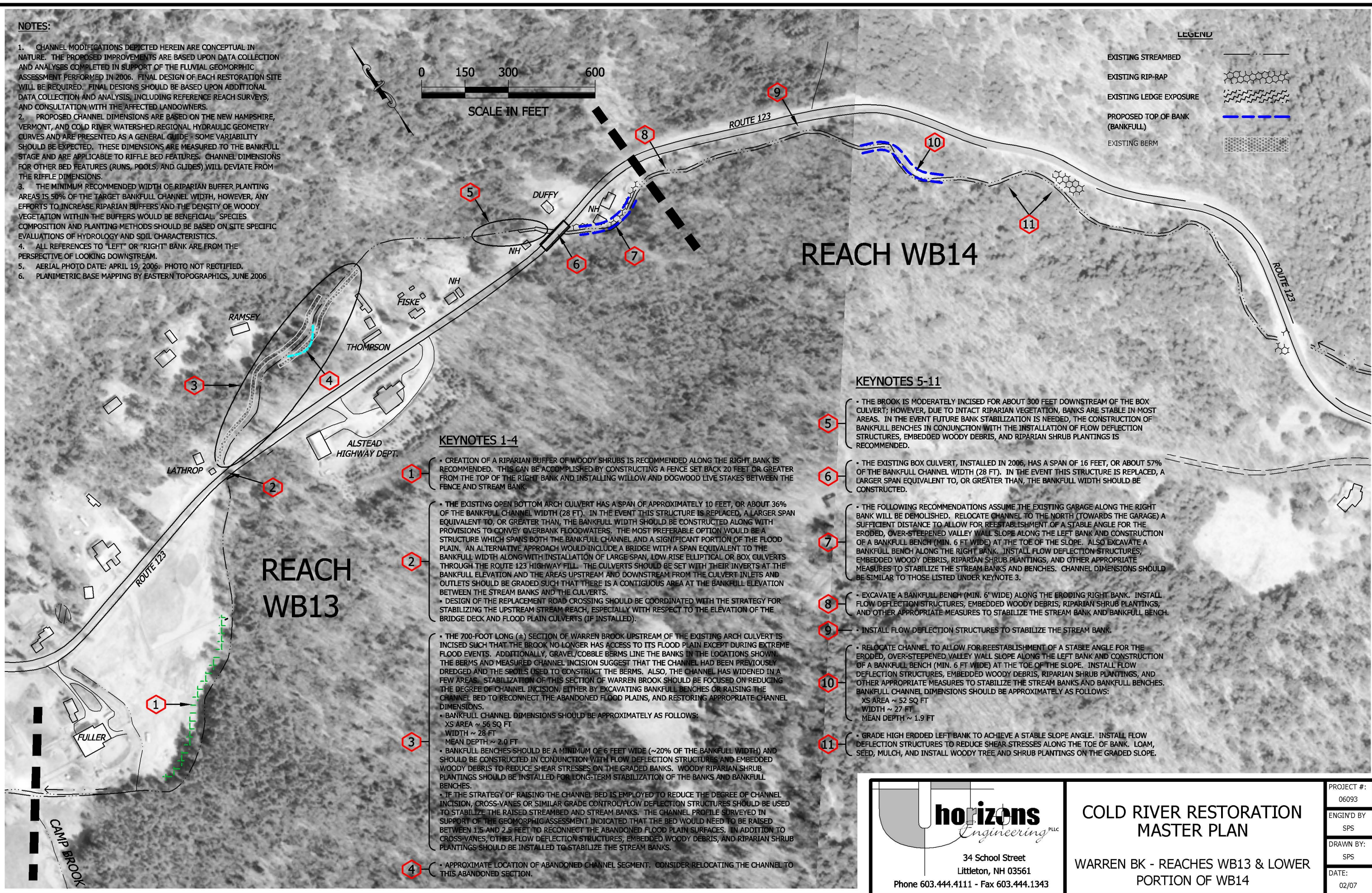
NOTES:

1. CHANNEL MODIFICATIONS DEPICTED HEREIN ARE CONCEPTUAL IN NATURE. THE PROPOSED IMPROVEMENTS ARE BASED UPON DATA COLLECTION AND ANALYSES COMPLETED IN SUPPORT OF THE FLUVIAL GEOMORPHIC ASSESSMENT PERFORMED IN 2006. FINAL DESIGN OF EACH RESTORATION SITE WILL BE REQUIRED. FINAL DESIGNS SHOULD BE BASED UPON ADDITIONAL DATA COLLECTION AND ANALYSIS, INCLUDING REFERENCE REACH SURVEYS, AND CONSULTATION WITH THE AFFECTED LANDOWNERS.
2. PROPOSED CHANNEL DIMENSIONS ARE BASED ON THE NEW HAMPSHIRE, VERMONT, AND COLD RIVER WATERSHED REGIONAL HYDRAULIC GEOMETRY CURVES AND ARE PRESENTED AS A GENERAL GUIDE - SOME VARIABILITY SHOULD BE EXPECTED. THESE DIMENSIONS ARE MEASURED TO THE BANKFULL STAGE AND ARE APPLICABLE TO RIFFLE BED FEATURES. CHANNEL DIMENSIONS FOR OTHER BED FEATURES (RUNS, POOLS, AND GLIDES) WILL DEVIATE FROM THE RIFFLE DIMENSIONS.
3. THE MINIMUM RECOMMENDED WIDTH OF RIPARIAN BUFFER PLANTING AREAS IS 50% OF THE TARGET BANKFULL CHANNEL WIDTH, HOWEVER, ANY EFFORTS TO INCREASE RIPARIAN BUFFERS AND THE DENSITY OF WOODY VEGETATION WITHIN THE BUFFERS WOULD BE BENEFICIAL. SPECIES COMPOSITION AND PLANTING METHODS SHOULD BE BASED ON SITE SPECIFIC EVALUATIONS OF HYDROLOGY AND SOIL CHARACTERISTICS.
4. ALL REFERENCES TO "LEFT" OR "RIGHT" BANK ARE FROM THE PERSPECTIVE OF LOOKING DOWNSTREAM.
5. AERIAL PHOTO DATE: APRIL 19, 2006. PHOTO NOT RECTIFIED.
6. PLANIMETRIC BASE MAPPING BY EASTERN TOPOGRAPHICS, JUNE 2006



LEGEND

- EXISTING STREAMBED
- EXISTING RIP-RAP
- EXISTING LEDGE EXPOSURE
- PROPOSED TOP OF BANK (BANKFULL)
- EXISTING BERM



KEYNOTES 1-4

- 1. CREATION OF A RIPARIAN BUFFER OF WOODY SHRUBS IS RECOMMENDED ALONG THE RIGHT BANK IS RECOMMENDED. THIS CAN BE ACCOMPLISHED BY CONSTRUCTING A FENCE SET BACK 20 FEET OR GREATER FROM THE TOP OF THE RIGHT BANK AND INSTALLING WILLOW AND DOGWOOD LIVE STAKES BETWEEN THE FENCE AND STREAM BANK.
- 2. THE EXISTING OPEN BOTTOM ARCH CULVERT HAS A SPAN OF APPROXIMATELY 10 FEET, OR ABOUT 36% OF THE BANKFULL CHANNEL WIDTH (28 FT). IN THE EVENT THIS STRUCTURE IS REPLACED, A LARGER SPAN EQUIVALENT TO, OR GREATER THAN, THE BANKFULL WIDTH SHOULD BE CONSTRUCTED ALONG WITH PROVISIONS TO CONVEY OVERBANK FLOODWATERS. THE MOST PREFERABLE OPTION WOULD BE A STRUCTURE WHICH SPANS BOTH THE BANKFULL CHANNEL AND A SIGNIFICANT PORTION OF THE FLOOD PLAIN. AN ALTERNATIVE APPROACH WOULD INCLUDE A BRIDGE WITH A SPAN EQUIVALENT TO THE BANKFULL WIDTH ALONG WITH INSTALLATION OF LARGE SPAN, LOW RISE ELLIPTICAL OR BOX CULVERTS THROUGH THE ROUTE 123 HIGHWAY FILL. THE CULVERTS SHOULD BE SET WITH THEIR INVERTS AT THE BANKFULL ELEVATION AND THE AREAS UPSTREAM AND DOWNSTREAM FROM THE CULVERT INLETS AND OUTLETS SHOULD BE GRADED SUCH THAT THERE IS A CONTIGUOUS AREA AT THE BANKFULL ELEVATION BETWEEN THE STREAM BANKS AND THE CULVERTS.
- 3. DESIGN OF THE REPLACEMENT ROAD CROSSING SHOULD BE COORDINATED WITH THE STRATEGY FOR STABILIZING THE UPSTREAM STREAM REACH, ESPECIALLY WITH RESPECT TO THE ELEVATION OF THE BRIDGE DECK AND FLOOD PLAIN CULVERTS (IF INSTALLED).
- 4. THE 700-FOOT LONG (±) SECTION OF WARREN BROOK UPSTREAM OF THE EXISTING ARCH CULVERT IS INCISED SUCH THAT THE BROOK NO LONGER HAS ACCESS TO ITS FLOOD PLAIN EXCEPT DURING EXTREME FLOOD EVENTS. ADDITIONALLY, GRAVEL/COBBLE BERMS LINE THE BANKS IN THE LOCATIONS SHOWN. THE BERMS AND MEASURED CHANNEL INCISION SUGGEST THAT THE CHANNEL HAD BEEN PREVIOUSLY DREDGED AND THE SPOILS USED TO CONSTRUCT THE BERMS. ALSO, THE CHANNEL HAS WIDENED IN A FEW AREAS. STABILIZATION OF THIS SECTION OF WARREN BROOK SHOULD BE FOCUSED ON REDUCING THE DEGREE OF CHANNEL INCISION, EITHER BY EXCAVATING BANKFULL BENCHES OR RAISING THE CHANNEL BED TO RECONNECT THE ABANDONED FLOOD PLAINS, AND RESTORING APPROPRIATE CHANNEL DIMENSIONS.
- 5. BANKFULL CHANNEL DIMENSIONS SHOULD BE APPROXIMATELY AS FOLLOWS:
XS AREA ~ 56 SQ FT
WIDTH ~ 28 FT
MEAN DEPTH ~ 2.0 FT
- 6. BANKFULL BENCHES SHOULD BE A MINIMUM OF 6 FEET WIDE (~20% OF THE BANKFULL WIDTH) AND SHOULD BE CONSTRUCTED IN CONJUNCTION WITH FLOW DEFLECTION STRUCTURES AND EMBEDDED WOODY DEBRIS TO REDUCE SHEAR STRESSES ON THE GRADED BANKS. WOODY RIPARIAN SHRUB PLANTINGS SHOULD BE INSTALLED FOR LONG-TERM STABILIZATION OF THE BANKS AND BANKFULL BENCHES.
- 7. IF THE STRATEGY OF RAISING THE CHANNEL BED IS EMPLOYED TO REDUCE THE DEGREE OF CHANNEL INCISION, CROSS-VANES OR SIMILAR GRADE CONTROL/FLOW DEFLECTION STRUCTURES SHOULD BE USED TO STABILIZE THE RAISED STREAMBED AND STREAM BANKS. THE CHANNEL PROFILE SURVEYED IN SUPPORT OF THE GEOMORPHIC ASSESSMENT INDICATED THAT THE BED WOULD NEED TO BE RAISED BETWEEN 1.5 AND 2.5 FEET TO RECONNECT THE ABANDONED FLOOD PLAIN SURFACES. IN ADDITION TO CROSS-VANES, OTHER FLOW DEFLECTION STRUCTURES, EMBEDDED WOODY DEBRIS, AND RIPARIAN SHRUB PLANTINGS SHOULD BE INSTALLED TO STABILIZE THE STREAM BANKS.
- 8. APPROXIMATE LOCATION OF ABANDONED CHANNEL SEGMENT. CONSIDER RELOCATING THE CHANNEL TO THIS ABANDONED SECTION.

KEYNOTES 5-11

- 5. THE BROOK IS MODERATELY INCISED FOR ABOUT 300 FEET DOWNSTREAM OF THE BOX CULVERT; HOWEVER, DUE TO INTACT RIPARIAN VEGETATION, BANKS ARE STABLE IN MOST AREAS. IN THE EVENT FUTURE BANK STABILIZATION IS NEEDED, THE CONSTRUCTION OF BANKFULL BENCHES IN CONJUNCTION WITH THE INSTALLATION OF FLOW DEFLECTION STRUCTURES, EMBEDDED WOODY DEBRIS, AND RIPARIAN SHRUB PLANTINGS IS RECOMMENDED.
- 6. THE EXISTING BOX CULVERT, INSTALLED IN 2006, HAS A SPAN OF 16 FEET, OR ABOUT 57% OF THE BANKFULL CHANNEL WIDTH (28 FT). IN THE EVENT THIS STRUCTURE IS REPLACED, A LARGER SPAN EQUIVALENT TO, OR GREATER THAN, THE BANKFULL WIDTH SHOULD BE CONSTRUCTED.
- 7. THE FOLLOWING RECOMMENDATIONS ASSUME THE EXISTING GARAGE ALONG THE RIGHT BANK WILL BE DEMOLISHED. RELOCATE CHANNEL TO THE NORTH (TOWARDS THE GARAGE) A SUFFICIENT DISTANCE TO ALLOW FOR REESTABLISHMENT OF A STABLE ANGLE FOR THE ERODED, OVER-STEEPENED VALLEY WALL SLOPE ALONG THE LEFT BANK AND CONSTRUCTION OF A BANKFULL BENCH (MIN. 6 FT WIDE) AT THE TOE OF THE SLOPE. ALSO EXCAVATE A BANKFULL BENCH ALONG THE RIGHT BANK. INSTALL FLOW DEFLECTION STRUCTURES, EMBEDDED WOODY DEBRIS, RIPARIAN SHRUB PLANTINGS, AND OTHER APPROPRIATE MEASURES TO STABILIZE THE STREAM BANKS AND BENCHES. CHANNEL DIMENSIONS SHOULD BE SIMILAR TO THOSE LISTED UNDER KEYNOTE 3.
- 8. EXCAVATE A BANKFULL BENCH (MIN. 6" WIDE) ALONG THE ERODING RIGHT BANK. INSTALL FLOW DEFLECTION STRUCTURES, EMBEDDED WOODY DEBRIS, RIPARIAN SHRUB PLANTINGS, AND OTHER APPROPRIATE MEASURES TO STABILIZE THE STREAM BANK AND BANKFULL BENCH.
- 9. INSTALL FLOW DEFLECTION STRUCTURES TO STABILIZE THE STREAM BANK.
- 10. RELOCATE CHANNEL TO ALLOW FOR REESTABLISHMENT OF A STABLE ANGLE FOR THE ERODED, OVER-STEEPENED VALLEY WALL SLOPE ALONG THE LEFT BANK AND CONSTRUCTION OF A BANKFULL BENCH (MIN. 6 FT WIDE) AT THE TOE OF THE SLOPE. INSTALL FLOW DEFLECTION STRUCTURES, EMBEDDED WOODY DEBRIS, RIPARIAN SHRUB PLANTINGS, AND OTHER APPROPRIATE MEASURES TO STABILIZE THE STREAM BANKS AND BANKFULL BENCHES. BANKFULL CHANNEL DIMENSIONS SHOULD BE APPROXIMATELY AS FOLLOWS:
XS AREA ~ 52 SQ FT
WIDTH ~ 27 FT
MEAN DEPTH ~ 1.9 FT
- 11. GRADE HIGH ERODED LEFT BANK TO ACHIEVE A STABLE SLOPE ANGLE. INSTALL FLOW DEFLECTION STRUCTURES TO REDUCE SHEAR STRESSES ALONG THE TOE OF BANK. LOAM, SEED, MULCH, AND INSTALL WOODY TREE AND SHRUB PLANTINGS ON THE GRADED SLOPE.

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**COLD RIVER RESTORATION
MASTER PLAN**

WARREN BK - REACHES WB13 & LOWER
PORTION OF WB14

PROJECT #:	06093
ENGIN'D BY:	SPS
DRAWN BY:	SPS
DATE:	02/07

KEYNOTES 1-3

- 1. EVALUATE THE POTENTIAL TO NARROW THE CHANNEL SUFFICIENTLY TO ALLOW FOR: (1) REESTABLISHMENT OF A STABLE ANGLE FOR THE ERODED, OVER-STEEPENED SLOPE ALONG THE LEFT BANK; AND (2) CONSTRUCTION OF A BANKFULL BENCH (MIN. 6 FT WIDE) AT THE TOE OF THE SLOPE. INSTALL FLOW DEFLECTION STRUCTURES, EMBEDDED WOODY DEBRIS, RIPARIAN SHRUB PLANTINGS, AND/OR OTHER APPROPRIATE MEASURES TO STABILIZE THE STREAM BANKS AND BANKFULL BENCHES. BANKFULL CHANNEL DIMENSIONS SHOULD BE APPROXIMATELY AS FOLLOWS:
XS AREA ~ 48 SQ FT
WIDTH ~ 25 FT
MEAN DEPTH ~ 1.9 FT
NARROWING THE CHANNEL TO ALLOW FOR A STABLE SLOPE ANGLE WITHOUT A BANKFULL BENCH WOULD BE AN ALTERNATE, THOUGH LESS DESIRABLE, METHOD. INSTALLATION OF FLOW DEFLECTORS AND/OR OTHER BANK STABILIZATION MEASURES WITHOUT SLOPE MODIFICATIONS OR A BANKFULL BENCH WOULD BE THE THIRD ALTERNATIVE.
- 2. THE EXISTING ROUND CULVERT HAS A DIAMETER OF 6 FEET, OR ABOUT 24% OF THE BANKFULL CHANNEL WIDTH (25 FT). IN THE EVENT THIS STRUCTURE IS REPLACED, AN OPEN-BOTTOM STRUCTURE WITH A SPAN EQUIVALENT TO, OR GREATER THAN, THE BANKFULL WIDTH SHOULD BE CONSTRUCTED. DUE TO THE STEEP CHANNEL GRADIENT IN THIS AREA, THE CROSSING SHOULD BE DESIGNED TO ALLOW FOR ENERGY DISSIPATION THROUGH THE STRUCTURE TO MINIMIZE SCOUR BELOW THE OUTLET. CONSTRUCT A SERIES OF STEPS AND POOLS DOWNSTREAM OF THE CROSSING FOR ENERGY DISSIPATION.
- 3. EVALUATE THE POTENTIAL TO NARROW THE CHANNEL SUFFICIENTLY TO ALLOW FOR: (1) REESTABLISHMENT OF A STABLE ANGLE FOR THE ERODED, OVER-STEEPENED SLOPES ALONG THE RIGHT BANK IN THESE AREAS; AND (2) CONSTRUCTION OF A BANKFULL BENCH (MIN. 6 FT WIDE) AT THE TOE OF THE SLOPE. INSTALL FLOW DEFLECTION STRUCTURES, EMBEDDED WOODY DEBRIS, RIPARIAN SHRUB PLANTINGS, AND/OR OTHER APPROPRIATE MEASURES TO STABILIZE THE STREAM BANKS AND BANKFULL BENCHES. BANKFULL CHANNEL DIMENSIONS SHOULD BE APPROXIMATELY AS FOLLOWS:
XS AREA ~ 48 SQ FT
WIDTH ~ 25 FT
MEAN DEPTH ~ 1.9 FT
NARROWING THE CHANNEL TO ALLOW FOR A STABLE SLOPE ANGLE WITHOUT A BANKFULL BENCH WOULD BE AN ALTERNATE, THOUGH LESS DESIRABLE, METHOD. INSTALLATION OF FLOW DEFLECTORS AND/OR OTHER BANK STABILIZATION MEASURES WITHOUT SLOPE MODIFICATIONS OR A BANKFULL BENCH WOULD BE THE THIRD ALTERNATIVE.

KEYNOTES 4-10

- 4. MODIFY DAM SPILLWAY TO PROVIDE GREATER HYDRAULIC CAPACITY AND REDUCE BACKWATER.
- 5. THE EXISTING BOX CULVERT HAS A SPAN OF 6 FEET, OR ABOUT 24% OF THE BANKFULL CHANNEL WIDTH (25 FT). IN THE EVENT THIS STRUCTURE IS REPLACED, A STRUCTURE WITH GREATER HYDRAULIC CAPACITY SHOULD BE CONSIDERED. HYDRAULIC MODELING OF THE STREAM REACH FROM BELOW THE MILL DAM UPSTREAM TO PRENTICE HILL ROAD SHOULD BE PERFORMED TO DETERMINE THE BENEFIT OF A LARGER STRUCTURE IF MODIFICATIONS TO THE MILL DAM ARE NOT MADE.
- 6. STABILITY OF THE LOWER PORTION OF REACH WB15 IS DIRECTLY RELATED TO THE HYDRAULIC CAPACITY OF THE MILL DAM AND BOX CULVERT. THE CHANNEL HAS WIDENED AND IS AGGRADING; HOWEVER, RESTORING APPROPRIATE CHANNEL DIMENSIONS IS UNLIKELY TO BE SUCCESSFUL UNTIL MODIFICATIONS TO THE DOWNSTREAM STRUCTURES ARE MADE WHICH REDUCE BACKWATER AND INCREASE SEDIMENT TRANSPORT COMPETENCE IN REACH WB15.
- 7. INSTALL RIPARIAN SHRUB PLANTINGS TO INCREASE THE DENSITY OF VEGETATION BETWEEN THE PASTURE FENCE AND THE STREAM BANK.
- 8. THE EXISTING BRIDGE HAS A SPAN OF 4 FEET (MEASURED BETWEEN THE STONE ABUTMENTS), OR ABOUT 16% OF THE BANKFULL CHANNEL WIDTH (25 FT). IN THE EVENT THIS STRUCTURE IS REPLACED, AN OPEN-BOTTOM STRUCTURE WITH A SPAN EQUIVALENT TO, OR GREATER THAN, THE BANKFULL WIDTH SHOULD BE CONSTRUCTED.
- 9. THE EXISTING OPEN-BOTTOM ARCH CULVERT HAS A SPAN OF 13 FEET, OR ABOUT 52% OF THE BANKFULL CHANNEL WIDTH (25 FT). IN THE EVENT THIS STRUCTURE IS REPLACED, A STRUCTURE WITH GREATER HYDRAULIC CAPACITY SHOULD BE CONSIDERED ALONG WITH RAISING THE ROADWAY GRADE.
- 10. INSTALL WATER STAGE RECORDER OR A SIMPLE CREST-STAGE GAGE AT THE EXISTING CONCRETE WEIR ON WARREN BROOK AND/OR AT THE DAM SPILLWAY. MONITOR FLOWS TO GATHER EMPIRICAL HYDROLOGIC DATA.

LEGEND

- EXISTING STREAMBED
- EXISTING RIP-RAP
- EXISTING LEDGE EXPOSURE

REACH WB14

REACH WB15

- NOTES:**
1. CHANNEL MODIFICATIONS DEPICTED HEREIN ARE CONCEPTUAL IN NATURE. THE PROPOSED IMPROVEMENTS ARE BASED UPON DATA COLLECTION AND ANALYSES COMPLETED IN SUPPORT OF THE FLUVIAL GEOMORPHIC ASSESSMENT PERFORMED IN 2006. FINAL DESIGN OF EACH RESTORATION SITE WILL BE REQUIRED. FINAL DESIGNS SHOULD BE BASED UPON ADDITIONAL DATA COLLECTION AND ANALYSIS, INCLUDING REFERENCE REACH SURVEYS, AND CONSULTATION WITH THE AFFECTED LANDOWNERS.
 2. PROPOSED CHANNEL DIMENSIONS ARE BASED ON THE NEW HAMPSHIRE, VERMONT, AND COLD RIVER WATERSHED REGIONAL HYDRAULIC GEOMETRY CURVES AND ARE PRESENTED AS A GENERAL GUIDE - SOME VARIABILITY SHOULD BE EXPECTED. THESE DIMENSIONS ARE MEASURED TO THE BANKFULL STAGE AND ARE APPLICABLE TO RIFFLE BED FEATURES. CHANNEL DIMENSIONS FOR OTHER BED FEATURES (RUNS, POOLS, AND GLIDES) WILL DEVIATE FROM THE RIFFLE DIMENSIONS.
 3. THE MINIMUM RECOMMENDED WIDTH OF RIPARIAN BUFFER PLANTING AREAS IS 50% OF THE TARGET BANKFULL CHANNEL WIDTH, HOWEVER, ANY EFFORTS TO INCREASE RIPARIAN BUFFERS AND THE DENSITY OF WOODY VEGETATION WITHIN THE BUFFERS WOULD BE BENEFICIAL. SPECIES COMPOSITION AND PLANTING METHODS SHOULD BE BASED ON SITE SPECIFIC EVALUATIONS OF HYDROLOGY AND SOIL CHARACTERISTICS.
 4. ALL REFERENCES TO "LEFT" OR "RIGHT" BANK ARE FROM THE PERSPECTIVE OF LOOKING DOWNSTREAM.
 5. AERIAL PHOTO DATE: APRIL 19, 2006. PHOTO NOT RECTIFIED.
 6. PLANIMETRIC BASE MAPPING BY EASTERN TOPOGRAPHICS, JUNE 2006



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**COLD RIVER RESTORATION
MASTER PLAN**

**WARREN BK - UPPER PORTION OF
REACH WB14 & REACH WB15**

PROJECT #:	06093
ENGIN'D BY:	SPS
DRAWN BY:	SPS
DATE:	02/07

Bowers Brook Restoration Site Plan

BERYL MTN. ROAD BRIDGE

REMNANTS OF BREACHED DAM

COLD RIVER

MICA SHED

HOUSE

BOWERS BROOK

RTE 123A (APPROX. LOCATION)

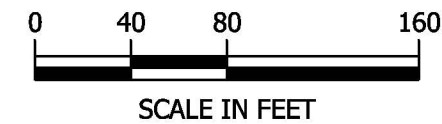
CHURCH OUTBUILDING

CHURCH

ABANDONED CHANNEL

LEGEND

- EXISTING TOP OF BANK
- EXISTING RIP-RAP
- EXISTING LEDGE EXPOSURE
- PROPOSED TOP OF BANK (BANKFULL)
- PROPOSED FILL AREA (FILL TO BANKFULL ELEVATION)
- PROPOSED RIPARIAN BUFFER PLANTING AREA



NOTES:

1. CHANNEL MODIFICATIONS DEPICTED HEREIN ARE CONCEPTUAL IN NATURE. THE PROPOSED IMPROVEMENTS ARE BASED UPON DATA COLLECTION AND ANALYSES COMPLETED IN SUPPORT OF THE FLUVIAL GEOMORPHIC ASSESSMENT PERFORMED IN 2006. FINAL DESIGN OF EACH RESTORATION SITE WILL BE REQUIRED. FINAL DESIGNS SHOULD BE BASED UPON ADDITIONAL DATA COLLECTION AND ANALYSIS, INCLUDING REFERENCE REACH SURVEYS, AND CONSULTATION WITH THE AFFECTED LANDOWNERS.
2. PROPOSED CHANNEL DIMENSIONS ARE BASED ON THE NEW HAMPSHIRE, VERMONT, AND COLD RIVER WATERSHED REGIONAL HYDRAULIC GEOMETRY CURVES AND ARE PRESENTED AS A GENERAL GUIDE - SOME VARIABILITY SHOULD BE EXPECTED. THESE DIMENSIONS ARE MEASURED TO THE BANKFULL STAGE AND ARE APPLICABLE TO RIFFLE BED FEATURES. CHANNEL DIMENSIONS FOR OTHER BED FEATURES (RUNS, POOLS, AND GLIDES) WILL DEVIATE FROM THE RIFFLE DIMENSIONS.
3. THE MINIMUM RECOMMENDED WIDTH OF RIPARIAN BUFFER PLANTING AREAS IS 50% OF THE TARGET BANKFULL CHANNEL WIDTH, HOWEVER, ANY EFFORTS TO INCREASE RIPARIAN BUFFERS AND THE DENSITY OF WOODY VEGETATION WITHIN THE BUFFERS WOULD BE BENEFICIAL. SPECIES COMPOSITION AND PLANTING METHODS SHOULD BE BASED ON SITE SPECIFIC EVALUATIONS OF HYDROLOGY AND SOIL CHARACTERISTICS.
4. ALL REFERENCES TO "LEFT" OR "RIGHT" BANK ARE FROM THE PERSPECTIVE OF LOOKING DOWNSTREAM.
5. PLANIMETRY FROM FIELD SURVEYS BY HORIZONS ENGINEERING PERFORMED

KEYNOTES 1-5

- 1. RELOCATE THE CHANNEL ACROSS THE NORTH END OF THE "ISLAND". BANKFULL CHANNEL DIMENSIONS SHOULD BE APPROXIMATELY AS FOLLOWS:
XS AREA ~ 50 SQ FT
WIDTH ~ 25 FT
MEAN DEPTH ~ 2.0 FT
TARGET STREAM TYPE: C3
TARGET DEGREE OF CHANNEL INCISION: 1.0
INSTALL FLOW DEFLECTION STRUCTURES, EMBEDDED WOODY DEBRIS, RIPARIAN SHRUB PLANTINGS, AND OTHER BANK STABILIZATION MEASURES AS MAY BE APPROPRIATE.
FILL EXISTING CHANNELS ON EITHER SIDE OF THE "ISLAND" TO THE BANKFULL ELEVATION.
- 2. GRADE "ISLAND" TO THE BANKFULL ELEVATION. SALVAGE EXISTING RIPARIAN SHRUBS AND TRANSPLANT TO THE OUTSIDE BANK OF THE RELOCATED BOWERS BROOK CHANNEL AND THE REGRADED BANK OF THE COLD RIVER.
- 3. INSTALL BURIED GRADE CONTROL STRUCTURES ACROSS THE FILLED CHANNEL.
- 4. EXCAVATE A BANKFULL BENCH (MIN. 6 FT WIDE) ALONG THE ERODING, UNDERCUT RIGHT BANK. INSTALL FLOW DEFLECTION STRUCTURES, EMBEDDED WOODY DEBRIS, RIPARIAN SHRUB PLANTINGS, AND OTHER BANK STABILIZATION MEASURES AS MAY BE APPROPRIATE TO STABILIZE THE BANK AND BANKFULL BENCH.
- 5. NARROW AND RELOCATE THE CHANNEL. BANKFULL CHANNEL DIMENSIONS SHOULD BE APPROXIMATELY AS FOLLOWS:
XS AREA ~ 50 SQ FT
WIDTH ~ 25 FT
MEAN DEPTH ~ 2.0 FT
TARGET STREAM TYPE: C3
TARGET DEGREE OF CHANNEL INCISION: 1.0
CREATE BANKFULL BENCHES (MIN. 6 FT WIDE) ALONG ALL STREAMBANKS.
INSTALL FLOW DEFLECTION STRUCTURES, EMBEDDED WOODY DEBRIS, RIPARIAN SHRUB PLANTINGS, AND OTHER BANK STABILIZATION MEASURES AS MAY BE APPROPRIATE.
THE STREAM REACH UPSTREAM FROM ROUTE 123A HAS INCISED SUCH THAT IT NO LONGER HAS ACCESS TO ITS FLOOD PLAIN EXCEPT DURING EXTREME FLOODS. BANKFULL BENCHES ARE RECOMMENDED TO REDUCE THE DEGREE OF CHANNEL INCISION; HOWEVER, AN ALTERNATE METHOD WOULD INVOLVE RAISING THE STREAMBED SUCH THAT THE ABANDONED FLOOD PLAIN SURFACES WERE AT THE BANKFULL ELEVATION. THIS WOULD LIKELY RAISE FLOOD ELEVATIONS; THEREFORE, DETAILED ANALYSES SHOULD BE PERFORMED TO QUANTIFY THE CHANGE IN FLOOD ELEVATIONS AND THE RESULTING IMPACTS TO NEARBY

KEYNOTES 6-7

- 6. THE EXISTING BRIDGE HAS A SPAN OF 10 FEET, OR ABOUT 40% OF THE BANKFULL CHANNEL WIDTH (25 FT). WHEN THIS STRUCTURE IS REPLACED, A LARGER SPAN EQUIVALENT TO, OR GREATER THAN, THE BANKFULL WIDTH SHOULD BE CONSTRUCTED ALONG WITH PROVISIONS TO CONVEY OVERBANK FLOODWATERS. THE MOST PREFERABLE OPTION WOULD BE A STRUCTURE WHICH SPANS BOTH THE BANKFULL CHANNEL AND A SIGNIFICANT PORTION OF THE FLOOD PLAIN. AN ALTERNATIVE, BUT LESS DESIRABLE, APPROACH WOULD INCLUDE A BRIDGE WITH A SPAN EQUIVALENT TO THE BANKFULL WIDTH ALONG WITH INSTALLATION OF LARGE SPAN, LOW RISE ELLIPTICAL OR BOX CULVERTS THROUGH THE HIGHWAY FILL. THE CULVERTS SHOULD BE SET WITH THEIR INVERTS AT THE BANKFULL ELEVATION AND THE AREAS UPSTREAM AND DOWNSTREAM FROM THE CULVERT INLETS AND OUTLETS SHOULD BE GRADED SUCH THAT THERE IS A CONTIGUOUS AREA AT THE BANKFULL ELEVATION BETWEEN THE STREAM BANKS AND THE CULVERTS.
DESIGN OF THE REPLACEMENT ROAD CROSSING SHOULD BE COORDINATED WITH THE STREAM RESTORATION DESIGN, ESPECIALLY WITH RESPECT TO THE ABUTMENT LOCATIONS AND, IF INSTALLED, THE NUMBER, SIZE, LOCATIONS, AND INVERT ELEVATIONS OF FLOOD PLAIN CULVERTS.
- 7. THE CHANNEL IS INCISED FOR SEVERAL HUNDRED FEET UPSTREAM OF THE MAPPING LIMITS. A WELL-DEFINED KNICKPOINT MARKS THE HEADWARD LIMIT OF INCISION. THE STREAMBANKS ARE ACTIVELY ERODING ALL ALONG THE INCISED REACH. SEDIMENT SUPPLY FROM THIS ERODING REACH COULD ADVERSELY AFFECT THE SUCCESS OF CHANNEL STABILIZATION MEASURES DEPICTED ON THIS PLAN; THEREFORE, THE ENTIRE INCISED REACH ABOVE ROUTE 123A SHOULD BE STABILIZED. THE RECOMMENDED APPROACH FOR STABILIZING THE INCISED REACH UPSTREAM OF THE MAPPING LIMITS INCLUDES THE EXCAVATION OF BANKFULL BENCHES (MIN. 6' WIDE) ALONG WITH THE INSTALLATION OF FLOW DEFLECTION AND GRADE CONTROL STRUCTURES (CROSS-VANES OR SIMILAR), EMBEDDED WOODY DEBRIS, AND RIPARIAN SHRUB PLANTINGS. SOME CHANNEL NARROWING MAY BE APPROPRIATE, IN WHICH CASE THE CHANNEL DIMENSIONS SHOULD BE SIMILAR TO THOSE LISTED UNDER KEYNOTES 1 AND 5. ONE OR MORE CROSS-VANES SHOULD BE INSTALLED IN THE VICINITY OF THE KNICKPOINT TO PREVENT ITS FURTHER HEADWARD ADVANCEMENT.

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COLD RIVER RESTORATION
MASTER PLAN
BOWERS BROOK

PROJECT #:	06093
ENGIN'D BY:	SPS
DRAWN BY:	SPS
DATE:	02/07

Regional Hydraulic Geometry Curves

Cold River Watershed Hydraulic Geometry Curves (2006 provisional)

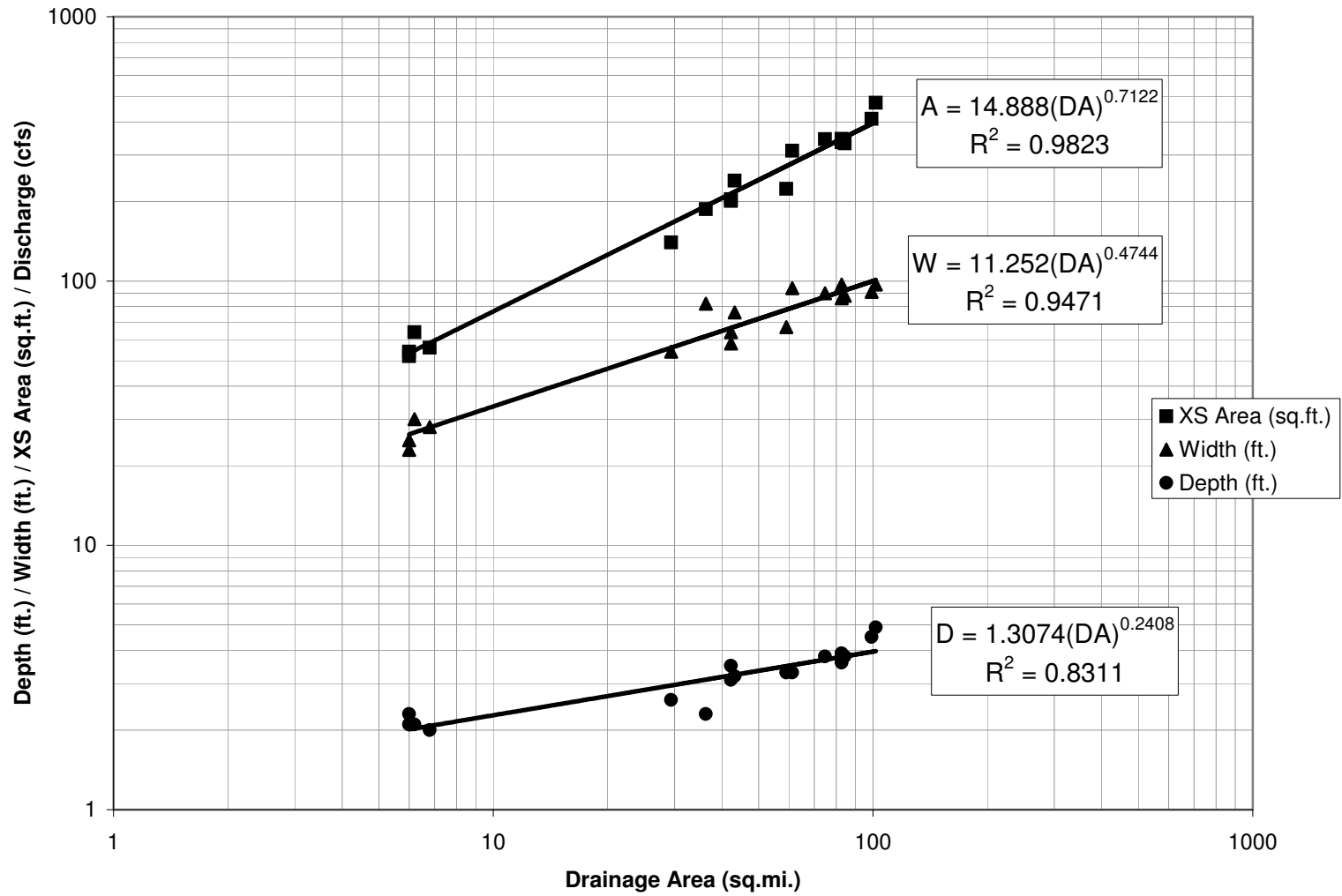
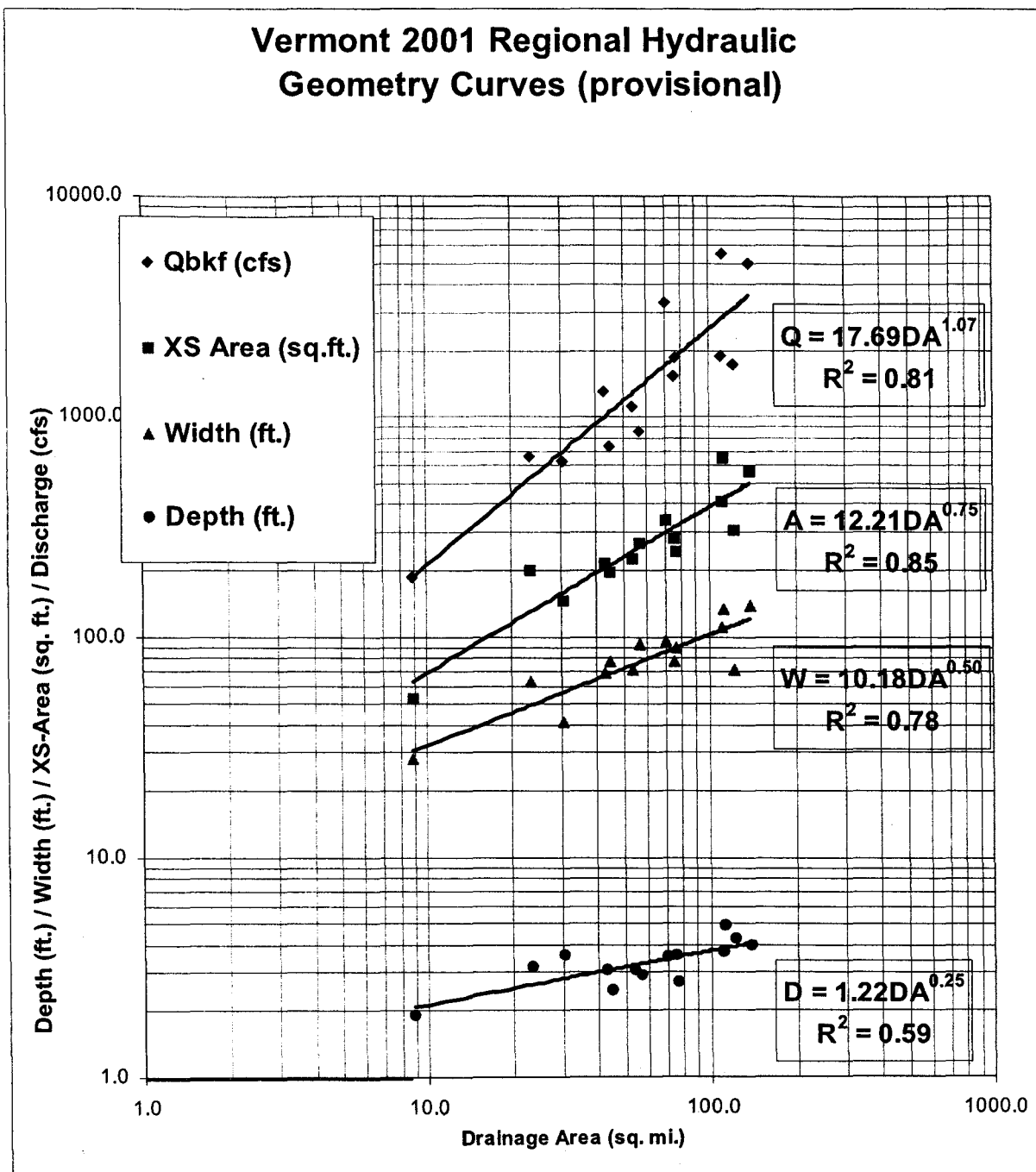
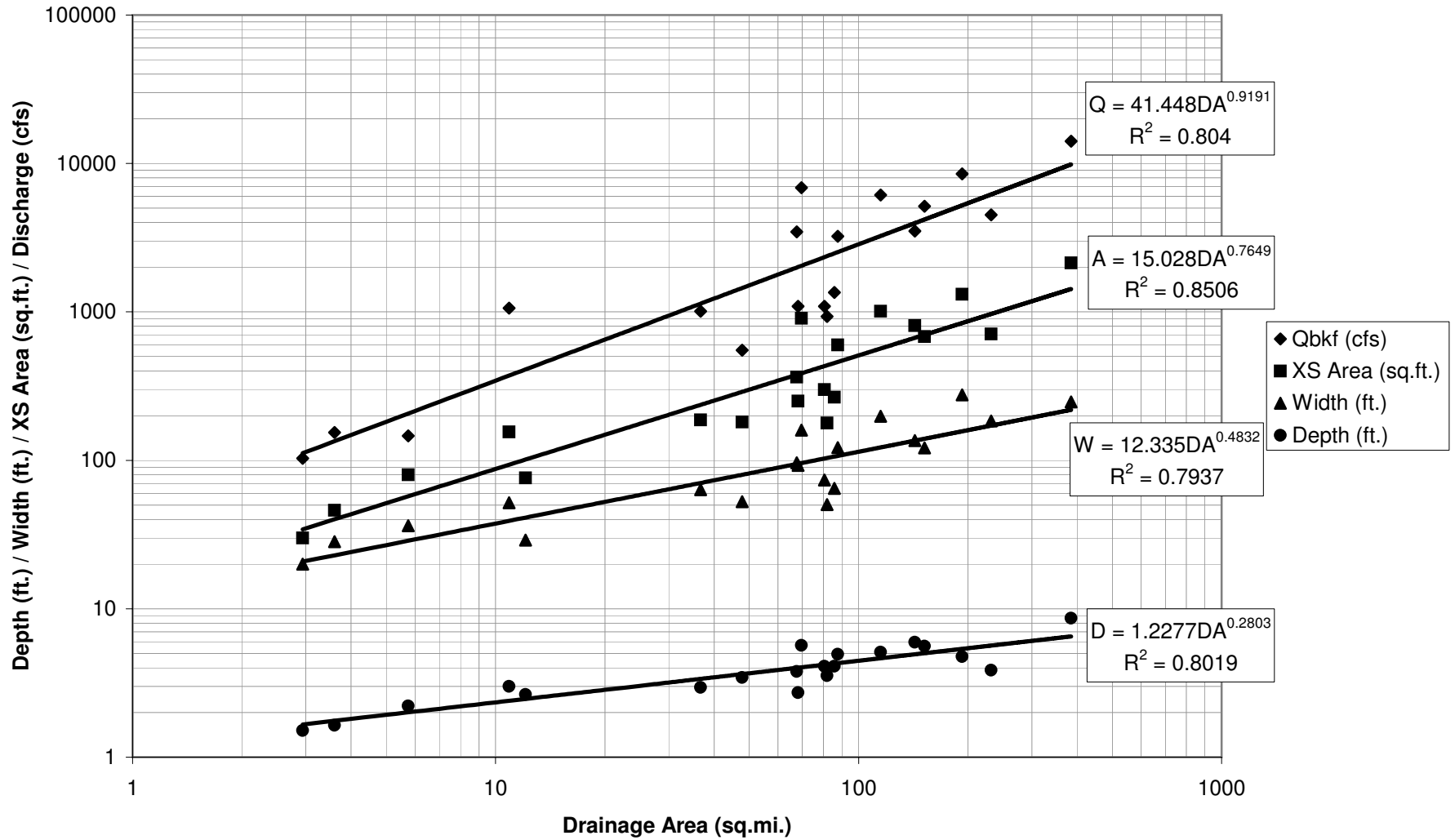


Figure 2



Note: These curves are provisional. Until the curves undergo field testing and peer review, caution is advised when using them for channel design purposes. Also, curves should only be used on streams of similar type and in similar hydro-physiographic settings as those from which the data was collected. The curves should not be applied to flow or sediment regulated streams (i.e. below flow regulating dams).

New Hampshire 2005 Regional Hydraulic Geometry Curves (provisional)



Hydraulic Geometry Curve Calculations

Cold River Restoration Project

Regional Hydraulic Geometry Curve Calculations

Reach	Drainage Area (sq mi)*	Discharge (cfs)		XS Area (sq ft)		Bankfull Width (ft)		Bankfull Depth (ft)		Cold River Watershed Curves			AVERAGE		
		VT	NH	VT	NH	VT	NH	VT	NH	Area	Width	Mean Depth	AREA	WIDTH	DEPTH
C1	101.7	2486	2900	391	516	103	115	3.9	4.5	400	101	4.0	436	106	4.11
C2	101.2	2473	2887	390	514	102	115	3.9	4.5	399	101	4.0	434	106	4.11
C2 (above Mountain Bk.)	99.1	2418	2832	384	505	101	114	3.8	4.5	393	100	4.0	427	105	4.09
C3	98.7	2408	2822	382	504	101	113	3.8	4.4	392	99	4.0	426	105	4.08
C4	84.2	2031	2438	339	446	93	105	3.7	4.3	350	92	3.8	379	97	3.92
C5	84.2	2031	2438	339	446	93	105	3.7	4.3	350	92	3.8	379	97	3.92
C6	83.6	2016	2422	338	444	93	105	3.7	4.2	348	92	3.8	377	97	3.91
C7	83.3	2008	2414	337	443	93	105	3.7	4.2	347	92	3.8	376	96	3.91
C8	83.3	2008	2414	337	443	93	105	3.7	4.2	347	92	3.8	376	96	3.91
C8 (above Darby Bk.)	76.3	1828	2227	315	414	89	100	3.6	4.1	326	88	3.7	352	92	3.82
C9	74.7	1787	2184	310	407	88	99	3.6	4.1	321	87	3.7	346	91	3.80
C10	74.6	1785	2181	310	407	88	99	3.6	4.1	321	87	3.7	346	91	3.80
C11	74.2	1774	2171	309	405	88	99	3.6	4.1	320	87	3.7	345	91	3.79
C12	61.5	1452	1827	268	351	80	90	3.4	3.9	280	79	3.5	300	83	3.61
C13	61.5	1452	1827	268	351	80	90	3.4	3.9	280	79	3.5	300	83	3.61
C14	61.3	1446	1821	267	350	80	90	3.4	3.9	279	79	3.5	299	83	3.61
C15	59.1	1391	1761	260	340	78	89	3.4	3.9	272	78	3.5	291	82	3.58
C16	59.1	1391	1761	260	340	78	89	3.4	3.9	272	78	3.5	291	82	3.58
C16 (above Crane Bk.)	55.8	1308	1670	249	326	76	86	3.3	3.8	261	76	3.4	279	79	3.52
C17	46.5	1076	1413	217	283	69	79	3.2	3.6	229	70	3.3	243	73	3.36
C17 (above Milliken Bk.)	43.2	995	1320	206	268	67	76	3.1	3.5	218	67	3.2	230	70	3.30
C18	42.3	973	1295	203	264	66	75	3.1	3.5	214	66	3.2	227	69	3.28
C19	42.3	973	1295	203	264	66	75	3.1	3.5	214	66	3.2	227	69	3.28
C20	36.3	826	1125	181	234	61	70	3.0	3.4	192	62	3.1	202	64	3.15
C21	29.4	659	927	154	200	55	63	2.8	3.2	165	56	3.0	173	58	2.99

* unless noted otherwise, drainage areas have been calculated at the downstream end of the reach

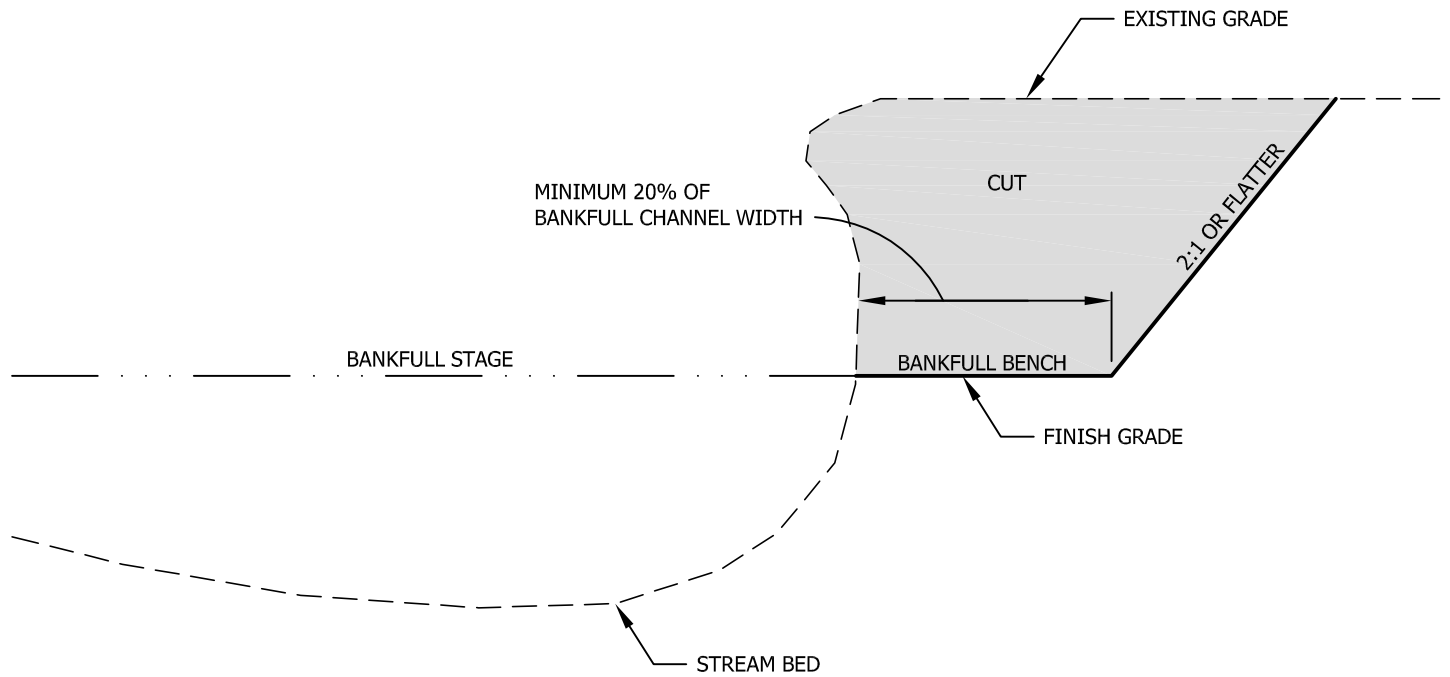
Cold River Restoration Project

Regional Hydraulic Geometry Curve Calculations

Reach	Drainage Area (sq mi)*	Discharge (cfs)		XS Area (sq ft)		Bankfull Width (ft)		Bankfull Depth (ft)		Cold River Watershed Curves			AVERAGE		
		VT	NH	VT	NH	VT	NH	VT	NH	Area	Width	Mean Depth	AREA	WIDTH	DEPTH
WB1	12.5	264	422	81	104	36	42	2.3	2.5	90	37	2.4	92	38	2.40
WB2	12.5	264	422	81	104	36	42	2.3	2.5	90	37	2.4	92	38	2.40
WB3	12.4	262	419	81	103	36	42	2.3	2.5	89	37	2.4	91	38	2.39
WB4	12.2	257	413	80	102	36	41	2.3	2.5	88	37	2.4	90	38	2.38
WB5	12.2	257	413	80	102	36	41	2.3	2.5	88	37	2.4	90	38	2.38
WB6	12.1	255	410	79	101	35	41	2.3	2.5	88	37	2.4	89	38	2.38
WB7	10.7	223	366	72	92	33	39	2.2	2.4	81	35	2.3	82	36	2.30
WB8	10.5	219	360	71	91	33	38	2.2	2.4	79	34	2.3	80	35	2.29
WB9	10.4	217	357	71	90	33	38	2.2	2.4	79	34	2.3	80	35	2.29
WB10	10.3	215	354	70	89	33	38	2.2	2.4	78	34	2.3	79	35	2.28
WB11	10.3	215	354	70	89	33	38	2.2	2.4	78	34	2.3	79	35	2.28
WB12	9.2	190	319	64	82	31	36	2.1	2.3	72	32	2.2	73	33	2.21
WB13	6.8	138	241	51	65	27	31	2.0	2.1	58	28	2.1	58	29	2.05
WB14	6.2	125	222	48	61	25	30	1.9	2.0	55	27	2.0	54	27	2.00
WB15	5.2	103	189	42	53	23	27	1.8	1.9	48	25	1.9	48	25	1.91
Bowers Bk	6.0	120	215	47	59	25	29	1.9	2.0	53	26	2.0	53	27	2.0

* unless noted otherwise, drainage areas have been calculated at the downstream end of the reach

Bankfull Bench Detail



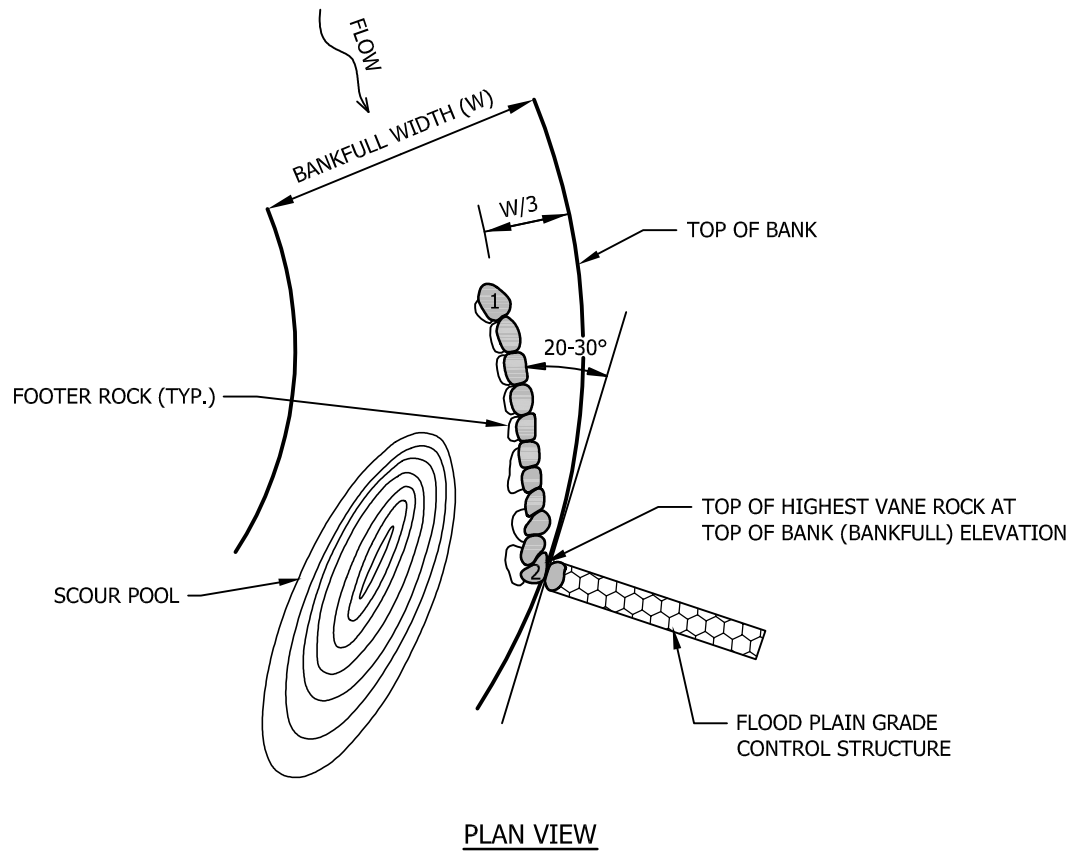
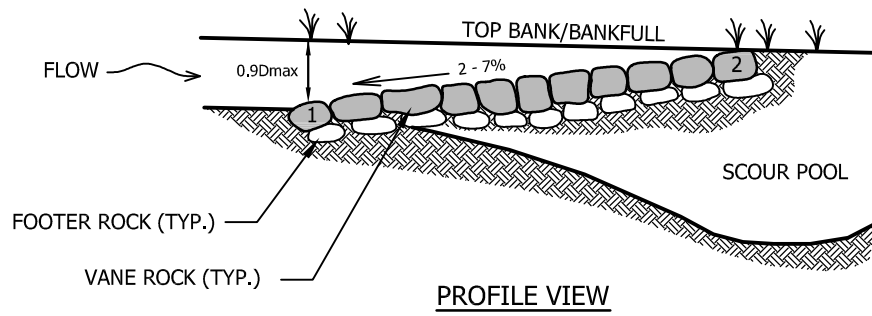
NOTES:

1. TOPSOIL AND SOD MATS SHALL BE SALVAGED FROM EXCAVATION AREAS AND APPLIED TO THE BANKFULL BENCH AND SLOPE. SEED AND MULCH TOPSOILED AREAS.
2. INSTALL RIPARIAN SHRUB PLANTINGS ON BANKFULL BENCH.
3. THIS DETAIL DEPICTS EXCAVATION OF A BANKFULL BENCH. BANKFULL BENCHES CAN ALSO BE CONSTRUCTED BY PLACING FILL OR A COMBINATION OF EXCAVATION AND FILL.

BANKFULL BENCH DETAIL

NOT TO SCALE

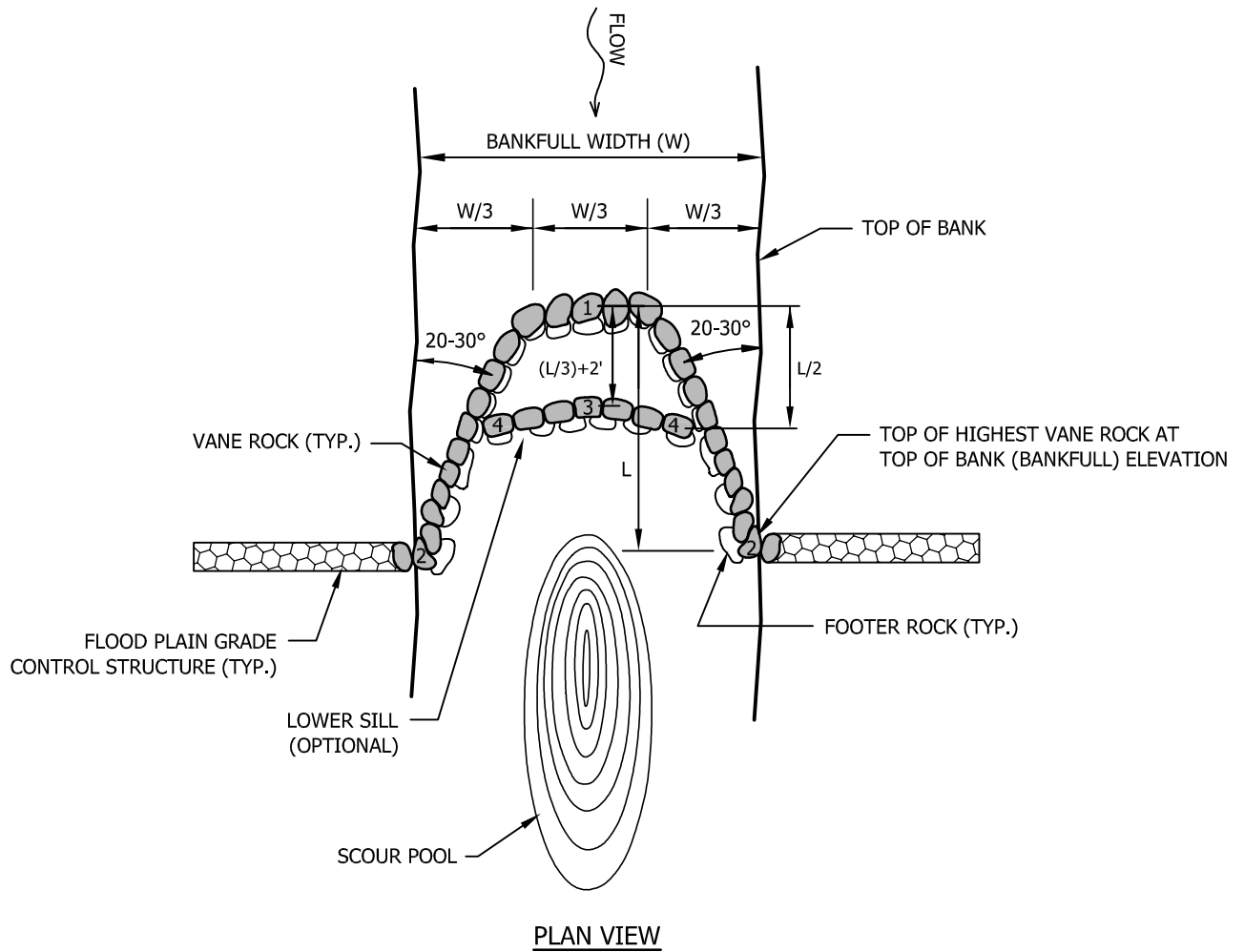
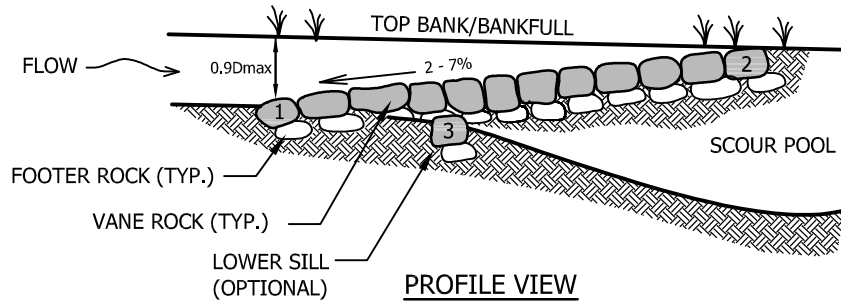
Rock Vane Detail



ROCK VANE DETAIL

NOT TO SCALE

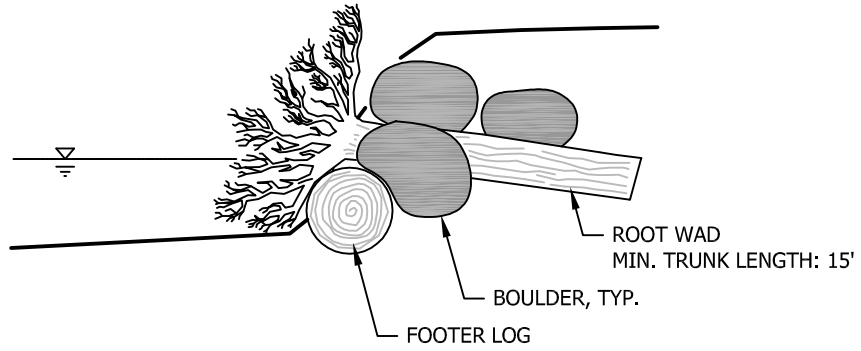
Cross Vane Detail



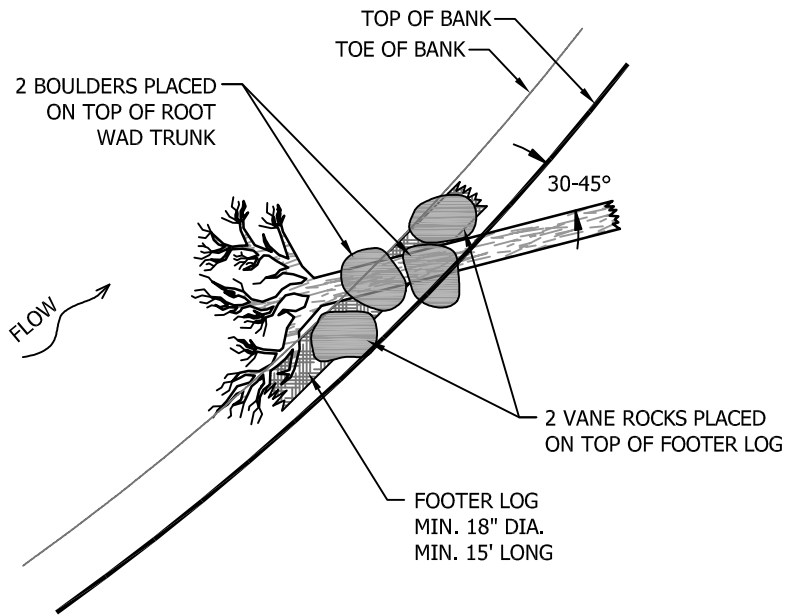
CROSS-VANE DETAIL

NOT TO SCALE

Root Wad Detail



SECTION VIEW

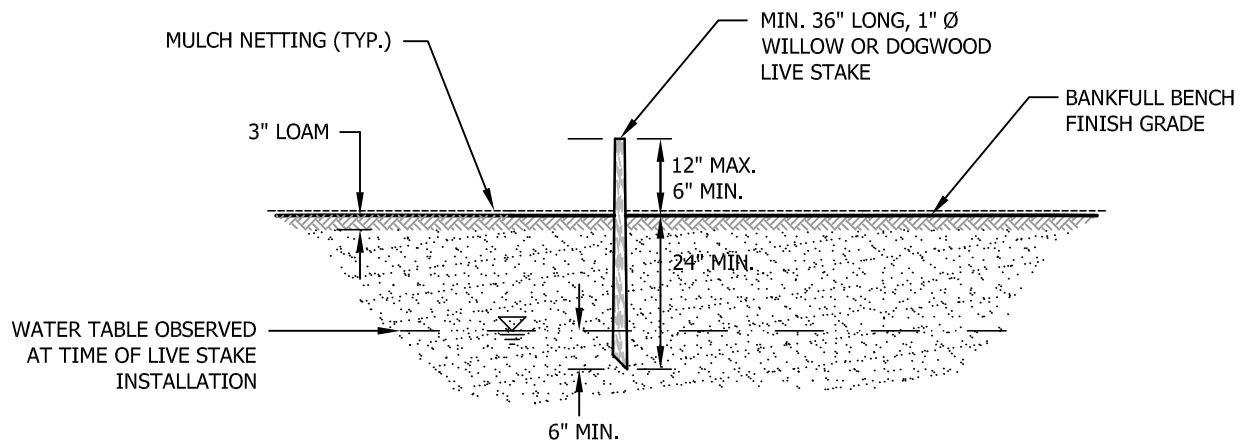


PLAN VIEW

ROOT WAD DETAIL

NOT TO SCALE

Live Stake Detail



LIVE-STAKE PLANTING DETAIL

NOT TO SCALE

List of Riparian Buffer Plantings Native to New Hampshire



Native Shoreland*/Riparian Buffer Plantings for New Hampshire

* The protected shoreland is the area of land that exists between the reference line of a waterbody and 250 feet from the reference line.

Common Name(s)	Latin Name	Height	Growth Rate	Rooting	Light Preference	Soil Preference	Habitat	Associated Birds & Mammals (Cover, Nesting or Food) & Food Value
Trees								
American Basswood (American Linden)	<i>Tilia americana</i>	Medium-Large 60-100'	Moderate	Deep	Full/Part Shade or Full Sun	Moist	Rich woods, valleys, gentle slopes	Wildlife: Pileated woodpecker, wood duck, other birds; deer, rabbit, squirrel Food: Seeds, twigs
American Beech	<i>Fagus grandifolia</i>	Medium-Large 60-90'	Slow	Shallow	Full/Part Shade or Full Sun	Dry or Moist	Rich woods, well-drained lowlands	Wildlife: Blue jay, chickadees, nuthatches, quail, ruffed grouse, tufted titmouse, wild turkey, wood duck, woodpeckers; bear, chipmunk, deer, fox, porcupine, snowshoe hare, squirrel Food: Nuts, buds, sap
American Hophornbeam (Ironwood)	<i>Ostrya virginiana</i>	Small 20-40'	Slow	Shallow	Full/Part Shade or Full Sun	Dry or Moist	Rich woods	Wildlife: Downy woodpecker, mockingbird, purple finch, ring-necked pheasant, rose-breasted grosbeak, ruffed grouse, wild turkey, wood quail; deer, rabbit, squirrel Food: Nuts, buds, seeds
American Hornbeam (Blue Beech/Musclewood)	<i>Carpinus caroliniana</i>	Small/Shrubby 20-40'	Slow	Moderate	Full/Part Shade or Full Sun	Dry, Moist, Flood Tolerant	Rich woods, forested wetlands, ravines, streambanks	Wildlife: Quail, ruffed grouse, wood duck; beaver, deer, squirrel Food: Seeds, buds
American Mountain Ash	<i>Sorbus americana</i>	Small Up to 25'	Fast	Shallow	Full/Part Shade or Full-Sun	Dry, Moist	Forested wetlands, rich woods	Wildlife: Bluebird, brown thrasher, catbird, cedar waxwing, grosbeak, mockingbird, robin, thrushes, wild turkey; bear Food: Fruit, twigs
Balsam Fir	<i>Abies balsamea</i>	Small-Medium 40-60'	Fast	Shallow	Full Sun	Moist, Flood Tolerant	Forested wetlands, streambanks, rich woods	Wildlife: Ruffed grouse, songbirds; small mammals, moose Food: Seeds
Balsam Poplar	<i>Populus balsamea</i>	Medium 60-80'	Fast	Shallow	Full Sun	Moist	Floodplains, riverbanks, streambanks, valleys	Wildlife: Beaver, deer, mouse, snowshoe hare Food: Buds, catkins, twigs, foliage
Big-Toothed Aspen	<i>Populus grandidentata</i>	Small-Medium 30-60'	Fast	Shallow	Full Sun	Dry or Moist	Sandy upland soils, floodplain streams; with quaking aspen	Wildlife: Black-capped chickadee, evening grosbeak, purple finch, ruffed grouse, yellow-bellied sapsucker; deer Food: Buds, catkins, bark, twigs, and foliage
Black Ash	<i>Fraxinus nigra</i>	Medium 60-80'	Moderate	Shallow	Full/Part Shade	Moist, Flood Tolerant	Forested wetlands, streambanks	Wildlife: Songbirds, wood duck; deer, moose, small mammals Food: Fruit, twigs, young leaves
Black Birch (Sweet Birch)	<i>Betula lenta</i>	Medium 40-60'	Moderate	Shallow	Full/Part Shade	Moist	Cool, moist uplands, rich woods	Wildlife: Grouse; deer, rabbit Food: Buds, catkins, seeds

Common Name(s)	Latin Name	Height	Growth Rate	Rooting	Light Preference	Soil Preference	Habitat	Associated Birds & Mammals (Cover, Nesting or Food) & Food Value
Trees (Continued)								
Black Cherry	<i>Prunus serotina</i>	Medium 40-60'	Moderate	Deep Taproot	Full/Part Shade	Dry or Moist	Rich woods, on many sites except very dry soils	Wildlife: Bluebird, blue jay, brown thrasher, cardinal, catbird, cedar waxwing, common crow, eastern kingbird, evening grosbeak, mockingbird, northern flicker, northern oriole, robin, ruffed grouse, sparrows, thrushes, veery, vireo, yellow-bellied sapsucker; bear, chipmunk, deer, fox, raccoon, squirrel Food: Berries, buds, sap
Black Gum (Tupelo)	<i>Nyssa sylvatica</i>	Medium 50-60	Slow	No Information Available	Full/Part Shade	Dry or Moist	Forested wetlands, floodplains	Wildlife: Bluebird, cardinal, catbird, chickadee, crow, finches, mallards, robin, ruby-throated hummingbird, ruffed grouse, vireo, wild turkey, woodpeckers, wood duck; honeybees, bear, chipmunk, deer, opossum, squirrel Food: Seeds, sap, nectar.
Black Spruce	<i>Picea mariana</i>	Small Up to 25'	Slow	Shallow	Full/Part Shade	Moist, Flood Tolerant	Bogs, forested wetlands, lake and pond shores	Wildlife: Songbirds, ruffed grouse, spruce grouse; chipmunk, cottontail, deer, porcupine, squirrel Food: Seeds, twigs, nectar, bark
Black Willow	<i>Salix nigra</i>	Small-Medium Up to 50'	Very Fast	Very Shallow	Full Sun	Moist, Flood Tolerant	Forested wetlands, lowlands, floodplains	Wildlife: Songbirds and mammals Food: Buds, catkins
Box Elder	<i>Acer negundo</i>	Medium 40-70'	Very Fast	Deep, Lateral	Full Sun	Dry, Moist, Flood Tolerant	Forested wetlands, lowlands, floodplains	Wildlife: Songbirds and mammals Food: Seeds
Eastern Cottonwood	<i>Populus deltoides</i>	Medium-Large 80-100'	Fast	Shallow	Full Sun	Dry or Moist	Floodplains, streambanks, valleys	Wildlife: Ruffed grouse Food: Catkins
Eastern Hemlock	<i>Tsuga canadensis</i>	Medium-Large 80-100'	Moderate	Shallow Lateral	Full/Part Shade	Dry or Moist, Acidic	Cool, moist uplands, ravines, rock outcrops, streambanks	Wildlife: Black-capped chickadee, blue and green warblers, crossbill, hawks, juncos, pine siskin, ruffed grouse, veery, wild turkey; deer, chipmunk, cottontail, porcupine, squirrel, white-footed mouse Food: Twigs, foliage, seeds
Eastern White Pine	<i>Pinus strobus</i>	Large 70-120'	Moderate	Shallow	Full Sun	Dry or Moist, Well-Drained	Forested wetlands, bogs, ravines, cool shady north slopes	Wildlife: Brown creeper, chickadee, crossbill, grosbeak, junco, nuthatch, pine warbler, sparrows, spruce grouse, wild turkey, woodpeckers; beaver, chipmunk, deer, snowshoe hare, squirrel Food: Seeds, foliage, twigs; excellent winter food
Gray Birch (Wire Birch)	<i>Betula populifolia</i>	Small 20-35'	Fast	Shallow	Full/Part Shade or Full Sun	Dry or Moist	Pioneer Species; poorest of sterile soils, sandy or gravelly slopes	Wildlife: American goldfinch, blue jay, chickadee, northern junco, pine siskin, red-tailed hawk, ruffed grouse, sparrows, vireo, yellow-bellied sapsucker, woodpeckers; snowshoe hare Food: Seeds, buds

Common Name(s)	Latin Name	Height	Growth Rate	Rooting	Light Preference	Soil Preference	Habitat	Associated Birds & Mammals (Cover, Nesting or Food) & Food Value
Trees (Continued)								
Green Ash	<i>Fraxinus pennsylvanica</i>	Medium-Large 60-80'	Fast	Shallow	Full/Part Shade or Full Sun	Moist, Flood Tolerant	Forested wetlands, floodplains, streambanks; never on dry soils	Wildlife: Cardinal, finches, evening grosbeak, mourning dove, red-winged blackbird, wood duck; beaver, chipmunk, deer, porcupine, squirrel Food: Seeds, foliage
Northern White Cedar (Arborvitae)	<i>Thuja occidentalis</i>	Medium 30-60'	Slow to Moderate	Shallow	Full Sun	Moist, Flood Tolerant	Bogs, wetlands, rich woods	Wildlife: Songbirds; small mammals, deer Food: Seeds, needles
Quaking/Trembling Aspen (Poplar)	<i>Populus tremuloides</i>	Small-Medium 30-60'	Fast	Shallow	Full Sun	Dry or Moist	Pioneer Species; dry open woods, sandy or gravelly slopes	Wildlife: Ruffed grouse; beaver, deer, porcupine, snowshoe hare Food: Buds, catkins, bark, twigs, and foliage
Red Maple	<i>Acer rubrum</i>	Medium 40-75'	Moderate to Fast	Very Shallow	Full Sun	Dry, Moist, Flood Tolerant	Forested wetlands, streambanks, lakeshores, rich woods,	Wildlife: Cardinal, chickadee, evening and pine grosbeaks, finches, robin, yellow-bellied sapsucker; beaver, chipmunk, deer; opossum, squirrel, snowshoe hare Food: Seeds, buds, bark, twigs, sap
Red Oak	<i>Quercus rubra</i>	Medium 60-90'	Moderate	Deep Lateral	Full/Part Shade or Full Sun	Dry or Moist	Bottomlands, moist slopes,	Wildlife: Blue jay, brown thrasher, ducks, hawks, quail, nuthatch, ruffed grouse, towhee, wild turkey, woodpecker; bear, chipmunk, deer, gopher, opossum, raccoon, squirrel Food: Acorns
Shagbark Hickory	<i>Carya ovata</i>	Large 70-100'	Fast	Deep Taproot	Full/Part Shade	Dry or Moist	Rich woods, valleys, upland slopes	Wildlife: Cardinal, field sparrows, pine warbler, rose-breasted grosbeak, rufous-sided towhee, white-breasted nuthatch, wild turkey, wood duck, yellow-rumped warbler; chipmunks, squirrels Food: Nuts
Silver Maple	<i>Acer saccharinum</i>	Medium 60-80'	Moderate	Shallow	Full/Part Shade or Full Sun	Moist, Flood Tolerant	Forested wetlands, riverbanks, floodplains, streambanks	Wildlife: Cardinal, goldfinch, evening and pine grosbeaks, northern oriole Food: Seeds, buds
Striped Maple (Moosewood/ Moose Maple)	<i>Acer pennsylvanicum</i>	Small/Shrubby 20-30'	Moderate	Shallow	Full/Part-Shade	Moist	Rich woods, cool moist sites	Wildlife: Ruffed grouse; beaver, deer, moose, porcupine, rabbit Food: Buds, bark, samaras
Sugar Maple	<i>Acer saccharum</i>	Medium-Large 60-100'	Slow	Shallow	Full/Part Shade or Full Sun	Moist	Valleys and uplands; tolerates almost all soil types	Wildlife: Cardinal, goldfinch, grosbeak, ring- necked pheasant, robin, ruffed grouse, vireo; beaver, chipmunk, porcupine; Browse for deer, rabbit, snowshoe hare Food: Seeds, twigs, bark

Common Name(s)	Latin Name	Height	Growth Rate	Rooting	Light Preference	Soil Preference	Habitat	Associated Birds & Mammals (Cover, Nesting or Food) & Food Value
Trees (Continued)								
Swamp White Oak	<i>Quercus bicolor</i>	Medium 60-70'	Fast	No Information Available	Full/Part Shade	Moist	Forested wetlands, floodplains, streambanks	Wildlife: Barred owl, blue jay, cardinal, brown thrasher, grouse, mallards, nuthatch, quail, red-bellied woodpecker, red-tailed hawk, ruffed grouse, starling, towhee, wild turkey, yellow-throated wabler, wren; beaver, chipmunk, cottontail, deer, gopher, opossum, raccoon, squirrel, white-footed mouse, wild turkey Food: Acorns
Sweet Gum	<i>Liquidambar styraciflua</i>	Medium-Large 60-100'	Moderate	No Information Available	Full Sun	Moist	Valleys, Lower slopes, mixed woodlands	Wildlife: Mourning dove, finches, junco, wren; beaver, chipmunk, squirrel Food: Seeds
Sycamore (Planetree/Buttwood)	<i>Platanus occidentalis</i>	Large 80-100'	Slow	No Information Available	Full/Part Shade or Full-Sun	Dry or Moist	Floodplains, lakeshores, streambanks	Wildlife: Finches; chipmunk, squirrel Food: Seeds
Tamarack (American/Eastern Larch)	<i>Larix laricina</i>	Small-Medium 40-80'	Variable	Moderate	Full Sun	Moist, Flood Tolerant	Bogs, swamps, wet peaty soils, drier upland loamy soils	Wildlife: Blue jay, kinglets, pheasant, red crossbill, robin, ruffed grouse, spruce grouse, yellow-bellied sapsucker; chipmunk, deer, porcupine, red squirrel, snowshoe hare Food: Needles, twigs, inner bark, seeds
White Ash	<i>Fracinus americana</i>	Medium-Large 70-100'	Moderate	Shallow	Full/Part Shade or Full Sun	Moist, Flood Tolerant	Rich woods, valleys, slopes, forested wetlands, floodplains, streambanks	Wildlife: Finches, grosbeaks, red-winged blackbird, wood duck; deer, squirrel Food: Seeds, foliage
White Birch (Paper Birch)	<i>Betula papyrifera</i>	Medium 50-75'	Fast	Shallow	Full Sun	Dry or Moist	Forested wetlands, rich woods	Wildlife: Grouse, siskins Food: Seeds, buds
White Oak	<i>Quercus alba</i>	Medium-Large 50-90'	Moderate	Deep	Full/Part Shade or Full Sun	Deep, rich, well-drained	Streambanks, lakeshores, gentle slopes; adapts to almost any condition	Wildlife: Blue jay, brown thrasher, nuthatch, quail, ruffed grouse, towhee, wild turkey, wood duck, woodpecker; chipmunk, bear, deer, gopher, opossum, raccoon, squirrel Food: Acorns
White Spruce	<i>Picea glauca</i>	Medium 40-70'	Moderate	Shallow	Full/Part Shade or Full Sun	Dry or Moist	Streambanks, lakeshores, rich woods, adjacent slopes	Wildlife: Fishers, martens, snowshoe hare, voles Food: Seeds
Yellow Birch (Sweet Birch)	<i>Betula alleghaniensis</i>	Medium-Large 70-100'	Slow	Shallow/Moderate	Full/Part Shade	Dry or Moist	Forested wetlands, floodplains, ravines, cool, rich woods of high elevations	Wildlife: Black-capped chickadee, common redpoll, goldfinch, pine siskins, red-shouldered hawk, ring-necked pheasant, ruffed grouse, wild turkey, wood duck, yellow-bellied sapsucker; beaver, chipmunk, deer, porcupine, squirrel, snowshow hare Food: Catkins, buds, bark, twigs, foliage, seeds

Common Name(s)	Latin Name	Height	Growth Rate	Light Preference	Soil Preference	Habitat	Associated Birds & Mammals (Cover, Nesting or Food) & Food Value
Shrubs							
American Hazelnut	<i>Corylus americana</i>	Medium 5-10'	Moderate	Full/Part Shade or Full Sun	Moist	Borders of woods, hillsides, thickets	Wildlife: Blue jay, brown thrasher, cedar waxwing, hairy woodpecker, ring-necked pheasant, ruffed grouse; chipmunk, deer, rabbit, squirrel Food: Nuts, berries, foliage
Beaked Hazelnut	<i>Corylus cornuta</i>	Small 6-10'	Moderate	Full/Part Shade or Full Sun	Dry	Dry places	Wildlife: Birds, mammals Food: Beaked nuts
Black Chokeberry	<i>Aronia meloncarpa</i>	Medium Up to 10'	Moderate	Full/Part Shade or Full Sun	Moist, Flood Tolerant	Shrub and forested wetlands	Wildlife: Cedar waxwing, chickadees, ruffed grouse, sharp-tailed grouse; deer, rabbit, squirrel Food: Berries, buds
Buttonbush	<i>Cephalanthus occidentalis</i>	Medium 6-12'	Moderate	Full/Part Shade or Full Sun	Moist, Flood Tolerant	Streambanks, lakeshores, ponds, shrub and forested wetlands	Wildlife: Ducks, rails, ruby-throated hummingbird; beaver, deer, muskrat, butterflies, honeybees and other insects Food: Fruit, twigs, leaves, seeds, nectar
Chokecherry	<i>Prunus virginiana</i>	Small 3-6'	Moderate	Full/Part Shade or Full Sun	Dry or Moist	With Aspen; dry soils	Wildlife: Bluebird, brown thrasher, catbird, crow, eastern kingbird, evening grosbeak, orioles, pileated woodpecker, ring-necked pheasant, robin, rose grosbeak, ruffed grouse, thrushes, yellow-bellied sapsucker; rabbit, squirrel Food: Berries, buds, foliage
Elderberry	<i>Sambucus canadensis</i>	Small-Medium 3-12'	Moderate	Full/Part Shade or Full Sun	Moist, Flood Tolerant	Rich woods, shrub and forested wetlands, marshes	Wildlife: Bluebirds, blue jay, brown thrasher, cardinal, catbird, grosbeak, indigo bunting, pileated woodpecker, ringed-neck pheasant, robin, rose-breasted grosbeak, ruffed grouse, thrushes, wild turkey, woodpecker; chipmunk, deer, rabbit, squirrel Food: Berries, nectar, twigs, bugs
Gray Dogwood (Red-Panicle Dogwood)	<i>Cornus racemosa</i>	Medium 10-15'	Moderate	Full/Part Shade or Full Sun	Dry or Moist	Roadsides, thickets, wetlands	Wildlife: Blue jay, cardinal, catbird, cedar waxwing, eastern kingbird, finch, flycatcher, grosbeak, hairy woodpecker, northern flicker, phoebe, pileated woodpecker, pine grosbeak, pine warbler, red-bellied woodpecker, ring-necked pheasant, robin, ruffed grouse, starling, swamp sparrow, tufted titmouse, veery, vireo, wild turkey, wood duck, wood thrush, woodcock, yellow-bellied sapsucker; chipmunk, deer, red fox, rabbit, squirrel Food: Berries, twigs
Highbush Blueberry	<i>Vaccinium corymbosum</i>	Medium 5-15'	Slow	Full/Part Shade or Full Sun	Dry, Moist, Flood Tolerant	Shrub and forested wetlands, rich woods	Wildlife: Baltimore oriole, bluebird, blue jay, cardinal, chickadee, gray catbird, kingbird, orioles, phoebe, red-bellied woodpecker, ring-necked pheasant, robin, ruffed grouse, rufous-sided towhee, scarlet tanager, tufted titmouse, veery, wild turkey, woodpeckers, wood thrush; black bear, chipmunk, deer, muskrat, rabbit, squirrel, white-footed mouse Food: Berries, foliage, twigs, buds
Hobblebush	<i>Viburnum alnifolium</i>	Medium Up to 10'	Moderate	Full/Part Shade	Moist, Flood Tolerant	Cool, moist ravines, shady lakeshores	Wildlife: Brown thrasher, cardinal, cedar waxwing, evening grosbeak, robin Food: Fruit

Common Name(s)	Latin Name	Height	Growth Rate	Light Preference	Soil Preference	Habitat	Associated Birds & Mammals (Cover, Nesting or Food) & Food Value
Shrubs (Continued)							
Juniper	<i>Juniperus communis</i>	Small 1-4'	Slow	Full Sun	Dry	Dry open land	Wildlife: Cedar waxwing, finches, grosbeaks, grouse, pheasant, robin; deer, rabbit, moose Food: Twigs, foliage, fruit
Lowbush Blueberry	<i>Vaccinium angustifolium</i>	1-2'	Slow	Full/Part Shade or Full Sun	Dry or Moist	Bogs, dry sandy flats, rocky slopes	Wildlife: Blue jay, grouse, kingbird, oriole, robin, tanagers, woodpeckers; squirrel Food: Berries, foliage, twigs
Maleberry	<i>Lyonia ligustris</i>	Up to 10'	Moderate	Full/Part Shade or Full Sun	Moist	Shrub and forested wetlands, rich woods, gentle slopes	Wildlife: Songbirds and mammals Food: Fruit
Mapleleaf Viburnum	<i>Viburnum acerifolium</i>	Small 3-6'	Moderate	Full/Part Shade or Full Sun	Moist	Rich woods	Wildlife: Songbirds and mammals Food: Fruit
Mountain Laurel	<i>Kalmia latifolia</i>	Up to 20'	Moderate	Full/Part Shade or Full Sun	Dry or Moist	Mixed uplands, acid soils	Wildlife: Ruffed grouse; deer Food: Foliage, buds, twigs, nectar
Nannyberry	<i>Viburnum lentago</i>	Medium-Large 10-25'	Moderate	Fall/Part Shade or Full Sun	Dry or Moist	Rich woods	Wildlife: Songbirds, mammals Food: Berries
Northern Arrowwood	<i>Viburnum recognitum</i>	Medium 10-15'	Moderate	Fall/Part Shade or Full Sun	Moist, Flood Tolerant	Shrub and forested wetlands, lakeshores, streambanks	Wildlife: Ruffed grouse, songbirds; bear, chipmunks, raccoon, squirrel, skunk, white-footed mouse Food: Berries
Northern Wild Raisin (Witherod Viburnum)	<i>Viburnum nudum var. cassinoides</i>	Medium 6-10'	Moderate	Full/Part Shade	Moist, Flood Tolerant	Shrub and forested wetlands, valleys, slopes, streambanks	Wildlife: Brown thrasher, cedar waxwing, flycatcher, ruffed grouse, veery, woodcock, yellow-warbler; chipmunk, deer, muskrat, squirrel, snowshoe hare Food: Bark, twigs, buds
Pussy Willow	<i>Salix discolor</i>	Medium-Large Up to 15'	Fast	Full Sun	Moist, Flood Tolerant	Shrub and forested wetlands, streambanks, lakeshores	Wildlife: American goldfinch, ruffed grouse; beaver, hare, rabbits, squirrel Food: Buds, catkins, twigs, bark
Raspberry	<i>Rubus idaeus</i>	Small Up to 6'	Fast	Full/Part Shade or Full Sun	Dry or Moist	Thickets, edges of woods	Wildlife: Songbirds and mammals Food: Fruits
Red Osier Dogwood	<i>Cornus stolonifera</i>	Small-Medium 4-8'	Fast	Full/Part Shade or Full Sun	Moist, Flood Tolerant	Rich woods, streambanks, lakeshores	Wildlife: Bluebird, brown thrasher, cardinal, catbird, cedar waxwing, downy woodpecker, eastern kingbird, finches, northern flicker, pine warbler, purple finch, ringed-neck pheasant, ruffed grouse, vireo, wild turkey, woodpeckers, wood duck; chipmunk, deer, rabbit, squirrel Food: Berries, twigs
Rhodora	<i>Rhododendron canadense</i>	Small 3-4'	Slow	Full Sun	Moist, Flood Tolerant	Bogs, slopes, rocky summits	Wildlife: Songbirds and mammals Food: Leaves

Common Name(s)	Latin Name	Height	Growth Rate	Light Preference	Soil Preference	Habitat	Associated Birds & Mammals (Cover, Nesting or Food) & Food Value
Shrubs (Continued)							
Shadbush (Serviceberry/Juneberry)	<i>Amelanchier spp.</i>	Large 15-25'	Slow	Full/Part Shade or Full Sun	Dry, Moist, Flood Tolerant	Shrub and forested wetlands, floodplains, streambanks, rich woods	Wildlife: Bluebird, brown thrasher, cardinal, catbird, cedar waxwing, gray catbird, junco, orioles, red squirrel, robin, ruffed grouse, scarlet tanager, thrushes, veery, woodpeckers; beaver, deer, red squirrel, skunk Food: Berries, twigs
Silky Dogwood	<i>Cornus amomum</i>	Medium 6-10'	Fast	Full/Part Shade or Full Sun	Dry, Moist, Flood Tolerant	Shrub and forested wetlands, streambanks	Wildlife: Baltimore oriole, black-capped chickadee, blue jay, brown thrasher, cardinal, catbird, cedar waxwing, downy woodpecker, eastern kingbird, flycatcher, mockingbird, northern flicker, pine warbler, purple finch, red-bellied woodpecker, ringed- neck pheasant, robin, rose-breasted grosbeak, ruffed grouse, song sparrow, starlings, tufted-titmouse, wild turkey, wood duck, wood thrush, veery; chipmunk, deer, rabbit, raccoon, skunk, squirrel, white-footed mouse Food: Berries, buds, twigs
Speckled Alder	<i>Alnus rugosa</i>	Large 15-25'	Fast	Full Sun	Moist, Flood Tolerant	Shrub and forested wetlands, streambanks, lakeshores	Wildlife: Alder flycatcher, catbird, goldfinch, mallards, pheasant, pine siskin, red-winged blackbird, ruffed grouse, swamp sparrow, yellow-bellied flycatcher, woodcock; bear, beaver, deer, cottontail, moose, muskrat, snowshoe hare Food: Buds, twigs, bark, leaves
Spicebush	<i>Lindera benzoin</i>	Small-Large 6-17'	Moderate	Full Sun	Moist, Flood Tolerant	Shrub and forested wetlands, rich woods	Wildlife: Catbird, kingbird, pheasant, quail, robin, ruffed grouse, veery, vireo, wood thrush; swallowtail butterflies; deer, muskrat Food: Fruit, buds, twigs, leaves
Swamp Azalea	<i>Rhododendron viscosum</i>	Up to 5'	Moderate	Full/Part Shade or Full Sun	Moist, Flood Tolerant	Shrub and forested wetlands, rich woods	Wildlife: Hummingbird; butterflies and other insects; deer Food: Leaves, nectar
Swamp Blackberry	<i>Rubus hispidus</i>	Small Up to 6'	Slow	Full/Part Shade	Dry or Moist	Shrub and forested wetlands, rich woods	Wildlife: Blue jay, brown thrasher, cardinal, cedar waxwing, grackle, gray catbird, grosbeak, mockingbird, oriole tanager, ring- necked pheasant, robin, ruffed grouse, rufus-sided thrushes, towhee, veery, wild turkey, woodcock, woodpeckers, wood thrush; chipmunk, cottontail, deer, raccoon, skunk, squirrel Food: Fruit, canes
Sweet Gale	<i>Myrica gale</i>	Small 1-4'	Slow	Full Sun	Moist, Flood Tolerant	Shrub and forested wetlands, lakeshores, streambanks	Wildlife: Black-capped chickadee, catbird, common yellowthroat, phoebe, pied-billed grebe, ruffed grouse, tree swallow, tufted titmouse, wild turkey; deer, muskrat Food: Buds, leaves
Sweet Pepperbush	<i>Clethra alnifolia</i>	Medium 3-10'	Moderate	Full/Part Shade or Full Sun	Moist, Flood Tolerant	Shrub and forested wetlands, lakeshores, streambanks	Wildlife: Butterflies and other insects Food: Fruit, seeds, nectar
Winterberry Holly (Black Alder)	<i>Ilex verticillata</i>	Medium 6-10'	Slow	Full/Part Shade or Full Sun	Moist, Flood Tolerant	Shrub and forested wetlands, lakeshores, streamabanks	Wildlife: Cardinal, catbird, cedar waxwing, chickadees, finches, flickers, ruffed grouse, thrushes, vireo, woodpeckers; bear, cottontail, deer, moose, skunk, white-footed mouse Food: Berries, twigs, leaves

Common Name(s)	Latin Name	Height	Growth Rate	Light Preference	Soil Preference	Habitat	Associated Birds & Mammals (Cover, Nesting or Food) & Food Value
Shrubs (Continued)							
Witch Hazel	<i>Hammamelis virginiana</i>	Large 20-30'	Slow	Full/Part Shade or Full Sun	Moist	Dry or rich woods	Wildlife: Cardinal, ring-necked pheasant, ruffed grouse, wild turkey; deer, squirrels Food: Seeds, buds, twigs, bark
Common Name(s)	Latin Name	Height		Light Preference	Soil Preference	Habitat	Associated Birds & Mammals (Cover, Nesting or Food) & Food Value
Groundcover/Herbaceous Perennials							
Boneset	<i>Eupatorium perfoliatum</i>	4-6'		Full Sun	Dry or Moist	Wet meadows, marshes, pond edges	Wildlife: Mallards, ruffed grouse, swamp sparrow, wild turkey; butterflies and other insects Food: Nectar
Blue Flag Iris	<i>Iris versicolor</i>	2-3'		Full Sun	Moist, Flood Tolerant	Marshes, lakeshores, streambanks	Wildlife: Blue-winged teal, ruby-throated hummingbird, wood duck; butterflies and other insects; muskrat Food: Nectar, shoots
Bunchberry	<i>Cornus canadensis</i>	3-8"		Full/Part Shade	Moist	Cool, moist woods	Wildlife: Sharp-tailed grouse, spruce-grouse; moose Food: Fruit, buds
Cardinal Flower	<i>Lobelia cardinalis</i>	2-4'		Full Sun	Moist, Flood Tolerant	Damp sites, streambanks	Wildlife: Ruby-throated hummingbirds; butterflies and other insects; bear, deer Food: Nectar
Cattail (Broad-Leaf)	<i>Typha latifolia</i>	Up to 10'		Full Sun	Moist, Flood Tolerant	Marshes, lakeshores, streambanks	Wildlife: Blue-winged teal, black-crowned night heron, red-winged blackbird, king rail, least and American bittern, mallards, marsh wren, swamp sparrow, Virginia rail; chipmunk, deer, muskrat Food: Seed heads
Christmas Fern	<i>Polystichium acrostichoides</i>	Up to 1'		Full/Part Shade	Moist	Rich woods	Wildlife: Ruffed grouse; box turtle, chipmunk, rabbit Food: Fronds, filldeheads
Cinnamon Fern	<i>Osmunda cinnamomea</i>	Up to 3'		Full/Part Shade	Moist, Flood Tolerant	Shrub and forested wetlands	Wildlife: Brown thrasher, ruby-throated hummingbird, ruffed grouse, yellow throat; chipmunk, deer, white-footed mouse, vole Food: Fronds, filldeheads
Foamflower	<i>Tiarella cordifolia</i>	Up to 1'		Full/Part Shade	Moist	Rich woods	Wildlife: Songbirds and mammals Food: Leaves
Goldenrod (Rough or Grass-Leaved)	<i>Solidago spp.</i>	1-5'		Full Sun	Dry or Moist	Wet meadows, marshes, damp swales	Wildlife: Goldfinch, junco, ruffed grouse, swamp sparrow; butterflies and other insects; cottontail, meadow mice Food: Seeds, nectar

Common Name(s)	Latin Name	Height	Light Preference	Soil Preference	Habitat	Associated Birds & Mammals (Cover, Nesting or Food) & Food Value
Groundcover/Herbaceous Perennials (Continued)						
Hay-Scented Fern	<i>Denstaedtia punctiloula</i>	Up to 2'	Full/Part Shade or Full Sun	Moist	Woodlands, hillside pastures	Wildlife: Mammals Food: Fronds, fiddleheads
Interrupted Fern	<i>Osmunda punctiloula</i>	3-4'	Full/Part Shade	Moist	Woodland edges, stony dry soil	Wildlife: Mammals Food: Fronds, fiddleheads
Jewelweed (Spotted-Touch-Me-Not)	<i>Impatiens capensis</i>	2-5'	Full/Part Shade or Full Sun	Moist, Flood Tolerant	Shrub and forested wetlands, streambanks	Wildlife: Ring-necked pheasant, ruffed grouse, ruby-throated hummingbird, veery; butterflies and other insects; white-footed mouse Food: Nectar, seeds
Joe Pye Weed	<i>Eupatorium purpureum</i>	2-6'	Full Sun	Moist, Flood Tolerant	Wet meadows, marshes, shores	Wildlife: Ruby-throated hummingbird, swamp sparrow; butterflies and other insects; cottontail, muskrat, raccoon Food: Nectar
New England Aster	<i>Aster novae-angliae</i>	Up to 5'	Full Sun	Dry or Moist	Wet meadows, wetlands	Wildlife: Songbirds; butterflies and other insects Food: Nectar, seeds
Ostrich Fern	<i>Pteretis pensylvanica</i>	Up to 6'	Full/Part Shade		Shrub and forested wetlands	Wildlife: Mammals Food: Fronds, fiddleheads
Partridgeberry	<i>Mitchella repens</i>	Up to 1'	Full/Part Shade	Dry or Moist	Rich woods	Wildlife: Grouse, mammals Food: Berries
Rattlesnake Manna Grass	<i>Glyceria canadensis</i>	Up to 3'	Full Sun	Moist	Marshes, bogs, forested wetlands, lakeshores	Wildlife: Songbirds and mammals Food: Seeds
Rice Cutgrass	<i>Leersia oryzoides</i>	Up to 5'	Full Sun	Moist, Flood Tolerant	Primarily fresh marshes	Wildlife: Deer, muskrat, moose Food: Seeds, foliage
Riverbank Grape (Vine)	<i>Vitis riparia</i>	Up to 25'	Full/Part Shade or Full Sun	Moist	Streambanks	Wildlife: Pileated woodpecker, ruffed grouse, wild turkey, wood duck; various mammals Food: Fruit
Royal Fern	<i>Osmunda regalis</i>	Up to 5'	Full/Part Shade or Full Sun	Moist, Flood Tolerant	Shrub and forested wetlands	Wildlife: Mammals Food: Fronds, fiddleheads
Sensitive Fern	<i>Onoclea sensibilis</i>	Up to 3'	Full/Part Shade	Moist, Flood Tolerant	Shrub and forested wetlands	Wildlife: Black-capped chickadee, ruffed grouse; bear, deer Food: Buds, foliage
Sheep Laurel	<i>Kalmia angustifolia</i>	Up to 4'	Fall/Part Shade or Full Sun	Dry, Moist, Flood Tolerant	Shrub and forest wetlands, fields/pastures	Poisonous to livestock.
Swamp Milkweed	<i>Asclepias incarnata</i>	Up to 2'	Fall/Part Shade	Moist	Wet meadows, wetlands, thickets, shores	Wildlife: Black duck, mallards, red-winged blackbird, ruby-throated hummingbird; Monarch butterfly, other butterflies and insects; muskrat Food: Nectar, seeds

Common Name(s)	Latin Name	Height	Light Preference	Soil Preference	Habitat	Associated Birds & Mammals (Cover, Nesting or Food) & Food Value
Groundcover/Herbaceous Perennials (Continued)						
Sweet Fern	<i>Comptonia perigrina</i>	1-3'	Full/Part Shade or Full Sun	Dry	Open, dry sandy soils and pastures	Wildlife: Flickers, sharp-tailed grouse; deer, moose Food: Fruit
Tall Meadow Rue	<i>Thalictrum polygamum</i>	2-8'	Full/Part Shade	Moist	Wetlands, wet meadows, streamsides	Wildlife: Bees, butterflies Food: Nectar
Tussock Sedge	<i>Carex stricta</i>	Up to 4"	Full Sun	Moist, Flood Tolerant	Marshes, rich woods	Wildlife: Finches, ruffed grouse, snipe, sparrows; deer Food: Seeds, foliage
Twinflower	<i>Linnaea borealis</i>	Up to 6"	Full/Part Shade	Moist	Rich woods	Wildlife: Mammals Food: Foliage
Virginia Creeper (Vine)	<i>Parthenocissus quinquefolia</i>	Up to 25'	Full/Part Shade or Full Sun	Dry or Moist	Woods, rocky banks	Wildlife: Bluebird, great-crested flycatcher, red-eyes vireo, pileated woodpecker Food: Berries
Whorled Loosestrife	<i>Lysimachia quadrifolia</i>	Up to 4'	Full/Part Shade or Full Sun	Dry or Moist	Dry or moist open woods, thickets	Wildlife: Mammals Food: Foliage
Wild Sarsaparilla	<i>Aralia nudicanlis</i>	8-15"	Full/Part Shade	Dry or Moist	Upland woods	Wildlife: Mammals Food: Foliage, seeds, berries
Wintergreen (Teaberry/Checkerberry)	<i>Gaultheria procumbens</i>	Up to 4"	Full Sun	Dry	Oak woods, sandy soils	Wildlife: Partridge, ruffed grouse, songbirds; chipmunk, deer, moose Food: Fruit, foliage

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