United States
Department
Of Agriculture

Natural
Resources
Conservation
Service

SUPPLEMENTAL WATERSHED PLAN No. 8 & ENVIRONMENTAL EVALUATION

For Rehabilitation of the
Rawson Hill Brook Floodwater Retarding Dam
SuAsCo Watershed
Worcester County, Massachusetts

Prepared By:
U.S. Department of Agriculture
Natural Resources Conservation Service

FINAL
September 2012

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Supplemental Watershed Plan No. 8 & Environmental Evaluation
for Rehabilitation of Rawson Hill Brook Floodwater Retarding Dam
SuAsCo Watershed
Worcester County, Massachusetts

Prepared By:
U.S. Department of Agriculture
Natural Resources Conservation Service

In Cooperation With:
Massachusetts Department of Conservation and Recreation
Worcester County Conservation District
Middlesex Conservation District
Massachusetts Division of Fisheries & Wildlife

AUTHORITY

The original watershed work plan was prepared, and works of improvement have been installed, under the authority of the Watershed Protection and Flood Prevention Act of 1954 (Public Law 83-566) as amended. The rehabilitation of the Rawson Hill Brook Floodwater Retarding Dam is authorized under Public Law 83-566 (as amended), and as further amended by Section 313 of Public Law 106-472.

ABSTRACT

Although the Rawson Hill Brook Floodwater Retarding Dam provides the original flood damage reduction benefits up to the 100-yr 24-hr rainfall event, the dam does not meet the current State or Natural Resources Conservation Service safety and performance standards for a high hazard dam. Runoff from current and build-out development is greater than the dam was originally designed to accommodate. For current and future build-out development conditions, the dam does not meet current Natural Resources Conservation Service design criteria for a high hazard dam. The local project sponsors have chosen to rehabilitate the dam to address the identified safety deficiencies. The purposes of the proposed rehabilitation of the Rawson Hill Brook Floodwater Retarding Dam are to maintain the present level of flood control benefits and comply with current performance and safety standards and criteria. Rehabilitation of the site will require the installation of a labyrinth weir within the auxiliary spillway and armoring the auxiliary spillway exit channel located downstream of the proposed labyrinth weir. Project installation cost is estimated to be $1,479,500, of which $985,200 will be paid from Small Watershed Rehabilitation funds and $494,300 from local funds.

COMMENTS AND INQUIRIES

For further information and to submit comments and inquiries, contact Luis E. Laracuente, State Conservation Engineer, USDA/NRCS, 451 West Street, Amherst, MA 01002-2953, 413-253-4362.

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Supplemental Watershed Plan No. 8 & Environmental Evaluation for Rehabilitation of Rawson Hill Brook Floodwater Retarding Dam SuAsCo Watershed Worcester County, Massachusetts

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List of Acronyms and Abbreviations

ACBs	Articulated Concrete Blocks
AMCII	Antecedent moisture content
APE	Area of Potential Effect
BCCM	Bituminous Coated Corrugated Metal
BMPs	Best Management Practices
BVWs	Bordering Vegetated Wetlands
CMR	Code of Massachusetts Regulations
CO	Carbon monoxide
DCR	Massachusetts Department of Conservation and Recreation
DEM	Massachusetts Department of Environmental Management
DEP	Massachusetts Department of Environmental Protection
DFW	Massachusetts Division of Fisheries and Wildlife
DWM	Massachusetts Division of Watershed Management
EFH	Essential Fish Habitat
EPA	United States Environmental Protection Agency
FBH	Freeboard Hydrograph
FEMA	Federal Emergency Management Agency
fps	feet per second
FWS	United States Fish and Wildlife Service
HUC	Hydrologic Unit Code
LUWB	Land Under Waterbodies
MassGIS	Massachusetts Geographic Information Systems
MEPA	Massachusetts Environmental Protection Act
NAAQS	National Ambient Air Quality Standards
NAVD88	North American Vertical Datum 1988
NED	National Economic Development
NEPA	National Environmental Policy Act
NHESP	Natural Heritage and Endangered Species Program
NO_2	Nitrogen dioxide
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NRCS	Natural Resources Conservation Service
NWI	National Wetland Inventory

O&M	Operation and Maintenance
O_3	Ozone
OARS	Organization for the Assabet, Sudbury, and Concord Rivers
OZn	Nashoba Formation
P&G	Principles and Guidelines
Pb	Lead
PL	Public Law
PMF	Probable Maximum Flow
PMP	Probable Maximum Precipitation
PSH	Principle Spillway Hydrograph
Qr	Rawson Hill Brook deposits
Qs	Swamp deposits
SCS	Soil Conservation Service
SDH	Stability Design Hydrograph
SHPO	State Historic Preservation Office
SITES	Site Analysis Integrated Development Environment
SO_2	Sulfur dioxide
SOvh	Vaughn Hills Quartzite
SWPPP	Stormwater Pollution Prevention Plan
Sztb	Tadmuck Brook Schist
T_c	Time of Concentration
THPO	Tribal Historic Preservation Officer
TMDL	Total Maximum Daily Load
TR-60	Technical Release 60
U.S.C.	United States Code
USACE	United States Army Corps of Engineers
USCB	United States Census Bureau
USDA	United States Department of Agriculture
USGS	United States Geological Survey
WinDAM	Windows™ Dam Analyses Models

Supplemental Watershed Plan No. 8 & Environmental Evaluation For Rehabilitation of the Rawson Hill Brook Floodwater Retarding Dam SuAsCo Watershed Worcester County, Massachusetts 3rd Congressional District

SUMMARY OF WATERSHED PLAN

Project Name: Rehabilitation of the Rawson Hill Brook Floodwater Retarding Dam [1], SuAsCo Watershed

Authorization: Public Law 83-566 Stat. 666 as amended (16 U.S.C.[2] Section 1001 *et. seq*.) 1954

Sponsors: Massachusetts Department of Conservation and Recreation
Worcester County Conservation District
Middlesex Conservation District
Massachusetts Division of Fisheries & Wildlife (DFW)

Purpose and Need for Action: The Rawson Hill Brook Dam does not meet the design criteria set forth by the NRCS dam safety and design standards and the Commonwealth of Massachusetts Dam Safety Rules and Regulations[3]. As such, the dam no longer provides intended project purpose of flood prevention. An engineering analysis was conducted to determine if the Rawson Hill Brook Dam qualifies for a reduction in the FBH storm, which is generated by the PMP storm, per the NRCS's design criteria for a "High Hazard Dam." The results of the analysis indicated that a difference in water surface elevations between the non-breach and breach conditions from the PMP storm is greater than the 2-foot maximum allowed by the FEMA-94 (FEMA 2004) and the NRCS at several locations downstream of the Rawson Hill Brook Dam. Dam safety deficiencies are related to overtopping of the dam under future watershed build-out conditions and to stability and integrity of the auxiliary spillway. The results indicate that a PMF dam breach would produce unacceptable downstream consequences, and therefore, the design criteria set forth by the NRCS dam safety and design standards were applied in evaluating, developing, and designing rehabilitation measures for the Rawson Hill Brook Dam. Dam failure could result in breach flood damages to approximately 1,205 residences, 164 non-residential properties, 19 major roads, 1 school, and 8 bridges, plus utilities. Dam failure could also cause the loss of life of residents, workers, or motorists.

[1] Rawson Hill Brook Floodwater Retarding Dam is identified in the original SuAsCo Watershed Plan (SCS 1958). It is designated as dam A-4-A in the original work plan, as MA304 in the NRCS list of PL-566 dams, as 3-14-328-9 by the DCR Office of Dam Safety, and as MA01000 in the National Inventory of Dams database.
[2] United States Code
[3] 302 CMR 10.00

Description of the Preferred Alternative: Rehabilitation of the Rawson Hill Brook Floodwater Retarding Dam would incorporate the use of a labyrinth weir design while maintaining the existing top of dam elevation and overall auxiliary spillway width. The labyrinth weir design provides an alternative to raising the dam crest and/or widening the auxiliary spillway by increasing flow capacity at the same upstream head and overall spillway width. Flow capacity would be enhanced by increasing the effective weir length through several cycles of trapezoidal shapes in a concrete wall that spans the width of the open channel spillway. In addition, the auxiliary spillway located downstream of the proposed labyrinth weir would be armored with articulated concrete blocks (ACBs). The evaluated life of the rehabilitated structure is 52 years.

Resource Information:

Latitude and Longitude: Lat. 42.317818 Lon. -71.705549
8 Digit HUC[4] Number: 01070005
Size of SuAsCo Watershed: 241,000 acres (377 mi^2)
Drainage area of the Rawson Hill Brook Dam: 1,018 acres (1.59 mi^2)

Climate (Worcester County):

Average annual precipitation: 49.2 inches
Average seasonal snowfall: 59.7 inches
Average winter temperature: 26.2°F Average winter daily minimum: 18.4°F
Average summer temperature: 67.7°F Average summer daily maximum: 76.9°F
Average (50 percent) freeze-free period of 172 days: April 27 – October 16
Source: NRCS (2006)

Topography:

The SuAsCo watershed lies within an area of previous glaciation, and many glacial features are present. In addition, the watershed is characterized by the prevalence of swamps, ponds, and lakes. The drainage pattern is dendritic with many tributary streams. Within the SuAsCo watershed, the Assabet River has a steeper gradient than the lower Sudbury River and upper Concord River and as a result has a more rapid runoff of floodwaters (SCS 1958). Figure 1 depicts the site on a location map.

Watershed Size:

Land Use in the Rawson Hill Brook Dam drainage area:

	Acres	% of drainage area
Agricultural	10	1
Forest	509	50
Developed, residential	417	41
Developed, commercial/industrial	31	3
Other (wetlands, open land, water, etc.)	51	5
Total	*1,018*	*100*

[4] Hydrologic Unit Code

Land Ownership:

Rawson Hill Brook Dam drainage area:	Private 82 %	State-Local 18 %	Federal 0 %
Rawson Hill Brook Dam floodplain area:	Private 78 %	State-Local 18 %	Federal 4 %

Number of farms (Worcester County): 1,547
Source: Massachusetts Farm Bureau (2002)

Average farm size (Worcester County): 69 acres
Source: Massachusetts Farm Bureau (2002)

Prime and important farmland:

	Drainage area (acres)	Floodplain (acres)
Prime farmland	112	10
Farmland of statewide importance	211	19
Farmland of unique importance	78	38

Population and Demographics:

Project Beneficiary Profile: The primary beneficiaries of the project are residential, industrial, and commercial property owners in the floodplain of Rawson Hill Brook and the Assabet River; the Towns of Shrewsbury, Boylston, and Northborough; and the Commonwealth of Massachusetts.

Characteristic	Shrewsbury	Worcester Co.	Massachusetts	United States
Per capita income	$38,000	$29,316	$33,203	$26,059
Median annual household income	$87,393	$61,121	$62,072	$50,046
Median house value	$195,500	$268,100	$334,100	$179,900
Median age	40.2	39.2	39.1	37.2
Population	35,608	798,552	6,547,629	308,745,538
Population age 65 and over	13.5%	12.8 %	13.8 %	13.0 %
Unemployment rate	4.0%	7.7%	6.9%	6.9%
Poverty level	2.0%	7.7%	8.2%	11.3%
Minority population	21.2%	14.8 %	20.2 %	27.9 %

Source: 2000 and 2010 U.S. Census Bureau data (USCB)

Relevant Resource Concerns:

Wetlands: Wetland habitats identified at the Rawson Hill Brook Dam included Bordering Vegetated Wetlands (BVWs), Banks, Land Under Water Bodies (LUWB), and Riverfront Area wetland types as defined by 310 CMR[5] 10.00. Figure 3 (Appendix C-1) depicts the Massachusetts Department of Environmental Protection (DEP) mapped wetlands in the vicinity of the dam.

[5] Code of Massachusetts Regulations

Wetland Type	Acres
Wooded Swamp Deciduous	110.37
Wooded Swamp Coniferous	1.27
Shrub Swamp	3.59
Shallow Emergent Marsh or Fen	13.30
Deep Marsh	0.45
Open Water	1.02
Total	*130.00*

Floodplains: Land uses within the 139-acre floodplain downstream of the dam:

	Acres	% of floodplain area
Agricultural	0	0
Forest	55	40
Developed, residential	13	9
Developed, commercial/industrial	1	1
Other (wetlands, open land, water, etc.)	70	50
Total	*139*	*100*

Highly Erodible Land:

Rawson Hill Brook Dam drainage area: 56 acres
Rawson Hill Brook Dam floodplain: 31 acres

Fisheries and Wildlife: The area around the dam provides fish and wildlife habitat. Four species of fish are known to occur in Cold Harbor Brook, downstream of the Rawson Hill Brook Dam (DWM 2005)**.**

Threatened and Endangered Species: No federally or state listed species are known to occur in the area (refer to letters in Appendix E-2). Figure 5 (Appendix C-1) shows the Massachusetts Natural Heritage and Endangered Species Program (NHESP) identified priority and estimated habitats for rare species in proximity to the site.

Cultural Resources: No historic properties that are listed on or eligible for listing on the National Register of Historic Places (National Register) are present in the project's Area of Potential Effect (APE). Construction will occur within the area of previous disturbance for the dam. In a letter dated November 17, 2011, the SHPO concurred that the project will not affect any historic properties (refer to Appendix E-2).

Alternative Plans Considered:

Alternative 1 – Future Without Project (No Federal Action Alternative)
The DCR, the owner of the dam, and the agency under which the Commonwealth's dam regulations are implemented, has determined that it would rehabilitate the dam to meet current federal dam safety criteria if federal funding assistance is not provided. The DCR may use other alternative rehabilitation methods other than those identified in this plan or develop their own plan to bring the dam into compliance with federal criteria.

Alternative 2 – Rehabilitation (National Economic Development (NED) Alternative)
In this alternative, the Rawson Hill Brook Floodwater Retarding Dam would be rehabilitated by use of a labyrinth weir design for the auxiliary spillway, while maintaining the existing top of dam elevation and auxiliary spillway width. The exit channel downstream of the proposed labyrinth weir would be armored with ACBs. Federal funding assistance would be provided to the project sponsors by NRCS. Engineering Plans showing Alternative 2 are provided in Appendix C-2 (Drawing A-5).

Additional Alternatives were considered, but not carried forward for additional analysis as further discussed in the *Alternatives* section of this Plan.

Project Cost:

	PL 83-566 funds	Other funds	Total
Construction	$687,100	$333,800	$1,020,900
Engineering	$230,800	$0	$230,800
Technical Assistance	$0	$0	$0
Relocation	$0	$0	$0
Real Property Rights	$0	$0	$0
Project Administration	$67,300	$36,200	$103,500
Permitting	$0	$124,300	$124,300
Total	*$985,200*	*$494,300*	*$1,479,500*
Annual O&M[6]	$0	$4,200	$4,200

Project Benefits: Economic benefits of the project are derived from ensuring the continued flood prevention purpose of the Rawson Hill Brook Dam by meeting current performance and safety standards and criteria. Benefits are based on continuing flood protection to the downstream area, which has an annual benefit of $131,900. Rehabilitation would also minimize the risk of loss of life to residents and motorists traveling on downstream roadways within the breach flood area. Net average annual equivalent benefits between the Future with Federal Project (Rehabilitation Alternative) and the Future without Federal Project (No Federal Action Alternative) equals $0.

[6] Operation and Maintenance

Identified Resource Concerns:

Concern	Degree of Concern	Degree of Significance to Decision Making
Dam safety	High	High
Human health and safety	High	High
Flood damages	High	High
Land use	Moderate	Moderate
Wetlands	Moderate	Moderate
Wildlife habitat	Moderate	Moderate
Threatened & endangered species	Moderate	Low
Water quality	Moderate	Low
Fish habitat	Moderate	Low
Prime farm lands	Moderate	Low
Soil resources	Moderate	Low
Cultural resources	Moderate	Low
Air quality	Moderate	Low
Environmental Justice and Civil Rights	Moderate	Low
Forest resources	Moderate	Low
Invasive species	Moderate	Low
Migratory birds	Moderate	Low
Riparian areas	Moderate	Low
Natural areas	Low	Low
Water resources	Low	Low
Scenic beautry	Low	Low
Sedimentation and erosion	Low	Low
Social resources	Low	Low

Environmental Values Changed or Lost:

Resource	Impact
Air quality	Short-term impact from construction equipment emissions.
Floodplains	Minor effects to floodplain; the installation of a labyrinth weir is proposed to be constructed in the auxiliary spillway.
Wetlands	0 acres of permanent loss of wetland habitat. Potential minor temporary impact to wetlands adjacent to construction area (less than 1 acre) as a result from construction access. Wetlands will be avoided if possible and temporary impacts will be restored with native vegetation.
Fisheries and fish habitat	No long-term effect, existing fisheries maintained.
Wildlife and wildlife	Potential for loss of <1.0 acre of wildlife habitat from the

Resource	Impact
habitat	installation of the ACBs; temporary disruption near construction area resulting from construction access and activity – disturbed areas would be re-planted with native vegetation; construction noise may cause wildlife to relocate temporarily.
Threatened and endangered species	No effect.
Land use	No effect.
Cultural resources	No effect.
Recreation	No long-term effect; temporary disruptions near construction area – noise and limited access to walking paths.
Prime farmland	No effect.

Direct Beneficiaries (within the 100-yr floodplain)**:**

Onsite: 0

Offsite: 15 residences, 1 non-residential property, 6 major roads, 2 bridges, plus utilities in the floodplain.

Benefit to Cost Ratio: 1.0:1.0

Authorized Rate – Not yet determined

Current Rate – 4.0 %

Net beneficial effects – $0

Funding Schedule: 2012 – 2017

Federal Funds: $985,200

Non-Federal Funds: $474,300

Period of Analysis: 53 years

Project Life: 100 years

Evidence of Unusual Interest: There is no evidence of unusual Congressional or local interest in the project.

Major Conclusions: Rehabilitation of the Rawson Hill Brook Floodwater Retarding Dam is necessary to minimize the risk of loss of life and property damage within the potential breach area and to allow the continuance of flood prevention benefits.

Areas of Controversy: There are no known areas of controversy.

Issues to be Resolved: There are no issues to be resolved.

Permits: The site-specific need for permits and mitigation, if required, will be determined during final design. The owner, the DCR, will be responsible for obtaining the necessary local, state, and federal permits, including:

(1) National Pollutant Discharge Elimination System (NPDES) general permit for construction,
(2) U.S. Army Corps of Engineers (USACE) permit under Section 404 of the Clean Water Act[7] of 1972,
(3) Massachusetts Environmental Protection Act[8] (MEPA) review
(4) Chapter 253 Permit to Construct or Alter a Dam,
(5) Chapter 91 Waterways License,
(6) Order of Conditions through the Massachusetts Wetlands Protection Act[9], and
(7) Section 401 Water Quality Certification.
(8) Section 7 U.S. Endangered Species Act[10] consultation with the U.S. Fish and Wildlife Service (FWS)
(9) Massachusetts Endangered Species Act[11] approval through NHESP, and
(10) NRCS will be responsible for Section 106 National Historic Preservation Act[12] consultation with the SHPO and the Tribal Historic Preservation Office (THPO) of with Wampanoag Tribe of Aquinnah

Is this report in compliance with executive orders, public laws, and other statutes governing the formulation of water resource projects? Yes X No _

[7] 33 U.S.C. ± 1251 *et seq.*
[8] 30 M.G.L. Sec. 61-62H
[9] 131 M.G.L. 40
[10] 16 U.S.C. §1531
[11] M.G.L. c. 131A and regulations at 321 CMR 10.00
[12] 16 U.S.C. 470 et *seq.*

CHANGES REQUIRING PREPARATION OF A SUPPLEMENT

INTRODUCTION

The Rawson Hill Brook Floodwater Retarding Dam (referred to hereafter as the "Rawson Hill Brook Dam" or the "dam") is one of ten floodwater retarding dams built between 1962 and 1987 in the watershed of the Sudbury, Assabet, and Concord Rivers (known as the SuAsCo watershed). One site, Constance M Fiske dam in the Town of Framingham was singled out as the Baiting Brook Watershed Project. Nine of those dams, including the Rawson Hill Brook Dam, were authorized to provide flood protection benefits in a 48 square mile subwatershed by the Natural Resources Conservation Service's (NRCS) 1958 Watershed Work Plan for Watershed Protection and Flood Prevention, SuAsCo Watershed, Middlesex and Worcester Counties, Massachusetts and five supplemental plans[13]. The Rawson Hill Brook Dam was constructed in 1963 in the Town of Shrewsbury, Worcester County, Massachusetts (Figure 1, Appendix C-1). The dam impounds flow along the Rawson Hill Brook, a tributary to the Cold Harbor Brook, which in turn flows through the Cold Harbor Brook Floodwater Retarding Dam to the Assabet River. Discharges from the dam flow northeasterly to the Northborough Reservoir prior to the confluence of Rawson Hill Brook with Cold Harbor Brook. Figure 2 (Appendix C-1) depicts the dam on an aerial photograph.

CHANGES IN THE WATERSHED

The Rawson Hill Brook Dam was built under the Watershed Protection and Flood Prevention Act of 1954[14] for the purpose of flood prevention. Since construction, land use changes (urban development) upstream of the dam have increased the quantity of stormwater runoff. The 2005 Rawson Hill Brook Dam Assessment Report (NRCS 2005) determined:

> For NRCS design criteria, the top of the dam is overtopped by 1.64 feet to 1.70 feet for current and ultimate build-out land use conditions during both the freeboard hydrograph (FBH) and the 5-point probable maximum precipitation (PMP) 24-hour storm.

As a result, the Massachusetts Department of Conservation and Recreation (DCR) applied to the NRCS in 2005 for funding assistance for rehabilitation of the dam to comply with current federal guidelines to ensure continued flood damage protection downstream of the dam.

Site Analysis Integrated Development Environment (SITES) and Windows ™ Dam Analysis Models (WinDAM) modeling results indicate that the Rawson Hill Brook Floodwater Retarding Dam does not meet all of the NRCS design criteria. The results of the modeling indicate that during the routing of build-out FBH through the dam and auxiliary spillway, the vegetative cover failed and the headcut breached the spillway crest. The results of the model also indicate that the dam does not meet the principal spillway capacity criteria because of discharge through the auxiliary spillway during the passage of the PSH 1-day/10-day 100-year storm.

[13] The original Plan and the first four supplements were prepared by the Soil Conservation Service, (SCS) which was the former name of the NRCS.
[14] Public Law (PL) 83-566

An engineering analysis was conducted to determine if the Rawson Hill Brook Dam qualifies for a reduction in the FBH storm, which is generated by the PMP storm, per the NRCS's Technical Release 60 (TR-60) for a "High Hazard Dam." The results of the analysis indicated that a difference in water surface elevations between the non-breach and breach conditions from the PMP storm is greater than the 2-foot maximum required by the Federal Emergency Management Agency (FEMA)-94 (FEMA 2004) and the NRCS at several locations downstream of the Rawson Hill Brook Dam. Dam failure would result in breach flood damages to approximately 1,205 residences, 164 non-residential properties, 19 major roads, 1 school, and 8 bridges, plus utilities . Dam failure would also potentially cause the loss of life of residents, workers, or motorists. Dam safety deficiencies are related to overtopping of the dam under future watershed build-out conditions and to stability and integrity of the auxiliary spillway. The results indicate that a Probable Maximum Flow (PMF) dam breach would produce unacceptable downstream consequences, and therefore, the design criteria set forth by the NRCS dam safety and design standards were applied in evaluating, developing, and designing rehabilitation measures for the Rawson Hill Brook Dam.

CHANGES PROPOSED BY THE SUPPLEMENT PLAN

As a result of greater-than-expected increases in development within the watershed, the Rawson Hill Brook Dam no longer provides the flood protection benefits it was designed to provide. To address this, proposed improvements to the dam include: the construction of a labyrinth weir within the auxiliary spillway and armoring the auxiliary spillway exit channel downstream of the proposed labyrinth weir.

This Supplemental Watershed Plan and Environmental Evaluation was prepared to evaluate the rehabilitation of the Rawson Hill Brook Dam. The dam was built in accordance with the 1958 SuAsCo Watershed Plan. An amendment to Public Law (PL) 83-566, the Watershed Rehabilitation Amendments of 2000[15], authorizes funding and technical assistance to upgrade dams under the U.S. Department of Agriculture (USDA) Watershed Program. The rehabilitation upgrade of the Rawson Hill Brook Dam is authorized under that Amendment. This Supplemental Plan documents the planning process by which the NRCS provided technical assistance to the local sponsors, technical advisors, and the public in addressing resource issues and concerns within the Assabet River watershed downstream of the Rawson Hill Brook Dam. The DCR cooperated in the preparation of the Plan by leading the public meeting, reviewing technical studies (hydrology and hydraulic modeling, preliminary engineering), and reviewing the Draft Supplemental Plan-Environmental Evaluation.

[15] Section 13 of PL 106-472

PURPOSE AND NEED FOR ACTION

The purpose of the project is to provide continual flood protection for downstream communities, residences, utilities, and to prevent the loss of life. The proposed federal action is needed to meet current federal and state dam safety criteria and standards and to continue to reduce breach flood damages to 1,205 residences, 164 non-residential properties, 19 major roads, 1 school, and 8 bridges, plus utilities .

The purpose of the proposed dam rehabilitation project is to continue to prevent flood damages by complying with current performance and safety standards and criteria. Failure of the dam would cause serious damage to homes and commercial facilities downstream of the dam and potentially result in the loss of life. Rehabilitation of the dam is needed to protect downstream properties, public utilities, and highways to reduce the risk of loss of life. Rehabilitation of the dam would extend the service life by 52 years and ensure the continued safe service of the dam throughout its original 100-year evaluation period.

WATERSHED PROBLEMS AND OPPORTUNITIES

Modeling results indicate that the Rawson Hill Brook Flood Retarding Dam does not meet all of the NRCS and Massachusetts design criteria for current land use and ultimate watershed build-out conditions. SITES and WinDAM modeling confirms that the dam does not meet the principal spillway criteria because of discharge through the auxiliary spillway during the passage of the PSH 1-day/10-day 100-year storm. The results of the analysis for the auxiliary spillway indicates that during the routing of the build-out FBH through the dam and auxiliary spillway, the vegetative cover will fail and the headcut will breach the spillway crest. The modeling shows that concentrated flows will likely develop during the passage of the stability design hydrograph (SDH) resulting in failure of the vegetative cover, ultimately breaching the auxiliary spillway. As such, the dam does not meet the NRCS design criteria or the Massachusetts dam safety criteria (302 CMR 10.00).

The Rawson Hill Brook Dam provides approximately $131,900 in average annual flood damage reduction benefits for the Rawson Hill Brook watershed. The downstream beneficiaries are the Commonwealth of Massachusetts, and the Towns of Shrewsbury, Boylston, and Northborough.

Primary concerns are the safety of the dam and the potential problems that failure of the dam would cause. Associated downstream hazards as a result of a breach flood include 1,205 residences, 164 non-residential properties, 19 major roads, 1 school, and 8 bridges, plus utilities . Dam failure would also potentially cause the loss of life of residents, workers, or motorists.

Opportunities that would be realized through the implementation of this watershed rehabilitation plan are:

- Compliance with current dam safety criteria,
- Protection of human health and safety and infrastructure and transportation systems,
- Maintenance of flood control benefits, and
- Prevention of increased flooding in the floodplain.

SCOPE OF THE PLAN

A scoping process was used to define project needs, determine important issues, and formulate alternatives. Scoping included a public meeting; written requests for input from state, local, and federal agencies; and coordination meetings with appropriate agencies. A steering committee of the NRCS, DCR, and technical experts was also formed to assist in the formulation and evaluation of alternatives.

Stakeholder agencies that were contacted concerning the proposed project are:

Worcester County Conservation District
Massachusetts Department of Conservation and Recreation
Massachusetts Division of Fisheries and Wildlife
Massachusetts Department of Fish & Game, Riverways Program
Massachusetts Department of Environmental Protection
Town of Shrewsbury
Organization of the Assabet River
Massachusetts Executive Office of Energy and Environmental Affairs
Massachusetts Executive Office of Energy and Environmental Affairs, Environmental Policy Act Office
U.S. Environmental Protection Agency (EPA) Region 1, Regulatory Section
U.S. Army Corps of Engineers, Regulatory Division
Massachusetts Office of Dam Safety
Massachusetts Historical Commission
Wampanoag Tribe of Gay Head (Aquinnah)

Table A presents the relevant resource concerns as a result of the scoping process. Table B summarizes the identified resource concerns applicable to the project through the scoping process.

Table A: Resource Concerns to the Proposed Action

Item/Concern	Relevant to the Proposed Action?		Rationale
	Yes	No	
NED P&G	X		Alternative 2 (below) is the NED Alternative.
Air quality	X		Minimal, temporary impact
Coastal zone management areas		X	The project site is not located within a coastal zone management area
Coral reefs		X	There are no coral reefs in the vicinity of the project site.

Table A: Resource Concerns to the Proposed Action

Item/Concern	Relevant to the Proposed Action?		Rationale
	Yes	No	
Cultural resources	X		Analysis of effects required by National Historic Preservation Act[16]; no historic sites present in APE
Dam safety	X		Primary concern of sponsors and NRCS
Ecologically critical areas		X	There are no ecologically critical areas in the vicinity of the site.
Environmental justice and civil rights	X		No impact. There are no Environmental Justice Zones within the project site.
Essential fish habitat (EFH)		X	No impact. There is no EFH in proximity to the dam.
Fish and wildlife	X		Minimal, temporary impact. Massachusetts Dept of Fish and Game requested consideration of providing fish passage; project purpose does not include fish and wildlife habitat.
Flood damages	X		Primary concern of sponsors and NRCS
Floodplain Management	X		Minor impact. Construction will be conducted withIN the auxiliary spillway which is mapped as within the 100-year floodplain.
Forest resources	X		Minimal impact. Construction will be conducted within the auxiliary spillway, mostly herbaceous vegetation.
Invasive species	X		Minimal impact. The area contains only limited areas with invasive species. Vegetated areas disturbed will be restored with native vegetation. Precautionary measure and best management practices (BMPs) will be utilized to reduce the risk of spreading invasive species to or from the site.
Land use	X		No impact. The land use of the area will not change as a result of the

[16] 16 U.S.C. § 470 *et seq*.

Table A: Resource Concerns to the Proposed Action

Item/Concern	Relevant to the Proposed Action?		Rationale
	Yes	No	
			dam rehabilitation.
Migratory birds	X		Minimal, temporary impact.
National Parks, Monuments, and Historical Sites		X	There are no national parks or historical sites in the project area.
Natural areas	X		Minimal, temporary impact. Dam and surrounding land is owned by the DCR and is effectively maintained as open space (i.e., natural area). After construction is completed, disturbed areas will be restored to their natural condition.
Parklands		X	There are no park lands in the vicinity of the project.
Prime and unique farmland	X		No prime or unique farmland will be affected by project.
Public health and safety	X		Primary concern of sponsors and NRCS
Regional water resource plans		X	There are no regional water resource plans in effect for the area.
Riparian areas	X		Minimal, temporary impact.
Scenic beauty	X		Minimal, temporary impact
Scientific resources		X	There are no scientific resources in the vicinity of the project area.
Sedimentation and erosion	X		Minimal temporary impact
Sole source aquifers		X	There are no sole source aquifers in the vicinity of the project area.
Social resources	X		Minimal, temporary impact
Soil resources	X		Soil resources will not be affected by the project.
Threatened and endangered species	X		Analysis of effects required by Endangered Species Act[17]; no federally or state protected species present.
Water quality	X		Minor, minimal, temporary impact.
Water quantity	X		No impact.
Water resources/supply	X		No impact
Waters of the United States	X		Potential for minor, temporary impact as a result of construction activites. No permanent impacts.

[17] 16 U.S.C. § 1531 *et seq*.

Table A: Resource Concerns to the Proposed Action

Item/Concern	Relevant to the Proposed Action?		Rationale
	Yes	No	
Wetlands	X		Analysis of effects required by Clean Water Act[18] and Executive Order 11990; potential for minor, temporary impact from construction; no permanent impact.
Wild and scenic rivers		X	There are no wild or scenic rivers in the vicinity of the site.

[18] 33 U.S.C. § 1251 *et seq*.

AFFECTED ENVIRONMENT

The area potentially affected by the rehabilitation of the Rawson Hill Brook Dam is the dam structure itself within the auxiliary spillway, the area adjacent to the dam that could be affected by construction, and the flood protection area downstream of the dam. The following discussions of existing conditions focus on these areas, plus the general project vicinity—the Town of Shrewsbury—where appropriate.

EXISTING CONDITIONS

Original Project

The Rawson Hill Brook Dam was one of nine floodwater-retarding structures proposed in the 1958 SuAsCo Watershed Plan under the authority of PL-83-566[19]. Construction of the dam was completed in 1963 with federal assistance provided by the USDA, Soil Conservation Service (SCS, now the NRCS). Subsequently, seven supplements to the original plan have been prepared, six of which have been approved[20] between 1964 and 2012. Through these supplements, two of the original dams were deleted from the Plan and three others were added, and as a result ten floodwater retarding structures were planned and constructed between 1962 and 1974 for watershed protection and flood prevention.

The Middlesex Conservation District and the Northeastern Worcester County Conservation District were the original local sponsoring organizations. The three conservation districts in Worcester County have combined into one district, known as the Worcester County Conservation District. Through the supplemental planning process and reorganization of state agencies, by 1996 the local sponsoring organizations also included the DFW and the Massachusetts Department of Environmental Management (DEM). Further state reorganizations since 1996 have resulted in renaming the DEM as the DCR.

Description of the Existing Dam

The dam is classified as a federal High Hazard dam, a hazard classification given to dams whose failure "may cause loss of life or serious damage to homes, industrial and commercial buildings, important public utilities, main highways, or railroads." The floodwater retarding structure is comprised of four major elements: the earthen embankment or main dam, the drop inlet principal spillway, the auxiliary spillway, and a dike. Drawing C-1 in Appendix C-2 presents a schematic drawing of the existing Rawson Hill Brook Dam. The embankment has a total structural height of approximately 16 feet, a hydraulic height[21] of approximately 13 feet, and an overall length of approximately 252 feet. Access to the dam is via an unpaved, gravel roadway located where Rawson Hill Brook intersects Prospect Street in the Town of Shrewsbury. A locked bar gate is located at the entrance from Prospect Street.

[19] As amended by PL 106-472, November 9, 2000.
[20] Supplemental Watershed Plan No. 6 for the Hop Brook Dam has been prepared and is currently in the process of becoming approved at the time this Draft Plan was published.
[21] Hydraulic height is defined as the difference between the elevation of the maximum controllable water surface elevation (auxiliary spillway crest) and the elevation of the lowest point in the original streambed.

Underlying the lower portion of the downstream slope, a foundation drain collects seepage water. As indicated in the as-built plans, the foundation drain is constructed of an approximately 3-foot thick sand and gravel filter layer with a 3 feet wide by 4 feet deep vertical interception drain. This system drains through rip-rap into a gutter along the toe of the downstream side of the dam. The drain extends approximately 23 feet into the embankment from the toe of the dam and is 128 feet long starting 18 feet to the right of the principal spillway and extending 110 feet to the left of the principal spillway.

The principal spillway for the structure is located left of the center of the dam near the auxiliary spillway. As depicted on the as-built drawings, the structure consists of a reinforced concrete riser that leads to a 30-inch diameter reinforced concrete outlet pipe. Normal flow of the brook enters the riser by means of a 12-inch diameter pipe. Access to the interior of the intake structure is through the top of the riser by removing a section of the guard fence. As indicated on the as-built drawings, a series of 2 anti-seep collars are provided along the length of the outlet pipe to limit seepage along the pipe. Flow through this outlet discharges at the downstream toe of the dam into a 20-foot long by 4-foot wide riprapped trapezoidal outlet basin. Flow leaves the outlet basin and enters the natural downstream channel.

The auxiliary spillway is located at the left end of the embankment and is primarily cut into the left abutment, which defines the left side of the spillway. The auxiliary spillway is a grass-lined channel with a crest elevation approximately 3 feet below the top of the dam. The crest of the emergency spillway is 20-feet long and 110-feet wide with the upstream slope at a 2% grade and the downstream slope at a 6% grade. The upstream entrance of the auxiliary spillway is located approximately 345-feet from the crest of the spillway. Downstream of the crest of the emergency spillway, the left abutment continues to define the left side of the spillway and the right side is primarily unconfined and rejoins the downstream channel. Originally designed to flow during a storm event greater than the 100-year flood event, flows would enter the auxiliary channel at its entrance roughly 345-feet upstream from the crest of the spillway and discharge approximately 250 feet downstream from the spillway crest entering the outlet channel. A 6-inch diameter drain pipe, embedded in a 4.0-foot deep by 2.5-foot wide trench consisting of filter material, collects water from the auxiliary spillway and discharges to the principal spillway outlet basin.

The Rawson Hill Brook Floodwater Retarding Dam includes a dike located near the southern most portion of the maximum pool impoundment and adjacent to Hill Street and Mercury Drive in Shrewsbury. This dike (referred to as the Hill Street Dike) runs parallel to and protects residential homes along Mercury Drive. The location of the existing dike is depicted on Figure 2.

In an October 13, 2004 dam inspection, the overall condition of the Rawson Hill Brook Floodwater Retarding Dam was noted as “Good” with evidence of regular maintenance (Bhatti 2005). During that inspection, specific concerns included the observed movement of the principal spillway riser, the condition of the auxiliary spillway drain, the condition of the riprap gutters, and trees and brush in the reservoir area. Based upon a comparison of data collected during monitoring of the spillway riser and that collected as part of this evaluation, the riser does appear to have moved since the data available from 1974 (Bhatti 2005).

The general condition of the Hill Street Dike was also noted in the 2004 site inspection as "Good", with areas of concern limited to the encroachment of residents upon the dike, deterioration of the corrugated metal pipe through the embankment, apparent settlement of sections of the toe drain, absence of back flow prevention on two of the drain lines, and the presence of yard waste within the drainage swale (Bhatti 2005). The apparent tilting of the riser was noted in annual dam inspection in the early 1970's. From these inspections, it was determined to monitor the riser by surveying the four corners of the concrete roof each month for one year. After one year, there was no movement recorded. The readings were then taken yearly. After several years of data, there was not recorded movement. Records kept during this period are available. Before abandoning the readings, in the late 1980's, it was decided to excavate behind the riser to see if there had been any movement at the joint between the riser wall thimble and the first section of pipe. If there had been actual movement of the riser to the degree of difference as shown between the four roof corners, the joint between the riser thimble and first section of outlet pipe would have to have been compromised. No movement was found; the joint was tight. It was concluded that the riser most likely was originally constructed with the four corner roof grades as currently shown.

SITES and WinDAM B modeling results indicate that the Rawson Hill Brook Flood Retarding Dam does not meet all of the NRCS and Massachusetts design criteria. The results of the modeling indicate that during the routing of build-out FBH through the dam and auxiliary spillway, the vegetative cover failed and the headcut breached the spillway crest. The results of the model also indicate that the dam does not meet the principal spillway capacity criteria because of discharge through the auxiliary spillway during the passage of the principal spillway hydrograph (PSH) 1-day/10-day 100-year storm. For NRCS design criteria, the top of the dam is overtopped by 1.64 feet and 1.70 feet for current and ultimate build-out land use conditions during both the FBH and the 5-point PMP 24-hour Storm. Maximum permissible velocities within the auxiliary spillway are also exceeded for Massachusetts dam safety criteria.

Existing Structural Data

Table B provides a summary of the existing structural data for the Rawson Hill Brook flood control structure.

Table B: Existing Structural Data—Rawson Hill Brook Floodwater Retarding Dam

Year completed	1963
Drainage area	1.59 square miles (1,018 acres)
Stream	Rawson Hill Brook
Purpose	Flood prevention
Dam type	Earthen embankment
Dam height	16.0 feet
Dam crest length	252 feet
Storage:	
Total, maximum pool	481 acre-feet
Total, auxiliary spillway crest	

Table B: Existing Structural Data—Rawson Hill Brook Floodwater Retarding Dam

Sediment	3.2 acre-feet
Flood	260.6 acre-feet
Principal spillway:	
Type	Reinforced concrete
Lower stage inlet height	1 foot
Lower stage inlet size	2 feet
Upper stage inlet height	1 foot
Outlet conduit size	30 inches
Auxiliary spillway:	
Type	Grass-lined channel
Width	110 feet
Principal spillway high stage crest elevation	541.8 feet NAVD88
Auxiliary spillway crest elevation	544.3 feet NAVD88
Top of dam (minimum crest) elevation	547.3 feet NAVD88

Dam Safety: Both the federal government, under FEMA (2004), and the DCR (301 CMR 10.00) have developed specific dam safety criteria.

As previously discussed, the dam does not meet current dam design and safety criteria. As such, the dam no longer provides the flood prevention services it was originally designed for. The Rawson Hill Broom Dam provides approximately $131,900 in average annual flood damage reduction benefits for the Rawson Hill Brook watershed. The beneficiaries of the structure are the Commonwealth of Massachusetts, and the Towns of Shrewsbury, Boylston, and Northborough. Primary concerns are the safety of the dam and the potential problems that failure of the dam would cause. Failure of the dam from a breach flood would impact 1,205 residences, 164 non-residential properties, 19 major roads, 1 school, and 8 bridges, plus downstream public utilities, and could result in the loss of life. Therefore, rehabilitation of the dam is necessary in order to bring the dam into compliance with federal and state dam safety criteria and standards. Rehabilitation of the dam would conform to the FEMA criteria (FEMA 2004) and the DEP standards[22] for a high hazard dam and large structure.

Hydrologic and hydraulic modeling of the freeboard storm predicts that the dam would be overtopped by 1.64 and 1.70 feet for current land use and build-out conditions, respectively. Overtopping of the dam could lead to embankment erosion and dam failure. The models also predict that maximum permissible velocities for the auxiliary spillway would be exceeded, and erosion of the spillway slope could occur.

[22] 302 CMR 10.00

Physical Features and Environmental Factors

Project Location: The Assabet River flows north for 30 miles to its confluence with the Sudbury River in Concord, Massachusetts, where the two rivers form the Concord River, which flows north for 15.5 miles to its confluence with the Merrimack River in Lowell, Massachusetts. The SuAsCo watershed encompasses a large network of tributaries that drain approximately 377 square miles in Middlesex and Worcester Counties. Massachusetts. The watershed contains 25 tributary sub-watersheds, one of which is the Rawson Hill Brook watershed. The drainage area for Rawson Hill Brook Dam is 1,018 acres (1.59 square miles) and extends through moderately developed areas within the Town of Shrewsbury surrounding the dam and areas of residential development within the Town of Shrewsbury and Boylston (Figure 1).

Climate: The average annual precipitation for Worcester County is 49.2 inches, and the average seasonal snowfall is 59.7 inches. In winter, the average temperature is 26.2 ºF, and the average daily minimum is 18.4 ºF. In summer, the average temperature is 67.7 ºF, and the average daily maximum temperature is 76.9 ºF. The average (50 percent) freeze-free period of 172 days extends from April 27 through October 16 (NRCS 2008a).

Geology and Soils: The project area is underlain by the contact of the Tadmuck Brook Schist (SZtb) and Nashoba Formation (OZn) of the Nashoba Zone and the Vaughn Hills Quartzite (SOvh) of the Merrimack Belt (Zen et. al. 1983). The SZtb is a Silurian to Ordovician aged andalusite, phyllite, and sillimanite schist. It is partly sulfidic and has local quartzite. The OZn is an Ordovician aged unit that includes sillimanite schist and gneiss, amphibolites, biotite gneiss, calc-silicate gneiss, and marble. The SOvh is a Silurian to Ordovician aged quartzite, phyllite, conglomerate, and chlorite schist.

According to the Surficial Geologic Map of the Shrewsbury Quadrangle (Shaw 1969), the surficial geology in the project area is characterized by swamp deposits (Qs) and Rawson Hill Brook deposits (Qr). The Qs consist of muck, peat, silt, and sand. The Qr consists of clay, silt, sand, and gravel deposits in the valley of Rawson Hill Brook. The Qr in the project area are represented by two distinct ages (as indicated by the numerical subscripts). The Qr includes both glaciofluvial and glaciolacustrine deposits.

Upland soils in the vicinity of the Rawson Hill Brook Dam are dominated by Hinckley sandy loam, Sudbury fine sandy loam, Paxton fine sandy loam, and Woodbridge fine sandy loam. Hinckley sandy loam is an excessively drained soil located on the shoulder and summit of slopes on outwash plains. The parent material is loose sandy and gravelly glaciofluvial deposits. Sudbury fine sandy loam is a moderately well drained soil located on footslopes of outwash plains. The parent material is eolian deposits over loose sandy glaciofluvial deposits. Paxton fine sandy loam is a well drained soil located on shoulders and backslopes of dense till deposits. The parent material is eolian deposits over lodgment till deposits. Woodbridge fine sandy loam is a moderately well drained soil located on shoulders of dense till deposits. The parent material is eolian deposits over lodgment till deposits.

Hydric soils in the vicinity of the Rawson Hill Brook Dam are dominated by Scarboro mucky fine sandy loam, Raynham silt loam, Freetown muck, and Ridgebury fine sandy loam. Scarboro mucky fine sandy loam is a very poorly drained organic soil located on toeslopes of outwash plains. The parent material is partly-decomposed herbaceous organic material over loose sandy glaciofluvial deposits. Raynham silt loam is a poorly drained soil located on toe slopes of former lacustrine deposits. The parent material is soft coarse-silty lacustrine deposits. Freetown muck is a very poorly drained organic soil located in low-lying areas. The parent material is highly-decomposed herbaceous organic material. Ridgebury fine sandy loam is a poorly drained soil located on footslopes of dense till deposits. The parent material is eolian deposits over dense till deposits.

The original design geology as interpreted from the boring logs provided on the as-built drawings indicated a variety of soil materials along the alignment of the dam and dikes. These materials varied from silt to poorly-graded silty sands to silty gravel and occasional pockets of well-graded sands and poorly to well-graded gravels. Although variation was observed across the site, all soils appeared to represent a granular type material with variable amounts of gravels and silts as is typical of the glacial history of the area (H&S Environmental 2010). Figure 4 (Appendix C-1) depicts the mapped soils in proximity to the dam.

Topography: The SuAsCo watershed lies within an area of previous glaciation, and many glacial features are present. In addition, the watershed is characterized by the prevalence of swamps, ponds, and lakes. The drainage pattern is dendritic with many tributary streams. Within the SuAsCo watershed, the Assabet River has a steeper gradient than the lower Sudbury and upper Concord Rivers and as a result has a more rapid runoff of floodwaters (SCS 1958). Figure 1 depicts the site on a location map.

Prime Farmland: Prime farmland is protected by the Farmland Protection Policy Act[23] in order to "minimize the extent to which Federal programs contribute to the unnecessary and irreversible conversion of farmland to non-agricultural uses" (NRCS 2008b). Soils that are designated as prime farmland and are present in the Rawson Hill Brook Dam drainage area are the Canton, Merrimac, Paxton, Sudbury, and Woodbridge fine sandy loam (SCS 1985). Table C presents the acreages of soils in the Rawson Hill Brook Dam drainage area and the downstream floodplain that are designated as prime farmland, farmland of statewide importance, or farmland of unique importance. Figure 4 depicts the mapped soils in the vicinity of the dam.

Table C: Important Farmland Soils

Soil Designation	Drainage Area (acres)	Floodplain (acres)
Prime farmland	112	10
Farmland of statewide importance	211	19
Farmland of unique importance	78	38

Sources: (MassGIS 2008b)

Highly Erodible Land: As summarized in Table D, less than 10 percent of the Rawson Hill Brook Dam drainage area and 22 percent of the downstream floodplain are highly erodible lands.

[23] 7 U.S.C. § 4201 *et seq*.

Table D: Highly Erodible Land

Land Use	Drainage Area		Floodplain	
	Acres	Percent	Acres	Percent
Highly erodible land	56	6	31	22
Potentially highly erodible land	140	15	7	5
Not highly erodible land	736	79	101	73

Source: MassGIS 2008b

Water Quality: Water quality data is not readily available for the Rawson Hill Brook. The Organization for the Assabet, Sudbury, and Concord Rivers (OARS) conducts water quality monitoring of Cold Harbor Brook, to which Rawson Hill Brook is a tributary, at Cherry Street in the Town of Northborough. Data from October 2008 are presented in Table E (OARS 2011). The OARS rated stream health in Cold Harbor as "excellent" or "good" for 6 of the 9 weeks sampled in June to September 2006 (OARS 2009). There is no other data readily available for the Rawson Hill Brook other than the OARS's data for Cold Harbor Brook.

Table E: Water Quality and Stream Health, Cold Harbor, October 25, 2008

Parameter	Result	Water Quality Standards
Total nitrogen	0.38 mg/L	0.71 mg/L
Total phosphorus	0.014 mg/L	0.31 mg/L
Total suspended solids	2 mg/L	Free from flowing, suspended and settleable solids in concentrations and combinations that would impair any use assigned to (Class B waters)
Dissolved oxygen	7.89 mg/L	>5.0 mg/L
pH	6.50	6.5 – 8.3
Water temperature	5.19 ºC	<28.3 ºC
Streamflow	N/A	N/A

Note: mg/L = milligrams/liter; ºC = degrees Celsius (centigrade);
Streamflow readings for this site currently impacted by beaver dams near the gage
Sources: OARS 2011b, EPA 2000, 314 CMR 4.05(b)(5), and 310 CMR 4.05 (3)(b)

Cold Harbor Brook discharges into the Assabet River. The Massachusetts Division of Watershed Management (DWM) summarized water quality in the Assabet River (DWM 2005):

> Historically, wastewater discharges and water withdrawals for public supply have deleteriously affected the Assabet River. A nutrient total maximum daily load (TMDL) for the Assabet River was completed in 2004.Implementation of the TMDL requires removal of total phosphorus to 0.1 mg/L in the effluent of the major municipal wastewater treatment plants and evaluation of the feasibility of sediment remediation to reduce phosphorus flux from the sediments.

Rehabilitation of the Rawson Hill Brook Dam is not expected to have a significant effect on water quality because it has no permanent impoundment.

Fish and Wildlife Resources: The area surrounding the Rawson Hill Brook Dam consists of undeveloped land bordered by moderately developed residential land. As such, the wildlife resources in the area are comprised of those species which are tolerant of human disturbances such as common fauna species found throughout the northeast United States. Typical wildlife species found in the area of the dam include gray squirrel (*Sciurus carolinensis*), raccoon (*Procyon lotor*), striped skunk (*Mephitis mephitis*), Virginia opossum (*Didelphis virginiana*), white-tail deer (*Odocoileus virginiana*), and small rodents as well as resident and migrant birds including great blue heron (*Ardea herodias*), mallard (*Anas platyrhynchos*), and Canada goose (*Branta canadensis*) in addition to common woodland avian species.

A large percentage of the watershed's amphibians, reptiles, birds, and mammals depend on wetland or riparian habitat. Common amphibians are the red-backed salamander (*Plethodon cinereus*), American toad (*Bufo americanus*), wood frog (*Rana sylvaticus*), green frog (*Rana clamitans)*, gray treefrog (*Hyla versicolor*), and spring peeper (*Pseudacris crucifer*). Reptiles include the painted turtle (*Chrysemys picta*), common garter snake (*Thamnophis sirtalis*), and northern water snake (*Nerodia sipedon*).

According to data provided by National Oceanic and Atmospheric Administration (NOAA), there is no essential fish habitat (EFH) within the Rawson Hill Brook or the Assabet River (NOAA 2011). Additionally, the Massachusetts Department of Fish and Game requested that fish passage be considered as part of the dam restoration. There are no fishery resources upstream of the dam since there is no permanent pool. Rehabiliation of the dam would also not affect any fish resources downstream of the dam. Since the dam does not contain a permanent pool, there is no suitable opportunity to include fish passage.

Rawson Hill Brook is a tributary to Cold Harbor Brook. The DFW conducted fish surveys at one station in Cold Harbor Brook in 2000. The 2000 survey identified four fish species, as listed in Table F (DWM 2005).

Table F: Fish Species Observed at the Cold Harbor Site

Common Name	Scientific Name	# Observed
Blacknose dace	*Rhinichthys atratulus*	37
Bluegill	*Lepomis macrochirus*	7
Largemouth bass	*Micropterus salmoides*	3
White sucker	*Catostomus commersoni*	9
	Total	56

Source: DWM (2005)

Threatened and Endangered Species: There are no federally listed or proposed, threatened or endangered species or critical habitat in the project area (FWS 2009). According to the NHESP database, there are no state-listed rare species or species of special concern in the area (NHESP 2009). Figure 5, located in Appendix C-1, depicts the NHESP estimated habitats of rare wildlife.

In a letter dated October 20, 2011, the NHESP confirmed that there were no known occurrences of any threatened or endangered species in proximity to the dam (see Appendix E-2).

Wetlands: A map of freshwater wetlands, as interpreted and classified according to cover type by the DEP using aerial photographs, was obtained from Massachusetts Geographic Information Systems (MassGIS) data (Figure 3). Wetland types within the drainage area of the dam are listed in Table G. A small wooded swamp (2.01 acres) is located immediately downstream of the dam.

Table G: DEP-Mapped Wetlands Summary

Wetland Type	Approximate Acreage
Wooded Swamp Deciduous	110.37
Wooded Swamp Coniferous	1.27
Shrub Swamp	3.59
Shallow Emergent Marsh or Fen	13.30
Deep marsh	0.45
Open Water	1.02
TOTAL	***130.00***

Source: MassGIS (2008b)

The extents of the wetlands were assessed in the vicinity of the dam and in the area where construction access could potentially be located in June of 2011. State-regulated wetland resources identified during the infield assessment include BVWs, Banks, LUWB, and Riverfront Area as defined by 310 CMR 10.55 – 10.58. A brief description of these resources is provided below. Figure 6 (Appendix C-1) shows the extents of the field-assessed wetlands.

Bordering Vegetated Wetland – BVWs were identified along the southern and eastern portions of the dam embankment and auxiliary spillway. As a state-regulated freshwater wetland, a 100 foot regulated buffer zone is applied to its boundary. These wetlands include a mosaic of wetland habitats including forested swamps, shrub-swamps, and shallow and deep emergent marshes. Dominant vegetation in these wetlands include red maple (*Acer rubrum*), swamp white oak (*Quercus palustris*), broad-leaf cattail (*Typha latifolia*), sensitive fern (*Onoclea sensibilis*), jewelweed (*Impatiens capensis*), dark-green bulrush (*Scirpus atrovirens*), spotted joe-pye weed (*Eupatorium maculatum*), lurid sedge (*Carex lurida*), tussock sedge (*Carex stipata*), woolgrass (*Scirpus cyperinus*), and poison ivy (*Toxicodendron radicans*). Soils in these wetlands exhibit dark chromas, some mottling, saturation, and other indicators typical of hydric soils.

Banks – Bank wetland resources are generally limited to the lands immediately adjacent to the banks of the Rawson Hill Brook and immediately downfall of the outfall. Onsite Banks are mostly vegetated and are comprised of mineral soils. Dominant vegetation within the Banks areas includes red maple, swamp white oak, jewelweed, sensitive fern, woolgrass, dark green bulrush, lurid sedge, and poison ivy.

Land Under Water Bodies and Waterways – This area is immediately adjacent to the dam and is limited to land under the Rawson Hill Brook and contributing spillway. Generally, this land is limited to mineral soils.

Riverfront Area – Riverfront Area is defined as the area of land between a river's mean annual high water line and a parallel line measured 200 feet horizontally from this high water line. Rawson Hill Brook is defined as a river as it is a perennial body of water that empties into another river. The boundary of the Riverfront Area associated with Rawson Hill Brook extends landward 200 feet from the mean annual high water line. Riverfront Area located within the potential project construction areas consists of existing cleared and previously disturbed land associated with Rawson Hill Brook Dam.

Floodplain: Floodplains are generally characterized as areas of land which are subject to flooding during a 100-year flood. Floodplains are typically considered to be hazardous to development activities. Usually, naturally vegetated floodplains provide habitat for wildlife, floodflow reduction, sedimentation control, maintain water quality, and aid in the transport and deposition of sediment and nutrients within riverine systems.

The majority of the upstream portion of the site, and a portion of the downstream portion, are within the 100 year floodplain (Figure 7 in Appendix C-1). Downstream of the dam, the floodplain is approximately 139 acres. Temporary, short-term minor adverse impacts to the floodplain would occur during the installation of the ACBs within the auxiliary spillway. After construction, the ACBs should not have any permanent adverse impacts on the downstream floodplain.

Air Quality: Air quality is generally defined as how clean or polluted air in a specific area is, and what associated health effects may be of concern. The DEP monitors several air quality criteria pollutants subject to National Ambient Air Quality Standards (NAAQS) including sulfur dioxide (SO_2), ozone (O_3), carbon monoxide (CO), nitrogen dioxide (NO_2), lead (Pb), and two categories of particulate matter (≤10 microns [PM10] and ≤ 2.5 microns [PM2.5]) (DEP 2011).

The Town of Shrewsbury falls within the Boston-Lawrence-Worcester 8-hour ozone nonattainment area as defined by the EPA[24]. The area is in attainment for all other criteria pollutants (EPA 2009). The Clean Air Act and Amendments of 1990[25] define a "nonattainment area" as a locality where air pollution levels persistently exceed NAAQS, or that contributes to ambient air quality in a nearby area that fails to meet standards. The area is in attainment for all other criteria pollutants (EPA 2011). Air quality data for the Summer Street sampling location in Worcester (the closest location to the dam) for 2010 is presented in Table H (DEP 2011).

[24] http://www.epa.gov/ozonedesignations/1997standards/areamaps/BostonMA.pdf
[25] 42 U.S.C 7401 *et seq.*

Table H: Summer Street Air Quality Data

Criteria Pollutant	Level[1/]	Standard
Sulfur dioxide (ppm)	0.002	0.03
Ozone (ppm)	0.083	0.075
Carbon monoxide (ppm)	1.55	9
Nitrogen dioxide (ppb)	13.99	53
Particulate Matter (PM10) (µg/m3)	15.5	150
Particulate Matter (PM2.5) (µg/m3)	8.7	15

Note: ppm=parts per million; ppb=parts per billion; $\mu g/m^3$=micrograms per cubic meter
Source: DEP (2011)
[1/]Annual arithmetic mean

Recreation: Although "No Trespassing" signs have been posted, the dam area is used informally for hiking and biking (i.e., recreation is not one of the dam's purposes).

Hazardous Waste: Included in the SuAsCo Watershed are seven Superfund Sites. The following Superfund Sites are found on the National Priorities List (NPL) in the SuAsCo Watershed: Fort Devens-Sudbury Training Anex, Hocomono Pond, W.R. Grace & Company Acton Plant, Nuclear Metals, Natick Laboratory, Nyanza, and Silresim (EPA 2011). These Sites are not within the vicinity of the proposed project, they will not be affected by rehabilitation of the dam.

Cultural and Historic Resources: The APE for the project is the access road into the site and the project construction area. The entire APE was previously disturbed for construction of the dam. Other than the dam itself there are no structures within the APE. No historic properties that are listed or eligible for listing on the National Register of Historic Places are present within the project's APE (NPS 2011). In a letter dated November 17, 2011, the SHPO stated that the project will not affect any historic properties (see Appendix E-2). Consultation was initiated with the THPO of the Wampanoag Tribe of Gay Head (Aquinnah) with correspondence dated 28 October 2011. Consultation was determined completd as of 16 July 2012.

Land Use: In the 1958 watershed plan, the SuAsCo watershed is described as 10 percent developed and 90 percent cropland, grassland, forest, and open water. In the 50 years since, the area has developed as a residential area for Boston and Worcester commuters. Current land use in the Rawson Hill Brook Dam drainage area (based on 2005 data in MassGIS) is summarized in Table J; 41 percent of the area is residential, mostly medium density and 50 percent of the area is forested.

Table I also summarizes land use under ultimate build-out conditions, as projected by updating the current conditions land use coverage with information obtained from the Massachusetts Executive Office of Environmental Affairs, Interstate 495 Corridor Region Community Preservation Initiative, and constraints set forth by nearby towns (i.e., 100-foot river inner riparian zones, wetlands, protected open space, and miscellaneous undevelopable areas) (NRCS 2005). Residential, commercial, and industrial development is projected to more than double in the area, and will result in a similar loss of forested land cover and agricultural land. A current

land use map of the Rawson Hill Brook Dam drainage area is presented as Figure 8 in Appendix C-1.

Table I: Land Use in the Rawson Hill Brook Dam Drainage Area

Land Use	Current		Ultimate Build-out	
	Acres	Percent	Acres	Percent
Residential	417	41	723	71
Forest	509	50	214	21
Agricultural	10	1	10	1
Commercial/Industrial	31	3	51	5
Other (wetlands, open land, water, etc.)	51	5	20	2
Total	*1,018*	*100*	*1,018*	*100*

Source: 2005 Land Use (MassGIS 2008a)

Land use in the Rawson Hill Brook Dam floodplain is summarized in Table J. Land in the floodplain is mostly privately owned (78 percent), with smaller proportions of state- or local government-owned (18 percent) and federally owned (4 percent) land. Future land use in the floodplain is not expected to change significantly because of zoning restrictions on floodplain development. Figure 9 (Appendix C-1) depicts the current land uses in the downstream floodplain.

Table J: Land Use in the Rawson Hill Brook Dam Floodplain

Land Use	Acres	Percent
Forest	55	40
Residential	13	9
Commercial, industrial	1	1
Agricultural	0	0
Other (wetlands, open land, water, etc.)	70	50
Total	*139*	*100*

Source: 2005 Land Use (MassGIS 2008a)

Socioeconomic: The Town of Shrewsbury, founded in 1727, has an estimated population of 35,608 according to the 2010 census (USCB 2011). The Town of Shrewsbury is located in eastern Massachusetts and bordered on the west by the City of Worcester and bordered on the east by the Towns of Northborough and Westborough. The town primarily serves as a residential community to rural commuters of the metropolitan areas of the Cities of Boston and Worcester. Table L summarizes the socioeconomic data for the Town of Shrewsbury (the location of the dam) compared to the Commonwealth of Massachusetts, and the United States. The Rawson Hill Brook Dam, as a flood control structure, provides an annual flood protection benefit of $131,900 to downstream communities. Socioeconomic characteristics of the Town of Shrewsbury and Worcester County—plus the state and the nation for comparison—from the United States Census in 2000 and available data from 2010 are presented in Table K.

Environmental Justice: Executive Order 12898 Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations[26] requires that "each federal agency shall make achieving environmental justice part of its mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations" (CEQ 1997). Environmental Justice neighborhoods are defined as neighborhoods with minority, non-English speaking, low-income, and/or foreign born populations. According to MassGIS data derived from the 2000 U.S. Census, the Town of Shrewsbury has no environmental justice populations that could be affected by project construction (MassGIS 2008a). As shown in Table L, minority groups constitute approximately 8 percent of the population in the Town of Shrewsbury, and families in poverty are approximately 3 percent of all town families.

The closest Environmental Justice area is a large Environmental Justice Zone located to the west and southeast of the dam. Figure 10 in Appendix C-1 depicts the Environmental Justice Zone in proximity to the dam. There would be no adverse effects to environmental justice communities downstream of Shrewsbury, because the project has no adverse effects downstream of the dam and only benefits downstream populations.

Human Health and Safety: The human health and safety of the dam includes items of risk such as flood, drought, or other disasters affecting the security of life or health; potential loss of life, property, and essential public services due to structural failure; and other environmental effects such as changes in air or water quality. As previously discussed, since the dam does not meet current federal and state dam safety criteria and standards, there is an increased risk of downstream flooding as a result from dam failure which could greatly impact the lives, health, and essential public services such as infrastructure and emergency assistance. Other factors, such as drought and air quality, would not be affected by a potential dam failure.

[26] Executive Order 12898 of February 4, 1994. Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations. Federal Register 59:32.

Table K: Summary of Socioeconomic Characteristics

	Shrewsbury		Worcester Co.		Massachusetts		United States	
Population and Race	**35,608**		**798,552**		**6,547,629**		**308,745,538**	
White	28,720	80.7%	699,611	87.6%	5,400,458	82.5%	231,040,398	74.8%
Black/African American	874	2.5%	40,856	5.1%	508,413	7.8%	42,020,743	13.6%
Asian	5,817	16.3%	36,340	4.6%	394,211	6.0%	17,320,856	5.6%
Other	736	2.1%	34,991	4.4%	369,611	5.6%	21,748,084	7.0%
Native American	113	0.3%	5,396	0.7%	50,705	0.8%	5,220,579	1.7%
Hispanic or Latino of any race	961	2.7%	75,422	9.4%	627,654	9.6%	50,477,594	16.3%
Age								
Median age	40.2		39.2		39.1		37.2	
Over 18 years of age	26,385	74.1%	611,321	76.6%	5,128,706	78.3%	234,564,071	76.0%
Over 65 years of age	4,818	13.5%	102,035	12.8%	902,724	13.8%	40,267,984	13.0%
Language Spoken At Home								
English only	26,032	78.9%	618,359	82.2%	4,849,884	78.3%	229,673,150	79.4%
"less than very well"	3,153	9.6%	55,071	7.3%	546,663	8.8%	25,223,045	8.7%
Spanish	528	1.6%	55,426	7.4%	484,965	7.8%	36,995,602	12.87%
Indo-European	3,257	9.9%	48,776	6.5%	555,058	9.0%	10,666,771	3.7%
Asian-Pacific	2,797	8.5%	19,733	2.6%	230,616	3.7%	9,340,583	3.2%
Other languages	377	1.1%	10,401	1.4%	70,396	1.1%	2,539,640	0.9%
Disability Status								
Population five years of age and older	2,935	8.4%	90,524	11.5%	699,252	10.8%	36,354,712	11.9%
Education								
High school graduate or higher	94.9%		88.5%		89.1%		85.6%	
High school including GED	3,871	16.5%	153,461	28.7%	1,168,464	26.2%	58,225,602	28.5%
Associates degree	1,6476	7.0%	47,073	8.8%	337,594	7.6%	15,553,106	7.6%
Bachelor's degree	7,337	31.2%	109,305	20.4%	992,307	22.3%	36,244,474	17.7%
Graduate or professional degree	6,133	26.1%	65,736	12.4%	746,592	16.7%	21,333,568	10.4%
Employment, Class of Worker and Commuter Status								
Labor force pool (population > age 16)	18,818	70.3%	634,931	79.5%	5,313,877	81.2%	243,832,923	79.0%
Employed	17,676	66.1%	381,625	60.1%	3,225,103	60.7%	139,033,928	57.0%
Unemployment	1,080	4.0%	48,866	7.7%	365,805	6.9%	16,883,085	6.9%
Private for profit workers	14,507	82.1%	306,453	80.3%	2,599,288	80.6%	108,824,974	78.3%
Self-employed workers – includes agriculture, forestry, fishing, hunting	766	4.3%	20,465	5.4%	198,627	6.2%	8,740,557	6.3%

Table K: Summary of Socioeconomic Characteristics

	Shrewsbury		Worcester Co.		Massachusetts		United States	
Non-profit workers	1,284	7.3%	36,300	9.5%	397,866	12.3%	10,970,221	7.9%
Government	2,434	13.8%	53,514	6.7%	424,996	13.2%	21,291,233	15.3%
Federal	246	1.4%	6,891	0.9%	64,128	1.0%	4,938,966	1.6%
State	736	4.2%	18,537	2.3%	116,608	1.2%	6,270,462	2.0%
Local	1,452	8.2%	28,086	3.5%	232,967	3.6%	10,453,506	3.4%
Occupation								
Management, professional and related occupations	10,120	57.3%	150,744	39.5%	1,402,764	43.5%	49,975,620	35.9%
Service occupations	2,093	11.8%	66,168	17.3%	559,683	17.4%	25,059,153	18.0%
Sales and office occupations	3,617	20.5%	94,147	24.7%	756,845	23.5%	35,711,455	25.0%
Production, transportation, and material moving occupations	1,022	5.8%	43,639	11.4%	285,760	8.9%	16,590,396	11.9%
Construction, extraction, and maintenance occupations	824	4.7%	26,927	7.1%	220,046	6.8%	12,697,304	9.1%
Commuting to Work								
Worked in county of residence	11,683	66.1%	268,686	42.3%	2,072,085	64.2%	99,361,852	72.6%
Worked outside county of residence	5,365	30.3%	91,150	14.3%	958,412	29.7%	32,364,811	23.6%
Worked outside the state of residence	377	2.1%	13,121	2.4%	121,049	3.8%	5,214,347	3.8%
Housing								
Number of households		13,424		303,080		2,547,075		116,716,292
Number of housing units		13,987		326,788		2,808,254		131,704,730
Occupied	13,424	96.0%	303,080	92.7%	2,547,075	90.7%	116,716,292	88.6%
Owner occupied	9,949	74.1%	200,322	66.1%	1,587,158	62.3%	75,986,074	65.1%
Income								
Median annual household income		$87,393		$61,121		$62,072		$50,046
Median family income		$101,614		$76,485		$78,653		$60,609
Per capita income		$38,000		$29,316		$33,203		$26,059
FT*, year-round male median income		$78,981		$56,337		$56,959		$46,500
FT*, year-round female median income		$52,794		$42,218		$46,213		$36,551
Poverty								
Number of families	192	2.0%	61,489	7.7%	208,860	8.2%	13,188,941	11.3%

Source: 2000 and 2011 USCB data * FT = Full-time

STATUS OF OPERATION AND MAINTENANCE

The DCR is responsible for operation and maintenance of the Rawson Hill Brook Dam. Site inspections of the dam occurred on 13 October 2004 by the DCR and NRCS consultants and H&S Environmental (Bhatti 2005). In general, the dam was found to be in "Good" condition, however, some areas of concern were observed. These include the apparent tilting of the riser, condition of the auxiliary spillway drain, and the encroachments at the Hill Street Dike. A discussion regarding the tilting of the riser is previously provided under the *Conditions of the Existing Dam* heading.

On the west side, the main dam embankment extends at slightly greater than a right angle forming a berm for the auxiliary spillway. An apparent discontinuity was observed in this berm which may have been due to a waste pile not shown on as-built drawings.

The west side of the downstream slope of the embankment may need some work to restore the partial armored gutter system to the originally designed system. A possible depression was also observed on slope midway up slope. A slight groove/swale was also noticed at the toe of slope leading from downstream right abutment. Some wetness was noted near the outlet pipe.

Visual inspection of the riser indicated a slight tilting (approximately 6 inches) of the structure. With the exception of minor rusting which is considered normal, upper trash racks were in good condition. Lower portions of the angle steel showed some deterioration.

The non–perforated section of the auxiliary spillway drain had a small animal guard at the outlet end that was missing. It may have corroded away. Slight settlement may have occurred in the middle section of the pipe.

SEDIMENTATION

Sedimentation of the dam over its current service-life has been minimal despite land changes within the upstream drainage area and potential for increased sediment storage from beaver activity as evidenced from measured sedemtn accumulation thicknesses and survey data from a limited reservoir sediment survey completed by the NRCS (NRCS 2012). That survey indicated that there is an average of approximately 9 inches of sediemtn within the sediment pool. The 2012 NRCS report concluded that sedimentation upstream of the dam should not be considered a principle concern and failure due to sedimentation is not probable.

BREACH ANALYSIS AND HAZARD CLASSIFICATION

As defined in Section 520.21(e) of the NRCS Title 210 National Engineering Manual, Rawson Hill Brook Floodwater Retarding Dam is classified as a high hazard dam "where failure may cause loss of life or serious damage to homes, industrial and commercial buildings, important public utilities, main highways, or railroads." The original NRCS hazard classification was as a significant hazard structure; but, development in the area and downstream hazards warranted a reclassification of the dam to a high hazard dam. Under Massachusetts Dam Safety Rules and

Regulations[27] the dam is currently classified as a Class II (Significant) hazard structure. However, development downstream of both the Rawson Hill Brook Dam and the Hill Street Dike warrants reclassification. Additionally, the Northborough Reservoir Dam located in-series downstream of the Rawson Hill Brook Dam is currently classified as a Class I (High) hazard structure under Massachusetts Dam Safety Rules and Regulations. Due to the limited storage capacity of that structure, a failure of the Rawson Hill Brook Dam may cause a subsequent failure of the Northborough Reservoir Dam. Therefore, under Massachusetts Dam Safety Rules and Regulations[28] as modified by Chapter 330 Acts of 2002, the Rawson Hill Brook Dam is reclassified as a Class I (High) hazard structure and is considered an Intermediate size structure.

Failure of the dam at maximum pool will likely cause loss of life and serious damage to home(s), industrial or commercial facilities, important public utilities, main highways or railroads. Flooding along Rawson Hill Brook and the Assabet River from a dam breach is expected to impact approximately 1,205 residences, 164 non-residential properties, 19 major roads, 1 school, and 8 bridges, plus utilities, as discussed in the *Consequences of Dam Failure* section of this report.

A comprehensive hydrologic and hydraulic analysis was performed to evaluate the capacity of the Rawson Hill Brook Dam under current and future build-out conditions (see Appendix D). The analysis included development of several hydrologic and hydraulic models to predict maximum water surface elevations under a series of design storms. Design storms were established based on NRCS design criteria for earthen dams. The primary tools used for the evaluation of the existing capacity and rehabilitation alternatives were the NRCS's SITES and WinDAM computer models.

The results indicated that, for current conditions, the Rawson Hill Brook Dam does not meet Massachusetts criteria, NRCS dam safety and design standards or the new 5-point PMP criteria. The model predicts that the dam is overtopped under existing and build-out watershed conditions during the routing of the FBH storm by 1.64 and 1.70 feet, respectively. Consequently, the dam does not meet the NRCS design criteria for the auxiliary spillway capacity and freeboard since it does not allow for passing of the FBH without overtopping the dam. The study also reported modeled velocities within the auxiliary spillway of 7.0 feet per second (fps) and greater, resulting in possible erosion and stripping of the vegetative cover.

For ultimate build-out conditions, the Rawson Hill Brook Dam does not meet Massachusetts dam safety criteria; NRCS design criteria or the new 5-point PMP criteria. The model predicts that during the routing of the build-out FBH hydrograph through the dam and auxiliary spillway, the vegetated cover failed and the headcut breached the spillway crest. The model indicated that concentrated flows will likely develop 2.9 hours after the beginning of the storm event and the headcut erosion could potentially cause the auxiliary spillway to breach approximately 3.9 hours after the beginning of the storm event, causing a potential final headcut depth of up to 12 ft. Using the 6-hour SDH to evaluate the stability of the auxiliary spillway, the results of the model indicated that the auxiliary spillway can reach the peak flow after 4.7 hours, which can cause a concentrated flow downstream of the crest. The downstream vegetated cover will likely fail,

[27] 302 CMR 10.00
[28] 302 CMR 10.00

causing the crest to breach at approximately 4.2 hours after the beginning of the storm event. The SDH model indicated that the velocity of flow within the spillway is 7.5 fps with an estimated shear stress of 0.056 pounds per square foot, which is erosive to vegetative cover.

Table L summarizes the hydrologic and hydraulic analyses for the original design and for current and build-out conditions.

Table L: Hydrologic and Hydraulic Analyses Summary

	Original Design[1]	**Current Conditions**[2/]	**Build-out Conditions**[2/]
Comparison elevations			
Principal spillway riser crest (elevation, feet)	541.8	541.8	541.8
Crest of auxiliary spillway (elevation, feet)	544.3	544.3	544.3
Top of dam low point (elevation, feet)	547.3	547.3	547.3
Bottom width of auxiliary spillway (feet)	110	110	110
PSH (principal spillway hydrograph)[1/]			
Maximum water elevation (feet)	–	545.94	546.03
Drawdown (days)	–	7.28	7.30
Starting pool elevation for SDH and FBH	–	537.29	537.56
SDH (spillway design hydrograph)			
Maximum water elevation (feet)	–	546.71	546.03
Meets stability criteria (Y/N)	–	N	N
Meets integrity criteria (Y/N)	–	N	N
FBH (freeboard design hydrograph 6-hr)			
Maximum water elevation (feet)	545.9	548.94	549.00
Available freeboard (feet)	1.4	-1.64	-1.70

[1/] Source: SuAsCo Watershed Project, July 5, 1960.
[2/] Source: WinDAM Model for Rawson Hill Brook Dam developed by AMEC Earth & Environmental, Inc., August 2011.

Breach inundation maps are provided in Appendix C-3.

POTENTIAL MODES OF DAM FAILURE

Several potential modes of failure for dams were examined for the Rawson Hill Brook Dam:

Sedimentation: Excessive sedimentation can reduce flood storage volume and clog spillways, reducing the hydraulic efficiency of the dam. Sedimentation of the Rawson Hill Brook Dam over the past 48 years has been minimal, and failure due to sedimentation is not probable.

Hydrologic Capacity: Hydrologic failure of a dam can occur by breaching the auxiliary spillway or overtopping the dam during a storm event. The integrity and stability of the auxiliary spillway and embankment is dependent on depth, velocity, and duration of flow; vegetative cover; and resistance to erosion. As discussed in the previous section, the dam does not meet

current dam safety design criteria for a high hazard dam. Therefore, the potential for failure due to a deficiency in hydrologic capacity at the dam is considered high.

Seepage: Embankment and foundation seepage can contribute to failure of an embankment by removing (piping) soil material through the embankment or foundation. As the soil material is removed, voids can be created, allowing ever increasing amounts of water to flow through the embankment or foundation until the dam collapses due to the internal erosion. Seepage that increases with an increase in pool elevation is an indication of a potential problem, as is stained or muddy water. Foundation and embankment drainage systems can alleviate the seepage problem by removing the water without allowing soil to be transported away from the dam.

No visible signs of seepage were observed during the inspection conducted in 2009 (H&S Environmental 2010). There was no outward evidence of sinkholes, seepage, or other surface anomalies which would indicate embankment instability. The possible depression and slight groove that were observed during the 2009 inspection of the dam appear to be isolated abnormalities that are likely the result of unsanctioned activities at the dam (e.g., all terrain vehicles, etc.). As such, the observed possible depression and slight groove can likely be remedied by maintenance activities that would repair these areas. In summary, the abnormalities that were observed during the 2009 inspection are not considered to be anomalies that would indicate any kind of embankment instability.

Seismic: The integrity and stability of an earthen embankment are dependent on the presence of a stable foundation. Foundation movement through consolidation, compression, or lateral movement can cause the creation of weak zones or voids within an embankment, separation of the principal spillway conduit joints, or in extreme cases, complete collapse of the embankment. Central Massachusetts is not an area of significant seismic risk, and there is low potential for seismic activity to cause the failure of the dam.

Embankment Slope Failure: An embankment slope failure allows increased saturation, weakens the integrity of the dam during large storms, and could result in a catastrophic failure. Slope failure can also create slides and sloughing that lower the top of the dam elevation so that overtopping may occur during large storms.

The Rawson Hill Brook Dam shows no visible signs of slope failure, sloughing, or any other noticeable indications of instability on the embankments. The embankments of the dam are grass covered. Recent inspection of the dam noted small depressions, and minor tire rutting within the topsoil along the crest. No animal burrows, depressions, woody growth, or other deficiencies were noted along the upstream and downstream slope. Moisture was noted along the downstream swale, right of the auxiliary spillway. The DCR is responsible for operations and maintenance of the dam. The grass is cut and limed once per year and other maintenance activities are completed as necessary and as resources are available (H&S Environmental 2010). Embankment slope failure presents a low potential mode of failure for Rawson Hill Brook Dam.

Material Deterioration: Materials used in the principal spillway system are common construction materials, but they are subject to weathering and chemical reaction due to natural elements within the soil, water, and atmosphere. As a result of this weathering, concrete

components can deteriorate and crack, metal components can rust and corrode, and leaks can develop. Embankment failure can occur from internal erosion caused by these leaks.

Based on the results of the site inspection in 2009 (H&S Environmental 2010), the structure appears to be in satisfactory condition with areas in need of minor maintenance. In general, the surveyed elevations showed no significant settlement or erosion along the structure that would limit the function of the dam. The potential failure of the existing dam due to deteriorating components is judged to be low. However, the dam should continue to be monitored, especially after significant storm events, because of the age of existing structural components.

CONSEQUENCES OF DAM FAILURE

Historically, the pool elevation at the Rawson Hill Brook Dam has never reached the level of the auxiliary spillway, but modeling indicates that the auxiliary spillway would discharge during the 100-year precipitation event (10-day drawdown simulation) under current or build-out conditions. Failure of the Rawson Hill Brook Dam under more-extreme wet weather conditions is anticipated to impact approximately 1,205 residences, 164 non-residential properties, 19 major roads, 1 school, and 8 bridges, plus utilities. The majority of which are located in the Towns of Northborough and Hudson. Most of these structures would have already experienced the effects of flooding resulting from the PMP storm prior to the dam breach. Maps depicting the breach inundation zone downstream of the dam are provided in Appendix C-3.

Within the Town of Shrewsbury, dam break flooding is anticipated along Rawson Hill Brook and the Assabet River. Flooding is expected to impact approximately 24 residential structures. The Town of Boylston would experience flooding along the Assabet River. Flooding is expected to impact 11 residential structures, 2 major roads, and 1 bridge. Within the Town of Northborough, flooding would likely impact 448 residential structures, 88 industrial buildings, 7 major roads, and 4 bridges. In the City of Marlborough, flooding is expected to impact 12 residential structures, 8 industrial buildings, 4 major roads, and 1 bridge. The Town of Berlin is expected to be experience flooding that would impact 61 residential structures, 7 industrial buildings, and 2 major roads. Within the Town of Hudson, flooding is expected to impact 649 residential structures, 61 industrial buildings, 4 major roads, 1 high school, and 2 bridges.

A catastrophic breach of the dam would affect an area larger than the 100-year floodplain, so the damages from a breach would far exceed the damages sustained from a 100-year flood event without the dam in place, and it would also most likely include the loss of lives.

ALTERNATIVES

FORMULATION PROCESS

The NRCS and DCR jointly developed a wide range of nonstructural and structural measures for flood protection downstream of Rawson Hill Brook Dam. Alternatives were developed that are ineligible for financial assistance under PL 83-566 as amended by PL 106-472 as well as alternatives that are eligible for federal funding. To be eligible for federal assistance, an alternative must meet the requirements of Section 14 of PL 83-566.

The following alternatives were considered:

- Future Without Project (No Federal Action)—the most probable future conditions to be realized if the federally funded NED Alternative is not implemented.
- Decommissioning—controlled breaching of the dam so that it no longer stores floodwater.
- Relocation
- Floodproofing
- Rehabilitation of the Auxiliary Spillway (NED Alternative).
- Other dam rehabilitation alternatives.

Alternatives that would provide no additional benefits and have similar or additional impacts but would cost substantially more than the NED Alternative were eliminated from detailed analysis. The Future Without Project Alternative was used to evaluate the remaining feasible rehabilitation alternative, which is the NED Alternative.

ALTERNATIVES CONSIDERED BUT ELIMINATED FROM DETAILED STUDY

Structural and nonstructural measures that were considered but eliminated from detailed study are described in the following paragraphs (AMEC 2011).

Decommissioning

Decommissioning would require taking the dam out of service through a full or partial breach of the dam. Decommissioning would eliminate flood storage behind the dam and eliminate the flood protection provided by the dam. Without further mitigation, downstream properties would be subject to increased flooding, increased property damage, and increased risk of loss of life. There would be construction costs and impacts related to the dam breach, but there would be no long-term dam maintenance and repair costs.

Decommissioning would not meet the sponsors' objective to maintain the downstream flood damage reductions provided by the existing project. To meet this objective, decommissioning would have to be supplemented by other measures such as flood-proofing or relocation. The estimated cost for this alternative is in excess of $16,436,000. As such, decommissioning the dam was not found to be reasonable.

Relocation

Land downstream of the dam that would be affected by failure of the dam would be purchased and the residences or businesses relocated out of the flood area. A conservative estimate of the downstream land value per individual residential house-lot is valued at approximately $290,000. Given that there are a total of 1,205 residences in the downstream breach inundation zone, the estimated cost-to-purchase is $349,450,000. When costs for purchasing and relocating the one school, protecting roads and other infrastructure, and relocation costs are added to this cost the cost of this nonstructural alternative far exceeds the cost of structural alternatives to rehabilitate. As such, relocation was not found to be reasonable.

Floodproofing

The use of downstream floodwalls for the floodproofing alternative was previously evaluated in the 2010 assessment report (H&S 2010). This alternative considers the placement or construction of floodwalls in the downstream area to protect areas of concern. Floodwalls would be required around major arteries such as Reservoir Street in the Town of Shrewsbury, Interstate 290 in the Town of Boylston, and Center Street, Interstate 290, Church Street, Fisher Street, and West Street in the Town of Northborough. This would likely require several miles of floodwalls with several penetrations. The 2010 report estimated the approximate cost to construct the downstream floodwalls was $15,480,000. Updated to November 2011[29] dollars, the cost of this alternative is $16,092,000. The cost to replace the dam with downstream floodwalls to protect property, utilities, and transportation structures, as well as the potential loss of life, was not found to be reasonable due to exhorbitant costs.

Raise the Dam by Using A Parapet Wall

Increasing the height of the dam to elevation 551 feet NAVD88[30] would provide additional protection against overtopping during the PMP event. This alternative would raise the dam by means of a parapet wall, which would span the entire length of the dam, and the parapet wall would tie-in into a side wall that would be constructed along the right side of the auxiliary spillway. Due to increased maximum water pool elevation, this alternative may require additional dike construction to protect residences in the Hill Street/Mercury Drive area from flooding. While the exact elevation of the existing dike is unknown, it is assumed that the current crest elevation of the dike is the same as the top of the dam elevation and would have to be increased to the proposed height of the dam. Raising the height of the existing dike and/or construction of additional dike may also require re-grading of Hill Street and Fox Hill Road or the construction of a closure device.

In addition, to meet the stability and integrity requirements of the NRCS design criteria, the auxiliary spillway would be armored using ACBs to provide erosion protection to underlying natural soils or structural embankments from the forces and stresses of flow. ACB systems are composed of a mattress of interconnected concrete block units, which are typically connected by geometric interlock, cables, or ropes. Geotextile fabric is provided beneath the ACB mattress to

[29] At the time of publication, the most current Consumer Price Index available was for November 2011.
[30] North American Vertical Datum 1988

provide a separation from sub-grade soil, preventing migration of sediment particles through the voids of the block. Due to its specific design, the system conforms to changes in the subgrade while maintaining the protective cover. The system can also be designed to allow for vegetation to be re-established and improve the visual appearance. The construction of an ACB system involves removal of existing vegetation and topsoil up to 8-inches below the existing grade.

Construction to increase the height of the dam with a parapet wall and create additional dikes would also create significant additional environmental and community impacts. Environmental impacts include permanent adverse impacts to wetlands and wildlife habitat as well as temporary impacts to water quality and migratory birds. Community impacts include primarily permanent adverse impact to recreation. Raising the height of the dam with a parapet wall is not considered a reasonable alternative because of the greater environmental impact and potential structural implications. The owner of the dam, the DCR, has objected to the use of a parapet wall due to the increased potential impacts to the physical environment, recreation, infrastructure. As such, this alternative is not considered feasible. The estimated cost to implement this alternative ($1,478,700,000) is approximately equal to the NED Alternative; however, due to the greater environmental and community impacts such as the need to construct additional dikes and regrade Hill Street and Fox Hill Road in addition to greater wetland, wildlife, and recreational impacts, this alternative was not found to be reasonable. Engineering Plans showing this alternative are provided in Appendix C-2 (Drawing A-2).

Raise the Earthen Embankment of the Dam

Under this alternative, the existing earthen embankment would be raised to elevation 551 feet NAVD88 to provide additional protection against overtopping during the PMP event. Unlike the previous alternative, raising the earthen embankment using earth material would involve impacting a large footprint to maintain the top width and side slopes of the existing dam. The embankment fill would be raised in a way that will provide integrity to the overall structure with respect to stability and seepage control. The resulting increase in reservoir level would create additional loads in the embankment fill structure and on adjacent outlet structures. An increase in storage capacity may change pore pressures and seepage patterns in the embankment and foundation. In addition, the existing outlet conduit would need to be extended beyond the proposed toe of the dam.

Similar to the alternative discussed above, due to increased maximum water pool elevation, this alternative may require additional dike construction to protect residences in the Hill Street/Mercury Drive area from flooding. While the exact elevation of the existing dike is unknown, it is assumed that the current crest elevation of the dike is the same as the top of the dam elevation and would have to be increased to the proposed height of the dam. Raising the height of the existing dike and/or construction of additional dike may also require re-grading of Hill Street and Fox Hill Road or the construction of a closure device.

The auxiliary spillway would require armoring to prevent stripping of vegetative cover and headcut erosion. As described above, armoring would be accomplished by means of ACBs.

Construction to increase the height of the dam would create significant additional environmental and community impacts. The estimated cost for this alternative is approximately $6,220,600. As such, this alternative is not considered to be an effective alternative and is therefore removed from further consideration. As such, this altnernative was not found to be reasonable. Engineering Plans showing this alternative are provided in Appendix C-2 (Drawing C-3).

Widen the Auxiliary Spillway to a Width of 600 Feet

This alternative involves increasing the width of the auxiliary spillway from 110 feet to 600 feet with a control section at elevation of 544.3 feet NAVD88 that would provide sufficient capacity to pass the FBH without overtopping the dam and its existing elevation of 547.3 feet NAVD88. The spillway would need to be extended to the west and require significant amount of excavation and tree removal. The existing underdrain, located along the center of the existing auxiliary spillway, would need to be relocated to accommodate the widening. This alternative, however, is not considered feasible as it would require relocation of several residences downstream of the dam to allow for proper tie-in of the spillway into the exit channel. Additionally, this alternative would require the "taking" of private land.

To meet the stability and integrity requirements of the NRCS dam safety and design standards, it is recommended to armor or reinforce the auxiliary spillway. Given the size of the widened spillway and exit channel, the spillway exit channel would be protected with reinforced/anchored vegetation.

Widening the auxiliary spillway would cause significant additional environmental and community impacts. This is not considered a reasonable alternative because of substantially higher cost of construction (approximately $11,028,704), greater environmental impact, and potential structural implications. As such, this alternative was not found to be reasonable. Engineering Plans showing this alternative are provided in Appendix C-2 (Drawing C-4).

DESCRIPTION OF ALTERNATIVE PLANS

The following alternatives were developed in detail and are evaluated in this Supplemental Watershed Plan and Environmental Evaluation.

Alternative 1 - Future Without Project (No Federal Action Alternative)

The Future Without Project Alternative or No Federal Action Alternative depicts the most probable future conditions to be realized in absence of any of the alternative plans studied. The DCR, the owner of the dam, and the agency under which the Commonwealth's dam regulations are implemented, has determined that it would rehabilitate the dam to meet current federal dam safety criteria without federal funds. The DCR may use other alternative rehabilitation methods or develop its own plan to bring the dam into compliance with federal safety criteria, but for the purposes of comparing this alternative to the NED Alternative, it is assumed that the DCR would implement the same plan as described in Alternative 2. This assumption was made because the recommended plan is the most cost-effective and least environmentally damaging of all plans considered. The total cost of this alternative is expected to be $1,479,500.

Alternative 2 – Rehabilitation (NED Alternative): Use of a Labyrinth Weir Design for the Auxiliary Spillway

A site layout of the rehabilitation alternative is provided in Appendix C-2 (Drawing C-5). In this Alternative, the Rawson Hill Brook Dam would be rehabilitated with federal funding assistance being provided by the NRCS. Rehabilitation of the dam would include a labyrinth weir design.

Inclusion of a labyrinth weir within the auxiliary spillway would protect against erosion and stabilize the structure by providing scour protection for the predicted velocity of 7 fps, which exceeds the allowable velocities for earthen spillways. Two different configurations of the labyrinth weir were evaluated to meet the NRCS's design criteria for freeboard. The optimal dimensions of the labyrinth weir for a 24-hr FBH include a weir thickness of 8-inches, 343 ft total length, and 63 feet width of labyrinth (AMEC 2011). Construction of the labyrinth weir requires the removal of the vegetation, rocks, clods, and other objects from the structure surface; excavation to the correct elevation; and installation of the labyrinth weir.

In addition to installing a labyrinth weir, the auxiliary spillway exit channel would be armored using ACBs to provide erosion protection to underlying natural soils or structural embankments from the forces and stresses of flow. ACB systems are composed of a mattress of interconnected concrete block units, which are typically connected by geometric interlock, cables, or ropes. Construction of an ACB type system requires the removal of the vegetation and organic topsoil layers (up to 8 inches), excavation to the subgrade elevation to enable installation of the bedding layer, installation of the drainage layer, placement of the ACBs which are typically fashioned into mats, and placement of infill materials. The drainage layer, which is an integral part of the system typically, consists of a geotextile designed to filter the embankment soils, and a crushed stone drainage media. Grading and placement of this layer is critical so as to enable the proper placement of the ACBs in intimate contact with the drainage layer. Should flow occur between the drainage layer and the ACB units, laboratory testing has shown that the blocks can lift and degrade the system. Due to its specific design, the system conforms to changes in the subgrade while maintaining the protective cover. The system can also be designed to allow for vegetation to be re-established and improve the visual appearance.

The limited disturbance required for installation, low frequency of use leading to reduced maintenance costs, overall cost savings, and the ability to cover the ACBs with a layer of sacrificial loam and seed to maintain the natural appearance of the area are significant benefits to using ACBs in this location. The spillway would be armored a total distance of 75 feet from the centerline of the dam to the approximate toe of the existing auxiliary spillway.

As a result of this alternative, it is expected that no compensatory mitigation will be required. In order to reduce the potential adverse effects on the environement during construction, sufficient erosion and sediment controls and other BMPs will be employed.

Upgrading the auxiliary spillway to incorporate the labyrinth weir appears to be the most feasible and cost effective alternative to address capacity deficiencies. Other options, while comparable

in cost, introduce other issues that would not be affected by the labyrinth weir alternative. The estimated total cost for this alternative is $1,479,500.

COMPARISON OF ALTERNATIVES

Table M summarizes and compares the two alternative plans. Refer to the NRCS-CPA-52 form provided in the Environmental Consequences section for additional information on the effects of each alternative.

Table M: Summary and Comparison of Candidate Plans

Effects	Alternative 1 Without Project	Alternative 2 (NED)
Measures	Incorporate labyrinth weir within the auxiliary spillway and armor auxiliary spillway exit channel	Incorporate labyrinth weir within the auxiliary spillway and armor auxiliary spillway exit channel
Project investment	$1,479,500	$1,479,500
National Economic Development Account[1/]		
Beneficial, annual	$174,800	$174,800
Adverse, annual	$174,800	$174,800
Net beneficial	$0	$0
Environmental Quality Account		
Air Quality	Minimal, temporary impact due to construction activity.	Minimal, temporary impact due to construction activity.
Cultural Resources	No impact. SHPO has confirmed that rehabilitation of the dam will not result in any impacts to cultural resources.	No impact. SHPO has confirmed that rehabilitation of the dam will not result in any impacts to cultural resources.
Environmental Justice	No impact. There are no Environmental Justice Zones in proximity to the dam.	No impact. There are no Environmental Justice Zones in proximity to the dam.
Fish and wildlife habitat	Continued availability of storage for fish and wildlife habitat; potential for loss of less than 1 acre of wildlife habitat; temporary disturbance near construction area (< 1 acre).	Continued availability of storage for fish and wildlife habitat; potential for loss of less than 1 acre of wildlife habitat; temporary disturbance near construction area (< 1 acre).
Forest resources	Minimal (< 1 acre), temporary clearing for construction access. Disturbed areas will be restored following construction.	Minimal (< 1 acre), temporary clearing for construction access. Disturbed areas will be restored following construction.

Table M: Summary and Comparison of Candidate Plans

Effects	Alternative 1 Without Project	Alternative 2 (NED)
Invasive species	Minimal impact (< 1 acre). The site contains limited areas of invasive species. Disturbed areas will be restored with native vegetation. BMPs will be utilized during construction to reduce the risk of spreading invasive species to or from the site.	Minimal impact (< 1 acre). The site contains limited areas of invasive species. Disturbed areas will be restored with native vegetation. BMPs will be utilized during construction to reduce the risk of spreading invasive species to or from the site.
Land use	No impact. The land use of the area will not change as a result of the dam rehabilitation.	No impact. The land use of the area will not change as a result of the dam rehabilitation.
Migratory birds	Minimal (< 1 acre), temporary impact due to construction activity.	Minimal (< 1 acre), temporary impact due to construction activity.
Natural resources	Minimal (< 1 acre), temporary effect from construction. Vegetated areas will be restored.	Minima. (< 1 acre)l, temporary effect from construction. Vegetated areas will be restored.
Prime and unique farmland soils	No effect.	No effect.
Riparian areas	Minimal (< 1 acre) temporary impact from construction.	Minima. (< 1 acre)l temporary impact from construction.
Scenic beauty	No impact. The viewshed is not impacted by the project.	No impact. The viewshed is not impacted by the project.
Sedimentation and erosion	Minimal (< 1 acre), temporary impact from construction. BMPs will be implemented during construction activities.	Minimal (< 1 acre), temporary impact from construction. BMPs will be implemented during construction activities.
Social issues	No impact. There are no socioeconomic or other social issues that would be affected as a result of rehabilitation of the dam.	No impact. There are no socioeconomic or other social issues that would be affected as a result of rehabilitation of the dam.
Soil resources	No impact. Soil resources in the vicinity of the dam will not be impacted as a result of rehabilitation.	No impact. Soil resources in the vicinity of the dam will not be impacted as a result of rehabilitation.

Table M: Summary and Comparison of Candidate Plans

Effects	Alternative 1 Without Project	Alternative 2 (NED)
Threatened and endangered species	No impact to federally or state protected habit or federally protected species.	No impact to federally or state protected habit or federally protected species.
Water quality	Minimal, temporary impacts from construction.	Minimal, temporary impacts from construction.
Water resources	Minimal, temporary impacts from construction.	Minimal, temporary impacts from construction.
Wetlands	Potential permanent and temporary impacts to wetlands of less than 1 acre; impacts will be avoided if possible and restored with native vegetation if affected by construction	Potential permanent and temporary impacts to wetlands of less than 1 acre; impacts will be avoided if possible and restored with native vegetation if affected by construction
Other Social Effects Account		
Dam safety	Reduced threat of dam failure	Reduced threat of dam failure
Human health and safety	Reduced threat to life from dam failure	Reduced threat to life from dam failure
Flood damages	Continued flood protection	Continued flood protection

[1/] Per sections 1.7.2(a)(4)(ii) and 2.1.1(b)(2) of the "Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies", U.S. Water Resources Council, March, 1983, allowing for abbreviated procedures, damage reduction benefits have not been estimated because they are the same for both alternatives, and no net change in benefits occurs when comparing the two candidate plans to each other. The federally assisted alternative (Alternative 2) is displayed within a zero-based accounting context that credits local costs avoided (adverse, annual) as adverse beneficial costs (beneficial, annual) consistent with P&G 1.7.2(b)(3). Net benefits are zero because the total project cost is equal to the claimed benefits and the resulting B/C ratio is 1.0:1.0.

ENVIRONMENTAL CONSEQUENCES

The proposed alternatives include construction of a labyrinth weir within the auxiliary spillway of Rawson Hill Brook Dam. Construction of the labyrinth weir requires the removal of the vegetation, rocks, clods, and other objects from the structure surface; excavation to the correct elevation; and installation of the labyrinth weir. A description of the effects that the proposed alternative will have on the natural and human environment is documented within the NRCS-CPA-52 Form (see pages 47 – 52).

CUMULATIVE IMPACTS

Construction of the Rawson Hill Brook Dam in 1963 had minor, long-term, direct effects on the environment through the excavation and filling of the structure. Rehabilitation of the dam under either alternative would occur within the area disturbed for construction of the existing structure and, therefore would have no cumulative impact on the environment other than the minor, temporary, construction-related impacts described above.

Since construction, the dam has indirectly affected the natural environment by temporary inundation of the floodplain upstream of the dam during rain events and by trapping sediment that would otherwise move downstream during rain events. The dam has also altered the hydrology of Rawson Hill Brook and the Assabet River by reducing downstream flows during storm events, and consequently protecting property and people in otherwise flood-prone areas. Rehabilitation of the dam under either alternative would not change the hydrology of Rawson Hill Brook or the Assabet River except for protecting the downstream area from catastrophic flooding that could occur if the dam were to fail. There would be no long-term, cumulative effects from the rehabilitation project.

Future actions in the watershed not related to this project include continued changes to upstream and downstream land use as a result of residential, industrial, and commercial development. Rehabilitation of the Rawson Hill Brook Dam would not affect future development, but it would allow the dam to safely pass storm flows under build-out conditions.

CONTROVERSY

There are no known areas of controversy.

RISK AND UNCERTAINTY

The areas of risk and uncertainty associated with this project lie in the accuracy of predicting flood flows and flood elevations, estimating costs associated with each alternative, estimating property values and damage costs and benefits. The uncertainty of flood flows and water surface elevations has the potential for increased damages as development of residential and commercial property alters land use. It is possible that these uncertainties could lead to increased risk to human life in the event of a dam breach regardless of rehabilitation or no federal action. Hydrologic methods and computer modeling used in this analysis are consistent with the standards of practice at this time. The potential impacts for each alternative are estimated using

techniques that relate potential damage to lost opportunity. However, these methods are in part based on professional judgment, and actual experiences could be different.

Uncertainties with the analysis of environmental impacts lie with the identification of wetland areas and the risk of invasive species colonizing areas of revegetation. Trained wetland specialists identified wetland areas using standard, well-accepted protocols. The sponsors will be responsible for verifying wetlands and consulting with DEP as required before construction. Native species will be used for planting to minimize introduction of invasive species, but introduction could occur from adjacent areas.

Within the context of this study, all alternatives were considered on a comparable basis. There does not appear to be any area that would have resulted in a different decision by using different procedures or conducting more intensive studies.

CONSULTATION AND PUBLIC PARTICIPATION

PROJECT SPONSORS

Local sponsoring organizations of the SuAsCo watershed plan and Supplement No. 8 are the Worcester County Conservation District, the Middlesex Conservation District, the DCR, and the DFW.

PLANNING TEAM

An interdisciplinary planning team provided for the administration of this project through the NRCS nine-step planning process according to the procedures in the NRCS National Planning Procedures Handbook (NRCS 2003). Some of the tasks undertaken by the planning team include preliminary investigations, hydrologic and engineering analysis, economic analysis, formulation and evaluation of alternatives, and preparation of the Supplemental Watershed Plan and Environmental Evaluation. The planning team included representatives of the NRCS Massachusetts state office, the NRCS National Water Management Center, the DCR, and technical consultants under contract to the NRCS.

PUBLIC PARTICIPATION

A public meeting was held in the Town of Berlin on May 24, 2011, to explain the Watershed Rehabilitation Program, obtain public input on the project, and scope resource problems, issues, and concerns of local residents associated with the Rawson Hill Brook Dam project area. The meetings were widely advertised to reach all residents in all demographic groups in the watershed. The NRCS distributed a press release on May 6, 2011, that resulted in an article about the meeting in the Metro West Daily News on May 25, 2011.

Potential alternative solutions to bring the Rawson Hill Brook Dam into compliance with current dam safety criteria were presented at the public meeting. A fact sheet summarizing the planned rehabilitation projects at six dams in the SuAsCo watershed was distributed at the meeting. Two members of the public attended the meeting. No verbal or written comments have been received in the intervening time to the publishing of this Plan.

AGENCY CONSULTATION

As previously discussed, a review of the FWS's Federally Listed Endangered and Threatened Species in Massachusetts (FWS 2009) indicates that there are no federally-listed threatened or endangered species located in proximity to the site. As such, a "no species present" letter (Appendix E-2) was acquired from the FWS. Additionally, the NHESP has confirmed that there is no habitat for any state-listed rare species in the vicinity of the site.

Consultations with SHPO and the THPO of the Wampanoag Tribe of Gay Head (Aquinnah) were conducted to determine the presence of any cultural or historic resources within the proposed project area. In a letter dated November 17, 2011, the SHPO indicated that no historic resources would be impacted as a result of the proposed project (see Appendix E-2).

Coordination with THPO is currently ongoing. As such, any correspondence received from THPO will be addressed in subsequent drafts of this plan.

During the scoping section, the Massachusetts Department of Fish and Game requested consideration of providing fish passage. However, since the dam does not contain a permanent pool behind the dam, the inclusion of fish passage design as part of the dam rehabilitation is not applicable.

PROVISIONS OF THE PREFERRED ALTERNATIVE

PREFERRED ALTERNATIVE

Alternative 2, rehabilitation of the Rawson Hill Brook Dam with PL 83-566 funding, is the preferred alternative. The auxiliary spillway would be modified to meet current safety criteria for a high hazard dam and maintain the service life and flood prevention purpose of the dam for the remaining 52 years of the original 100-year planning period. The rehabilitation will consist of incorporating a labyrinth weir within the auxiliary spillway and armoring the downstream spillway with ACBs to safely pass the SDH and FBH storm discharge flows. Estimated construction cost is $1,020,900 and total installation cost, including engineering and administration is $1,479,500.

The risk of dam failure will be greatly reduced by the installation of a labyrinth weir within the auxiliary spillway and armoring the downstream auxiliary spillway with ACBs. Although other potential modes of dam failure (e.g. sedimentation, seepage, seismic, and embankment slope failure) are considered to be low or minimal, a failure of the dam would endanger any development in the breach inundation zone. Based on existing land-use and development within the breach inundation zone, 1,205 residences, 164 non-residential properties, 19 major roads, 1 school, and 8 bridges, plus utilitiesdownstream would be affected (Refer to the Breach Inundation Maps in Appendix C-3).

Table N compares structural data from the original as-built structure, the existing structure, and the planned rehabilitation.

Table N: Comparison of Structural Data

Rawson Hill Brook Floodwater Retarding Dam	Unit	As Built	Existing Conditions	Planned
Drainage Area	acres	954	1,018	1,018
Elevation, top of dam (effective)	feet	547.3	547.3	547.3
Length of dam	feet	252	252	252
Principal spillway	type	Reinforced concrete riser	Reinforced concrete riser	Reinforced concrete riser
Elevation, principal spillway riser crest	feet	541.8	541.8	541.8
Elevation, principal spillway low stage	feet	533.05	533.05	533.05
Pipe diameter, principal spillway	inches	30	30	30
Auxiliary spillway	type	grass-lined channel	grass-lined channel	labyrinth weir and ACB armored exit channel
Elevation, auxiliary spillway crest	feet	544.3	544.3	544.3
Bottom width, auxiliary spillway	feet	110	110	110
Storage, permanent pool	acre-feet	0	0	0
Storage, floodwater retarding pool	acre-feet	260.6	260.6	260.6
Storage, maximum pool	acre-feet	481	481	481

RATIONALE FOR ALTERNATIVE PREFERENCE

Alternative plans were formulated as required by NRCS policy, Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (P&G) (U.S. Water Resources Council 1983) and the National Environmental Policy Act[31] (NEPA). According to P&G, an alternative that reasonably maximizes net national economic development benefits is to be formulated. This alternative (Alternative 2) is to be identified as the NED Plan.

Alternative plans were formulated in consideration of the purposes of the project and concerns expressed during the public scoping process. Formulation of the alternative plans gave consideration to four criteria: completeness, effectiveness, efficiency, and acceptability. Alternatives 1 and 2 are the same project, with the only difference being the use of federal funds for a portion of the project costs, and both alternatives meet all four of these criteria. Both alternatives maintain the present level of flood control benefits and comply with current performance and safety criteria. Both alternatives produce the same monetary benefits, but the net average annual equivalent benefits between the Future with Federal Project (NED Alternative) and the Future without Federal Project (No Federal Action Alternative) is $0.

PERMITS, COMPLIANCE AND REQUIREMENTS PRIOR TO CONSTRUCTION

Potential Permits Needed

Specific permitting needs will be determined during the final design of the dam rehabilitation. The DCR is responsible for obtaining all permits. Federal and state permitting and consultation requirements that are likely to be required are summarized in Table O.

Table O: Summary of Federal and State Permit and Consultation Requirements

Permit/Consultation	Regulatory Authority	Status
NPDES General Permit for Construction	EPA	(Not yet acquired)
Section 404 CWA General Permit	Conservation Commission	(Not yet acquired)
Section 7 Endangered Species Act consultation	USFWS	Completed
Section 106 NHPA consultation	SHPO/THPO	SHPO Completed THPO In Progress
Chapter 91 Waterways License	DEP	(Not yet acquired)
Chapter 253 Permit to Construct or Alter a Dam	DEP	(Not yet acquired)
Massachusetts WPA Order of Conditions	DEP	(Not yet acquired)
Section 401 Water Quality Certificate	DEP	(Not yet acquired)
Massachusetts Endangered Species Act consultation	NHESP	Completed

[31] 42 U.S.C. § *et seq*.

Compliance with Local, State, and Federal Laws

The sponsors will comply with all applicable local, state, and federal laws in the installation of this project. Under the conditions of the NPDES general permit for construction, the sponsors or their contractor will prepare a stormwater pollution and prevention plan (SWPPP), including an erosion and sediment control plan. In the event that cultural resources are discovered during project installation, construction will be halted in that area, and the resources will be evaluated in accordance with NRCS General Manual 420 part 401.

Mitigation

It is expected that most construction activities would be confined to existing disturbed and cleared areas. No permanent impacts to wetlands are expected, so no compensatory wetlands mitigation would be required. Removal of wetland vegetation may be required for temporary construction activities; these disturbed areas would be re-graded to pre-construction contours and re-planted with native wetland vegetation. The sponsors would be responsible for preparing an approved sediment and erosion control plan to minimize erosion of disturbed soils and sediment runoff into Rawson Hill Brook. The sponsors would also be responsible for ensuring that the sediment and erosion control plan is implemented and maintained during construction and that the site is stabilized after construction. After construction, all temporarily disturbed areas will be re-graded to pre-construction contours and reseeded with native species as per NRCS Critical Area Seeding Standard 342. Any seeding will be completed with a native seedmix free from invasive species. BMPs will be implemented during construction and reseeding to reduce the potential of invasive species spreading.

During the scopting session, the Massachusetts Department of Fish and Game requested that fish passage be considered as part of the dam rehabilitation. As previously discussed, fish passage at the dam is not feasible since the dam does not contain a permanent pool.

Operation, Maintenance, and Replacement

The project will be operated and maintained by the owner. A new Operation and Maintenance (O&M) Agreement will be developed by both the DCR and NRCS for the remaining 52-year project life of the structure and signed by both parties before the Project Agreement is signed. O&M activities include but are not limited to inspection, maintenance, and repair of the principal spillway, dam, vegetation, and the auxiliary spillway. Based on data from the DCR, it is estimated that O&M activities and replacement costs will total about $4,200 per year.
The new O&M Agreement will be based on the National Operation and Maintenance Manual. Although the sponsors' responsibility to the Federal Government for O&M ends when the O&M agreement expires upon completion of the evaluated life of measures covered by the agreement, the sponsors acknowledge that continued liabilities and responsibilities associated with works of improvement may exist beyond the evaluated life.

Emergency Action Plan

Emergency Action Plan: At the time the dam was constructed in 1963, an Emergency Action Plan (EAP) was not required because originally the dam was classified as a significant hazard structure (NRCS) and a Class II (Significant) hazard structure (State). However, development in the area and downstream hazards has reclassified the dam as a high hazard dam, "where failure may cause loss of life or serious damage to homes, industrial and commercial buildings, important public utilities, main highways, or railroads" (NRCS) and as a Class I (High) hazard structure and an Intermediate size structure (State).

As such, under the DCR dam safety regulations as well as to secure funding from the USDA NRCS for the rehabilitation of the dam, an EAP will need to be developed prior to construction of the proposed rehabilitation measures.

The DCR will provide leadership in developing an EAP prior to construction and will update the EAP annually with the assistance from the local emergency response officials. The EAP shall meet the minimum content specified in the NRCS Title 180, National Operation and Maintenance Manual (NOMM), Part 500, Subpart F, Section 500.52, and meet applicable State agency dam safety requirements. NRCS will provide technical assistance in preparation and updating the EAP. The NRCS State Conservationist will determine that an EAP is prepared prior to the execution of fund obligating docments for construction of the structure.

Project Agreement

The DCR and NRCS will enter into a Project Agreement in accordance with the NRCS National Contract Grants and Agreement Manual before any work is initiated by either the owner or the NRCS.

COST, INSTALLATION AND FINANCING

The construction associated with the project will be financed jointly by the DCR and the NRCS. Financial and other assistance by NRCS and DCR is contingent on the continuing availability by Congress and state legislature. The DCR will need to file legislation for funds specifically for this project. The NRCS will use funds appropriated for this purpose. The eligible project costs including construction, engineering, and project administration to be paid by the DCR and NRCS are as follows:

	DCR	NRCS	Estimated Total Cost
Rehabilitation of Rawson Hill Brook Dam	$494,300	$985,200	$1,479,500

The NRCS cost share shall be 65 percent of the total eligible project cost, not to exceed 100 percent of the actual construction costs. An amount up to the percentage rate specified may be satisfied by the DCR through the cost of engineering and construction. Real property acquisition could also be used as a portion of the DCR's cost-share, but is not expected to be required for this project since the preferred alternative is to be installed entirely on DCR property. The

decision on specific DCR-funded components will be negotiated between the DCR and the NRCS and will be included in the Project Agreement executed before implementation. Construction and engineering costs are eligible for project cost sharing; however, permits are not eligible for cost sharing.

The NRCS is responsible for the engineering services and project administration costs it incurs. These costs are not used in the calculation of the federal cost share, but they are included in the Estimated Installation Cost (Table 1). Also, costs of federal, state, and local permits are the responsibility of DCR and are not counted toward the local cost share. See Table 2 below for a complete description of the total rehabilitation costs.

In the past, installation of PL-566 works of improvement was accomplished using local contracting methods. The DCR has requested that federal contracting procedures be used to install rehabilitation program measures. The Rawson Hill Brook Dam preferred alternative will be installed using federal contracting procedures.

The furnishing of financial and other assistance by the NRCS is contingent on the continuing availability of appropriations by Congress from which payment may be made and shall not obligate the NRCS if Congress fails to so appropriate.

ECONOMIC AND STRUCTURAL TABLES

Table 1: Estimated Installation Cost
Rawson Hill Brook Dam
SuAsCo Watershed, Massachusetts
(Dollars)[1/]

Installation Cost Item	Estimated Cost[2/]		
	PL 83-566 Funds	Other Funds	Total
Structural measures to rehabilitate Rawson Hill Brook Dam	$998,008	$500,726	$1,498,734
Total Project	**$998,008**	**$500,726**	**$1,498,734**

[1/] Price base: 2012 May 2012

[2/] PL 83-566 Funds include NRCS Engineering and Project Administration ($301,976), and "Other Funds" include sponsors' Permitting ($125,916), neither of which are included when calculating eligible federal cost share. Therefore, federal cost share is based on Total Eligible Project Cost of $1, 070,842.

Table 2: Estimated Cost Distribution – Structural and Nonstructural Measures
Rawson Hill Brook Dam
SuAsCo Watershed, Massachusetts
(Dollars) [1/]

	Installation Cost – PL 83-566 Funds [2/]				**Installation Cost – Other Funds**				**Total Installation Cost**
	Construction	Engineering	Project Administration	Total PL 83-566	Construction	Permitting	Project Administration	Total Other	
Structural measures: Rawson Hill Brook Dam	$696,032	$233,801	$68,175	$998,008	$338,139	$125,916	$36,671	$500,726	$1,498,734
Nonstructural measures	$0	$0	$0	$0	$0	$0	$0	$0	$0
Grand total	**$696,032**	**$233,801**	**$68,175**	**$ 998,008**	**$338,139**	**$125,916**	**$36,671**	**$ 500,726**	**$1,498,734**

[1/] Price base: 2012 May 2012

[2/] Federal Engineering and Project Administration costs and sponsors' Permitting costs ($427,892) are not included when calculating eligible federal cost share. Therefore, federal cost share is based on Total Eligible Project Cost of $1,070,842.

Table 3: Structural Data – Dams with Planned Storage Capacity
Rawson Hill Brook Dam
SuAsCo Watershed, Massachusetts

Item	Unit	Rawson Hill Brook Dam
Class of structure		High Hazard
Seismic zone		2
Total drainage area	mi^2	1.59
Runoff curve number (1-day) (AMC II[1/])		73 existing development 81 future build-out
Time of concentration (T_c)	hr	3.50
Elevation top of dam	ft	547.3
Elevation crest of auxiliary spillway	ft	544.3
Elevation high stage weir	ft	541.8
Elevation low stage orifice	ft	533.05
Maximum height of dam	ft	16.0
Total capacity (auxiliary spillway crest)		
Sediment pool	ac-ft	3.2
Aerated sediment	ac-ft	0
Flood	ac-ft	260.6
Surface area		
Sediment pool	acre	3
Floodwater retarding pool	acre	53
Principal spillway		
Rainfall volume (10-day)[2/]	in	13.0
Runoff volume (1-day)	in	3.75
Runoff volume (10-day)	in	7.5
Type (standard drop inlet)		reinforced concrete
Diameter	in	30
Auxiliary spillway		
Type		Labyrinth Weir w/ concrete ACB protection
Bottom width	ft	110
Exit slope	%	6
Frequency of operation[3/]	% chance	more than 1
Auxiliary spillway hydrograph[4/]		
Rainfall volume	in	10.61
Storm duration	hr	6
Freeboard hydrograph[5/]		
Rainfall volume	in	25
Storm duration	hr	6

[1/] Antecedent Moisture Content
[2/] Based on Northeast Regional Climate Center Precipitation Tables
[3/] Frequency of use is based on the 100-year 24-hour duration, Type II distribution storm event from the Northeast Region Climate Center's Extreme Precipitation in New York and New England.
[4/] SDH is based on the 6-hr storm
[5/] FBH is based on the most critical condition form the 6-hr and 24-hr storms

Table 4: Estimated Average Annual NED Costs
Rawson Hill Brook Dam
SuAsCo Watershed, Massachusetts
(Dollars)[1/]

Evaluation Unit	Project Outlays		Total
	Amortization of Installation Cost [2/]	Operation, Maintenance and Replacement Cost	
Rawson Hill Brook Dam	$159,548	$17,525	$177,073
Grand Total	**$159,548**	**$17,525**	**$177,073**

[1/] Price base 2012 May 2012
[2/] Amortized over 53 years at 4.0%

Table 5: Estimated Average Annual Flood Damage Reduction Benefits
Rawson Hill Brook Dam
SuAsCo Watershed, Massachusetts
(Dollars)[1/]

Item	Estimated Average Annual Damage		Damage Reduction Benefit[3/]
	Without Project[2/]	With Project[2/]	
Floodwater			
Crop and Pasture	$0	$0	$0
Other Agricultural	$0	$0	$0
Nonagricultural (Road and Bridge)	$1,317	$1,317	$0
Nonagricultural (Urban)	$132,298	$132,298	$0
Subtotal	$133,615	$133,615	$0
Grand Total	**$133,615**	**$133,615**	**$0**

[1/] Price Base: 2012 May 2012
[2/] Original downstream damages updated using applicable indices and updated data.
[3/] Damage reduction benefits resulting from the recommended plan equal zero as compared to the No Federal Action (future without project) Alternative because they are the same in scope, cost, and effects, and therefore yield equivalent benefits. Positive benefits will accrue as a result of this project as compared to existing conditions, but no attempt was made to compute an estimate of the difference between the future with project and existing conditions because the existing conditions are not the most likely future conditions. The added details would not alter the recommended alternative and, therefore, would not justify the added planning costs. Sections 1.7.2(a)(4)(ii) and 2.1.1(b)(2) of the P&G allow for the abbreviated procedures.

Table 6: Comparison of NED Benefits and Costs
Rawson Hill Brook Dam
SuAsCo Watershed, Massachusetts
(Dollars)[1/]

Evaluation Unit	Benefits			Average Annual Costs[3/]	Benefit/Cost Ratio
	Average Annual Benefits		Average Annual Benefits		
	Agriculture-related[2/]	Nonagricultural[3/]			
Rawson Hill Brook Dam	$0	$ 177	073	$ 177	1.0:1.0
Total	**$0**	**$ 177,073**	**$177,073**	**$177,073**	**1.0:1.0**

[1/] Price Base: 2012 May 2012

[2/] From Table 5

[3/] From Table 4. The costs and the benefits for the future with project plan are the same as those for the future without project plan. To maintain consistency with the display in Table 4, the costs associated with the No Federal Action Alternative (Future Without Project) are tracked as a benefit of the preferred alternative. Per sections 1.7.2(a)(4)(ii) and 2.1.1(b)(2) of the P&G allowing for abbreviated procedures, damage reduction benefits have not been estimated because they are the same for both alternatives, and no net change in benefits occurs when comparing the two candidate plans to each other. The federally assisted alternative is displayed within a zero-based accounting context that credits local costs avoided as "other" benefits consistent with P&G 1.7.2(b)(3). Net benefits are zero because the total project cost is equal to the claimed benefits and the resulting B/C ratio is 1.0:1.0.

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ENVIRONMENTAL EVALUATION

Under NRCS regulations for implementing NEPA, the proposed action qualifies as a categorical exclusion (7 CFR 650.6(15)):

Exclusion No. 15 - Repairing or improving (deepening/widening/armoring) existing auxiliary/emergency spillways associated with dams, originally constructed to NRCS standards, in order to meet current safety standards. Work will be confined to the dam or abutment areas, and no major change in reservoir or downstream operation will result.

FINDINGS

I have considered the effects of this proposed action on resource, economic, and social considerations; special environmental concerns; and extraordinary circumstances criteria in the instructions for form NRCS-CPA-52. I find, for the reasons stated below, that the selected alternative is categorically excluded from further environmental analysis and there are no extraordinary circumstances. No additional environmental analysis is required.

_____	State Conservationist	_____
Signature	Title	Date

RATIONALE

The recommended action will protect human health and safety and the infrastructure and transportation system in the watershed by extending the life of the dam and bringing the structure up to current performance and safety standards. Existing flood control benefits will be maintained. The primary beneficiaries of the project are residential, industrial, and commercial property owners in the floodplain of the Assabet River; the Towns of Northborough, Shrewsbury, and Boylston; and the Commonwealth of Massachusetts.

The proposed action will not permanently affect wetlands. Construction may temporarily disturb less than one acre of wetlands, but disturbed areas will be restored if they cannot be avoided.

There are no historic properties in the project area, which was previously disturbed for construction of the dam. The SHPO has concurred with a determination of no effect on historic resources.

No federally protected threatened or endangered species or state-listed rare species will be affected by the project.

No impacts to floodplains, land use, prime farmland, park lands, wild and scenic rivers, or ecologically critical areas will result from the recommended action. Fish and wildlife habitats may be temporarily disturbed during construction, but will not be permanently affected by the project. Water quality and air quality may be temporarily affected by construction, but will not be permanently affected by the project. Best management practices will be employed to

minimize soil erosion and stream sedimentation, and all disturbed areas will be restored and revegetated with native species after construction.

No significant adverse environmental impacts will result from the proposed action, and there are no extraordinary circumstances.

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APPENDIX A

COMMENTS AND RESPONSES

There were no comments or responses received as a result of the published public notices and/or meetings.

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APPENDIX B

PROJECT MAP

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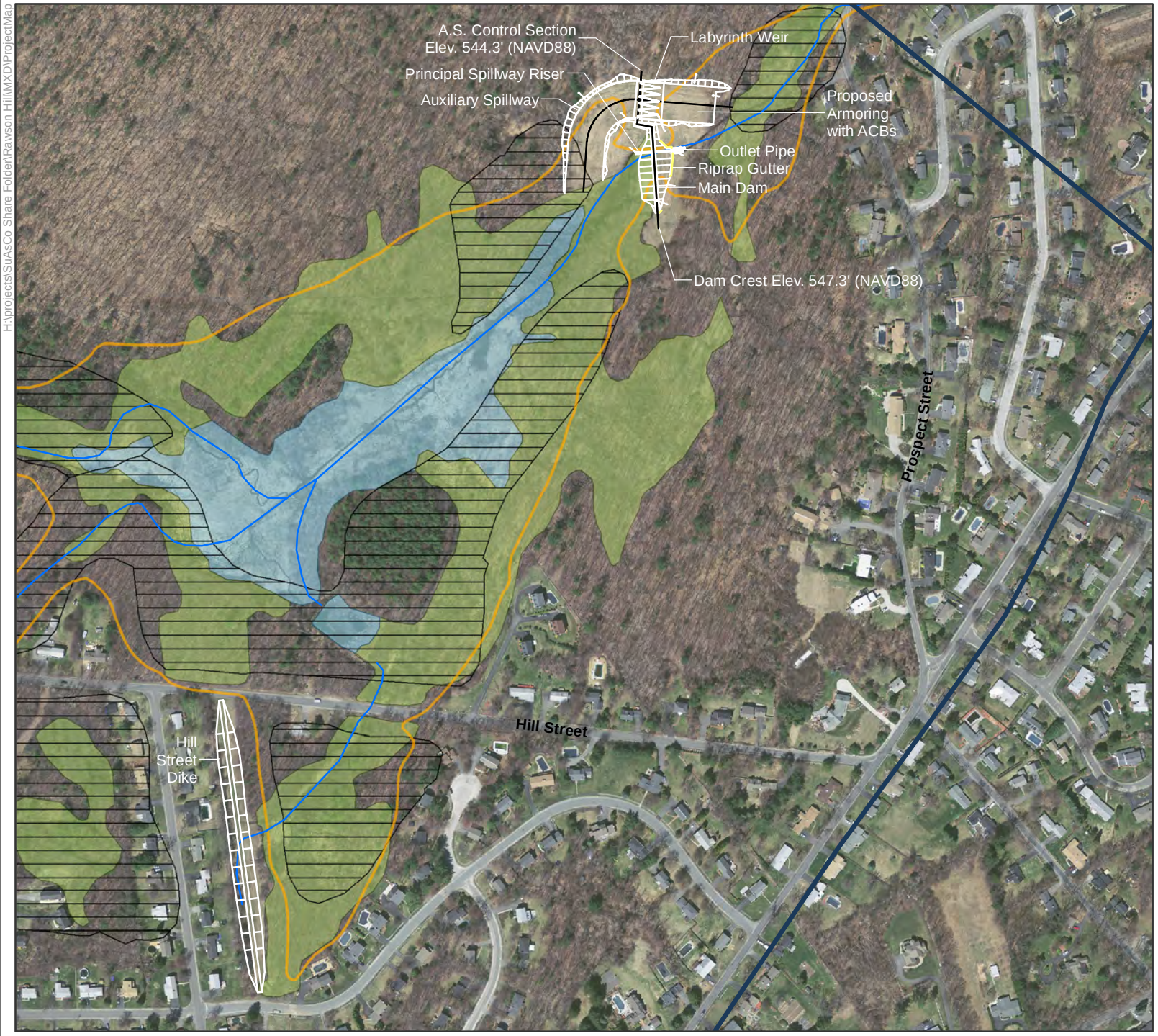
H:\projects\SuAsCo Share Folder\Rawson Hill\MXD\ProjectMap



SuAsCo: Rawson Hill Brook Dam

Project Map

Legend

- Stream
- 100yr Floodplain
- Rawson Hill Brook Dam Watershed

DEP Wetlands

- Marsh/Bog
- Wooded marsh

NWI Wetlands

- Freshwater Forested/Shrub Wetland

N

0 100 200 400

Feet

NRCS Natural Resources Conservation Service

Sources: AMEC, 2011; esri, 2006; USFWS, 2010; Office of Geographic Information (MassGIS), Commonwealth of Massachusetts Information Technology Division, U.S. Geological Survey (USGS), National Geospatial-Intelligence Agency (NGA) and Fugro Earthdata, Inc., 2009

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APPENDIX C

SUPPORT MAPS

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Appendix C-1

Report Maps

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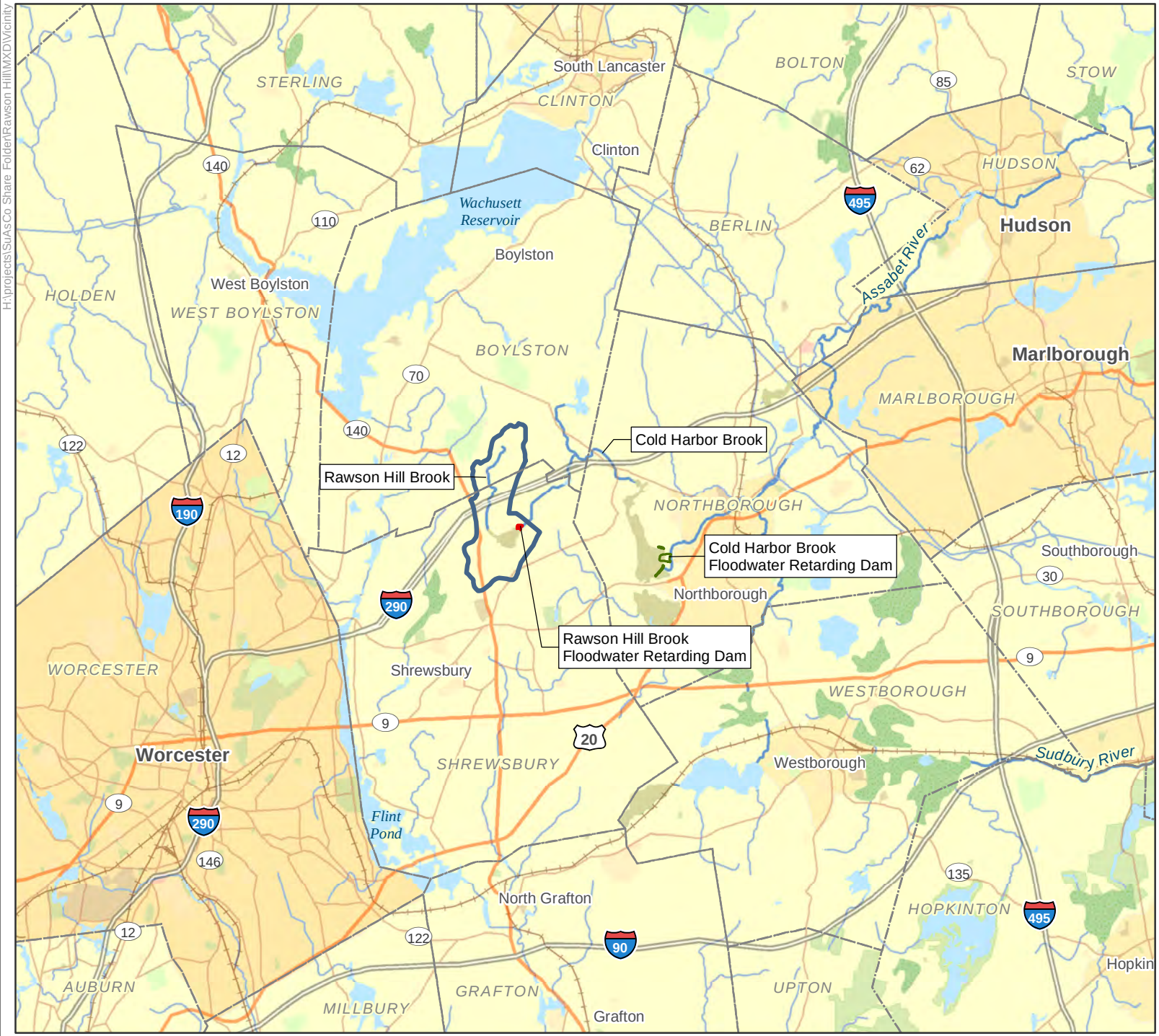
SuAsCo: Rawson Hill Brook Dam

Figure 1. Location Map



Legend

- Cold Harbor Brook Dam
- Rawson Hill Brook Dam
- Rawson Hill Brook Dam Watershed
- Town Boundaries

0 0.5 1 2

Miles

Sources: AMEC, 2011; esri, 2006

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H:\projects\SuAsCo Share Folder\Rawson Hill\MXD\CAD

SuAsCo: Rawson Hill Brook Dam

Figure 2. Existing Conditions

Legend

- Crest Centerline
- Rawson Hill Brook Dam Watershed

0 200 400 800

Feet

NRCS Natural Resources Conservation Service

Sources: AMEC, 2011; esri, 2006; U.S. Geological Survey (USGS), National Geospatial-Intelligence Agency (NGA) and Fugro Earthdata, Inc., 2009

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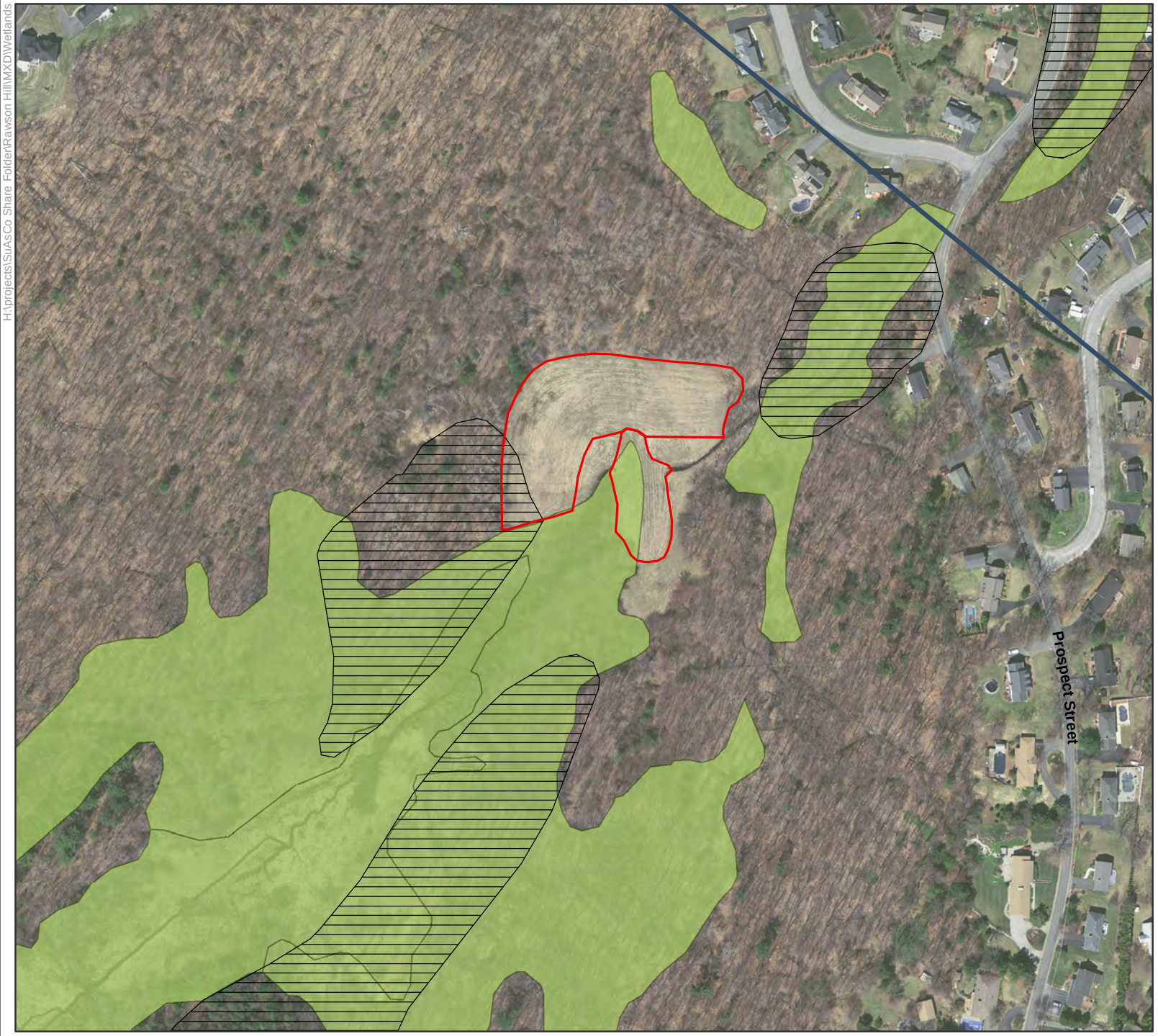
H:\projects\SuAsCo Share Folder\Rawson Hill\MXD\Wetlands

SuAsCo: Rawson Hill Brook Dam

Figure 3. DEP and NWI Wetlands



Legend

- Rawson Hill Brook Dam
- Rawson Hill Brook Dam Watershed
- DEP Wetlands
- NWI Wetlands

N

0 100 200 400

Feet

NRCS
Natural Resources Conservation Service

Sources: AMEC, 2011; esri, 2006; USFWS, 2010; Office of Geographic Information (MassGIS), Commonwealth of Massachusetts Information Technology Division, U.S. Geological Survey (USGS), National Geospatial-Intelligence Agency (NGA) and Fugro Earthdata, Inc., 2009

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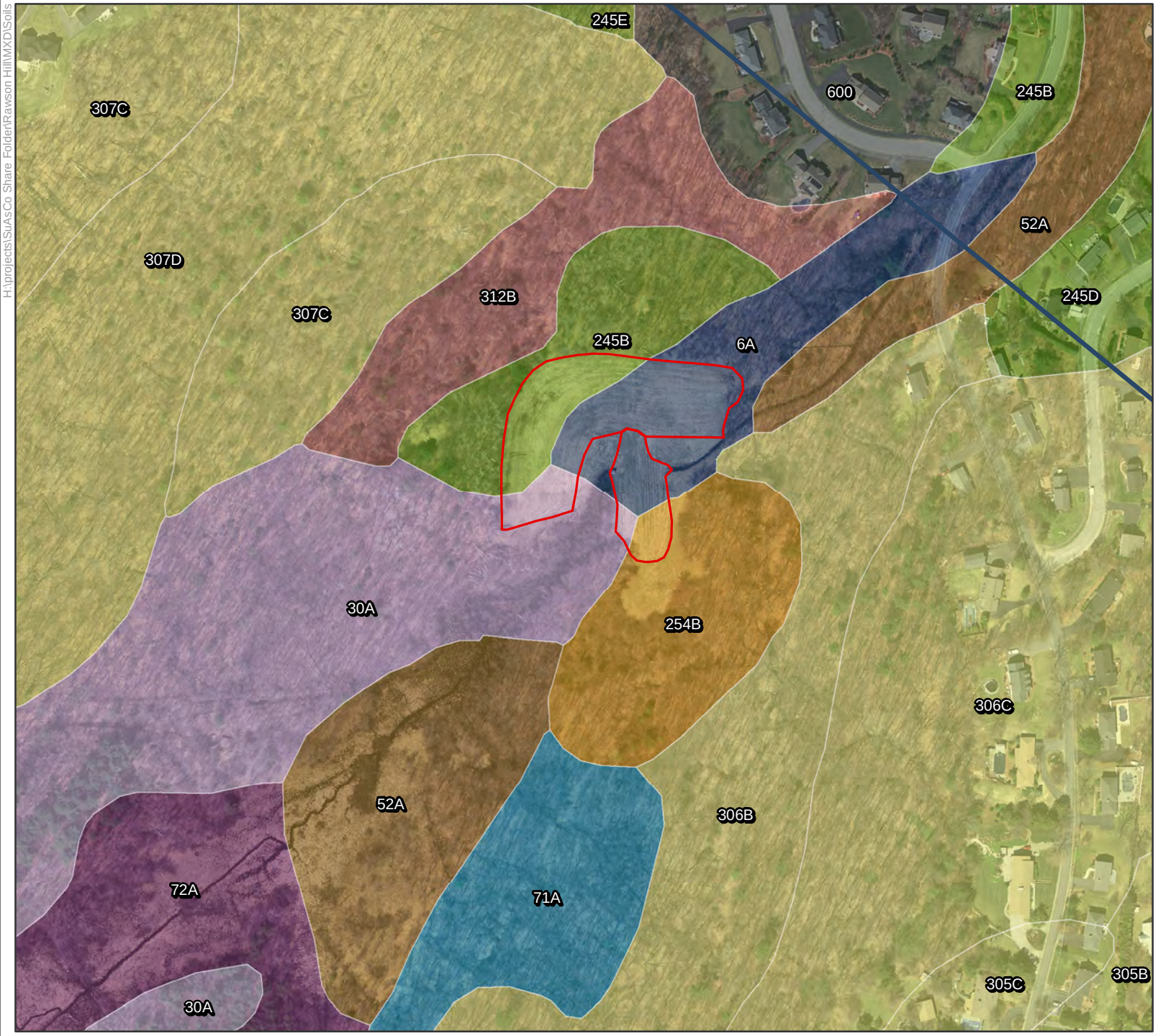
H:\projects\SuAsCo Share Folder\Rawson Hill\MXD\Soils



SuAsCo: Rawson Hill Brook Dam

Figure 4. Soils Map

Legend

- Rawson Hill Brook Dam
- Rawson Hill Brook Dam Watershed

Soils

- Freetown muck (52A)
- Hinckley sandy loam (245B, 245D, 245E)
- Merrimac fine sandy loam (254B)
- Paxton fine sandy loam (305B, 305C, 306B, 306C, 307C, 307D)
- Pits, gravel (600)
- Raynham silt loam (30A)
- Ridgebury fine sandy loam (71A)
- Scarboro mucky fine sandy loam (6A)
- Whitman loam (72A)
- Woodbridge fine sandy loam (312B)

N

0 100 200 400

Feet

NRCS Natural Resources Conservation Service

Sources: AMEC, 2011; esri, 2006; Office of Geographic Information (MassGIS), Commonwealth of Massachusetts Information Technology Division, U.S. Geological Survey (USGS), National Geospatial-Intelligence Agency (NGA) and Fugro Earthdata, Inc., 2009

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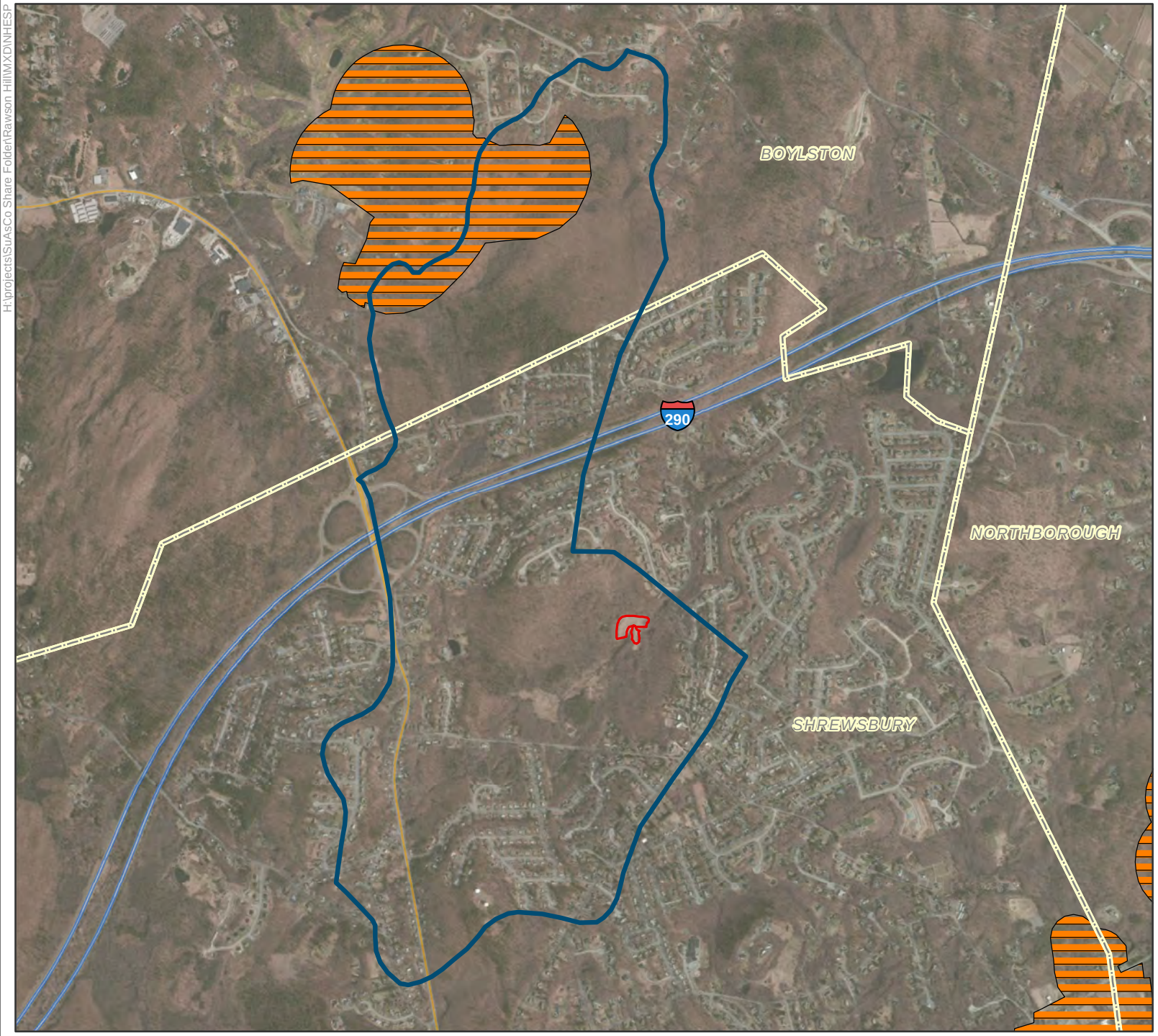
H:\projects\SuAsCo Share Folder\Rawson Hill\MXD\NHESP

SuAsCo: Rawson Hill Brook Dam

Figure 5. NHESP Habitats of Rare Species



Legend

- NHESP Estimated Habitats of Rare Wildlife
- Rawson Hill Brook Dam
- Rawson Hill Brook Dam Watershed
- Town Boundaries

N

0 1,000 2,000

Feet

NRCS Natural Resources Conservation Service

Sources: AMEC, 2011; esri, 2006; Microsoft (Bing Maps), 2010; Office of Geographic Information (MassGIS), Commonwealth of Massachusetts Information Technology Division; U.S. Census Bureau, 2010

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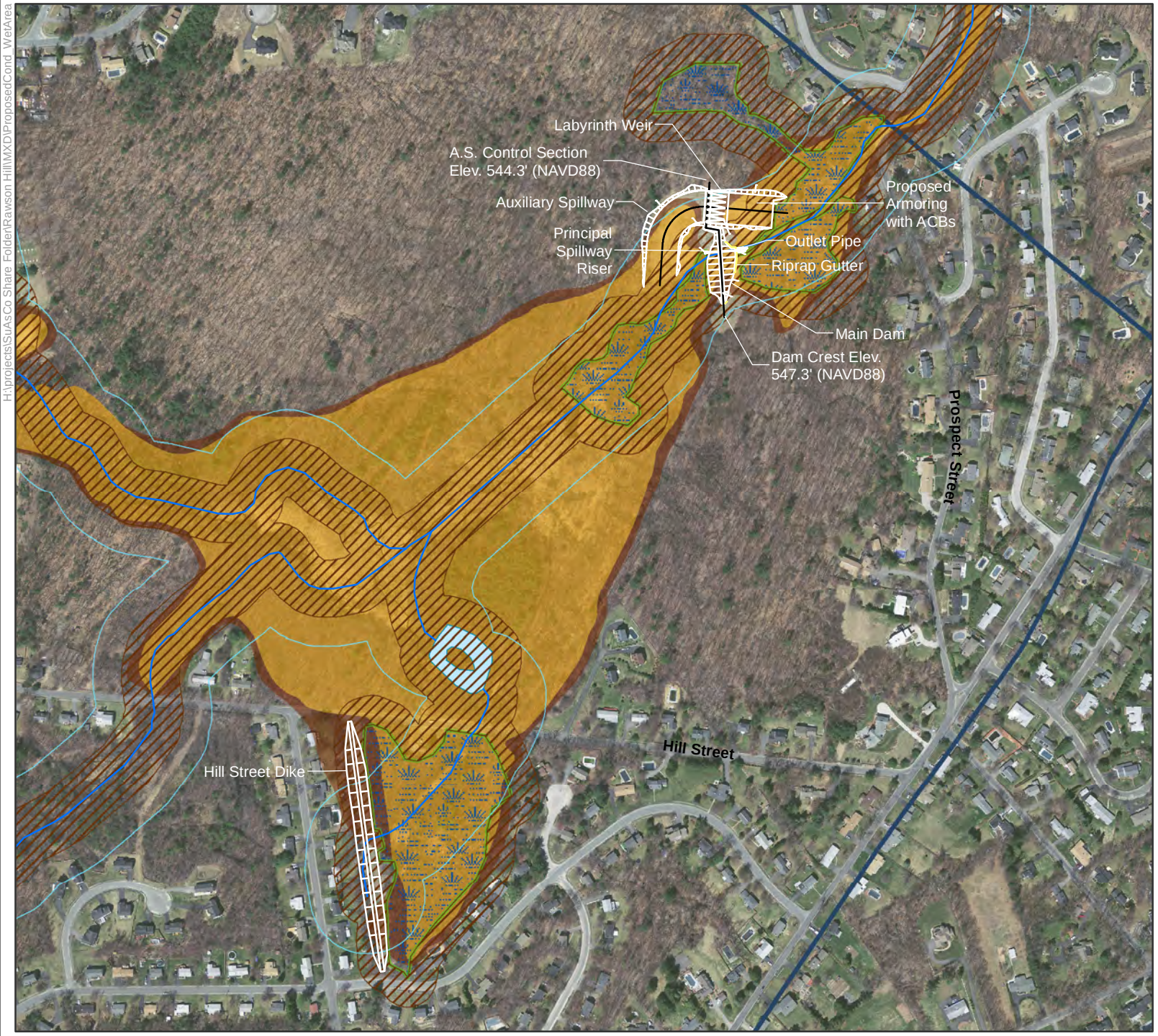
H:\projects\SuAsCo Share Folder\Rawson Hill\MXD\ProposedCond_WetArea

SuAsCo: Rawson Hill Brook Dam

Figure 6. Field-Assessed Wetlands



Legend

- Crest Centerline
- Perennial Streams
- 100yr Floodplain
- 500yr Floodplain
- Banks
- Buffer Zone
- Field-Assessed Wetlands
- Rawson Hill Brook Dam Watershed
- Riverfront Area

N

0 200 400 800

Feet

NRCS Natural Resources Conservation Service

Sources: AMEC, 2011; esri, 2006; FEMA, 1997; Office of Geographic Information (MassGIS), Commonwealth of Massachusetts Information Technology Division, U.S. Geological Survey (USGS), National Geospatial-Intelligence Agency (NGA) and Fugro Earthdata, Inc., 2009

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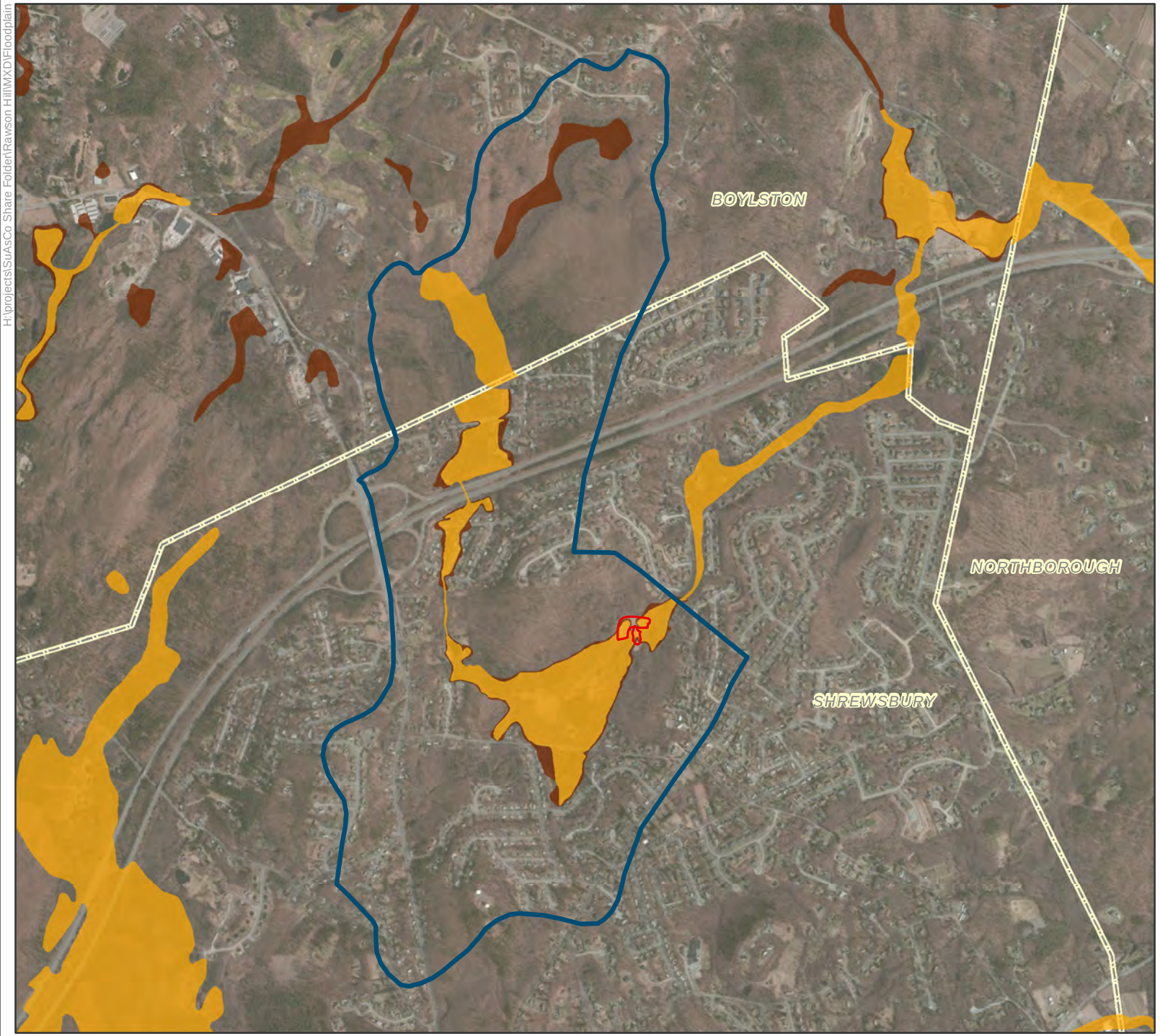
H:\projects\SuAsCo Share Folder\Rawson Hill\MXD\Floodplain



SuAsCo: Rawson Hill Brook Dam

Figure 7. Floodplains

Legend

- 100yr Floodplain
- 500yr Floodplain
- Rawson Hill Brook Dam
- Rawson Hill Brook Dam Watershed
- Town Boundaries

N

0 1,000 2,000

Feet

NRCS Natural Resources Conservation Service

Sources: AMEC, 2011; esri, 2006; FEMA, 1997; Office of Geographic Information (MassGIS), Commonwealth of Massachusetts Information Technology Division, 2008-9

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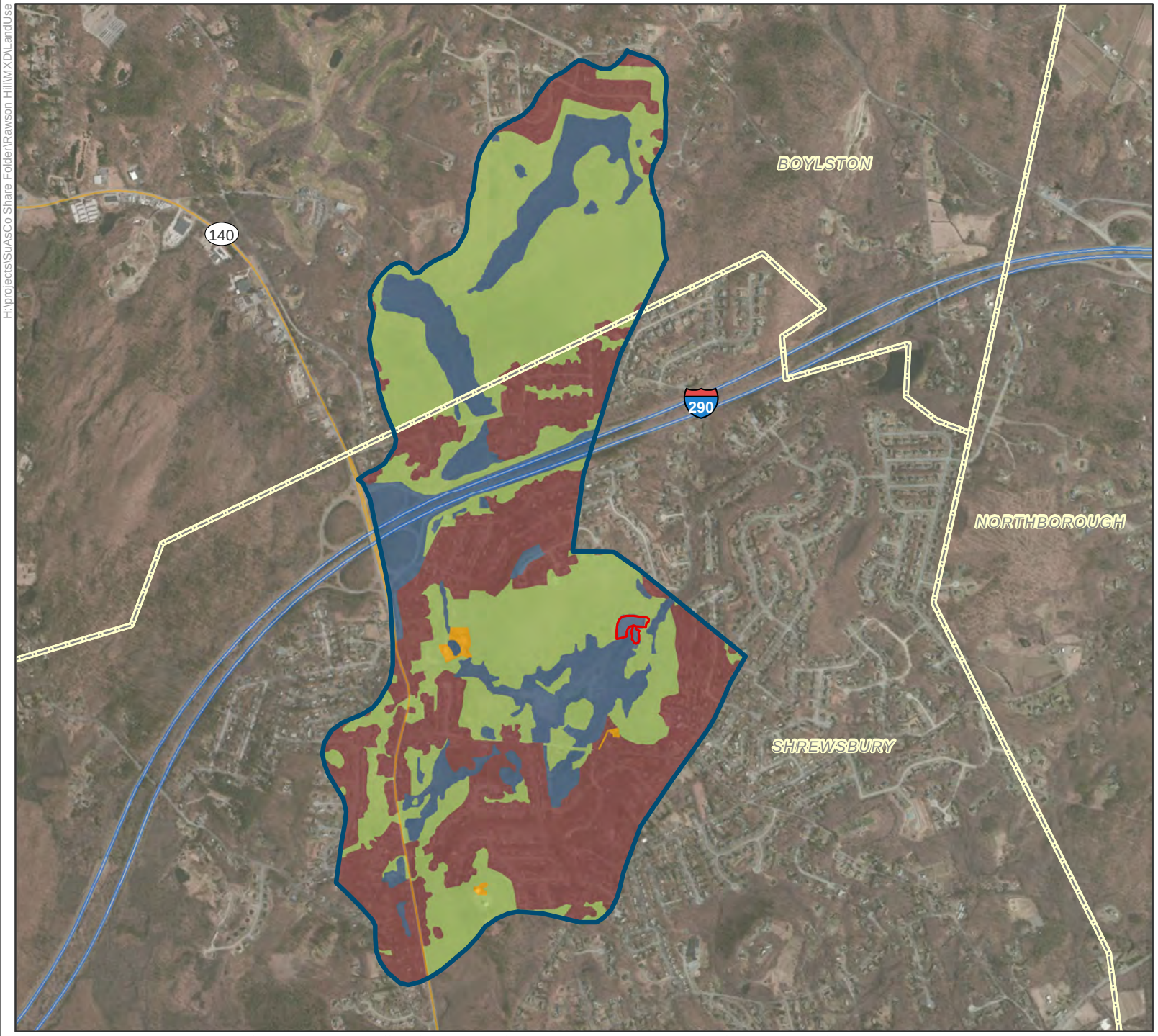

SuAsCo: Rawson Hill Brook Dam

Figure 8. Current Land Use in Drainage Area

Legend

- Rawson Hill Brook Dam
- Rawson Hill Brook Dam Watershed
- Town Boundaries

Land Use Category

- Developed Industrial/Commercial
- Developed Residential
- Forest
- Other

0 1,000 2,000

Feet

NRCS Natural Resources Conservation Service

Sources: AMEC, 2011; esri, 2006; Microsoft (Bing Maps), 2010; Office of Geographic Information (MassGIS), Commonwealth of Massachusetts Information Technology Division

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H:\projects\SuAsCo Share Folder\Rawson Hill\MXD\LandUse_DSFloodplain

SuAsCo: Rawson Hill Brook Dam

Figure 9. Current Landuse in the Downstream Floodplain

Legend

- 100yr Floodplain
- 500yr Floodplain
- Rawson Hill Brook Dam Watershed
- Town Boundaries

Land Use Category

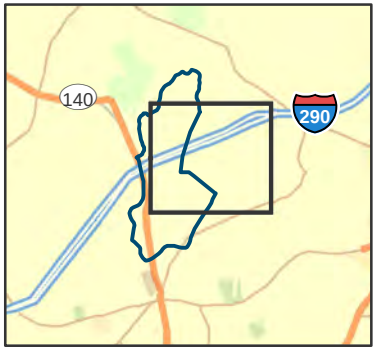
- Developed Residential
- Forest
- Other

N

0 500 1,000

Feet

NRCS Natural Resources Conservation Service



Sources: AMEC, 2011; esri, 2006; FEMA, 1997; Microsoft (Bing Maps), 2010; Office of Geographic Information (MassGIS), Commonwealth of Massachusetts Information Technology Division, 2008-9

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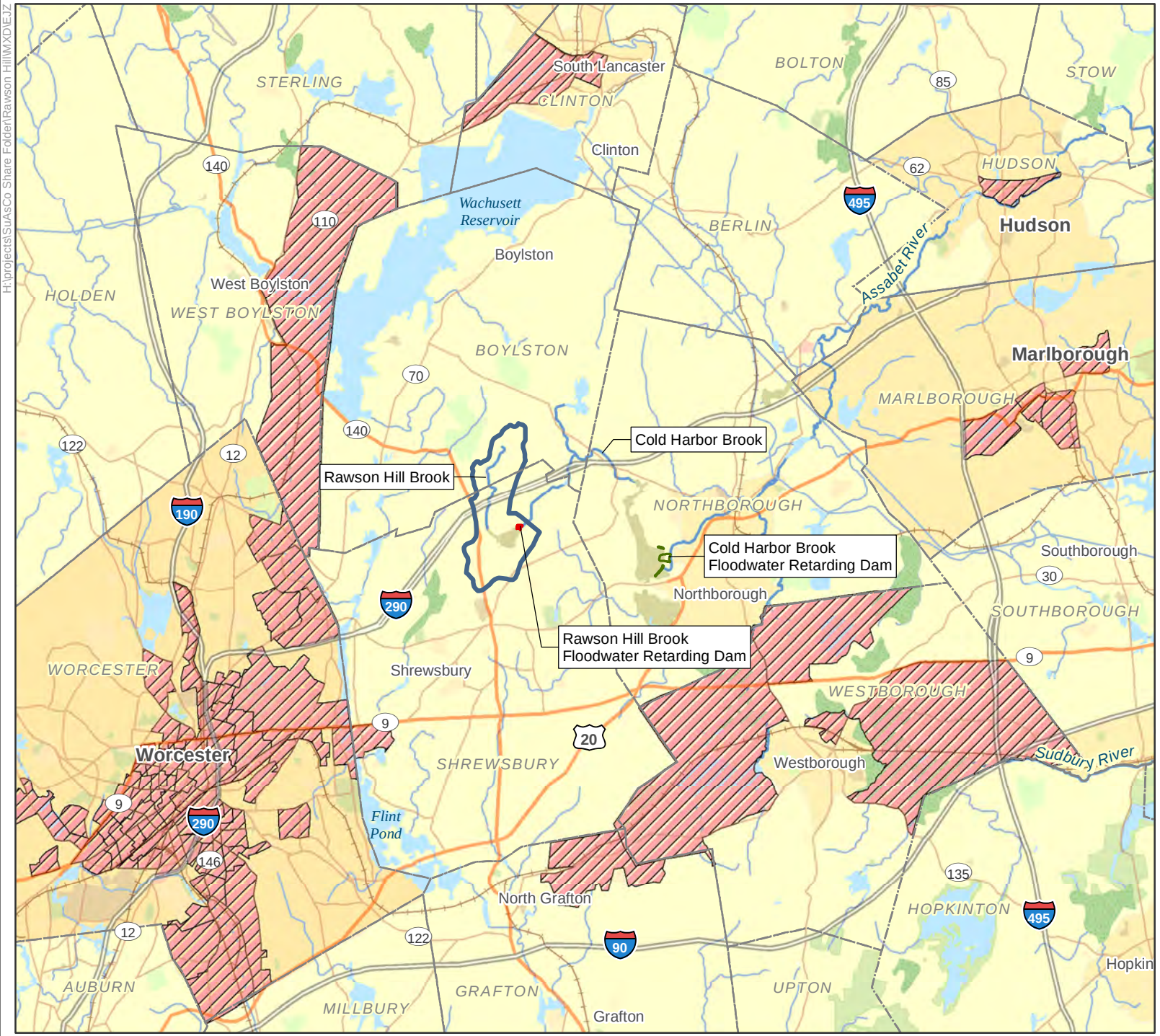
H:\projects\SuAsCo Share Folder\Rawson Hill\MXD\EJZ

SuAsCo: Rawson Hill Brook Dam

Figure 10. Environmental Justice Zones



Legend

- Cold Harbor Brook Dam
- Environmental Justice Zone
- Rawson Hill Brook Dam
- Rawson Hill Brook Dam Watershed
- Town Boundaries

0 0.5 1 2

Miles

Sources: AMEC, 2011; esri, 2006; Office of Geographic Information (MassGIS), Commonwealth of Massachusetts Information Technology Division, 2003; U.S Census Bureau, 2000

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Appendix C-2

Engineering Plans

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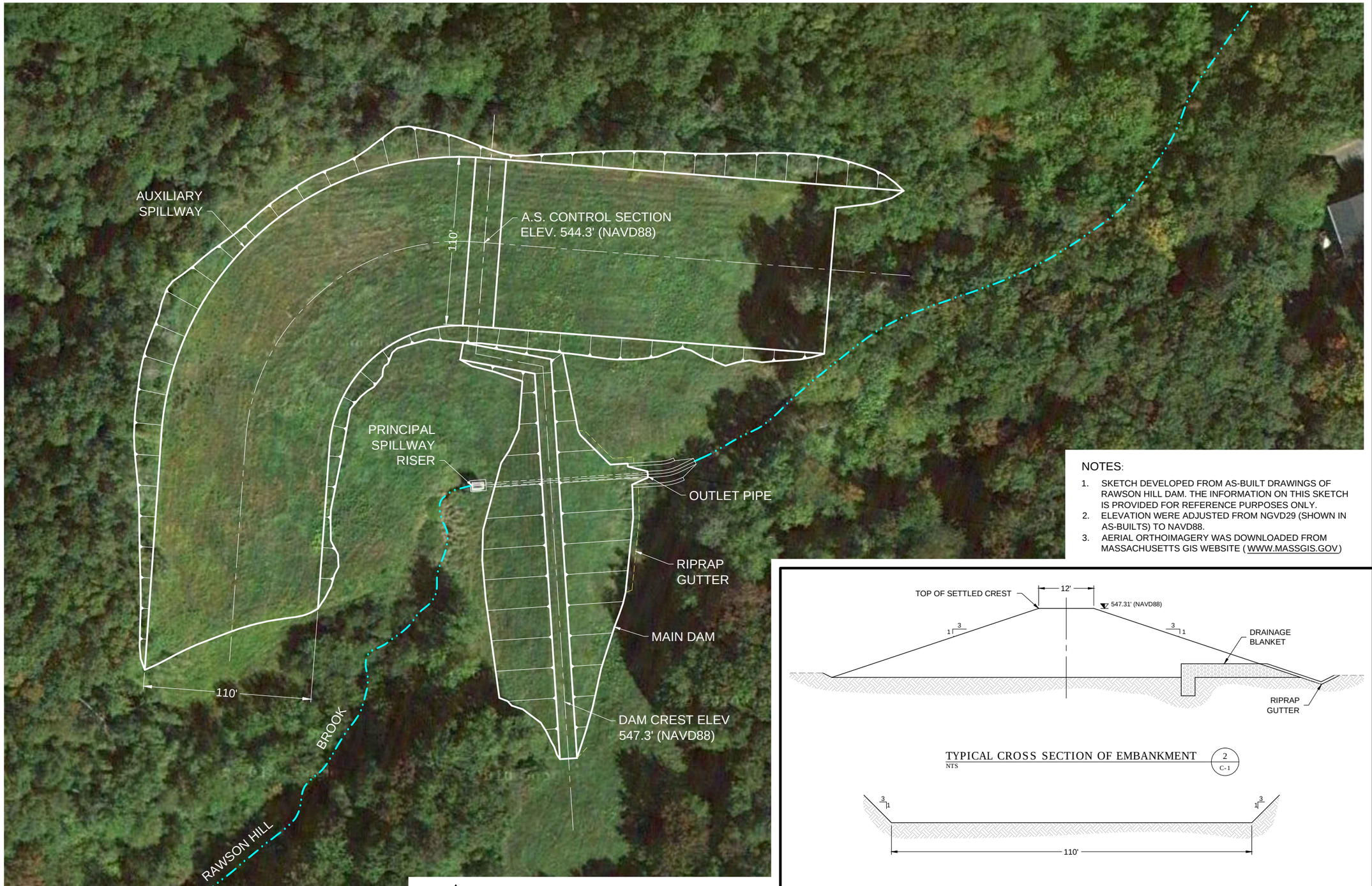

LAYOUT PLAN 1 C-1
1"=30'

NOTES:

1. SKETCH DEVELOPED FROM AS-BUILT DRAWINGS OF RAWSON HILL DAM. THE INFORMATION ON THIS SKETCH IS PROVIDED FOR REFERENCE PURPOSES ONLY.
2. ELEVATION WERE ADJUSTED FROM NGVD29 (SHOWN IN AS-BUILTS) TO NAVD88.
3. AERIAL ORTHOIMAGERY WAS DOWNLOADED FROM MASSACHUSETTS GIS WEBSITE (WWW.MASSGIS.GOV)

TYPICAL CROSS SECTION OF EMBANKMENT 2 C-1
NTS

TYPICAL CROSS SECTION OF AUXILIARY SPILLWAY 3 C-1
NTS

Designed JVB
Drawn MA
Checked PM
Approved JVB

Rev.	Description	Date
0	Final Submission	11.14.11

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Rawson Hill Brook Floodwater Retarding Dam Rehabilitation Alternatives

EXISTING CONDITIONS

Rawson Hill Brook, Shrewsbury, Worcester County, Massachusetts

United States Department of Agriculture Natural Resources Conservation Service NRCS

Drawing No. **C-1**

Sheet 1 of 6

Plot Time 9:05 PM
Save Time 9:03 PM
File Name Rawson Hill Alternatives.dwg

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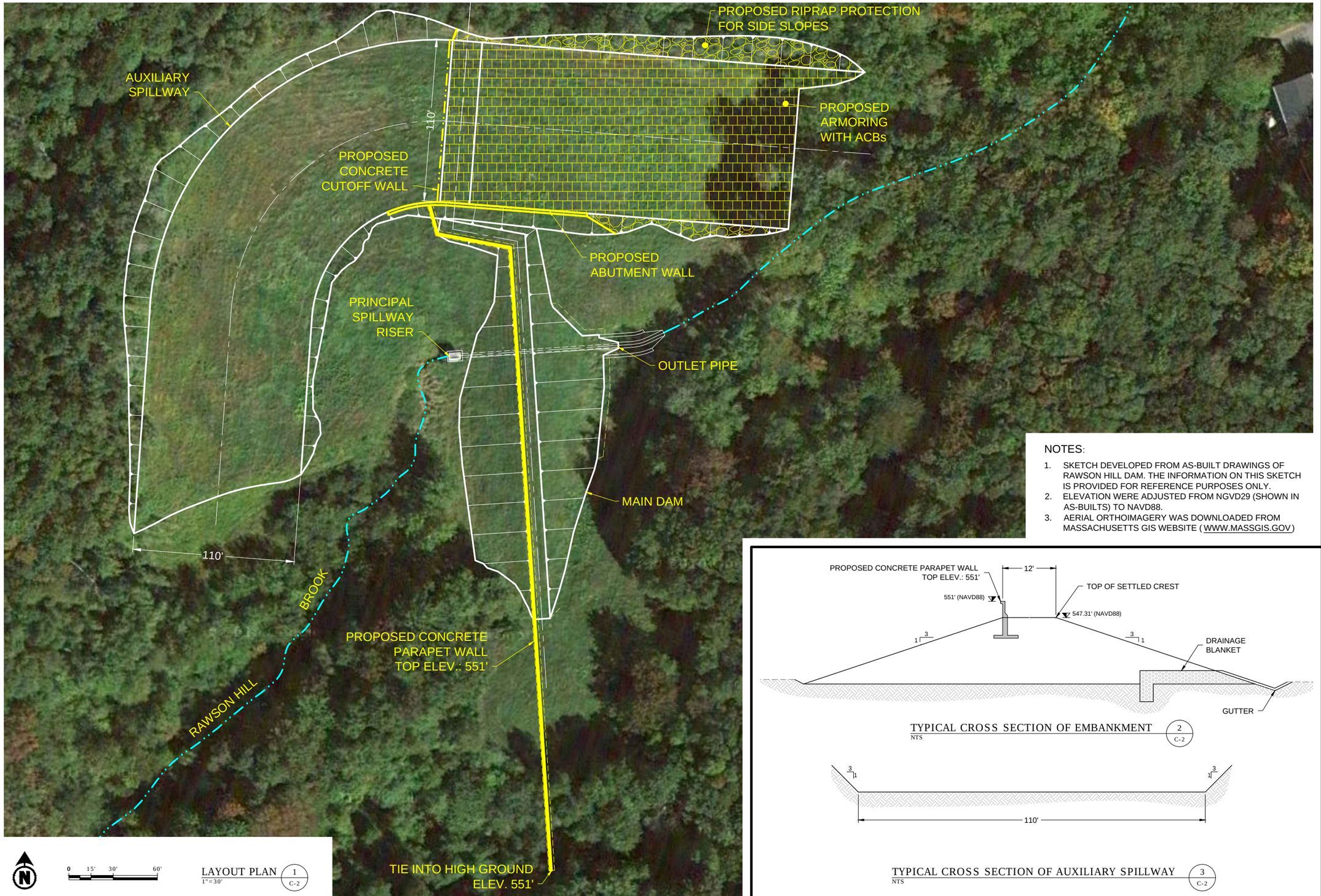

NOTES:

1. SKETCH DEVELOPED FROM AS-BUILT DRAWINGS OF RAWSON HILL DAM. THE INFORMATION ON THIS SKETCH IS PROVIDED FOR REFERENCE PURPOSES ONLY.
2. ELEVATION WERE ADJUSTED FROM NGVD29 (SHOWN IN AS-BUILTS) TO NAVD88.
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TYPICAL CROSS SECTION OF EMBANKMENT — NTS — 2 / C-2

TYPICAL CROSS SECTION OF AUXILIARY SPILLWAY — NTS — 3 / C-2

0 15' 30' 60'

LAYOUT PLAN — 1" = 30' — 1 / C-2

Designed JVB
Drawn MA
Checked PM
Approved JVB

Rev.	Description	Date
0	Final Submission	11.14.11

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Rawson Hill Brook Floodwater Retarding Dam Rehabilitation Alternatives

RAISING THE DAM - PARAPET WALL

Rawson Hill Brook, Shrewsbury, Worcester County, Massachusetts

United States Department of Agriculture Natural Resources Conservation Service NRCS

Drawing No. **C-2**

Sheet 2 of 6

Plot Time 9:05 PM
Save Time 9:03 PM
File Name Rawson Hill Alternatives.dwg

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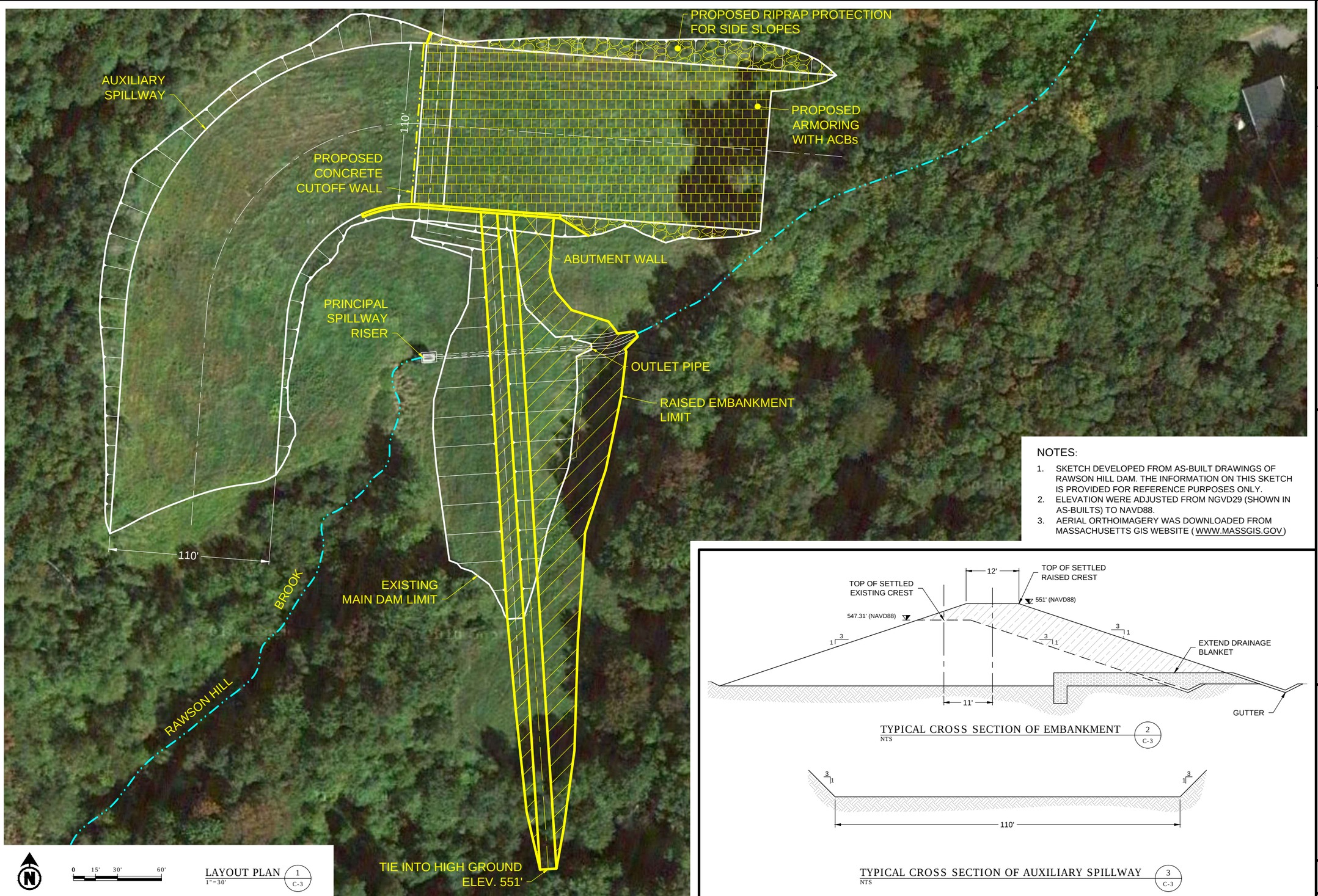

LAYOUT PLAN 1 / C-3
1"=30'

NOTES:

1. SKETCH DEVELOPED FROM AS-BUILT DRAWINGS OF RAWSON HILL DAM. THE INFORMATION ON THIS SKETCH IS PROVIDED FOR REFERENCE PURPOSES ONLY.
2. ELEVATION WERE ADJUSTED FROM NGVD29 (SHOWN IN AS-BUILTS) TO NAVD88.
3. AERIAL ORTHOIMAGERY WAS DOWNLOADED FROM MASSACHUSETTS GIS WEBSITE (WWW.MASSGIS.GOV)

TYPICAL CROSS SECTION OF EMBANKMENT 2 / C-3
NTS

TYPICAL CROSS SECTION OF AUXILIARY SPILLWAY 3 / C-3
NTS

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Drawn MA
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Approved JVB

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Rawson Hill Brook Floodwater Retarding Dam Rehabilitation Alternatives

RAISING THE DAM - RAISED EMBANKMENT

Rawson Hill Brook, Shrewsbury, Worcester County, Massachusetts

United States Department of Agriculture Natural Resources Conservation Service NRCS

Drawing No. **C-3**

Sheet 3 of 6

Plot Time 9:05 PM
Save Time 9:03 PM
File Name Rawson Hill Alternatives.dwg

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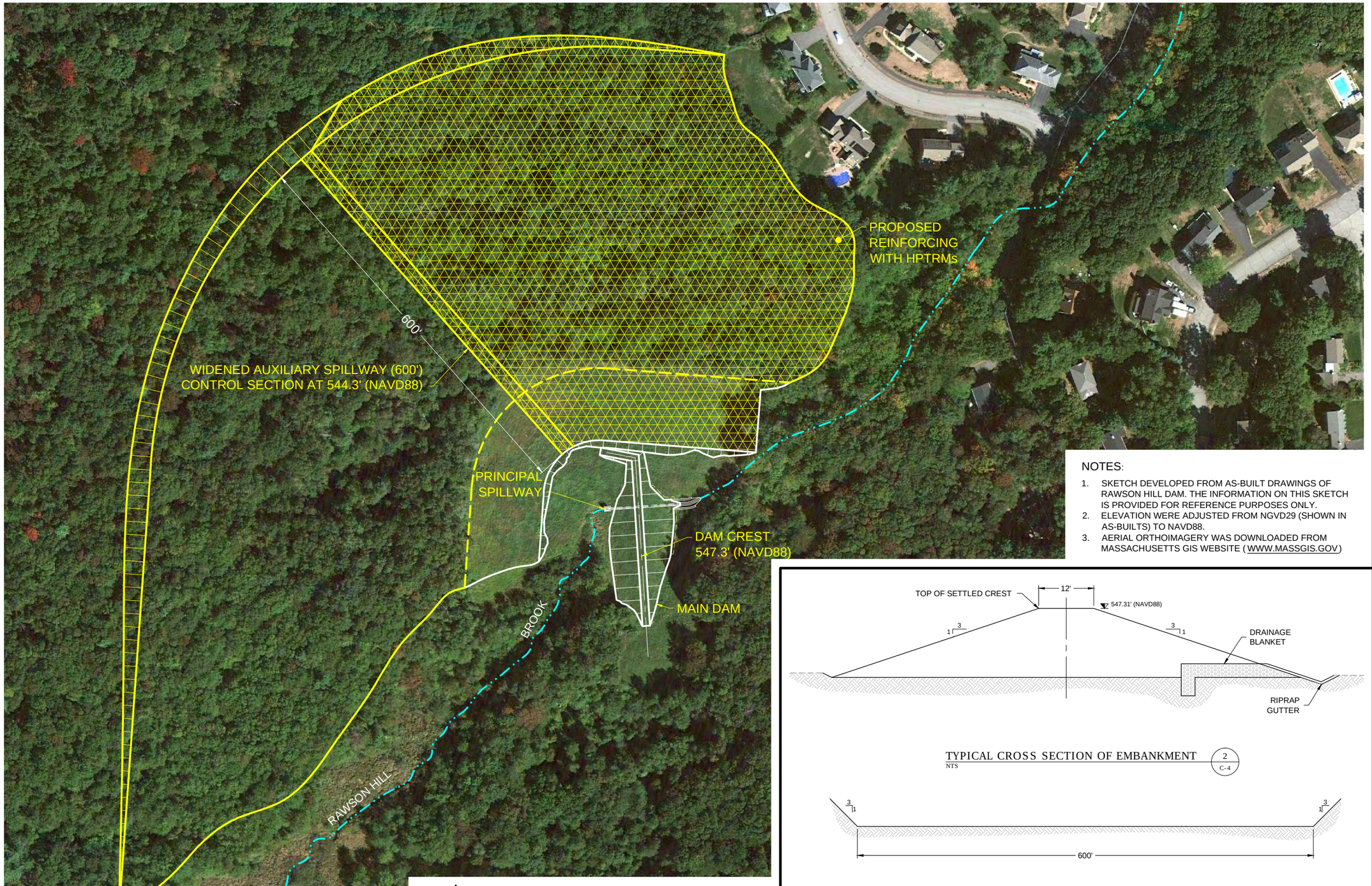

LAYOUT PLAN 1 C-4
1"=70'

NOTES:

1. SKETCH DEVELOPED FROM AS-BUILT DRAWINGS OF RAWSON HILL DAM. THE INFORMATION ON THIS SKETCH IS PROVIDED FOR REFERENCE PURPOSES ONLY.
2. ELEVATION WERE ADJUSTED FROM NGVD29 (SHOWN IN AS-BUILTS) TO NAVD88.
3. AERIAL ORTHOIMAGERY WAS DOWNLOADED FROM MASSACHUSETTS GIS WEBSITE (WWW.MASSGIS.GOV)

TYPICAL CROSS SECTION OF EMBANKMENT 2 C-4
NTS

TYPICAL CROSS SECTION OF AUXILIARY SPILLWAY 3 C-4
NTS

Designed JVB
Drawn MA
Checked PM
Approved JVB

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Rawson Hill Brook Floodwater Retarding Dam
Rehabilitation Alternatives
600' WIDE AUX. SPILLWAY
Rawson Hill Brook, Shrewsbury, Worcester County, Massachusetts

United States Department of Agriculture
Natural Resources Conservation Service
NRCS

Drawing No.
C-4

Sheet 4 of 6

Plot Time 9:06 PM
Save Time 9:03 PM
File Name Rawson Hill Alternatives.dwg

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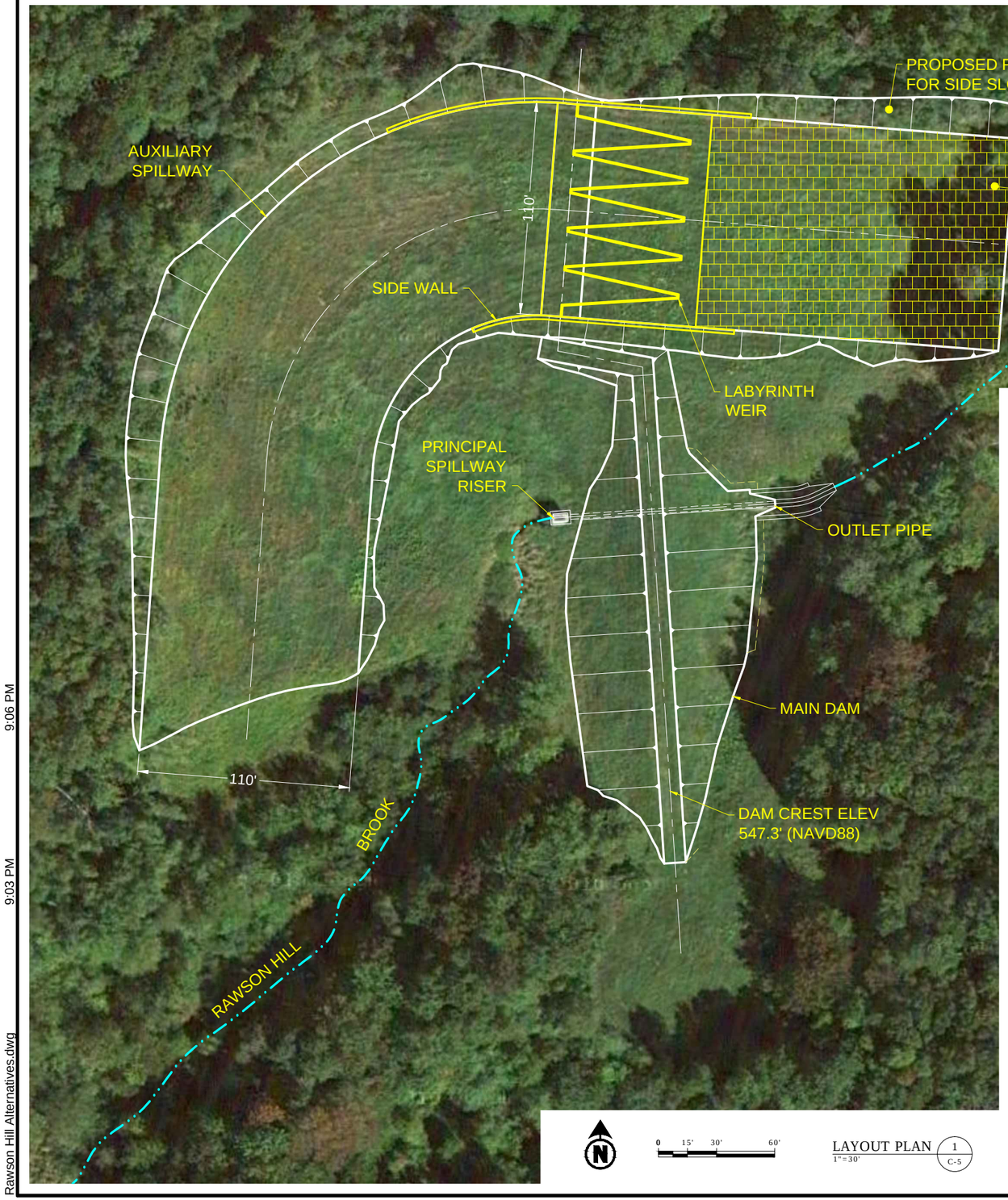
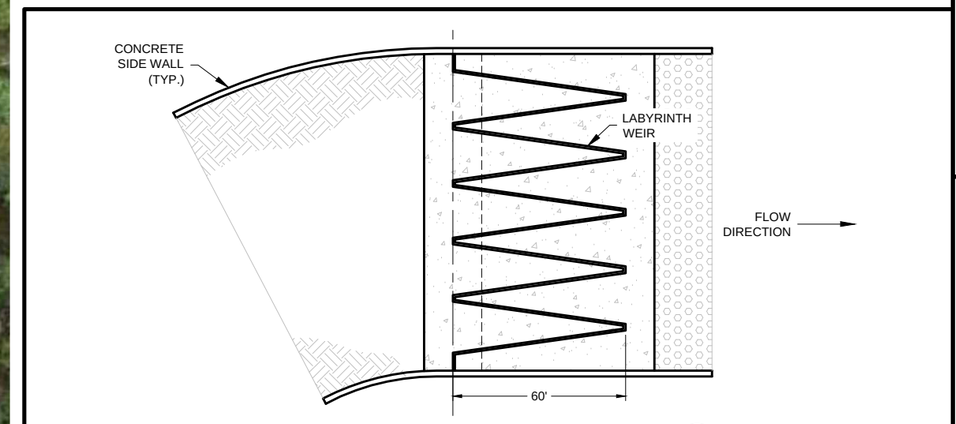


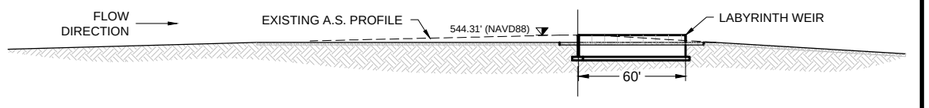
LAYOUT PLAN 1 (C-5)
1" = 30'

NOTES:

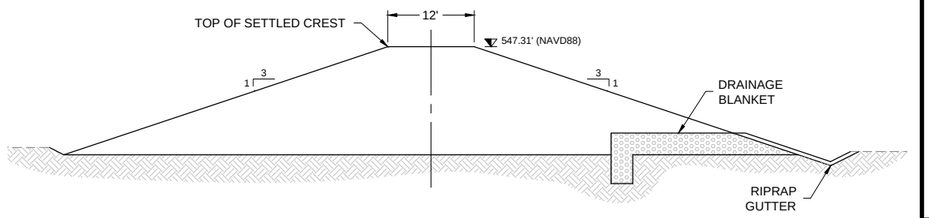
1. SKETCH DEVELOPED FROM AS-BUILT DRAWINGS OF RAWSON HILL DAM. THE INFORMATION ON THIS SKETCH IS PROVIDED FOR REFERENCE PURPOSES ONLY.
2. ELEVATION WERE ADJUSTED FROM NGVD29 (SHOWN IN AS-BUILTS) TO NAVD88.
3. AERIAL ORTHOIMAGERY WAS DOWNLOADED FROM MASSACHUSETTS GIS WEBSITE (WWW.MASSGIS.GOV)



LABYRINTH WEIR PLAN VIEW 2 (C-5)
NTS



PROFILE ALONG AUXILIARY SPILLWAY 3 (C-5)
NTS



TYPICAL CROSS SECTION OF EMBANKMENT 4 (C-5)
NTS

Designed	JVB
Drawn	MA
Checked	PM
Approved	JVB

Rev.	Description	Date
0	Final Submission	11.14.11

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Rawson Hill Brook Floodwater Retarding Dam Rehabilitation Alternatives

LABYRINTH WEIR

Rawson Hill Brook, Shrewsbury, Worcester County, Massachusetts

United States Department of Agriculture Natural Resources Conservation Service NRCS

Drawing No. **C-5**

Sheet 5 of 6

Plot Time 9:06 PM
Save Time 9:03 PM
File Name Rawson Hill Alternatives.dwg

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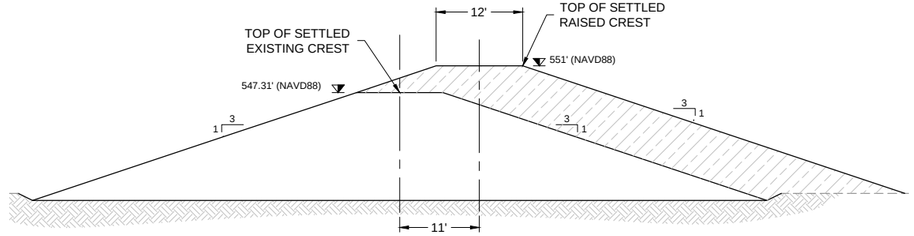

TYPICAL CROSS SECTION OF DIKE
NTS

4
C-6

NOTES:

1. SKETCH DEVELOPED FROM AS-BUILT DRAWINGS OF RAWSON HILL DAM. THE INFORMATION ON THIS SKETCH IS PROVIDED FOR REFERENCE PURPOSES ONLY.
2. ELEVATION WERE ADJUSTED FROM NGVD29 (SHOWN IN AS-BUILTS) TO NAVD88.
3. AERIAL ORTHOIMAGERY WAS DOWNLOADED FROM MASSACHUSETTS GIS WEBSITE (WWW.MASSGIS.GOV)

0 75' 150' 300'

LAYOUT PLAN
1" = 150'

1
C-6

Designed JVB
Drawn MA
Checked PM
Approved JVB

Rev.	Description	Date
0	Final Submission	11.14.11

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United States Department of Agriculture
Natural Resources Conservation Service
NRCS

Rawson Hill Brook Floodwater Retarding Dam Rehabilitation Alternatives

RAISE SECONDARY DIKE

Rawson Hill Brook, Shrewsbury, Worcester County, Massachusetts

Drawing No.
C-6

Sheet 6 of 6

Plot Time 9:06 PM
Save Time 9:03 PM
File Name Rawson Hill Alternatives.dwg

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Appendix C-3

Breach Inundation Maps

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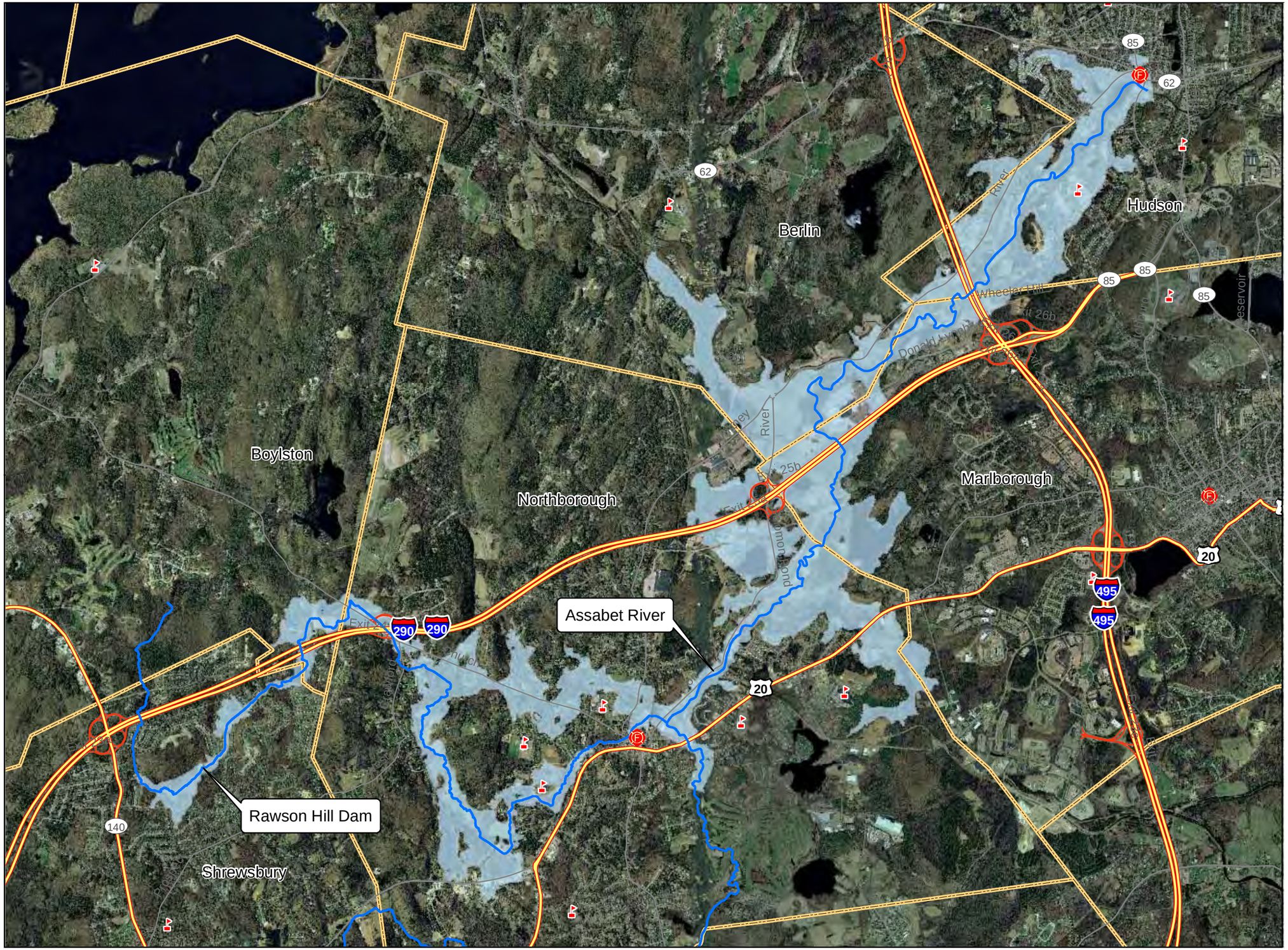
FIGURE 1-1

Structures Within the PMP Breach Inundation Zone

RAWSON HILL DAM



Legend

- Town Boundary
- Highways
- Main Roads
- Stream
- PMP Breach Inundation Zone
- Fire Station
- Public School

*There are no Hospitals, Colleges/Universities, or Police Stations located in the inundation zone.

Location of Project Site

Notes and Sources

Notes: Imagery provided by ESRI.

N

0 3,750 Feet

AMEC Earth & Environmental, Inc.
2 Robbins Road
Westford, MA 01886
(978) 692-9090

H:\NRCS\Northborough_MA\Task1\MXD\RawsonHillDam_Structures.mxd August 23, 2011 DWN: JDP CHKD: PM

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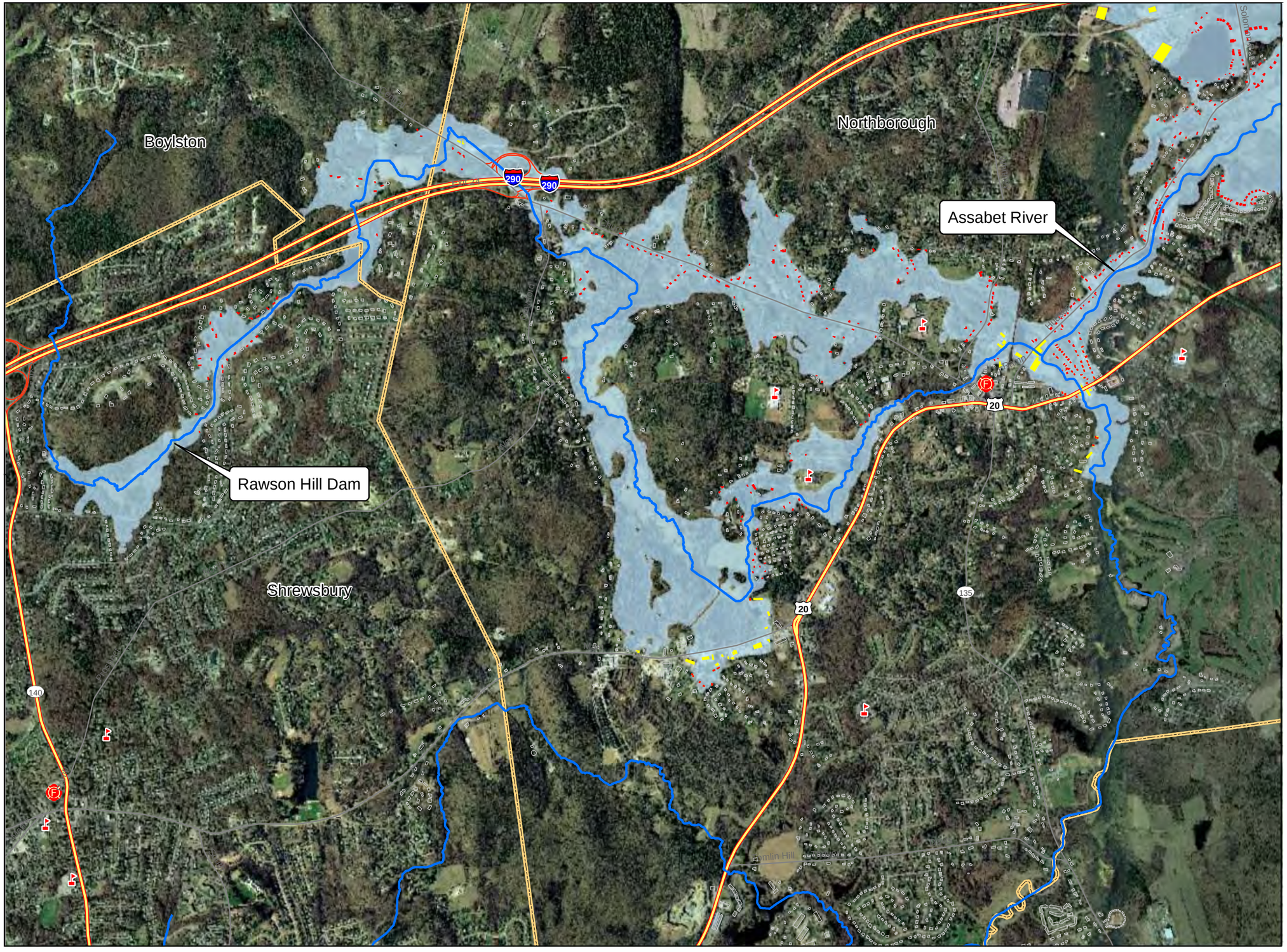

FIGURE 1-2

Structures Within the PMP Breach Inundation Zone

RAWSON HILL DAM

Legend

- Residential Buildings
- Non-Residential Buildings
- Buildings Outside of the PMP Breach Inundation Zone
- Town Boundary
- Highways
- Main Roads
- Stream
- PMP Breach Inundation Zone
- Fire Station
- Public School

*There are no Hospitals, Colleges/Universities, or Police Stations located in the inundation zone.

Location of Project Site

Notes and Sources

Notes: Imagery provided by ESRI.

N

0 2,000 Feet

AMEC Earth & Environmental, Inc.
2 Robbins Road
Westford, MA 01886
(978) 692-9090

H:\NRCS\Northborough_MA\Task1\MXD\RawsonHillDam_StructuresZoom1.mxd August 24, 2011 DWN: JDP CHKD: PM

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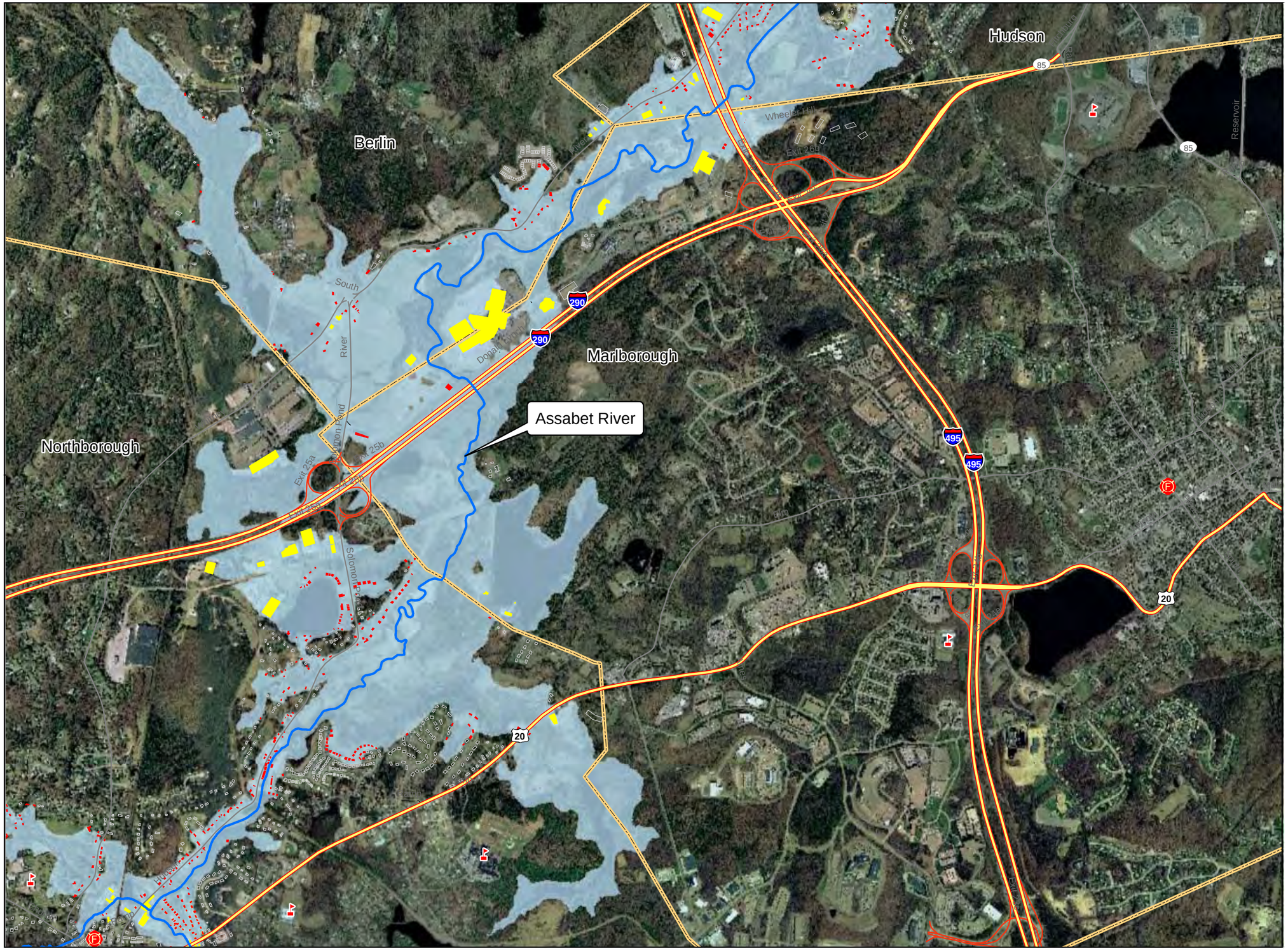
FIGURE 1-3

Structures Within the PMP Breach Inundation Zone

RAWSON HILL DAM



Legend

- Residential Buildings
- Non-Residential Buildings
- Buildings Outside of the PMP Breach Inundation Zone
- Town Boundary
- Highways
- Main Roads
- Stream
- PMP Breach Inundation Zone
- Fire Station
- Public School

*There are no Hospitals, Colleges/Universities, or Police Stations located in the inundation zone.

Location of Project Site

Notes and Sources

Notes: Imagery provided by ESRI.

N

0 2,000 Feet

AMEC Earth & Environmental, Inc.
2 Robbins Road
Westford, MA 01886
(978) 692-9090

H:\NRCS\Northborough_MA\Task1\MXD\RawsonHillDam_StructuresZoom2.mxd August 24, 2011 DWN: JDP CHKD: PM

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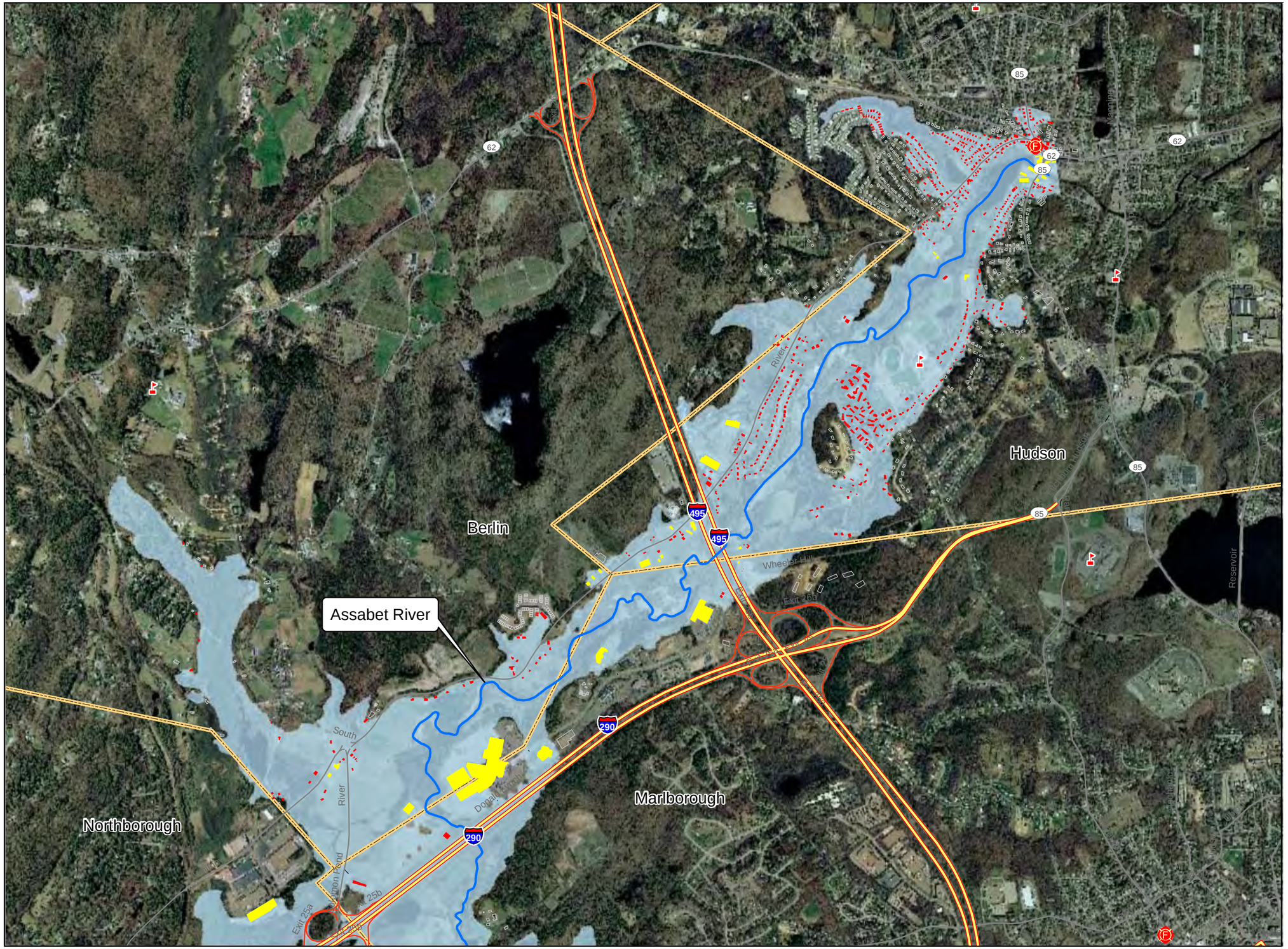
FIGURE 1-4

Structures Within the PMP Breach Inundation Zone

RAWSON HILL DAM



Legend

- Residential Buildings
- Non-Residential Buildings
- Buildings Outside of the PMP Breach Inundation Zone
- Town Boundary
- Highways
- Main Roads
- Stream
- PMP Breach Inundation Zone
- Fire Station
- Public School

*There are no Hospitals, Colleges/Universities, or Police Stations located in the inundation zone.

Location of Project Site

Notes and Sources

Notes: Imagery provided by ESRI.

N

0 2,000 Feet

AMEC Earth & Environmental, Inc.
2 Robbins Road
Westford, MA 01886
(978) 692-9090

H:\NRCS\Northborough_MA\Task1\MXD\RawsonHillDam_StructuresZoom3.mxd August 24, 2011 DWN: JDP CHKD: PM

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APPENDIX D

INVESTIGATION AND ANALYSIS REPORT

Clean Air Act: The Clean Air Act[32] regulates air pollutants at the national level. The 8-hour Ozone Nonattainment Area State/Area/County Report (EPA 2011) was reviewed to determine if the site was within any of the 8-hour nonattainment areas designated by the U.S. Environmental Protection Agency (EPA), which it is. Additionally, the Massachusetts 2010 Air Quality Report (DEP 2011) was reviewed to determine the existing conditions of the air quality in the vicinity of the site. Furthermore, the project was reviewed to analyze potential air quality impacts that may occur as a result of the dam rehabilitation. It was determined that only minor, temporary impacts related to construction-related activities would occur which would result in a limited decrease in air quality during construction. Once construction has been completed, it is expected that existing air quality will resume to the current existing conditions. Refer to the Clean Air Environmental Procedures Guidesheets (NECH 610.21) as part of the NRCS-CPA-52.

Clean Water Act / Waters of the U.S.: The Clean Water Act[33] (CWA) applies to waters of the U.S. which generally refers to waters (i.e., rivers, lakes, etc.) that are traditionally navigable and their adjacent and contributing waters (i.e., streams, wetlands, etc.) Typically, projects are most often affected by the CWA under Section 401 and Section 404. In summary, Section 401 prohibits the degradation of water quality by regulated activities; Section 404 regulates the discharge of dredged or fill material into waters of the U.S.

As part of the planning process for the rehabilitation of the dam, Massachusetts Geographic Information Systems (MassGIS) (MassGIS 2009) and National Wetlands Inventory (NWI) (FWS 2009a) wetlands data was overlain on the project area to determine if there were any mapped wetland habitats in the vicinity of the dam. An infield site assessment was completed to determine the presence of any wetlands or other waters of the U.S. within the proposed project area in order to "ground truth" the wetlands mapping. As a result, several wetlands and watercourses were identified within the vicinity of the site. These potentially regulated areas were overlaid onto the proposed engineering plans to determine if there would be any significant impacts to those resources as a result of the dam rehabilitation.

It was determined that rehabilitation of the dam will result in only minor temporary impacts and no permanent impacts as a result of construction due to construction access or other construction-related activities. The water quality of Rawson Hill Brook will not be affected by temporary construction-related disturbance resulting in erosion and sedimentation. Compliance with state laws, application of best management practices (BMPs), and revegetation of any disturbed areas would minimize any potential impacts. As such, it is likely that the project will likely not require a Section 401 Water Quality Certificate from the Massachusetts Department of Environmental Protection (DEP) or a Section 404 General Permit (GP) Permit from the U.S. Army Corps of Engineers (USACE).

[32] 42 U.S.C. 7401 *et seq*.
[33] 33 U.S.C. §1251 *et seq*.

Refer to the Clean Water and Wetlands Environmental Procedures Guidesheets (NECH 610.22 and 610.34) as part of the NRCS-CPA-52.

Coastal Zone Management: Massachusetts's Coastal Management Programs consists of enforceable programs and management principles which govern activities within a coastal zone. The Massachusetts coastal zone is generally restricted to land within 0.5 miles of coastal waters and salt marshes as well as all islands.

To evaluate the potential effects of dam rehabilitation on Coastal Zone Management areas, data from the Massachusetts Ocean Resources Information System (MORIS) was reviewed (MassGIS 2008a). The review indicated that the dam is not within any Coastal Zone Management areas. Refer to the Coastal Zone Environmental Procedures Guidesheets (NECH 610.23) as part of the NRCS-CPA-52.

Coral Reefs: The dam is located over 30 miles inland from the nearest coastal waters in Boston, Massachusetts. Since the dam is not in the vicinity of any coastal waters, it was determined that rehabilitation of the dam will not result in any impacts to coral reefs. Given the dam's inland locale, further consideration of impacts to coral reefs is not warranted. Refer to the Coral Reefs Environmental Procedures Guidesheets (NECH 610.24) as part of the NRCS-CPA-52.

Cultural Resources: The National Register of Historic Places (National Register) (NPS 2011a) was reviewed to determine the presence of any places listed or eligible for listing on the National Register. No places listed or eligible for listing in the vicinity of the dam were identified. Additionally, the Massachusetts State Historic Preservation Office (SHPO) and the Tribal Historic Preservation Office (THPO) were both consulted regarding the presence of known historic and cultural resources at the site. In a letter dated November 17, 2011, SHPO responded that the proposed project would not have an effect on any historic properties. To date, no correspondence has been received from the THPO. Any future correspondence will be addressed in subsequent drafts of this Plan. Refer to the Cultural Resource Environmental Procedures Guidesheets (NECH 610.25) as part of the NRCS-CPA-52.

Economic Analysis: The Natural Resources Conservation Service's (NRCS) National Watershed Program Manual (NRCS 2009) and the National Watershed Program Handbook (NRCS 2010) were used as references for the economic analysis along with two economic analysis guidance documents: Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (P&G) (WRC 1983) and the Economics Handbook, Part II for Water Resources (NRCS 1998). These guidance documents were used to evaluate potential flood damages, and estimate project benefits and associated costs. P&G was developed to define a consistent set of project formulation and evaluation instructions for all federal agencies that carry out water and related land resource implementation studies. The basic objective of P&G is to determine whether or not benefits from proposed actions exceed project costs. P&G also requires that the "National Economic Development" or NED Alternative, which maximizes monetary net benefits, be selected for implementation unless there is an overriding reason for selecting another alternative based on federal, state, local or international concerns related to the social and environmental accounts. The allowance for

exceptions to the NED plan recognizes the fact that not all project considerations or benefits can be quantified and monetized when it comes to some ecological system and social effects.

Per sections 1.7.2(a)(4)(ii) and 2.1.1(b)(2) of the P&G allowing for abbreviated procedures, damage reduction benefits have not been estimated because they are the same for both alternatives, and no net change in benefits occurs when comparing the two candidate plans to each other. The federally assisted alternative (Alternative 2) is displayed within a zero-based accounting context that credits local costs avoided (Adverse, annual) as beneficial costs (Beneficial, annual) consistent with P&G 1.7.2(b)(3). Net benefits are zero because the total project cost is equal to the claimed benefits and the resulting B/C ratio is 1.0:1.0.

Positive benefits would accrue as a result of this project as compared to existing conditions, but no attempt was made to compute an estimate of the difference between the future with project and existing conditions because the existing conditions are not the most likely future conditions. The added details would not alter the recommended alternative and, therefore, would not justify the added planning costs. Project flood-prevention benefit estimates were updated to 2011 dollars from the 1958 watershed plan. The Consumer Price Index (CPI) was used for updating reduction benefits for roads and bridges. Original downstream damage reduction benefits for residential and commercial properties were updated using the average increase in tax receipts. Values for selected commercial properties that constitute a major portion of the benefit calculations were updated to reflect current market values. These benefit estimates were not used to compare alternatives, because both alternatives provide the same benefit, but they show the ongoing value to the Commonwealth of Massachusetts and the local towns of the flood prevention provided by the Rawson Hill Brook Dam.

All costs of installation and operation and maintenance were based on 2011 prices. One year was assumed for development, review, and approval of the final design and installation of the proposed rehabilitation project. Structural measures were assumed to have a 52-year useful life. Thus, a 53-year period of analysis was used along with the mandated 4.0 percent discount rate for all federal water resource projects for Fiscal Year 2012 (FY12) to discount and amortize the anticipated streams of costs and benefits.

An economic analysis utilizing HEC-Flood Damage Assessment or URB1 to analyze the potential economic impact of dam failure as well as the economic impacts resultant from flood protection was not completed. As such, there is some risk and uncertainty from not completing an analysis utilizing either HEC-Flood Damage Assessment or URB1; however, the project sponsors awcknowledge that risk and are confident in the approach to calculate the economic impacts associated with rehabilitation of the dam.

Endangered and Threatened Species: Initial assessment of potential environmental impacts was based on review of natural resources information in MassGIS and consultations with U.S. Fish and Wildlife Service (FWS) and Massachusetts Natural Heritage and Endangered Species Program (NHESP). The FWS's list of Federally Listed Endangered and Threatened Species in Massachusetts (FWS 2009b) was reviewed to determine the potential presence of any federally-listed threatened or endangered (T&E) species in the vicinity of the site. As such, it was

determined that there are no federally-protected threatened or endangered species in the project area. The NHESP's Priority Habitat for Rare Species (MassGIS 2008b) and Estimated Habitat for Rare Species (MassGIS 2008c) datasets were reviewed for the presence of rare species or their suitable habitats in the vicinity of the dam. As such, no state-listed species were identified as occurring in the vicinity of the dam. The NHESP was contacted in consultation with the DEP regarding the potential presence of any rare species in the project area. The NHESP indicated that there were no known occurrences of any rare species in proximity to the dam. Refer to the Endangered and Threatened Species Environmental Procedures Guidesheets (NECH 610.26) as part of the NRCS-CPA-52.

Engineering: NRCS contracted H&S Environmental and AMEC to complete engineering studies of the Rawson Hill Brook Dam. Several alternatives were screened out from further analysis because of cost, constructability, or environmental impacts:

- Raise the dam to elevation 551 feet by using a parapet wall
- Raise the earthen embankment of the dam to elevation 551 feet
- Widen the auxiliary spillway to 600 feet, while remaining the existing top of dam elevation

Structural alternatives evaluated in detail were:

- Use of labyrinth weir design for the auxiliary spillway, while maintaining the existing top of dam elevation and auxiliary spillway width with ACB armored exit channel.

The project team performed a spillway integrity analysis to determine whether the existing auxiliary spillway would withstand the exit velocities estimated for the stability design hydrograph (SDH) and freeboard hydrograph (FBH) design storms for the future watershed build-out condition. The project team used the Site Analysis Integrated Development Environment (SITES) and Windows™ Dam Analyses Models (WinDAM) models to evaluate the stability of the auxiliary spillway. The project team developed a soil profile of the auxiliary spillway using information from the soil boring descriptions and Unified Soil Classification System designations described in the as-built plans for Rawson Hill Brook Dam. The model indicated that, under the potential future watershed condition, during the SDH event, sod stripping would occur along the control section. During the FBH event, vegetal cover fails and the headcut breaches the spillway crest. The depth of the headcut in the control section was approximately 8 feet; the deepest headcut was approximately 13.5 feet. Under the build-out condition, Rawson Hill Brook Dam does not meet the auxiliary spillway integrity requirements of the NRCS's Technical Release 60 (TR-60). The installation of a labyrinth weir with the ACB armored channel was recommended to provide scour protection to the spillway.

Breach Analysis – A comprehensive hydrologic and hydraulic analysis was performed to evaluate the capacity of the Hop Brook Dam under current and build-out conditions. The analysis included development of several hydrologic and hydraulic models to predict maximum water surface elevations under a series of design storms. Design storms were established based on NRCS design criteria for earthen dams. The primary tool used for the evaluation of the existing capacity and rehabilitation alternatives was the NRCS's beta-test version of the

WinDAM B computer model, intended to replace the Site Analysis Integrated Development Environment (SITES) model in the near future. Inflow hydrographs for the model were developed by modeling different rainfall scenarios in a HEC-HMS model and routing the hydrographs in a HEC-RAS unsteady-state model.

Results of the analysis indicate that under current and build-out conditions the dam does not meet the principal spillway capacity criteria because the 10-day drawdown requirement is not met during the passage of the principal spillway hydrograph (PSH). The dam is overtopped under existing and potential future watershed build-out conditions by 1.64 feet and 1.70 feet, respectively. Consequently, the dam does not meet the design freeboard criteria since it does not allow for passing of the FBH without overtopping the dam.

Stability (surface erosion potential) and integrity (breaching potential) of the auxiliary spillway were also evaluated by routing the stability design hydrograph (SDH) and FBH, respectively. The results of the analysis indicate that under current and build-out conditions concentrated flows will likely develop during the passage of design storms, ultimately resulting in severe headcut erosion and likely breaching of the auxiliary spillway. The HEC-RAS computer program and its Dam Breach component were used to perform breach analysis of the dam during a PMF flood event. The results of analysis predict that a breach of Rawson Hill Brook Dam would occur 3.9 hours from the beginning of the PMP event. The peak flows associated with the PMF breach event are expected to be an order of magnitude greater than the 100-year flood event for Rawson Hill Brook and the Assabet. Maximum water surface elevations resulting from the breach wave progression were used to estimate inundation areas downstream of the dam.

Environmental Justice: MassGIS data (2003) depicting Environmental Justice Zones was reviewed to determine if there were any zones within close proximity to the dam. The data shows that there are no Environmental Justice Zones in the vicinity of the project site. Refer to the Environmental Justice Environmental Procedures Guidesheets (NECH 610.27) as part of the NRCS-CPA-52.

Essential Fish Habitat: To analyze whether rehabilitation of the dam will impact essential fish habitat, National Oceanic and Atmospheric Administration's (NOAA) Essential Fish Habitat Mapper[34] was reviewed. The mapper shows that there is no essential fish habitat within close proximity to the dam. As such, further analysis regarding potential impacts to essential fish habitat is not warranted. Refer to the Essential Fish Habitat Environmental Procedures Guidesheets (NECH 610.28) as part of the NRCS-CPA-52.

Floodplain Management: The 100-year floodplain (MassGIS 1997) was reviewed to determine what, if any, impacts rehabilitation of the dam would have on the floodplain. As a result of the review, it was determined that rehabilitation of the dam will likely not impact the downstream floodplain. In fact, because the rehabilitation will bring the dam into federal and state dam safety criteria and standards, the downstream floodplain will benefit from the rehabilitation. The rehabilitation will reduce the potential of the dam from failing. Failure of the dam would result in high velocity flows through the auxiliary spillway and downstream of the dam which would

[34] NOAA Essential Fish Habitat Mapper. Available [online]: <http://sharpfin.nmfs.noaa.gov/website/EFH_Mapper/map.aspx>. Accessed October 5, 2011.

likely cause heavy erosion and sedimentation of the downstream floodplain. Refer to the Floodplain Management Environmental Procedures Guidesheets (NECH 610.29) as part of the NRCS-CPA-52.

Hydrology: NRCS prepared an assessment report on the Rawson Hill Brook Floodwater Retarding Dam in 2005 based on a comprehensive study in 2005 of the hydrologic conditions of the dam for existing and future watershed build-out conditions. The study evaluated the hydrological parameters of Rawson Hill Brook watershed using Massachusetts dam safety design criteria and NRCS dam safety and design standards, with NRCS runoff curve numbers for existing and future build-out conditions of 72 and 81.2, respectively, and a time of concentration of approximately 3.50 hours.

Using the SITES and WinDAM models, the Rawson Hill Brook Dam was evaluated with the SITES and WinDAM models using NRCS dam safety and design standards and was determined to be a High Hazard structure in accordance with federal standards. The Principal Spillway Hydrograph (PSH) was based on the 100-year frequency and 10-day storm duration. The stability design hydrograph (SDH) used a precipitation amount greater than the 100-year event and less than the probably maximum precipitation (PMP) and a 6-hour design storm for developing the Auxiliary Spillway Hydrograph. The 2005 Dam Assessment Report indicated that the Rawson Hill Brook Dam does not meet all of the NRCS and Massachusetts design criteria under existing or future build-out conditions.

For NRCS design criteria, the top of the dam is overtopped by 1.64 feet to 1.70 feet for current and ultimate build-out land use conditions, respectively, during both the FBH and the 5-point PMP 24-hour Storm. Maximum permissible velocities within the auxiliary spillway are also exceeded for Massachusetts dam safety criteria.

Invasive Species: During infield investigations, plant communities were identified throughout the site. In particular, the presence of invasive species was noted. As a result of the infield investigations, several invasive species including common reed (*Phragmites australis*), purple loosestrife (*Lythrum salicaria*), and reed canary grass (*Phalaris arundinacea*). Although the presence of invasive species was noted at the site, they were observed in only sporadic clusters. In order to reduce the potential of construction activities transporting invasive species material to or from the site, best management practices will be employed to ensure that rehabilitation of dam does not spread invasive species material. Refer to the Invasive Species Environmental Procedures Guidesheets (NECH 610.30) as part of the NRCS-CPA-52.

Migratory Birds / Bald and Golden Eagle Protection Act: The Migratory Birds Treaty Act[35] seeks to protect migratory birds. As such, the law makes it illegal to pursue, hunt, take, capture, kill or sell protected birds. The Bald and Golden Eagle Protection Act[36] prohibits the "taking" of bald and golden eagles.

During the infield investigations, numerous species of migratory birds where observed. However, it is likely that these species will not be harmed as a result of dam rehabilitation. The

[35] 16 U.S.C. §§703-717
[36] 16 U.S.C. 668-668d

majority of the project impacts will occur on the dam itself (i.e., embankments, spillways, dikes, etc.). These areas are routinely mowed and do not provide suitable habitat for migratory species. It is likely that migratory species that may be affected by rehabilitation of the dam will relocate to other areas adjacent to the proposed project area during construction. Once construction has been completed, it is expected that those species will return to the area.

There is no suitable habitat for bald (*Haliaeetus leucocephalus*) or golden eagles (*Aquila chrysaetos*) at the site. Additionally, the bald eagle is a state-listed endangered species. If bald eagles were known to occur in the vicinity of the site, the NHESP would have identified such an occurrence during their project review. As such, it is highly unlikely that the project would affect any bald or golden eagles.

Refer to the Migratory Bird and Bald and Golden Eagle Environmental Procedures Guidesheets (NECH 610.31) as part of the NRCS-CPA-52.

Plants: During the infield site investigation, vegetative communities were noted as they occurred throughout the site. Plant species in each vegetative community were noted. The majority of the site consists of upland forests and wetland habitats.

Construction activity would likely result in minor impacts affecting the vegetation due to the installation of the proposed armoring of the auxiliary spillway and raising of the embankment and dikes. However, at the completion of construction, equipment would be removed and the disturbed area would be restored.

Prime and Unique Farmlands: The list of Prime and other Important Farmland Soils (NRCS 2007) was reviewed to determine what soils are considered to be prime or unique farmland soils in Worcester County, Massachusetts. Soil mapping data resources (NRCS 2007b) were reviewed to determine the extent of any prime and/or unique farmland soil mapped on the site.

In total, there are 190 acres of prime and unique farmland soils mapped in the drainage area of the dam. In the downstream floodplain, 48 acres of prime and unique farmland soils are mapped. Refer to the Prime and Unique Farmland Environmental Procedures Guidesheets (NECH 610.32) as part of the NRCS-CPA-52.

Riparian Areas: Riparian areas are generally described as habitats that exist in the vicinity of the interface between watercourses and land. In order to determine the extent of riparian areas in the vicinity of the dam, available watercourse mapping data (MassGIS 2000) was reviewed to identify areas on the site where riparian areas likely existed. During infield investigations, these areas were traversed to determine the condition of riparian habitat in the vicinity of the dam.

Riparian areas were identified along the banks of the Rawson Hill Brook. In general, these areas consisted of forested floodplain, forested wetland, and upland forest habitat. Refer to the Riparian Area Environmental Procedures Guidesheets (NECH 610.33) as part of the NRCS-CPA-52.

Socioeconomics: Sources for the data included in the social and economic conditions section of this supplement include the U.S. Census Bureau, Department of Commerce, 2000 and 2010 Census, and interviews conducted with local contacts.

Sedimentation: Excessive sedimentation can reduce flood storage volume and clog spillways, reducing the hydraulic efficiency of the dam. Sedimentation of the Rawson Hill Brook Dam over the past 48 years has been minimal, and failure due to sedimentation is not probable. There is no permanent pool at the Rawson Hill Brook Dam; therefore, sedimentation upstream of the dam is not a concern.
A limited reservoir sediment survey was completed by the NRCS on 19 July 2012 (NRCS 2012). During that survey, hand excavated test holes were advanced as select locations within the sediment basin to characterize the thickness of the total sediment profile. The test holes indicated that the sediment profile thickness varied between 6 to 12 inches at sampling points and were averaged to 9 inches for current conditions.

An estimate of sediment storage volume for the dam was determined by the NRCS in 2009 for the planned build-out. The drainage area of 1.49 square miles used in the 2009 sedimentation design analyses varies from a reported value of 1.59 square miles proposed by AMEC in their 2010 report (NRCS 2012). That discrepancy may be attributed to previous use of out-dated watershed data and revised data from more sophisticated mapping through the use of GIS. It was recommended that the drainage area be revised in the analysis to reflect the most current value which, in turn, increases the calculated sediment delivered to the site to 59 tons/year (present) from 48 tons/year and 82 tons/year (future) from 71 tons/year (NRCS 2012).

The sediment delivery ratio of 20 percent appears to be valid based on the observed sediment accumulation data (NRCS 2012). Sedimentation of the dam over the current service-life has been minimal despite increases in urban development within the upstream drainage area . No known quantities of sediment were dredged or otherwise romved from the facility, altering the reliability of the measured sediment yield. As a result, sedimentation upstream of the dam shoud not be considered a principle concern and failure due to sediment is not probable.

Soil: NRCS (2007b) soil mapping data for Worcester County, Northeastern Part, and Massachusetts was reviewed to determine the soil types mapped in the vicinity of the dam. Review of the soils mapping for site shows that several major soil types are mapped in the area of dam including Hinckley sandy loam, Sudbury fine sandy loam, Paxton fine sandy loam, and Woodbridge fine sandy loam.

Wetlands: A field survey was conducted by EA Engineering, Science, and Technology, Inc. (EA) to identify and assess wetlands upstream and downstream of the dam in the potential construction area. Wetlands identified include Bordering Vegetated Wetlands, Land Under Water Bodies, Banks, and Rivers.

Based on the surveys and the conceptual project design, most of the construction for dam rehabilitation would occur within the existing area previously disturbed for construction of the dam and maintained as mowed grass. Refer to the Wetlands Environmental Procedures Guidesheets (NECH 610.34) as part of the NRCS-CPA-52.

Wild and Scenic Rivers: The Wild and Scenic Rivers Act[37] established the National Wild and Scenic Rivers System. To determine if any Wild and Scenic Rivers were present in the vicinity of the dam, the River Mileage Classification for Components of the National Wild and Scenic Rivers System (NPS 2011b) was reviewed. According that list, the Assabet River (of which the Cold Harbor Brook is a tributary which the Rawson Hill Brook discharges into) is listed. The section of the Assabet River is located downstream of the dam from 1,000 feet downstream of the Damon Mill Dam to its Confluence with the Concord River. This section of the river, approximately 4.4 miles, is located completely within the Town of Concord, Massachusetts. Refer to the Wild and Scenic Rivers Environmental Procedures Guidesheets (NECH 610.35) as part of the NRCS-CPA-52.

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[37] 16 U.S.C. 1271-1287

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APPENDIX E

OTHER SUPPORTING INFORMATION

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Appendix E-1

Consultation and Public Scoping Process

Stakeholder agencies that were contacted concerning the proposed project are:

- Worcester County Conservation District
- Massachusetts Department of Conservation and Recreation
- Massachusetts Department of Fish & Game, Division of Fisheries and Wildlife
- Massachusetts Department of Fish & Game, Riverways Program
- Massachusetts Department of Environmental Protection
- Town of Shrewsbury
- Organization for the Assabet River
- Massachusetts Executive Office of Energy and Environmental Affairs
- EPA Region 1,Regulatory
- USACE, Regulatory Division
- Massachusetts Office of Dam Safety

In a letter dated November 17, 2011, SHPO agreed that the proposed project would not have any effect on historical properties. Coordination the THPO of the Wampanoag Tribe of Gay Head (Aquinnah) is currently ongoing to determine the presence of any cultural or historical resources within the proposed project area. Any response from the THPO will be included in subsequent drafts of this plan.

A "no species present" letter was obtained from the FWS, which indicates that no federally listed threatened or endangered species are known to occur within the area. It was determined from MassGIS that there was no habitat for a state-protected species lies in the Hop Brook floodplain. Consultation with NHESP is continuing; ultimately, DCR is responsible for completing the consultation and obtaining any permits that may be required.

A public meeting was held in the Town of Berlin on May 24, 2011, to explain the Watershed Rehabilitation Program, obtain public input on the project, and scope resource problems, issues, and concerns of local residents associated with the Rawson Hill Brook Dam project area. The meeting was widely advertised to reach everyone in the watershed including minorities. NRCS distributed a press release on May 6, 2011, that resulted in an article about the meeting in the Metro West Daily News on May 25, 2011.

Potential alternative solutions to bring the Rawson Hill Brook Dam into compliance with current dam safety criteria were presented at the public meeting. A fact sheet summarizing the planned rehabilitation projects at six dams in the SuAsCo watershed was distributed at the meeting. Members of the public attended the meeting. No verbal or written comments have been received in the intervening time to the publishing of this plan.

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Appendix E-2

Regulatory Correspondence

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United States Department of the Interior

FISH AND WILDLIFE SERVICE
New England Field Office
70 Commercial Street, Suite 300
Concord, New Hampshire 03301-5087
http://www.fws.gov/northeast/newenglandfieldoffice

January 2, 2009

To Whom It May Concern:

This project was reviewed for the presence of federally-listed or proposed, threatened or endangered species or critical habitat per instructions provided on the U.S. Fish and Wildlife Service's New England Field Office website:

(http://www.fws.gov/northeast/newenglandfieldoffice/EndangeredSpec-Consultation.htm)

Based on the information currently available, no federally-listed or proposed, threatened or endangered species or critical habitat under the jurisdiction of the U.S. Fish and Wildlife Service (Service) are known to occur in the project area(s). Preparation of a Biological Assessment or further consultation with us under Section 7 of the Endangered Species Act is not required.

This concludes the review of listed species and critical habitat in the project location(s) and environs referenced above. No further Endangered Species Act coordination of this type is necessary for a period of one year from the date of this letter, unless additional information on listed or proposed species becomes available.

Thank you for your cooperation. Please contact Mr. Anthony Tur at 603-223-2541 if we can be of further assistance.

Sincerely yours,

Thomas R. Chapman
Supervisor
New England Field Office

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Commonwealth of Massachusetts

Division of Fisheries & Wildlife

MassWildlife

Wayne F. MacCallum, *Director*

October 20, 2011

P. Chase Bernier
EA Engineering, Science and Technology
2374 Post Road, Suite 102
Warwick RI 02886

RE: Project Location: Rawson Hill Brook Dam
Town: SHREWSBURY
NHESP Tracking No.: 11-30192

To Whom It May Concern:

Thank you for contacting the Natural Heritage and Endangered Species Program ("NHESP") of the MA Division of Fisheries & Wildlife for information regarding state-listed rare species in the vicinity of the above referenced site.

Based on the information provided, the NHESP has determined that at this time the site is not mapped as Priority or Estimated Habitat. The NHESP database does not contain any state-listed species records in the immediate vicinity of this site.

This evaluation is based on the most recent information available in the NHESP database, which is constantly being expanded and updated through ongoing research and inventory. If you have any questions regarding this letter please contact Lauren Glorioso, Endangered Species Review Assistant, at (508) 389-6361.

Sincerely,

Thomas W. French

Thomas W. French, Ph.D.
Assistant Director

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The Commonwealth of Massachusetts
William Francis Galvin, Secretary of the Commonwealth
Massachusetts Historical Commission

November 17, 2011

P. Chase Bernier
Project Scientist
EA Engineering Science & Technology Inc.
2374 Post Road Suite 102
Warwick RI 02886

RE: Rawson Hill Dam Rehabilitation, Birch Brush Road, Shrewsbury, MA. MHC #RC.51638.

Dear Mr. Bernier:

Staff of the Massachusetts Historical Commission, office of the State Historic Preservation Officer, have reviewed the information that you submitted for the project referenced above, for installation of a labyrinth weir in the auxiliary spillway.

Review of the MHC's Inventory of Historic and Archaeological Assets of the Commonwealth identified no inventoried historic or archaeological resources.

The MHC does not recommend additional identification effort for the project.

The MHC recommends that the Natural Resource Conservation Service make a finding of "no historic properties affected" (36 CFR 800.4(d)(1)) for the undertaking.

These comments are offered to assist in compliance with Section 106 of the National Historic Preservation Act of 1966 as amended (36 CFR 800). Please contact Edward L. Bell of my staff if you have any questions.

Sincerely,

Brona Simon
State Historic Preservation Officer
Executive Director
Massachusetts Historical Commission

xc:
Thomas Akin, NRCS
Shrewsbury Historical Commission

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