July 8, 2010

Scientists, Engineers & Environmental Planners Designing Innovative Solutions for Water, Wetland and Soil Resource Management

MEMORANDUM REPORT

To: Joyce Kennedy Raymes
Study Coordinator
Lower Farmington River/Salmon Brook
Wild & Scenic Study
749 Hopmeadow Street
Simsbury, CT 06070

From: Laura Wildman, P.E.
Princeton Hydro Engineering, PC
20 Bayberry Road
Glastonbury, CT 06033

cc: Geoff Goll, P.E.

Re: Tariffville Gorge Hydrologic Study
Discussion of Upper Wild & Scenic Boundary for Rainbow Dam
Farmington River
Project No. 1036.007

Introduction and Data Reviewed

Princeton Hydro Engineering, PC (Princeton Hydro) has been retained by the Lower Farmington River / Salmon Brook Wild & Scenic Study Committee to perform a cursory hydrologic study of the Tariffville Gorge area of the Farmington River, based on existing data, to estimate the extent of the current Rainbow Dam impoundment, give recommendations regarding two different potential boundary locations between the Farmington River's Wild & Scenic designated reach and the exempt Rainbow Dam's impounded reach, and comment on the potential impacts related to raising the existing flashboards or the crest of the Rainbow Dam to some height greater than which currently exists. This study assesses whether pushing the Wild & Scenic boundary further upstream, to extend the reach exempted from the Wild & Scenic designation by the Rainbow Dam impoundment as requested by Stanley Black & Decker (SBD), would impact the recreational resources of the Tariffville Gorge. Recreational resources considered for potential impact included the bedrock features exposed as a result of the proposed removal of the Spoonville Dam and the Tariffville Gorge whitewater run.

As part of this analysis Princeton Hydro Engineering reviewed the following documents:

- The Alford Survey provided by Stanley Black & Decker (SBD) to substantiate the vertical datum utilized.

- The bathymetric survey and base mapping completed by Princeton Hydro for the Farmington River Watershed Association for the Spoonville Dam Fish Passage Improvements, dated January 12, 2010.
- The effective FEMA Flood Insurance Study (FIS) and water surface profiles for the Farmington River, dated September 26, 2008. The data for the 2008 effective FEMA FIS was apparently compiled using older Flood Insurance Studies for the Town of Bloomfield (FIS 1991) and the Town of Windsor (FIS 1986). However the 2008 FIS is unclear as to what was revised or resurveyed for a later revision of the water surface modeling in 1993.
- The FEMA floodplain mapping index sheet stating that FEMA used NAVD88 as the vertical control for the effective FEMA FIS and mapping.
- Datum information in tabular format from Kurt Link, dated 5/19/10
- Rainbow Reservoir Dam Elevations in tabular format compiled by J. Bolton, dated 3/13/10 and GIS mapping of the Estimated Rainbow Reservoir Impoundment Areas prepared by J. Bolton.
- An update memo of the Lower Farmington River / Salmon Brook Wild & Scenic Study prepared by the chair of the Wild & Scenic Committee for the purposes of background and context..
- MDC transmittal letter to Princeton Hydro regarding the MDC datum used for the January 12, 2010 Spoonville Dam Fish Passage Improvements Plans.
- A phone call to and e-mail from MDC regarding their datum for their GIS mapping, used in preparation of the January 2010 Spoonville Dam Fish Passage Improvements Plans.
- A page from The Metropolitan District's contract with James W. Sewall Company (RFP 178-Aerial Photography, Photogrammetry and Digital Orthophotography for the Metropolitan District Service Area) referencing the MDC's GIS interactive mapping service horizontal datum (NAD83) and vertical datum (NAVD88) and stating that the data was collected by a flight by James W. Sewall in the Spring of 2002 and Spring of 2003. And the data is complied in accordance with ASPRS accuracy standards for Class I large-scale digital mapping.
- A phone call to Alford Survey on June 14, 2010 confirming their datum used in preparation of their May 6, 2010 topographic survey and their October 9th, 1989 survey for the Property of the Farmington River Power Company, East Granby, CT.
- Attendance at one Wild & Scenic Study Committee meeting on June 14, 2010 and multiple conversations via telephone with Ms. Joyce Kennedy at the Farmington River Watershed Association.

Discussion of Survey Datum

From the review of the documents listed above it is now clear that two different vertical datum have been used while discussing the Rainbow Dam structural elevations and impoundment elevations. The two datum discussed are an assumed MDC datum, which is no longer in use, and the North American Vertical Datum of 1988, typically referred to as NAVD88. Below we clarify which vertical datum is used for each piece of data or mapping reviewed for this study. For the purpose of this study we will primarily refer to elevations based on NAVD88.

Assumed MDC Datum: The MDC formerly used an assumed datum, unique to MDC. The elevations using this datum are consistently 2.7 feet higher than elevations using the NAVD88 datum. This

assumed MDC datum is no longer used for the digital mapping distributed by MDC, however older paper MDC maps may still show elevations using this assumed datum. The following mapping, assessed for this review of the Rainbow Dam's impoundment, uses the now obsolete assumed MDC datum.

- May 6, 2010 topographic survey by Alford Associates, Inc.
- October 9th, 1989 survey for the Property of the Farmington River Power Company, East Granby, CT, by Alford Associates, Inc

NAVD88: North American Vertical Datum of 1988. The following mapping and water surface profile modeling, assessed for this review of the Rainbow Dam's impoundment, use the NAVD88 datum.

- Current MDC GIS Mapping
- The 2008 effective FEMA Flood Insurance Study, water surface profiles, and floodplain mapping.
- Princeton Hydro Engineering's January 2010 bathymetric mapping and base mapping for the Spoonville Dam Fish Passage Improvements
- Connecticut's LIDAR Elevation Data
- Macchi Engineers, LLC June 2007 mapping for DEP's Improvements to the Rainbow Dam Fishway (referred to in J. Bolton's 3/13/10 review of the Rainbow Reservoir Dam Elevations but not reviewed as part of this study)

The following is a summary of critical elevation data relating to the Rainbow Dam listing both datum, as modified by the table sent to us by Kurt Link on 5/19/10.

Critical Rainbow Dam Elevations	Obsolete Assumed MDC Datum*	NAVD88*	Comments
Height to Crest of 53 ft. high by 400 ft. wide Concrete Dam	94.4	91.7	FRP dam crest (concrete)
Height to Top of 6 ft. High Flash Boards	100.4	97.7	+ 6' over dam crest
Height of FRPCo. Flowage Right Easement Around Impoundment Banks	107.4	104.7	+ 13' over dam crest

* All elevations are in feet

In order to clarify the datum confusion from past discussions of the Rainbow Dam's upper Wild & Scenic boundary, we will always refer to the datum of any elevation discussed in this study.

Water Surface Elevation Analysis to Estimate Impoundment Extent

The primary analysis completed for this study was a review of the 2008 effective FEMA water surface profile for the Rainbow Dam, and a determination of where the critical Rainbow Dam Elevations listed in the previous table intersect with the riverbed. In addition, we used the 2008 effective FEMA water surface profile for the Rainbow Dam to estimate the likely extent of the dam's impoundment, under the

10-yr, 50-yr, 100-yr and 500-yr reoccurrence interval storm events modeled in the 2008 effective Flood Insurance Study, at approximately 11,000 feet upstream of Rainbow Dam.

Figure 1, entitled "Rainbow Dam Impoundment – 2008 Effective FEMA Water Surface Profile Model ", shows where the crest of the Rainbow Dam spillway (91.7 NAVD88), the top of the existing 6-foot flash boards (97.7 NAVD88), and the flowage right easement at 13-foot above the crest of the dam (104.7 NAVD88), intersect with the riverbed on the FEMA water surface profile. In addition Figure 1 also demonstrates that the Rainbow Dam impoundment extends approximately 11,000 feet upstream from the Rainbow Dam under the 10-yr, 50-yr, 100-yr, and 500-yr FEMA storm flows modeled.

Figure 2, entitled "Proposed Conditions – Spoonville Dam Fish Passage Improvements", shows a delineation of the 97.7 NAVD88 contour representing where the elevation of the top of the existing 6-foot flashboards intersects the riverbed, as well as a delineation of the 104.7 NAVD88 contour representing where the elevation of the FRPCo. Flowage right easement, 13-feet above the crest of the Rainbow Dam, would intersect the riverbed, based on the October 12, 2009 bathymetric survey by Princeton Hydro, using the NAVD88 datum.

A summary of this data is provided in the table below:

Critical Rainbow Dam Elevations	Intersection with the Riverbed*
Rainbow Dam spillway (91.7 NAVD88)	Elevation 91.7 (NAVD88) currently intersects the riverbed approximately 700 feet downstream of the Route 187 Bridge Crossing
Top of the existing 6-foot flash boards (97.7 NAVD88)	Elevation 97.7 (NAVD88) currently intersects the riverbed at the breach in the Spoonville Dam.
FRPCo. Flowage right easement at 13-foot above the crest of the dam (104.7 NAVD88)	Elevation 104.7 (NAVD88) currently intersects the riverbed at the base of the renowned whitewater run at the upper end of the current Spoonville Dam impoundment.

* Based on the 2008 FEMA profile and then refined where possible with the October 12, 2009 bathymetric survey taken to prepare the January 12, 2010 design plans for the Spoonville Dam Fish passage Improvements Project.

Note: Based on visual observations the 97.7 NAVD88 contour may actually first intersect with the riverbed within the channel that was previously lowered to act as the tailrace for the Spoonville Dam, however we have no bathymetric data in this area to confirm this.

The riverbed location where these critical Rainbow Dam elevations intersect the riverbed represent the uppermost possible limit of the Rainbow Dam's impoundment if the dam crest was at 91.7 NAVD88 (the current spillway crest), 97.7 NAVD88 (the current dam crest elevation if the 6-ft flashboards are left on), and 104.7 NAVD88 (if the dam crest was raised 13 feet above the current crest elevation), and if there was little to no flow in the Farmington River. However the actual extent of backwater induced due to these varying crest elevations would actually be further downstream, as seen by the extent of the impoundment shown on the FEMA profile for the 10-yr, 50-yr, 100-yr and 500-yr storm events, which were modeled with a crest elevation of 91.7 NAVD88 since it was assumed the 6-foot flashboards would blow out during those storm events. The FEMA profile actually shows that the dam's impoundment created with a crest elevation of 91.7 NAVD88 only extends approximately 11,000 feet upstream of the dam during these storm events (or approximately 9,000 feet downstream of the Route 187 Bridge crossing). The upper end of the impoundment created by the dam without flashboards would,

therefore, likely under more typical non-storm flow events, be downstream of the Windsor/Bloomfield town line. And the upper end of the impoundment created by the dam with 6-ft of flashboards would likely, under more typical non-storm flow events, be downstream of the Route 187 Bridge crossing and highly likely downstream of the FRPCo.'s requested upstream boundary (approx. 425 feet downstream from the downstream face of Spoonville Dam) as per Alford Associates' May 6, 2010 topographic survey. Given the limited amount of data we have for this study, Princeton Hydro is reasonably confident that the FRPCo.'s requested upstream boundary shown on the Alford Associates' May 6, 2010 topographic survey will protect the current operations of the Rainbow Dam without allowing future water surface elevation increases upstream of the proposed FRPCo. boundary, due to changes in current dam operations, that could potentially impact the renowned Tariffville Gorge whitewater course and the bedrock features that will be exposed if the Spoonville Dam is removed upstream. However, the exact extent of the Rainbow Dam's impoundment under current operations (or any future operations) could be determined if the effective FEMA model was updated and run at different dam crest elevations for non-storm event flows and the dam's inflow design flow.

An effort was made to obtain the original water surface profile model used to create the 2008 effective FEMA water surface profiles for the reach between the Spoonville Dam and the Tariffville Gorge, however according to FEMA the model was only for a portion of the reach, including FEMA cross sections M through Q, which extend from the Windsor town line to the just downstream of the Spoonville Dam. However, a further investigation of the microfiche data received from FEMA indicates that the model likely extends from the Rainbow Dam to Tunxis Avenue upstream of the Spoonville Dam site, although it appears the Rainbow Dam spillway itself was not modeled. The microfiche input from this model could potentially be typed in and converted to a modern HEC-RAS water surface profile such that different dam crest elevations and flow events, associated with more common flows for the Farmington River, could be run to better define the Rainbow Dam's impounded reach under current typical dam operations. At that time it would likely be necessary to add more information regarding the specific crest geometry for the Rainbow Dam. This larger modeling effort is outside the scope of this study, but can be completed if additional assurance is requested.

FRPCo. Flowage Rights and Requested Upstream Boundary

Although no formal record was produced for review of the deed that gives the Farmington River Power Company the flowage rights to a contour line 13 feet above the dams current crest, the Alford survey map dated October 9th, 1989, entitled Property of the Farmington River Power Company, East Granby, CT refers to an elevation of 107.4 based on the old MDC datum (equivalent to 104.7 NAVD88), 13 feet above crest of Rainbow Dam. The 1989 mapping also references a deed (Volume 116, page 191) with the quote "boundary follows a contour line 13 feet above the crest of the concrete dam now located in Rainbow". We have been told that this flowage right ended at the former Route 187 Bridge Crossing, just downstream of the current Route 187 Bridge Crossing, however again we were provided with no document to confirm this information. According to the May 6, 2010 Alford Associates topographic survey the 107.4 (old MDC datum) contour interval (equivalent to 104.7 NAVD88) is approximately midway up the riverbank for the river water surface elevation surveyed on that day in the area where the old Route 187 Bridge abutments are still visible along the River.

At first, the newly proposed FRPCo. upstream boundary seemed relatively random in nature, since it corresponds with an edge of water elevation of approximately 104.4 NAVD88 (~107.1 in the old MDC datum) on the Bloomfield side and approximately 100.7 NAVD88 (~103.4 in the old MDC datum) on the

E. Granby side, and no bathymetric data (instream elevations) were provided such that the extent of the impoundment could be determined under flow conditions different than the single event surveyed for the May 6, 2010 mapping by Alford Associates. However in an e-mail dated June 1, 2010 from Kurt Link at Stanley Works, we were informed that the newly proposed upstream boundary was meant to protect ongoing dam operations to 2 feet above the height of the existing flashboard elevation of 97.7 NAVD88 to an elevation of 99.7 NAVD88 (equivalent to an elevation of 102.4 in the old MDC datum). The additional 2 feet above the current flashboard elevation represents the depth of water over the flashboards during a "normal high flow" which is stated to typically occur several times a year. However, no statistical flow event was used to define "normal high flows", so it is unclear exactly what flow this represents. It may be that the 2 feet above the current flashboard elevation represents the point of incipient failure for the flashboards, and therefore may equate to a flow where the impoundment extent is at its maximum, but this has not been confirmed with FRPCo. According to the May 6, 2010 Alford Associates topographic survey the 99.7 NAVD88 contour (equivalent to an elevation of 102.4 in the old MDC datum) intersects with the river's water surface elevation on that particular day about midway along the HELCO Island. The upper end of the HELCO Island was then selected by FRPCo. to provide an adequate buffer above the 99.7 NAVD88 elevation (102.4 old MDC datum – 2 feet above the top of flashboards) and set a recognizable landmark as the boundary. It is noted that the water surface elevation was approximately 1.4 feet higher during the May 6, 2010 Alford topographic survey as compared to the October 12, 2009 bathymetric survey that was conducted by Princeton Hydro for the Spoonville Dam Fish Passage Improvements design.

It would be helpful for us to better understand if the 2 foot depth above the flashboards elevation represents the point of incipient failure for the flashboards, and if this is meant to represent "normal high flow", or if not what is truly meant by "normal high flow". We also caution that the HELCO Island is not a fixed feature and that the final description of the agreed upon upper boundary be based on a distance from a fixed feature or specific coordinates, such that it can be easily identified in the future.

Conclusions

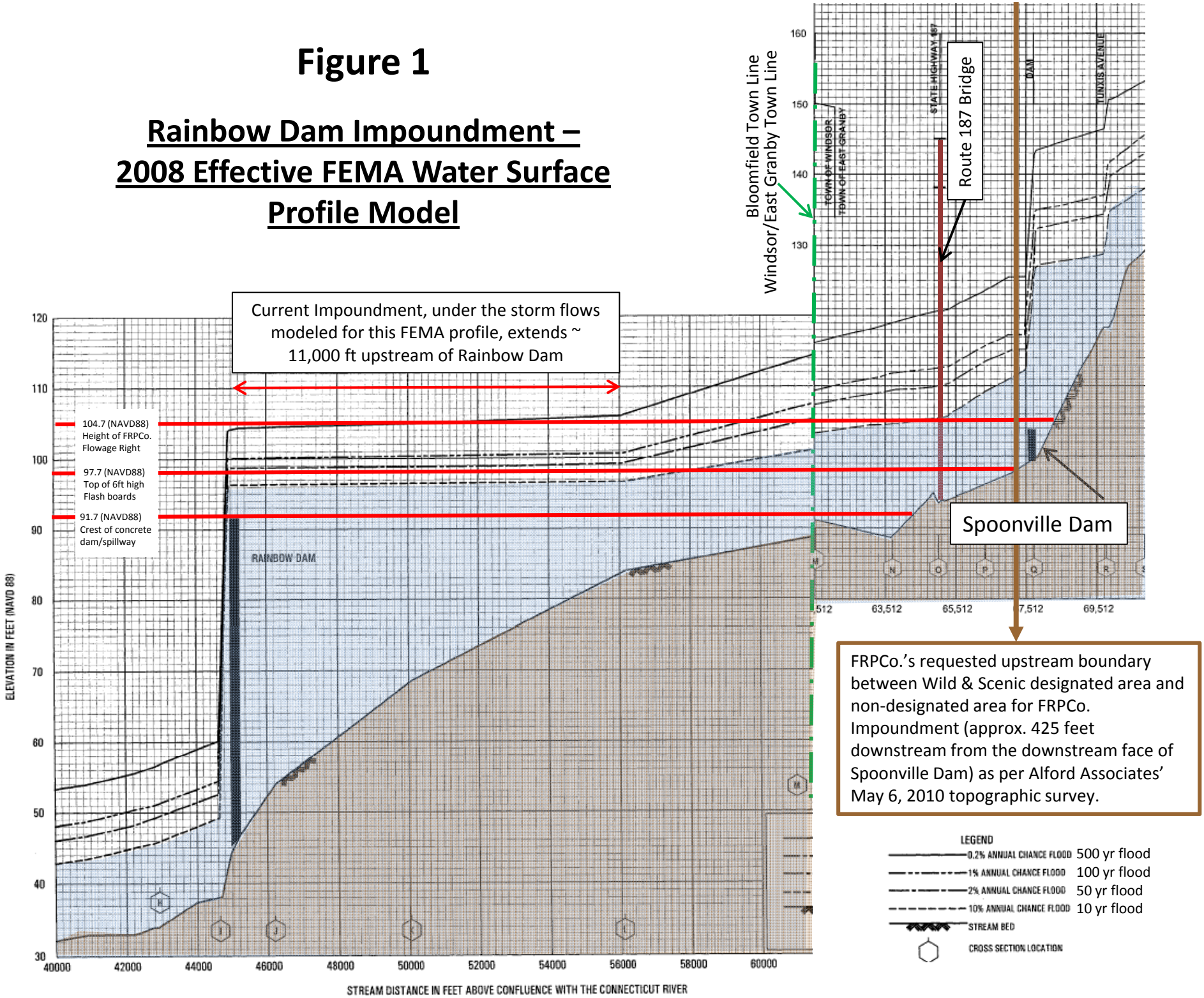
1. Given the limited amount of data we have for this study, Princeton Hydro is reasonably confident that the current Rainbow Dam impoundment is below the upstream boundary requested by FRPCo. as shown on the Alford Associates' May 6, 2010 topographic survey and is possibly below the Route 187 Bridge Crossing. The delineation of the impoundment can be more definitively determined if the effective FEMA model, currently on microfiche, is converted to a modern HEC-RAS model and run with the flashboards in condition for the "normal high flow" described by FERC as the flow used to determine the impoundment reach. However the actual quantity of flow described as the "normal high flow" would need to be better defined by either FERC or FRPCo. Perhaps the point of incipient failure of the flashboards would be best used to define the "normal high flow".
2. If the dam crest or future flashboards were raised above their current elevations the resulting increase in impoundment length and depth could potentially submerge the lower portion of the renowned Tariffville Gorge whitewater course and the bedrock features that will be exposed if the Spoonville Dam is removed upstream. The exact extent of this impact can only be determined with an updated water surface profile model, the specifics of any proposed increases in dam or flashboard elevation, and agreement on what flows should be assessed.
3. Shifting the upstream end of the boundary between the Wild & Scenic designated area and the non-designated area for FRPCo.'s impoundment from the old Route 187 Bridge abutments to

the upstream end of HELCO Island , as shown on the May 6, 2010 Alford Associated topographic survey, will not impact the recreational resources of the Tariffville Gorge, since all of the current and potential future whitewater features are upstream of this location. It is assumed that by setting the upstream boundary at the upstream end of HELCO island that increases in water surface elevation above this location will not be allowed in the future, in the event that the operations at Rainbows Dam are ever altered, thereby protecting the Tariffville Gorge white water run and any bedrock features exposed if the remainder of the Spoonville Dam is removed. However, moving the boundary upstream does potentially expose the reach from the old Route 187 Bridge abutments to the upstream end of HELCO Island to additional inundation if operations at the Rainbow Dam propose future increases in inundation elevation. In preparation of this study, we had no data regarding what recreational or ecological resources might exist in the reach between the old Route 187 Bridge abutments to the upstream end of HELCO Island.

4. It is our recommendation, based on the information we have reviewed, that establishing the FRPCo. proposed boundary at the upstream end of HELCO Island will likely protect both existing hydro operations at Rainbow Dam as well as protect the recreational resources of the Tariffville Gorge, by not allowing future water surface elevation increases above the upstream end of HELCO Island as a result of any future changes in dam operation. In addition establishing the proposed boundary at the former Route 187 Bridge crossing will also protect the recreational resources of the Tariffville Gorge and any additional recreational or ecological resources between the upstream end of HELCO Island and the former Route 187 Bridge crossing, however in order for us to determine if the former Route 187 Bridge crossing boundary will protect current Rainbow Dam operations we would need more information regarding the definition of “normal high flow”, the dam’s inflow design flow, and would need to run an updated version of the FEMA water surface profile model.

Figure 1

Rainbow Dam Impoundment – 2008 Effective FEMA Water Surface Profile Model



Drawing name: P:\1036\Projects\1036001\CAD\Sheets\Revised_03152010\SHEET_3_PROPOSED_CONDITIONS.dwg Plotted on: Jun 09, 2010 - 6:16pm

UPSTREAM EXTENT OF IMPOUNDMENT UNDER TYPICAL FLOWS UNDER EXISTING CONDITIONS

EXISTING THALWEG (TYP.)

Delineation of the 104.7 NAVD88 contour representing where the elevation of the FRPCo. Flowage right easement, 13-feet above the crest of the Rainbow Dam, would intersect the riverbed.

Delineation of the 97.7 NAVD88 contour representing where the elevation of the top of the existing 6-foot flashboards intersects the riverbed.

EXISTING BREACH ANTICIPATED TO BECOME SECONDARY FLOW PATH

EXISTING CHUTE AND SCOUR HOLE TO RECEIVE LESS FLOW. SOME DEPOSITION POSSIBLE IN SCOUR HOLE.

SEDIMENT DEPOSITS BEHIND DAM ARE ANTICIPATED TO BE TRANSPORTED DOWNSTREAM
AVG. DEPTH OF SEDIMENT: 18" - 24"
ESTIMATED VOLUME: 512 C.Y.
NO EXCAVATION REQUIRED

EXISTING CONCRETE FRAGMENTS TO BE REMOVED
- ESTIMATED TOTAL CONCRETE VOLUME: 400 C.Y.:
  - "CAR ROCK" -- 35 C.Y.
  - "AIRCRAFT CARRIER" -- 350 C.Y.
  - UNNAMED FRAGMENT -- 15 C.Y.

CONTOURS SHOWN IN RIVER CHANNEL HAVE BEEN APPROXIMATED AND WILL VARY UNDER FINAL CONDITIONS DEPENDING ON ACTUAL CONFIGURATION OF UNDERLYING BEDROCK AND RIVER BOTTOM. BEDROCK FORMATION UNDER EXISTING DAM IS INTERPOLATED FROM SURVEYED POINTS AND HISTORIC DATA AND MAY VARY UNDER FINAL CONDITIONS.

RIVER RIGHT ANTICIPATED TO BECOME PRIMARY FLOW PATH (ANTICIPATED THALWEG)

ENTIRE EXISTING CONCRETE STRUCTURE TO BE REMOVED
ESTIMATED CONCRETE VOLUME: 1,485 C.Y.

AREA ANTICIPATED TO RECEIVE DIRECT FLOW. SCOUR OF UNCONSOLIDATED SEDIMENTS ANTICIPATED.

FUTURE DEPOSITIONAL AREA

LEGEND

- LIMIT OF SANDBAR
- EXISTING CONTOURS (MDC)
- EXISTING CONTOURS (PH)
- EXISTING SPOT ELEVATIONS (PH)
- EXISTING WETLAND LIMIT
- EXISTING TREELINE
- CONCRETE STRUCTURE (REMOVED)
- EXISTING BEDROCK OUTCROP
- EXISTING SAND/GRAVEL BAR
- EXISTING THALWEG
- EXISTING OVERHEAD ELECTRIC LINES
- EXISTING EDGE OF WATER
- ANTICIPATED POST-REMOVAL CONTOURS
- ANTICIPATED POST-REMOVAL THALWEG

GRAPHIC SCALE

0 10 20 30 60 90 120 FEET

SCALE: 1" = 30'

CALL BEFORE YOU DIG!
CONNECTICUT LAW REQUIRES
2 FULL WORKING DAYS NOTICE
PRIOR TO CONSTRUCTION – STOP CALL
CALL BEFORE YOU DIG, INC.
REFERENCE CONNECTICUT SECTION I:
SECTION 16-345-1 THROUGH 16-345-7
1-800-922-4455

PROJECT NOTES

1. HORIZONTAL DATUM NORTH AMERICAN DATUM OF 1983 (NAD83) STATE PLANE CONNECTICUT, FIPS 3100, FEET. VERTICAL DATUM NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88), FEET.

2. IN-STREAM TOPOGRAPHIC INFORMATION AS OBTAINED FROM FIELD SURVEY BY PRINCETON HYDRO PERSONNEL, OCTOBER 12, 2009.

3. SUPPLEMENTAL TOPOGRAPHIC INFORMATION OBTAINED FROM THE METROPOLITAN DISTRICT (MDC) IN DIGITAL FORMAT.

4. WETLAND DELINEATION COMPLETED BY JMM WETLAND CONSULTING SERVICES, LLC, OCTOBER 2009.

DATE	DESCRIPTION
03/15/2010	REVISED AS PER PROJECT PARTNERS

REVISIONS

STATE OF CONNECTICUT CERTIFICATE OF REGISTRATION NO.: 0001188

LAURA A.S. WILDMAN
Professional Engineer
CT Lic. No. 18596

DATE

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PROJECT NAME/LOCATION:

SPOONVILLE DAM FISH
PASSAGE IMPROVEMENTS
FARMINGTON RIVER
TOWNS OF BLOOMFIELD AND EAST GRANBY
COUNTY OF HARTFORD, CONNECTICUT

DRAWING NAME:

PROPOSED CONDITIONS

DATE:	JANUARY 12, 2010
PROJECT NO.:	1036.001
SCALE:	1" = 30'
DRAWN BY:	JEH/PMW
CHECKED BY:	LASW

SHEET NO. 3 OF 8