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Flood of October 8 and 9, 2005, on Cold River in Walpole, Langdon, and Alstead and on Warren Brook in Alstead, New Hampshire

Open-File Report 2006–1221

U.S. Department of the Interior
U.S. Geological Survey

Cover. Devastation along Warren Brook, Route 123 in Alstead, NH, after the October 8 and 9, 2005 flood. (Photograph courtesy of the New Hampshire State Police Aviation Unit)

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DIRK KEMPTHORNE, Secretary

U.S. Geological Survey
P. Patrick Leahy, Acting Director

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Conversion Factors, Abbreviations, and Vertical Datum

Multiply	By	To obtain
	Length	
inch (in.)	25.40	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
	Area	
square foot (ft^2)	0.09290	square meter (m^2)
square mile (mi^2)	2.589	square kilometer (km^2)
	Volume	
acre-foot (acre-ft)	1,233	cubic meter (m^3)
	Velocity and flow	
foot per second (ft/s)	0.3048	meter per second (m/s)
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
cubic foot per second per square mile [$(ft^3/s)/mi^2$]	0.01094	cubic meter per second per square kilometer [$(m^3/s)/km^2$]
	Slope	
foot per mile (ft/mi)	0.1894	meter per kilometer (m/km)

Other Abbreviations

CHWx-L	Cold River high-water mark, left bank
CHWx-R	Cold River high-water mark, right bank
FEMA	Federal Emergency Management Agency
NOAA	National Oceanic and Atmospheric Administration
NWS	National Weather Service
USGS	U.S. Geological Survey
WHWx-L	Warren Brook high-water mark, left bank
WHWx-R	Warren Brook high-water mark, right bank

In this report, the words “right” and “left” refer to directions that would be reported by an observer facing downstream.

NAVD 88: In this report, “NAVD 88” refers to the North American Vertical Datum of 1988.

Flood of October 8 and 9, 2005, on Cold River in Walpole, Langdon, and Alstead and on Warren Brook in Alstead, New Hampshire

By Scott A. Olson

Abstract

Southwestern New Hampshire experienced damaging flooding on October 8 and 9, 2005. The flooding was the result of a storm producing at least 7 inches of rain in a 30-hour period. The heavy, intense rainfall resulted in runoff and severe flooding, especially in regions of steep topography that are vulnerable to flash flooding. Some of the worst property damage was in the towns of Alstead, Langdon, and Walpole, New Hampshire along Cold River and Warren Brook. Warren Brook was severely flooded and had flows that exceeded a 100-year recurrence interval upstream of Cooper Hill Road. Downstream of Cooper Hill Road, the flooding was worsened as a result of a sudden release of impounded water, making the flood levels greater than what would be experienced from a 500-year recurrence-interval flood.

Along Cold River, upstream of its confluence with Warren Brook, flooding was at approximately a 100-year recurrence interval. Downstream of the confluence of Cold River and Warren Brook, the streamflows, which were swollen by the surge of water from Warren Brook, exceeded a 500-year recurrence interval.

Introduction

Major flooding occurred in southwestern New Hampshire on October 8 and 9, 2005, as a result of torrential rainfall. The flooding resulted in seven deaths—four of which were in Alstead, NH. More than 100 buildings or homes were damaged or destroyed. Many miles of roads in the region were damaged and remained impassable for days, even weeks, following the flood.

On October 26, 2005, President George W. Bush declared a major disaster area in five counties in the State of New Hampshire as a result of widespread damage caused by the flooding. In response to this declaration, the U.S. Geological Survey (USGS), in cooperation with the Federal Emergency Management Agency, measured the high-water elevations, determined peak discharges as a result of the flooding, and estimated flood-flow frequency for selected watercourse areas affected by the flooding. The purpose of this report is to document the flood on Cold River in Walpole, Langdon, and Alstead, and on Warren Brook in Alstead, NH. Because of the severity of the flooding, the following communities and stream reaches were included in this report: (1) a 6.7-mi reach of Cold River from its mouth where it drains into the Connecticut River in Walpole, NH, to Vilas Pool Dam in Alstead, and (2) a 4.5-mi reach of Warren Brook from its mouth where it drains into Cold River to Warren Lake in Alstead.

Description of Investigated Reaches

Cold River (fig. 1) flows southwesterly through Alstead, Langdon, and Walpole along a relatively steep slope, averaging 45 ft/mi, and drains into the Connecticut River at an elevation of about 230 ft. The headwaters of Cold River reach 1,900 ft in elevation. Cold River is in the New England Upland physiographic region of southwestern New Hampshire. The drainage area of Cold River at its confluence with the Connecticut River is 102 mi^2.

Warren Brook (fig. 1) flows westerly through Alstead, draining into Cold River in steep topography. It is an upland stream, and is also in the New England Upland physiographic region. The elevation of the mouth of the Warren Brook is approximately 510 ft, and the headwaters extend to elevations above 1,500 ft. The average channel slope of the reach investigated is 150 ft/mi. The drainage area of Warren Brook at its confluence with Cold River is 12.5 mi^2.

Storm Characteristics

The storm of October 8 and 9, 2005, produced at least 7 in. of precipitation (National Weather Service Forecast Office, 2005) in southwestern New Hampshire. Unverified accounts indicated as much as 12 in. of rain fell in a 30-hour period (Sarah Liebowitz, Concord Monitor, written commun., October 20, 2005). The precipitation station at Keene, NH, operated by the National Oceanic and Atmospheric Administration, recorded 7.68 in. of rainfall from

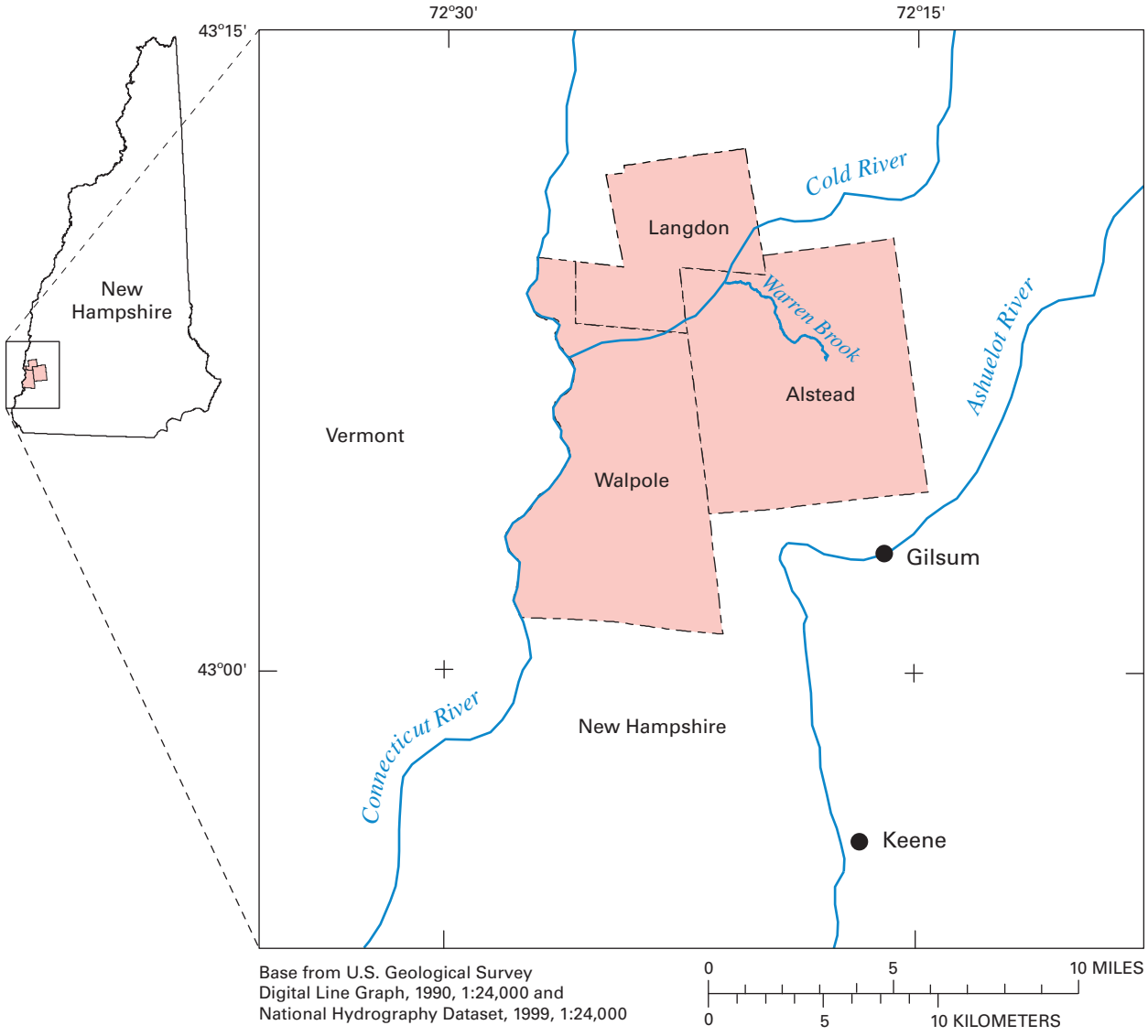

Figure 1. Location of investigated reaches and the towns of Walpole, Langdon, and Alstead, NH.

October 8 through 9, 2005 (National Weather Service Forecast Office, 2005). Prior to the storm, hydrologic conditions in the area were predominately normal (U.S. Geological Survey, 2006). The heavy, intense rainfall resulted in runoff and severe flooding, especially in regions of steep topography that are vulnerable to flash flooding.

High-Water Marks

USGS personnel identified and flagged high-water marks along the investigated reaches of Cold River and Warren Brook following the flood. The high-water marks were tied into the North American Vertical Datum of 1988 (NAVD 88), using closed level-loop surveying techniques between October 31 and November 18, 2005. Latitude and longitude of the high-water marks were determined, using Global Positioning System instrumentation.

The elevation and location of the high-water marks are described in tables 1 and 2 (back of report) and the locations are plotted on USGS orthophotos in appendix 1. The high-water marks also are plotted in profile format for each investigated reach in appendix 2.

The high-water marks also are rated for accuracy. This rating is subjective and is based upon the type of high-water mark and the abundance of other confirming marks in the immediate vicinity (Benson and Dalrymple, 1967). The accuracy of the mark is defined as follows: A high-water mark having (1) an excellent rating is within 0.05 ft of the actual water surface, (2) a good rating is within 0.1 ft, (3) a fair rating is within 0.2 ft, and (4) a poor rating may be greater than 0.2 ft from the true peak water surface.

Elevation reference marks used to establish the elevations of the high-water marks are reported in appendix 3.

Peak-Discharge Estimates

In addition to obtaining high-water marks, USGS personnel surveyed cross sections in select locations so that the surveyed geometry data and the high-water-mark elevation data could be used together in hydraulic models to estimate the peak discharges. Peak-discharge estimates, using these indirect techniques, were made in four locations: Warren Brook at Mill Hollow, Cold River at Vilas Pool Dam, Cold River downstream of the Warren Brook confluence, and Cold River at the Drewsville USGS stream-gaging station (fig. 2). The peak-discharge estimates are discussed in upstream to downstream order.

Peak-discharge estimates of Warren Brook downstream of Cooper Hill Road (fig. 2) were made using a dam-breach model. This was used because of the nature of the failure of the Cooper Hill Road embankment that impounded flood waters.

Warren Brook at Mill Hollow

An indirect discharge measurement was made at the Route 123 crossing of Warren Brook at Mill Hollow. Although the Mill Hollow site has complex hydraulics, the site was selected because excellent high-water-mark elevations were available and the dam and culvert incurred minimal damage during the flooding. At the Mill Hollow site, the surveyed geometry of the dam, the Route 123 culvert, Route 123 roadway, and an approach cross section were input into the U.S. Army Corps of Engineers (2004) HEC-RAS program. Discharges were iteratively selected so that the resulting water-surface elevations output from HEC-RAS at the approach section matched the high-water marks surveyed upstream of the site. The resulting peak discharge for the October 2005 flood event was 820 ft^3/s for the 5.21-mi^2 drainage area.

Warren Brook Downstream of Cooper Hill Road

Peak-discharge estimates were determined immediately downstream of the Cooper Hill Road crossing of Warren Brook. During the flood, the Cooper Hill Road embankment impounded flood waters flowing down Warren Brook. Using the National Elevation Dataset (U.S. Geological Survey, 2001), the impoundment was computed to be 421 acre-ft of water. When the nearly 30-ft tall road embankment was overtopped, it breached, sending the entire impounded pool of floodwaters rushing downstream.

Because of the apparent similarities of the impoundment failure to an earthen dam failure, the National Weather Service's Simplified Dam-Break (SMPDBK) Flood Forecasting Model (Wetmore and Fread, 1991) was used to estimate the peak discharges downstream of the breached road embankment. The geometry of the breached road embankment was surveyed and used as input along with the impoundment volume. Additional cross sections downstream of the Cooper Hill Road crossing along Warren Brook to its mouth were estimated from the USGS 1:24,000 topographic map (U.S. Geological Survey, 1998a) and also used as input to the model. The additional cross sections allowed the SMPDBK model to route the peak discharge down Warren Brook to its mouth where it drains into Cold River.

The discharges computed by the SMPDBK model were sensitive to the amount of time that the road embankment was given to completely breach. The breach occurred in about a 20- to 30-minute timeframe (David Crosby, town of Alstead Director of Public Works, oral commun., December 19, 2005). Thus, a breach time of 25 minutes was used in the model. The results from SMPDBK indicate a peak discharge immediately downstream of Cooper Hill Road of 24,900 ft^3/s and a peak discharge of 20,100 ft^3/s at the confluence with Cold River. Decreasing the time to 20 minutes increased peak discharges by approximately 7 percent; increasing the breach time to 30 minutes decreased peak discharges by about 3 percent.

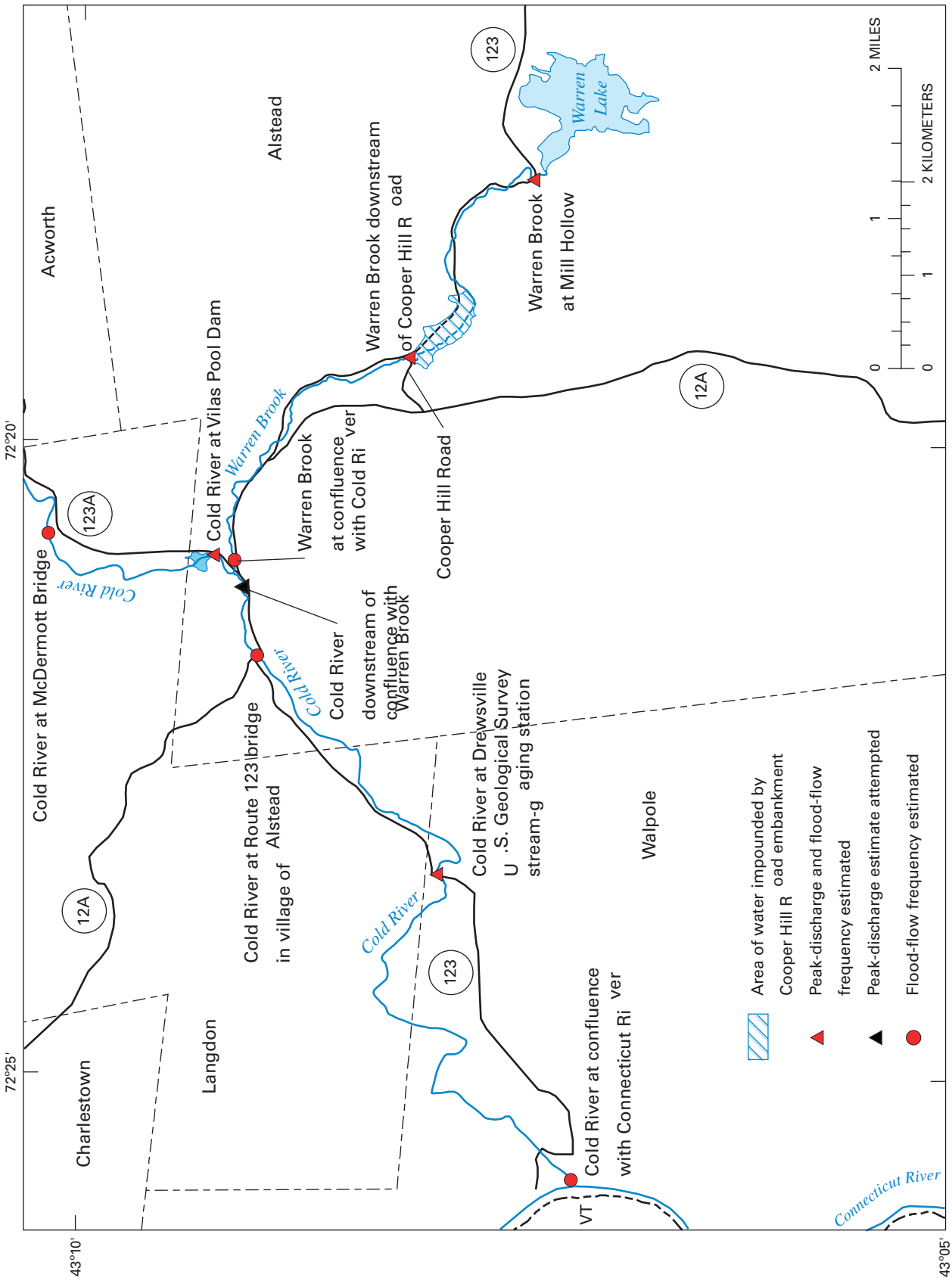

Figure 2. Locations where peak discharge and flood-flow frequency were estimated in Walpole, Langdon, and Alstead, NH.

Photograph courtesy of Reggie Clark, Alstead, NH

Figure 3. View looking upstream at the Cooper Hill Road embankment failure October 2005 in Alstead, NH.

Cold River at Vilas Pool Dam

An indirect discharge measurement was made for Cold River at Vilas Pool Dam. The site is not considered ideal for an indirect discharge measurement as described by Hulsing (1967) because a large percentage of the flow is diverted over Route 123A adjacent to the dam. The flow over Route 123A and Vilas Pool Dam were modeled as a broad-crested weir. The geometry of the dam, the Route 123A overflow section, and an approach cross section were surveyed and input into the U.S. Army Corps of Engineers (2004) HEC-RAS program. Discharges were iteratively selected so that the resulting water-surface elevations output from HEC-RAS at the approach section matched the high-water-mark elevations at the approach section at Vilas Pool Dam. The resulting peak discharge was 6,370 ft^3/s for the 61.3-mi^2 drainage area.

Cold River Downstream of the Warren Brook Confluence

An indirect discharge measurement was attempted on Cold River downstream of the Warren Brook confluence (fig. 2). However, an acceptable indirect discharge could not be generated because of complex hydraulics.

Cold River at the Drewsville USGS Stream-Gaging Station

An indirect discharge measurement was made for the discontinued USGS stream-gaging station, Cold River at Drewsville, NH, station number 01155000. The streamgage is located about 60 ft upstream of the Route 123 crossing of Cold River in Drewsville and has a drainage area of 82.7 mi^2. Continuous record was collected at the station from 1940 to 1978. During the period of record, the maximum recorded discharge was 6,710 ft^3/s on December 21, 1973 (U.S. Geological Survey, 1978). The corresponding maximum stage was 12.30 ft, which when converted to NAVD 88 is 390.58 ft. The October 9, 2005, peak stage was 401.98 ft, or 11.40 ft higher than the peak stage of December 21, 1973.

The reach used for the indirect discharge measurement was a straight section of river with a broad flood plain left of the channel starting at about 2,500 ft upstream of the station. The reach met all the criteria for an indirect discharge measurement using the Slope-Area method as described in Dalrymple and Benson (1967). Three cross sections were surveyed and used as input into the Slope-Area Computation program (Fulford, 1994) along with the corresponding high-water elevations. The resulting peak discharge was estimated to be 21,800 ft^3/s. The wide flood plains downstream of the Village of Alstead and upstream of the reach used for the indirect measurement may have attenuated some of the flood wave from the breached Cooper Hill Road embankment on Warren Brook.

Flood-Flow-Frequency Characteristics

The flood-flow-frequency estimates are discussed in upstream to downstream order. Flood-flow frequency estimates for Warren Brook were estimated using regression equations developed by LeBlanc (1978) (table 3, fig. 4). Basin characteristics used as input to the regression equations include drainage area, mean channel slope, and the 2-year,

Table 3. Basin characteristics and flood-flow frequency estimates for selected recurrence intervals at selected sites on Warren Brook, Alstead, NH.

[Location of sites shown in figure 2. Flood-flow frequency estimates plotted against drainage area are in figure 4. ft^3/s, cubic feet per second; ft/mi, feet per mile; hr, hour; in., inches; mi^2, square mile; yr, year]

Warren Brook site	Drainage area, mi^2	Channel slope, ft/mi	2-yr, 24-hr rainfall, in.	Flood-flow frequency estimates for selected recurrence intervals, ft^3/s			
				10 yr	50 yr	100 yr	500 yr
Mill Hollow	5.21	101	2.7	289	508	615	958
Downstream of Cooper Hill Road	9.24	147	2.7	629	1,140	1,380	2,190
Confluence with Cold River	12.5	125	2.7	805	1,430	1,740	2,710

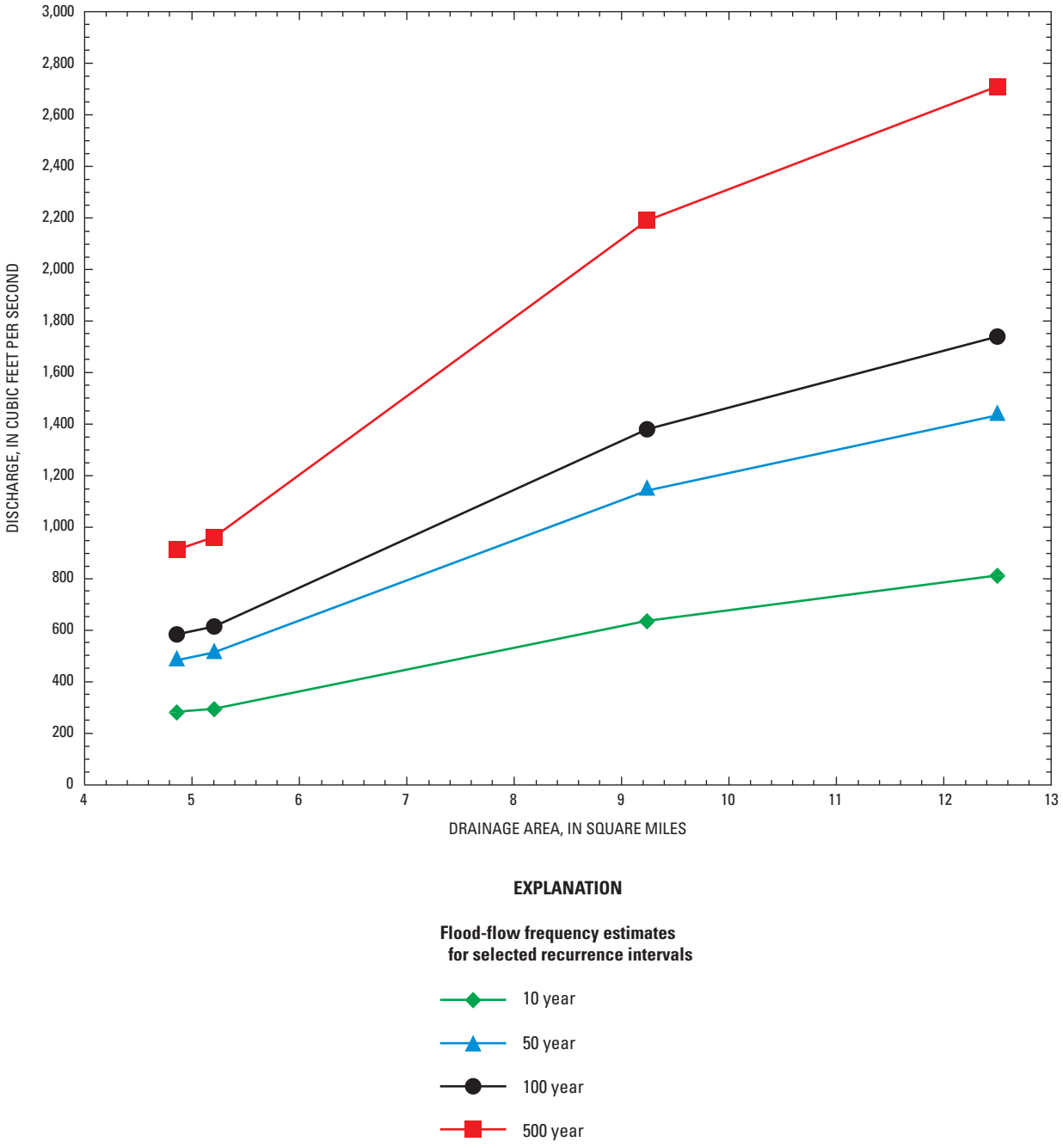

Figure 4. Flood-flow frequency estimates for selected recurrence intervals at selected sites on Warren Brook, Alstead, NH. Location and information for selected sites are shown in figure 2 and table 3 (outlet of Lake Warren is represented by the first data points but values are not shown on table 3).

24-hour rainfall for the basin. Drainage area and mean channel slope were determined using a Geographic Information System, electronic copies of USGS 1:24,000 topographic maps (U.S. Geological Survey, 1998a–d) and the National Elevation Dataset (U.S. Geological Survey, 2001). The 2-year, 24-hour rainfall was determined from a rainfall-frequency atlas (Hershfield, 1961). These data sources for the basin characteristics are nearly identical to the data sources used to derive the LeBlanc regression equations.

Flood discharges at the 10-, 50-, 100-, and 500-year recurrence intervals for Cold River at Drewsville were determined using a log-Pearson Type III analysis (U.S. Interagency Advisory Committee on Water Data, 1982). Peak-flow data from Cold River at Drewsville, NH, stream-gaging station were used for computing the frequency curve. The October 2005 peak was adjusted to a "natural" peak—without the effect of the embankment breach on Warren Brook.

Several approaches were investigated to determine a natural peak at Cold River station. The first approach involved applying the peak runoff rate in cubic feet per second per square mile for this flood from the nearby Ashuelot River (fig. 1), as a way to estimate the natural peak on Cold River. The peak discharge of the Ashuelot River at the discontinued Gilsum, NH, USGS stream-gaging station was determined to be 10,200 ft^3/s using the Slope-Area technique (Dalrymple and Benson, 1967). The drainage area at the Ashuelot River at Gilsum, NH, station is 71.1 mi^2, resulting in a 143-ft^3/mi^2 runoff rate for the peak discharge. The drainage area of Cold River at Vilas Pool Dam (61.3 mi^2) had a peak runoff rate, however, of 104 ft^3/mi^2; applying the runoff rate of the Ashuelot River to Cold River likely would have resulted in an overestimate of the natural peak flow.

Another approach was to apply the 104-ft^3/mi^2 runoff rate from Vilas Pool Dam to Cold River at the Drewsville site. The runoff rate at Warren Brook at Mill Hollow was much greater at 158 ft^3/mi^2; however, applying the lower Vilas Pool Dam runoff rate may result in an underestimate of the peak flow.

It was determined that the best approach to determine a natural peak was to use a drainage-area-weighted runoff rate using the Warren Brook runoff rate and Cold River at Vilas Pool Dam runoff rate. This weighted approach resulted in a runoff rate of 113 ft^3/mi^2. Applying this runoff rate to Cold River at Drewsville stream-gaging station drainage area of 82.7 mi^2 resulted in a rate of 9,360 ft^3/s. This rate was the natural peak-discharge estimate that was included in the log-Pearson Type III analysis. The results of the frequency analysis are shown in table 4 and figure 5. The frequency curve then was adjusted to locations upstream and downstream of the station by applying a drainage-area ratio. For example, Q=Qgage(A/Agage), where Qgage and Agage are the discharge and drainage area of the station and Q and A are the discharge and drainage area of the site of interest, respectively.

Table 4. Flood-flow frequency estimates for selected recurrence intervals at selected sites on Cold River, southwestern New Hampshire, 2005.

[Location of sites shown in figure 2. Flood-flow frequency estimates plotted against drainage area are shown in figure 5. ft^3/s, cubic feet per second; mi^2, square mile; yr, year]

Cold River site	Drainage area, mi^2	Flood-flow frequency estimates for selected recurrence intervals, ft^3/s			
		10 yr	50 yr	100 yr	500 yr
McDermott Bridge, Langdon, NH	59.2	2,930	4,910	5,980	9,090
Vilas Pool Dam, Alstead, NH	61.3	3,030	5,080	6,190	9,410
Route 123 bridge in Village of Alstead, NH	74.6	3,690	6,190	7,530	11,500
Cold River at Drewsville, NH, USGS stream-gaging station	82.7	4,090	6,860	8,350	12,700
Confluence with the Connecticut River	102	5,040	8,460	10,300	15,700

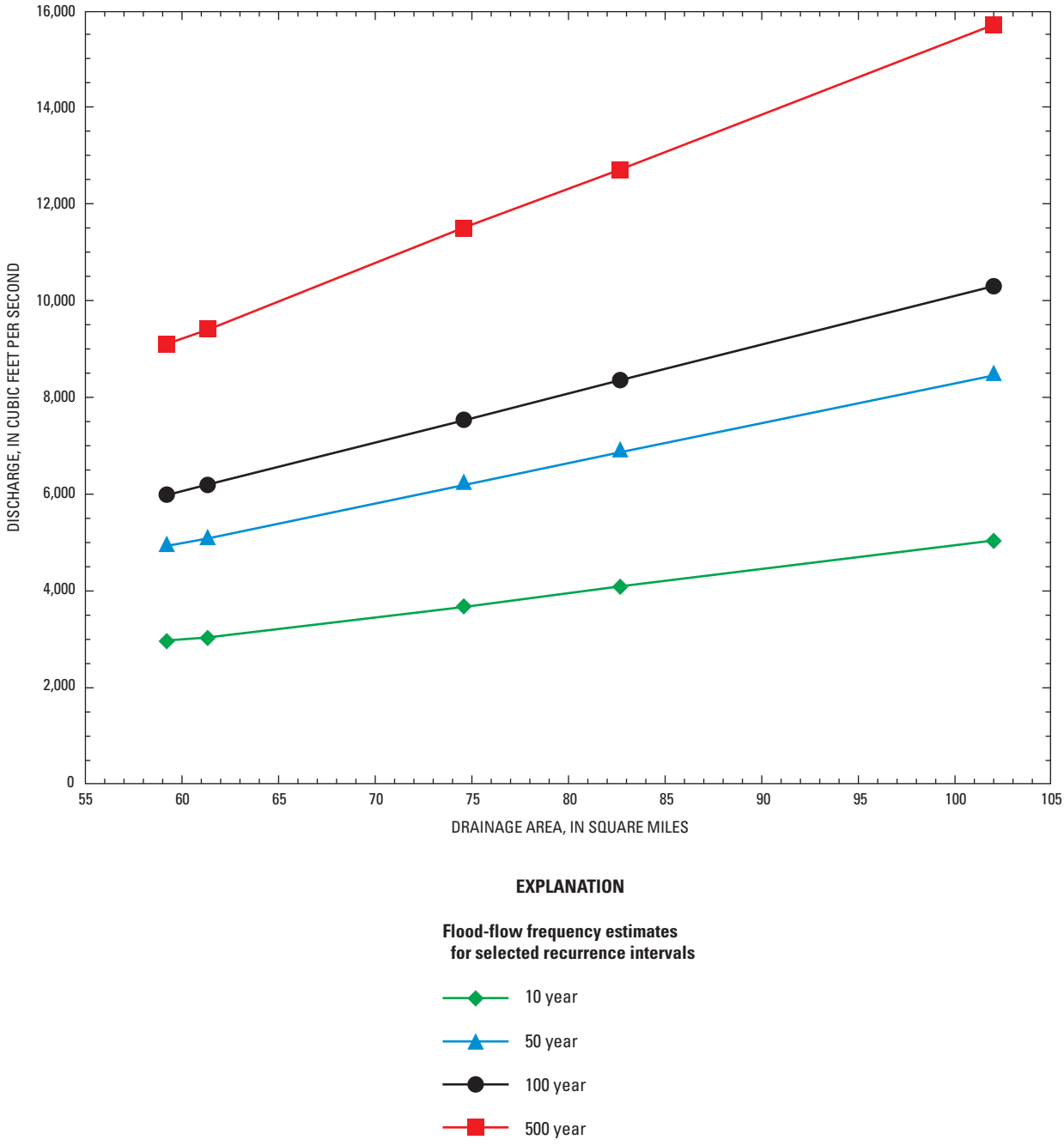

Figure 5. Flood-flow frequency estimates for selected recurrence intervals at selected sites on Cold River, Alstead, Langdon, and Walpole, NH. Location and information for selected sites are shown in figure 2 and table 4.

Summary of flood-flow frequency estimates and peak-discharge estimates of the October 2005 flood at selected locations in Walpole, Langdon, and Alstead, NH.

[ft^3/s, cubic feet per second; mi^2, square miles; yr, year; --, no data; >, greater than; ~, approximately]

Location	Drainage area, mi^2	Flood-flow frequency estimates for selected recurrence intervals, ft^3/s				Peak discharge, October 2005, ft^3/s	Recurrence interval of peak discharge
		10 yr	50 yr	100 yr	500 yr		
Warren Brook							
At Mill Hollow, Alstead, NH	5.21	289	508	615	958	820	>100-year
Downstream of Cooper Hill Road, Alstead, NH	9.24	629	1,140	1,380	2,190	24,900	>500-year
At confluence with Cold River, Alstead, NH	12.5	805	1,430	1,740	2,710	20,100	>500-year
Cold River							
At McDermott Bridge, Langdon, NH	59.2	2,930	4,910	5,980	9,090	--	--
At Vilas Pool Dam, Alstead, NH	61.3	3,030	5,080	6,190	9,410	6,370	~100-year
At Route 123 bridge in Village of Alstead, NH	74.6	3,690	6,190	7,530	11,500	--	--
At Cold River at Drewsville, NH, USGS stream-gaging station	82.7	4,090	6,860	8,350	12,700	21,800	>500-year
At confluence with Connecticut River, Walpole, NH	102	5,040	8,460	10,300	15,700	--	--

Summary

The U.S. Geological Survey, in cooperation with the Federal Emergency Management Agency, surveyed high-water marks along the flooded reaches of Cold River in Alstead, Langdon, and Walpole, NH, and Warren Brook in Alstead, NH, to document the flood of October 8 and 9, 2005. Discharge estimates also were made in selected locations along these reaches. The peak discharges in Warren Brook downstream of Cooper Hill Road and in Cold River downstream of the confluence of Cold River and Warren Brook are attributed to the failure of a road embankment that released 421 acre-feet of impounded water in a 20- to 30-minute timeframe. New flow-frequency curves were determined for the investigated reaches as well.

Selected References

Benson, M.A., and Dalrymple, Tate, 1967, General field and office procedures for indirect discharge measurements: U.S. Geological Survey Techniques of Water-Resources Investigations, book 3, chap. A1, 30 p.

Bodhaine, G.L., 1968, Measurement of peak discharge at culverts by indirect methods: U.S. Geological Survey Techniques of Water-Resource Investigations, book 3, chap. A3, 60 p.

Dalrymple, Tate, and Benson, M.A., 1967, Measurement of peak discharge by the slope-area method: U.S. Geological Survey Techniques of Water-Resource Investigations, book 3, chap. A2, 12 p.

Federal Emergency Management Agency, 2000, Flood insurance study, Town of Walpole, Cheshire County, New Hampshire: Washington, DC, p. 16.

Fulford, J.M., 1994, User's guide to SAC, A computer program for computing discharge by slope-area method: U.S. Geological Survey Open-File Report 94–360, 31 p.

Hershfield, D.M., 1961, Rainfall frequency atlas of the United States for durations from 30 minutes to 24 hours and return periods from 1 to 100 years: U.S. Department of Commerce Weather Bureau Technical Paper No. 40, 61 p.

Hulsing, Harry, 1967, Measurement of peak discharge at dams by indirect methods: U.S. Geological Survey Techniques of Water-Resource Investigations, book 3, chap. A5, 29 p.

LeBlanc, D.R., 1978, Progress report on hydrologic investigations of small drainage areas in New Hampshire—Preliminary relations for estimating peak discharges on rural, unregulated streams: U.S. Geological Survey Water-Resources Investigations 78–47, 9 p.

National Weather Service Forecast Office, 2005, Daily climate data, accessed December 20, 2005, at *http://www.erh.noaa.gov/er/box/dailystns.shtml*.

U.S. Army Corps of Engineers, 2004, HEC-RAS River Analysis System Version 3.1.2: Hydrologic Engineering Center, accessed October 26, 2004, at *http://www.hec.usace.army.mil/*.

U.S. Geological Survey, 1978, Water resources data for New Hampshire and Vermont, water year 1978: U.S. Geological Survey Water-Data Report NH-VT-78-1, 188 p.

U.S. Geological Survey, 1998a, Alstead, New Hampshire 7.5-minute series quadrangle map: U.S. Geological Survey Topographic Maps, scale 1:24,000.

U.S. Geological Survey, 1998b, Bellows Falls, Vermont-New Hampshire 7.5-minute series quadrangle map: U.S. Geological Survey Topographic Maps, scale 1:24,000.

U.S. Geological Survey, 1998c, Gilsum, New Hampshire 7.5-minute series quadrangle map: U.S. Geological Survey Topographic Maps, scale 1:24,000.

U.S. Geological Survey, 1998d, Walpole, New Hampshire-Vermont 7.5-minute series quadrangle map: U.S. Geological Survey Topographic Maps, scale 1:24,000.

U.S. Geological Survey, 2001, National elevation dataset, accessed May 5, 2004, at *http://edcnts12.cr.usgs.gov/ned/*.

U.S. Geological Survey, 2006, Water resources conditions in New Hampshire and Vermont September 2005, accessed April 21, 2006, at *http://nh.water.usgs.gov/WaterData/2005/sep05.htm*.

U.S. Interagency Advisory Committee on Water Data, 1982, Guidelines for determining flood flow frequency, Bulletin 17-B of the Hydrology Subcommittee: Reston, VA, U.S. Geological Survey, Office of Water Data Coordination, 183 p.

Wetmore, J.N., and Fread, D.L., 1991, The National Weather Service simplified dam-break flood forecasting model (CD Rom with documentation): National Weather Service Hydrologic Research Laboratory, National Technical Information Service order no. PB 2003-500005, accessed December 2005, at *http://www.NTIS.gov*.

Tables 1–2

Table 1. High-water elevations of the October 2005 flood on Cold River in Walpole, Langdon, and Alstead, NH.

[L, left; R, right; --, no data]

Identifier	Elevation[1]	Station[2]	Latitude/ longitude	Description	Rating
CHW1-L	244.5	1,580	43°7'17.1"/ 72°25'35.7"	Stake marking debris line 140 feet south of Route 123 bridge over Cold River at base of Route 123 road embankment, at edge of corn field on left bank, and streamward of utility pole 51/3	Excellent to good.
CHW2-L	248.5	1,836	43°7'19.1"/ 72°25'33.8"	Spike marking grass/seed line in tree on left bank approximately 100 feet upstream of Route 123 bridge over Cold River	Good to fair.
CHW3-L	249.7	2,583	43°7'24.3"/ 72°25'26.4"	Spike, about 4 feet above ground, marking grass/seed line in 1-foot-diameter hemlock near bottom of road embankment left of Cold River	Good.
CHW4-L	256.7	4,035	43°7'35.4"/ 72°25'16.5"	Spike, about 5 feet above ground, marking grass/seed line in 18-inch-diameter oak tree streamward of Brewery Road and approximately 300 feet left of left bank of Cold River	Good.
CHW5-L	402.0	18,487	43°7'54.0"/ 72°23'23.0"	Mud line inside Cold River at Drewsville, NH. U.S. Geological Survey stream-gaging station on left bank of river upstream of Route 123 bridge	Excellent.
CHW6-L	402.4	20,902	43°7'54.6"/ 72°23'0.1"	Left flood plain	--
CHW7-L	402.6	21,113	43°7'56.5"/ 72°22'58.4"	Left flood plain	--
CHW8-R	402.3	21,164	43°8'1.4"/ 72°23'4.7"	Spike marking grass/seed line in 5-inch-diameter spruce tree approximately 40 feet downstream of a white house and 75 feet right of right bank of Cold River	Fair.
CHW9-L	402.6	21,190	43°7'57.1"/ 72°22'58.1"	Left flood plain	--
CHW10-L[3]	402.0	21,341	43°7'58.0"/ 72°22'57.9"	Left flood plain	--
CHW11-R[3]	402.8	21,411	43°8'1.2"/ 72°23'4.7"	Spike marking grass/seed line in 7-inch-diameter spruce tree approximately 100 feet upstream of a white house and 45 feet right of right bank	Fair.
CHW12-L[3]	403.8	21,521	43°7'59.6"/ 72°22'56.7"	Debris line on left flood plain	Poor.
CHW13-R	404.3	21,631	43°8'3.1"/ 72°23'3.4"	Stake marking washline 50 feet right of right bank	Good.
CHW14-L	403.9	21,678	43°8'1.1"/ 72°22'55.6"	Debris line on left flood plain	Poor.
CHW15-R[3]	405.2	21,782	43°8'4.3"/ 72°23'2.6"	Spike marking grass/seed line in 6-inch-diameter deciduous tree near toe of Route 123 road embankment, 50 feet right of right bank, and 30 feet upstream of a utility pole	Fair.
CHW16-L	404.1	21,806	43°8'2.7"/ 72°22'55.0"	Stake marking debris line 50 feet upstream of downstream end of corn field on left flood plain	Fair.
CHW17-L[3]	406.1	21,881	43°8'3.4"/ 72°22'54.7"	Left flood plain	--
CHW18-L[3]	407.8	21,968	43°8'4.1"/ 72°22'53.6"	Spike marking grass/seed line in 2-inch-diameter tree 5 feet bankward of treeline at edge of corn field on left flood plain	Good to fair.
CHW19-R[3]	406.3	22,046	43°8'6.6"/ 72°23'0.9"	Spike marking grass/seed line in 12-inch-diameter pine tree near toe of Route 123 road embankment and approximately 30 feet right of right bank of Cold River	Good.

Table 1. High-water elevations of the October 2005 flood on Cold River in Walpole, Langdon, and Alstead, NH.—Continued

[L, left; R, right; --, no data]

Identifier	Elevation[1]	Station[2]	Latitude/ longitude	Description	Rating
CHW20-L	408.4	22,070	43°8'5.0"/ 72°22'53.0"	Spike marking mudline on a 4-inch-diameter bankward leaning tree at the treeline at the bankward edge of field on left flood plain	Good.
CHW21-L	408.3	22,306	43°8'6.8"/ 72°22'51.9"	Spike marking grass/seed line in 4-inch-diameter tree at the treeline at the bankward edge of field on left flood plain	Good.
CHW22-R	407.7	22,327	43°8'9.2"/ 72°22'59.4"	Spike, about 4 feet above ground, marking grass/seed line in 8-inch-diameter maple tree near top of right bank, 50 feet downstream and 50 feet streamward of utility pole 52/111	Good.
CHW23-L	408.4	22,361	43°8'7.3"/ 72°22'51.7"	Spike marking grass/seed line in a 8-inch-diameter dead tree at the treeline at the bankward edge of field of left flood plain	Good to fair.
CHW24-L	408.2	22,557	43°8'10.1"/ 72°22'55.7"	Left flood plain	--
CHW25-R[3]	408.2	22,579	43°8'11.1"/ 72°22'58.2"	Spike, about 4 feet above ground, marking grass/seed line in 5-inch-diameter poplar tree 40 feet right of right bank and streamward of utility pole 51/112	Good to fair.
CHW26-L[3]	408.5	22,591	43°8'9.0"/ 72°22'51.4"	Spike marking grass/seed line in 4-inch-diameter tree at the treeline at the bankward edge of field of left flood plain	Fair.
CHW27-R	411.1	22,771	43°8'12.5"/ 72°22'57.0"	Spike in 4-inch-diameter elm tree 15 feet right of right bank	Fair.
CHW28-R	411.2	22,820	43°8'12.5"/ 72°22'56.9"	Spike marking grass/seed line in 10-inch-diameter elm tree 20 feet right of right bank and streamward of utility pole 55/50/113	Fair to poor.
CHW29-L	408.5	22,878	43°8'11.5"/ 72°22'50.6"	Stake marking debris line 40 feet streamward of treeline at edge of field of left flood plain	Good.
CHW30-R	412.2	23,001	43°8'14.8"/ 72°22'56.1"	Stake marking washline on left bank 25 feet streamward of utility pole 117/49	Good.
CHW31-R	414.2	23,182	43°8'16.3"/ 72°22'54.7"	Spike, about 5 feet above ground, marking grass/seed line in 10-inch-diameter sycamore tree on right bank 25 feet streamward of utility pole 48. May be affected by velocity head	Excellent to good.
CHW32-L	411.1	23,278	43°8'13.7"/ 72°22'48.2"	Left flood plain	--
CHW33-R	413.9	23,383	43°8'18.0"/ 72°22'52.5"	Stake marking debris line on right bank15 feet streamward of the edge of Route 123 and 30 feet upstream of downstream end of mowed area between Cold River and Route 123	Excellent.
CHW34-L	414.5	23,675	43°8'15.9"/ 72°22'45.3"	Spike marking grass/seed line in 4-inch-diameter birch tree at treeline at edge of field on left flood plain	Fair.
CHW35-R	416.6	23,894	43°8'20.7"/ 72°22'47.1"	Stake marking washline on right bank 25 feet streamward of the edge of Route 123 and near the downstream end of guardrail at upstream end of mowed area between Cold River and Route 123	--
CHW36-L	415.3	23,982	43°8'17.9"/ 72°22'42.2"	Spike marking grass/seed line in 2-inch-diameter birch tree at treeline at edge of field on left flood plain	Fair.
CHW37-R	424.5	24,652	43°8'25.5"/ 72°22'39.6"	Spike marking grass/seed line in 14-inch-diameter pine tree on right bank streamward of utility pole 127/41	--
CHW38-R	434.9	26,402	43°8'31.2"/ 72°22'23.9"	Spike marking grass/seed line in 2-foot-diameter poplar tree 25 feet right of right bank and streamward of Connecticut River bank	Good.

Table 1. High-water elevations of the October 2005 flood on Cold River in Walpole, Langdon, and Alstead, NH.—Continued

[L, left; R, right; --, no data]

Identifier	Elevation[1]	Station[2]	Latitude/ longitude	Description	Rating
CHW39-R	447.5	27,976	43°8'45.0"/ 72°22'12.6"	Spike marking grass/seed line in 1-foot-diameter oak tree on right flood plain 30 feet streamward of Route 123 and 80 feet downstream of utility pole 23	Good.
CHW40-R	454.8	28,952	43°8'52.0"/ 72°22'1.8"	Spike marking seed line in apple tree on right flood plain upstream of driveway to house at 75 River Street	Good.
CHW41-R	465.1	29,874	43°8'54.3"/ 72°21'50.8"	Spike marking grass/seed line in apple tree on right flood plain 30 feet streamward of utility pole 6	Fair.
CHW42-L	467.1	30,300	43°8'54.6"/ 72°21'43.8"	Spike in 8-inch-diameter pine tree 24 feet bankward of the Library Avenue and 20 feet upstream of utility pole 4/26	Excellent.
CHW43-L	477.4	30,650	43°8'56.6"/ 72°21'41.6"	Spike marking grass/seed line in trunk of spruce tree near the southeast corner of the Shedd-Porter Library in Alstead	Good.
CHW44-L	480.4	31,066	43°8'58.5"/ 72°21'36.1"	Spike, about 1 foot above ground, marking grass/seed line in 18-inch-diameter maple tree about 50 feet upstream of the upstream side of the Alstead Municipal building and 25 feet streamward of the Municipal building parking lot	Excellent.
CHW45-L	480.4	31,359	43°8'59.1"/ 72°21'33.0"	Line on stake, driven into Route 123 streamward road embankment, 60 feet upstream of entrance to cemetery, 18 feet streamward of the edge of Route 123, and across Route 123 from utility pole 6	Excellent.
CHW46-L	486.7	32,116	43°9'1.6"/ 72°21'23.8"	Debris line on lawn across Route 123 from entrance to Alstead elementary school and upstream of 5 Forest Road	Good.
CHW47-L	492.3	32,666	43°9'2.2"/ 72°21'17.6"	Spike, about 1 foot above ground, marking grass/seed line in a 6-inch-diameter tree near top of left bank, 10 feet downstream of a stone retaining wall and 6 feet bankward of downstream end of retaining wall	Poor.
CHW48-L	514.9	33,381	43°9'2.4"/ 72°21'9.5"	Spike marking grass/seed line in 6-inch-diameter oak tree on left bank	Poor.
CHW49-L	514.9	33,645	43°9'2.8"/ 72°21'4.5"	Spike marking grass/seed line in 5-inch-diameter maple tree left of Route 123 near pool on opposite side of Route 123 from Cold River and about 50 feet downstream of utility pole VZ24	--
CHW50-R	3522.9	35,020	--/--	Debris line on right bank of Cold River approximately 100 feet downstream of Vilas Pool Dam	--
CHW51-L	540.0	35,088	43°9'12.9"/ 72°20'53.5"	Spike in tree left of Vilas Pool dam	--
CHW52-L	542.0	35,128	43°9'13.0"/ 72°20'52.7"	Spike, about 2 feet above ground, marking grass/seed line in 24-inch-diameter tree 25 feet left of Route 123A beside Vilas Pool Dam	Excellent.
CHW53-L	3542.1	35,238	43°9'14.1"/ 72°20'52.0"	Spike marking grass/seed line in 2.5-foot-diameter pine tree on left side of Route 123A and about 120 feet upstream of Vilas Pool Dam	Excellent.

[1]Elevations are in feet above the North American Vertical Datum of 1988.

[2]River distance in feet above mouth of the Cold River.

[3]High-water mark used in hydraulic model to estimate peak discharge.

Table 2. High-water elevations of the October 2005 flood on Warren Brook in Alstead, NH.

[L, left; R, right; --, no data]

Identifier	Elevation[1]	Station[2]	Latitude/ Longitude	Description	Rating
WHW1-L	525.4	51	43°9'3.8"/ 72°21'2.5"	Stake driven into ground marking debris line 150 feet left of intersection of Routes 123 and 123A	--
WHW2-L	534.4	532	43°9'5.2"/ 72°20'55.5"	Spike marking grass/seed line in 18-inch-diameter tree 50 feet left of road in front yard of 20 Forest Road (Route 123). A mud line inside yellow house across street from 20 Forest Road and 60 feet upstream of WHW2-L has an elevation of 535.1 feet	Excellent.
WHW3-L	544.2	1,028	43°9'5.9"/ 72°20'48.9"	Spike marking grass/seed line in 20-inch-diameter maple tree 35 feet left of Route 123, 80 feet upstream of unmarked utility pole, and on downstream side of drive leading up hill	Good.
WHW4-L	545.3	1,085	43°9'6.8"/ 72°20'48.2"	Spike, 7 feet above ground, marking grass/seed line in 7-inch-diameter hemlock 33 feet right of Route 123 in grove of coniferous trees	Good.
WHW5-L	559.1	1,589	43°9'7.2"/ 72°20'42.2"	Spike, 8 feet above ground, marking grass/seed line in 20-inch-diameter maple tree approximately 50 feet left of Route 123 and 75 feet downstream of 57 Forest Road (Route 123)	Good.
WHW6-R	595.8	2,304	43°9'7.3"/ 72°20'34.7"	Stake marking washline at top of ledge falls and right of channel	Poor.
WHW7-R	611.4	2,678	43°9'6.8"/ 72°20'29.7"	Spike marking grass/seed line in 20-inch-diameter spruce tree right of channel	Fair to poor.
WHW8-R	631.3	3,408	43°9'7.3"/ 72°20'21.6"	Spike marking grass/seed line in 6-inch-diameter yellow birch tree about 4 feet above base of tree. Tree is right of channel across Warren Brook from a blue house	Fair.
WHW9-R	634.6	3,666	43°9'5.3"/ 72°20'18.7"	Spike marking grass/seed line in base of 4-inch-diameter white pine tree right of channel and across Warren Brook from automotive garage	Fair.
WHW10-R	636.2	3,760	43°9'4.3"/ 72°20'17.8"	Spike marking grass/seed line in 4-inch-diameter white birch tree right of channel and across Warren Brook from downstream side of brown house at 119 Forest Road	Good to fair.
WHW11-L	641.5	3,899	43°9'2.1"/ 72°20'21.6"	Stake driven into ground marking debris line across Route 123 from 119 Forest Road	Good.
WHW12-R	660.5	4,831	43°8'58.7"/ 72°20'10.5"	Spike marking grass/seed line in 15-inch-diameter tree about 100 feet west of Griffin Hill Road bridge over Warren Brook and immediately downstream of a tributary to Warren Brook	Excellent.
WHW13-R	665.2	5,136	43°8'57.4"/ 72°20'6.4"	Spike, about 7 feet above ground, marking grass/seed line in 5-inch-diameter tree 35 feet right of right bank of Warren Brook and approximately 175 feet east of Griffin Hill Road bridge over Warren Brook	Good.
WHW14-R	681.3	6,008	43°8'51.8"/ 72°19'56.9"	Spike marking grass/seed line in 10-inch-diameter apple tree approximately 275 feet east of Route 123 bridge over Warren Brook and 60 feet downstream of house at 211 Forest Road	Excellent.
WHW15-L	684.0	6,057	43°8'50.3"/ 72°20'0.0"	Spike marking grass/seed line in base of 3-foot-diameter oak tree on left bank approximately 200 feet upstream of Route 123 bridge over Warren Brook	Poor.
WHW16-R	697.0	6,685	43°8'48.9"/ 72°19'51.5"	Spike, about 8 feet above ground, marking grass/seed line on streamward side of a 3-foot-diameter pine tree 60 feet right of right bank and 20 feet downstream of small tributary	Excellent.
WHW17-L	694.9	6,715	43°8'47.5"/ 72°19'52.0"	Spike marking grass/seed line in base of 24-inch-diameter oak tree on left bank across Warren Brook from downstream end of a greenhouse	Fair.
WHW18-L	706.2	7,393	43°8'46.4"/ 72°19'43.8"	Spike, about 3 feet above ground, marking grass/seed line on a 10-inch-diameter maple tree on left overbank across Warren Brook and 50 feet upstream of a red and brown gambrel style home	Fair.

Table 2. High-water elevations of the October 2005 flood on Warren Brook in Alstead, NH.—Continued

[L, left; R, right; --, no data]

Identifier	Elevation[1]	Station[2]	Latitude/ Longitude	Description	Rating
WHW19-R	714.2	7,727	43°8'46.8"/ 72°19'38.7"	Spike marking grass/seed line in 2-foot-diameter pine tree 25 feet right of Route 123 and 120 feet upstream of utility pole 1/35	Excellent.
WHW20-L	712.6	7,764	43°8'45.3"/ 72°19'39.8"	Spike, about 5 feet above ground, marking grass/seed line on a 6-inch-diameter yellow birch tree on left overbank across Warren Brook and 500 feet upstream of a red and brown gambrel style home	Fair.
WHW21-R	725.2	8,201	43°8'43.6"/ 72°19'33.1"	Base of stake driven into ground marking debris line 15 feet upstream along Warren Brook from a tributary to Warren Brook	Excellent.
WHW22-L	726.1	8,361	43°8'41.0"/ 72°19'34.9"	Spike marking grass/seed line in base of 12-inch-diameter oak tree on top of left bank across Warren Brook from a gray and blue house	Poor.
WHW23-R	735.3	8,556	43°8'39.8"/ 72°19'30.6"	Spike, about 6 feet above ground, marking grass/seed line in 8-inch-diameter poplar tree about 150 feet right of Route 123	Good.
WHW24-L	737.4	8,717	43°8'37.6"/ 72°19'33.6"	Spike marking grass/seed line in base of 8-inch-diameter spruce tree on left overbank	Fair to poor.
WHW25-L	738.1	8,882	43°8'36.1"/ 72°19'32.7"	Spike marking grass/seed line in base of 20-inch-diameter white pine on left overbank approximately 200 feet downstream of a cluster of apple trees	Fair to poor.
WHW26-R	740.1	8,950	43°8'36.6"/ 72°19'28.6"	Base of stake driven into ground marking debris line in grass near base of utility pole 53 in middle of large lawn right of Route 123	Good.
WHW27-R	745.4	9,117	43°8'35.3"/ 72°19'28.8"	Spike marking grass/seed line in base of 2-foot-diameter maple tree 10 feet right of Route 123 and 50 feet downstream of driveway to house at 327 Forest Road	Good.
WHW28-L	750.3	9,424	43°8'32.4"/ 72°19'32.5"	Spike marking grass/seed line in base of apple tree on left overbank on upstream edge of a field	Fair.
WHW29-L	759.6	9,704	43°8'29.3"/ 72°19'32.8"	Spike marking grass/seed line in base of 20-inch-diameter spruce tree across Warren Brook from a mobile home damaged by the flood	Fair to poor.
WHW30-R	763.9	9,805	43°8'28.1"/ 72°19'29.2"	Stake driven into ground marking washline in grass on right side of Route 123 across street from utility pole VZ61	Fair to poor.
WHW31-R	769.7	10,141	43°8'26.1"/ 72°19'27.9"	Spike marking grass/seed line in 10-inch-diameter oak tree 15 feet right of Route 123 and 60 feet upstream of utility pole 62	Good.
WHW32-R	778.8	10,340	43°8'23.9"/ 72°19'29.4"	Spike marking grass/seed line in 5-inch-diameter maple tree 25 feet right of right bank of Warren Brook and 100 feet downstream of house at 380 Forest Road	Excellent.
WHW33-R	776.5	10,412	43°8'23.8"/ 72°19'27.4"	Spike marking grass/seed line in 18-inch-diameter tree on left overbank and near intersection of Route 123 and driveway to house at 380 Forest Road	Excellent.
WHW34-R	789.4	10,750	43°8'20.4"/ 72°19'26.6"	Spike marking grass/seed line in downstream side of 20-inch-diameter maple tree 7 feet right of right bank of Warren Brook and streamward of utility pole VZ66	Good.
WHW35-R	788.9	11,012	43°8'18.8"/ 72°19'23.2"	Spike, about 2 feet above ground, marking grass/seed line in 5-inch-diameter oak tree 20 feet right of Route 123 and 150 feet upstream of utility pole VZ67	Excellent.
WHW36-R	803.1	11,404	43°8'14.5"/ 72°19'21.1"	Spike marking grass/seed line in 4-inch-diameter maple tree immediately right of Route 123 and near front yard of a white house	Good.
WHW37-R	806.1	11,602	43°8'12.9"/ 72°19'21.5"	Spike marking grass/seed line in 15-inch-diameter hemlock tree 50 feet right of right bank and 30 feet downstream of utility pole 1/73/73	Fair.

Table 2. High-water elevations of the October 2005 flood on Warren Brook in Alstead, NH.—Continued

[L, left; R, right; --, no data]

Identifier	Elevation[1]	Station[2]	Latitude/ Longitude	Description	Rating
WHW38-R[3]	834.0	12,713	43°8'4.3"/ 72°19'18.5"	Spike marking grass/seed line in 15-inch-diameter spruce tree on right bank immediately streamward of Route 123, and 275 feet upstream of the intersection of Cobb Hill Road and Route 123	Excellent to good.
WHW39-L	860.4	17,016	43°7'51.8"/ 72°18'41.0"	Spike marking grass/seed line in tree 240 feet upstream of Route 123 culvert over Warren Brook, 25 feet downstream of utility pole 102, and 18 feet streamward of road	--
WHW40-L	1,196.3	23,107	43°7'23.4"/ 72°17'56.4"	Spike marking grass/seed line in base of apple tree 50 feet upstream of Route 123 culvert	Good.
WHW41-L[3]	1,196.4	23,127	43°7'23.1"/ 72°17'56.0"	Spike, about 2 feet above ground, marking grass/seed line in tree 75 feet upstream of Route 123 culvert	Fair.
WHW42-L	1,196.4	23,142	43°7'23.1"/ 72°17'55.6"	Spike, about 4 feet above ground, marking grass/seed line in tree 15 feet left of left bank	Fair.
WHW43-L	1,196.4	23,159	43°7'22.7"/ 72°17'55.9"	Spike, about 3 feet above ground, marking grass/seed line in tree approximately 100 feet upstream of Route 123 culvert and 20 feet downstream of stone wall	Excellent.
WHW44-L	1,196.5	23,188	43°7'22.5"/ 72°17'55.5"	Spike, about 2 feet above ground, marking grass/seed line in large tree along stone wall	Good.
WHW45-L	1,196.5	23,267	43°7'21.7"/ 72°17'54.6"	Spike marking grass/seed line in base of large tree in horse field	Good to fair.
WHW46-R	1,196.3	23,314	43°7'22.5"/ 72°17'53.1"	Spike, about 2 feet above ground, marking grass/seed line in 2-foot-diameter elm(?) tree along Pine Cliff Road road embankment and approximately 50 feet south of intersection of Pine Cliff Road and Route 123	Excellent.
WHW47-L	1,196.6	23,485	43°7'20.6"/ 72°17'53.9"	Stake marking debris line near base of large white pine tree in horse field left of Warren Brook	Fair.

[1]Elevations are in feet above the North American Vertical Datum of 1988.

[2]Stream distance in feet upstream of mouth.

[3]High-water mark used in hydraulic model to estimate peak discharge.

Appendixes 1–3

Appendix 1: Maps Showing Location of High-Water Marks Flagged in Walpole, Langdon, and Alstead, NH, Following the Flood of October 8 and 9, 2005

Figures in appendix 1 begin at the mouth of Cold River, proceed upstream along Cold River to confluence of Cold River and Warren Brook, and then proceed upstream along Warren Brook to Warren Lake.

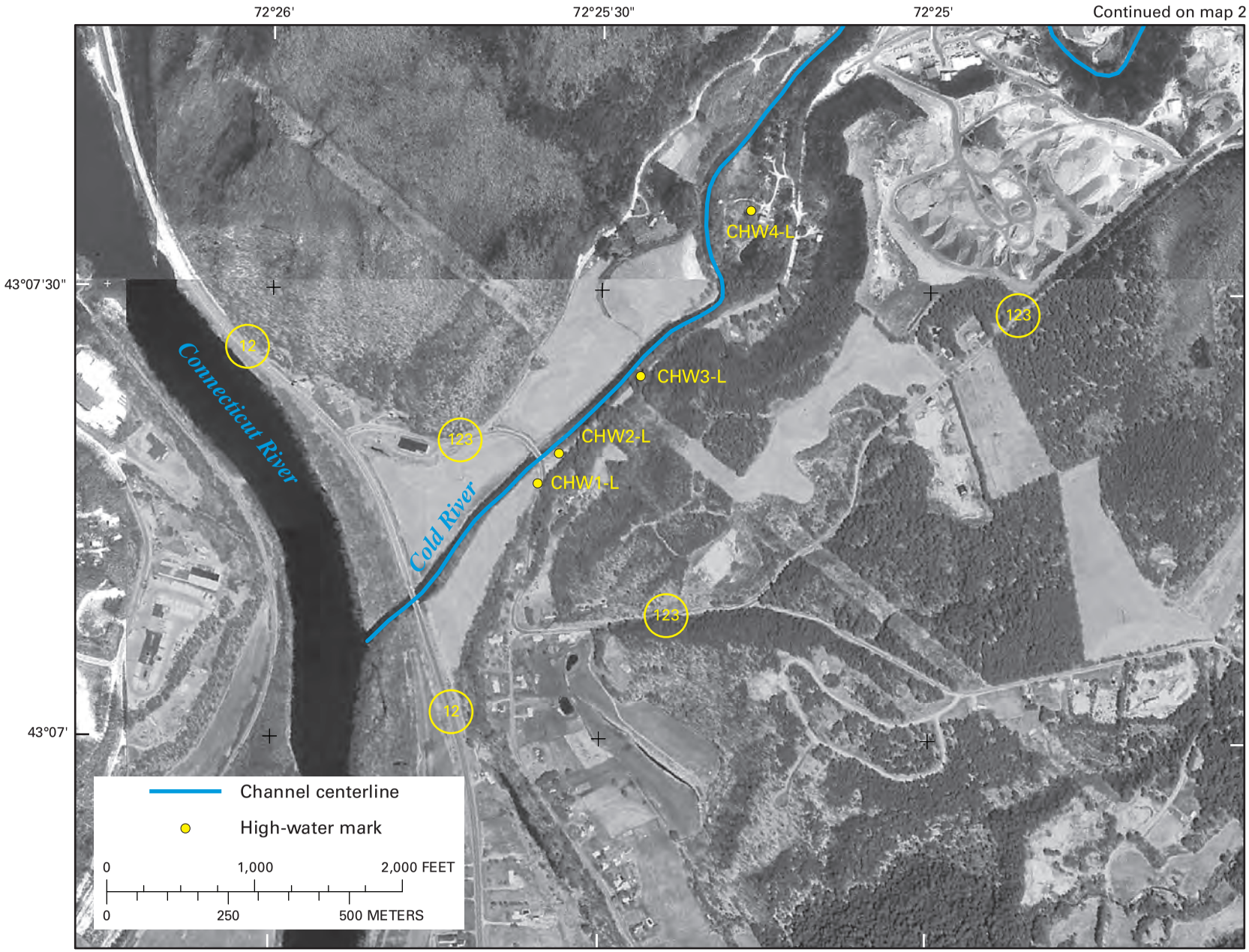

Figure 1-1. Location of high-water marks along Cold River, Walpole, NH (map 1 of 7).

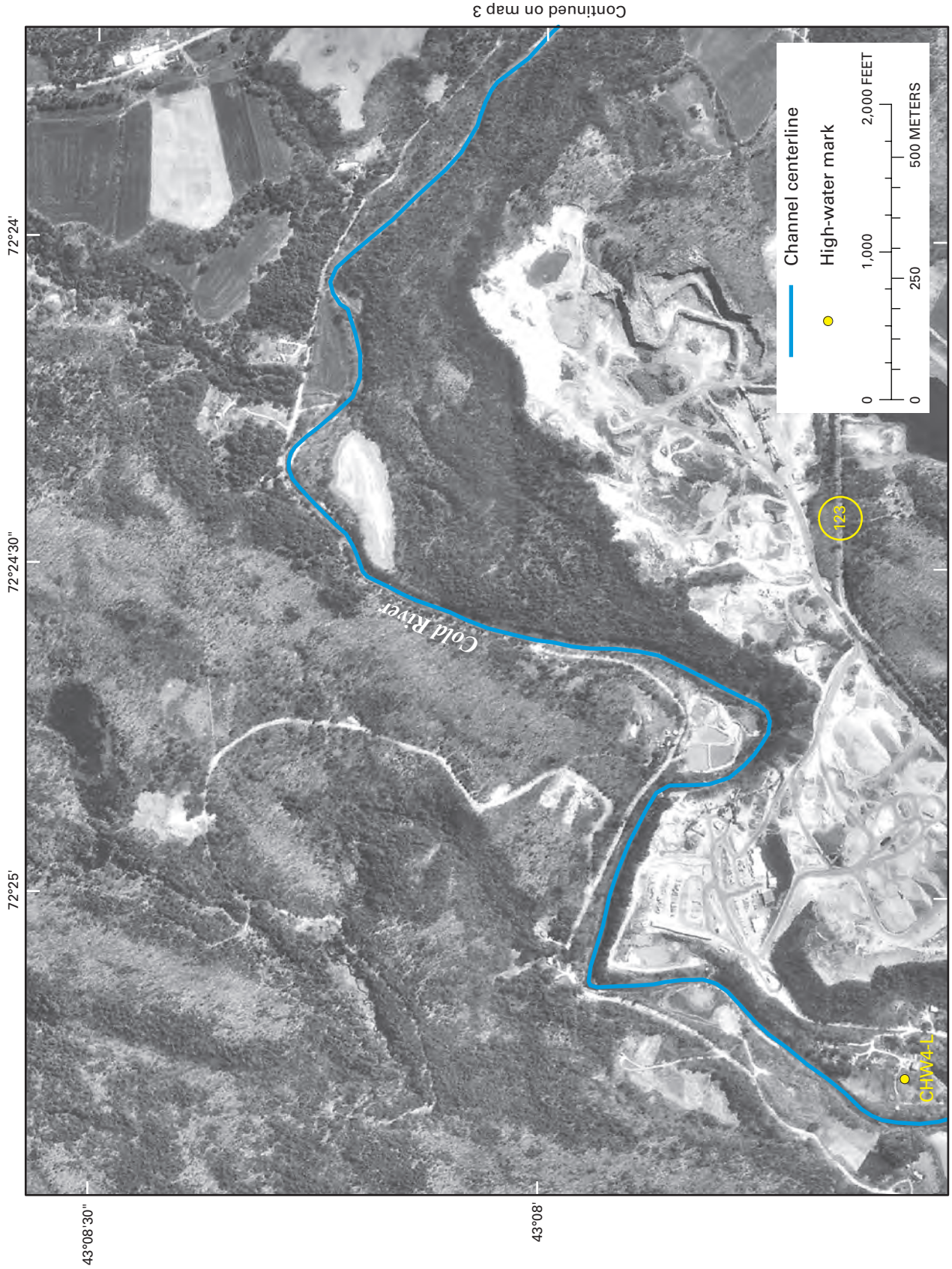

Figure 1-2. Location of high-water marks along Cold River, Walpole, and Langdon, NH (map 2 of 7).

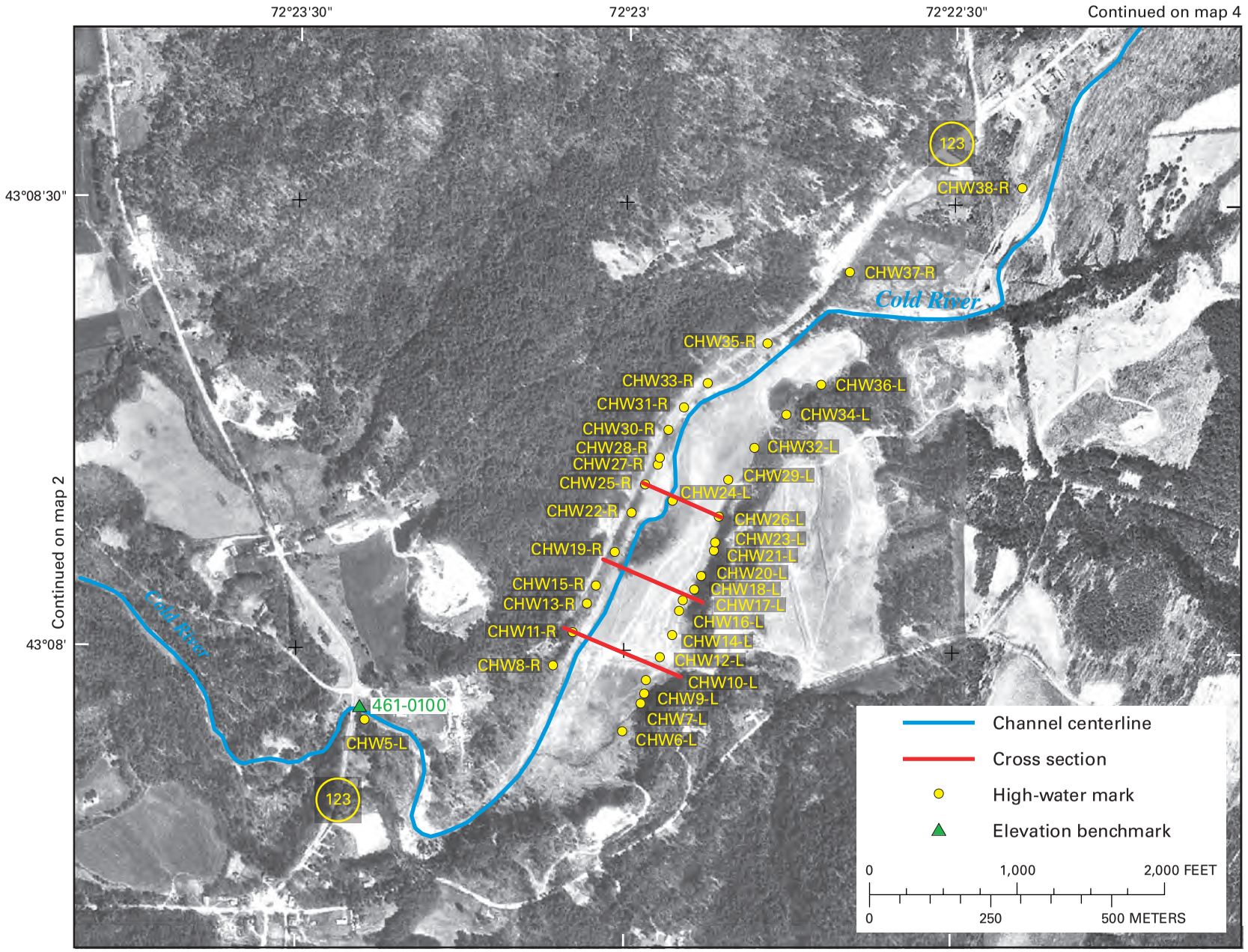

Figure 1-3. Location of high-water marks, cross sections, and elevation benchmark along Cold River, Walpole, Langdon, and Alstead, NH (map 3 of 7).

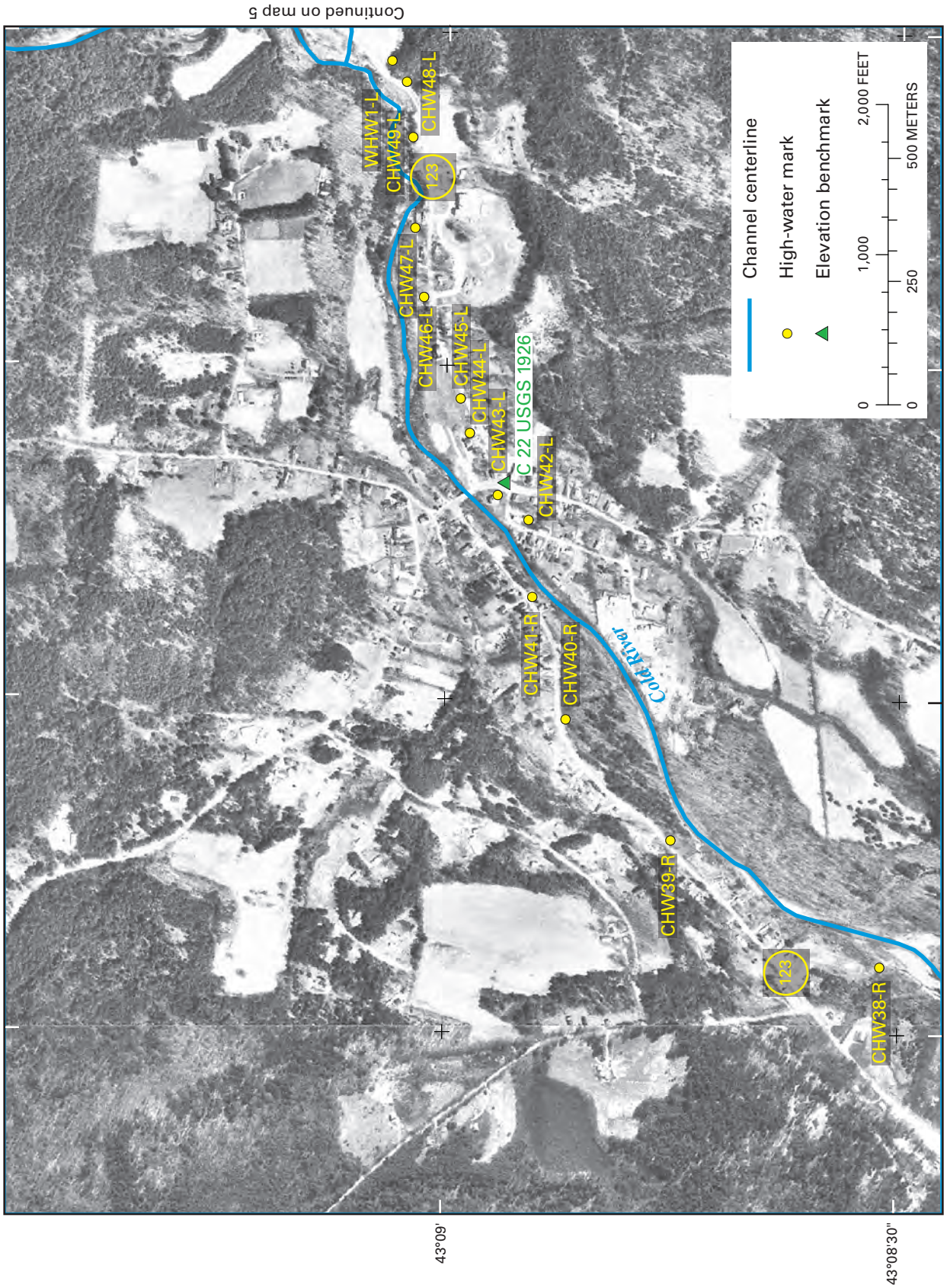

Figure 1-4. Location of high-water marks and elevation benchmark along Cold River, Alstead, NH (map 4 of 7).

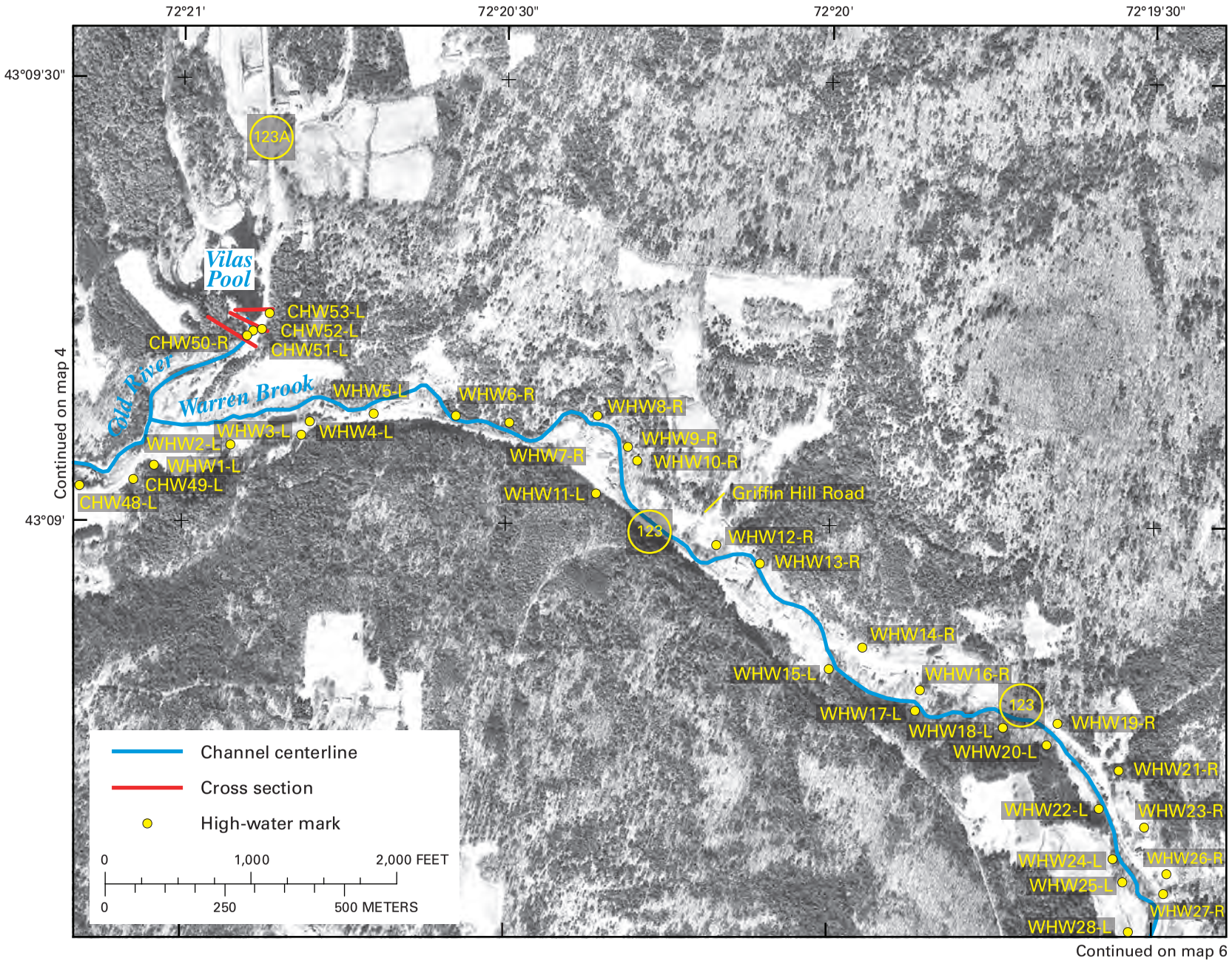

Figure 1-5. Location of high-water marks and cross sections along Cold River and Warren Brook, Alstead, NH (map 5 of 7).

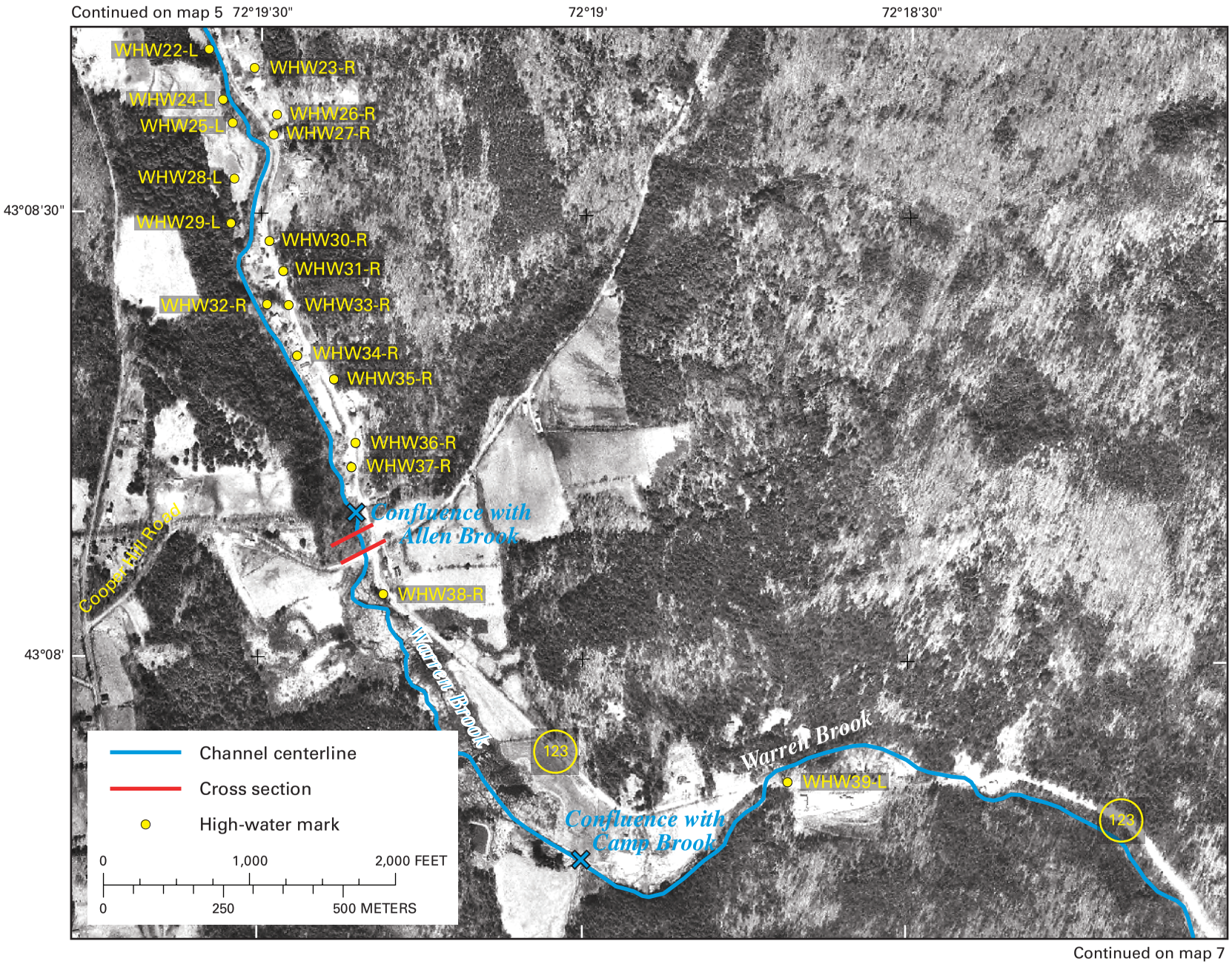

Figure 1-6. Location of high-water marks along Warren Brook, Alstead, NH (map 6 of 7).

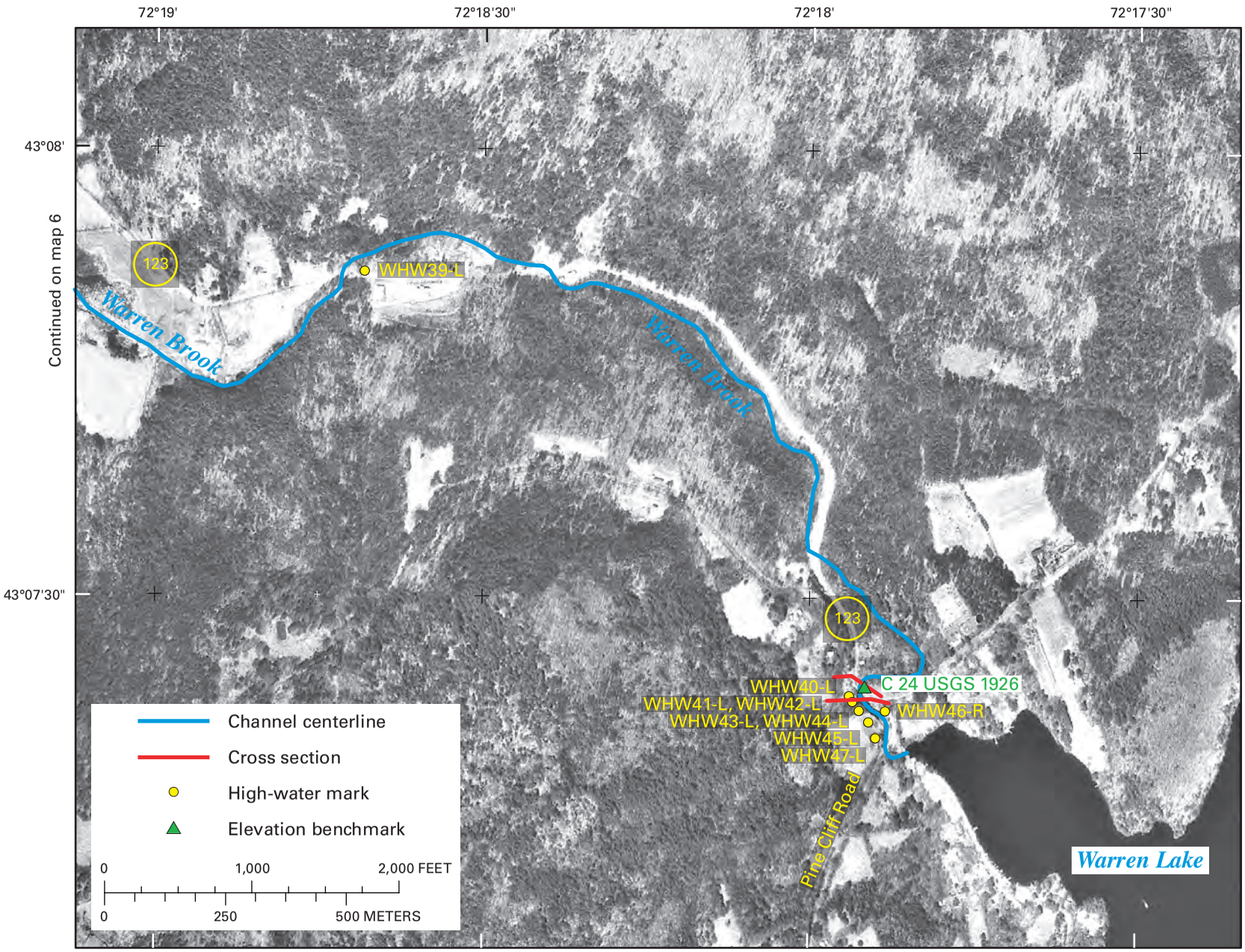

Figure 1-7. Location of high-water marks, cross sections, and elevation benchmark along Warren Brook, Alstead, NH (map 7 of 7).

Appendix 2: Profiles of the October 2005 Flood on Cold River and Warren Brook, Southwestern New Hampshire

Flood profiles in appendix 2 are in order from downstream to upstream. The Cold River flood profile is shown first, followed by the Warren Brook flood profile.

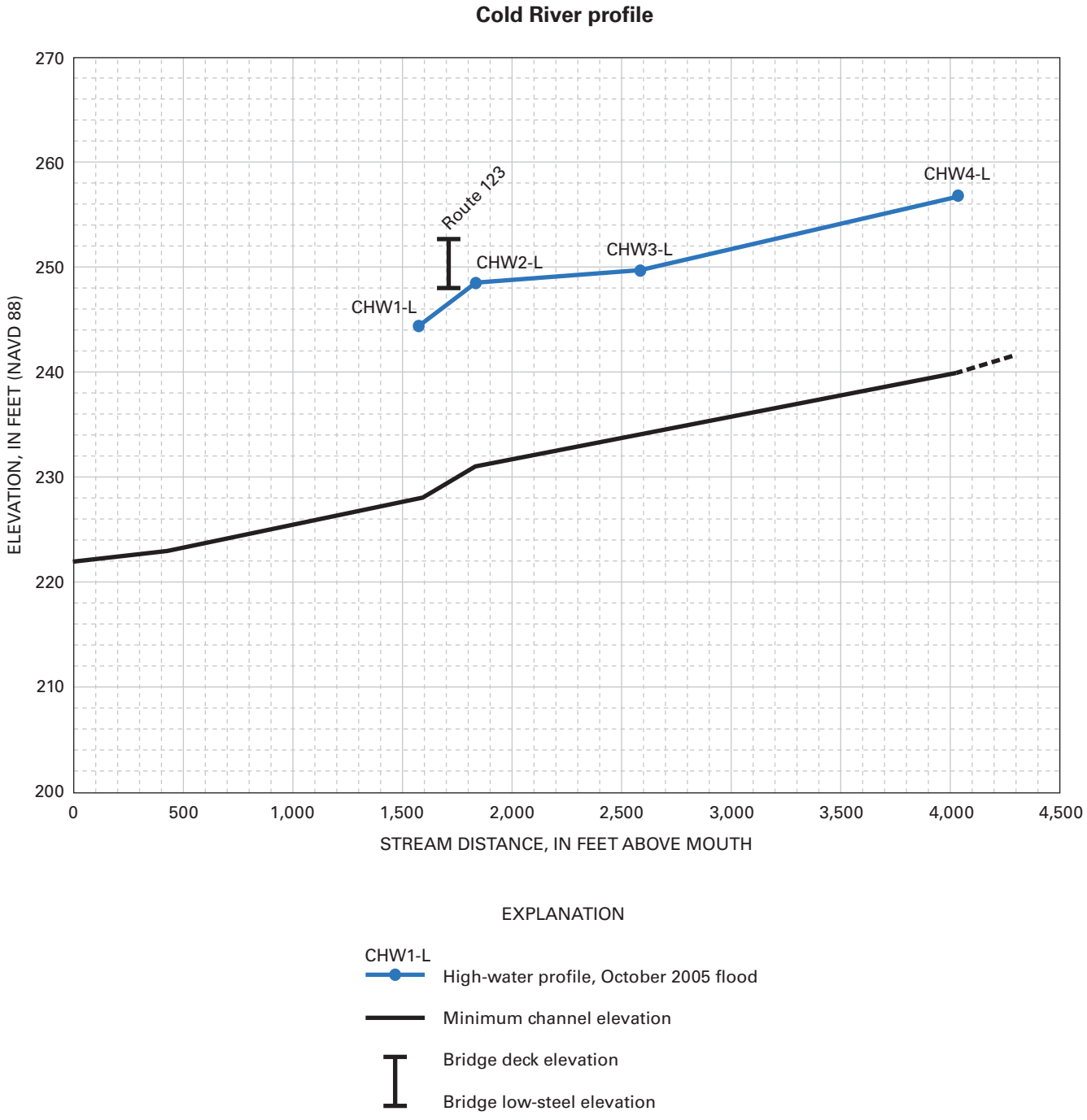

Figure 2-1. Profiles for Cold River, Walpole, NH.

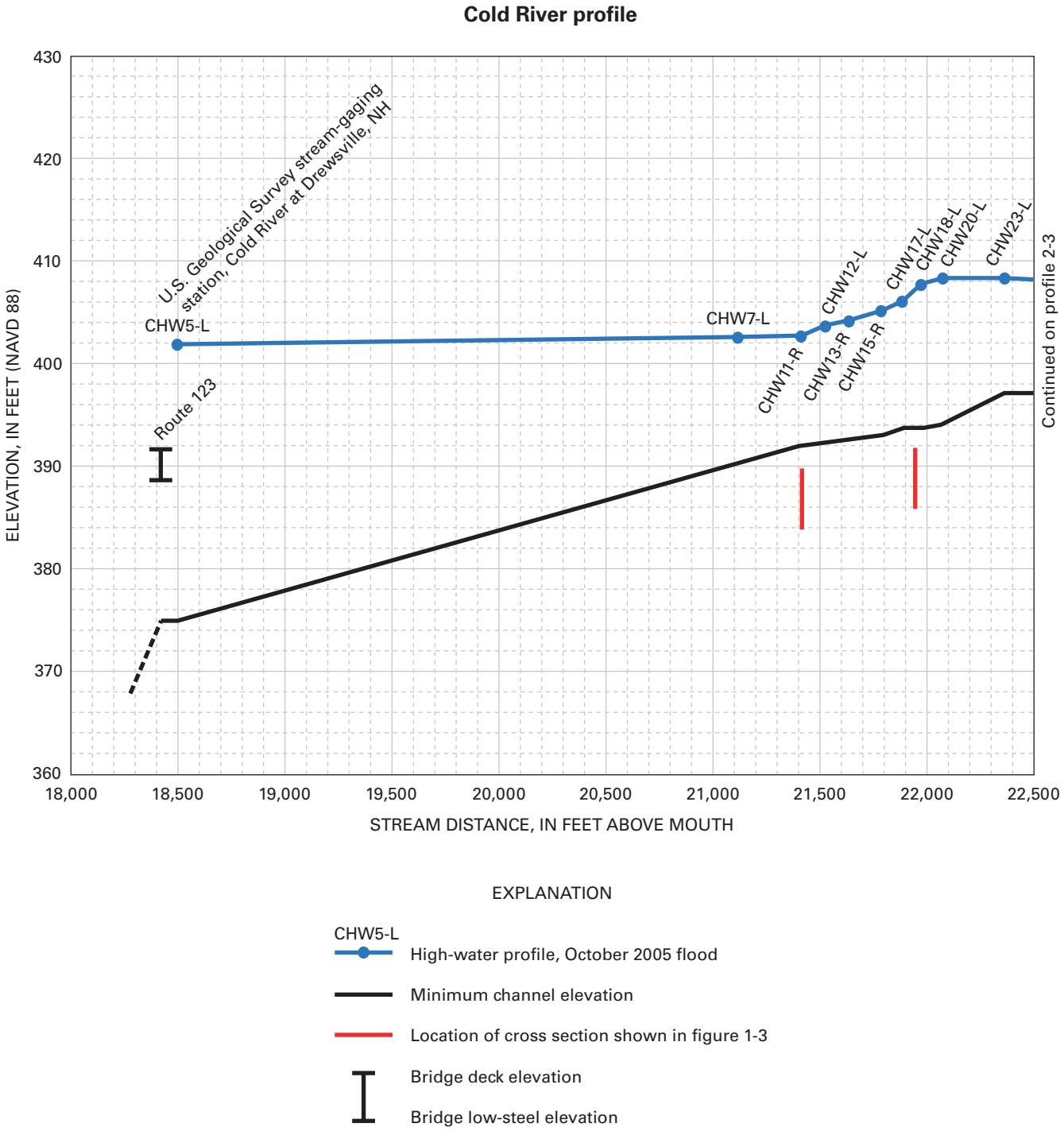

Figure 2-2. Profiles for Cold River, Walpole, and Langdon, NH.

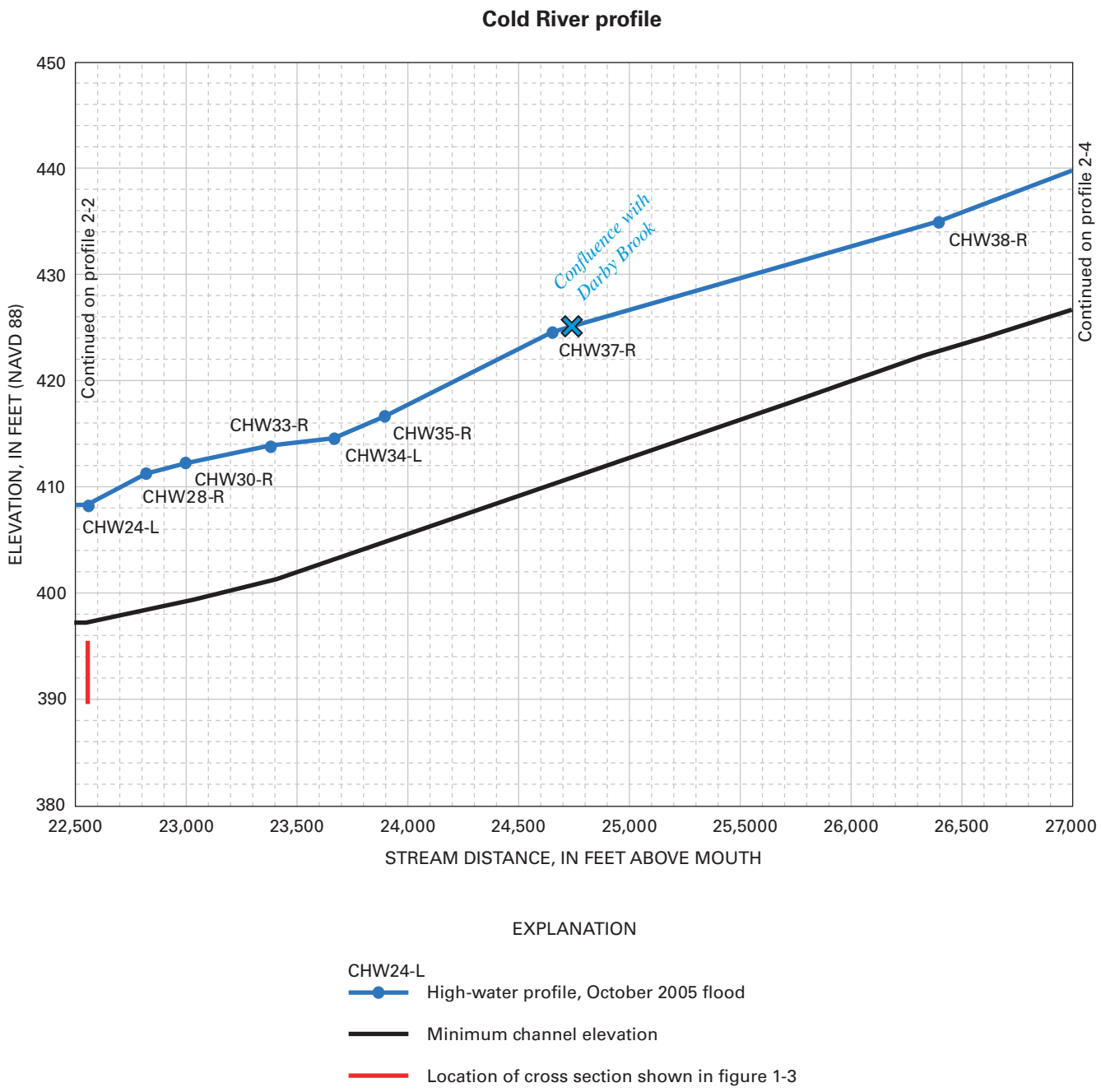

Figure 2-3. Profiles for Cold River, Langdon and Alstead, NH.

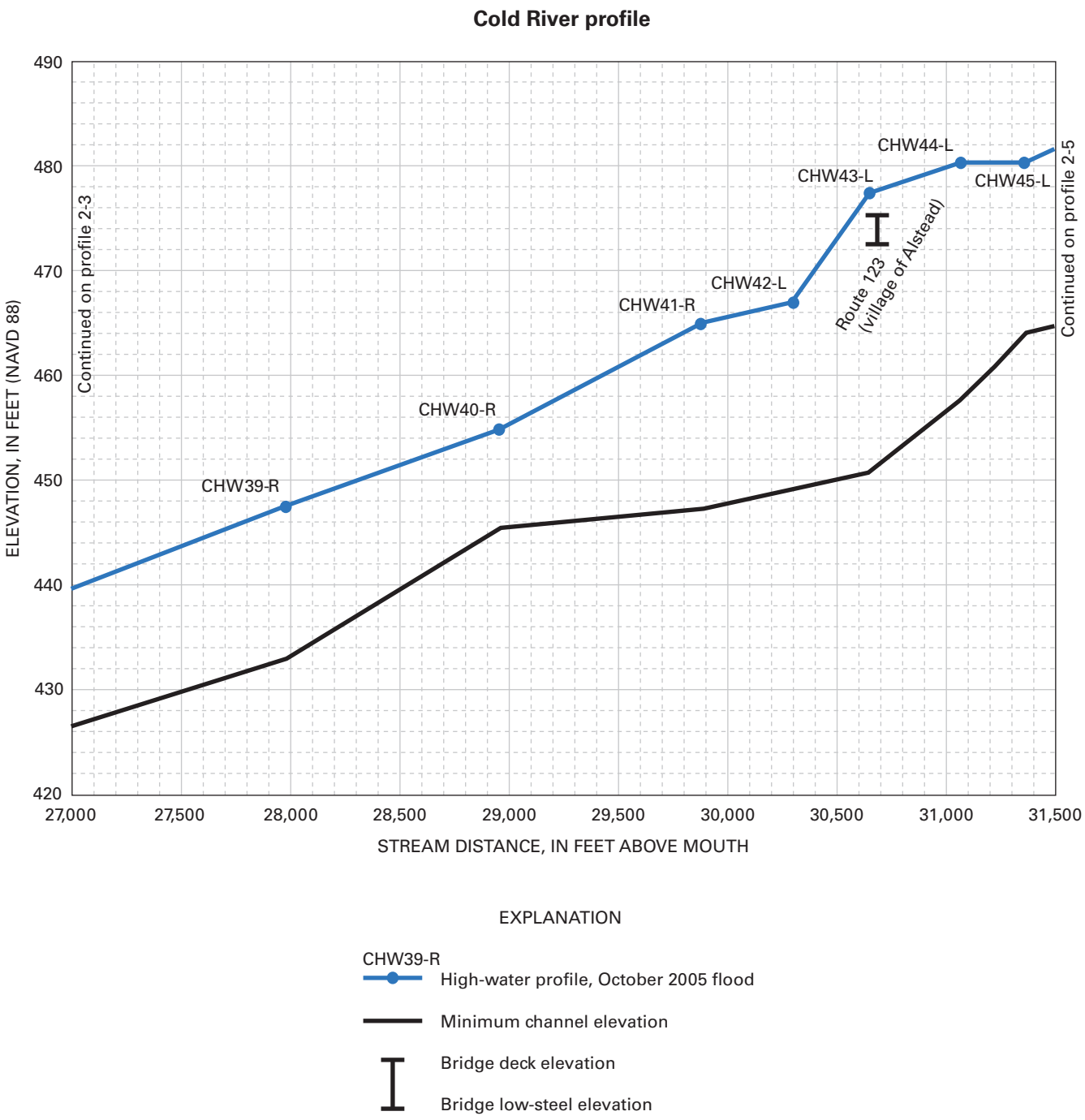

Figure 2-4. Profiles for Cold River, Alstead, NH.

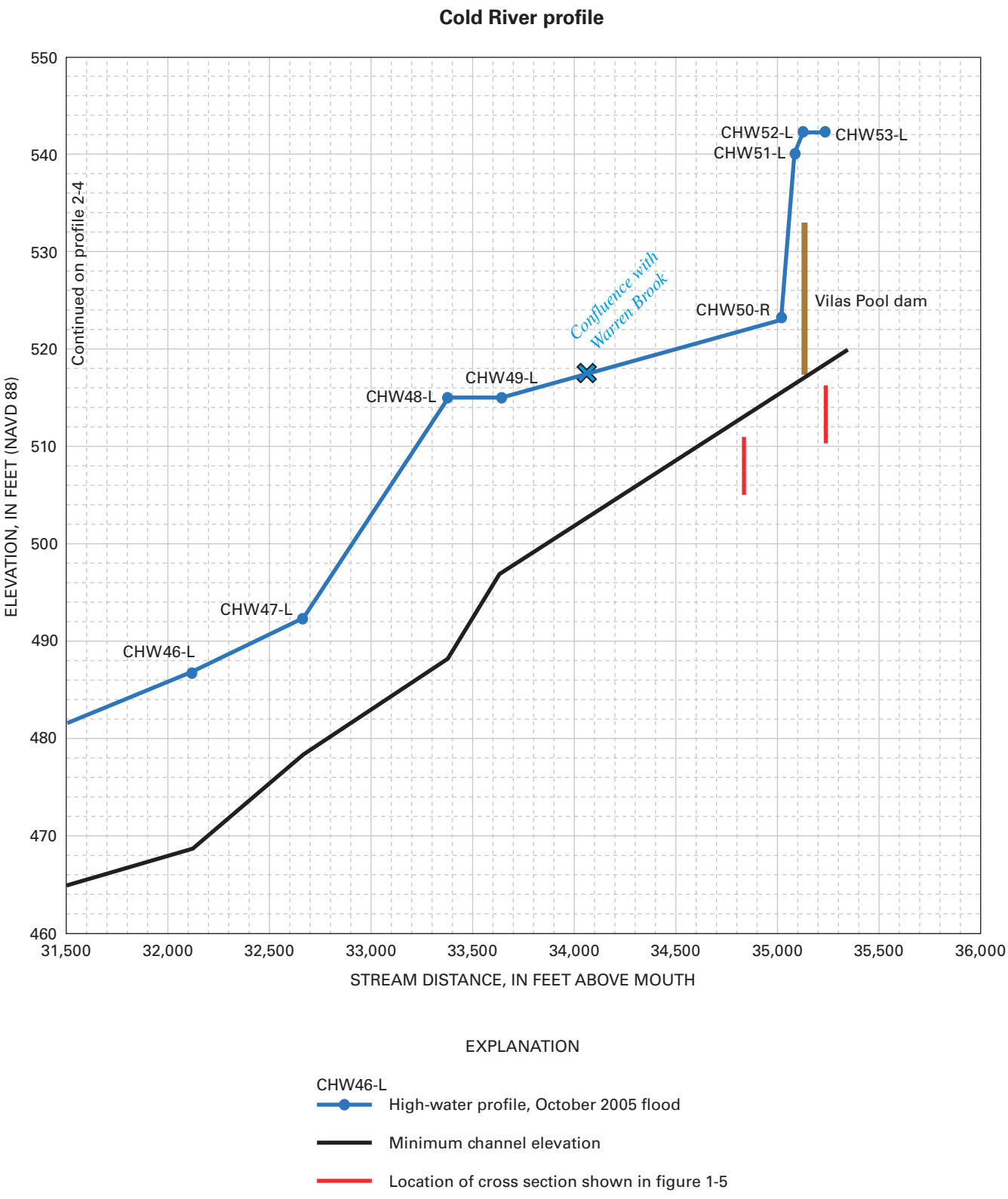

Figure 2-5. Profiles for Cold River, Alstead, NH.

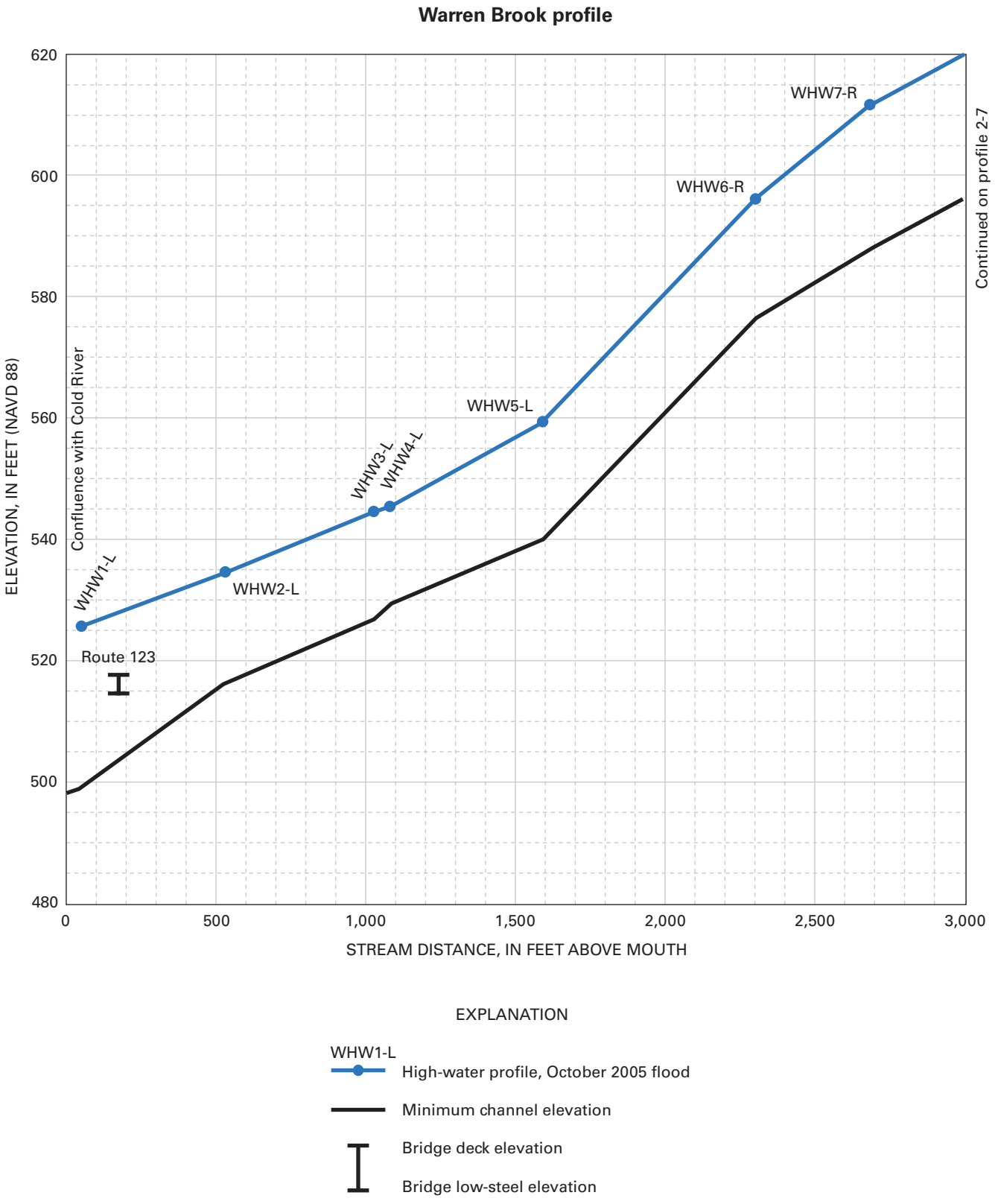

Figure 2-6. Profiles for Warren Brook, Alstead, NH.

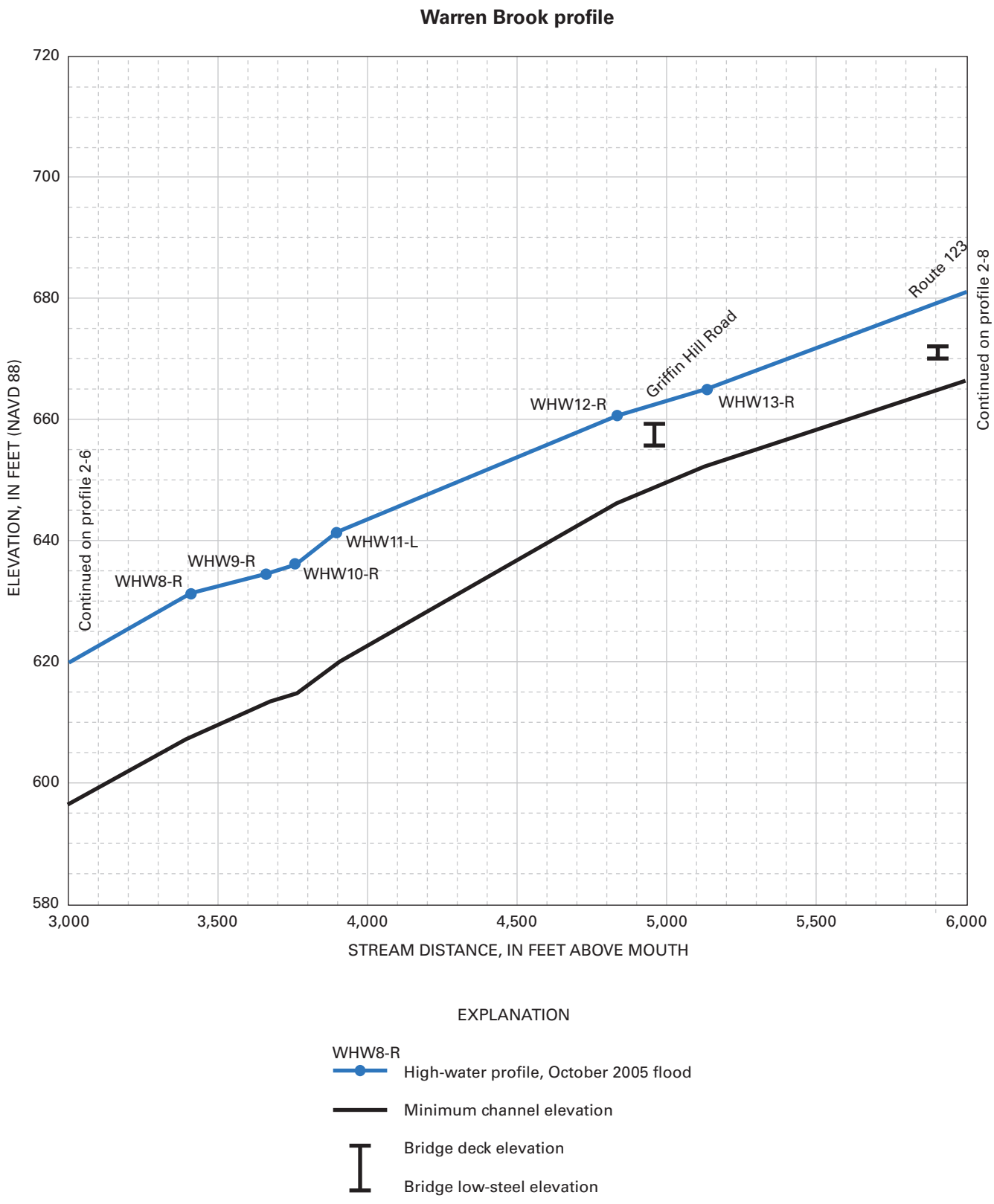

Figure 2-7. Profiles for Warren Brook, Alstead, NH.

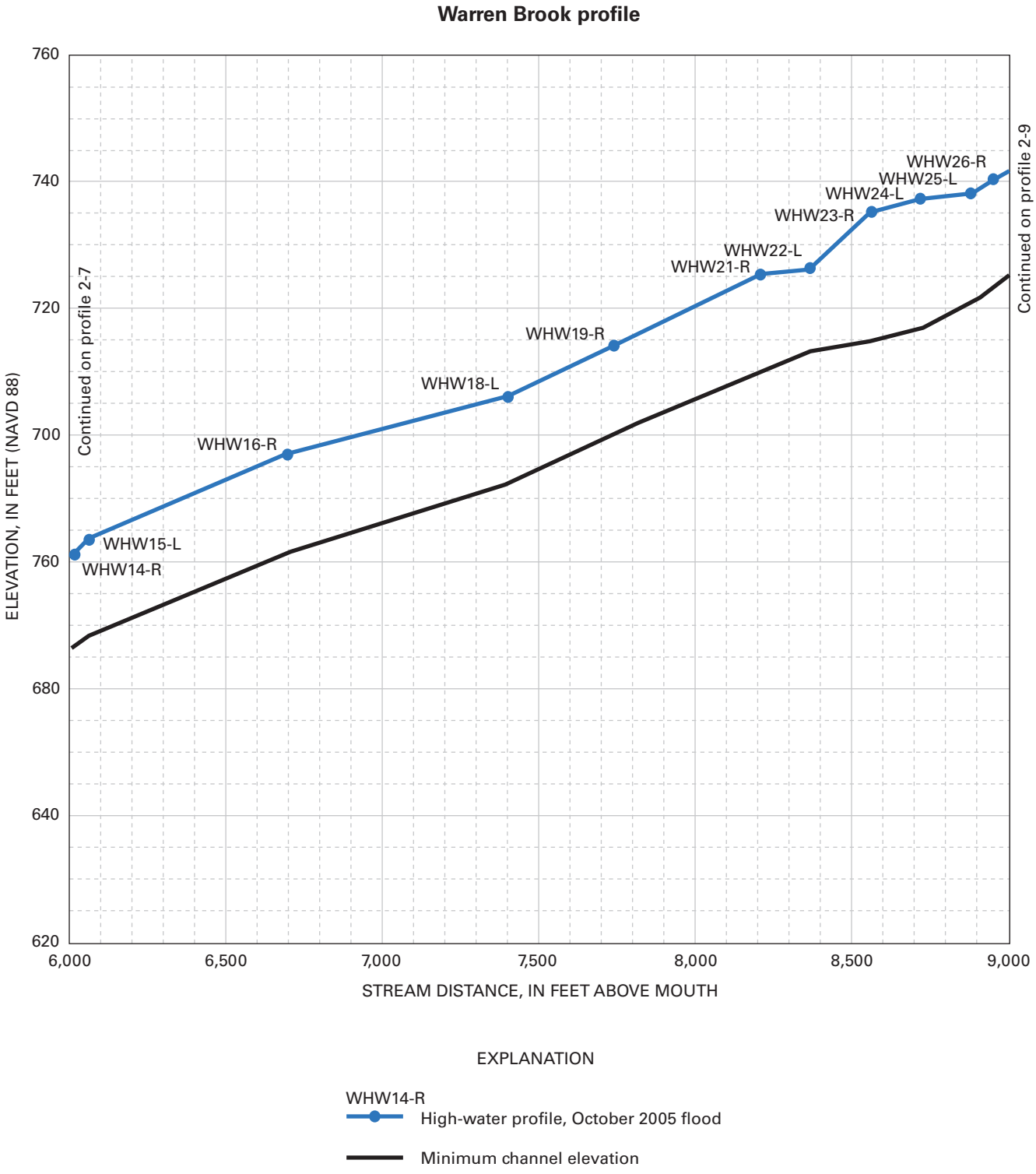

Figure 2-8. Profiles for Warren Brook, Alstead, NH.

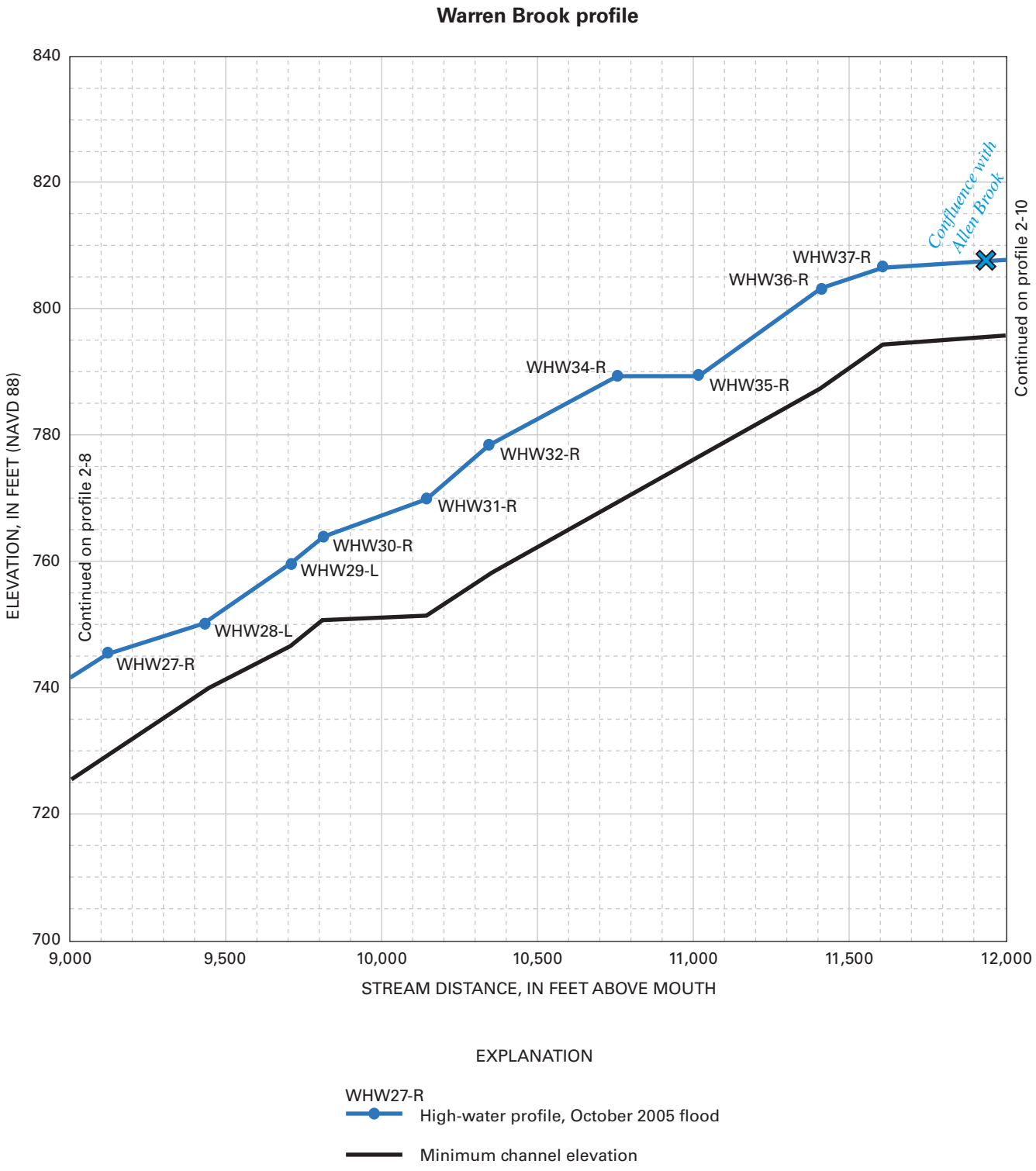

Figure 2-9. Profiles for Warren Brook, Alstead, NH.

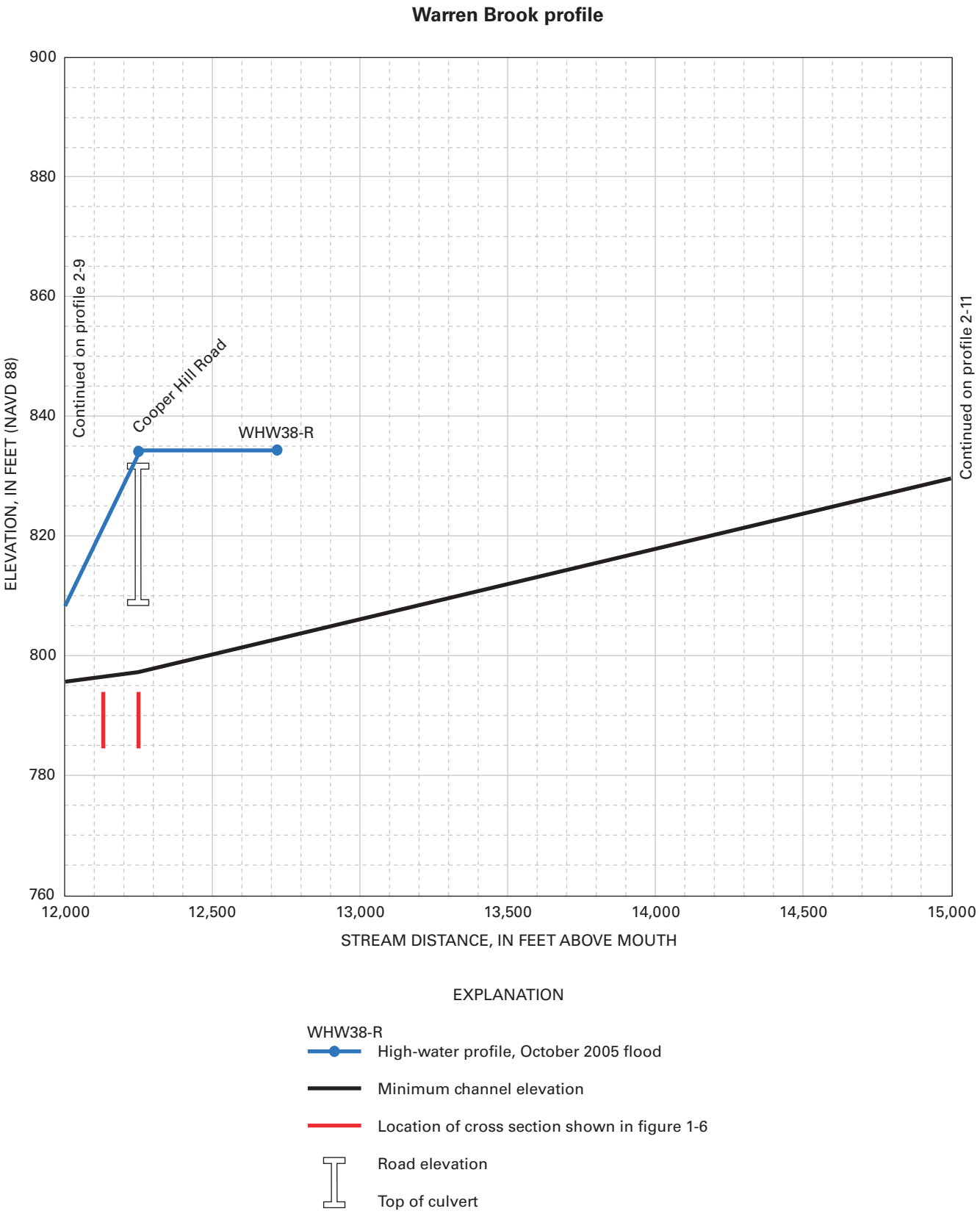

Figure 2-10. Profiles for Warren Brook, Alstead, NH.

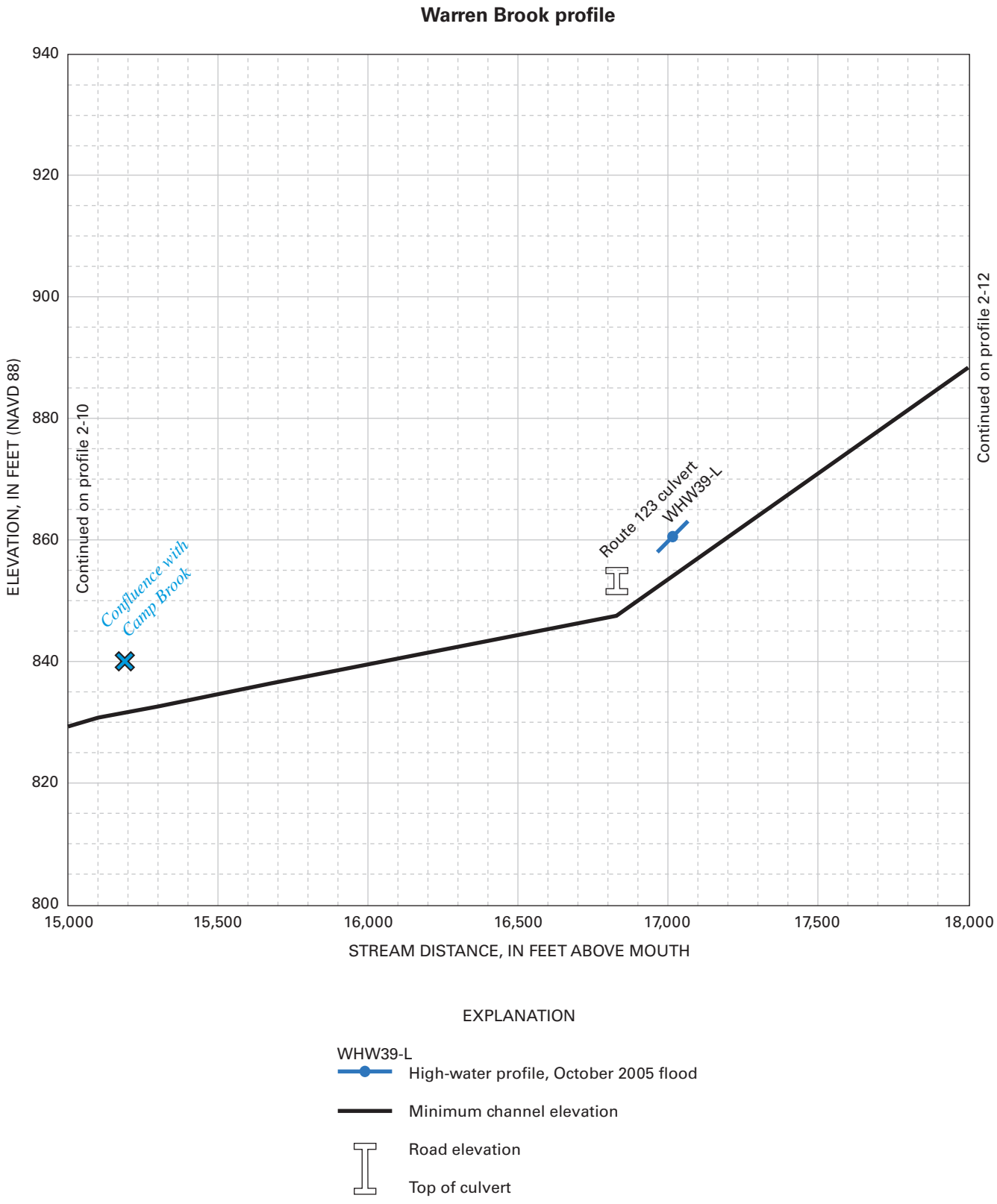

Figure 2-11. Profiles for Warren Brook, Alstead, NH.

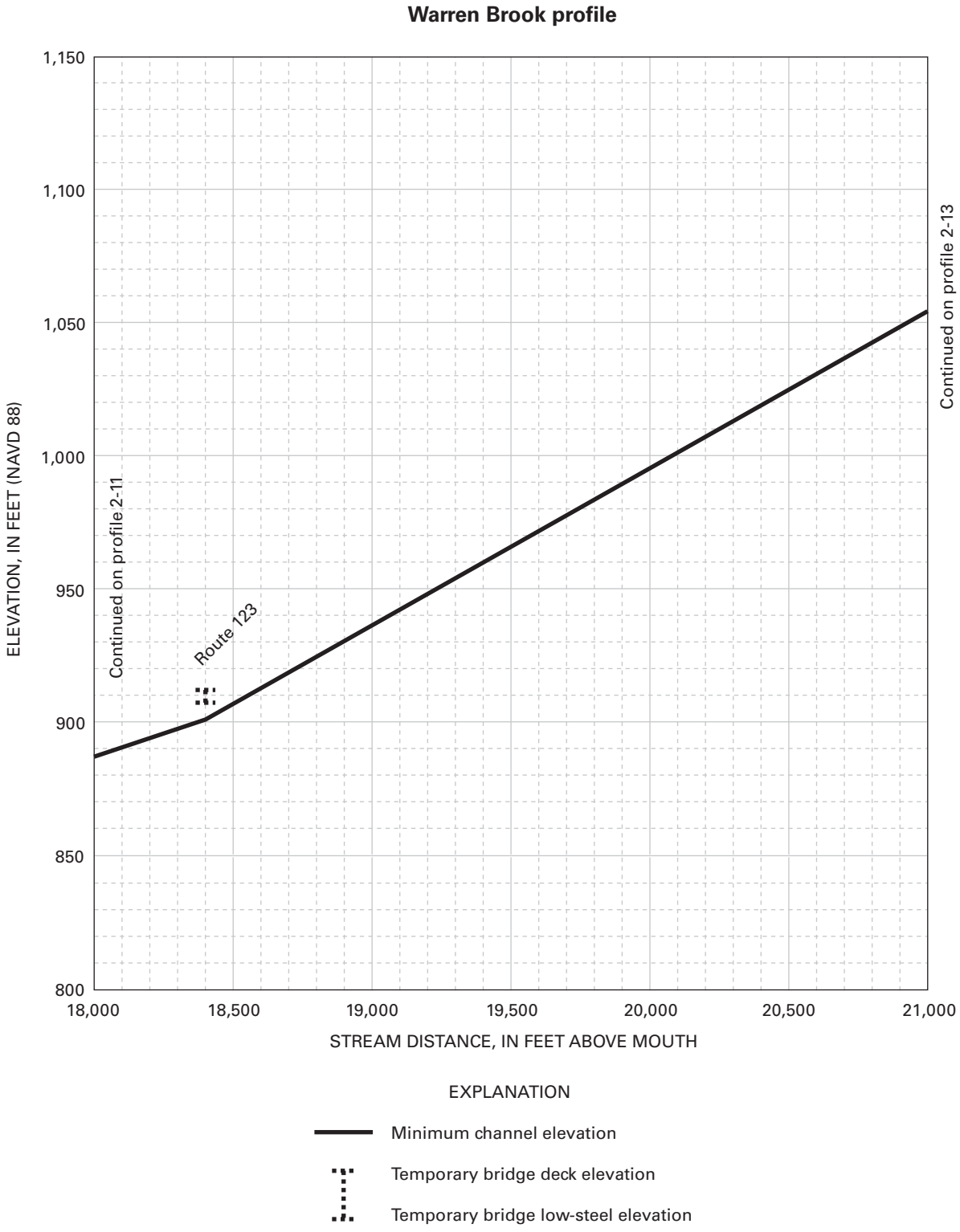

Figure 2-12. Channel profile for Warren Brook, Alstead, NH.

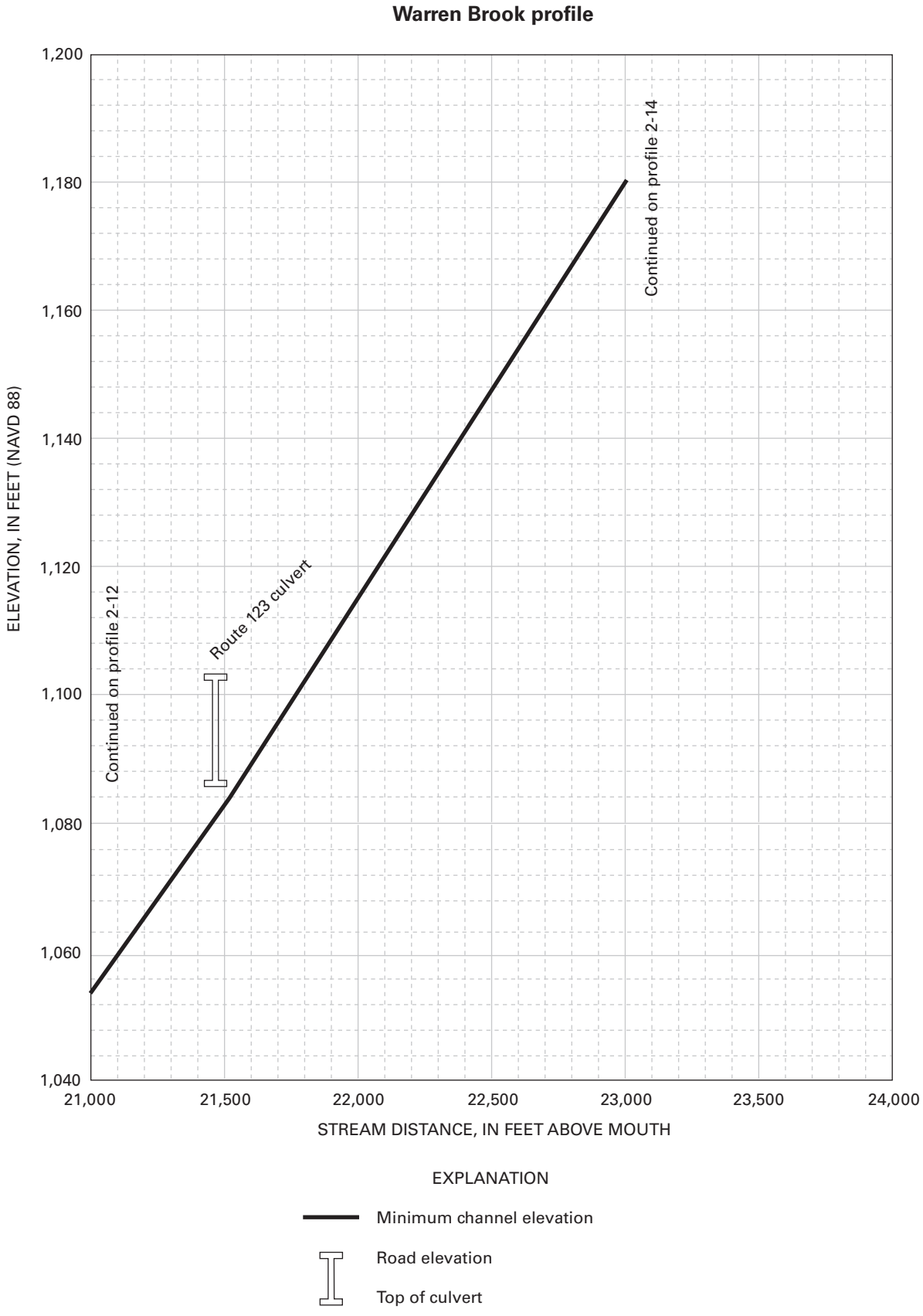

Figure 2-13. Channel profile for Warren Brook, Alstead, NH.

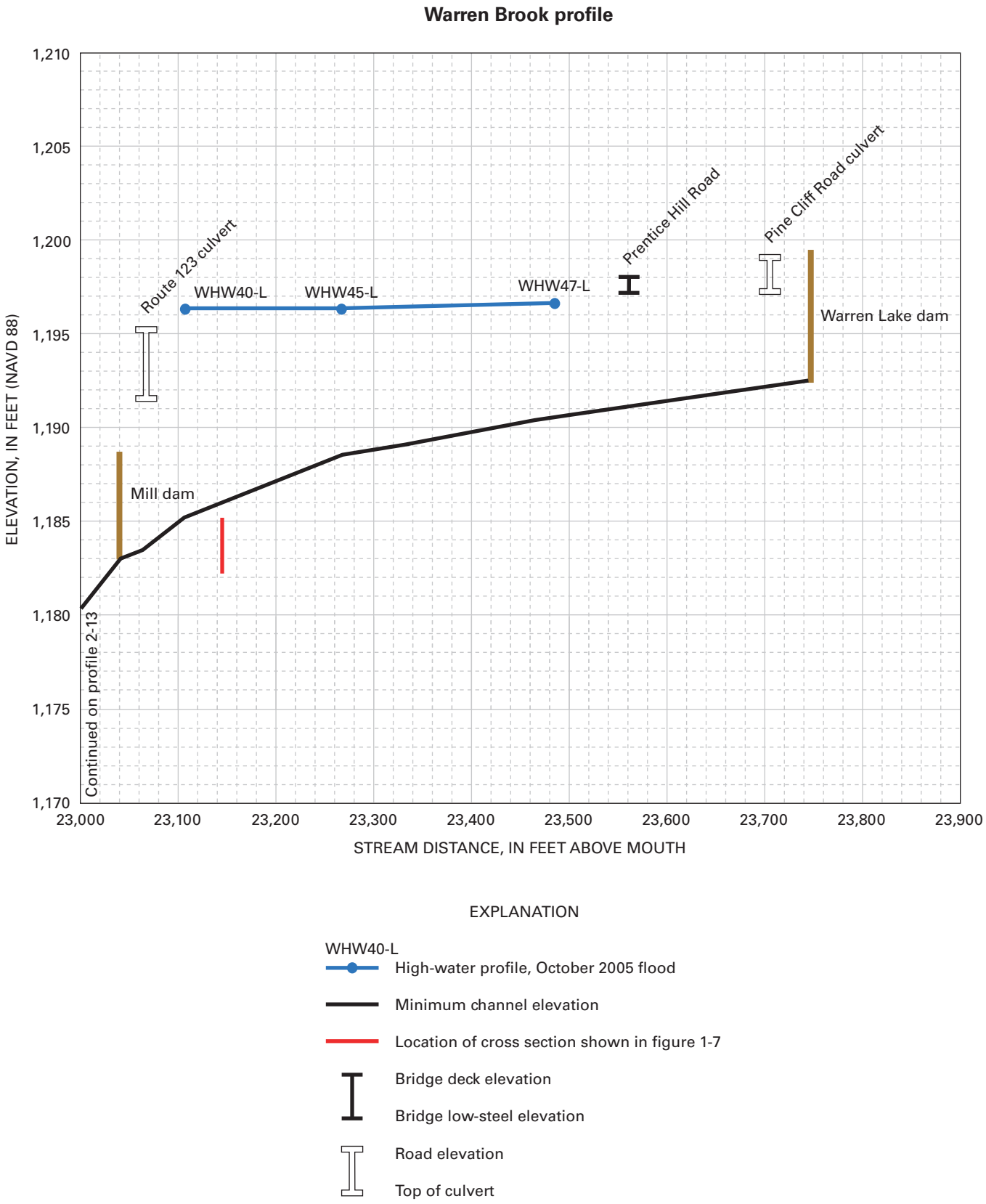

Figure 2-14. Profiles for Warren Brook, Alstead, NH.

Appendix 3: Elevation Benchmarks Along Cold River and Warren Brook, New Hampshire

Table 3-1. Elevation reference marks along Cold River and Warren Brook.

Designation	Elevation, feet (NAVD 88)[1]	Description
461-0100	391.70	Standard tablet stamped "461-0100" set in the top of the upstream end of the north abutment of the Route 123 bridge over Cold River in Drewsville, NH.
C 22 USGS 1926	477.28	Standard USGS Disk stamped "C 22 1926" set in the north concrete curb of the grass triangle formed by the road junctions of State Routes 12-A and 123 and Hill Road in Alstead, NH.
C 24 USGS 1926	1,190.35	Standard USGS Disk stamped "C 24 1926" set in a concrete dam and foundation to an old grist mill (circa 1767) 40 feet north from the center of State Route 123 and 525 feet northwest of the outlet of Warren Lake, Alstead, NH.

[1] North American Vertical Datum of 1988.

Prepared by Publications Service Center 1

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