NEW HAMPSHIRE HISTORIC PROPERTY DOCUMENTATION

BALDWIN STREET BRIDGE
[Preceded by West Bridge Street Bridge]
OVER FORMER BOSTON & MAINE RAILROAD

NH State No. 715

LOCATION: Baldwin Street spanning former Boston & Maine Railroad right-of-way, Nashua, Hillsborough County, New Hampshire.
USGS Nashua North NH Quadrangle UTM Coordinates: 19.297335.4737908

BUILDER: Boston & Maine Railroad

ENGINEERS: Pussey Jones, Engineer of Structures,
Arthur B. Corthell, Chief Engineer,
Boston & Maine Railroad, Office of Chief Engineer, Boston

DATE: 1919

PRESENT OWNER: New Hampshire Department of Transportation

PRESENT USE: Highway bridge

SIGNIFICANCE: The Baldwin Street Bridge is a three-span timber framed trestle highway bridge built by the Boston & Maine Railroad (B&M) Worcester, Nashua & Portsmouth Division in 1919 to span their tracks in Nashua. It is considered a "rare survivor of a once common type…reflecting B&M policy and bridge management during the B&M's period of significance."[1] The B&M Worcester, Nashua & Portsmouth Division headquarters was located in Nashua and employed over 500 city residents, a significant force in the social and financial health of the city. The West Bridge Street Bridge, predecessor of the Baldwin Street Bridge, can be "directly tied to the development of the dwellings [in the Fairmount Heights neighborhood] and is a significant part of the broad settlement pattern in this suburban area of Nashua; the current bridge continued the role of neighborhood connectivity."[2]

PROJECT INFORMATION: Baldwin Street Bridge was documented in accordance with the standards of the New Hampshire Historic Property Documentation Program in the spring of 2013 by Historic Documentation Company Inc. (HDC), Portsmouth, RI, for the City of Nashua, NH. The report was written and compiled by Richard M. Casella, Engineering Historian, HDC. Rob Tucher Photographic Documentation conducted and processed the large-format film photography in accordance with HABS/HAER standards. This documentation was undertaken to mitigate the removal and relocation of the bridge as part of the Broad Street Parkway construction project.

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[1] NH Division of Historical Resources Determination of Eligibility Form No. NAS0209, West Bridge Street Bridge, Nashua, NH.
[2] *Ibid.*

FIGURE 1: Location Map USGS Nashua North, NH 7.5 min. quadrangle, 1985.

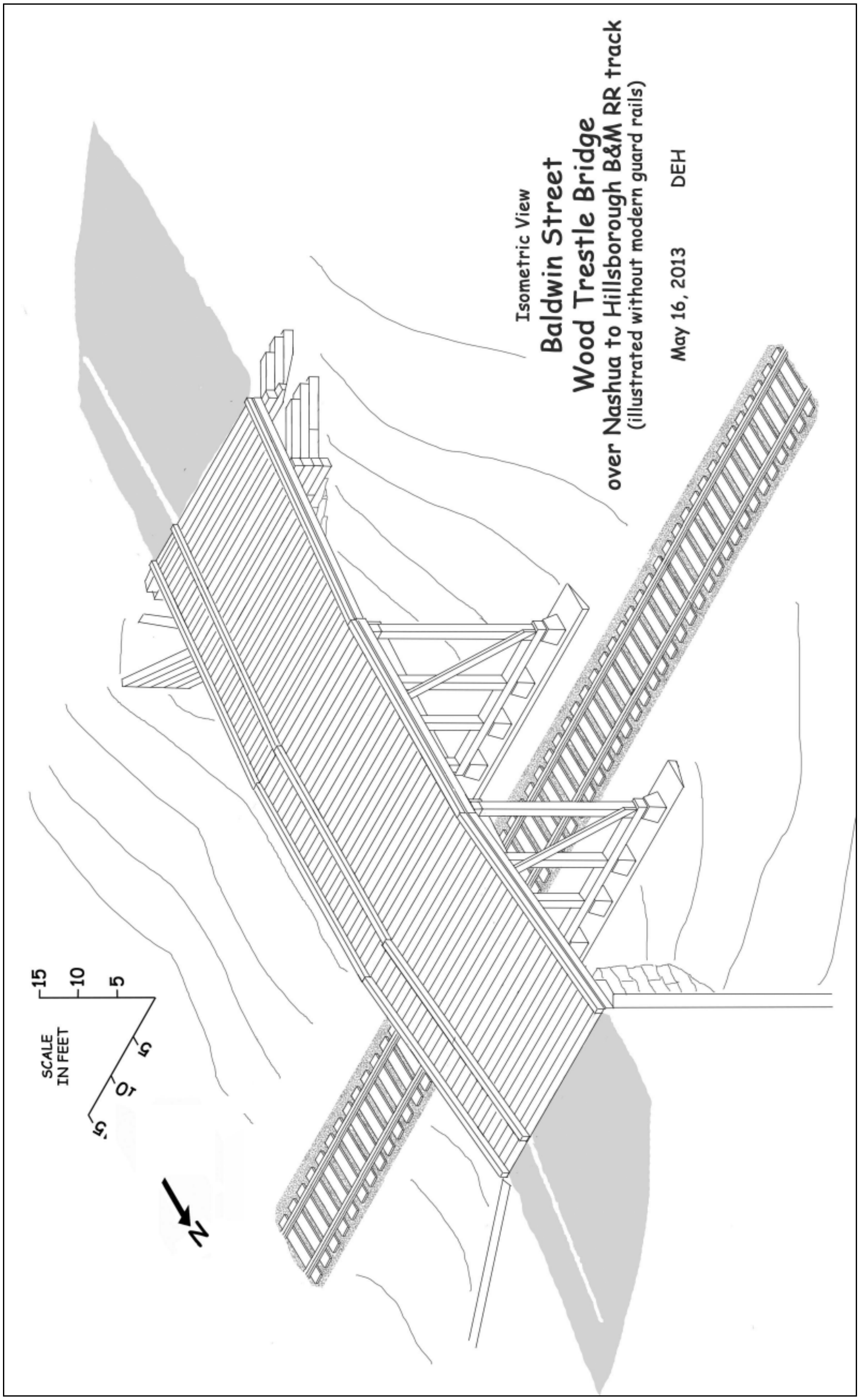

FIGURE 2: Baldwin Street Bridge, measured isometric drawing (Drawn by Dennis Howe, May 2013).

DESCRIPTION

Baldwin Street Bridge is a three-span, frame trestle highway bridge carrying Baldwin Street over the tracks of the former Boston and Maine Railroad, in Nashua New Hampshire (Figures 1 & 2). The bridge is oriented northeast-southwest. The area north of the bridge is densely settled with late 19th and early 20th century residences on the two blocks between the bridge and Amherst Street/NH 101A, a primarily artery through Nashua. The area south of the bridge along Baldwin Street for roughly 900 feet to Fairmount Street is wooded and undeveloped. Baldwin Street is roughly 28' wide but the bridge deck is only 12'-8" between the curbs forcing traffic down to one lane of travel over the bridge.

Bridge Background

The 1953 Boston and Maine Railroad Engineering Department Main Track Structures List for New Hampshire lists the Baldwin Street Bridge as Bridge Number 1.64 on the Hillsboro Branch, a framed trestle built in 1919. Original B&M plans identify the bridge as "Bridge No. 71 Baldwin St." on the Keene Branch of the Worcester, Nashua & Portland Division. The plans confirm that the bridge was built in 1919 to replace an existing trestle bridge of lighter design.[3] The existing granite footings and a granite pier were reused in the construction of the new bridge. The 1917 General Plan (Figure 3) shows the preceding bridge as a 5 span structure with two short "approach spans" approximately 2'-4" long at the south end and 6' long at the north end. It is supported on – from south to north – a wood sill abutment, a low timber frame bent, two high timber frame bents flanking the tracks, a low concrete pier and a wood sill abutment. The concrete pier is almost certainly a misidentification because it is clearly the same pier identified on the later plans as "stone laid in cement" that exists today serving as the north abutment.[4]

The August 27, 1918 Survey Plan (Figure 4) provides typical professional land survey information not included on the 1917 General Plan, including property boundaries, structures on nearby properties, line grade, elevations as well as bridge structure measurements. Baldwin

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[3] Plans all refer to the structure as "Bridge No. 71, Baldwin St., 0.7 miles west of Nashua, NH" and include a General Plan drawing dated 8/7/17 with the note "Valuation Section No. 17," apparently prepared by B&M pursuant to the [Railroad] Valuation Act of 1913, discussed below; a Survey Plan drawing dated 8/27/18 prepared by B&M apparently in anticipation of grade and clearance improvements to the line and replacement of the bridge; and a General Plans & Details drawing dated 11/13/18, revised 2/23/20, revised 8/18/23 which were the construction drawings for the present bridge. The 1923 date on the plans is outside the title block, standard practice for the date of the final engineer's inspection of the completed construction and any as-built modifications added to the plans. The NHDOT, current owner of the bridge, lists the construction date as 1935 which, like many dates in the bridge summary, is incorrect. The NHDHR inventory form for the bridge (NAS 0209) reports that "the personal recollection of the chief bridge engineer is that the bridge has been re-decked sometime during his 40-year career, obviously after 1935." The redecking referred to was probably done with the construction of the sidewalk after 1979.

[4] There was incentive for the railroads at the time to over-value their assets or it may have been an honest mistake. The [Railroad] Valuation Act of 1913 required the Interstate Commerce Commission to verify the value of railroad properties. Beginning in 1914 the railroads inventoried and appraised the value of their properties, producing right-of-way maps and plans of structures, typically dated 1917 or 1918, which were then verified as correct by the ICC. It is unlikely that a concrete pier that would not have been very old at the time, would have been removed and replaced with a stone pier of rough masonry construction typical of 19th century work.

Street south of Prescott Street (the first cross street north of the bridge) is identified as a "private way." The Survey Plan was evidently prepared to assist B&M engineers in the design of a new bridge for the crossing, the same practice today.

The next plan, General Plans & Details, drawn November 13, 1918 (Figure 5) shows the new bridge as it exists today with the exception of the sidewalk extension (added after 1979, discussed below). The 1918 plan called for raising the railbed approximately 16", raising the bridge approximately 24" and increase the load capacity of the bridge from 5-1/2 tons to 14 tons. This work included: the addition of 24" high concrete footings and caps atop the existing granite footings to carry the new 4-column bents in place of the existing 3-column bents; larger stringers (10"x14") to replace the existing 6"x14" stringers; timber sills added (or replacing) the existing timber abutments to increase their height by about 14". The short timber bent under the south approach span was reconstructed as a solid timber retaining wall (no longer supporting the stringers) with the timbers resting on a rubble stone footing as it currently exists. None of the plans detail this stone footing so its origin is unknown. The south timber abutment was reconstructed with timbers stacked on wood sills to meet the new grade.

The stone pier carrying the north approach span became the present north abutment due to the filling of the embankment slopes in conjunction with the raising of the railbed. With the addition of timber retaining walls flanking the stone pier, the slope under the approach span was filled and the span eliminated. Timber sills were added to the top of the pier (now serving as an abutment) to meet the new grade. The slope fill and roadbed fill also buried the previously exposed granite footings under the main span bents. These alterations converted the structure from 5-spans to 3-spans, with the slightly longer length of the two new side spans accommodated structurally by the much heavier stringers.

Description

The bridge is 73 feet long overall with spans measuring 23', 21' and 24' from south to north. It is carried on two timber-framed bents on concrete footings and abutments of timber and stone construction. Bridge inspection drawings prepared in 1979 by Sverdrup & Parcel Engineers for the New Hampshire Department of Transportation (NHDOT) and are presented below (Figures 6,7,8).

The bents are identical consisting of four timber 12"x12" (all timber sizes are nominal) columns 14'-6" tall with 12"x12" cap and sill beams. The columns are spaced on 4' centers and joined with two 3"x10" diagonal timber braces and 1" diameter thru-bolts. The bent sills rest on four concrete pedestal footings 24" square at the base and 24" high, cast in the form of a truncated square pyramid. The footings are aligned with the columns, and in turn rest on buried but partly exposed concrete caps cast on top of granite footings of unknown dimensions that carried the preceding bridge bents. The concrete pedestal footings and foundation caps were added to raise the height of the new bridge roughly 2 feet.

At the east end of each bents is a single 4"x14" timber post that rises at a steep angle to support the sidewalk. The sidewalk post rests on the bent footing and supports an outside stringer that carries the sidewalk. Two 4"x10" timbers are bolted to the bent cap and extend out 5' to hold the sidewalk post. The sidewalk and its supporting members are not shown on the 1979 inspection drawings indicating the sidewalk assembly was added after that time. The bridge decking was reportedly replaced within the last 40 years which was likely done when the sidewalk was added.[5] Decking was noted as 4"x10 on the 1979 inspection sketches; current decking is 4"x12".

The north abutment is constructed of rough coursed, split-face granite blocks, that appear to have been originally dry-laid with later pointing or "grouting", referred to as "stone laid in cement" on one of the original plans. This abutment previously served as a pier carrying the approach span of the preceding bridge. On top of the granite abutment are two rows of 12"x12" timbers, the first row laid perpendicular to the abutment with spacing, the second laid parallel to it (transverse to the stringers), upon which the stringers rest. These timbers were added to raise the height of the new bridge. At the east side of the stone abutment is a 5-foot wide timber crib-type abutment constructed of stacked treated timbers or railroad ties. This extension was added sometime after 1979 to carry the sidewalk that was added to the bridge at the same time. The south abutment is of timber construction consisting of three rows of stacked treated timbers or railroad ties resting on earth. Stacked timber retaining walls flank the abutments, braced in some places with sections of steel rail driven vertically into the ground. A similar 5' extension was added to the south abutment to carry the sidewalk.

Deck stringers consist of seven 10"x14" timbers spaced 27" on centers. Wood decking consisting of 4"x12" planks is laid flat and perpendicular to the stringers. The sidewalk, added to the east side of the bridge after 1979, is approximately 5' wide with a wood deck of 4"x12" treated timbers separated from the roadbed by a 10"x10" timber curb. An asphalt sidewalk extends from the bridge sidewalk about 40' along the southeast side of the road. Standard W-section steel guardrail guards the steep bank along the sidewalk. Along the west side of the bridge is a timber curb and a 38" high aluminum guardrail consisting of two-rails on aluminum H-posts bolted to the outside stringer. A 38"-high chain-link fence is attached to the outside of the guardrail. On the east side along the outside of the sidewalk is standard 5-foot-high vinyl-covered chain-link fencing on metal pipe posts bolted to the sidewalk stringer.

The engineers of the bridge are listed on the original B&M plans as A. B. Corthell, Chief Engineer and Pussey Jones, Engineer of Structures. Arthur Bateman Corthell (1860-1924) was a highly accomplished professional engineer when in 1911 he assumed the position of Chief Engineer of the B&M following the resignation of J.P. Snow. He remained in that position until his sudden death on May 24, 1924 while spending the weekend at his farm in New Boston, New Hampshire. Following graduation from Brown University in 1881 Corthell held several engineering positions with railroads across the country. Among his many notable projects was the design and construction of the new Providence Terminal in 1892, followed by South Station, Boston, one of the largest terminals in the world at the time. On both terminals he worked in association with the renown engineer George B. Francis. Then, from 1902 to 1911 Corthell was connected with the construction of Grand Central Terminal.

Pussey Jones (1880-?) joined the B&M in 1916 as chief draftsman. He was appointed acting engineer of structures in 1917 and promoted to bridge engineer in 1920.

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[5] See note 3.

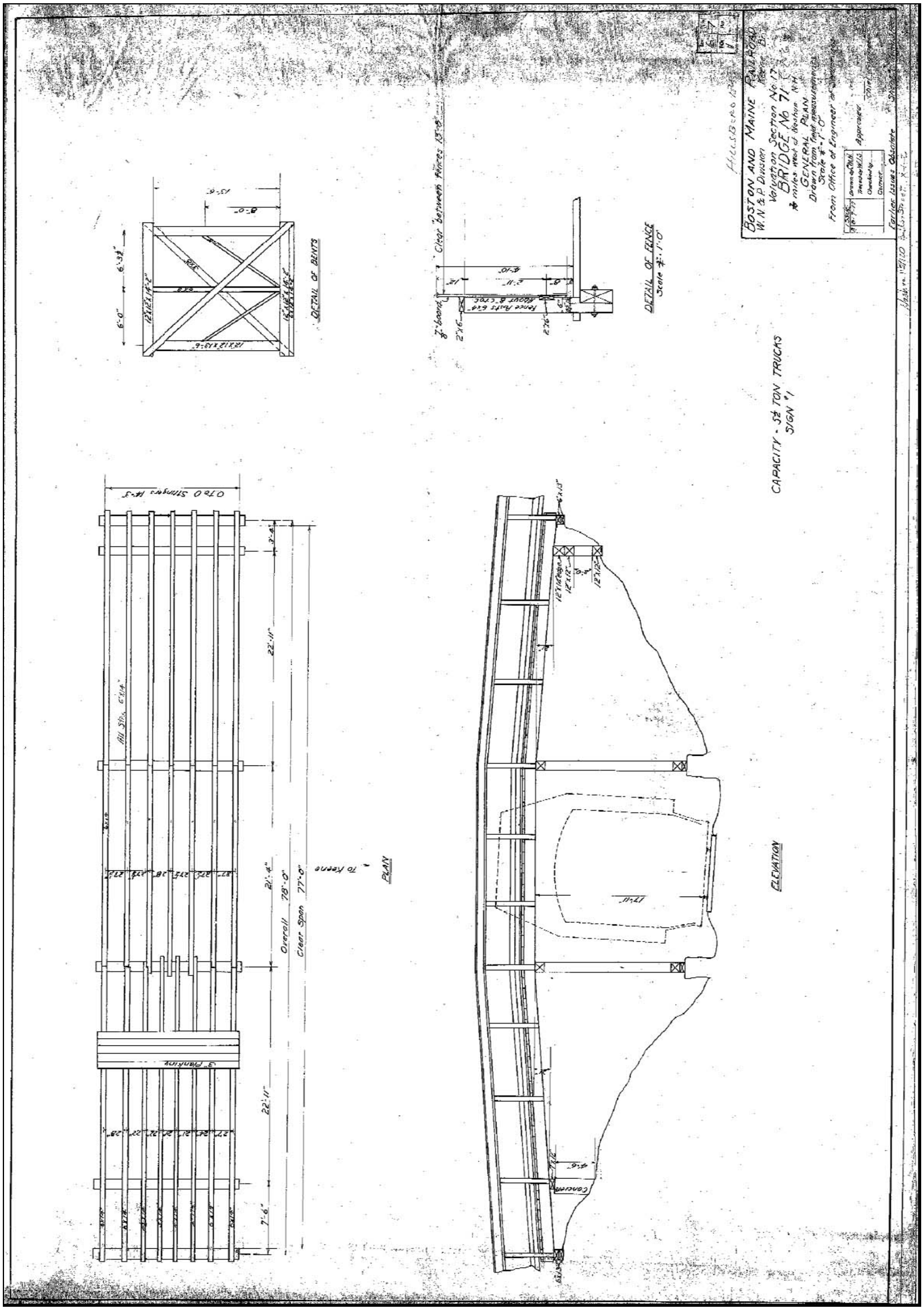

FIGURE 3: Baldwin Street Bridge, "General Plan," dated 8/7/1917 (Boston and Maine Railroad Plans, 1917).

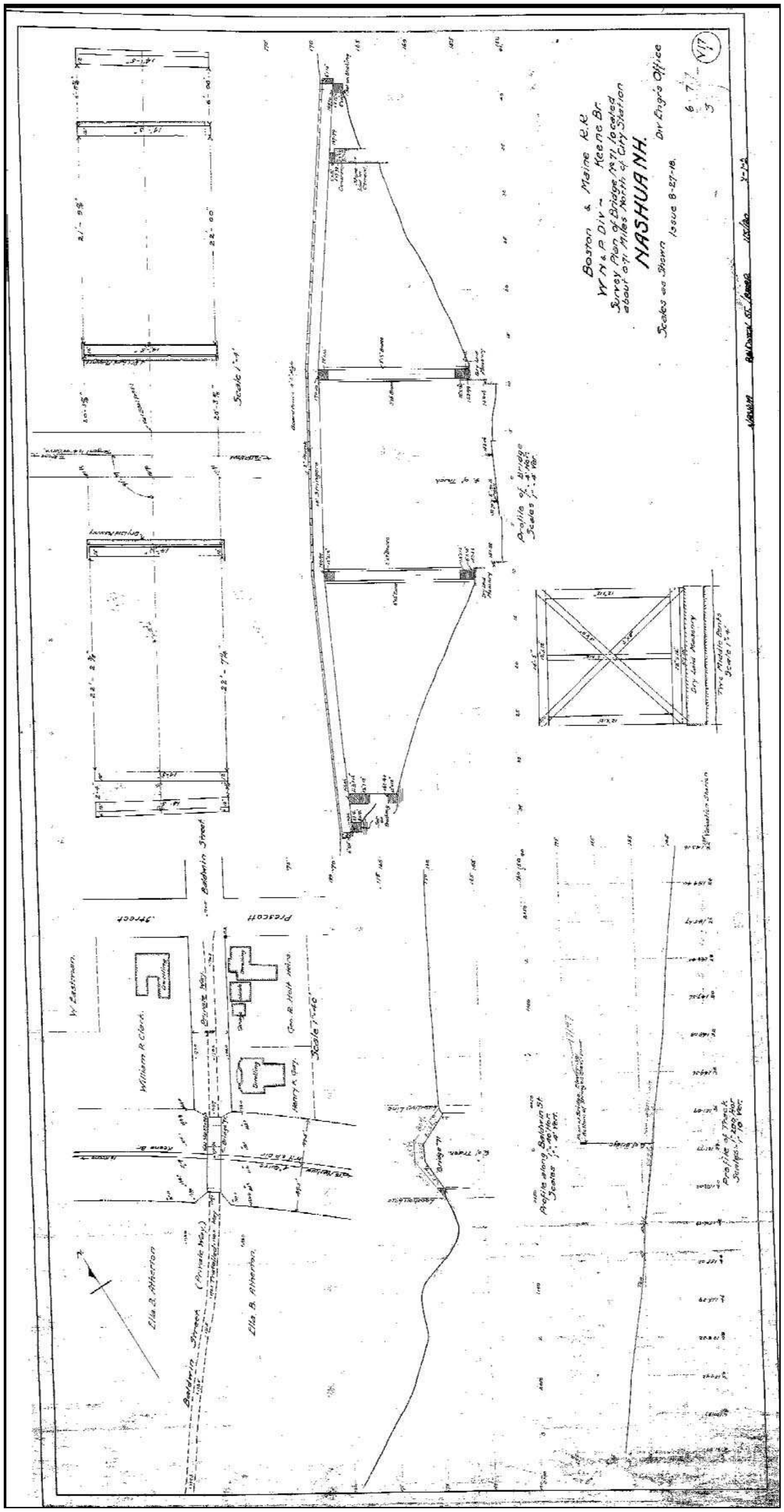

FIGURE 4: Baldwin Street Bridge, "Survey Plan," dated 8/27/1918 (Boston and Maine Railroad Plans, 1918).

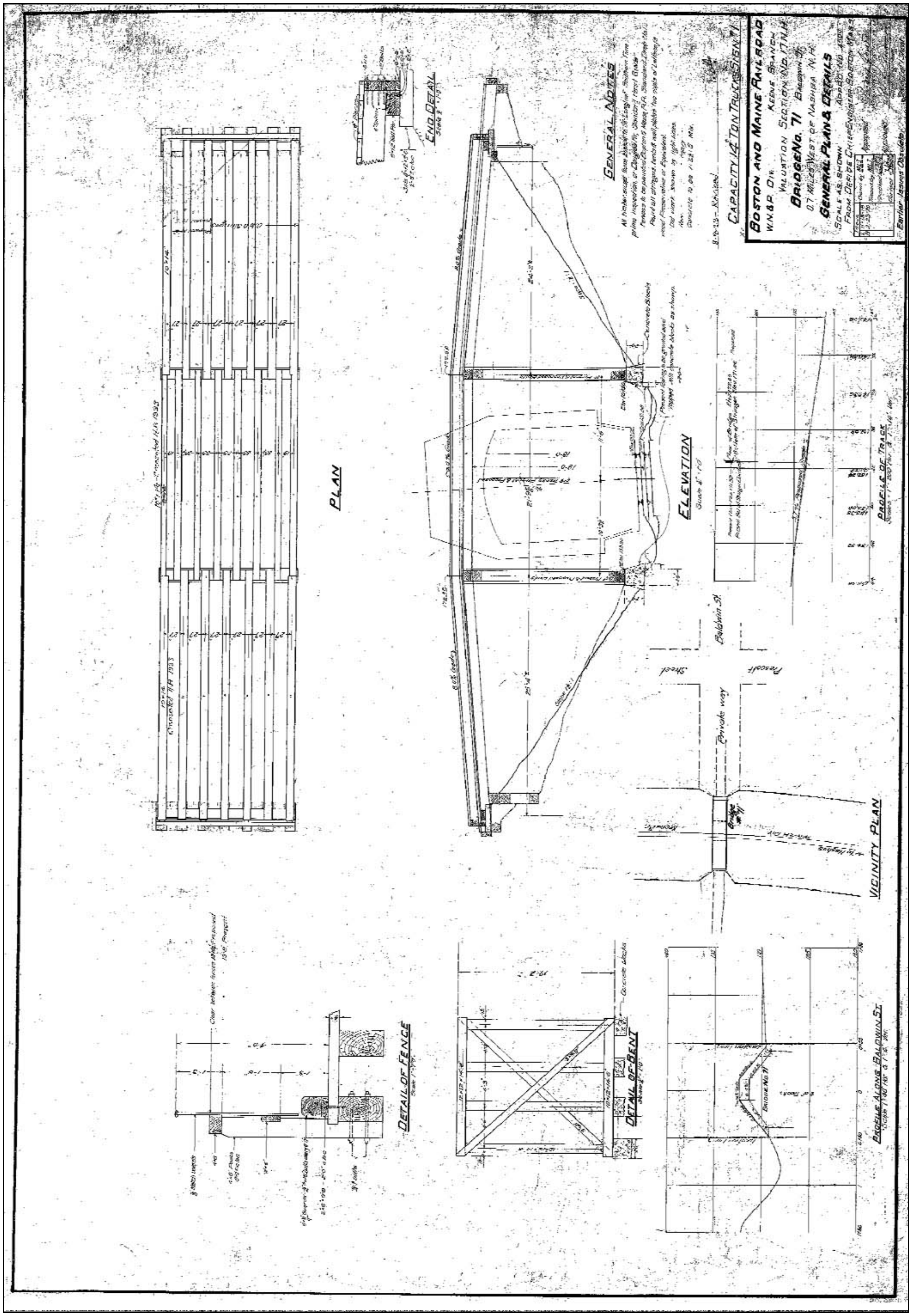

FIGURE 5: Baldwin Street Bridge, "General Plans & Details," dated 11/13/1918, 2/23/1920, 8/18/1923 (Boston and Maine Railroad Plans, 1923).

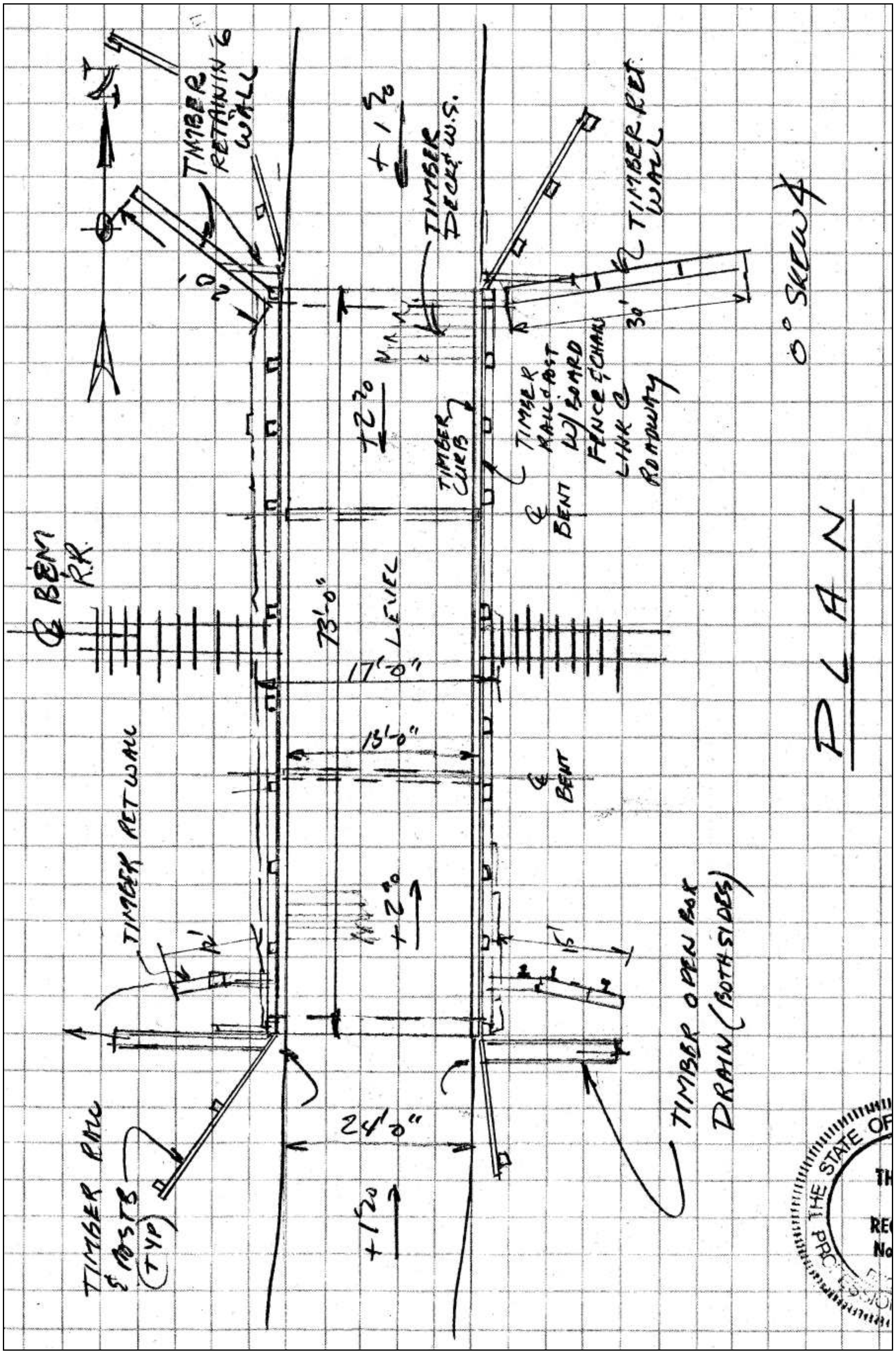

FIGURE 6: Baldwin St. Bridge Engineering Inspection Sketch by Thomas Regan, Jr. CE, Sverdrup & Parcel Engineers, October 1979 (NHDOT Bridge Inspection File).

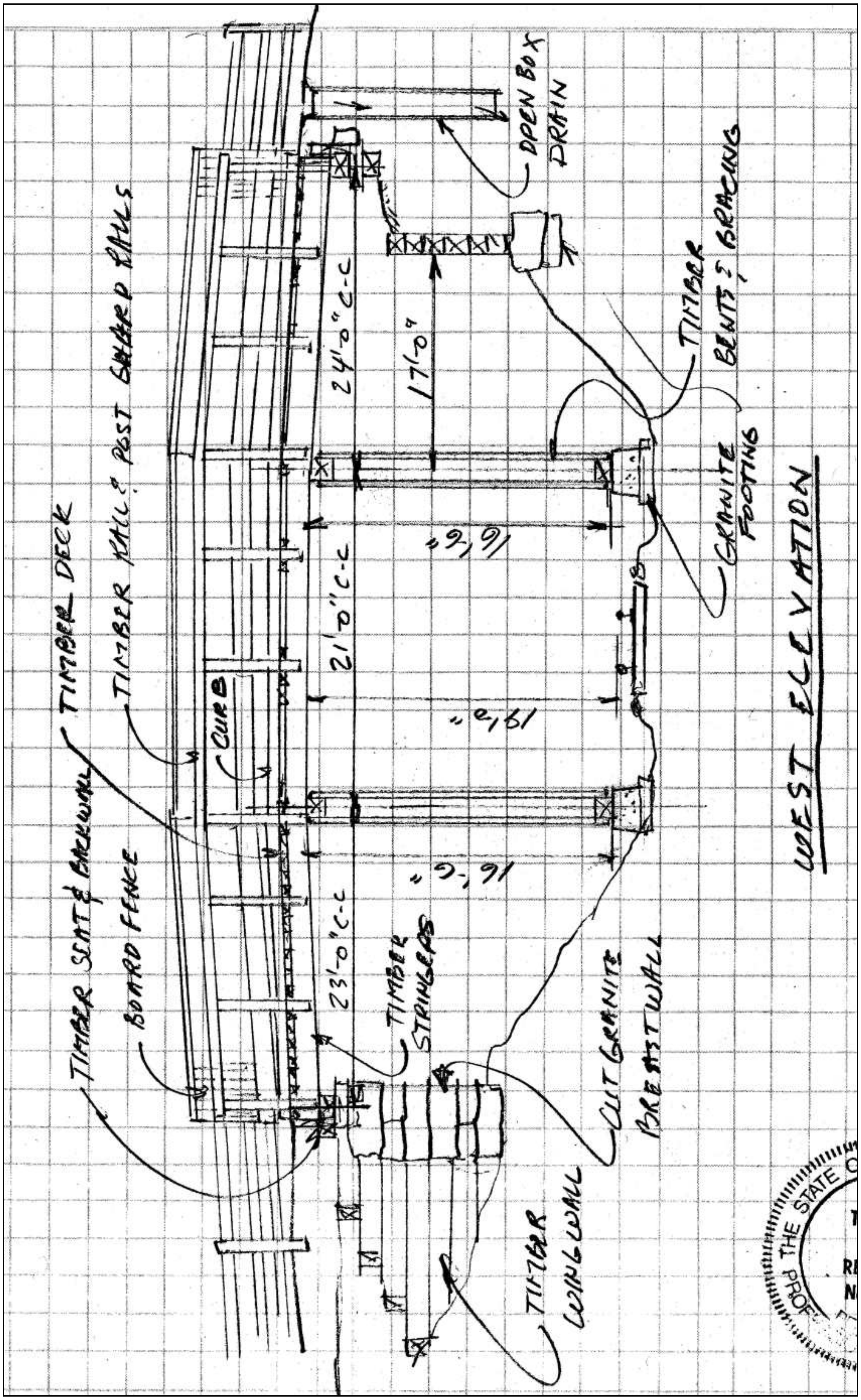

FIGURE 7: Baldwin St. Bridge Engineering Inspection Sketch by Thomas Regan, Jr. CE, Sverdrup & Parcel Engineers, October 1979 (NHDOT Bridge Inspection File).

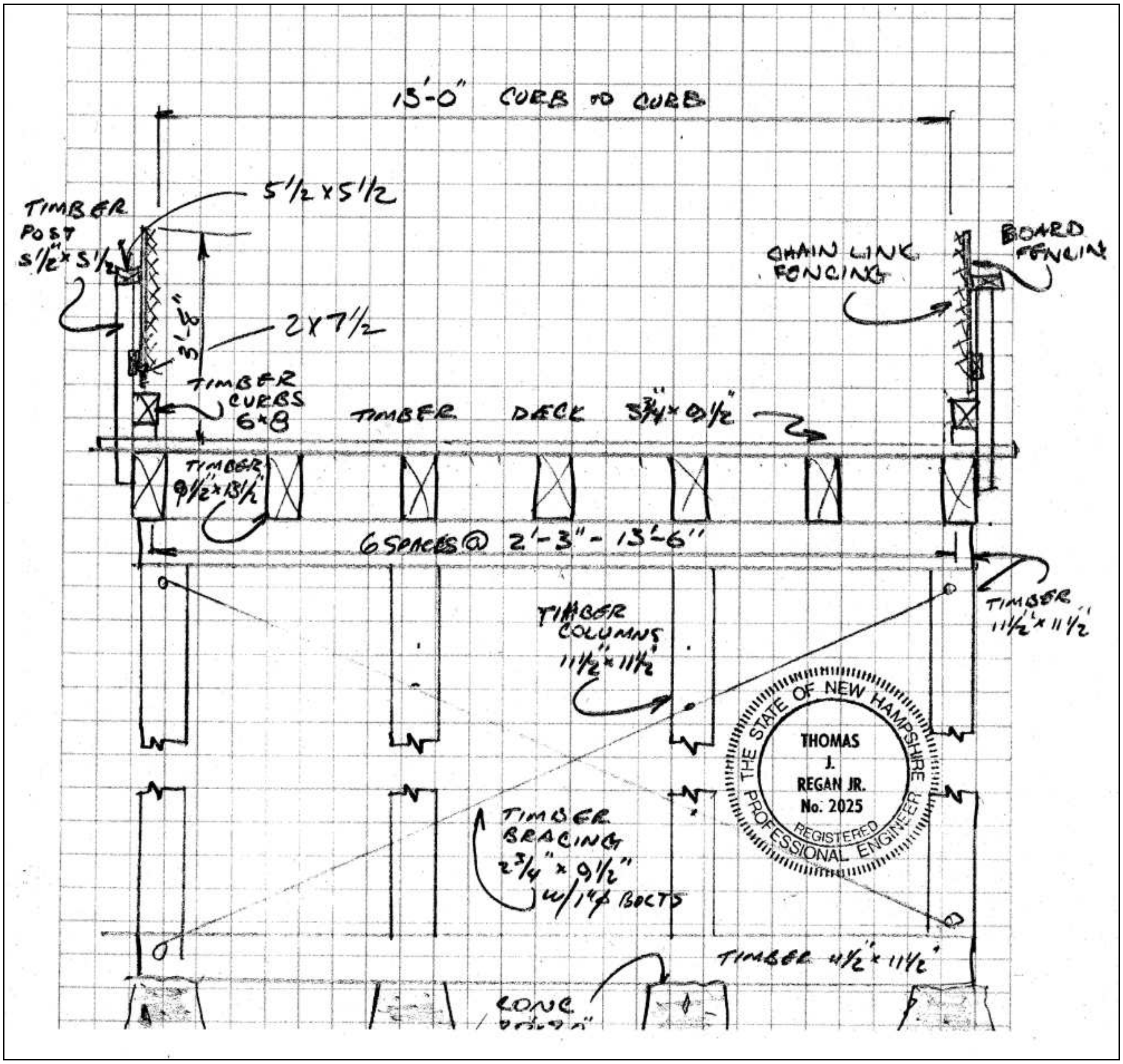

FIGURE 8: Baldwin St. Bridge Engineering Inspection Sketch by Thomas Regan, Jr. CE, Sverdrup & Parcel Engineers, October 1979 (NHDOT Bridge Inspection File).

HISTORICAL BACKGROUND

With the establishment of large water-powered manufacturing industries in Lowell and Nashua about 1824 the need arose for a transportation system to move goods with greater capacity than what horse teams and canals could provide. The railroad, developed in England and established in the US by 1830, was demonstrating seemingly unlimited potential to move vast quantities of cargo and people over great distances at unprecedented speed. Farmers opposed the railroads fearing the loss of market for hay and grain as horse teams were made obsolete. But the more powerful manufacturing interests prevailed and state legislatures proceeded with granting charters to railroad corporations by the dozens.

The building of the 26-mile Boston & Lowell Railroad, chartered June 30, 1830 and opened five years later on June 26, 1835, laid the groundwork for the extension of the first rail line into New Hampshire. Three days before the opening of the Boston & Lowell, the Nashua & Lowell Railroad was chartered by the New Hampshire legislature to build from Nashua to the Massachusetts line. In April the following year, mostly the same men incorporated the Lowell and Nashua Railroad to build and join with their New Hampshire road. Construction began in 1837 and in 1838 the two corporations were united under the New Hampshire corporate name.
In August 1839 the Directors of the Nashua and Lowell Railroad Corporation delivered their first report to the stockholders, noting the opening of the line:

> "The dividend which has just been declared has afforded you the most gratifying and tangible evidence that your rail-road is at length in operation. The passenger cars commenced running on the 8th of October last [1838], and freight cars on the 23rd of November last, to a temporary depot, about three-fourths of a mile from the village. The bridge across the Nashua now being finished, and the permanent depot completed, the cars commenced running to the village on the 23rd of December. Up to December 15th the moving power was furnished by the Boston & Lowell R. R. Corporation, under a contract by which we were to receive therefore one half of the proceeds. We now do our own business, having *three* locomotive engines, three large passenger cars, capable of carrying 60 passengers each, and 24 freight cars." [6]

With increasing business and the opening of the Concord Railroad to Nashua in 1842 the line flourished and in 1845 added a second track. Meanwhile the Wilton Railroad was incorporated in 1844 to build a line 16 miles in length between Nashua and Wilton. The projected route of the Wilton line is shown on 1847 map prepared by the company (Figure 9). The company encountered financial hardship during construction of the line and it was only through an operating agreement with the Nashua & Lowell Railroad that further backing was obtained and the line completed. When it opened to Amherst in 1848 the Nashua & Lowell was paid $24 a day to operate it. The line was completed to Wilton in December, 1851. In 1853, never having operated independently, the Wilton Railroad was leased in its entirety to the Nashua & Lowell Railroad.

In 1857 a joint operating agreement was made between the Nashua & Lowell Railroad and the Boston and Lowell Railroad that included the Wilton Railroad, among other branch lines. In

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[6] Nashua and Lowell Railroad Corporation. *Report of the Directors of the Nashua and Lowell Railroad Corporation Made to the Stockholders, August, 1839.* Nashua: Printed by P. Morrill, 1839.

1866, the Peterborough Railroad was chartered to continue the Wilton line to Greenfield and Peterborough which was completed in 1874. The line was continued to Hillsborough with a branch to Keene in the 1880s. The Wilton line and other lines built into Nashua are shown on Figures 10-11.

After the operating lease with Nashua & Lowell Railroad expired in 1878 the Wilton Railroad went through a series of leasing and operating agreements culminating with the lease of the line to the Boston and Maine Railroad in 1890.[7] In 1901 the Nashua Daily Telegraph reported that the Worcester, Nashua and Portsmouth Division of the B&M, headquartered in Nashua, employed 528 residents of the city. The wages paid totaled $1,028 per day, equaling an average weekly salary of $11.68 for a six day work week. With a "grand yearly total of wages paid of more than $300,000, it can be readily seen from these figures the benefits that Nashua derives from the Boston & Maine are large and substantial and go a great ways toward increasing the wealth of the town as well as helping the trades interests of the city.[8]

The B&M operated the line continuously after that until becoming part of Guilford Transportation Industries in 1983 which changed its name to Pan Am Railways in 2006. "The section of track between Nashua and Wilton is currently owned by Pan Am, but the section from Wilton through Bennington is now owned by the New Hampshire Department of Transportation (NHDOT), as is the Baldwin Street Bridge." [9]

History of the Baldwin Street Bridge and Area [10]

In Nashua, the railroad ran from the depot in the center of town, turning northwest and roughly paralleling Amherst Street on its journey to one of its early stops in Amherst. In the mid-19th century, the neighborhoods along Amherst Street were just beginning to expand to the northwest from the center of town. This was part of the general growth of Nashua due to the prosperity of the Nashua Manufacturing Company and Jackson Mills textile mills, which attracted other industry to the city. From after the Civil War through the end of World War I, the area saw the construction of free-standing wood-frame houses built for artisans, merchants and industrialists. The 1858 map of the City of Nashua [Figure 10] shows a few dwellings had been built along Amherst Street in the area of Vernon Street and Circuit Street, the north leg of which later became Fairmount Street. The area around the Baldwin Street Bridge, however, does not appear on the map. The 1883 G. H. Bailey & Co. Bird's Eye View of Nashua (Figure 12) shows the growing residential area along Amherst Street connected to Fairmount Heights, a plateau above the north bank of the Nashua River, by two railroad trestles over the Nashua-Wilton line. The bridge furthest to the northwest is the predecessor to the current Baldwin Street Bridge, the other is the predecessor to the current Fairmount Street Bridge.[11]

[7] See "West Bridge Street Bridge," NHDHR Inventory Form NAS0209 for additional information on the leasing of the Wilton Railroad at this time.
[8] Nashua Daily Telegraph. "Big Staff of Employees on B&M Divisions." Nashua Daily Telegraph, April 22, 1901.
[9] "West Bridge Street Bridge," NHDHR Inventory Form NAS0209.
[10] This section is taken from "West Bridge Street Bridge," NHDHR Inventory Form NAS0209.
[11] See Fairmount Street Bridge NH Historic Property Documentation NH State No. 715 and NHDHR Inventory Form NAS0199.

Baldwin Street was first named West Bridge Street, presumably after its trestle bridge, and existed at least by 1869 or 1870.[12] West Bridge Street and the other residential streets close to the bridge were just beginning to become populated in the late 1860s and 1870s. Before there were people living near the bridge, there would have been little demand for crossings over the right-of-way to and from Fairmount Heights. The original bridge was most likely constructed, therefore, in the late 1860s. A deed dated September, 1885 for the parcel that is now 12-14 Baldwin Street continues to refer to the street as West Bridge Street, but the Hurd Atlas of 1892 shows the street as Baldwin Street, indicating that the name changed in the period between these two years.

[12] Nashua City Directories, 1868 and 1870

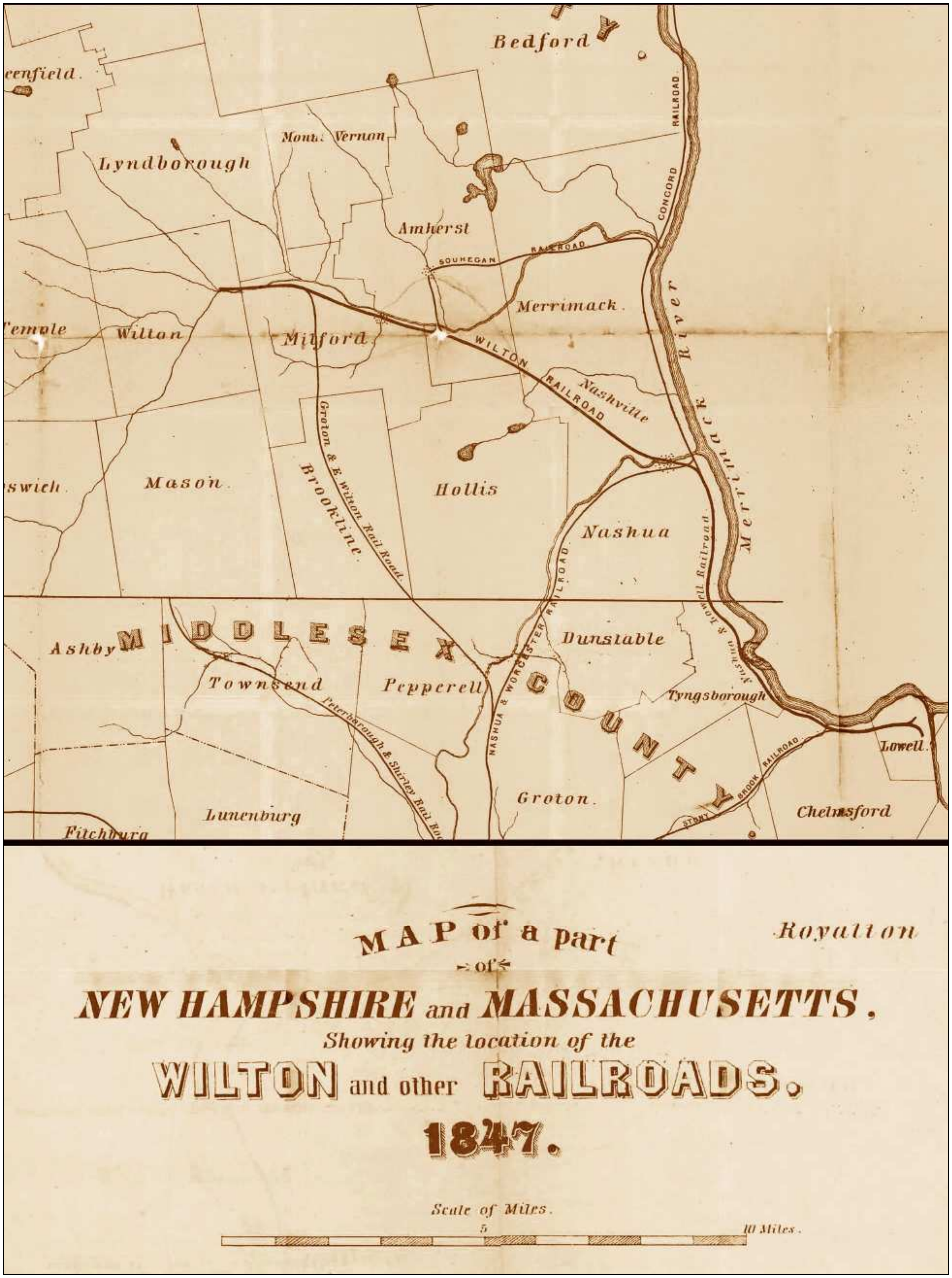

FIGURE 9: Railroad Map, 1847, showing projected route of Wilton Railroad and its junction with the Nashua & Lowell RR and Concord Railroad in Nashua (Wilton Railroad, 1847).

FIGURE 10: 1858 Walling Map showing development of Nashua, location of Wilton Railroad and Worcester & Nashua Railroad (Walling, H.F., 1858).

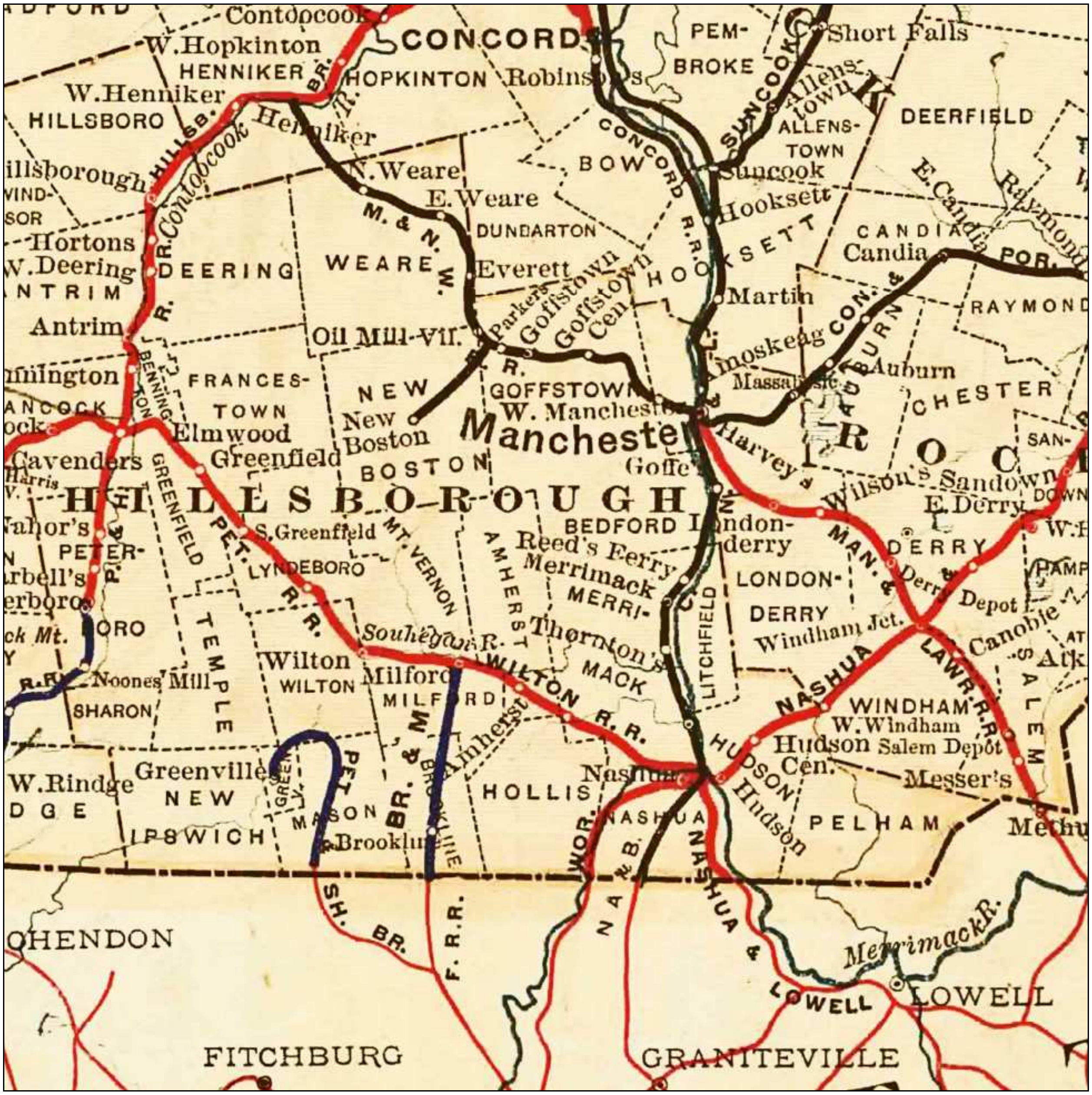

FIGURE 11: Railroad Map of New Hampshire, 1894 (New Hampshire Railroad Commissioners, 1894).

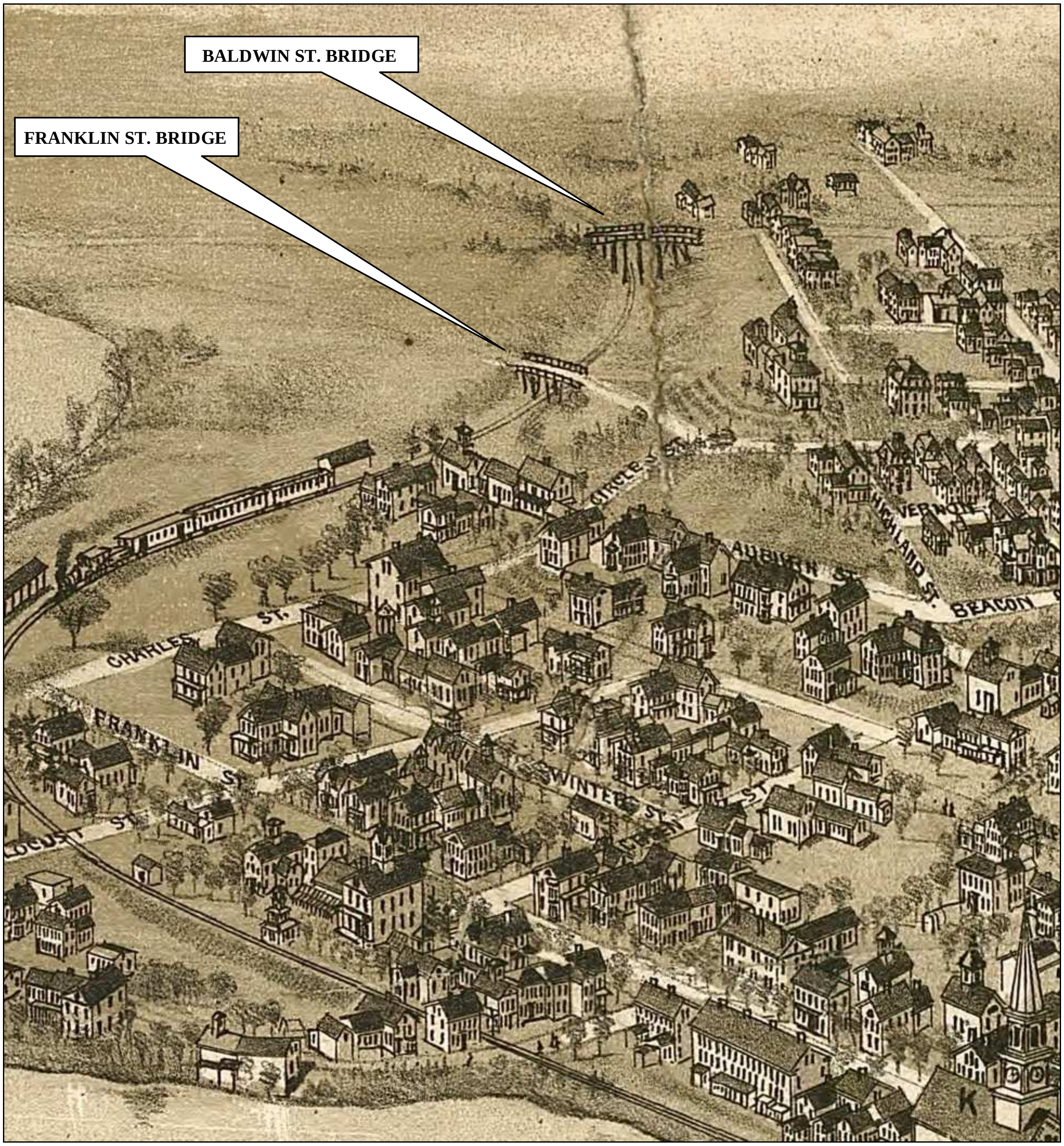

FIGURE 12: 1883 Birdseye view map of Nashua, depicting Baldwin Street and Franklin Street trestle bridges over the Wilton Railroad (Bailey, O.H., 1883).

HISTORY & TECHNOLOGY OF THE WOOD TRESTLE BRIDGE

Bridge engineer J.A.L. Waddell Trestle defines a trestle as "a bridge structure composed of bents or towers and supporting stringers or girders forming the floor system."[13] He further defines three subtypes: a *framed trestle* is one having framed bents, a *pile trestle* has pile bents, and a *knee-braced trestle* is one having knee braces. Trestles may be primarily of wood, concrete or steel construction, or a combination of materials. Wood trestles that carry highways over railroads, railroads over highways, or in some cases span streams where rock or firm foundation material is near the surface, are typically framed trestles with the vertical bent members consisting of sawn timbers resting on stone or concrete footings (Figure 13). Wood trestles crossing water bodies or wetlands are typically pile trestles with the vertical bent members consisting of log pilings driven to refusal or nearly so (Figure 14). The knee-braced trestle utilizes diagonal braces extending from the vertical bent members to the stringers or girders to effectively shorten their span length. An example of the less common knee-braced trestle is the former Tilton & Franklin (Boston & Maine) Railroad trestle spanning the Winnepesaukee River in Franklin NH (Figure 15).

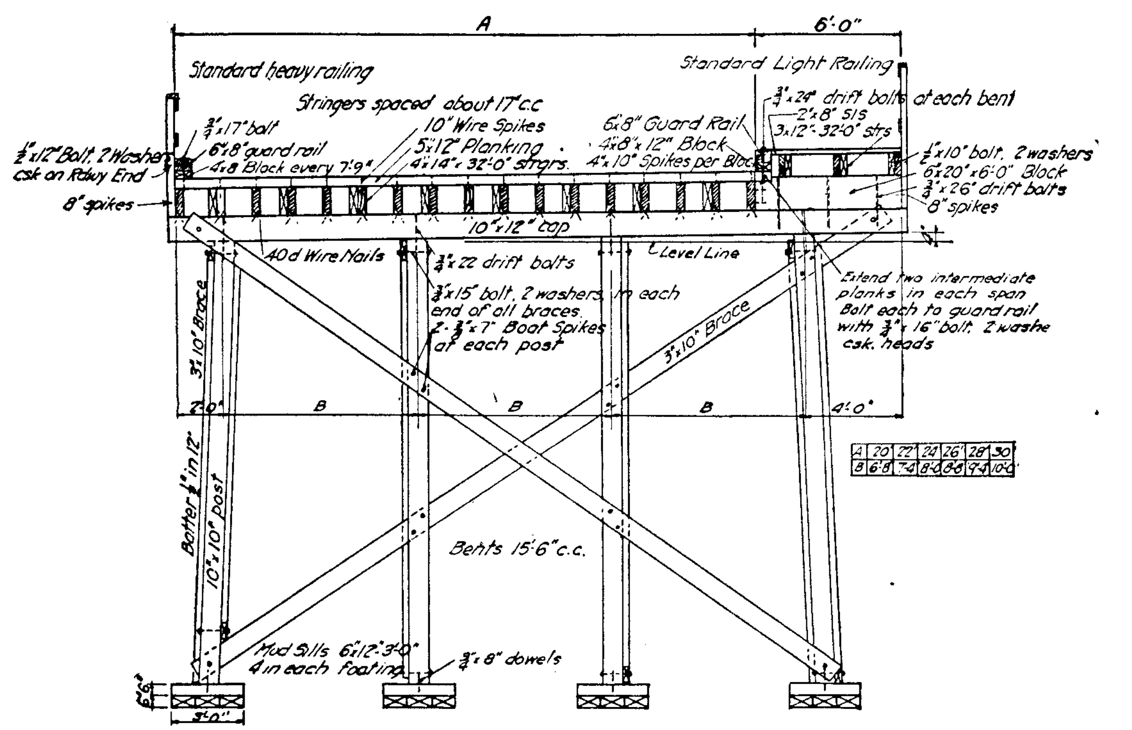

Fig. 31.—Typical section of roadway timber trestle, City of Seattle.

FIGURE 13: Typical framed bent trestle for highway loading (Hool & Kinne, 1924, p. 402).

[13] Waddell, 1916, volume 2, Glossary.

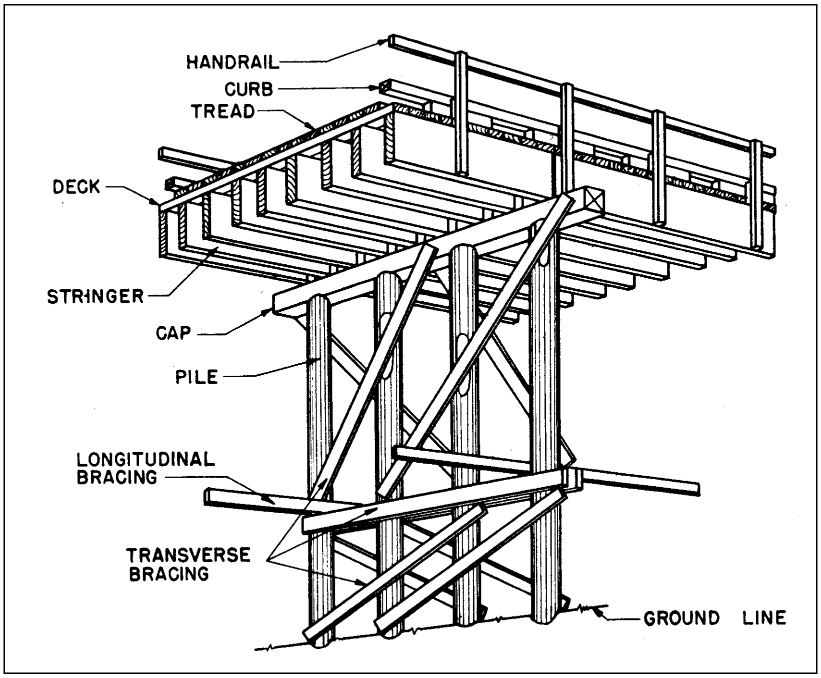

FIGURE 14: Typical pile bent trestle for highway loading (War Department, 1945, p. 2).

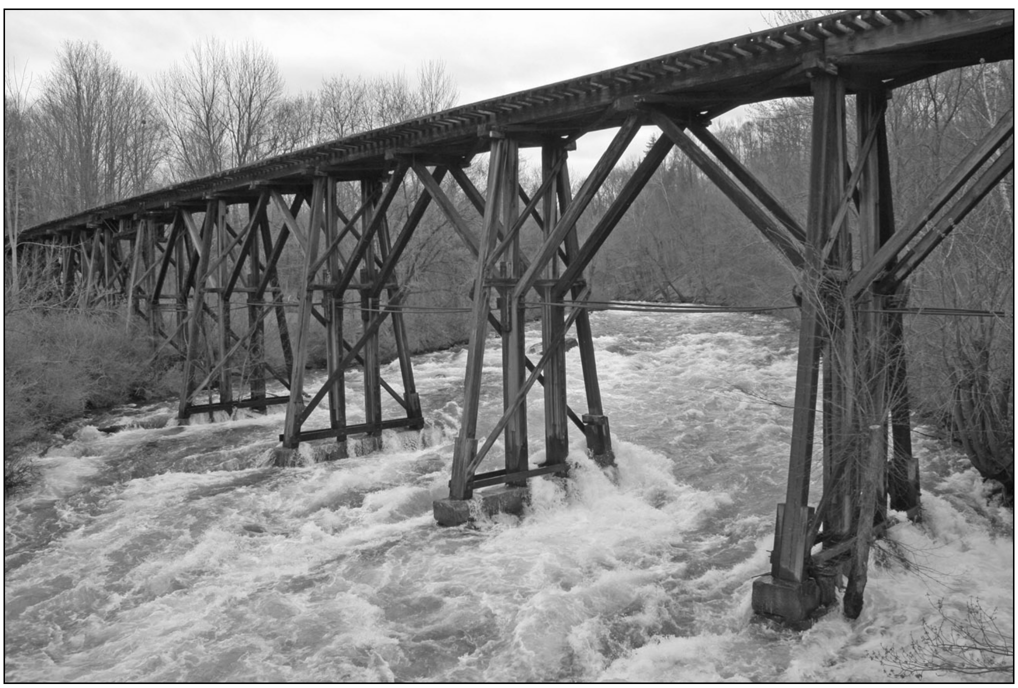

FIGURE 15: B&MRR Knee-braced railroad trestle over Winnipesaukee River, Franklin NH.

Trestle bridges are one of the oldest bridge forms constructed by man, a multi-span version of the simple wood girder or stringer span. They were common during the American Colonial period when they were built with hand tools – an axe, adze, hammer, chisel, pry bar and cant-hook sufficed – and consisted of logs laid across a stream resting on simple stone footings or abutments of timber or stone. The logs were typically flattened on top and at their bearings, with smaller logs of uniform size laid atop crossways to form a solid deck. Flat planks were laid longitudinally down the center to provide a smooth roadway. Simple short spans were repeated as needed to cross wide streams with the ends resting on rock-filled timber cribs, wood piling or timber-framed bents, or stone piers.[14]

Due to the limited strength of solid wood beams, stringer spans have seldom exceeded 30 feet for highway loading and half that for railroad loading. Little if any mathematical engineering went into the design of single span timber stringer highway bridges prior to the 19th century. Timber bridge builders were carpenters who sized timbers on the basis of judgment or assessment of previous failures and simply increased the size and number of stringers as the span and anticipated loads increased. According to bridge engineer Charles C. Schneider:

> The earlier wooded and iron bridges were built very much in the same manner as the ancient Roman bridges, in accordance with empirical rules, by practical men who had no accurate knowledge of the strains produced on the various members of the structure by the exterior forces, but who were men of unusual constructive ability and sound judgment, who had to depend upon their own resources and natural instinct, experimenting with models and profiting by previous failures. Practice always preceded the science, thus the structural systems were invented before their theory was developed.[15]

During the 19th century as timber bridges were called upon for railroad loading, the necessary sizes of the beams for a given span were established. The development of the field of materials testing in the latter part of the 19th century led to specifications for timber construction based on the physical properties of various types of wood. Tables were published in the engineering literature listing the strength of the various species and the recommended dimensions of timbers for varying spans.[16] By the end of the century a substantial body of information on the physical properties of various species of wood had accumulated, a large portion of which was attributable to the work of Filbert Roth at the Forestry Division of the Department of Agriculture. Beginning

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[14] See Llewellyn N. Edwards. "The Evolution of Early American Bridges." *Transactions of the Newcomen Society*, 13 (1932):95-116, and also his later work, *A Record of History and Evolution of Early American Bridges* (Orono, ME: University of Maine Press, 1959) for a discussion of the earliest wooden stringer bridges built in the Colonies. A pen and ink drawing of a 19th century log stringer "horse bridge" in New Hampshire, drawn by Edwards, appears in *American Wooden Bridges* [ASCE Historical Publication No. 4] New York: ASCE, 1976, on page 147.

[15] Charles C. Schneider. "The Evolution and Practice of American Bridge Building." *Transactions of the American Society of Civil Engineers* 54 (June, 1905):217.

[16] Dozens of articles on the subject can be found in the literature from 1885 to 1900; a few of the more important articles include: Carl S. Fogh. "Diagram for Proportioning Wooden Beams, *Engineering News* 32 (September 26, 1894):244; J. M. Michaelson. "A Simple Diagram, Giving, By Inspection, the Dimension of Wooden Beams for a Given Span and Load," *Transactions of the American Society Civil Engineers* 25 (August 1891):231; Onward Bates. "Pine Stringers and Floor Beams for Bridges," *Transactions of the American Society Civil Engineers* 23 (November 1890):261. Handbooks such as the *Civil Engineer's Pocket-Book*, first published by John C. Trautwine in 1876 gave formulas for calculating timber beam strength and tables of the relative strength of various wood types.

in 1889, Roth began a series of investigations into many aspects of the nations forests and the properties of wood that became generally known as the US Timber Investigations.[17] In 1898, J.B. Johnson, the renown Dean of Engineering at the University of Wisconsin published his seminal treatise on *The Materials of Construction* which presented a compilation of much of the Forest Service's work.[18] Johnson's book became a standard text and reference for student and professional engineer alike.

Southern species of pine, in particular southern yellow pine, were found to possess structural attributes that made it the wood of choice for long, large-dimension beams. In the northeast the availability of native structural timber was on the wane and pressure-treated Southern yellow pine of superior quality could be had at a competitive cost. Even though the pressurized treatment of wood with creosote was shown to extend the service life of wood by decades, the cost of treatment and transportation, combined with increasing cost of timber and its perception as "non-permanent construction" still made wood an unpopular choice for short spans compared to concrete.

In a discussion of wood pile trestles in 1908, Ketchum said, "Timber highway bridges were formerly quite generally used, and are still in use for temporary structures and in localities where transportation is difficult and suitable timber is available."[19] In 1916, Waddell stated that the use of timber in bridge construction was gradually being reduced for "three good reasons: first, its perishability; second, its increasing scarceness; and, third, its consequently augmented price. It is still employed largely for trestles, both railway and highway and will continue to be so used until the price of timber becomes prohibitory, the day for which is not far distant. It is employed largely for piling, but even there it is being gradually replaced by reinforced concrete." [20] In 1924, Phil Franklin, structural engineer with the McClintock-Marshall Company (primarily a builder of steel bridges) opened his discussion of timber bridges in *Steel and Timber Structures* with the following: "The only excuse for a timber bridge is that it is cheaper than some other form of construction."[21] He further noted that "until very recently highway loadings were not studied with any seriousness" and that "the heavy motor truck of today is as heavy as the railway engine of the early days … [and] it is this greatly increased weight that calls for far more careful consideration of the details of the wooden highway bridge than was customary a few years ago." [22]

Advances in heavy timber connectors, such as ring-type shear connectors, are seldom used in one or two story pile-trestle construction since the loads on the cross-bracing - the only members

[17] Filbert Roth. *Timber: An elementary discussion of the characteristics and properties of wood.* [US Department of Forestry Bulletin No. 10]. (Washington, DC: US Government Printing Office, 1895). Filbert Roth. *Timber Physics. Resume of investigations carried on in the US Division of Forestry, 1889-1898.* (Washington, DC: US Government Printing Office, 1899).

[18] John Butler Johnson. *The Materials of Construction,* New York: John Wiley and Sons, 1898. Johnson conducted many materials tests himself in the University's laboratory. His other widely used textbook was Theory and Practice in *Designing Modern Framed Structures* first published in 1893.

[19] Milo S. Ketchum, *The Design of Highway Bridges of Steel, Timber and Concrete.* (New York: McGraw-Hill Book Co., 1908):389.

[20] J.A.L. Waddell, *Bridge Engineering* (New York: John Wiley and Sons 1916), p. 52.

[21] Phil A. Franklin, "Timber bridges and Trestles," in *Steel and Timber Structures*, George A. Hool and W.S. Kinne, Editors (New York: John Wiley and Sons, 1924):372.

[22] Ibid.

subject to significant bolt shear on the bridge - are generally within the limits of standard thru-bolt connections. Small town highway bridges continued to be erected by local carpenters without plans, and it was only when state highway engineers entered the business in the early 20th century that modern engineering practice was engaged.

For highway and railroad engineers located in areas with an abundant supply of high quality structural timber, timber bridges found renewed popularity during the Depression years as a more economical alternative to steel and concrete. The low cost of wood trestles made them the practical choice for railroad overpass bridges during the widespread grade-crossing elimination projects undertaken during the late 1920s and 1930s.

During World War II the shortage of war critical materials such as steel and concrete led to a resurgence in the use of timber trestles bridges which could built with largely unskilled labor from standardized plans found in engineering textbooks and wartime construction manuals such as the War Department's *Technical Manual TM5-286: Semi-permanent Highway and Railway Trestle Bridges.* Engineered wood beams and structural members, including bolt-laminated, glue-laminated, composite wood-concrete and wood-steel, were all developed during World War II to reduce the use of war-critical materials.

From about the 1960s on, research has continued in the use of glue-laminated wood beams for bridge construction, including prestressing and improved preservative treatment methods.[23] During the 1980s there was a resurgence of interest in the advantages of wood bridges and numerous technical papers were published on the subject.[24] With over 70,000 wood bridges in the United States in 1990, there was interest in improved methods of inspection maintenance and renewal as well.[25] Today, most modern bridge engineering texts include sections on the design of wood bridges.[26]

Boston and Maine Wood Trestle Bridges [27]

When the early railroad construction was at its peak in the 19th century, the timber trestle was a common bridge form because of the availability of timber at or near the construction site. Timber trestles that have survived have generally been rebuilt several times since their original construction (Wallace and Mausolf, 2001: 116). Mostly due to financial constraints, wood railroad bridges dominated on the Boston and Maine lines long past the time they were being abandoned in other parts of the country. By 1910 national practice favored iron or steel bridge

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23 Richard M. Gutkowski and Thomas G. Williamson. "Timber Bridges: State-of-the-Art." *Journal of Structural Engineering* 109 (September, 1983):2177-2178.
24 See "Timber Bridges: State-of-the-Art." cited above for a bibliography of papers on the subject. Also see John R. Verna, et.al., "Timber Bridges: Benefits and Costs." *Journal of Structural Engineering* 110 (July, 1984):1563-1570.
25 Frank Muchmore. "Techniques to Bring New Life to Timber Bridges." *Journal of Structural Engineering* 110 (August, 1984):1832-1846; Michael A. Ritter. *Timber Bridges: Design, Construction, Inspection, and Maintenance.* Washington, DC: U.S. Dept. of Agriculture, Forest Service, Engineering Staff, 1990.
Michael A. Ritter, "Timber Bridges – Design, Construction, Inspection and Maintenance," United States Department of Agriculture, Forest Service, EM 7800-8. Washington, DC, . 1990
26 See Richard M. Barker and Jay A. Puckett. *Design of Highway Bridges*. New York: John Wiley & Sons, Inc., 1998.
27 This section is taken from excerpted "West Bridge Street Bridge," NHDHR Inventory Form NAS0209

construction while, by contrast, the Boston and Maine often replaced wood structures in kind well into the 1940s.[28]

Wood trestles remained popular with the B&M Corporation because of the availability of creosote wood preserving treatments. In early 1923, the B&M awarded the contract to build and operate a wood treatment plant on property it owned in Nashua to the Pittsburgh Wood Preserving Company. Later that year, the Pittsburgh Wood Preserving Company assigned the 10-year lease to the New England Wood Preserving Company, which had been created by the Pittsburgh Wood Preserving Company to operate the Nashua plant. The lease with B&M was reassigned several times to various companies who subsequently came to own the assets of the treatment plant, until both the lease and the plant came to Koppers Company in 1940. The lumber was treated by being loaded into treatment tanks where creosote or other preserving agent was forced into the wood at high temperatures of 190 degrees and under a pressure of 160 to 190 psi. The plant closed in the 1980s.[29]

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28 Wallace and Mausolf, 2001, p. 99.
29 Nashua City Station Railroad History, Koppers Company, Inc.

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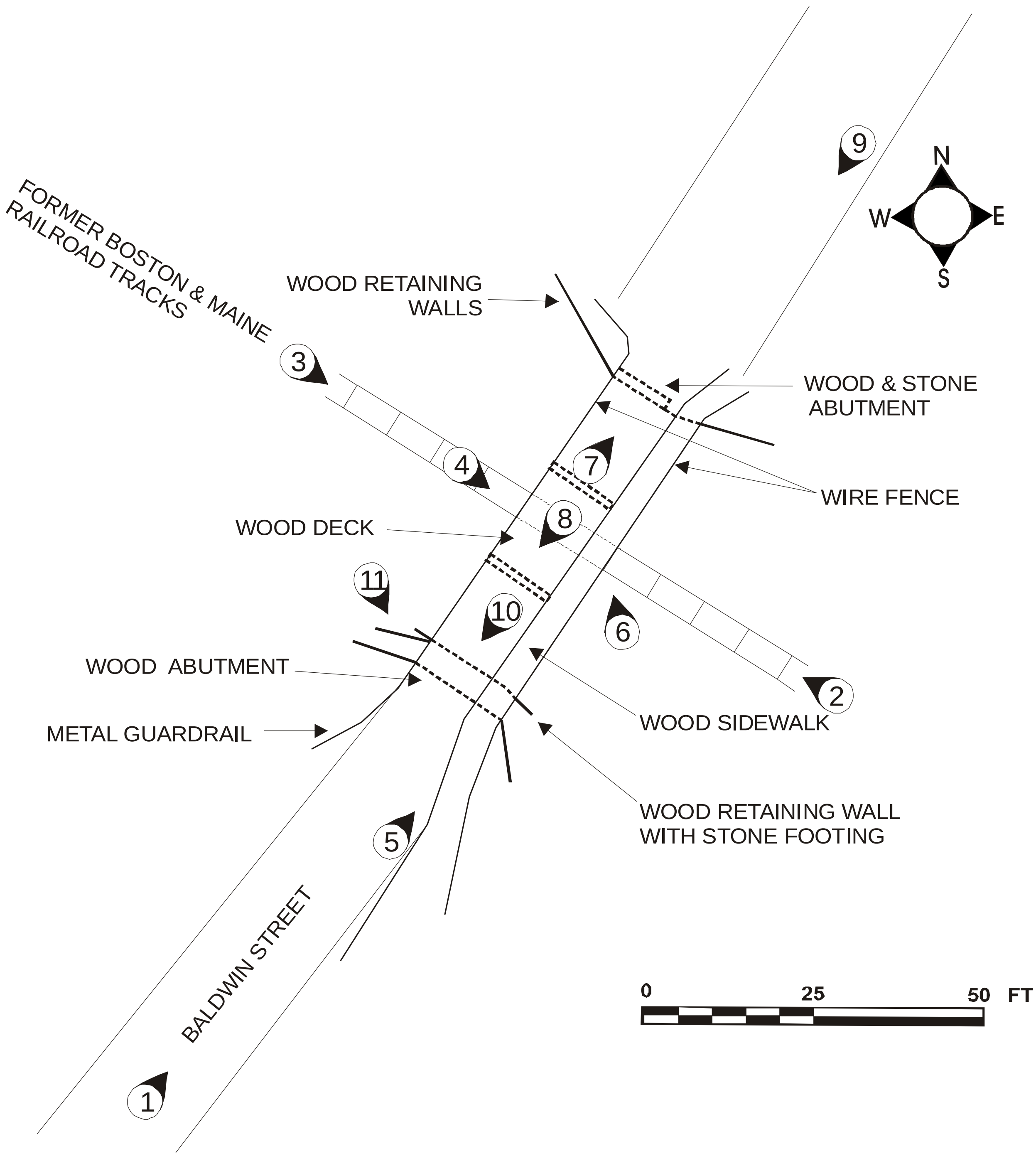
BALDWIN STREET BRIDGE OVER FORMER BOSTON & MAINE RAILROAD
Nashua,
Hillsborough County,
New Hampshire.

New Hampshire State No. 715
Photographer: Rob Tucher
April, May 2013

NH-715-1	View of bridge in context from Baldwin Street, south of bridge. Looking northeast.
NH-715-2	East elevation and context from railroad tracks. Looking northwest.
NH-715-3	West elevation and context from railroad tracks. Looking southeast.
NH-715-4	West elevation. Looking southeast.
NH-715-5	Roadway deck and sidewalk. Looking northeast.
NH-715-6	North bent. Looking north.
NH-715-7	North abutment and underside of deck. Looking northeast.
NH-715-8	South abutment, south bent and underside of deck. Looking southwest.
NH-715-9	View of bridge in context from Baldwin Street, north of bridge. Looking southwest.
NH-715-10	South timber retaining wall (former pier). Looking southwest.
NH-715-11	Oblique view of south abutment. Looking southeast.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NH-715-1:View of bridge in context from Baldwin Street, south of bridge. Looking northeast.

NH-715-2: East elevation and context from railroad tracks. Looking northwest.

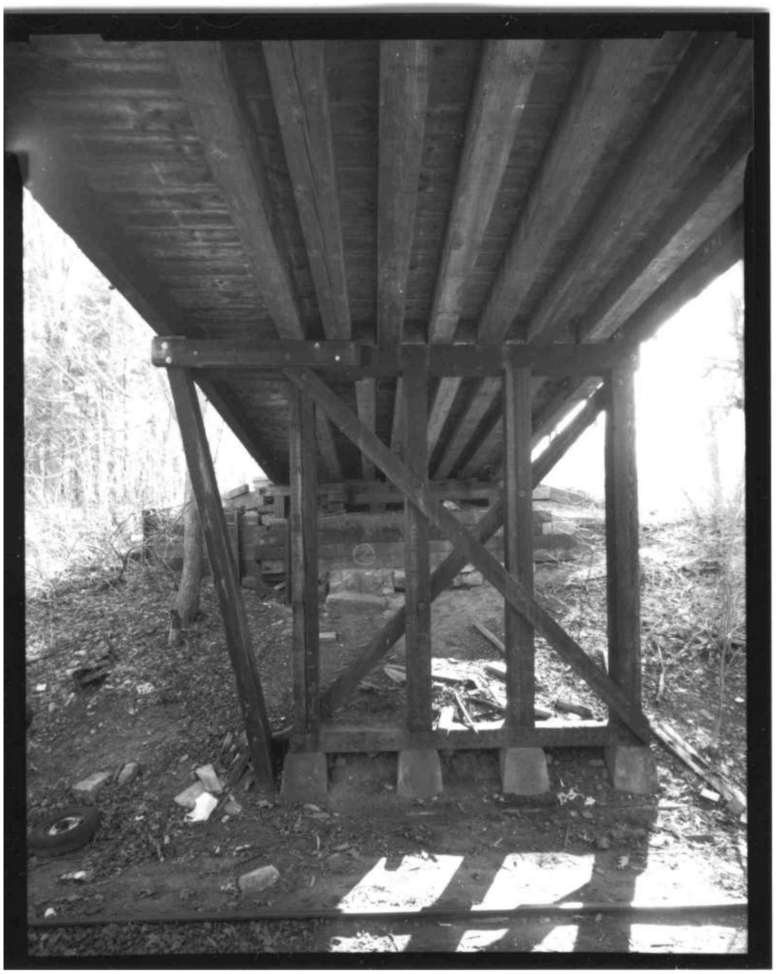
NH-715-3: West elevation and context from railroad tracks. Looking southeast.

NH-715-4: West elevation. Looking southeast.

NH-715-5: Roadway deck and sidewalk. Looking northeast.

NH-715-6: North bent. Looking north.

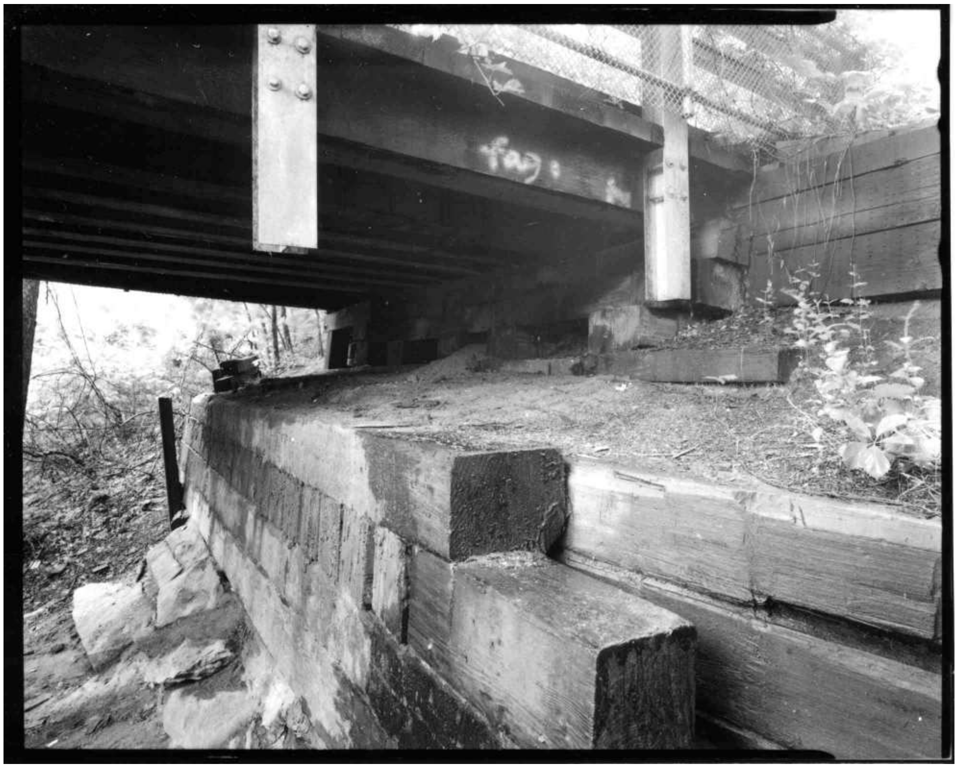
NH-715-7: North abutment and underside of deck. Looking northeast.



NH-715-8: South abutment, south bent and underside of deck.
Looking southwest.

NH-715-9:View of bridge in context from Baldwin Street, north of bridge. Looking southwest.

NH-715-10: South timber retaining wall (former pier). Looking southwest.



NH-715-11: Oblique view of south abutment. Looking southeast.