NPS Form 10-900
(Rev. 8-86)

OMB No. 1024-0018

United States Department of the Interior
National Park Service

National Register of Historic Places Registration Form

This form is for use in nominating or requesting determinations of eligibility for individual properties or districts. See Instructions in *Guidelines for Completing National Register Forms* (National Register Bulletin 16). Complete each item by marking "x" in the appropriate box or by entering the requested information. If an item does not apply to the property being documented, enter "N/A" for "not applicable." For functions, styles, materials, and areas of significance, enter only the categories and subcategories listed in the Instructions. For additional space use continuation sheets (Form 10-900-a). Type all entries.

1. Name of Property

historic name: Tacoma Narrows Bridge .Ruins
other names/site number: Galloping Gertie

2. Location

street & number: Highway 16 over the Tacoma Narrows ☐ not for publication
city, town: Tacoma ☐ vicinity
state: Washington code: WA county: Pierce code: 053 zip code: 98406

3. Classification

Ownership of Property
- ☐ private
- ☐ public-local
- ☒ public-State
- ☐ public-Federal

Category of Property
- ☐ building(s)
- ☐ district
- ☒ site
- ☐ structure
- ☐ object

Number of Resources within Property

Contributing	Noncontributing	
		buildings
1		sites
		structures
		objects
1	0	Total

Name of related multiple property listing: N/A

Number of contributing resources previously listed in the National Register 0

4. State/Federal Agency Certification

As the designated authority under the National Historic Preservation Act of 1966, as amended, I hereby certify that this ☒ nomination ☐ request for determination of eligibility meets the documentation standards for registering properties in the National Register of Historic Places and meets the procedural and professional requirements set forth in 36 CFR Part 60. In my opinion, the property ☒ meets ☐ does not meet the National Register criteria. ☐ See continuation sheet.

[signature] 6/30/92
Signature of certifying official Date

Washington State Office of Archaeology and Historic Preservation
State or Federal agency and bureau

In my opinion, the property ☐ meets ☐ does not meet the National Register criteria. ☐ See continuation sheet.

Signature of commenting or other official Date

State or Federal agency and bureau

5. National Park Service Certification

I, hereby, certify that this property is:
- ☒ entered in the National Register. — [signature] — 8/31/92
  - ☐ See continuation sheet.
- ☐ determined eligible for the National Register. ☐ See continuation sheet.
- ☐ determined not eligible for the National Register.
- ☐ removed from the National Register.
- ☐ other, (explain:)

for Signature of the Keeper Date of Action

6. Function or Use

Historic Functions (enter categories from instructions)
Transportation/road-related/bridge

Other:

Current Functions (enter categories from instructions)
underwater ruins

7. Description

Architectural Classification
(enter categories from instructions)

N/A

Materials (enter categories from instructions)

foundation N/A
walls N/A

roof N/A
other N/A

Describe present and historic physical appearance.

The first Tacoma Narrows Bridge was revolutionary in its design and historic in its collapse. Its failure on November 7, 1940 marked the end of a trend in bridge engineering towards a maximum of lightness, grace and flexibility. Since the turn of the century, suspension bridge construction valued structural grace and slenderness to achieve an artistic appearance. With its shallow stiffening trusses and slender towers, the bridge across the Narrows was the epitome of artistry in bridge construction.

Prior to the Narrows Bridge, conventional engineering wisdom recommended that stiffening trusses on a suspension bridge be a minimum of 1:40 in depth and that the minimum roadway width compared to the length of the span be 1:30. The eight foot stiffening girders supporting the 2,800 foot span on the Narrows bridge was 1:350 and the roadway to length of span ratio was 1:72. This lightweight design and long center span gave the bridge unparalleled flexibility and beauty.

The original plan for the first bridge was designed by Clark Eldridge, an engineer with the Washington State Department of Highways. His design called for a 5,000-foot, two-lane suspension bridge. The two approach (side) spans were 1,100 feet long, the center span 2,800. Two 425-foot towers rested on deep piers of the cellular caisson deign. When completed, the structure was the third longest suspension bridge in the world (The George Washington Bridge in New York City and the Golden Gate Bridge in San Francisco being longer).

Eldridge's plans were reviewed by a State-appointed engineering consultant, Moran and Proctor, who suggested major revisions to the design. These revisions were ultimately scrapped during the bidding process when a group of contractors informed the State that the revised substructure specifications could not be built. Eldridge's plan for the substructure was reintroduced into the design. In addition, the State retained Leon S. Moisseiff, a world-renowned bridge designer (Golden Gate Bridge) to examine the design of the superstructure. Moisseiff substituted Eldridge's 25-foot deep, open stiffening truss with an eight foot, shallow plate grid.

The contract was awarded to the Pacific Bridge Company for their bid of $5,594,730.40 and the associate contractor was Bethlehem Steel Company for the steel and wire. The bridge was opened July 1, 1940. The specifications are listed on the next page.

[X] See continuation sheet

Today the center span and other debris lie on the floor of Puget Sound, where they fell. A site plan of these remains, developed from sonar soundings of the Narrows, is attached. The remains of the center span are readily identifiable on the plan. The videotape "Gertie Gallops Again," prepared by Tacoma Municipal Television for the show "CityScape," is also submitted with the nomination for the historic footage of the collapse and the underwater filming of the present remains.

The side spans were removed and salvaged for their high resale value during the war effort. The original piers were used for the second bridge (1952), and new towers were constructed.

SPECIFICATIONS OF THE FIRST TACOMA NARROWS BRIDGE:

Total length	5,939 feet
Suspension bridge section	5,000 feet
Center span	2,800 feet
Shore suspension spans, each	1,100 feet
East approach and anchorage	345 feet
West approach and anchorage	594 feet
Center span height above water	195 feet
Width of roadway	26 feet
Width of sidewalks, each	5 feet
Diameter of main suspension cable	17-1/2 inches
Weight of main suspension cable	3,817 tons
Weight sustained by cables	11,250 tons
Number of No. 6 wires each cable	6,308
Weight shore anchors	52,500 tons
Towers:	
Height above piers	425 feet
Weight of each tower	1,927 tons
Piers:	
Area	118 feet, 11 inches x 65 feet, 11 inches
East pier, total height	247 feet
Depth of water	140 feet
West pier, total height	198 feet
Depth of water	120 feet

8. Statement of Significance

Certifying official has considered the significance of this property in relation to other properties:
☒ nationally ☐ statewide ☐ locally

Applicable National Register Criteria ☒ A ☐ B ☐ C ☐ D

Criteria Considerations (Exceptions) ☐ A ☐ B ☐ C ☐ D ☐ E ☐ F ☐ G

Areas of Significance (enter categories from instructions)
Engineering

Period of Significance
1940

Significant Dates
1940

Cultural Affiliation
N/A

Significant Person
N/A

Architect/Builder
N/A

State significance of property, and justify criteria, criteria considerations, and areas and periods of significance noted above.

The significance of the first Tacoma Narrows Bridge is derived directly from its startling collapse on November 7, 1940, which brought engineers world-wide to the realization that aerodynamic phenomena in suspension bridges were not adequately understood in the profession nor had they been addressed in this design. New research was necessary to understand and predict these forces. The official investigation into the collapse (Farquharson et al., 1949-54) recommended the use of wind-tunnel tests to aid in the design of the second Tacoma Narrows Bridge and resulted in the testing of all existing and future bridges across the country. New mathematical theories of vibration in suspension bridges were published as a result of the bridge failure (Bleich et al., 1950) and continues today (Peterson, 1990). Aerodynamics, wave phenomena, and harmonics were all part of the new studies. "Based on these investigations (Farquharson, et al., Bleich et al.), procedures for the design of suspension bridges for aerodynamic excitations were set up, and became in important part of the design process for all major cable supported bridges to be built in the future,"[1] wrote Danish engineer Niels J. Gimsung.

The film of the bridge collapsing is a dramatic and on-going teaching tool shown to engineering and physics students, both here and abroad. Physics professors Zollman and Fuller (1982) describe the film as providing "physics teachers with the most captivating demonstration of wave phenomena ever devised."[2] Ivars Peterson, engineer, describes the film as "among the most dramatic and widely known images in science and engineering."[3]

The collapse of the Tacoma Narrows Bridge was a singular event in the history of engineering with far-reaching implications in the development of aerodynamics and bridge design, implications which extend beyond political borders and are part of the evolution of civil engineering. The collapse was a failure, but "the most important and spectacular failure in suspension bridge history."[4] As is common in much of human history, we often learn more from our failures than from our successes. For these reasons, the first Tacoma Narrows Bridge is worthy of listing in the National Register by virtue of its role in the history of civil engineering and bridge design.

☒ See continuation sheet

HISTORICAL BACKGROUND:

There is one point in the 20,000 square miles of Puget Sound where the Washington mainland and the Olympic Peninsula are close - the Narrows at Tacoma. For years, it had been clear to State officials that the Narrows would have to be bridged in order to open up the spectacular and thinly populated Peninsula. Aware of this situation, the Washington State Legislature created the Washington Toll Bridge Authority in 1937, with a mandate to finance, construct and operate toll bridges.

The City of Tacoma and Pierce County Board of Commissioners asked the State to construct a bridge across the Narrows. The legislature appropriated $25,000 to study the request. Satisfied with the results of the study, on May 23, 1938, the State of Washington submitted an application to the Public Works Administration (PWA) requesting funds for construction of a bridge.

Between the time the state legislature authorized the money to study the proposal and the completion of that study, Lacey Murrow, Director of the Washington State Department of Highways, had given Clark Eldridge, a bridge engineer with the department, a green light to design a bridge to span the Narrows. Eldridge went to work, and when he finished, his plan called for a 5,000 foot, two-lane suspension bridge. When completed, the structure would be the third longest suspension bridge in the world (only the George Washington Bridge in New York City and the Golden Gate Bridge in San Francisco were longer).

After examination of Eldridge's plans in May of 1938, the Public Works Administration agreed to finance 45 percent of the construction, provided that the State of Washington retain a board of independent engineering consultants to reexamine Eldridge's design. The State complied and employed the firm of Moran and Proctor to study the plans for the substructure. Furthermore, the State retained Leon S. Moisseiff, the world-renowned suspension bridge builder who had designed the Golden Gate Bridge, to examine the plans concerning the superstructure. Both Moran and Proctor and Moisseiff made significant alterations to Eldridge's original design. Specifically, Moran and Proctor wanted an entirely different substructure. As to Moiseiff, he substituted the 25 foot deep open stiffening truss with an eight foot, shallow plate girder, resulting in a much lighter bridge. His international stature as a builder of suspension bridges was immense; his plans for the Narrows Bridge were the culmination of Moiseiff's efforts to combine grace, lightness and flexibility in suspension bridge construction. The Narrows Bridge was "to stretch like a taut ribbon" across the Narrows.

Prior to the opening of the construction bids, a group of contractors notified the engineers they could not meet the specifications for the substructure. As a result, Moran and Proctor's plans for the substructure were scrapped, and Eldridge's original plans for the substructure were reintroduced. After consultation with Moiseiff, it was agreed that Eldridge's design for the substructure would be used in conjunction with Moiseiff's plans for the superstructure. This modified plan was approved by the Public Works Administration and bids for construction were opened on September 27, 1938. The Pacific Bridge Company's low bid of $5,594,730.40 was accepted. The Bethlehem Steel Company was an associate contractor which supplied and erected the steel and wire. Work on the bridge began in early 1939. On July 1, 1940, the $6.4 million bridge opened; the link between the Washington mainland and the Olympic Peninsula was complete.

Vertical oscillations of the roadbed occurred even during the construction phase and raised questions about the structure's stability. Some breezes as low as four miles per hour caused oscillations, while stronger breezes often had no effect. Hydraulic buffers were installed at the towers to control the stresses, prior to the bridge's opening. The undulations continued, however, and further studies were undertaken at the University of Washington. Their recommendation of the installation of tie-down cables in the side spans were implemented, but to little effect.

Local folks lost no time in nicknaming the bridge "Galloping Gertie." Fascinated by Gertie, thousands of people drove hundreds of miles to experience the sensation of crossing the rolling center span, an experience often times highlighted by the disappearance and then reappearance of cars up ahead. For four months, the Washington Toll Bridge Authority thrived as traffic had trebled from what had been expected. Although concerns about the bridge's stability had been voiced, bridge officials were so confident of the structure, they considered cancelling the insurance policies in order to obtain reduced rates on a new one.

Throughout the early morning hours of Thursday, November 7, 1940, the center span had been undulating three to five feet in winds of 35 to 46 miles per hour. Alarmed by this constant motion, highway officials and state police closed the bridge at 10:00 A.M. Shortly afterwards, the character of the motion dramatically changed from a rhythmic rising and falling to a two-wave twisting motion. The twisting motion grew stronger with each twist; span movement had gone from three to five foot undulations to 25 to 28 foot rises and falls caused by the twisting motion. At this point, the roadbed tilted 45 degrees from horizontal one way, and then 45 degrees from horizontal the other way.

For about 30 minutes, the center span endured the twisting. At about 10:30 A.M., a center span floor panel dropped into the water 195 feet below. The roadbed was breaking up, and chunks of concrete were raining into the Sound. At 11:02 A.M., 600 feet of the western end of the span twisted free, flipped over, and plunged down into the water. Engineers on the scene hoped that once this had happened, the remainder of the span would settle down. This was not to be. The twisting continued, and at 11:09 A.M., the remainder ripped free and thundered down into the Sound. When this happened, the 1,100 foot side spans dropped 60 feet, only to bounce up and then settle into a sag of 30 feet. As for the center span, it rested on the dark and tide-swept bottom of the Narrows.

The spectacular failure was news around the world and was highlighted by the photographs, reports, and film from reports and engineers on the scene. The shock to the engineering profession created much interest in studies of the cause of the collapse. The official investigation team was composed of a prestigious group of engineers from across the country, lead by Professor F. B. Farquharson of the University of Washington, whose studies for the bridge authority began before the bridge's opening. The professional civil engineering society and the U.S. Department of Commerce authorized an Advisory Board on the Investigation of Suspension Bridges, as it was dramatically evident that oscillation and wind effects were not adequately understood.

Although there had been no suspension bridge failures for 51 years, ten suspension bridges were destroyed or damaged by wind in the 19th century, five of these in Great Britain, with the effect that no suspension bridges were built there for over 100 years. During this half century, the trend in bridge design was for spans of ever-increasing length and load-carrying ability, a thin, ribbon-like, artistic appearance, and a belief that a bridge could withstand wind if designed for a static wind pressure of 30 pounds per square foot. The Tacoma Narrows Bridge had met this specification and had been expected to withstand winds greater than the ones which destroyed it.

The aerodynamic studies done after the collapse were the first extensive studies on the effect of wind on bridges. The result was the discovery that the shape of the bridge structure has a primary effect on the bridge's ability to handle wind eddies and stress. The solid floor deck and side panels of Galloping Gertie, when combined with the wind of November 7, 1940, caused stresses which the bridge was not designed to handle. The second Tacoma Narrows Bridge was designed with open side railings and steel grid on the floor deck for the wind to pass through.

The new research stated that the lack of suspension bridge failures for the previous 51 years was due more to a lack of optimum winds for a sufficient period of time than to the design of those bridges. Bridge authorities around the country carried out tests on their suspension bridges with resulting modifications to many structures. Wind tunnel testing became an integral part of the design process for new bridges and for testing existing ones.

The collapse of the Tacoma Narrows Bridge was a hallmark in the history of bridge design and civil engineering. Its impact is still felt in the profession today. The bridge's remains at the bottom of the Sound are a permanent record of man's capacity to build structures without fully understanding the implications of the design and the forces of nature.

FOOTNOTES:

[1]Gimsung, Niels J., Cable Supported Bridges: Concept and Design. New York City: John Wiley and Sons, 1983, p. 21.

[2]Zollman, Dean and Fuller, Robert, "The Puzzle of the Tacoma Narrows Bridge Collapse: An Interactive Videodisc Program for Physics Instruction," Creative Computing, Vol. 8, No. 10, October, 1982, p. 100.

[3]Peterson, Ivars, "Rock and Roll Bridge: A New Analysis Challenges the Common Explanation for a Famous Collapse," Science News, Vol. 137, June 2, 1990, p. 344.

[4]Bleich, Friedrich, et al., The Mathematical Theory of Vibration in Suspension Bridges. Washington: U.S. Government Printing Office, 1950, p. 8.

9. Major Bibliographical References

See continuation sheet.

☒ See continuation sheet

Previous documentation on file (NPS):
- ☐ preliminary determination of individual listing (36 CFR 67) has been requested
- ☐ previously listed in the National Register
- ☐ previously determined eligible by the National Register
- ☐ designated a National Historic Landmark
- ☐ recorded by Historic American Buildings Survey # ____
- ☐ recorded by Historic American Engineering Record # ____

Primary location of additional data:
- ☐ State historic preservation office
- ☐ Other State agency
- ☐ Federal agency
- ☐ Local government
- ☐ University
- ☐ Other

Specify repository: ____

10. Geographical Data

Acreage of property Approximately 20

UTM References

	Zone	Easting	Northing		Zone	Easting	Northing
A	10	533620	5235420	B	10	534500	5234440
C				D			

☐ See continuation sheet

Verbal Boundary Description

The nominated property is described as that underwater property outlined on the attached site plan, drawn to a scale of 1mm = 3.48 feet. The site is generally described as that underwater area between the east and west pilings of the bridge, and beneath the extant new Tacoma Narrows Bridge.

☐ See continuation sheet

Boundary Justification

The nominated property includes the underwater area that contains the remains of the collapsed Tacoma Narrows Bridge, as documented by underwater sonar soundings and video photography. The nominated area is generally defined by the east and west pilings of the bridge and the expanse between, now spanned by the new Tacoma Narrows Bridge.

☐ See continuation sheet

11. Form Prepared By

Name/title Valerie Sivinski/Penny Chatfield Sodhi/John M. Simpson
organization Tacoma Office of Historic Preservation/consultants date January 1991
street & number 747 Market Street, Room 900 telephone (206) 591-5220
city or town Tacoma state Washington zip code 98402

Advisory Board on the Investigation of Suspension Bridges, The Failure of the Tacoma Narrows Bridge. College Station, Texas: School of Engineering, Texas Engineering Experiment Station, 1944.

Andrews, Charles E., Final Report on Tacoma Narrows Bridge, Tacoma, Washington. N.P., June, 1952.

Bleich, Friedrich, et al., The Mathematical Theory of Vibration in Suspension Bridges. Washington, D.C.: Department of Commerce, U.S. Government Printing Office, 1950.

Blumenfeld, Irving, Sturdy Gertie: The Test Tube Bridge. N.P., December 7, 1960.

"Fall of the First Tacoma Narrows Bridge," Washington Highways, December 21, 1964, pp.1-3.

Farquharson, F. B., et al., A Dynamic Model for the Tacoma Narrows Suspension Bridge. Seattle: University of Washington, 1940.

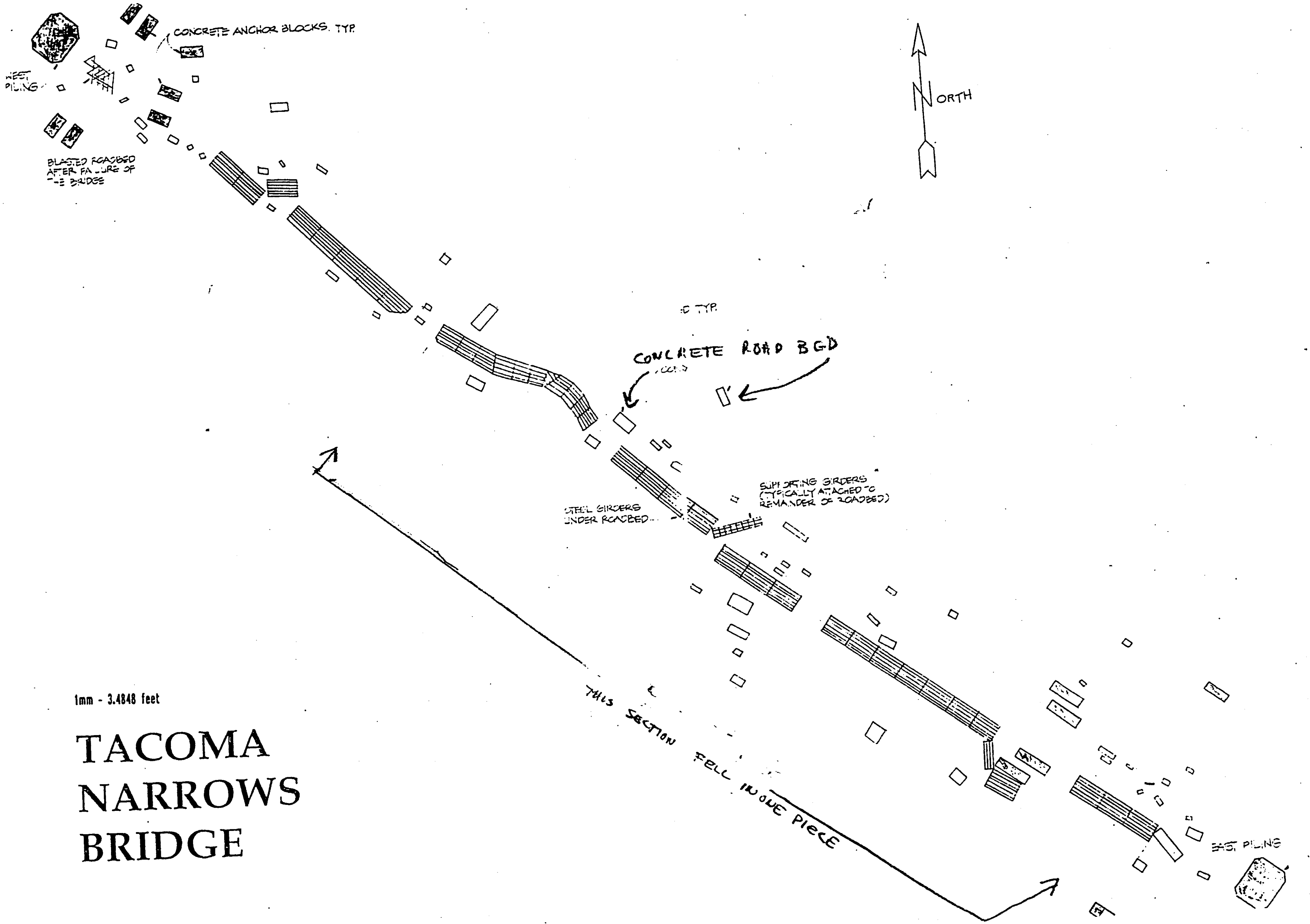
Gimsung, Niels R., Cable Supported Bridges: Concept and Design. New York: John Wiley and Sons, 1983.

Peterson, Ivars, "Rock and Roll Bridge," Science News, Vol. 137, June 2, 1990, pp. 344-346.

University of Washington Structural Research Laboratory (Farquharson, F.B. et al.), Aerodynamic Stability of Suspension Bridges With Special Reference to the Tacoma Narrows Bridge; a Report of an Investigation Conducted by the Structural Research Laboratory, University of Washington. Seattle: University of Washington Press, 1949-54.

Wardlaw, Robert L., "The Wind Resistant Design of Cable-Stayed Bridges," Cable Stayed Bridges. New York: American Society of Civil Engineers, 1988.

Zollman, Dean and Fuller, Robert, "The Puzzle of the Tacoma Narrows Bridge Collapse: An Interactive Videodisc Program for Physics Instruction," Creative Computing, Vol. 8, No. 10, October, 1982, pp. 100-109.



1mm - 3.4848 feet

TACOMA NARROWS BRIDGE