

5.9 ABBOTSFORD BRIDGE

(Swan Hill Type, built 1928)

5.9.1 Description of the Bridge

The Bridge over the Murray River at Curlwaa named Abbotsford consists of a mild steel vertical lifting span with length 60 ft. three mild steel riveted trusses with lengths ranging from 120 to 123 ft. and nine mild steel I-beam spans 24 ft. long. The supports of the lift span and trusses comprise of piers made from pairs of circular reinforced concrete columns connected by a reinforced concrete diaphragm. The bridge has a clearance over normal water level of 23 ft. with the lift span closed and 52 ft. with the lift span open.

The upper framework of the lifting span consists of four steel lattice towers that are restrained at the top by longitudinal Warren type girders and transverse lattice girders. The bridge currently carries a single lane of road controlled by traffic lights.



Figure 5.103 View of Abbotsford Bridge from the NSW side.

Development of roads and transportation in the Wentworth region

In 1859 Wentworth was established, at the strategic position at the intersection of the Darling and Murray Rivers. The location was used as the clearing port for the wool trades. Numerous overland teams travelled to the town using camels or bullocks to bring wool-bales for shipment to coastal markets. From the 1890s, irrigated farming greatly expanded in the Sunraysia

region which was known for its fruit production, and traffic volumes increased further. It was decided to install a punt at this location (then known as Abbot's Ford).

Design and construction

By 1924 it was decided that the punt was not sufficient for the traffic flow and this warranted the expense of a significant bridge being planned for the site (NSW Heritage Report). The Abbotsford Bridge was designed by H. Leahy and the drawings were also signed off by Percy Allan, Chief Engineer of Public Works at the time. This was the third bridge that was constructed under the Border Department Railways Act. The bridge was designed to be able to carry the loads required for a railway; and although opened as a traffic bridge, it was intended to be converted to allow rail once the Mildura railway line was extended to the bridge. The line was never extended beyond Yelta, where the terminus remains to this day.

The contract for providing steelwork was let to Messrs. MacLelland & Co. of Glasgow at a value £22,763 and Messrs. Christiani & Nielsen was issued with a contract for the erection of the steelwork and construction of the reinforced concrete piers for £45,594. The majority of the cost was borne by the Victorian Government with New South Wales contributing the remaining one third of the cost. The construction of the bridge was delayed as the erection of the piers slowed due to the high level of the river. Figure 5.104 shows the bridge under construction during 1927. The bridge was completed and finally opened for traffic by the NSW Governor Dudley de Chair on 10 July, 1928 (PWD 1925-1928).



**Figure 5.104 Abbotsford Bridge under construction in September 1927
(Source: PWD 1927)**

Operational history

A major accident occurred at the bridge in August 1931. The paddle steamer *E.R.O.* struck the lift span of the bridge. The span had not been raised to a high enough level, causing it to clip the top of the steamer's funnel and rip apart the upper deck. High pressure steam was released during the accident causing some onlookers to believe the boat was on fire. It was at first thought the captain would be found amongst the wreckage of the upper deck, but he had been navigating the boat from the lower deck at that time. And through his actions as the boat progressed downstream caught in the current, he prevented the boat becoming stuck at the bridge (*Murray Pioneer and Australian River Record* (Renmark, SA). 28 August 1931:4).



Figure 5.105 Ship approaching Abbotsford Bridge with span raised (Source: Tucker, August 2012)

Operational steam paddlers based at Renmark and Mannum in South Australia make regular trips to Wentworth and these have been augmented by house boats more recently. Collectively they ensure that the lift span is opened regularly though lifts are timed to try and avoid traffic delays. Accurate records have not been kept since the bridge was completed though in 2005 it is noted 48 openings took place; current numbers would be similar.

Maintenance History

Access arrangements on the bridge have been modified since construction to better meet worker health and safety requirements as required.

5.9.2 Statement of significance

Abbotsford Bridge, completed in 1928, is of Local significance. The form and setting have high aesthetic and social significance. The bridge is a unique

type in the Murray River Crossing in the combination of materials and lift span.

Source: RMS s170 Register

Heritage Listings

Listing	Status
Australian Heritage Database (formerly the Register of the National Estate)	Not listed
OEH Heritage Division State Heritage Register	Not listed
Victorian Heritage Register	Not listed
Wentworth Shire Council Local Environmental Plan, 2011	Not listed
NSW National Trust Register	Not listed
RTA s.170 Heritage and Conservation Register	Listed

Evolution of modifications

In summary, the Abbotsford design is a modification from the Swan Hill Bridge designed by Percy Allan. The modifications include the alignment of the longitudinal girders with the towers along with the introduction of longitudinal and transverse gusset plates for the top tower to girder connections. The use of a mild steel girder with longitudinal stiffeners for the lift spans was also a first for the old type designs. It is also evident that the superstructure of the lift span is made up of entirely mild steel and cast iron opposed to the adoption of wrought iron as the major structural material in previous bridges.

Table 5-20 Abbotsford Bridge – Summary of modifications

Preceding Designs	Issues with Design	Evolution at Abbotsford
Longitudinal girders set in from towers.	Design does not provide efficient load path.	Alignment of longitudinal girders with towers.
No gusset plates for designs with transversely orientated sheaves.	Reduced strength of connection and stiffness of superstructure.	Introduction of both transverse and longitudinal gusset plates into design.
Longitudinal girder alignment offset from towers for transverse sheave bridge designs.	Inefficient load path for superstructure	Align longitudinal girders with towers.
Primarily wrought iron construct	Weaker material, though it does have good resistance to fatigue due to laminations.	Primarily made of mild steel and cast iron construct.

5.9.3 Description of lift span mechanism components

Towers

The form and fabric of the lift span towers is of EXCEPTIONAL significance.

The design of the Abbotsford Bridge appears to be the last design of the old generation vertical lift span bridges in NSW. The design was informed by the preceding Swan Hill Bridge design of Percy Allan, though modifications were incorporate in the new design. As evident with the Tooleybuc Bridge, the Swan Hill design was not the latest vertical lift bridge design available and the circumstances surrounding its use for this crossing are unknown.

The towers of the bridge consist of a mild steel lattice type structure with a square top section with mild steel plating (Figure 5.106). Following on from preceding designs, the tops of the towers are restrained Warren type longitudinal girders, transverse diagonal cross braced girders and wind bracing.



Figure 5.106 Abbotsford lift towers (Source: GHD)

The longitudinal girders are aligned with the towers. This is the first time that a Swan Hill type vertical lift span has changed this alignment. Gusset plates have also been installed in both the transverse and longitudinal directions at the girder to tower connections and this increases the overall stiffness of the superstructure. This was not the first time gussets were used as they were included in the designs as early as Hinton Bridge. However it is the first time that a transversely orientated sheave bridge design has been modified to include gusset plates (Figure 5.107). The longitudinal girders also provide support to the longitudinal shaft connecting the sheaves at the either end of the span.

Counterweight

The form and fabric of the counterweight is of MODERATE significance.

The balance weights of the system were hung on the sides of the lifting towers and consist of cast iron with adjustable lead ingot filling (Figure 5.109). There is also an allowance for adjustments in case of any weight fluctuations due to water on the road or future modifications to the lift span. The balance weights worked on solid core steel v girders that were bolted to the two edges of the lattice tower facing the weights.

As with the Swan Hill Bridge design, the arrangement of having the balance weights on the outside of the tower had two advantages. The first was a reduction in friction compared to positioning the weights inside the tower. The second advantage is that this arrangement allowed for the sheaves to be mounted on the centre line of the towers thus eliminating eccentricities.

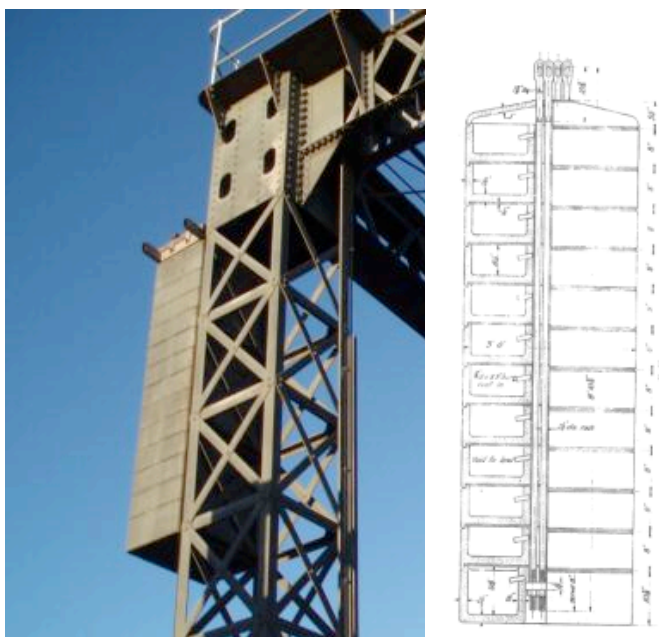


Figure 5.109 Counterweights on Abbotsford (Source: RMS)

Sheaves and winch mechanism

The form and fabric of the sheaves is of MODERATE significance.

The sheaves consist of a cast wheel that is mitred on the inside of the rims to allow a pinion to key into the sheave and provide driving force (Figure 5.110). The winch mechanism is mounted at the midpoint of a tower.

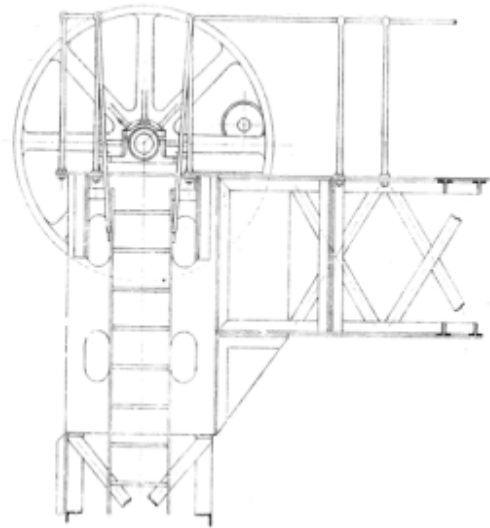


Figure 5.110 Drawing of Abbotsford sheave

Mechanical components

The form and fabric of the mechanical components is of MODERATE significance.

Despite other modifications to the bridge design, the lifting mechanism is the same as that adopted for the preceding Swan Hill Bridge design with the sheaves orientated in the transverse direction once again.

The driving control for the bridge is provided by a combination of shafts and wire ropes. The winch placed just above deck level turns a vertical shaft reaching up to the top of the tower. The direction of rotation is then transferred by a pinion and gear into the first longitudinal shaft that protrudes onto the mitred rim of the sheave causing rotation, thus lowering the balance weight and lifting the span that is joined to the wire ropes (Figure 5.111). The uniform transfer of driving force to all sheaves is provided by the linking of two longitudinal shafts by a transverse shaft. This arrangement also allows for the single person operation of the lifting bridge.

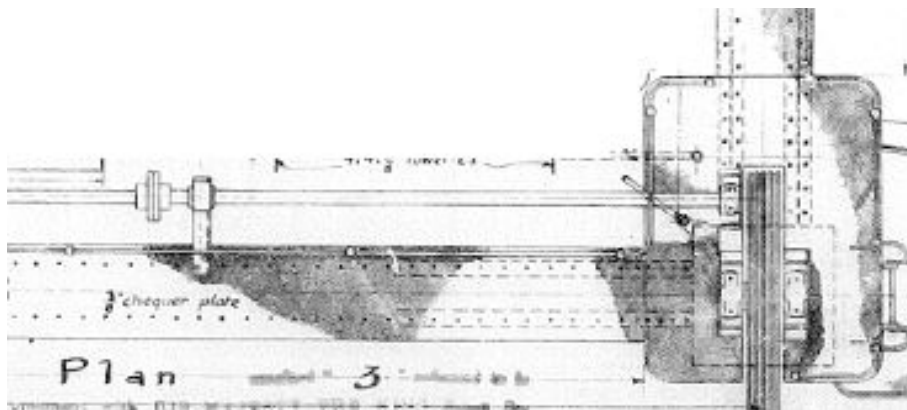


Figure 5.111 Plan of Abbotsford Bridge

Vehicle and pedestrian barrier

The form and fabric of the vehicle and pedestrian barriers are LOW significance.

The bridge is fitted with metal safety gates positioned either side of the movable span.

Ropes

The form and fabric of the ropes is LOW significance.

The wire ropes on Abbotsford Bridge are used for connecting the counterweight to the movable span. Four ropes are located at each corner of the span and pass up over the transversely oriented sheaves into the counterweights.

Motors and electrical

NO significance.

Motors and electrical components were never installed on Abbotsford Bridge. It remained manually operated throughout the initial period of its operation. From the 1990s a portable electric drill has been used to drive the opening mechanism of the bridge.

Summary of heritage assessments

The significances of each bridge component are summarised in the table below.

Table 5-21 Abbotsford Bridge – Summary of heritage significance

Bridge Component	Significance Grading
Towers	EXCEPTIONAL
Movable Span	MODERATE
Counterweights	MODERATE
Sheaves and winch drums	MODERATE
Mechanical components	MODERATE
Vehicle and pedestrian barriers	LOW
Ropes	LOW
Motors and electrical	NO

5.10 MORORO BRIDGE

(Robinvale Type, built 1935)

5.10.1 Description of the Bridge

The bridge over the Clarence River named Mororo consists of a steel vertical lifting span with length 56 ft., two steel trusses with length 121 ft. each and ten approach spans each approximately 35 ft. in length.

The upper framework of the lifting span generally consists of four steel plate columns that are restrained at the top by both transverse and longitudinal warren type steel girders. The lift span is a steel plate web girder with transverse stiffeners and the entire superstructure is supported by concrete piers.



Figure 5.112 General View of Mororo Bridge from the 1993 south bound bridge

Development of roads and transportation in the Mororo region

The area surrounding the Mororo Bridge was discovered due to the activities of an escaped convict named Richard Craig in the early 1800s. After his escape from the Moreton Bay penal settlement, he travelled south through the Clarence River Valley before finally arriving at Sydney. The information gathered by Craig initiated an expedition of the area in 1838 under the direction of Thomas Small (Ainsworth Heritage, 2009). Motivation for the initial settlement was due to the rich cedar deposits that were believed to be in the area. Thomas Small was the owner of the Kissing Point timber yard on the Parramatta River and this prospect led to the schooner *Susan*, a ship built for the cedar trade, taking the voyage to the area (Maclean Shire, 2006).

The cedar trade had a boom through the 1840s before the resource became scarce by 1850. The region was also utilised as pastoral grounds and activity in the area continued to increase (Maclean Shire, 2006).

Transportation for the area was heavily reliant on the river network, as made evident in an entry in the *Sydney Morning Herald* in 1871 “The Clarence River is to this part of the country pretty much what the Nile is to Egypt”. Nevertheless, road transportation continued to increase and requirements for river crossings became apparent. Initially a crossing at Mororo was provided by hand powered ferry before being finally upgraded to an engine powered ferry in 1928 (Figure 5.113).

Design and construction

In 1928 the Main Roads Board began planning for a bridge adjacent to the ferry location. The final site was chosen due to the narrowing width of the river, shallow depth and high embankments. The Bridge was completed in 1935 with the opening ceremony held on the 8th of June. The Minister for Transport attended the ceremony along with approximately 600 spectators (Ainsworth Heritage, 2009). Towards the end of the project, the final construction cost was estimated to be £25,000 (*Northern Star*, 1935).

The Mororo Bridge was duplicated in 1993 and now carries north bound Pacific Highway traffic only.

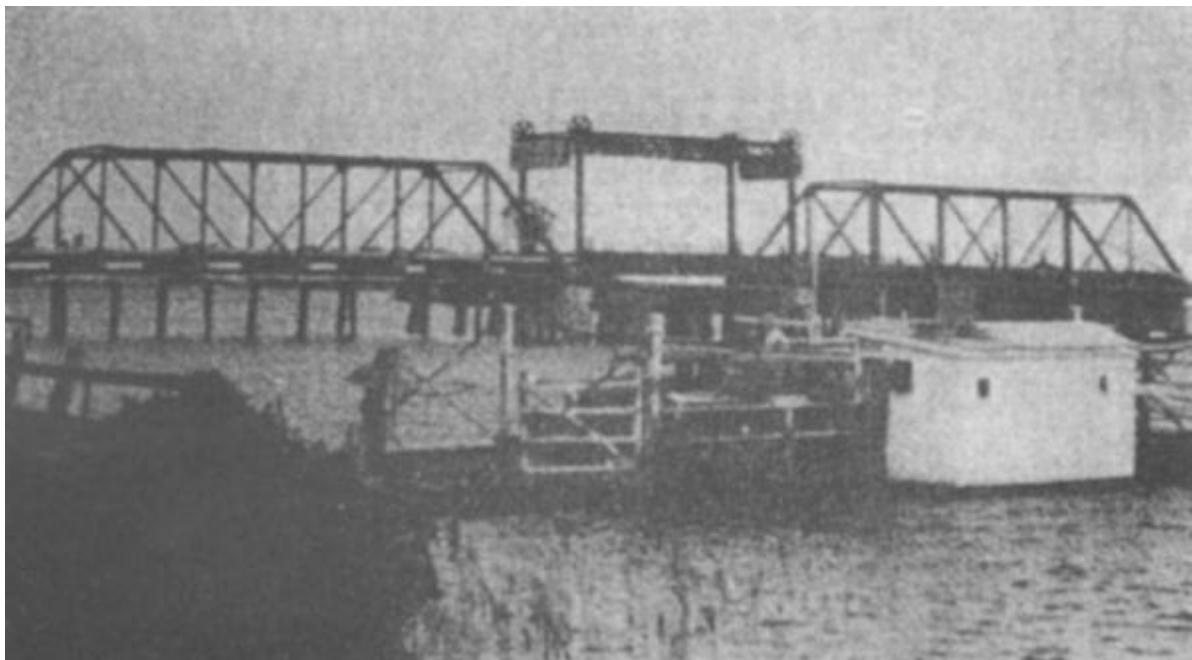


Figure 5.113 Mororo’s ferry in operation (post 1935) with Mororo Bridge in the background. The photo is taken from east of the bridge looking upriver (Source: Maclean Historical Society)

Operational History

While it has been suggested that the lift span was never used (see Section 5.10.2), Figure 5.114 show that sheaves, counterweights and ropes were fitted to the bridge at the time of opening. It can be inferred that test lifts were carried out to ensure even distribution of weight. There is no record

that operational lifts for the passage of river craft were undertaken prior to the mechanism and counterweights being removed from the bridge.



Figure 5.114 Mororo Bridge in 1935 with counterweights and ropes in place (Source: RMS photographic archives)

Maintenance History

Access arrangements on the bridge have been modified since construction to better meet worker health and safety requirements as required.

5.10.2 Statement of significance

The 1935 Bridge at Mororo is significant both historically and socially to the local area through enabling better communication and ease of travel. The bridge is also important in demonstrating the power of local communities in the lobbying of Government to better provide for their infrastructure needs. Additionally, the installation of a lift span, though never used, indicates the importance of river traffic at the time of the Bridge's construction.

The bridge also allowed easier communications and travel between the communities of the area and an improvement in services. In addition, the Mororo Bridge is a good representative example of a mid-twentieth century steel truss bridge and is remarkably intact for its age (Ainsworth Heritage, 2009).

Heritage Listings

Listing	Status
Australian Heritage Database (formerly the Register of the National Estate)	Not listed

Listing	Status
OEH Heritage Division State Heritage Register	Not listed
Clarence Valley Council Local Environmental Plan, 2011	Not listed
NSW National Trust Register	Not listed
RTA s.170 Heritage and Conservation Register	To be listed

Evolution of modifications

In summary, the Mororo Bridge design modifications consist of an improved rope connection system and mechanism gearing arrangement.

Table 5-22 Mororo Bridge – Summary of modifications

Preceding Designs	Issues with Design	Evolution at Mororo
A number of gearing arrangements exist.	Possible less efficiency of system	New gearing arrangement for design.

5.10.3 Description of lift span mechanism components

Towers

The form and fabric of the lift span towers is of EXCEPTIONAL significance.

The design of the Mororo Bridge is similar to the preceding design of Gonn Crossing Bridge. The towers of the bridge consist of a mild steel plate construct with concrete infill. Top restraint is provided by steel Warren type transverse and longitudinal girders and the wind bracing also consists of Warren type trusses (Figure 5.115).



Figure 5.115 Towers of Mororo Bridge (Source: RMS)

The longitudinal girders are aligned with the towers and the piers supporting the towers are made entirely of reinforced concrete. The bottom end fixing of the tower bases is achieved by base plates and hold down bolts.

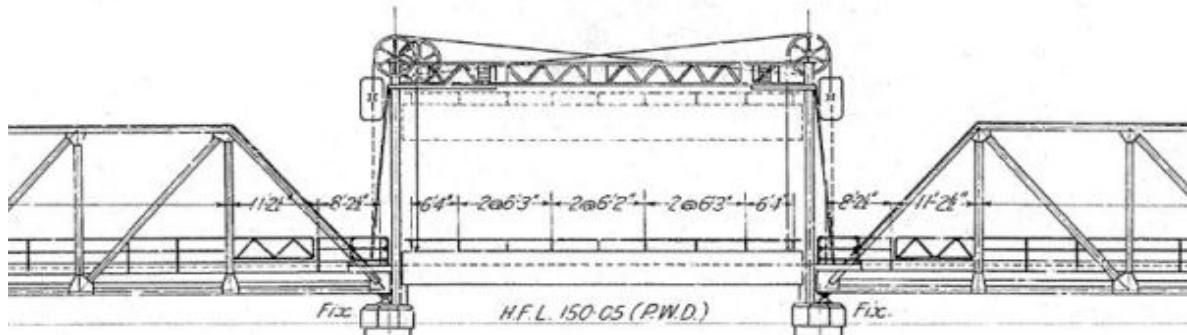


Figure 5.116 Original Extract from the Elevation Plans of Mororo Bridge

Movable span

The form and fabric of the movable span is of MODERATE significance.

The lift span consists of a mild steel plate web girder with transverse stiffeners. These girders support steel plate web cross girders and steel stringers that finally supports the timber decking (Figure 5.117).

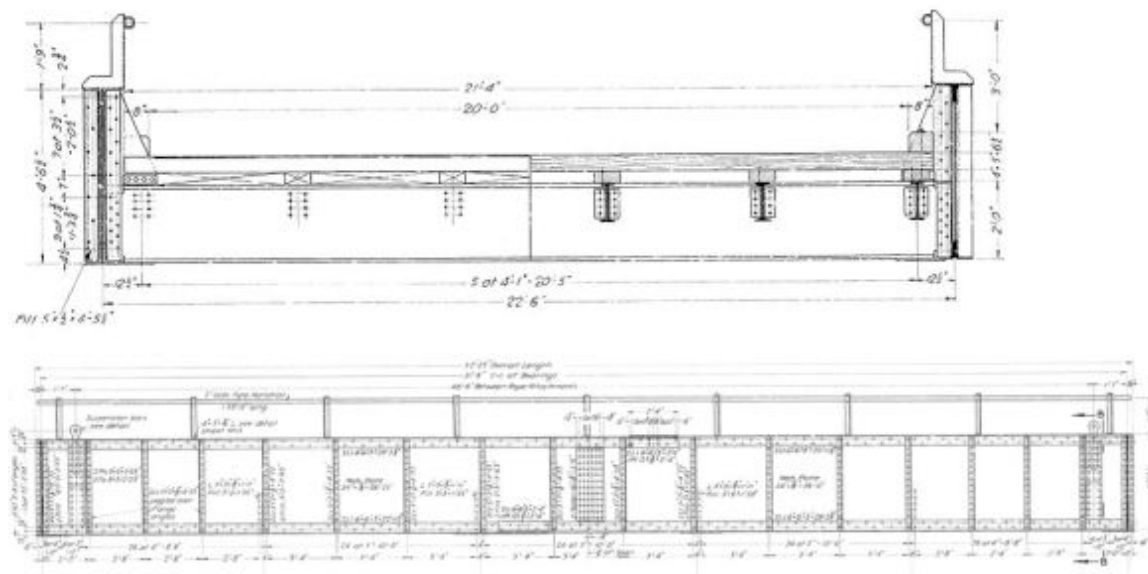


Figure 5.117 Cross section and elevation of Mororo Bridge lift span

The connection between the wire ropes and the lift span is achieved by a different design than that of Gonn Crossing Bridge. The wire ropes are joined to the lift span by adjustable eye bolts. The even distribution of wire rope loads is ensured by compensating bracket designed to incorporate all three wire ropes (Figure 5.118).

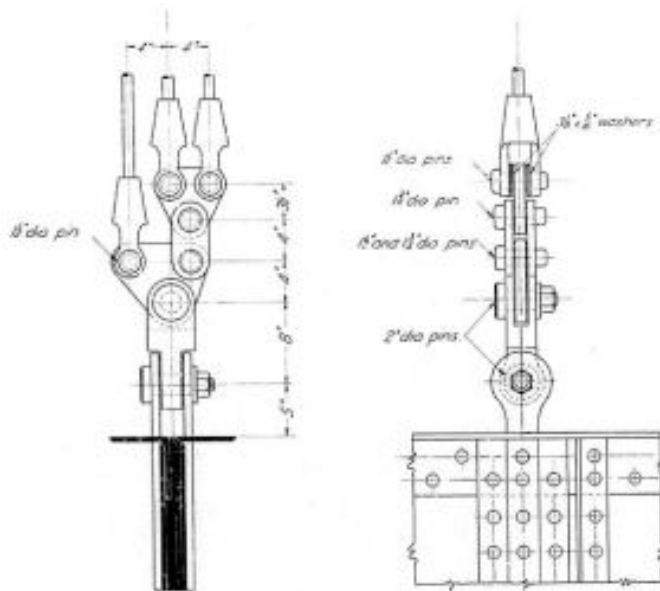


PLATE GIRDER ATTACHMENT

Figure 5.118 Mororo Bridge lift span compensating brackets

Counterweight

NO significance.

The counter weights of the system were originally similar to those adopted for the Gonn Crossing Bridge design. The bridge only had two balance weights that were extended across the width of the bridge, being supported by wire ropes at each end. The counterweights consisted of a reinforced concrete mass with top voids as to allow for extra weights to be added to the system when required (Figure 5.119). The weights were hung on the opposite side of the tower to the lift span and there was a guide wheel arrangement, whereby the weights run along the flange of each tower, thus restricting lateral movement.

As with the Gonn Crossing Bridge design, the arrangement of having the balance weights on the opposite side of the tower has the advantage that the sheaves can be mounted on the centre line of the towers thus eliminating eccentric loads.

The counterweights have since been removed from the bridge.

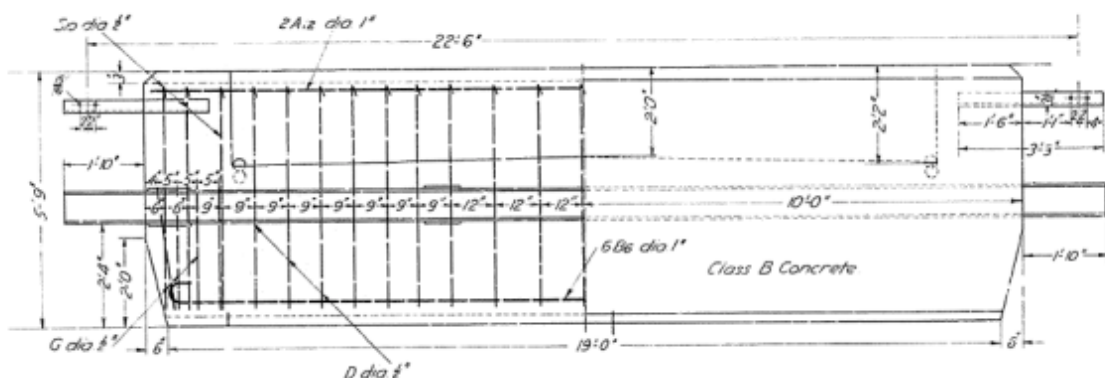


Figure 5.119 Counterweights on Mororo Bridge

Sheaves and winch mechanism

NO significance.

The sheaves originally used on Mororo Bridge consisted of a cast iron rope wheel (Figure 5.120). Four grooves were set into the casting to allow for the counterweight and haul ropes. The winch was mounted at the top of the tower and was keyed into a number of gears before driving power was transferred into the sheaves.

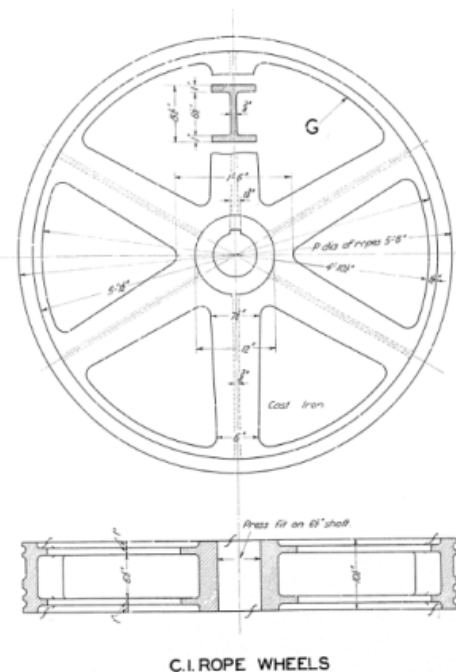


Figure 5.120 Original sheaves for Mororo Bridge

Mechanical components

The form and fabric of the mechanical components is LOW significance.

The lifting mechanism implemented on the Mororo Bridge is a modification of the Gonn Crossing Bridge design. The arrangement of the longitudinal sheaves, transverse shafts and wire ropes are identical, however the gearing arrangement at the top of the tower has been altered.

The driving control is provided by a combination of wire ropes and shafts. The winch mechanism is located at the top of the tower and it turns a number of gears gaining a mechanical advantage before transferring rotation to the first transverse shaft. The rotation of this shaft causes the rotation of the sheaves, lowering of the balance weights and subsequently lifting the span (Figure 5.121 to Figure 5.122).

The majority of the mechanical components have since been removed. The spur-wheel and some gearing components still remain.

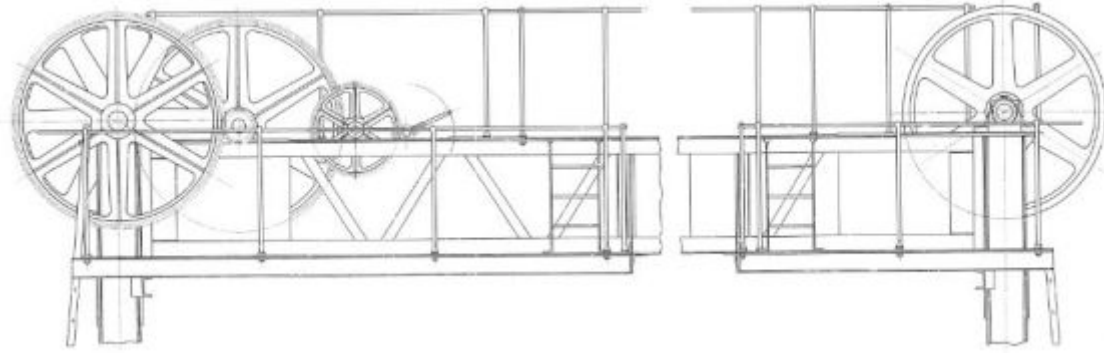


Figure 5.121 Elevation of Mororo Bridge lifting mechanism arrangement

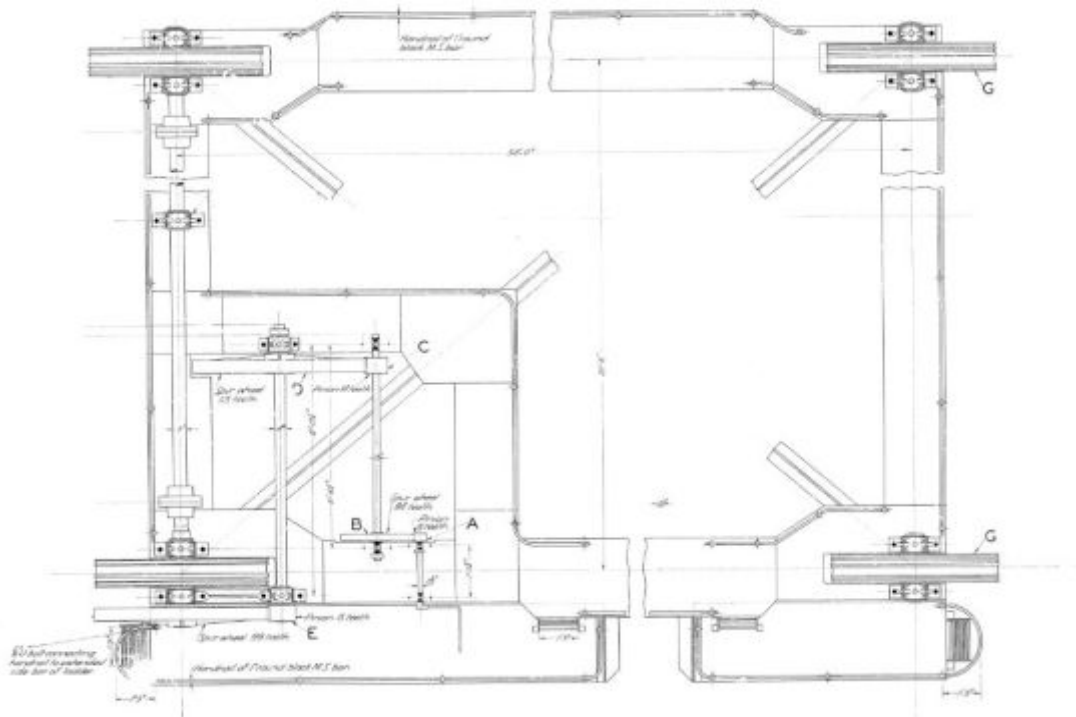


Figure 5.122 Plan of Mororo Bridge lifting mechanism arrangement

Vehicle and pedestrian barrier

NO significance.
 There are currently no vehicle and pedestrian barriers on Mororo Bridge.

Ropes

NO significance.

The uniform transfer of driving force to all sheaves is provided by the implementation of transverse shafts and the wire rope arrangement in the longitudinal direction. Starting from the lifting span, wire ropes pass around the sheave and cross longitudinally along the vertical span. After which the ropes pass over the sheave at the opposite end of the span and attach to the counter weight. The rope arrangement as described above only relates to one of the wire ropes connected to a corner of the lift span. The remaining two ropes at each corner simply travel from the lift span up and over the sheave and directly down onto the counter weight. The ropes are distinguished as being either haul ropes or counter weight ropes.

The wire ropes have since been removed

Motors and electrical

NO significance.

Motors and electrical components were never installed on Mororo Bridge. It remained manually operated throughout the initial period of its operation.

Actions required in order to restore the bridge to lifting operation

- Reinstall wire ropes.
- Overhaul existing mechanism and reinstall remaining mechanism.
- Reinstall counterweights.
- Reinstall sheaves.

Summary of heritage assessments

The significances of each bridge component are summarised in the table below.

Table 5-23 Mororo Bridge – Summary of heritage significance

Bridge Component	Significance Grading
Towers	EXCEPTIONAL
Movable Span	MODERATE
Counterweights	NO
Sheaves and winch drums	NO
Mechanical components	LOW
Vehicle and pedestrian barriers	NO
Ropes	NO
Motors and electrical	NO

5.11 RYDE BRIDGE

(Ryde Type, built 1935)

5.11.1 Description of the Bridge

The bridge over the Parramatta River at Ryde is the first Waddell type vertical lift bridge built by the Department of Main Roads, NSW. The Waddell type vertical lift bridge is an American design that was used in many other countries (Karmalsky, 1961).

The upper framework of the lifting span generally consists of two independent steel towers with sufficient stiffness to prevent encroaching on each other, with the span itself consisting of a steel Pratt type truss arrangement. The entire superstructure is supported on reinforced concrete piers.



Figure 5.123 General view of Ryde Bridge in 2012 (Source: RMS Section 170 Register)

Development of roads and transportation in the Ryde district

The history of the Ryde district dates back to the early European settlement of Sydney Cove. The land in the district was named Field of Mars by Governor Philip and some of the first land grants were made in 1792 on the northern bank of the Parramatta River. In 1804 the Governor King declared that the 5050 acres of the Field of Mars was to become a common that would provide an area for local settlers to use the land for grazing, thus freeing up their own lots for cropping. Over time this common land was incrementally sold to private individuals and the vicinity was proclaimed as a municipality in 1870.

The district still remained essentially rural due to its distance from Sydney, however in 1874 a bill was passed for the resumption of land sale at Field of Mars and in 1885 the Government surveyed and subdivided the land for sale. Proceeds for the sale also assisted in funding the new railway from Strathfield to Hornsby (Beecroft and Cheltenham History Group, 1995).

Prior to the construction of the bridge, a number of punt and ferry services operated to connect the Ryde district and the North Shore to Sydney. The services operated in a number of locations from 1820s onwards and in 1896 a man-powered punt was installed at the present location of the Ryde Bridge.



Figure 5.124 View of Ryde Bridge in 1970 with lift span closed and counterweights in regular position (Source: Photograph courtesy of Canada Bay Council)

Design and construction

The construction of The Bridge was enabled by the *Parramatta River Bridge Act* passed in 1931. This Act gave the Ryde Council the power to acquire land, secure a loan and construct the bridge. The design was completed by the Department of Main Roads with W. I. Muntz taking the role of Supervising Engineer onsite.

The circumstances surrounding the need for a different design in Australia are a combination of a number of factors. Previous vertical lift bridges were typically constructed in rural locations where the river vessel dimensions were limited to paddle steamers or small sailing ships and the crossing lengths were not excessive. Furthermore, restricting traffic to a single lane did not pose any issues as traffic volumes were minimal. The location of the Ryde Bridge demanded two specific requirements, namely the greater traffic volume carried on three lanes and the allowance for large ships.

Construction works commenced in 1933 and the Bridge was completed two years later. The official opening for traffic was held on the 7th of December 1935 with the Honourable B. S. B. Stevens, Premier of NSW, and a number of other Government officials attending. The finished bridge is depicted in Figure 5.125.

The final construction cost was £10,000 less than the original £133,000 estimate. The State Government freely contributed a value of £53,000 with the remaining £80,000 raised by capital debt (*The Sydney Morning Herald*, 9th December 1935). The bridge was initially operated as a toll bridge which proved to be a great financial success and in 1946 the revenue reached £16,148 with over one million vehicles passing over the bridge that year. Based on these revenues the council proposed to remove the toll in 1950, five years before the loan was to mature. In the early 1990s a second bridge was built adjacent to Ryde Bridge and the usage was shifted to cater solely to northbound traffic.



Figure 5.125 Ryde Bridge with lift span fully raised in the 1960s, note the counterweights are at rest just above deck level (Source: MCI Levy Collection, Ryde Library Service)

The operation of the bridge is achieved by a mechanism that is characteristic of the Waddell type movable bridges. It contains a complex arrangement of ropes, sheaves and motors. In essence the bridge is raised by simultaneously adding to the downhaul rope and subtracting from the uphaul rope by the turning of the winch drum. As evident in Figure 5.126, the rope either side of the idler sheaves are stationary and the movable span passes up the ropes.

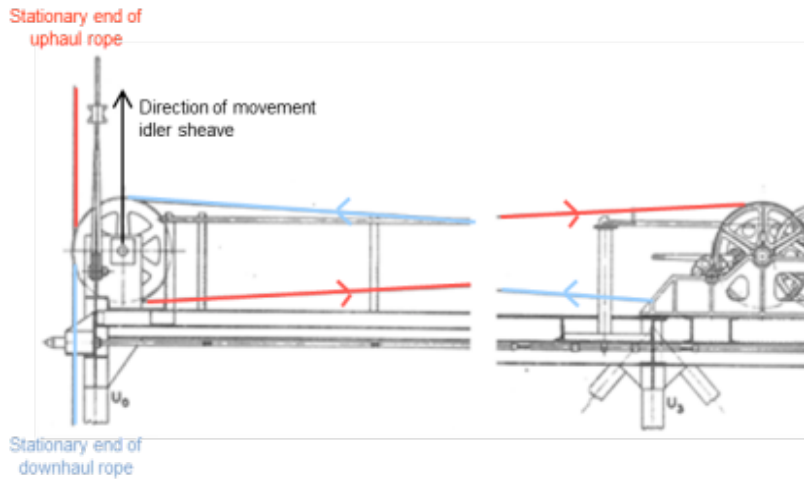


Figure 5.126 Ryde Type Bridge Operation Schematic

Operational history

No accurate records were kept of the number of operational lifts undertaken by the bridge following its opening in 1935. Figure 5.125 shows an instance of the lift span raised to full height possibly during a test lift in the 1960s. Following the construction of a southbound concrete bridge adjacent the height of water traffic into Homebush Bay was limited and the lift bridge was converted to a fixed bridge with the removal of the ropes and counterweights.

Maintenance history

The bridge was modified in use to carry northbound traffic with the opening of a new southbound bridge in the 1990s. An extra steel member was added over the entry portal to assist in strengthening the bridge against impact by over height vehicles. The end principal truss members were concrete filled for the same purpose. The lifting mechanism was removed along with the counterweights, leaving only the pulley wheels over which the counterweight ropes passed. The deck joints either side of the movable span were in filled and replaced.



Figure 5.127 Replacement of deck joints by HMS Civils Pty Ltd

5.11.2 Statement of significance

Ryde Bridge has rarity value at a State level and historical significance locally. Ryde Bridge spans the Parramatta River between Church Street in Ryde (Uhrs Point) and Concord Road in Rhodes, replacing an earlier ferry service between these two points established in the late nineteenth century. It is rare at a state level because it is the only lift span bridge on Sydney Harbour and its tributaries (although the mechanism to operate the vertical lift span has been removed). Ryde Bridge, constructed in 1935, is also a relatively rare example of a steel truss bridge with a lift span in NSW. It is similar to Hexham Bridge on the Hunter River in that both are movable span bridges, although Ryde Bridge was designed and constructed around a decade earlier. By the early 1950s, the bascule span was the preferred option for bridges with opening spans, meaning that vertical lift span bridges such as Ryde Bridge were no longer being designed and built. Ryde Bridge has local historical significance because it is located at an important crossing over the Parramatta River, between Ryde and Rhodes, which was one of the narrowest points on the river. Ryde Council initiated the construction of the bridge in order to open up the municipality for suburban development. Thereafter, Ryde Bridge has provided an important transportation route for outer suburbs in the municipalities of Ryde and Hornsby to access Sydney by car.

Source: RMS s170 Register

Heritage Listings

Listing	Status
Australian Heritage Database (formerly the Register of the National Estate)	Not listed
OEH Heritage Division State Heritage Register	Not listed
Ryde City Council Local Environmental Plan, 2013	Listed
NSW National Trust Register	Not listed

Evolution of modifications

Ryde Bridge was the first of the second generation vertical lift span bridges and adopted the American Waddell type vertical lift span design which had first been built in America in 1893.

5.11.3 Description of lift span mechanism components

Towers

The form and fabric of the lift span towers is of EXCEPTIONAL significance.

The design of the Ryde Bridge is based on the Waddell type American design.

The superstructure consists of two independent towers that extend into the adjacent truss spans. The towers consist of two braced mild steel vertical members and two lattice steel vertical members that support two longitudinally oriented counter weight sheaves (Figure 5.128 to Figure 5.129). The towers are independent however the bracing arrangement gives them sufficient inherent stiffness to prevent them encroaching on each other and jamming the lift span during operation.



Figure 5.128 View of bridge in 1981. Engine house has since been removed

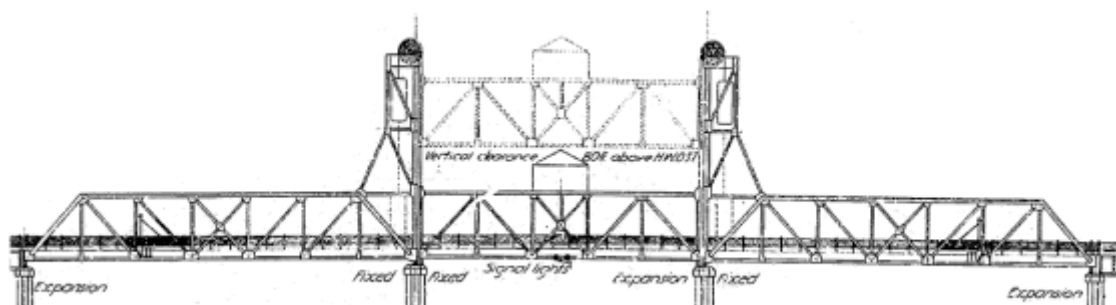


Figure 5.129 Elevation of Ryde Bridge

Movable span and engine house

The form and fabric of the movable span is of MODERATE significance.

The movable span of the Ryde Bridge consists of mild steel truss arrangement. The truss supports steel plate web cross girders that subsequently support the R. S. J stringers and reinforced concrete deck. The engine house consisted of a small gable roofed building.

The lift span is also fitted with locking pins that are inserted when the lift span is resting on the end bearings. These locking pins prevent the lift span from rising off the bearing due to the pull of the counter weights when the span is not in operation.

The majority of the mechanical components and the control panel were situated inside an engine house mounted on the top of the movable span. This engine house has since been removed.

Counterweight

NO significance.

The original counterweight consisted of a large concrete mass suspended in a steel basket, which allowed for attach points to the wire ropes.

The counterweights have since been removed (Figure 5.130).



Figure 5.130 View in 2013 with counterweights removed

Sheaves

The form and fabric of the sheaves is of EXCEPTIONAL significance.

The Ryde Type bridges are distinctive by the presence of the two sets of sheaves.

There are four counter weight sheaves mounted, two at the top of each towers and four haul sheaves are mounted on the upper corners of the movable span. Grooves were set into the casting to accommodate for the wire ropes required for the mechanism.

Mechanical components

The form and fabric of the mechanical components is of LOW significance.

The lifting mechanism on Ryde Bridge previously operated by the integration of motors, drums, haul ropes, sheaves, gearing and counter weights.

The power for operation was provided by an electric motor which turned centre mounted gearing and subsequently rotated the four drums that would coil/uncoil the wire ropes.

Once movement was initiated the idler sheaves at the four corners of the lift span would essentially 'pass through' the haul ropes as the span rises. The lengths of haul rope either side of the idler sheave remain stationary as the drums add to the downhaul rope and subtract from the uphaul rope simultaneously, with the mechanism operating in reverse during lowering.

The majority of the lifting mechanism has been either rehabilitated or upgraded for enhanced performance.

Due to the size of the lift span and the large force applied to the counter weight sheaves a critical detail is the trunnion to sheave interface. Ryde Bridge had issues with the hubs 'rolling' on the trunnions emitting loud rifle shot sounds during operation. There was a solution proposed and implemented on the Ryde Bridge. This design was later improved upon in the subsequent design of Hexham Bridge.

The majority of the mechanical components have since been removed.

Vehicle and pedestrian barrier

NO significance.

Since the locking of the span, the vehicle and pedestrian barriers that were mounted on the truss approach spans have been removed.

Ropes

NO significance.

Originally Ryde Bridge was fitted with substantial counterweight and haul wire ropes. The counterweight ropes would pass from the movable span over the top sheaves and onto the counterweight. The haul ropes were fixed to the top and bottom of the tower and were integral in the operation of the bridge.

All the wire ropes have since been removed.

Motors and electrical

NO significance.

The power for operation is provided by an electric motor that turns centre mounted gearing and subsequently rotates the four drums that coil/uncoil the wire ropes.

The motors on Ryde Bridge have since been removed.

Actions required in order to restore the bridge to lifting operation

- Reinstall wire ropes
- Reinstall mechanism
- Reinstall counterweights
- Reinstall motors

Summary of heritage assessments

The significances of each bridge component are summarised in the table below.

Table 5-24 Ryde Bridge – Summary of heritage significance

Bridge Component	Significance Grading
Towers	EXCEPTIONAL
Movable Span and engine house	MODERATE
Counterweights	NO
Sheaves and winch drums	EXCEPTIONAL
Mechanical components	LOW
Vehicle and pedestrian barriers	NO
Ropes	NO
Motors and electrical	NO

5.12 NYAH BRIDGE

(Robinvale Type, built 1941)

5.12.1 Description of the Bridge

The bridge over the Murray River at Nyah consists of a steel vertical lifting span with length 62 ft. and two steel plate girder spans with lengths 70 ft. each. Another two simple beam approach spans of 25 ft. are located at each end of the bridge. The maximum clearance over high water level is approximately 32 ft.

The upper framework of the lifting span generally consists of four steel plate columns that are restrained at the top by both transverse and longitudinal Warren type steel girders. The lift span itself is a steel plate web girder with transverse stiffeners and the entire superstructure is supported on reinforced concrete piers.



Figure 5.131 General View of Nyah Bridge

Development of roads and transportation in the Nyah region

The area surrounding the Nyah Bridge was first settled in the 1894 campaign by the South Australian Government to combat unemployment during the economic difficulties of the early 1890s. The settlement on the Murray had Utopian ideals with communal control and no individual ownership. The Victorian State also provided assistance for irrigation pumps for the area (NSW Heritage).

The leader of the community was utopian socialist Jim Thwaites from Mildura, who created his own irrigation for a grape-vine plantation. Mr Thwaites and

another family, the McAlphines, survived the difficult period until 1906 when the Victorian Government provided a steam pump for irrigation and 800 hectares of land was opened up for more settlements (NSW Heritage).

Nyah became a successful grape growing district and also produced a wide range of dried fruits. An iron foundry was later established to provide material for agricultural machinery and pumps.

Design and construction

The need for a bridge over the Murray River at Nyah arose due to the establishment of another fruit growing district named Koraleigh on the NSW side of the river. To improve communications between the two towns a bridge was planned in 1939 (NSW Heritage). The Bridge was completed in 1941 with the opening ceremony held on the Thursday the 17th of July. In the presence of 500 attendees the bridge was opened by NSW official Mr. Lawson MLA. The final cost of the works was estimated at £30,000 and it successfully replaced a punt that was in operation at the same location (The Argus, 1941).



Figure 5.132 Nyah Bridge under construction (Source: Swan Hill Regional Library)

Operational history

As with other later movable span bridges (post 1900), the Nyah Bridge lift span was used relatively infrequently as river trade, by the period of its construction, was on the decline (Fraser, 2005). Test lifts have been made at regular intervals but accurate records of operational lifts have never been kept.

From the 1990s after more than ten years of drought and a low Murray River, river traffic was at a minimum and the high clearance under the bridge

resulted in very few lift requests from river boats or paddle steamers; in 2004 only 8 lifts were recorded. The lift span remains in regular but infrequent use.



Figure 5.133 Lift span raised in 2000 (Source: Swan Hill Regional Library)



Figure 5.134 Lowered counterweights during a test lift (Source: RMS)

Maintenance history

Access arrangements on the bridge have been modified since construction to better meet worker health and safety requirements as required.

5.12.2 Statement of significance

Nyah Bridge, completed in 1941, is of Local significance. It is a unique type in the Murray River Crossings, in the design and detail of both main spans and lift spans.

Source: RMS s170 Register

Heritage Listings

Listing	Status
Australian Heritage Database (formerly the Register of the National Estate)	Not listed
OEH Heritage Division State Heritage Register	Not listed
Victorian Heritage Register	Not listed
Wakool Shire Council Local Environmental Plan, 2013	Not listed
NSW National Trust Register	Listed
RTA s.170 Heritage and Conservation Register	Listed

Evolution of modifications

In summary, the modifications of the Nyah design consist of the implementation of k-bracing in the transverse direction, a different winch and gearing arrangement, alternate counterweight connection, along with the introduction of balance chains and an enhanced counterweight design.

Table 5-25 Nyah Bridge – Summary of modifications

Preceding Designs	Issues with Design	Evolution of Nyah
Portal frame design in transverse direction	Inefficient design	K-bracing adopted in transverse direction
Stretching screws at span to wire rope attachment	-	Rope adjustments allowed for at counterweight attachment
Segmented concrete counterweight encased in cage	-	Reinforce concrete counterweight
No balance chains	Increased differential in self-weight of span during operation	Balance chains adopted in design
Winch and gearing positioned at first sheave	High congestion	Alternate arrangement of shafts and gearing

5.12.3 Description of lift span mechanism components

Towers

The form and fabric of the lift span towers is of EXCEPTIONAL significance.

The design of the Nyah Bridge is similar to that adopted for Gonn Crossing Bridge. However a number of small alterations to the bracing and counter weight arrangements are apparent.

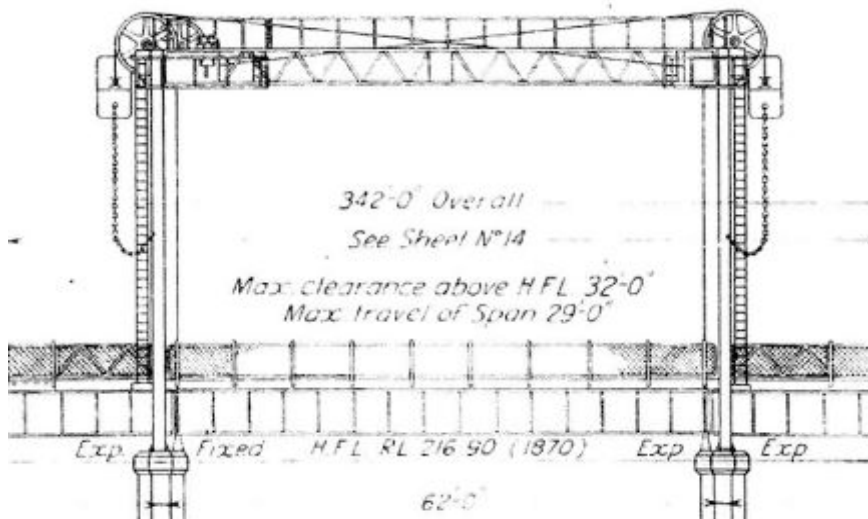


Figure 5.135 Elevation and Plan of Nyah Bridge

The towers of the bridge consist of a mild steel plate construct with concrete infill. Top restraint is provided by steel Warren type transverse and longitudinal girders and the wind bracing is also achieved by Warren type trusses (Figure 5.135 to Figure 5.136).

Longitudinal girders on the super structure have been orientated concurrent to the towers creating a desirable load path. The piers supporting the towers are made entirely of reinforced concrete before being finally founded on piles.

The bottom end fixing of the tower is achieved by base plates that are bolted into the top of the piers. It is also noteworthy that in the transverse direction, k-bracing has been adopted to improve the stability of the superstructure in the transverse direction.

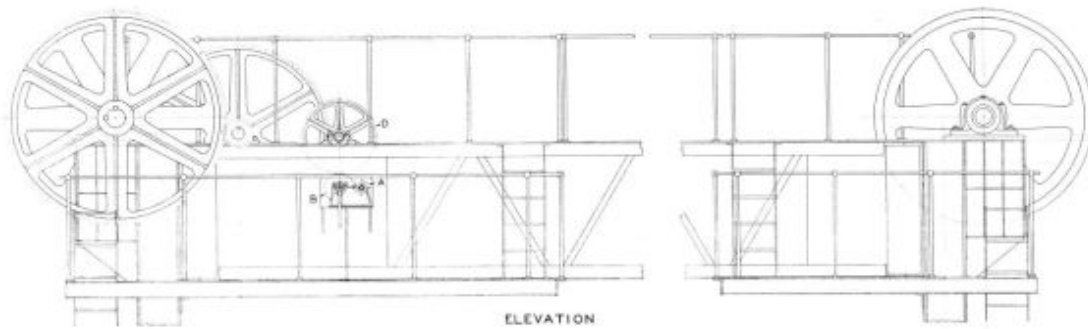


Figure 5.136 Nyah Bridge Bracing Girder

Movable span

The form and fabric of the movable span is of EXCEPTIONAL significance.

The movable span is primarily made up of a mild steel construct. The design adopts primary steel girders with transverse stiffeners. These girders support steel web cross girders and steel stringers that finally supports the reinforced concrete deck (Figure 5.137).

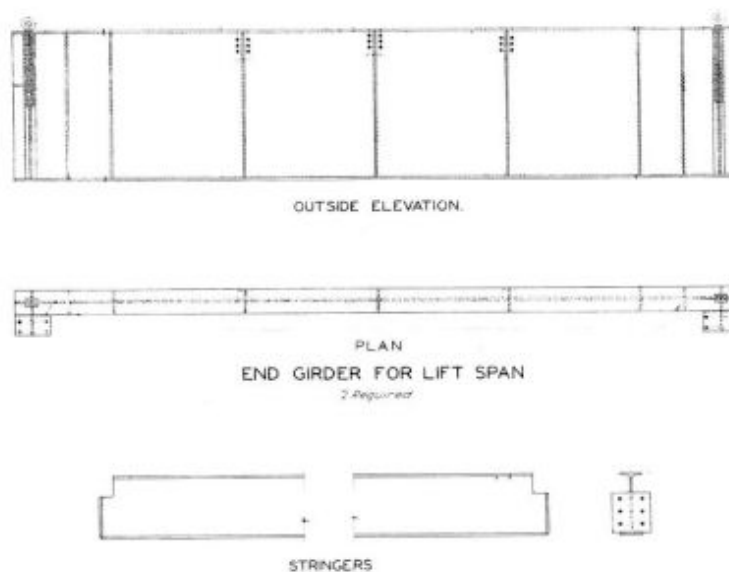


Figure 5.137 Nyah plans for End Cross Girder and Stringers on Lift Span

Disparate to the connection adopted for Gonn Crossing, stretching screws were not included in the design. Nyah Bridge adopts an alternate counterweight design which encompasses an allowance to adjust the rope length at the counterweight attachment point. Hence, the connection to the lift span only implements a compensating bracket for the three wire ropes (Figure 5.138).

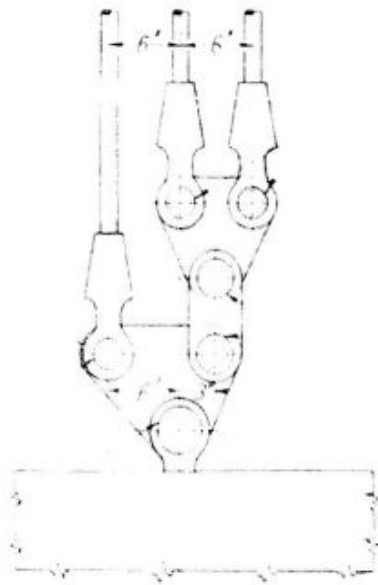


Figure 5.138 Nyah movable span attachment (Source: RMS)

Counterweight

The form and fabric of the counterweight is of MODERATE significance.

The counterweights of the system are a different design to those adopted previously. The design still implements the larger individual weights on each end of the bridge, however their design is a complete concrete reinforced unit opposed to segmented blocks encased in a cage (Figure 5.139). The arrangement of having the balance weights on the opposite side of the tower has the advantage that the sheaves can be mounted on the centre line of the towers thus eliminating eccentricities. As noted above, the rope to counterweight attachment also allows for the adjustment of rope length to ensure an even distribution of loads.

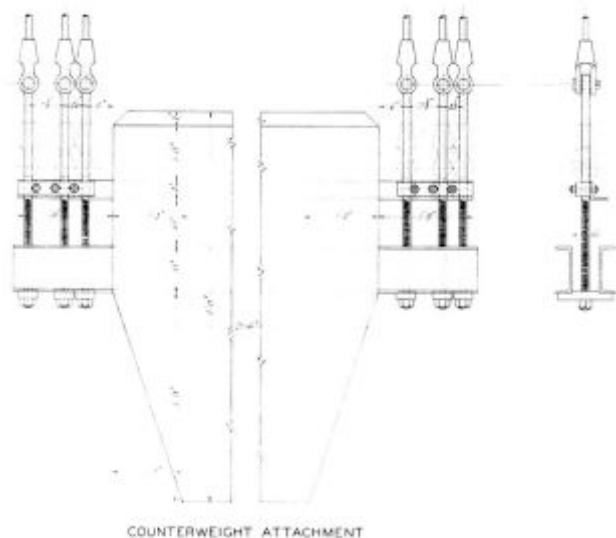


Figure 5.139 Counterweights for Nyah Bridge (Source: RMS)

The implementation of balance chains has been previously included in vertical lift bridge designs however they have not appeared in recent designs. They have been introduced on Nyah Bridge and they act to counter the self-weight

of the wire ropes as they pass to the other side of the sheaves during operation (Figure 5.140).

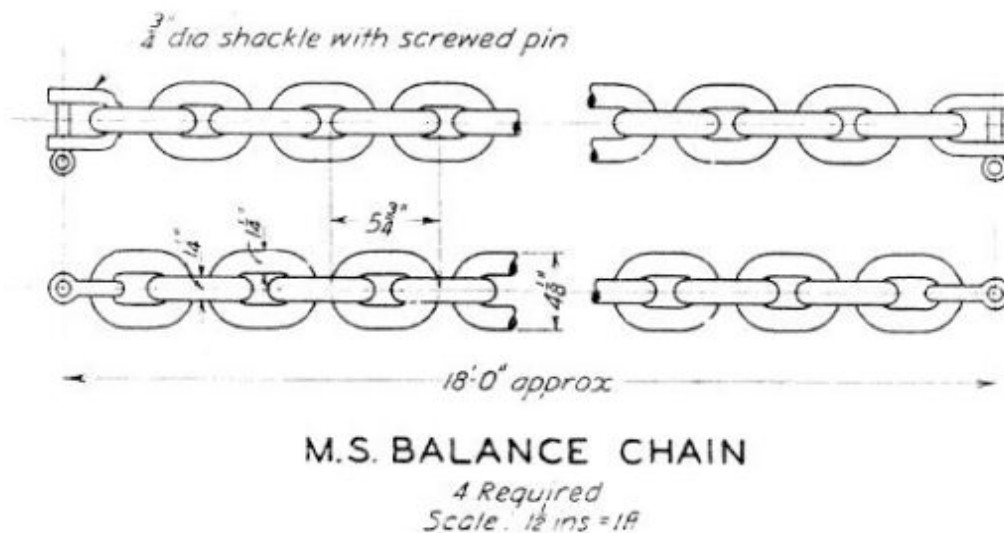


Figure 5.140 Nyah Balance Chains

Sheaves and winch mechanism

The form and fabric of the sheaves is of EXCEPTIONAL significance.

The sheaves on Nyah Bridge consist of a cast iron rope wheel with grooves set in to cradle the ropes during operation (Figure 5.141).



Figure 5.141 Sheaves on Nyah Bridge (Source: RMS)

Mechanical components

The form and fabric of the mechanical components is of MODERATE significance.

The lifting mechanism is a further progression on the previous E. M. De Burgh designs of Barham-Koondrook and that adopted for the preceding Gonn Crossing Bridge. For this design, the driving control is provided by a combination of wire ropes and shafts (Figure 5.142).



Figure 5.142 Spur wheels and sheave arrangement on Nyah Bridge

The winch mechanism is located at the top of the span, offset back from the longitudinal sheaves. This winch drives an initial transverse shaft before turning a spur wheel, increasing the mechanical advantage to another transverse shaft. A second spur wheel is then turned before transferring the force into the first set of sheaves. The rotation of the sheaves lowers the counterweights and subsequently lifts the span. Figure 5.143 shows a plan of the mechanical components that operate the movable span.

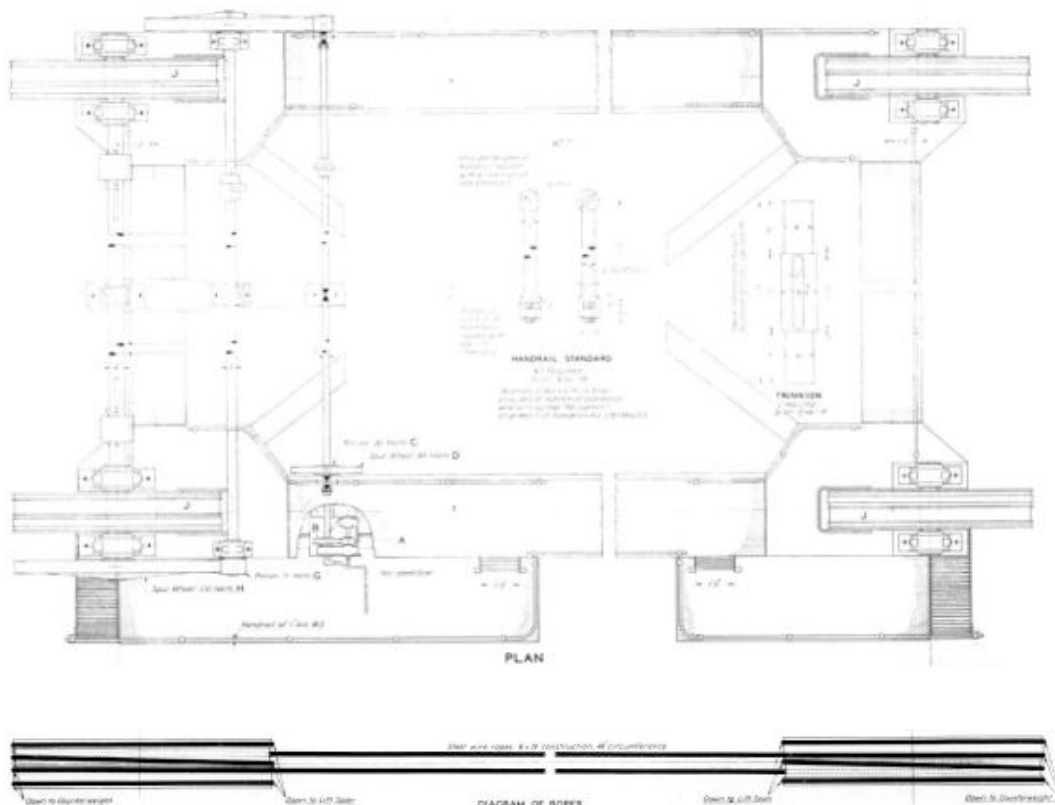


Figure 5.143 Plan of Nyah Bridge lifting mechanism arrangement

Ropes

The form and fabric of the ropes is of LOW significance.

The uniform transfer of driving force to all sheaves is provided by the implementation wire ropes in the longitudinal direction. Starting from the lifting span, wire ropes pass around the sheave and cross longitudinally along the vertical span. After which the ropes pass over the sheave at the opposite end of the span and attach to the balance weight. The rope arrangement as described above only relates to one of the wire ropes connected to each corner of the lift span. The remaining two ropes at each corner simply travel from the lift span up and over the sheave and directly down onto the balance weight. It is likely that the revised lifting mechanism was adopted to reduce the congestion of gearing bear the first sheave.

Hence two types of wire ropes are implemented on Nyah Bridge, the counterweight rope and the haul rope. As evident in Figure 5.144, two of the ropes are perfectly vertical and the centre rope enters horizontally before passing around the sheave and down to the deck. This centre rope is the haul rope.



Figure 5.144 Ropes on Nyah Bridge (Source: RMS)

Vehicle and pedestrian barrier

The form and fabric of the vehicle and pedestrian barriers is of LOW significance.

Vehicle and pedestrian gates a located at either end of the movable span. They are manually operated and closed prior to operating the span.

Motors and electrical

The form and fabric of the motor component is LOW significance.

Motors were not originally installed on Nyah Bridge. It remained manually operated throughout the initial period of its operation. Since 1996 a small hydraulic motor has been fitted at the previous location of the winch handle (Figure 5.145).



Figure 5.145 Hydraulic motor on Nyah Bridge (Source: RMS)

Summary of heritage assessments

The significances of each bridge component are summarised in the table below.

Table 5-26 Nyah Bridge – Summary of heritage significance

Bridge Component	Significance Grading
Towers	EXCEPTIONAL
Movable Span	EXCEPTIONAL
Counterweights	MODERATE
Sheaves and winch drums	EXCEPTIONAL
Mechanical components	MODERATE
Ropes	LOW
Vehicle and pedestrian barriers	LOW
Motors and electrical	LOW

5.13 HEXHAM BRIDGE

(Robinvale Type, built 1952)

5.13.1 Description of the Bridge

The bridge over the Hunter River at Hexham is the second Waddell type vertical lift bridge built by the Department of Main Roads (Karmalsky, 1961). The bridge consists of a vertical lift span with length approximately 120 ft., five steel Pratt truss spans with lengths of 120 ft. and thirteen Rolled Steel Joist spans each 40 ft. long.

The upper framework of the lifting span generally consists of two independent steel towers with sufficient stiffness to prevent encroaching on each other, with the span itself consisting of a steel Pratt type truss arrangement. Finally the entire superstructure is supported on reinforced concrete piers.



Figure 5.146 General view of Hexham Bridge

Development of roads and transportation in the Hexham region

The Hunter River was discovered by Lieutenant Shortland, when he sought shelter after an unsuccessful voyage to Port Stephens to locate escaped convicts in 1797. While the area was being explored, it was noted that coal deposits were lying beside the river banks. Over the next two years coal was shipped from the area down to Sydney and coal exports then commenced in

1799. The settlement that was later to become Newcastle was first established by Governor King at the mouth of the Hunter River. The goal of the settlement was to create a penal colony where the difficult convicts could be sent.

There were two advantages, firstly it was an extremely isolated location and the second advantage was that coal mining could be used as an occupation for these convicts. The penal settlement was later abandoned in 1802, however it was re-established in 1804 and continued to operate for another 17 years until 1819 when convicts began to be moved to Port Macquarie and the area was finally opened up to free settlement by Governor Macquarie (Regional Histories, 1996).

Following the departure of the penal settlement, Newcastle experienced a decline. However the mining industry began to develop when the Australian Agricultural Company's monopoly ended and James Brown opened the first private mine at Four Mile Creek in the 1840s. Numerous other coal mines began to develop from then on and by the 1860s there were mines at Waratah, Lambton, Cardiff, Stockton, New Lambton and Hexham. The establishment of BHP's iron and steel works in 1913 contributed with the coal industry in transforming Newcastle into a major city in the region (NSW Heritage).

Design and construction

The circumstances leading the construction of the Hexham Bridge began after World War I as the increase in traffic volumes in NSW led to the established of the Main Roads Board in 1925. The Board quickly decided that the significant project of constructing a new road between Sydney and Newcastle was to be completed. This new road was to reduce the nine hour travel time between Sydney and Newcastle by half. The new highway had a number of waterway crossings with ferries utilised in twelve locations and these were continually replaced as funds became available. The insufficiency of the ferry at Hexham became apparent as the traffic continued to increase and it was noted that the lack of a bridge at Hexham was also an impediment to the industrial development of sites north of the Hunter River (*Newcastle Sun*, 15 December 1952).

The first set of plans for an opening bridge at Hexham was completed in 1940 under the supervision of Bridge Engineer, Spencer Dennis. However the commencement of World War II delayed the project as labour and material were restricted and traffic volumes also decreased. Following the war, the Department began a maintenance and improvement program for the State roads. This program included a policy that was aimed at eliminating ferries and replacing them with bridges. Hexham Bridge was the ninth major bridge built on the Pacific Highway to replace ferry crossings (DMR, 1976; *Newcastle Morning Herald*, 18th Dec 1952).

The River was navigated primarily by small colliers and the requirement from the Maritime Services Board that there be a clearance of at least 100 ft. was satisfied by the proposed vertical lift bridge (Berger, 2003). The construction of the bridge was swamped with issues including difficulties in obtaining labour and materials, combined with the reoccurrence of major floods.

The two original contracts were awarded to Thomas C. Pollard for the steelwork and J. King & Son for the construction of piers, erection of steelwork and the laying of decks. These contracts were later terminated and handed over to the State Dockyard of Newcastle for the supply of steel work and the Department took over the construction works, which was completed using day labour. It is interesting to note that the original design stipulated only nine approach spans. However this was increased to thirteen due to the desire to have a larger waterway and the inadequacy of the foundation soil.

The bridge was finally completed in December 1952, with the official opening being completed by the Acting Minister for Transport, the Hon. George Weir. The President of the Lower Hunter Shire Council noted during his speech that the bridge would not only open up the Hunter Valley but the whole of the North Coast and it would be a gateway to allow for the speedy delivery of products and bring the industrial area of Raymond Terrace closer to Newcastle.

During the 1980s, traffic volumes across the river were rapidly increasing, especially with the opening of section after section of the F3 and the bridge soon became a major bottleneck. The need for the bridge to open caused the greatest concern so planning began on a new high-level crossing on the western side of the existing bridge. The new high-level bridge would carry three lanes of northbound traffic, with 2 lanes forming the major approach from Newcastle and one lane coming from the New England Hwy. This new bridge opened to traffic in April 1987 and the northern approach, the Pacific Hwy, was duplicated in January 1990.



Figure 5.147 View showing horizontal separation between lift span bridge and high level bridge built in 1987

Operational history

Operation of the bridge was first conducted by George Budd until his retirement in 1987. He worked with his offsider Bill Steeler under a contract of the Department of Main Roads whilst they both retained their jobs at the Hunter Valley Dairy Company's plant adjacent to the bridge. Mr. Budd recalls how the "60-milers", coastal colliers operated between Hexham and Sydney and the Bridge needed to be opened up to 5 times a day. The Nobby's signal station would inform the operator that a ship was travelling up the river and from that time it was approximately an hour and a half till it would arrive at Hexham.

On occasion the fog was so thick that someone on the bank was used to see if the ship had fully passed through so that the span could be lowered. From the 1980s onward lifts only occurred weekly to mainly test the mechanism and occasionally allow a large trawler to pass (*Newcastle Herald*, 22 July 1987).

After the 1980s, continual industrial development of the area, including the establishment of the Tomago Aluminium Smelter, drastically increased road traffic volumes and a second bridge of the river was built in 1987. The operation of the lift span is now far less frequent as the river traffic carrying coal has ceased (Berger, 2003). Pleasure craft and local boat tour operator still use the bridge on average 2 to 3 times per month.

Maintenance history

Impact damage occurred in 2004 and repairs were undertaken on select critical members. These works are described in more detail below.

5.13.2 Statement of significance

The Hexham Bridge exhibits a high degree of historical, aesthetic and technical significance as one of the largest of several important bridges constructed on the Pacific Highway in the post-World War II period as part of the Department of Main Roads' program of maintaining and improving the State's main roads and eliminating ferry crossings. The vertical lift span structure accommodated river traffic, particularly colliers, and played an important part in the industrial, commercial and agricultural development of the local area as well as the North Coast region generally. It stands as a testimony to the once thriving coal industry and to its subsequent decline and is thus associated with a significant phase in the area and the State's history. Its height makes it a landmark in the surrounding area and it acts as a gateway to the suburbs of Hexham and Tomago. It has rarity value as the largest of few surviving lift span bridges in New South Wales, still in working order.

Source: RMS s170 Register

Heritage Listings

Listing	Status
Australian Heritage Database (formerly the Register of the National	Not listed

Estate)	
OEH Heritage Division State Heritage Register	Not listed
Newcastle City Council Local Environmental Plan, 2012	Listed
NSW National Trust Register	Not listed
RTA s.170 Heritage and Conservation Register	Listed

Evolution of modifications

Hexham Bridge was essentially an adoption with minor improvements on the Ryde Bridge design which was the first to adopt the American Waddell type vertical lift span design. The minor improvements consist of the implementation of guide wheels for the counter weights and a new design for the trunnions.

Table 5-27 Hexham Bridge – Summary of modifications

Preceding Designs	Issues with Design	Evolution of Hexham
No guide wheels on counter weight		Implementation of a hinge spring counter weight guide
Inadequate trunnion detail	Sheaves ‘rolling’ on trunnions emitting loud rifle shot sounds during operation	New trunnion detail with additional collar to lock sheaves into place on trunnion

5.13.3 Description of lift span mechanism components

Towers

The form and fabric of the lift span towers is of EXCEPTIONAL significance.

The design of the Hexham Bridge is based on the Waddell type American design with reference to the American specification for Movable Highway Bridges (A. A. S. H. O.). The design was overseen by Department of Main Roads, N. S. W. Supervising Engineer V. Karmalsky.

The superstructure arrangement is similar to that adopted for the Ryde Bridge design and consists of two independent towers that extend into the adjacent truss spans. The towers consist of four braced mild steel vertical members that support two longitudinally oriented counter weight sheaves (Figure 5.148 to Figure 5.149). The towers are independent however the bracing arrangement gives them sufficient inherent stiffness to prevent them encroaching on each other and jamming the lift span during operation.

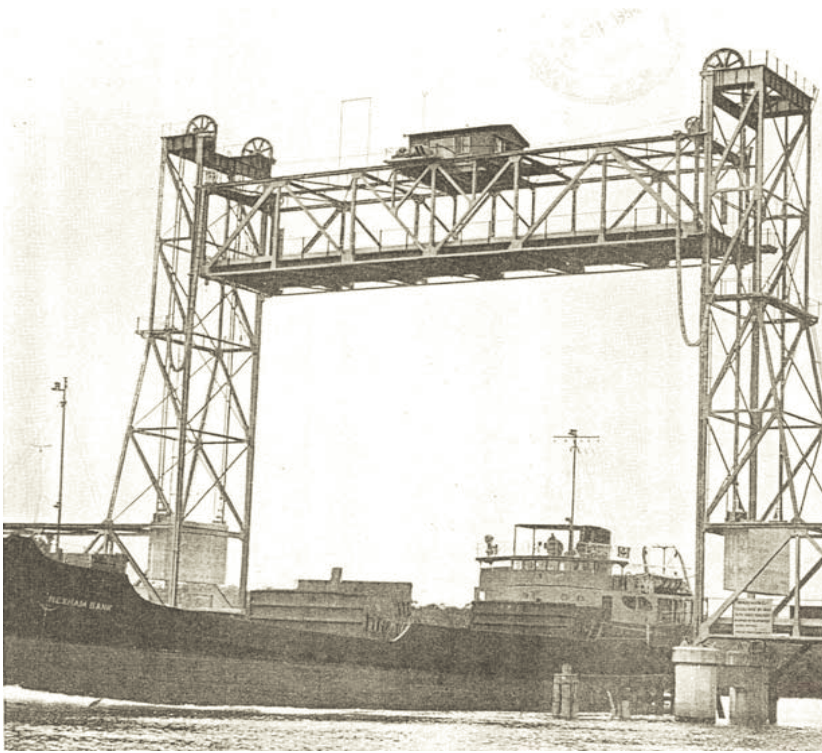


Figure 5.148 Ship passing under Hexham Bridge in 1954 (Source: Main Roads Journal, volume 12 no 2)

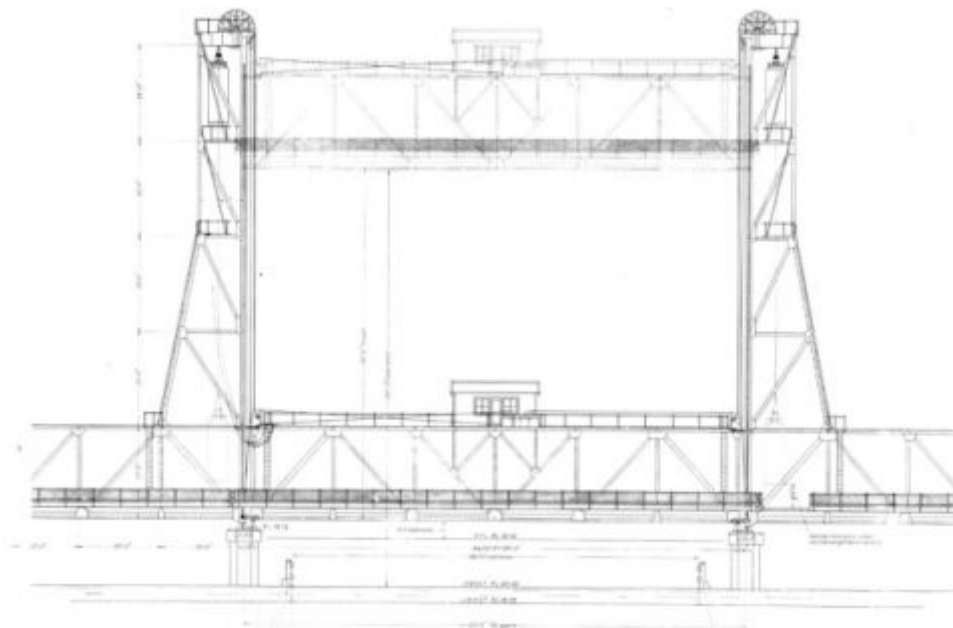


Figure 5.149 Elevation of Hexham Bridge

The front vertical members of the towers were given a slight gradient forward during the construction process, as the deflection from the dead weight of the span would bring the alignment back to vertical. The counter weight sheaves are supported on longitudinal and transverse girders at the tops of the towers, with the majority of the load transferring to the front members (Figure 5.150) that have been designed to be stronger than those at the rear.

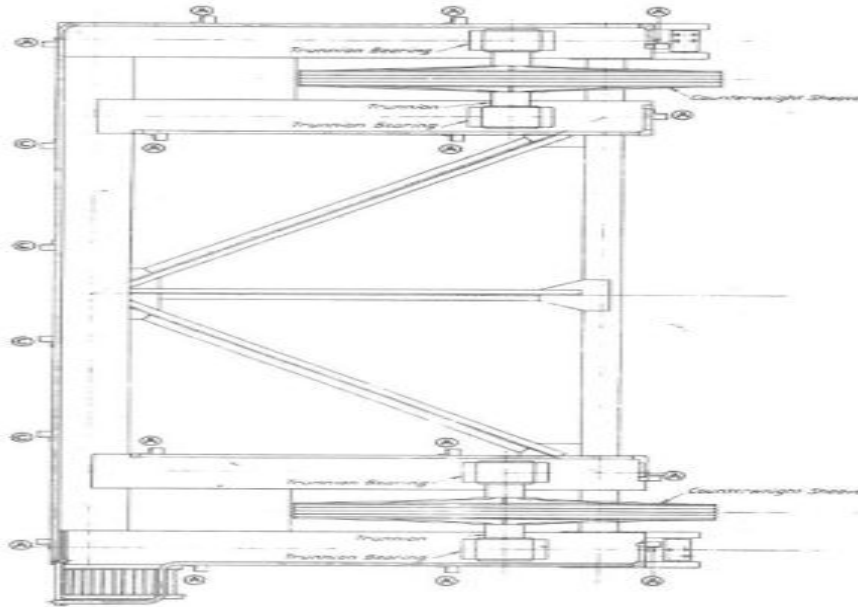


Figure 5.150 Plan of Hexham Bridge counterweight sheave arrangement

Impact damage occurred in 2004 and repairs were undertaken on select critical members.

Movable span and engine house

The form and fabric of the movable span and engine house is of MODERATE significance.

The lift span of the Hexham Bridge consists of mild steel truss arrangement as depicted in Figure 5.151. The truss supports steel plate web cross girders that subsequently support the R. S. J stringers and reinforced concrete deck.

The lift span has been modified by adding stairs and a new traffic barrier. Impact damage incurred during 2004 resulted in repairs to the overhead cross bracing members.

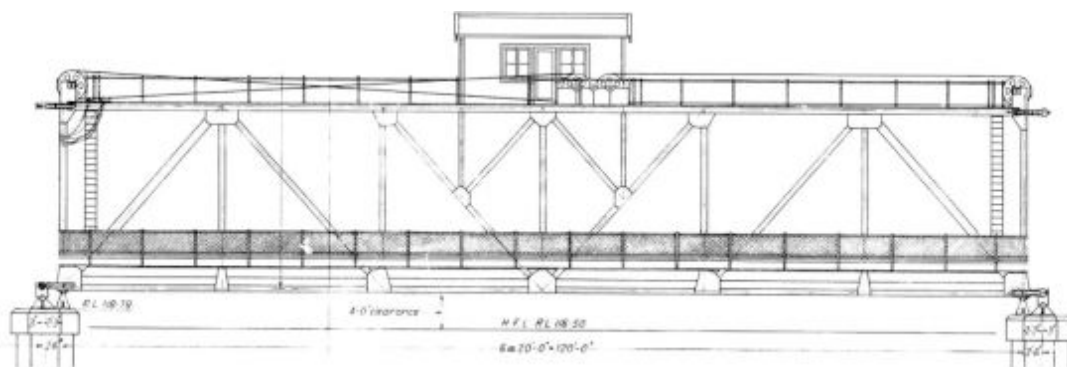


Figure 5.151 Hexham Bridge movable span

The motors, gearing and drum components of the lift mechanism are protected by a machinery house positioned at the centre of the lift span. The machinery house was replaced in 2005 by a similar style gable roof shed.

Counterweights

The form and fabric of the counterweight components is of MODERATE significance.

Counter weights are implemented on Hexham Bridge to help balance the weight of the lift span. The original design consisted of a concrete block with dimensions 22' 3" long, 5' 0" wide and 16' 7½" high. There was also an internal cavity to accommodate removable weights should the need for a second footpath or other modifications arise during the life of the bridge. However, due to concerns about corrosion of the internal steel frame the counter weights were replaced in 2005 with a design incorporating an external steel support frame. The connection between the framing and the counter weight ropes is achieved by a pin to saddle arrangement.



Figure 5.152 Hexham Bridge counterweight (Source: RMS)

The introduction of guide wheels for the counter weight was a further improvement on the Ryde Design, with the implementation of a hinge and spring arrangement. As depicted in Figure 5.153, this arrangement allows for the sway of the counter weight from wind and operation to be lessened.

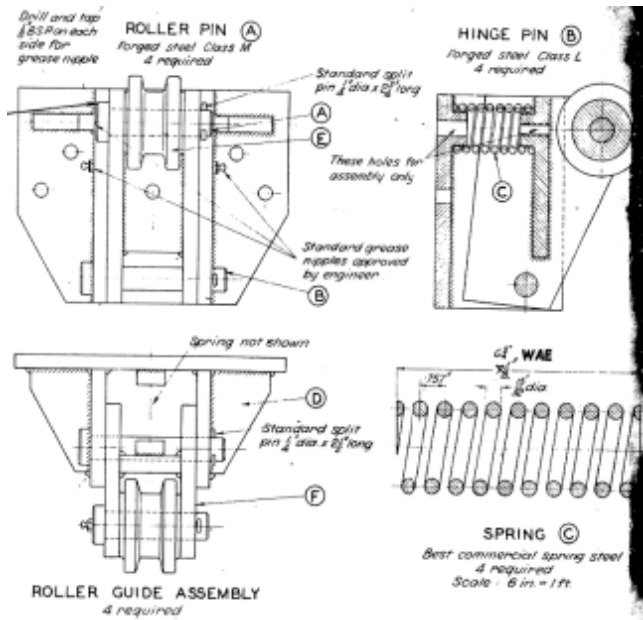


Figure 5.153 Counter weight roller guide for Hexham Bridge

Sheaves

The form and fabric of the sheave component is of EXCEPTIONAL significance.

The Ryde Type bridges are distinctive by the presence of the two sets of sheaves.

There are four counter weight sheaves mounted, two at the top of each towers and four haul sheaves are mounted on the upper corners of the movable span. The counter weight sheaves are 9 feet in diameter and are made of cast iron. Grooves were set into the casting to accommodate for the four wire ropes required for the counter weights (Figure 5.154).

The counterweight sheaves were refurbished in 2005.

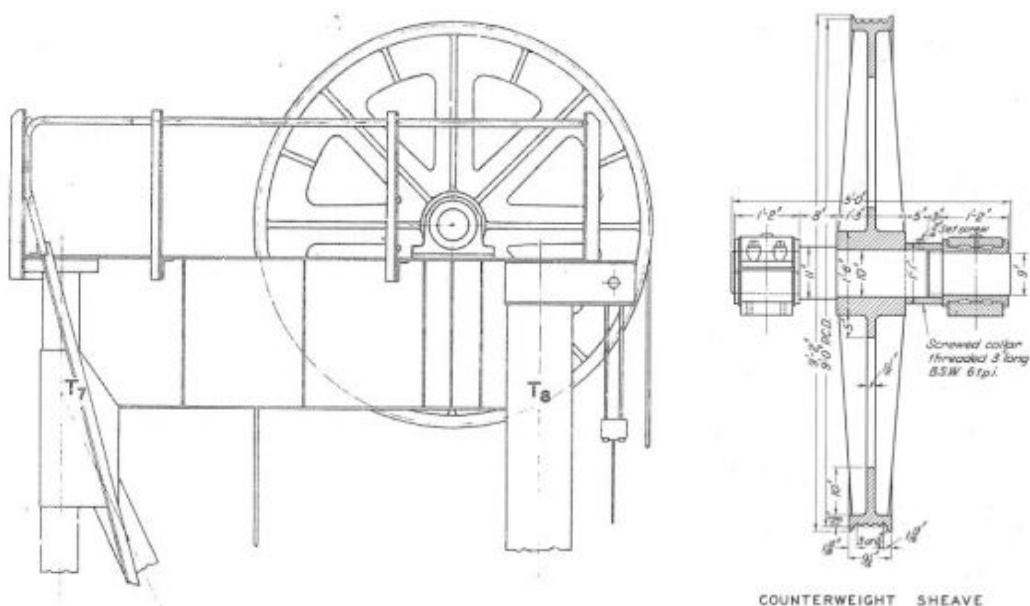


Figure 5.154 Elevation of Hexham Bridge counterweight sheave

Due to the size of the lift span and the large force applied to the counter weight sheaves a critical detail is the trunnion to sheave interface. The previous design of Ryde Bridge has issues with the hubs ‘rolling’ on the trunnions emitting loud rifle shot sounds during operation. There was a solution proposed and implemented on the Ryde Bridge, however this solution was superseded for the Hexham design as shown in Figure 5.155.

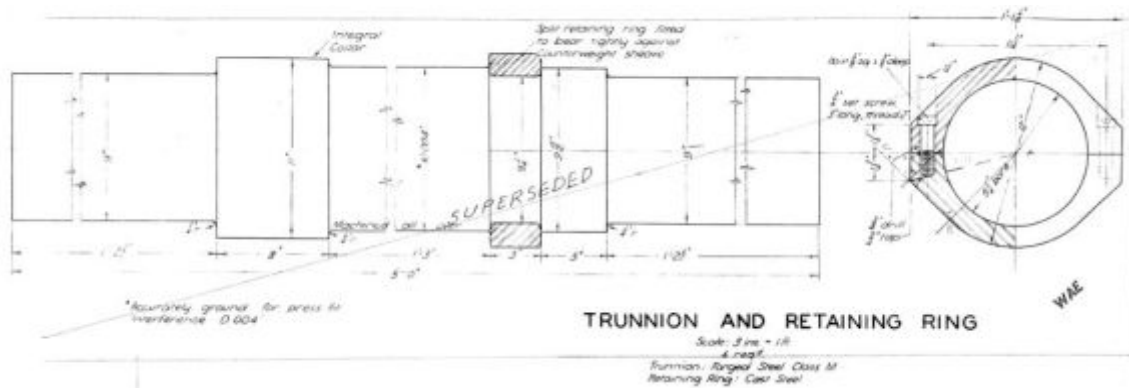


Figure 5.155 Superseded trunnion design from Hexham Bridge

The final design for the trunnions on Hexham was the implementation of a threaded sleeve that would butt up against the hub of the sheave through being screwed into the trunnion, thus eliminating differential movement at the trunnion to hub interface.

Mechanical components

The form and fabric of the mechanical components is of MODERATE significance.

The lifting mechanism on Hexham Bridge operates by the integration of motors, drums, haul ropes, sheaves, gearing and counter weights. The power for operation is provided by an electric motor that turns centre mounted gearing and subsequently rotates the four drums that coil/uncoil the wire ropes.

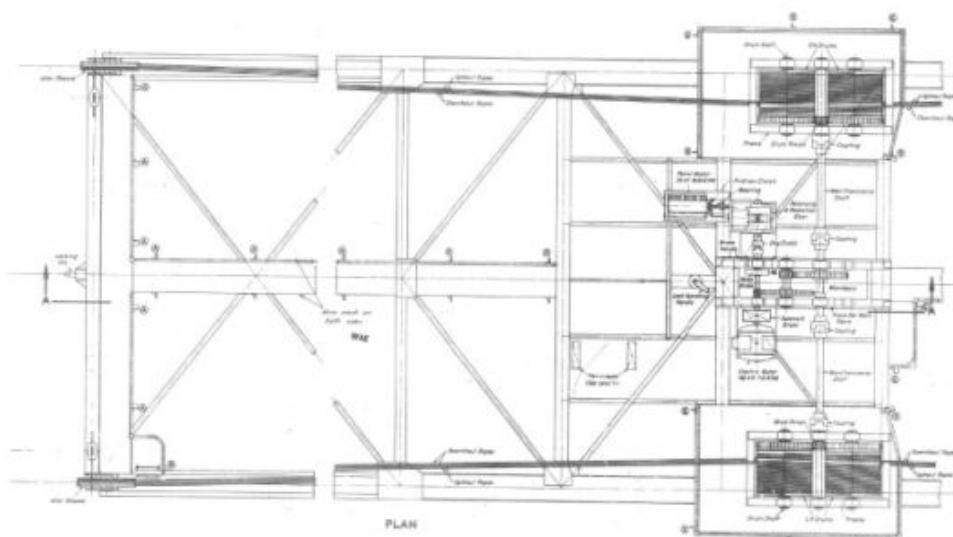


Figure 5.156 Hexham Bridge Operating Mechanism

Once movement is initiated the idler sheaves at the four corners of the lift span essentially ‘pass through’ the haul ropes as the span rises. The lengths of haul rope either side of the idler sheave remain stationary as the drums add to the downhaul rope and subtract from the up-haul rope simultaneously, with the mechanism operating in reverse during lowering. Figure 5.156 depicts a schematic of the operating system.

The counter weight rope is not engaged by the lifting drums and purely passes from a connection on the lift span, up over the counter weight sheaves before attaching to the counter weight.

The lift span is also fitted with locking pins that are inserted when the lift span is resting on the end bearings. These locking pins prevent the lift span from rising off the bearing due to the pull of the counter weights when the span is not in operation.

The majority of the lifting mechanism has been either rehabilitated or upgraded for enhanced performance.

Vehicle and pedestrian barriers

The form and fabric of the vehicle and pedestrian barrier components are MODERATE significance.

Hexham Bridge is closed using a fully automated system including traffic lights, bells, barriers and advanced warning signs (Figure 5.157).



Figure 5.157 Traffic control system on Hexham Bridge

Ropes

The form and fabric of the rope component is of LOW significance.

The original wire ropes consisted of wire strands wound around a hemp core. These were replaced in 2005, with pre-stretched wire ropes with a nylon core.

Motors and electrical

The form and fabric of the motors and electrical components is of LOW significance.

The power for operation is provided by an electric motor that turns centre mounted gearing and subsequently rotates the four drums that coil/uncoil the wire ropes. There is a backup petrol motor adjacent to the electric motor, which can be utilised if the electric motor fails. New main and auxiliary drive motors were installed in 2005. This included the associated gear box, distribution boards and controls.

Summary of heritage assessments

The significances of each bridge component are summarised in the table below.

Table 5-28 Hexham Bridge – Summary of heritage significance

Bridge Component	Significance Grading
Towers	EXCEPTIONAL
Movable Span	MODERATE
Counterweights	MODERATE
Sheaves	EXCEPTIONAL
Mechanical components	MODERATE
Vehicle and pedestrian barriers	MODERATE
Ropes	LOW
Motors and electrical	LOW

5.14 BATEMANS BAY BRIDGE

(Ryde Type, built 1956)

5.14.1 Description of the Bridge

The bridge over the Clyde River at Batemans Bay is a Waddell type vertical lift bridge. The bridge consists of a vertical lift span with length approximately 94 ft., five steel Pratt truss spans with lengths of 121 ft. and four steel girder spans each 62 ft. long. When opened, the span has a vertical clearance of 75 ft. above high water level.

The upper framework of the lifting span generally consists of two independent steel towers with sufficient stiffness to prevent encroaching on each other, with the span itself consisting of a steel Pratt type truss arrangement. Finally the entire superstructure is supported on reinforced concrete piers.



Figure 5.158 General view of Batemans Bay Bridge

Development of roads and transportation in the Batemans Bay region

The area surrounding Batemans Bay was originally occupied by the South Coast Aboriginals of the Bugelli-Manji and Yuin tribes. The area was first noted by Europeans when Captain James Cook took shelter in the area during a voyage in April 21st, 1770. Development would not commence for another ninety years when the timber industry became prominent in the area (HO / DUAP, 1996).

The first punt crossing the Clyde River at Batemans Bay was installed in 1871, and into the 1880s the area continued to develop rapidly with a number of saw mills, cheese producing facilities and ship building and farming thriving. The lack of a railway resulted in a strong reliance on the Prince's Highway as the main avenue of communication along the coast from Nowra to the Victorian Border (DMR, 1948).

At the inception of the Main Roads Board in 1925, the main coastal road between Sydney and Victoria, now the Princes Highway included several crossings of waterways by ferry. With increases in the volume of traffic, the ferry crossings caused considerable delays to traffic and, as funds became available, bridges were constructed to replace them.

Design and construction

Batemans Bay Bridge was built to replace the only remaining vehicular ferry on the Prince's Highway between Sydney and the Victorian Border. Preliminary investigations with a view to bridging the Clyde River were commenced before the outbreak of World War II, when the reconstruction of the Prince's Highway between Ulladulla and Batemans Bay was being undertaken. However, due to war conditions, the necessity to conserve labour and materials for essential industries, and the reduction in traffic, no

arrangements could be made for commencement of the work at that time. After the war drawings and specifications for the new bridge were prepared by the DMR, and tenders were invited in October, 1947.

The work was divided into two contracts, one for the manufacture and supply of the steelwork and machinery and the other for the construction of piers and abutments, erection of steelwork and final completion of the Bridge. The tender of the Balgue Construction Company Pty. Ltd. was accepted in December, 1947, and a contract for the manufacture, supply and delivery of metalwork and machinery was awarded to the Clyde Engineering Co. Ltd. of Granville in January, 1948. However, post-war shortages of materials and skilled labour handicapped both contracting firms and necessitated the making of other arrangements for the completion of the work.

In May 1951, the contract with Balgue Constructions Pty. Ltd. was terminated by mutual consent, and arrangements were then made for the remaining work covered by that contract to be completed by the Department of Main Roads by day labour, the services of Mr. George Balgue being retained by the Department to supervise the carrying out of the work (DMR, 1953:13). At that stage the cylinders for all piers, except pier 4, had been driven down to rock foundation, in some cases more than 60 feet below high water and sealed, and headstocks had been constructed on piers 1,2,6,7,8 and 9 ready for the erection of structural steel (Figure 5.159).



Figure 5.159 View of some of the completed piers in 1953 (Source: DMR, 1953:13)

In October, 1952, fabrication of the structural steelwork was transferred from the Clyde Engineering Company to the State Dockyard, Newcastle. Despite continued shortage of materials, steady though slow progress was made until the middle of 1955, after which a faster rate of construction was achieved. The Clyde Engineering Company was retained to construct the machinery for the opening span (DMR, 1956:45).

A coffer dam of steel sheet piling was constructed at the site of each pier and the piles were driven inside the coffer dam after the silt and sand had been dredged out. The tops of the piles were then held in a thick concrete “raft” placed in the bottom of the excavation, under water, and the reinforced concrete piers were then built upon this foundation. Each pier of the Bridge consists of two reinforced concrete cylinders founded on rock, which occurs a moderate distance below the riverbed. The northern abutment was founded on spread footings on rock, while the southern abutment was supported by driven reinforced concrete piles.

The trusses and girder spans were erected *in situ* on timber pile falsework. The superstructure of the truss spans and lift span were manufactured from Australian rolled steel plates and sections. Workshop connections, including the fabrication of the truss members, were carried out by electric welding. Field connections were made by riveting, which, under field conditions, was cheaper and allowed more flexibility to provide for minor defects in workmanship than welding.

The approaches at each end, and the bituminous wearing surface of the bridge deck were constructed by the Department with its own labour force (DMR, 1953:14).



Figure 5.160 Batemans Bay Bridge Opening Ceremony (Source: DMR, 1956)

The work at Batemans Bay Bridge was carried out under the general supervision of the DMR Divisional Engineer at Bega, Mr. R.W. Hirt and the total cost of the Bridge was £350,000 (DMR, 1956:45). The Bridge was officially opened for traffic by the Hon. J. B. Renshaw, M.L.A., Minister for Local Government and Minister for Highways, on November 21, 1956 (Figure 5.161).

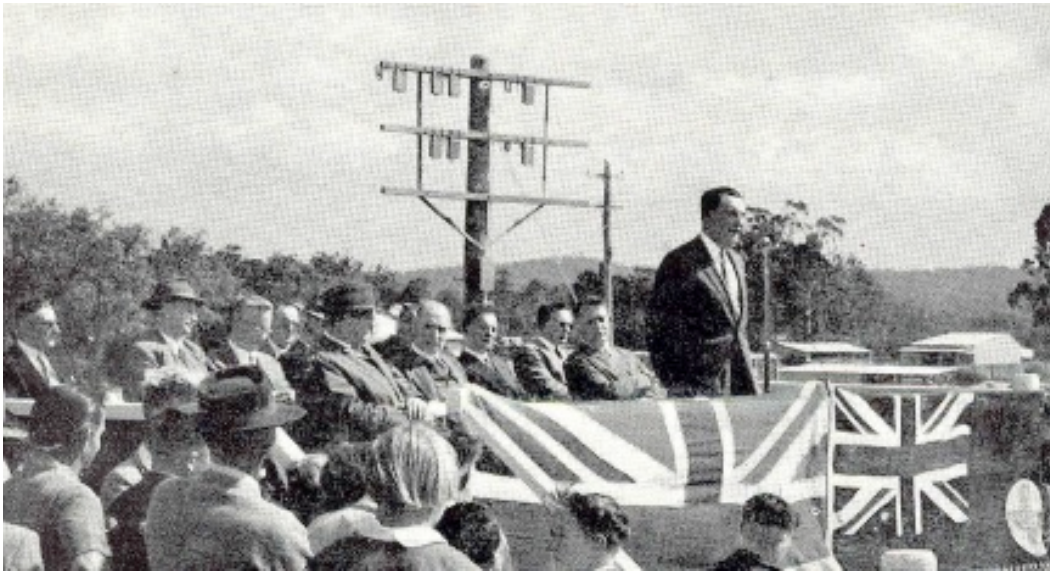


Figure 5.161 The Hon. J.B. Renshaw, M.L.A., Minister for Highways, addressing the assembly at the Bridge opening (Source: DMR, 1956:46)

The ferry which the Bridge replaced was the last in operation between Sydney and the Victorian border. It was a power-driven rope-operated unit with a deck capacity of 28 average size vehicles. During the year of operation ending on June 30, 1956, the ferry made 50,149 trips and carried a total of 233,073 vehicles (DMR, 1956:46).

The anniversary of the opening of the bridge in November 1956 is celebrated annually by the Clyde River Carnival held on the first full weekend of November.

Operational history

Since the bridge's construction timber-related and fishing industries have become less viable in Batemans Bay, though tourism and pleasure boating have taken on a major economic focus.

In May, 2012 the *Bay Post* ran an article on the retirement of the bridge operator George Merceica who had served in the role for 20 years. His timetable was planned around whenever boats had made an appointment to have the bridge lifted though he remained on standby 24 hours a day every second week to lift the bridge in an emergency. When commencing lifting the span he would listen out for sirens in the event that an ambulance needed to get through, in which case he would close the bridge again if safe to do so.

He recounted a memorable "near miss" several years previously, when he was on his own and the automatic vehicle gates wouldn't close so he had to stop traffic by himself using traffic cones before climbing up the ladder to the engine house. One motorist didn't want to wait and, just as Mr. Mercieca commenced lifting the bridge, the car accelerated to try and make it across before it opened. Fortunately they were able to brake hard just in time to avoid falling into the river.



Figure 5.162 George Merceica at the control panel within the engine house of the bridge (Source: Bay Post, May 2, 2012)

While detailed records of lifts are not available for the entire period of operation, those recorded in 2011 are included in the table below. Currently bridge operations are run by Mike Foskett of Batemans Bay Power & Sail who requests a minimum of one hour's notice. Mr Foskett also coordinates tour boats in and around the Bay.

Table 5-29 Record of lifts of the Batemans Bay Bridge opening span in 2011

Lifts	Jan	Feb	March	April	May	June	July	Aug	Sep	Oct	Nov	Dec	Total
2011	75	66	81	60	8	6	51	46	60	89	42	80	664

Maintenance history

In 2004, the NSW Roads and Traffic Authority (RTA) installed truss protection barriers as well as the replacement of some damaged vertical truss members due to vehicular impacts on the Bridge.

In 2012 in order to meet Worker Health and Safety requirements given the high usage of the lift span the ladders to the engine house were replaced with stairs and connecting walkways. In addition new access paths were fitted around the counterweights to make it easier and safer to service the ropes.

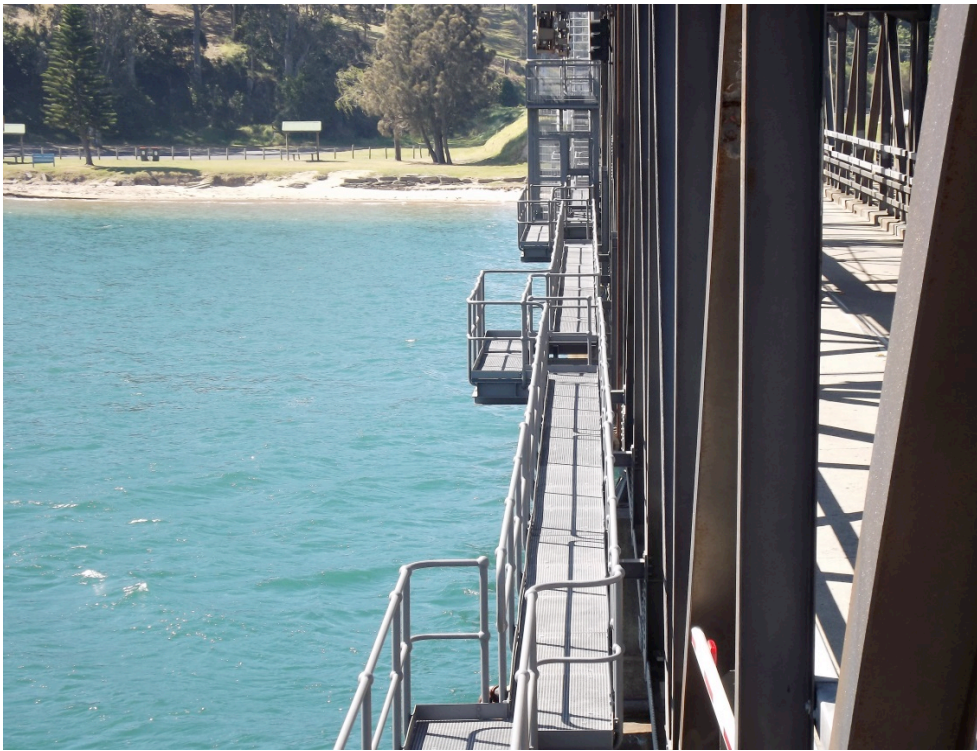


Figure 5.163 Stairs and walkways fitted to lift span in 2012

5.14.2 Statement of significance

The Batemans Bay Bridge was built in 1956 to replace a vehicular ferry and is of a relatively standard design for the period. The Bridge forms a local landmark that has a “gateway” quality for the town of Batemans Bay due to its impressive size. The Batemans Bay Bridge has been assessed as being of local significance.

Heritage Listings

Listing	Status
Australian Heritage Database (formerly the Register of the National Estate)	Not listed
OEH Heritage Division State Heritage Register	Not listed
Eurobodalla Shire Council Local Environmental Plan, 2012	Not listed
NSW National Trust Register	Not listed
RTA s.170 Heritage and Conservation Register	To be listed

Evolution of modifications

Batemans Bay Bridge was essentially an adoption of the Hexham Bridge design, with no significant variances evident.

5.14.3 Description of lift span mechanism components

Towers

The form and fabric of the lift span towers is EXCEPTIONAL significance.

The design of the Batemans Bay Bridge is another Waddell type arrangement and it is a similar design to the preceding Hexham Bridge. The evident variations in the design include a modified lift span truss and the reduced clearance of the lift span opening.

The superstructure arrangement consists of two independent towers that extend into the adjacent truss spans. The towers consist of four braced mild steel vertical members that support two longitudinally oriented counter weight sheaves (Figure 5.164 to Figure 5.165). The towers are independent however the bracing arrangement gives them sufficient inherent stiffness to prevent them encroaching on each other and jamming the lift span during operation.



Figure 5.164 Detailed view of towers of Batemans Bay Bridge

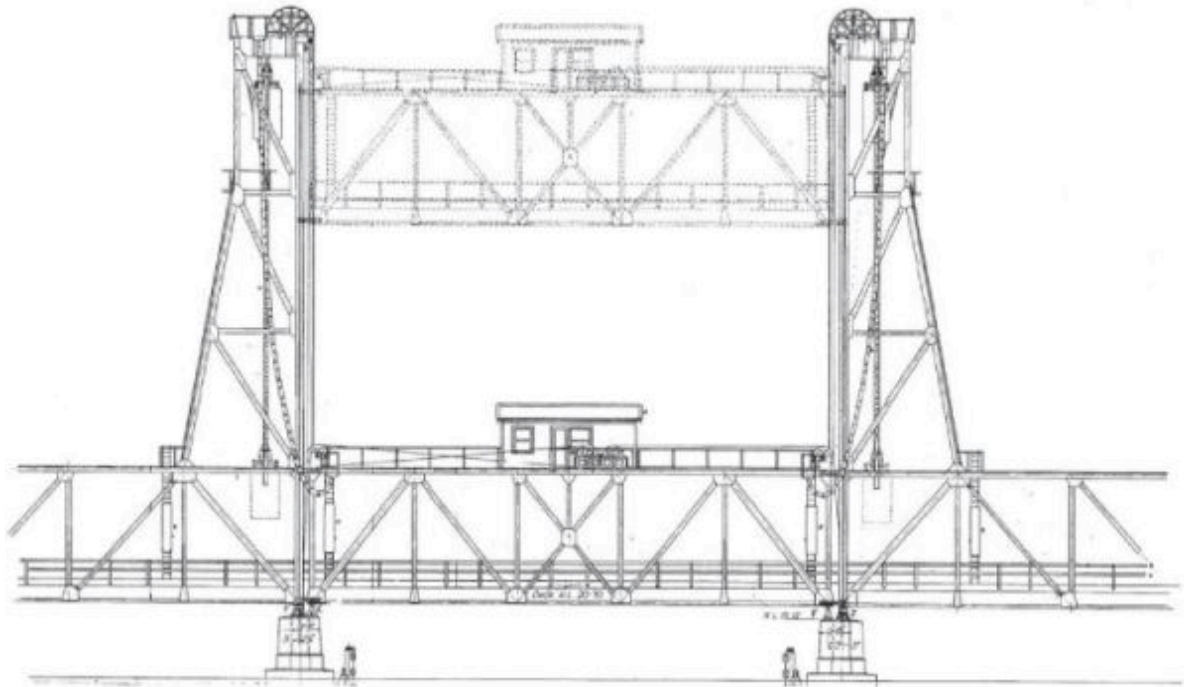


Figure 5.165 Elevation of Batemans Bay Bridge

Movable span and engine house

The form and fabric of the movable span and engine house is of MODERATE significance.

The lift span of the Batemans Bay Bridge consists of mild steel truss arrangement as depicted in Figure 5.166. The truss supports steel plate web cross girders that subsequently support the R. S. J stringers and reinforced concrete deck.

The motors, gearing and drum components of the lift mechanism are protected by a machinery house positioned at the centre of the lift span.

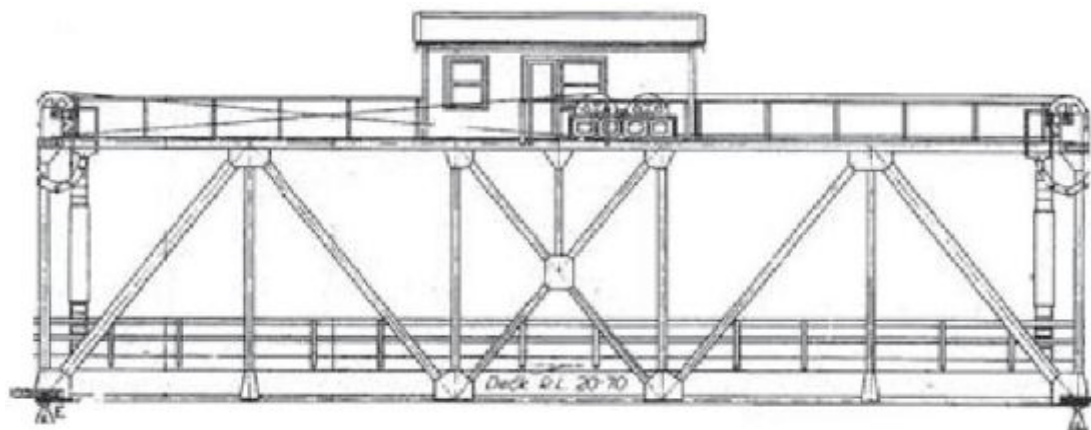


Figure 5.166 Batemans Bay Bridge Lift Span

Counterweight

The form and fabric of the counterweight is MODERATE significance.

The counter weights implemented on Batemans Bay Bridge to help balance the weight of the lift span. The original design consisted of a reinforced concrete block with a steel frame set into the counter weight to provide an attach point (Figure 5.167). The connection between the framing and the counter weight ropes is achieved by a pin to saddle arrangement as shown in Figure 5.168.



Figure 5.167 Image of Batemans Bay Bridge counterweight (Source: RMS)

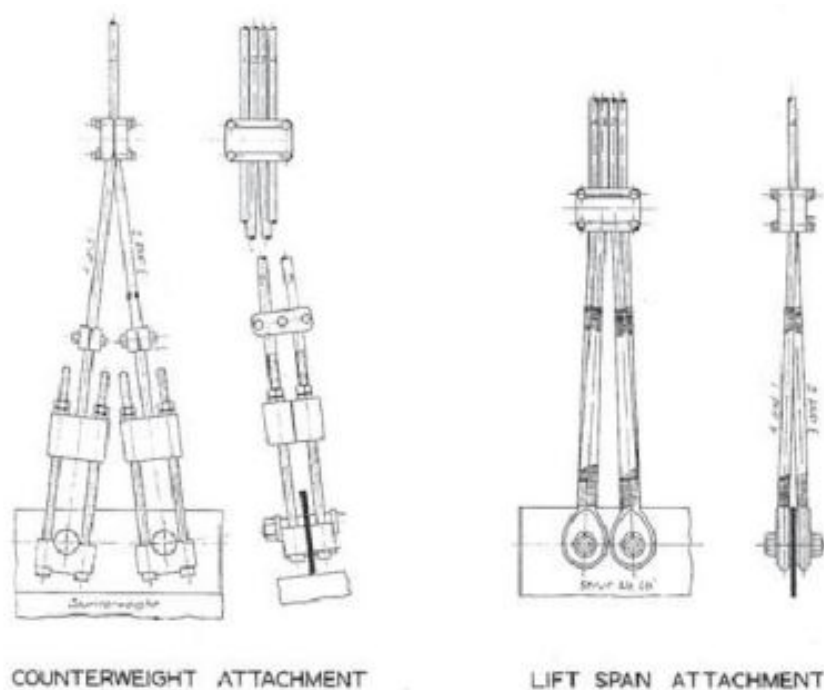


Figure 5.168 Batemans Bay Bridge wire rope attachments

Sheaves

The form and fabric of the sheaves is of EXCEPTIONAL significance.

The counter weight sheaves are supported on longitudinal and transverse girders at the tops of the towers, with the majority of the load transferring to the front members that have been designed to be stronger than those at the rear. These sheaves are approximately 8 ft. 4 in. in diameter and are made of cast iron (Figure 5.169). Grooves have been set into the casting to cater for the four wire ropes that attach to the counter weights.

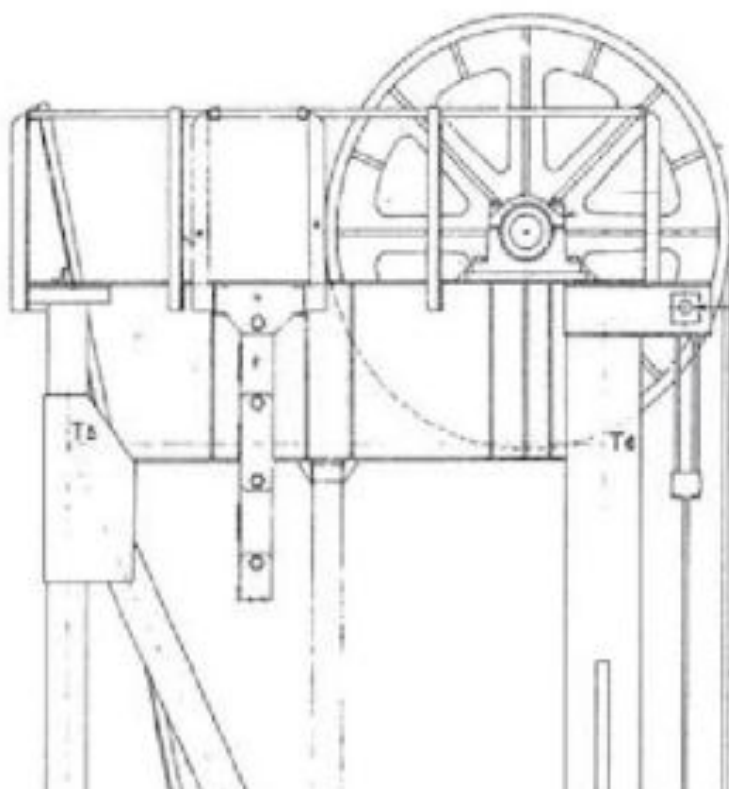


Figure 5.169 Elevation of Batemans Bay Bridge sheave arrangement

Mechanical components

The form and fabric of the mechanical components is of MODERATE significance.

The lifting mechanism on Batemans Bay Bridge operates by a combination of motors, drums, haul ropes, sheaves, gearing and counter weights. The power for operation is provided by an electric motor that turns centre mounted gearing and subsequently rotates the four drums that coil/uncoil the wire ropes.

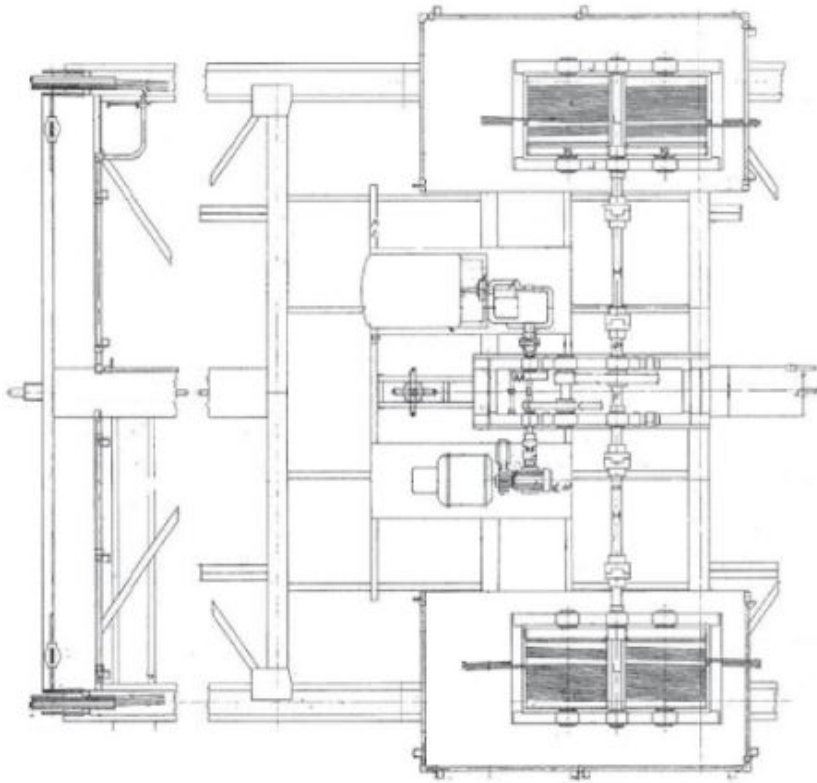


Figure 5.170 Batemans Bay Bridge plan of gearing and drum mechanism

Once movement is initiated the idler sheaves at the four corners of the lift span essentially ‘pass through’ the haul ropes as the span rises. The lengths of haul rope either side of the idler sheave remain stationary as the drums add to the downhaul rope and subtract from the uphaul rope simultaneously, with the mechanism operating in reverse during lowering. Figure 5.171 depicts a schematic of the operating system that is adopted for Hexham Bridge, the same system was adopted for Batemans Bay Bridge.

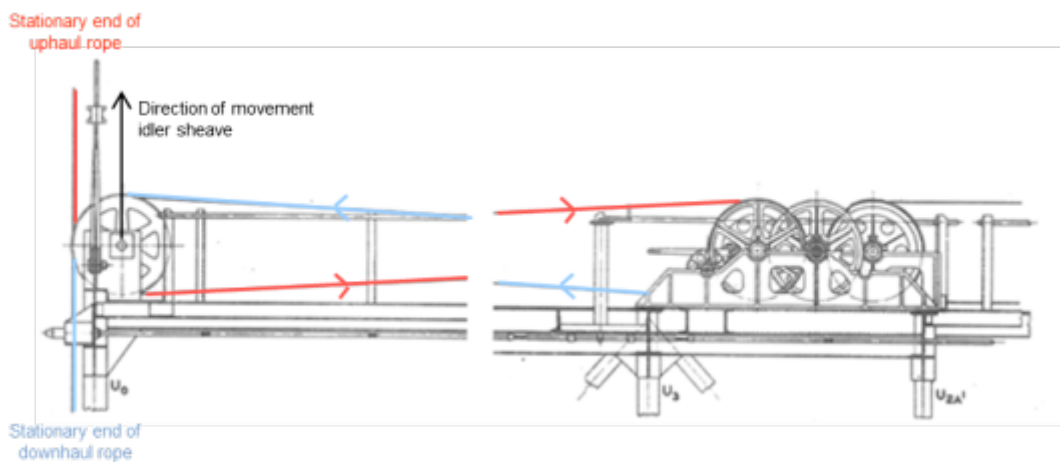


Figure 5.171 Hexham Bridge Operation Schematic

It is noteworthy that unlike the smaller vertical lift bridges, the counter weight rope in the Waddell type bridges is not engaged by the lifting drums and purely passes from a connection on the lift span, up over the counter weight sheaves before attaching to the counter weight.

Following the lessons learned for the Ryde Bridge, the Batemans Bay design implements the same trunnion design that was adopted for Hexham Bridge and shown in Figure 5.172.

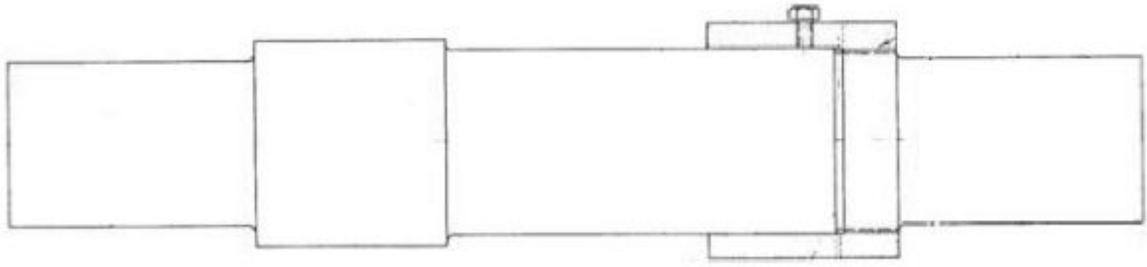


Figure 5.172 Trunnion design for Batemans Bay Bridge

The bridge is also fitted with locking pins that are inserted when the lift span is resting on the end bearings. These locking pins prevent the lift span from rising off the bearing due to the pull of the counter weights when the span is not in operation.

Batemans Bay bridge has two braking mechanism that are implemented on the design. The first is a solenoid brake that is mounted adjacent to the 35 H.P electric motor. The second is a hand brake located in the centre of the mechanism. It is operated by a manual lever from the operating house (Figure 5.173).

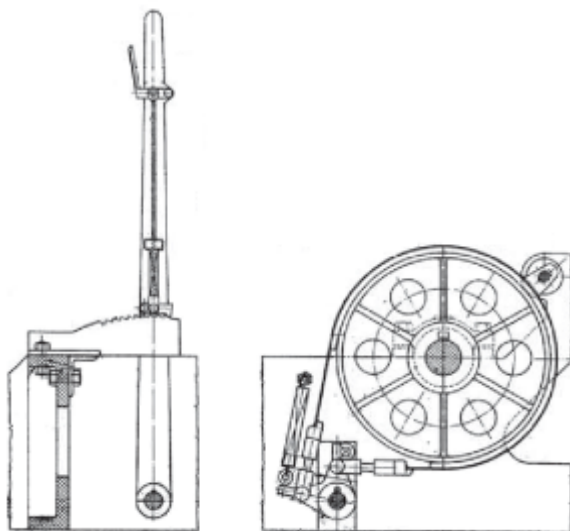


Figure 5.173 Batemans Bay hand brake

Ropes

The form and fabric of the ropes is of LOW significance.

The wire ropes consisted of wire strands wound around a hemp core. Four ropes are fixed to each corner of the movable span and pass up over the counterweight sheaves before connecting to the counterweight.

Vehicle and pedestrian barrier

The form and fabric of the vehicle and pedestrian barriers is of LOW significance.

The original gates were manually operated and were closed when the bridge was in operation. These gates have since been replaced by automatic gates and signalling lights.

Motors and electrical

The form and fabric of the motors and electrical components is of LOW significance.

The power for operation is provided by an electric motor that turns centre mounted gearing and subsequently rotates the four drums that coil/uncoil the wire ropes. There is a backup petrol motor adjacent to the electric motor, which can be utilised if the electric motor fails.

Summary of heritage assessments

The significances of each bridge component are summarised in the table below.

Table 5-30 Batemans Bay Bridge – Summary of heritage significance

Bridge Component	Significance Grading
Towers	EXCEPTIONAL
Movable Span	EXCEPTIONAL
Counterweights	MODERATE
Sheaves	EXCEPTIONAL
Mechanical components	MODERATE
Vehicle and pedestrian barriers	LOW
Ropes	LOW
Motors and electrical	LOW

5.15 WARDELL BRIDGE

(Ryde Type, built 1964)

5.15.1 Description of the Bridge

The bridge over the Richmond River at Wardell is a Waddell type vertical lift bridge. The bridge consists of a vertical lift span with length approximately 80 ft., seven reinforced concrete approach spans.

The upper framework of the lifting span generally consists of two independent steel towers with sufficient stiffness to prevent encroaching on each other, with the span itself consisting of a steel Pratt type truss arrangement. Finally the entire superstructure is supported on reinforced concrete piers on both faces of the tower.



Figure 5.174 Wardell Bridge (Source: Sean Eyre, January 11th 2012)

Development of roads and transportation in the Wardell region

The Wardell township and surrounding areas was originally occupied by the Bundjalung Nation until the European settlement in the 1840s. The initial drive for settlement was provided by the desire to access the rich cedar sources in the region. As noted in the Sydney Morning Herald in December 1842, sawyers were sent to the Richmond River for the purpose of “cutting the finest specimens of cedar”. This enterprise was employed by a Mr. Small, who was also responsible for the settlement of the Harwood area a number of years earlier (SMH, 1842). Through the 1840s to 1850s, the number of cedar camps continued to grow and the establishment of Blackwall, within the vicinity of the present-day township of Wardell, was ongoing from 1863 onwards (Ballina Shire Council, 2004).

The land near Wardell was also considered as valuable due to its rich alluvial fertility and the proximity to the large Richmond River. This allowed for the successful farming of sugar cane and pastoral activities including dairy production. Due to the location near the ocean, warmer temperatures were also maintained during the winter seasons reducing the probability of frost and significant crop damage (Ballina Shire Council, 2004).

Transportation across the Wardell River was provided by a Ferry for over 60 years. The ferry would accommodate all number of cargo including; foot passengers, livestock and vehicles. As traffic increased due to the advent of the motor vehicle and the increase in tourism to the coast line, the ferry was deemed insufficient and during holiday periods a second ferry was engaged to operate during the peak season (Ballina Shire Council, 2004). However this was only a temporary solution and it gave rise to the need for a permanent structure to be built.



Figure 5.175 Wardell Bridge towers and counterweights

Design and construction

The Wardell Bridge was constructed under the Department of Main Roads NSW by Lismore firm Dayal Singh Constructions. It was completed at a cost of \$830,000 and was officially opened on the 10th of April 1964 by the Minister for Highways and Local Government, Mr. Pat Hills (*Blackwall Bungle*, 2012) and a large crowd gathered at the opening ceremony.



**Figure 5.176 Crowd in attendance at opening ceremony of Wardell Bridge
(Source: Blackwall Historical Society)**

Operational history

Following its completion the bridge was opened regularly for cane barges operating on the Richmond River travelling back and forth from the Broadwater sugar mill. With the improvement of local roads to the mill the cane barges ceased to operate. The bridge still opens once a month primarily for test lifts, though boats with masts lower than 5m are able to pass beneath the bridge when it is closed.



**Figure 5.177 The Burns Point vehicular ferry floating beneath the bridge on
its way back to Ballina after repairs**

Maintenance history

The lift towers were grit blasted, treated for corrosion and repainted over three months in 2013. During this period the towers were encircled by light weight scaffolding and the lift span remained locked shut.



Figure 5.178 Scaffolding on lift towers in 2013, (Source: Layher Scaffold website)

5.15.2 Statement of significance

The Wardell Bridge was built in 1964 to replace a vehicular ferry and is of a relatively standard design for the period. The Bridge forms a local landmark that has a “gateway” quality for the town of Wardell due to its impressive size. The Wardell Bridge has been assessed as being of local significance.

Heritage Listings

Listing	Status
Australian Heritage Database (formerly the Register of the National Estate)	Not listed
OEH Heritage Division State Heritage Register	Not listed
Ballina Shire Council Local Environmental Plan, 2012	Not listed
NSW National Trust Register	Not listed
RTA s.170 Heritage and Conservation Register	To be listed

Evolution of modifications

Wardell Bridge was essentially an adoption of the Hexham Bridge design. The principle change is due to the lack of adjacent truss spans resulting in the adoption of alternate tower base foundations.

Table 5-31 Wardell Bridge – Summary of modifications

Preceding Designs	Issues with Design	Evolution of Wardell
Towers integrated into adjacent spans	Requires integration with truss spans	Tower supported by a second pier founded on piles

5.15.3 Description of lift span mechanism components

Towers

The form and fabric of the lift span towers is of EXCEPTIONAL significance.

The design of the Wardell Bridge is another Waddell type arrangement and it is a similar design to the preceding Hexham and Batemans Bay Bridges. The principle difference is found in the span dimensions and the detailing of the tower bases due to a lack of adjacent trusses.

The superstructure arrangement consists of two independent towers that extend into support piers. The towers consist of four braced mild steel vertical members that support two longitudinally oriented counter weight sheaves (Figure 5.179). The towers are independent however the bracing arrangement gives them sufficient inherent stiffness to prevent them encroaching on each other and jamming the lift span during operation.

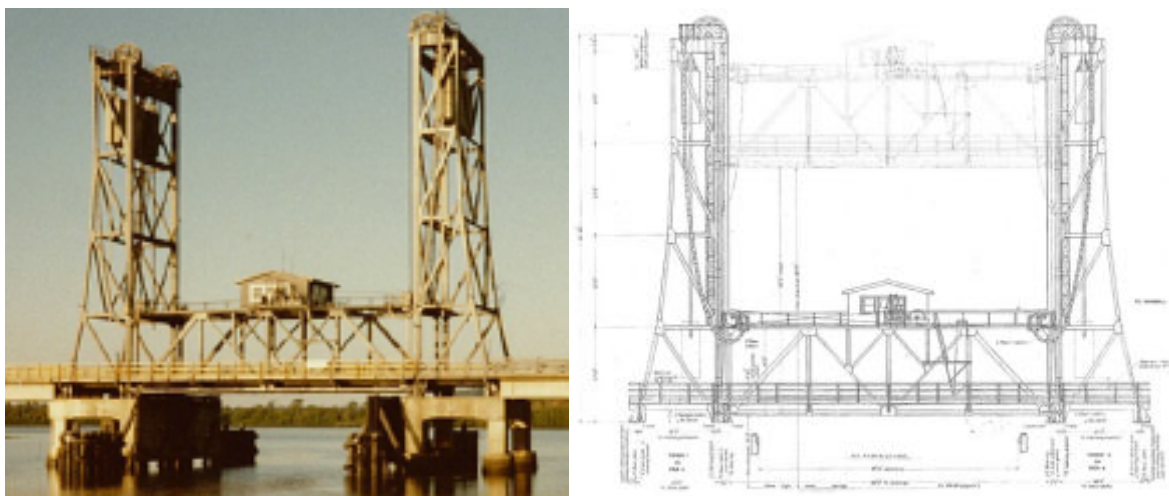


Figure 5.179 Elevation of Wardell Bridge (Source: RMS)

As mentioned above, it is noteworthy that the tower supports for Wardell Bridge adopt a different design to the preceding Waddell type bridges. Previous designs integrated the base of the tower with the adjacent fixed span. Since the approaches on Wardell Bridge are not trusses, the support of the rear vertical members was achieved by a second pier founded on piles (Figure 5.180).

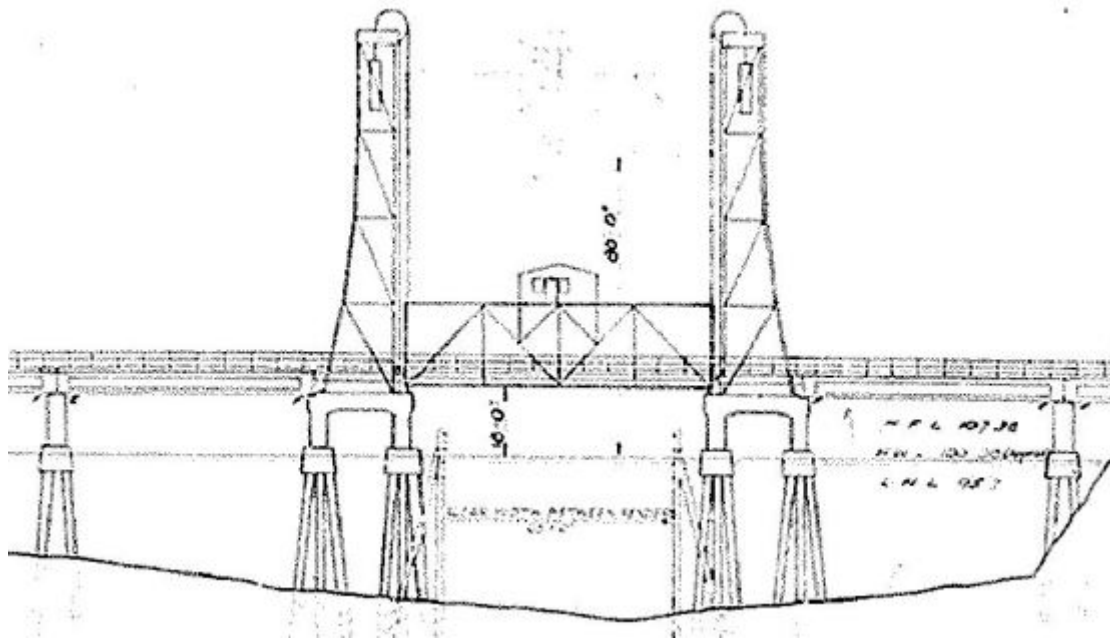


Figure 5.180 Foundations for Wardell Bridge towers

The counter weight sheaves are supported on longitudinal and transverse girders at the tops of the towers, with the majority of the load transferring to the front members due to the location of the sheave mounts (Figure 5.181), hence the front tower columns have been designed to be stronger than those at the rear.



Figure 5.181 Plan of Wardell Bridge sheaf arrangement

Movable span and engine house

The form and fabric of the movable span is of EXCEPTIONAL significance.

The lift span of the Wardell Bridge consists of mild steel truss arrangement as depicted in Figure 5.182. The truss supports steel plate web cross girders that subsequently support the R. S. J stringers and reinforced concrete deck.

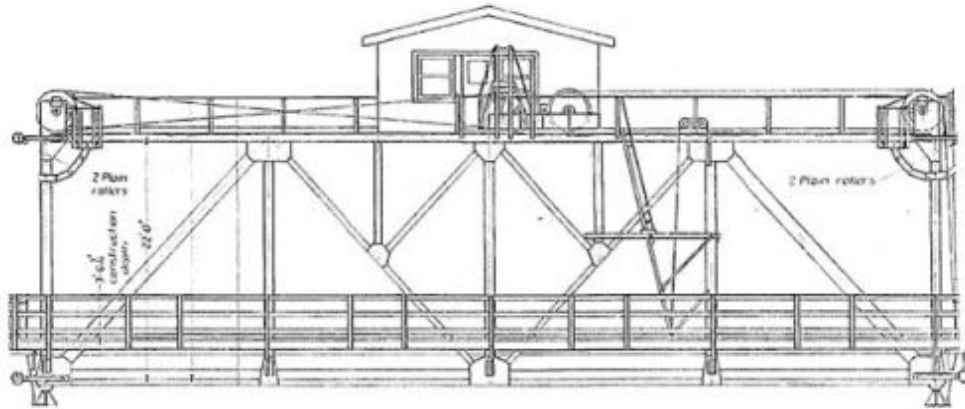


Figure 5.182 Wardell Bridge Lift Span

The motors, gearing and drum components of the lift mechanism are protected by a machinery house positioned at the centre of the lift span. Figure 5.183 shows the house adopted for the Wardell design.

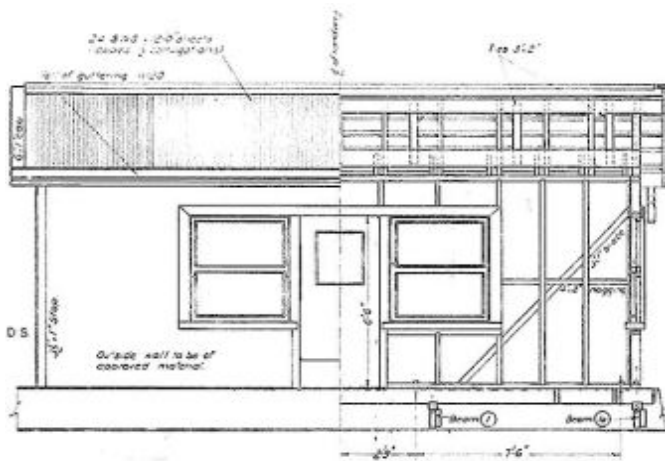


Figure 5.183 Wardell Machinery House Section AA

The lift span is also fitted with locking pins that are inserted when the lift span is resting on the end bearings. These locking pins prevent the lift span from rising off the bearing due to the pull of the counter weights when the span is not in operation.

Counterweight

The form and fabric of the counterweight is of MODERATE significance.

Counter weights are implemented on Wardell Bridge to help balance the weight of the lift span. The original design consisted of a reinforced concrete block with a steel frame set into the counter weight to provide an attach point (Figure 5.184).



Figure 5.184 Wardell counterweights in 1985 (Source: RMS)

The connection between the framing and the counter weight ropes is achieved by a pin to saddle arrangement as shown in Figure 5.185.

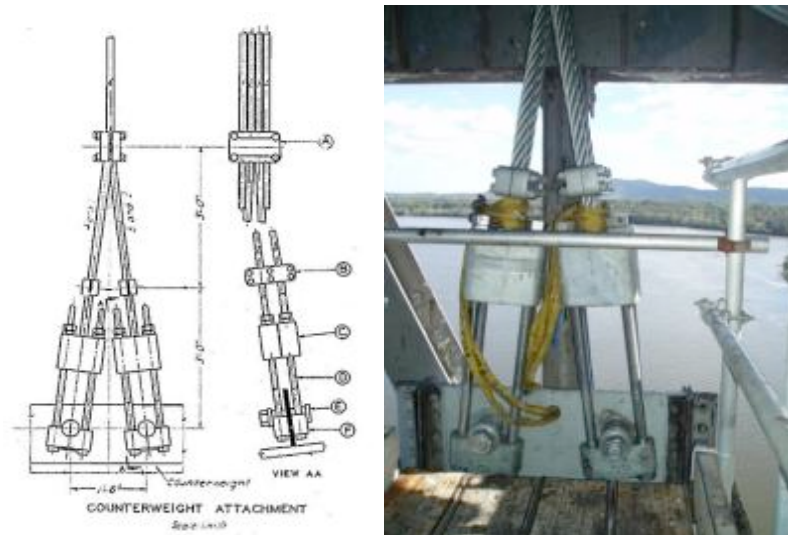


Figure 5.185 Wardell counter weight to wire rope saddle pin connection

Sheaves

The form and fabric of the sheaves is of EXCEPTIONAL significance.

The counter weight sheaves are approximately 9 feet in diameter and are made of cast iron. Grooves have been set into the casting to cater for the four wire ropes required for the counter weights (Figure 5.186).

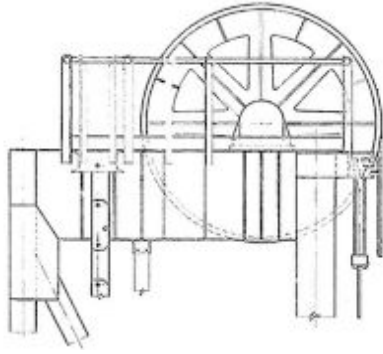


Figure 5.186 Elevation of Wardell Bridge sheaves

Mechanical components

The form and fabric of the mechanical components is MODERATE significance. The lifting mechanism on Wardell Bridge operates by the integration of motors, drums, haul ropes, sheaves, gearing and counter weights (Figure 5.187 to Figure 5.189). The power for operation is provided by an electric motor that turns centre mounted gearing and subsequently rotates the four drums that coil/uncoil the wire ropes.

Once movement is initiated the idler sheaves at the four corners of the lift span essentially ‘pass through’ the haul ropes as the span rises. The lengths of haul rope either side of the idler sheave remain stationary as the drums add to the downhaul rope and subtract from the uphaul rope simultaneously, with the mechanism operating in reverse during lowering. Figure 5.187 depicts a schematic of the operating system that is adopted for Hexham Bridge and this same system was adopted for Wardell Bridge.

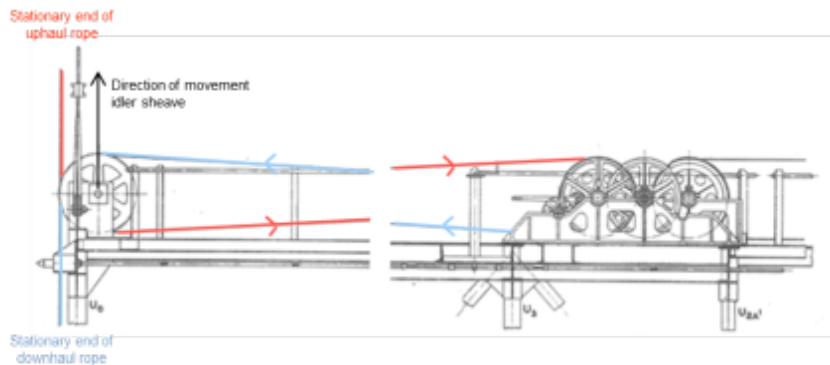


Figure 5.187 Hexham Bridge Operation Schematic

Summary of heritage assessments

The significances of each bridge component are summarised in the table below.

Table 5-32 Wardell Bridge – Summary of heritage significance

Bridge Component	Significance Grading
Towers	EXCEPTIONAL
Movable Span	EXCEPTIONAL
Counterweights	MODERATE
Sheaves	EXCEPTIONAL
Mechanical components	MODERATE
Vehicle and pedestrian barriers	LOW
Ropes	LOW
Motors and electrical	LOW

5.16 HARWOOD BRIDGE

(Ryde Type, built 1966)

5.16.1 Description of the Bridge

The bridge over the Clarence River at Harwood is the last Waddell type vertical lift bridge built by the Department of Main Roads. The bridge consists of a vertical lift span with length approximately 124 ft., six steel Pratt truss spans with lengths of 141 ft. and twenty-seven Steel Girder spans each approximately 71 ft. long. The Bridge when raised has a clearance over high water level of 120 ft., and a horizontal clearance between fenders of 100 ft.

The upper framework of the lifting span generally consists of two independent steel towers with sufficient stiffness to prevent encroaching on each other, with the span itself consisting of a steel Pratt type truss arrangement. Finally the entire superstructure is supported on reinforced concrete piers.



Figure 5.191 General view of Harwood Bridge



Figure 5.192 Aerial view of Harwood Bridge on its opening day 20th August, 1966 (Source: DMR, 1967)

Development of roads and transportation in the Harwood area

The history of the Harwood area is closely associated with the cedar trade of the Clarence River Valley. As noted for the history of Mororo, the area was discovered by escaped convict Richard Craig in the early 1800s. Following his arrival in Sydney, discussions with timber yard owner Thomas Small led to the first expedition to the area to locate proposed cedar deposits. The cedar trade then began, and would boom up until the 1840s when the resource became scarce. Settlements in the area continued as land was also used as pastoral grounds (Maclean Shire, 2006).

The Clarence River played a crucial role for the area and was heavily relied upon for transportation. The only means of crossing the Clarence River at Harwood prior to 1885 was by row-boat which was privately owned by a nearby hotelkeeper. The first ferry, a steam vessel, commenced service in 1885. In the early days of this service a toll was charged but this was later removed. The ferry transported foot passengers, horses, buggies, carts, sulkies, wagons and cattle.

Ferry service at Harwood

The Main Roads Board assumed control of the ferry service in 1928 and the service was progressively improved. When the service ceased with the opening of the new bridge, two ferries were operating in parallel on a regular quarter hourly service and a third ferry was available when traffic warranted its use. In the first half of 1967 the ferries carried an average of more than 61,000 vehicles of all types per month.

History of the Pacific Highway

The development of the Pacific Highway (formerly known as the Coastal Road) was extremely slow. Early means of communication between the northern settlements and Sydney was by sea and numerous small ships traded up and down the coast and on the northern rivers.

Raymond Terrace was the northern centre of road communication and the coastal road extended northwards from it linking with other inland roads. By 1857 the coast road had been extended to Kempsey where a road ran inland to Armidale then northeast to Grafton and Lismore.

The North Coast Road, by 1895, ran from Hexham to Raymond Terrace, Stroud, Gloucester, Taree, Port Macquarie, Kempsey, Fredrickton, Coffs Harbour, terminating at Grafton. From there travellers going north had to take a steamer downstream along the Clarence River to either Lawrence or Harwood. A coach route then linked up with Casino and Lismore and from the latter a railway ran to Murwillumbah from where travellers had to take another coach to proceed into Queensland.

Improvements to the road route were extremely slow and most travellers considered it was quicker and more comfortable by sea. Even in the 1920s, when the use of motor vehicles was becoming more widespread, many miles of the North Coast road consisted of earth formation only.

With the formation of the Main Roads Board in 1925 a systematic programme of improvements to the Coastal Road was undertaken. Most significantly, the thirteen ferries that operated on the river crossings along this route were replaced with bridges. The Coastal Road was named the Pacific Highway in 1931, Queensland having previously adopted the name for the link road from the border to Brisbane.

Design and construction

With the completion of the bridge over the Richmond River at Wardell in 1964 the Clarence River was the only remaining river crossing to be bridged on the route of the Pacific Highway in New South Wales. Much of the area around Grafton and along the river is inundated in times of high flood. It was important therefore that a bridge to replace the ferry should be sited so that its approaches ultimately could be made flood free, if not from the outset.

The river is reasonably straight and of fairly constant width (about 750 metres) with low banks for some distance both upstream and downstream from the ferry crossing. In consequence, any site near the ferry was satisfactory for the bridge providing it could be adapted to give the necessary flood free approaches.

Preliminary investigation surveys for a bridge were first carried out in 1956 when it was at first thought possible that a bridge might be feasible within 30 metres and downstream of the ferry. However, during boring operations it became obvious that an attempt to construct a bridge so close to the ferry crossing could be dangerous because of the deviation of the ferry downstream from its direct route across the river.

A new site was surveyed 200 metres downstream from the ferry and arrangements were made to conduct a comprehensive site boring investigation to determine the requirements for the bridge foundations.

In common with a number of the Northern Rivers, the Clarence for many years carried quite extensive river traffic. Its broad expanse of waterway and good depth enabled ships of several thousand tons to travel well inland from the sea almost direct to the source of their cargoes (principally sugar cane). Although this shipping traffic had diminished considerably by the 1960s, the Maritime Services Board determined that the river crossing should permit the passage of such large ships.

The type of opening span to be built in the bridge was given detailed consideration. A vertical lift span was favoured for the site and in addition the Department had accumulated considerable experience in the design, construction and operation of this type of bridge. Earlier examples include of this type were Hexham Bridge (1952), Batemans Bay Bridge (1956) and Wardell Bridge (1964).

Preliminary proposals for the bridge were ready late in 1960 and the final design was decided upon in 1962. Specifications were prepared for the construction of the bridge in two contracts. The first contract was for the manufacture, supply and delivery of steelwork for the superstructure and the machinery for the lift span including supply and erection of the electrical control equipment. The second contract was for the construction of the substructure and erection of the superstructure including lift span machinery.



Figure 5.193 First stages of the tower span under construction (Source: DMR, 1967:5)

The contract for the bridge steelwork was awarded to Arcos Industries Pty Ltd of Sydney and the contract for the construction of the substructure (Figure 5.193) and erection of the steelwork was awarded to Reed and Stuart Pty Ltd, who constructed the concrete arch bridge over the Parramatta River at Gladesville.

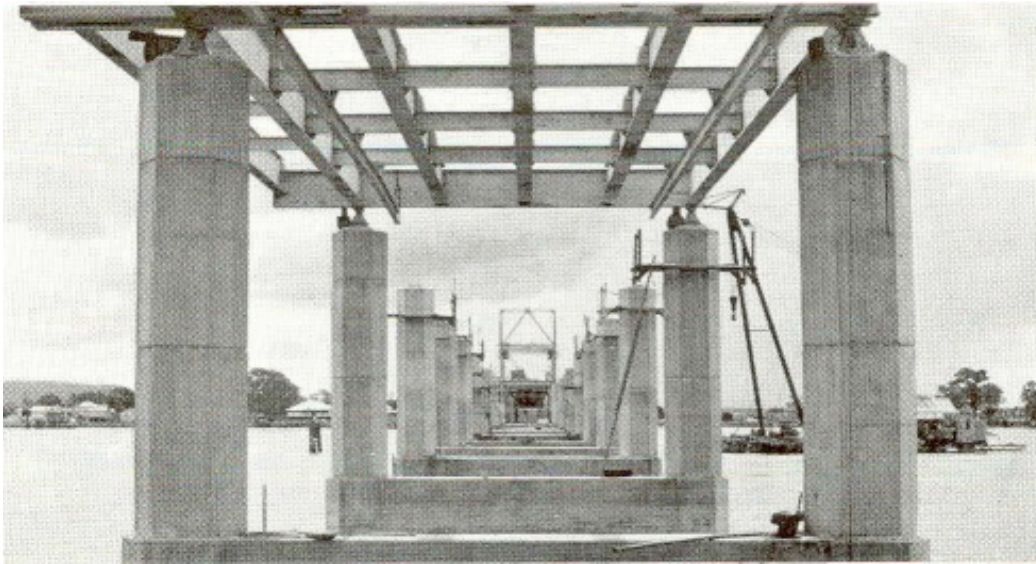


Figure 5.194 Erection of the two-column piers and the steel plate girder spans underway in 1967 (Source: DMR, 1967:5)

Harwood Bridge was officially opened by His Excellency the Governor of New South Wales, Sir Roden Cutler on 20th August, 1966. The cost of the bridge was approximately \$2.5 million, with another \$1.3 million spent on the approach roads and three over bridges required for the Highway detour.

At 888 metres in length when completed it was the third longest bridge in NSW, behind the Sydney Harbour Bridge (1149 m) and the Bridge over the Murrumbidgee River at Gundagai (922 m). Its construction also marked a significant achievement for the Department of Main Roads as this bridge replaced the last remaining ferry service on the Pacific Highway; one of the primary objectives for the formation of its predecessor the Main Roads Board in 1925. Prior to 1925, travel along the coastal route between Sydney and the Queensland state border involved thirteen ferry crossings (DMR, 1966).

It also removed a notorious bottleneck on the Highway – the Maclean town centre. This was also the first of many major town bypasses that would eventually be built on the Pacific Highway.

Operational history

When completed the main water traffic requiring the lift span to be opened were cane barges travelling back and forth from the Broadwater sugar mill. The vertical clearance of the bridge above the waterway is 8.5 m so all but the tallest could pass underneath with the lift span closed.

More recently the Clarence River has become popular with recreational boaters as it is a broad and generally deep river mostly free of shoal banks. Sailing between Yamba on the coast and Maclean is a common route for recreational boaters and often necessitates the opening of the Harwood Bridge (see below). In 2006 the bridge was recorded as opening on average 13 times a month, a frequency that remained unchanged in 2013.



Figure 5.195 Lift span raised to allow for a yacht to pass under (Source: Daily Examiner, 27 January 2014)

Maintenance history

In 2006 Ospreys commenced nesting on the movable span of Harwood Bridge and the nearby Glebe Bridge at Coraki. As Ospreys are listed as “vulnerable” on the *NSW Threatened Species Conservation Act* the bridge operators adopted a “do not disturb” policy, leaving the birds in peace during their breeding season. A steel nesting basket was subsequently attached to the eastern (downstream) side of the bridge at the top of the northern tower, since Ospreys have a tendency to search for the highest possible location in the area to nest. An Osprey pair continues to use the basket each year and it ensures minimal disruption of the bird nests as well as ongoing protection of the road and pedestrians using the walkway on the upstream side of the bridge.



Figure 5.196 Steel nesting basket on the northern tower in use by Ospreys in 2012

In 2010 Roads and Maritime Services completed a \$7.5 million major maintenance overhaul of the Harwood Bridge which focussed on improved safety for the bridge operator and maintenance crews and minimising the likelihood of future traffic disruption. These works included:

- Installation of a set of stairs from the side of the pedestrian footpath to the walkway at the engine house level to access the Bridge.
- Modifications to the existing ladders up the lift span towers including installation of a latch way system and provision of a handrail at the top of the individual ladders where they step through to the next ladder.
- Installation of new platforms at either side of the top of the towers for the new greasing system and uphaul rope tensioners.
- Installation of a new platform on the counterweight accessed from the top platform.

A barge and floating crane was used to safely and efficiently load and unload mechanical and electrical materials required for the upgrade (see below).



Figure 5.197 Barge and floating crane in position during access upgrading project in 2010

5.16.2 Statement of significance

The Harwood Bridge was built in 1966 to replace the last vehicular ferry in use on the Pacific Highway and is of a relatively standard design for the period. The Bridge forms a local landmark that has a “gateway” quality for the village of Harwood due to its impressive size. This bridge replaced the last remaining ferry service on the Pacific Highway; prior to 1925, travel along the coastal route between Sydney and the Queensland state border involved thirteen ferry crossings. The Harwood Bridge has been assessed as being of **local** significance.

Source: RMS s170 Register

Heritage Listings

Listing	Status
Australian Heritage Database (formerly the Register of the National Estate)	Not listed
OEH Heritage Division State Heritage Register	Not listed
Clarence Valley Local Environmental Plan, 2011	Not listed
NSW National Trust Register	Not listed
RTA s.170 Heritage and Conservation Register	Listed

Evolution of modifications

In summary, the modifications of the Harwood Bridge design consist of the altered trunnion design and increase in overall size of the structure.

Table 5-33 Harwood Bridge – Summary of modifications

Preceding Designs	Issues with Design	Evolution at Harwood
Single thread on one side of trunnion	-	Thread on each side and use of locking nuts for design
Smaller tower heights	-	Increased tower height allowing for greater clearance when open.
No painting gantry	Safety and access concerns	Implementation of a painting gantry for bridge

5.16.3 Description of lift span mechanism components

Towers

The form and fabric of the lift span towers is of EXCEPTIONAL significance.

The design of the Harwood Bridge is based on the Waddell type American design with reference to the American specification for Movable Highway Bridges (A. A. S. H. O.). The design was completed by Department of Main Roads, N. S. W. Supervising Engineer V. Karmalsky.

The superstructure arrangement is similar to that adopted for the Wardell Bridge design and consists of two independent towers that extend into the adjacent truss spans. The towers consist of four braced mild steel vertical members that support two longitudinally oriented counter weight sheaves (Figure 5.198).

The towers are independent however the bracing arrangement gives them sufficient inherent stiffness to prevent them encroaching on each other and jamming the lift span during operation. It is also noteworthy that the towers on the Harwood Bridge are approximately 36 ft. taller than the preceding Wardell Bridge design and this allows from the high ship clearance of 120 ft. above high water level.

As noted for the tower design, the lift span was also given a camber to ensure that under dead weight the span would remain level. The lift span is fitted with locking pins that are inserted when the lift span is resting on the end bearings. These locking pins prevent the lift span from rising off the bearing due to the pull of the counter weights when the span is not in operation.

Another noteworthy feature of the Harwood Bridge design is the painting gantry design shown in Figure 5.200, this is the first time that a purpose built painting gantry had been installed on a vertical lift bridge in NSW at the time of construction.

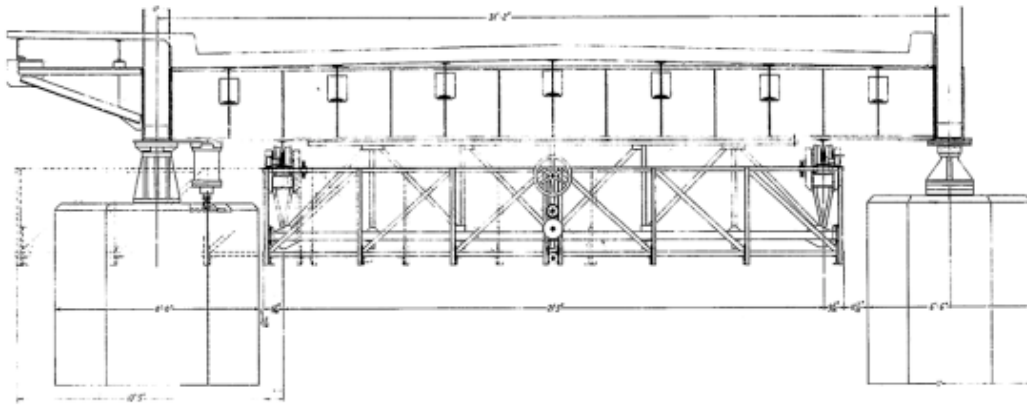


Figure 5.200 Harwood Painting Gantry

Counterweight

The form and fabric of the counterweight is MODERATE significance.

The counterweights that are implemented on Harwood Bridge consist of a reinforced concrete block, with large voids to allow for the introduction of future ballast. The ballast allows from any future modifications that may be required on the lift span. Steel plates have also been set into the counterweight to allow for the connection of the six wire ropes. Guide wheels for the counter weight are also a feature of the design and the implement a hinge and spring to lessen the impact of the swaying counterweight during operation (Figure 5.201).

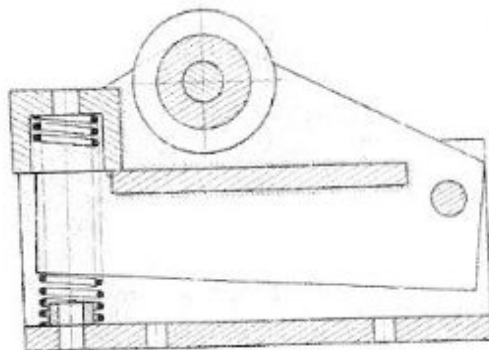


Figure 5.201 Counterweight Roller Guide

The counterweight rope is not engaged by the lifting drums and purely passes from a connection on the lift span, up over the counter weight sheaves before attaching to the counter weight. This connection consists of a pin and saddle arrangement, as shown in Figure 5.202, the pin passes through the connection plate and a saddle catches the pin and joins to the end of the wire ropes.

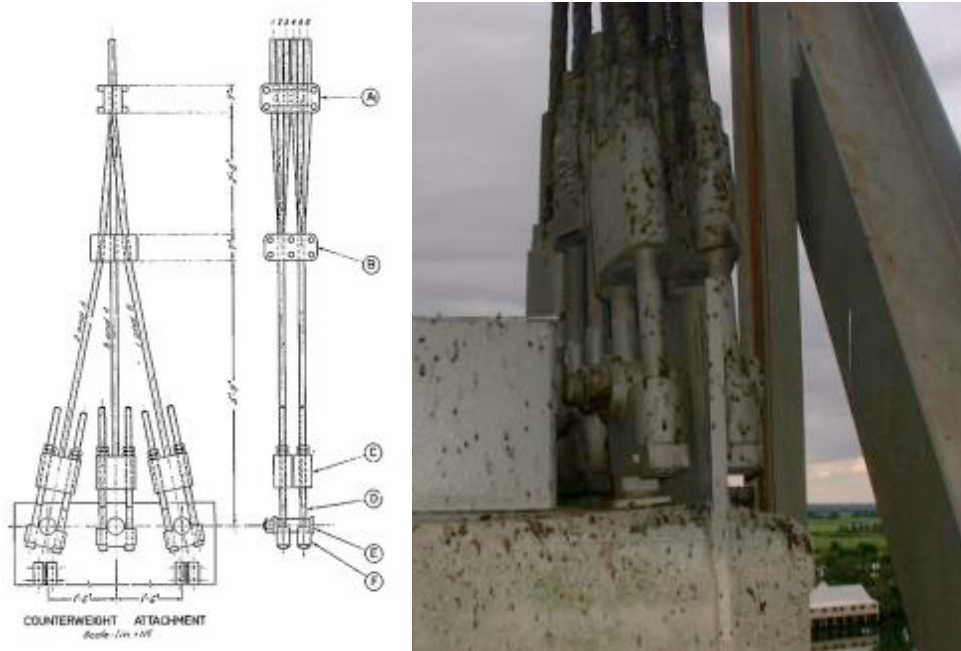


Figure 5.202 Counterweight to wire rope saddle pin connection

Sheaves

The form and fabric of the sheaves is EXCEPTIONAL significance.

The counterweight sheaves are approximately 9 feet in diameter and are made of cast iron. Grooves have been set into the casting to cater for the six wire ropes required for the counterweights. The sheaves are depicted in Figure 5.203 to Figure 5.204.



Figure 5.203 Top of Harwood tower

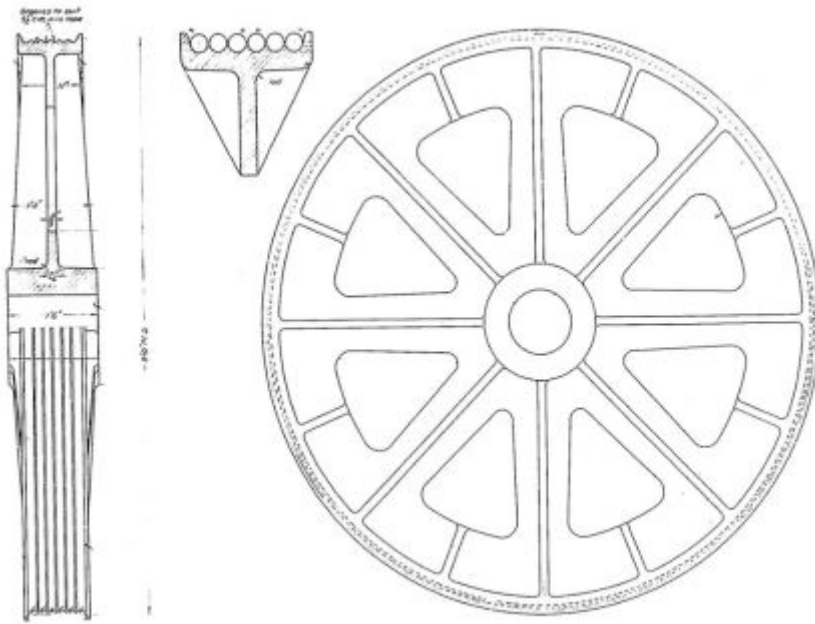


Figure 5.204 Sheave design from Harwood Bridge

Mechanical components

The form and fabric of the mechanical components is of MODERATE significance.

The lifting mechanism on Harwood Bridge is similar to other Waddell Type bridges built in NSW and operates by the integration of motors, drums, haul ropes, sheaves, gearing and counter weights. The power for operation is provided by an electric motor that turns centre mounted gearing and subsequently rotates the four drums that coil/uncoil the wire ropes. The majority of these components are shown in Figure 5.205.

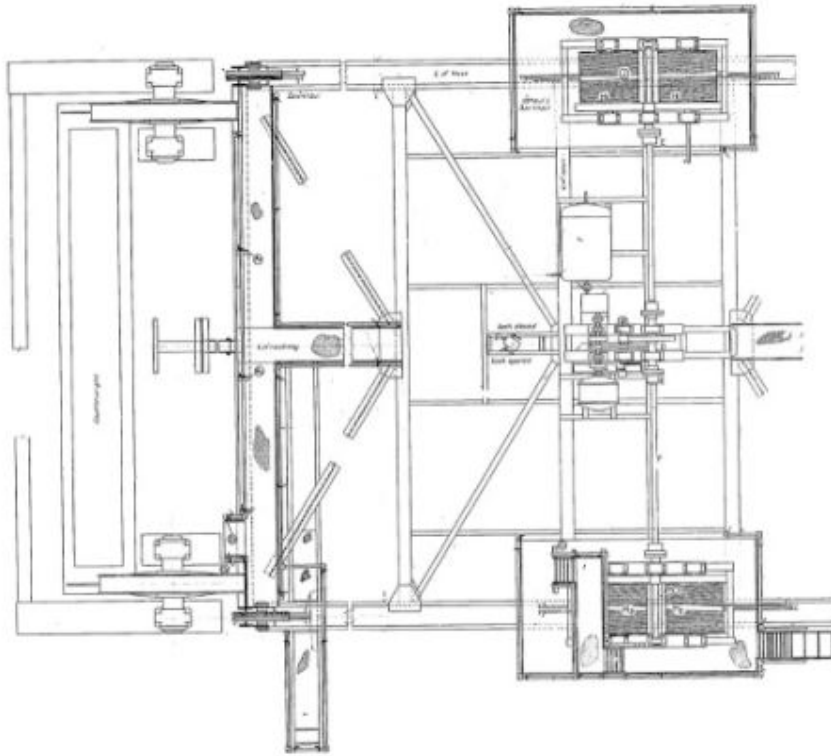


Figure 5.205 Harwood Bridge Operating Mechanism

Once movement is initiated the idler sheaves at the four corners of the lift span essentially ‘pass through’ the haul ropes as the span rises. The lengths of haul rope either side of the idler sheave remain stationary as the drums add to the downhaul rope and subtract from the uphaul rope simultaneously, with the mechanism operating in reverse during lowering. Figure 5.206 depicts a schematic of the operating system.

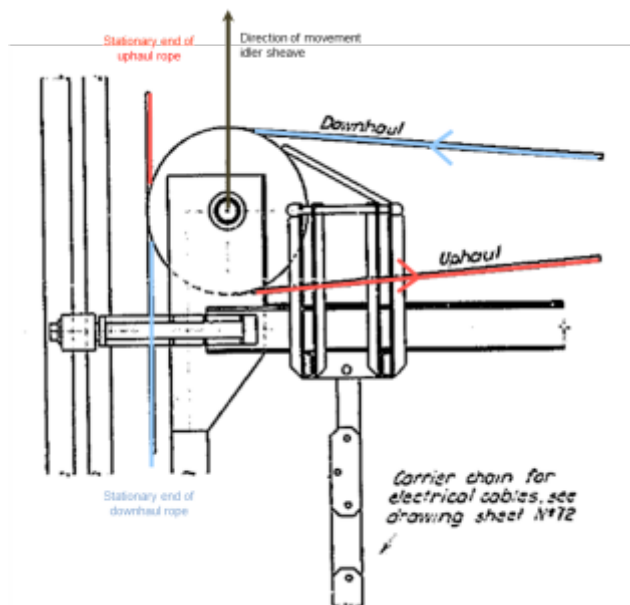
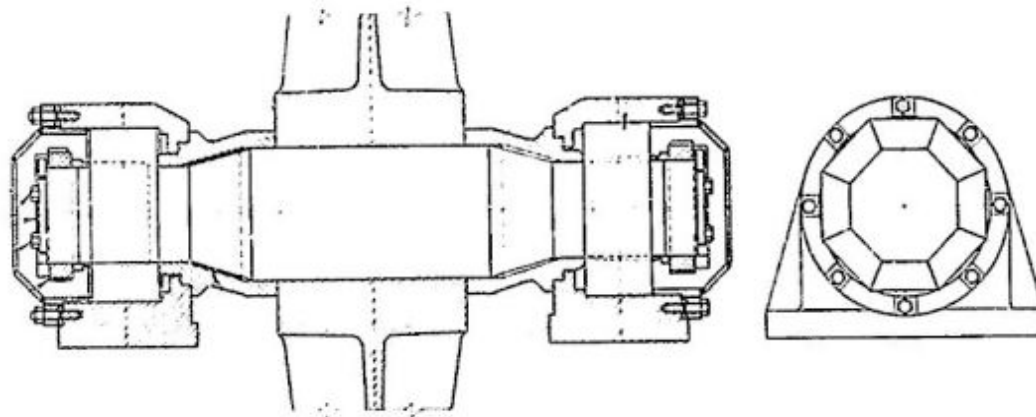


Figure 5.206 Harwood Bridge Operation Schematic

The trunnion design is a critical feature as previous designs such as Ryde Bridge have had issues with the counterweight sheaves ‘rolling’ on the trunnions causing intermittent rifle shots sounds. This issue was resolved for

the Hexham Bridge design, however once again a different design was adopted for Harwood Bridge. This design consists of a lock nut in either side of the sheave to keep the system secure during operation (Figure 5.207).



ASSEMBLY OF COUNTERWEIGHT SHEAVE AND BEARINGS.

Figure 5.207 Trunnion design for Harwood Bridge

Ropes

The form and fabric of the ropes is of LOW significance.

The wire ropes consisted of wire strands wound around a hemp core. Six ropes are fixed to each corner of the movable span and pass up over the counterweight sheaves before connecting to the counterweight.

Vehicle and pedestrian barrier

The form and fabric of the vehicle and pedestrian barriers is of LOW significance.

Hardwood is fitted with a pedestrian barrier and signalling lights which are operated when the span is being raised.

Motors and electrical

The form and fabric of the motors and electrical components is of LOW significance.

The power for operation is provided by an electric motor that turns centre mounted gearing and subsequently rotates the four drums that coil/uncoil the wire ropes. There is a backup petrol motor adjacent to the electric motor, which can be utilised if the electric motor fails.

Summary of heritage assessments

The significances of each bridge component are summarised in the table below.

Table 5-34 Harwood Bridge – Summary of heritage significance

Bridge Component	Significance Grading
Towers	EXCEPTIONAL
Movable Span	EXCEPTIONAL
Counterweights	MODERATE
Sheaves	MODERATE
Mechanical components	MODERATE
Vehicle and pedestrian barriers	LOW
Ropes	LOW
Motors and electrical	LOW

5.17 WENTWORTH BRIDGE

(Table Lift, built 1969)

5.17.1 Description of the Bridge

The bridge over the Darling River at Wentworth is a table type movable bridge which consists of a lifting span with length 56 ft. and six fixed approach spans with lengths ranging from 70 ft. to 73 ft.

The table span of the bridge generally consists of a steel girder with strengthening provided by transverse web stiffeners. The primary girders support stiffened cross girders which subsequently support rolled steel stringers, bridge planks and deck topping. The superstructure bears on reinforced concrete piers that are founded on piles. The separate components that make up the bridge are shown in Figure 5.208.

It has two central hollow concrete piers which house the hydraulic telescopic cylinders and lift the bridge for river traffic



Figure 5.208 Profile view of Wentworth Bridge with lift span closed

Development of roads and transportation in the Wentworth region

In 1838 Joseph Hawdon and Charles Bonney drove cattle from NSW to Adelaide when they reached a junction between the two rivers. This junction was originally known as “The Rinty” and a camp site was established with the popularity driven by the new overland route users.

Following the arrival of the first paddle streamers in 1853, this junction was considered as the ideal strategic location for an administrative and commercial centre for the NSW farming regions. Surveys of the area were completed in 1857 by Surveyor General Barney and the township was

officially established on the 21st of June 1859. The town was named in the honour of politician and explorer William Charles Wentworth (Tulloch, 1969).

The Wentworth river port was well utilised through the paddle steamer era, however the improvement of overland transportation eventually halted the river trade and the port no longer played a large role in the towns operations. Within the township there are few remains of the important commercial functions of the river boats in the Shire. The major bond stores and warehouses that were erected adjacent to Wentworth wharf have been removed or remodelled. The customs officers' residence is the only related structure existing today.

Accounts of a punt used at Wentworth appear in an early Melbourne newspaper description of the town (*The Argus*, 1876). However as the population increased the need for an efficient crossing, which did not interfere with the river trade, arose.

In 1893 a vertical lift bridge designed by J. A. MacDonald was completed and this bridge allowed for the passage of both river vessels and land traffic (Figure 5.209 and Figure 5.210). This bridge was in service for approximately 76 years before it was replaced by the existing bridge in 1969.

Design and construction

The Western Herald of 24 March, 1967 advised that a tender of \$493,752 had been accepted by the Department of Main Roads for the construction of a new bridge on the Darling at Wentworth “just upstream from the present one”.

The early 1900s saw the introduction of irrigation systems into the area and this allowed the agricultural industries to grow and the town to continue developing.



Figure 5.209 View of the lift tower of the first Wentworth Bridge an example of the “Mulwala” type design (Source: Annual Report Public Works Department, 1893-1894)

Operational history

The local community is very reliant on the bridge as it provides the only crossing of the Darling River and links to crossings of the Murray River.

Initially, openings were conducted on an ad hoc basis with the associated disruption to road users. This culminated in a letter of concern being sent from Wentworth Development Association to Divisional Engineer, DMR in December 1983. This letter echoes a common sentiment relating to movable span bridge operation and the tension between road users and river users:

There appears to be no set times for the lifting of the bridge which makes it very inconvenient for townspeople and public transport operators. Would it be possible for the bridge to be lifted at advertised set times or if this is not practical, at off peak traffic times.

As this bridge is the only reasonable means of crossing the river in an emergency, the length of time the completed lifting operation takes is of great concern. The minimum time taken is at least 20 minutes. Could you please give some consideration to this matter.

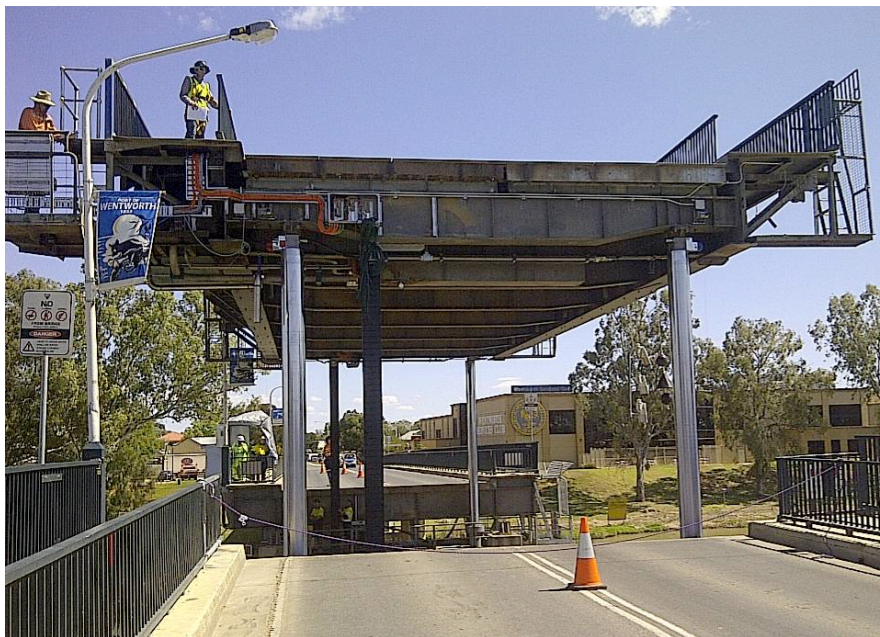


Figure 5.210 Lift span raised to full height (6 metres) during a maintenance lift to test new controls. The hydraulic cylinders at each corner are clearly visible

Following on from this the following times were posted in August 1985 and remain unchanged:

Emergencies: as required

Weekdays: before 7:30 am, between 9:30 am and 11:00 am and between 1:30 pm and 2:45 pm, after 5:00 pm

Weekends and NSW public holidays: as required

RMS schedules openings to be no longer than 15 minutes at a time and not during peak periods.

Complete records for any given year are unfortunately rare making a table detailing the consistency of usage difficult to piece together. However, the following trends can be observed:

1. Between 1970 and August 1981 the sole vessel using the waterway that required the movable span to open was the paddle steamer “Wanera”. After August 1981 there appears to have been a significant increase in interest by the boating community in navigating up the Darling River with multiple vessels making the voyage.
2. Peak usage was in the mid-1980s with a maximum recorded usage in any given month of 30 lifts. No data is shown for 1990s but the previous trend continued.
3. Between 2004 and 2009 drought conditions prevailed in much of the Murray River catchment with the result that water levels were sufficiently low that only shallow draught levels could utilise the upper reaches. Such vessels were typically small enough to slip under the movable spans of the Murray River Bridges while in the closed position and as a result very few openings were recorded during this period.
4. More recently, house boats divert from the Murray to sail up the Darling River under the Wentworth Bridge to access the Wentworth Sewerage Pumpout Station which is a further 500 m upstream. This is operated free of charge by Wentworth Shire Council. Current levels are approaching those recorded in 1980 and 1981.

Overall, depending on the water levels the bridge may be lifted very regularly (5-10 times a week) or not often (5-10 times a month).

Table 5-35 Record of lifts of the Wentworth Bridge opening span

Lifts	Jan	Feb	March	April	May	June	July	Aug	Sep	Oct	Nov	Dec	Total
2011	2	9	14	22	12	12	9	1	2	5	6	9	103
2008	1	1	1	2	5	0	3	4	4	1	1	4	27
1986	26	20	26	26	30	18	24	24	28	30	27	17	296
1981	7	10	14	12	12	2	4	6	16	27	15	7	132
1980	9	6	8	10	6	14	4	6	5	4	9	9	90
1972	0	3	8	8	10	2	0	11	8	10	8	4	80



Figure 5.211 Paddle Boat “Bungunyah” passing under Wentworth Bridge with the lift span raised to half height (Source: RMS)

Maintenance History

The bridge uses a programmable logic controller to operate four hydraulically operated lifting cylinders that ensure the span remains level during the six metre lift. The system also includes a set of traffic lights and boom gates.

During a planned shutdown in August-September 2013 the bridge underwent extensive repairs and upgrading. These works included replacement of the existing damaged hydraulic cylinders with new cylinders, with the latest seal and hydraulic control systems to improve reliability of the lift span operation. All sump pumps inside the piers were also brought to operating condition.

RMS Fleet Services developed a special method of placing the large hydraulic cylinders into the bridge without damaging the structure and with minimal disruption to road traffic. The method was computer modelled, and physically trialed, to ensure that the large cylinders, 9.5 m long and 6.5 tonne in mass, could be lifted by crane into a position to allow works to proceed underneath the road traffic. To speed up the construction program, a concept of lifting and incrementally adjusting the large hydraulic cylinders within the restricted space below the road deck was then developed, designed and fabricated.



Figure 5.212 View of bridge raised to full height in December 1992. Note operator at right on lift span

In addition, operator safety was improved by removing the operator's station from the lift span. This location was deemed unsafe in the event that that the lift span was stuck in the open position. The location also offered limited visibility to ensure that vessels had passed through completely before the closing sequence could commence (see Figure 5.213).



Figure 5.213 New operator's station controls

The new operator's station controls are installed on the southern fixed span of the bridge adjacent to the lift span. These controls now feature a PLC programme that allows remote access and any changes or troubleshooting can be done remotely. In another improvement to operator safety a new automatic vehicle barrier replaced the manual gate at the old operator control area.

Lastly, a new compact power unit replaced the old machinery that drove the hydraulic cylinders.



Figure 5.214 New motor installed to power hydraulic cylinders and electrical components on bridge

5.17.2 Statement of Significance

The Wentworth Bridge is the only table lift bridge to be built in Australia. Unlike other vertical lift bridges it lacks towers supporting counterweights and the movable components of the bridge are hidden from view when not in use. The lift span opens regularly every month to allow the passage of house boats and paddle steamers travelling up the Darling River from the Murray River. The local community is very reliant on the bridge as it provides the only crossing of the Darling River in Wentworth. The bridge is assessed as being of local significance.

Heritage Listings

Listing	Status
Australian Heritage Database (formerly the Register of the National Estate)	Not listed
OEH Heritage Division State Heritage Register	Not listed
Victorian Heritage Register	Not listed
Wentworth Shire Council Local Environmental Plan, 2011	Not listed
NSW National Trust Register	Not listed
RTA s.170 Heritage and Conservation Register	To be listed

Evolution of modifications

Due to the lack of precedent to this design, no evolution of modifications is distinguishable.

5.17.3 Description of lift span mechanism components

The Wentworth Bridge is a visually inconspicuous type of movable bridge. The lifting mechanism is largely hidden from view, contained inside hollow piers adjacent to the table span and as evident by Figure 5.215 the table span appears similar to the other approach spans.

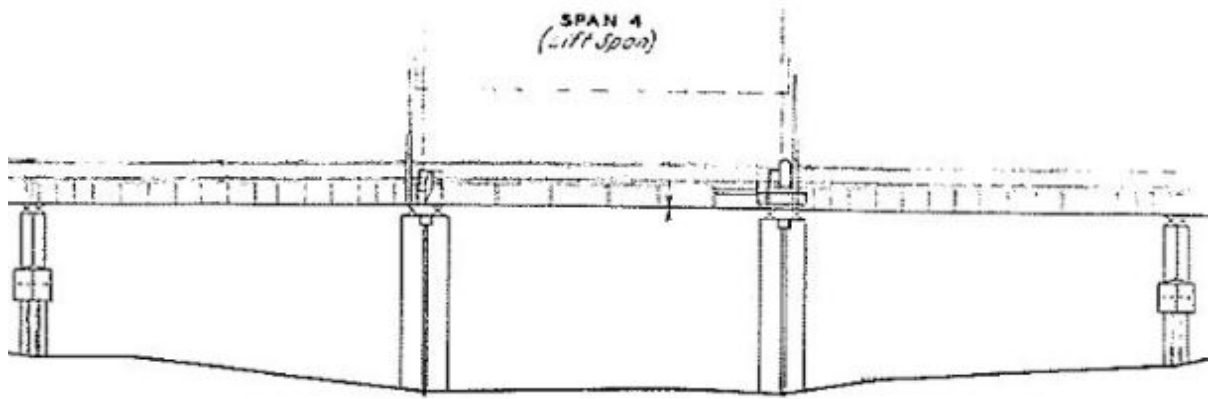


Figure 5.215 Elevation of Wentworth Bridge table span

Movable Span

The form and fabric of the movable span is EXCEPTIONAL significance.

The table span on Wentworth Bridge consists of two main steel girders 4 ft. 5 in. deep that are strengthened with transverse web stiffeners at regular intervals (Figure 5.216 to Figure 5.218).



Figure 5.216 Wentworth Bridge open position

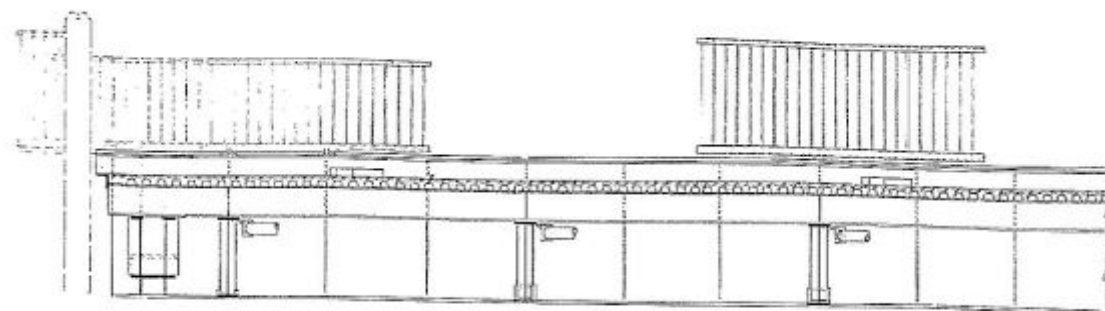


Figure 5.217 Wentworth Bridge table span main girders

The main girders support steel cross girders with depth 2 ft. 5 in. that are also strengthened by transverse web stiffeners. Rolled steel stringers bear on the cross girders and support the bridge plank sections and subsequently the road deck topping (Figure 5.218). The span is also laterally braced by circular hollow sections.

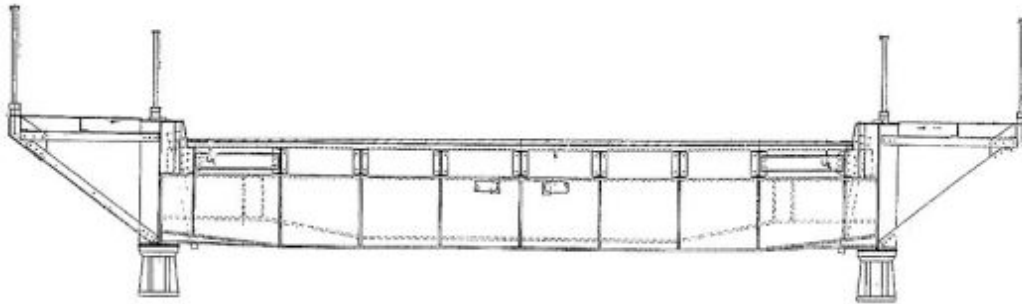


Figure 5.218 Cross girders on Wentworth Bridge

It is noteworthy that the table span has been fabricated with a camber as to create a level deck under dead load conditions thus reducing excessive deflections from traffic loads (Figure 5.219).

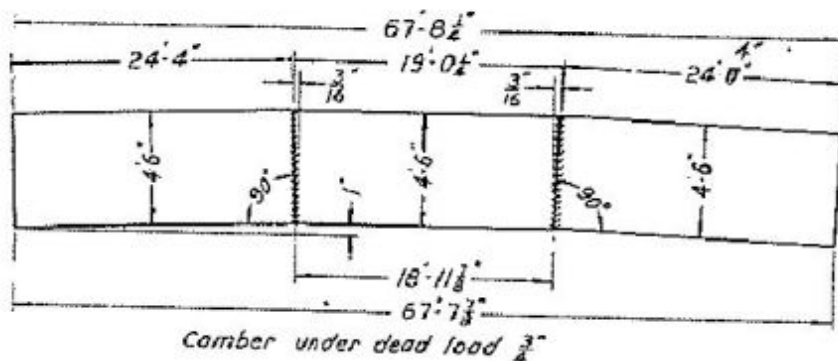


Figure 5.219 Main girder camber on Wentworth Bridge

When lowered, the lift span sits on steel fabricated bearing units at each corner of the span. Figure 5.220 displays the fabrication of the bearing units.

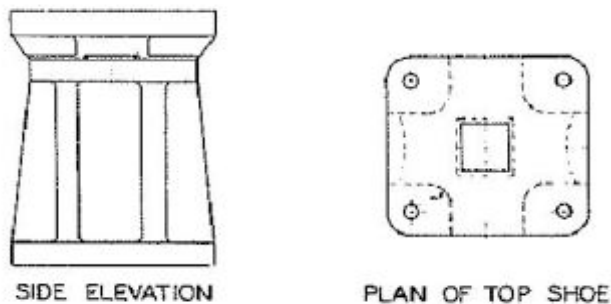


Figure 5.220 Wentworth Bridge lift span bearings

In 1992 remedial work was carried out on the movable span. This involved re-welding the ARMCO decking to the roadway stringers, patching of AC surface and applying a 10 mm reseal. The purpose of the reseal was to waterproof the running surface and prevent further moisture exposure to the ARMCO decking.

Preventing water penetration through the deck has been an ongoing maintenance consideration for The Bridge.

Mechanical components

The form and fabric of the mechanical components is HIGH significance.

The lift mechanism implemented on Wentworth Bridge is primarily a hydraulic system (Figure 5.221). Electric pumps provide the driving force of the mechanism and they are attached to telescopic cylinders positioned at the four corners of the vertical lift span. During operation the cylinders extend and raise the span vertically approximately 6.5 metres from rest position, maintaining a level span throughout the lift. Due to the inherent strength of the cylinders, no counter weights are required in the Wentworth Bridge mechanism.

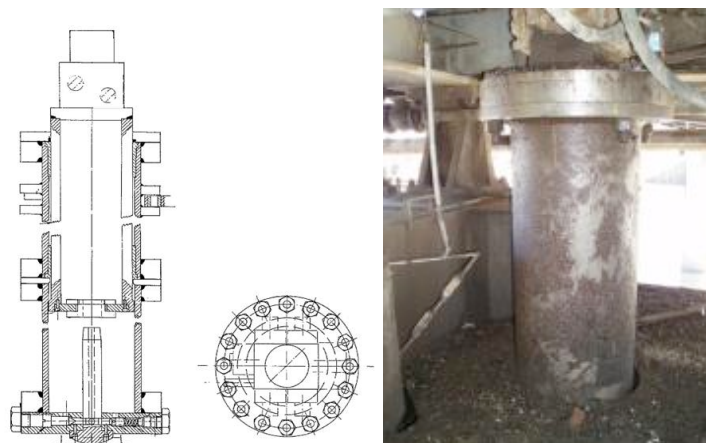


Figure 5.221 Wentworth Bridge cylinder

In 1991 the following information on the hydraulic cylinders was recorded in Bridge File DMR 22/485.120/3:

Cylinder diameter	= 250 mm
Normal operating pressure	= 900 psi
Maximum operating pressure	= 1050 psi
Normal operating capacity of Hydraulic Rams ram	= 30.46 tonnes /
Combined capacity of 4 Hydraulic Rams = 4 x 30.46	= 121.8 tonnes
Maximum operating capacity of Hydraulic Rams ram	= 35.54 tonnes /
Combined capacity of 4 hydraulic rams = 4 x 35.54	= 142.2 tonnes

Estimated total weight of existing lift span including decking with reinforced concrete infill = 101.0 tonnes.

The hydraulic rams have the capacity (121.8 tonnes) to carry the total estimated dead load of the lift span with the reinforced concrete infill (101.0 tonnes).

The cylinders in the mechanism are housed with piers 3 and 4 at side of the span (Figure 5.222). These piers are a reinforced concrete construction that are founded on concrete piles. Voids in the centre of each pier, and subsequent ladders, provide access for maintenance.

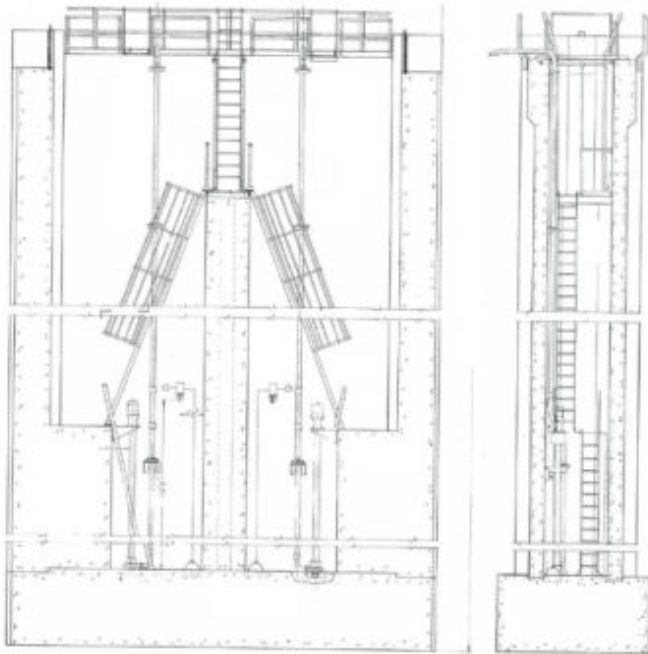


Figure 5.222 Wentworth Bridge pier 3 & 4 detail

Vehicle and pedestrian barriers

The form and fabric of the vehicle and pedestrian barriers are LOW significance.

One of the safety features installed on the Wentworth Bridge are the end gates which automatically close prior to span operation (Figure 5.223 to Figure 5.223). The gates are driven by small electric motor mounted at the abutments each end of the bridge. Smaller pedestrian gates are also mounted on the bridge with the either electrical or manual operation required to close them.



Figure 5.223 Vehicle barrier Wentworth Bridge

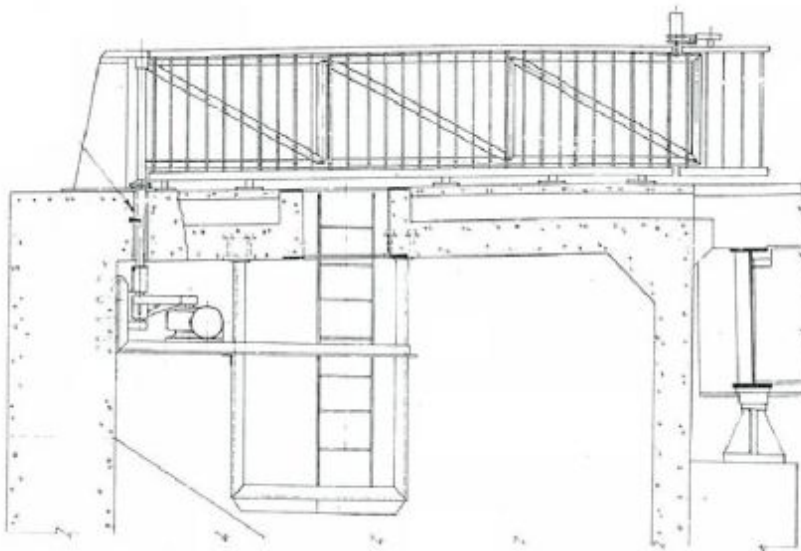


Figure 5.224 Vehicle barrier mechanism Wentworth Bridge

Motors and electrical

The form and fabric of the motors and electrical components are LOW significance.

There are a number of electrical components on Wentworth Bridge. They effectively operate the electric pumps, which drive the hydraulic mechanism and operate the vehicle and pedestrian gates. Electrical systems also operate the signalling for both the road traffic and vessels that pass beneath the bridge.

Summary of heritage assessments

The significances of each bridge component are summarised in the table below.

Table 5-36 Wentworth Bridge – Summary of heritage significance

Bridge Component	Significance Grading
Movable Span	EXCEPTIONAL
Mechanical components	MODERATE
Vehicle and pedestrian barriers	LOW
Motors and electrical	LOW