Medlow Bath Pedestrian Bridge

Optioneering report

November 2021 | Version: 3

Contents

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1 Purpose of this report

This report documents the strategic development and optioneering process applied to reach the preferred design of the pedestrian bridge displayed as part of the Review of Environmental Factors of the Medlow Bath Upgrade.

2 Existing Provisions

The design development process undertaken for the Medlow Bath Upgrade design started with a review of the existing conditions, features and deficiencies that could be addressed as part of planning for the widening of the Great Western Highway to a dual divided carriageway.

For more information on the Great Western Highway Upgrade Program objectives and design standards applied to the *Medlow Bath Upgrade Review of Environmental Factors (MRB July 2021)*.

Village context – 2016 Census

Census Data indicates that Medlow Bath is a community with an ageing population. Over fifteen years the proportion of children (0-14 halved from 23.4% in 2001 to 11.4% in 2016). During that same period, the proportion of residents aged over 65 years almost doubled from 10.6 to 20.4 per cent. High quality urban amenity, public transport links and mobility provisions are crucial elements to maintaining an active lifestyle, mobility and independence in the elderly.

Crossing the Great Western Highway

The table below lists a review of treatments on the existing upgraded sections of Great Western Highway between Emu Plains and Katoomba identified treatment types in use at other previously upgraded sections through the lower Blue Mountains.

Pedestrian Crossing of the Great Western Highway between Emu Plains and Katoomba

Location	Crossing Type	Connects with Rail Station	Highway grade separated
Glenbrook	*TCS Intersection*	*No*	*No*
Blaxland	*Pedestrian Bridge*	*Yes*	*Yes*
Warrimoo	*Pedestrian Bridge*	*Yes*	*Yes*
Sun Valley & Valley Heights	*Pedestrian Bridge*	*Yes*	*Yes*
Springwood	*Town & Station Bypassed*	*N/A*	*N/A*
Faulconbridge	*Pedestrian Bridge*	*Yes*	*Yes*
Linden	*TCS Pedestrian Crossing*	*Yes*	*No*
Woodford	*Pedestrian Bridge*	*Yes*	*Yes*
Hazelbrook South	*Pedestrian Bridge*	*No*	*Yes*
Hazelbrook	*Pedestrian Bridge*	*Yes*	*Yes*
Lawson	*TCS Intersection & Underpass*	*Yes*	*Yes*
Bullaburra	*Pedestrian Bridge*	*Yes*	*Yes*
Wentworth Falls	*TCS Intersection*	*N/A*	*N/A*
Leura	*Town & Station Bypassed*	*N/A*	*N/A*
Katoomba	*TCS Intersection*	*Yes*	*No*

2.1 Existing features

The existing access across the Great Western Highway and Western Railway Line occurs at several locations within the township of Medlow Bath. These existing facilities link transport elements such as bus stops and the Medlow Bath Railway Station with the adjoining local footpath network. These paths provide formal and informal connections to Medlow Bath Park, commercial operations such as the Hydro Majestic, Mazda dealership, United Service Station and a Tournament Café in Railway Parade.

The existing access comprises:

- A 1.2m wide footpath along the western side of the highway
- An existing at grade pedestrian crossing with small central refuge island on the highway
- Pedestrian level crossing at the southern end of the platform at Medlow Bath Station which provides connection between the highway and Railway Parade and the station platform via a steep ramp
- Access to the northern end of the platform via a pedestrian bridge and stairs. The bridge also provides access between the eastbound side of the highway and Railway Parade
- Signalised pedestrian crossing at the intersection of the highway and Railway Parade/Station Street
- A westbound bus stop on the highway south of the Hydro Majestic Road bar
- An eastbound bus stop on the highway at the station
- A school bus stop on Railway Parade opposite the station

The key access routes and related features around the Station Precinct are shown in Figure 1.

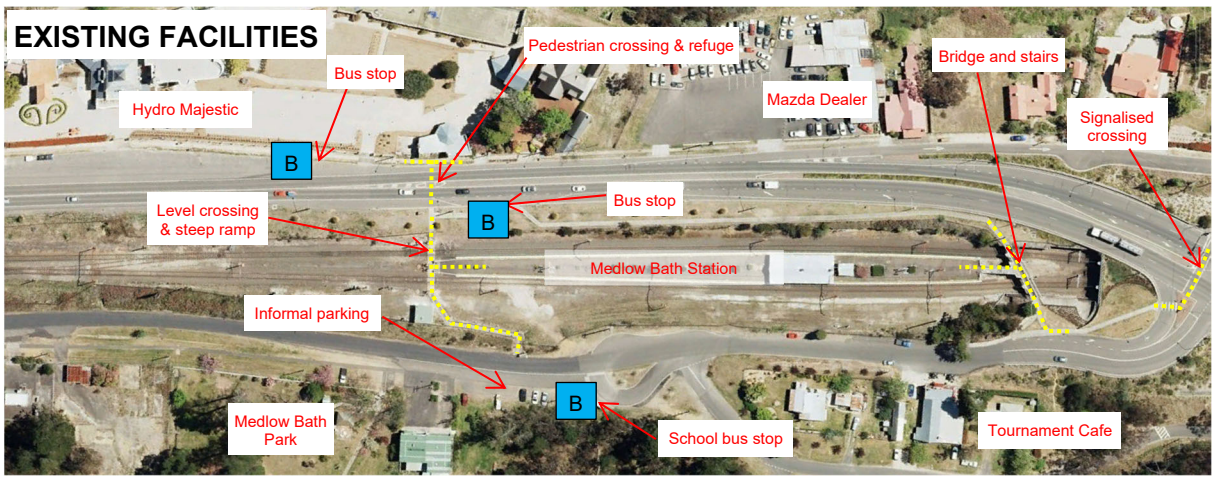


Figure 1-Existing transport facilities and features

2.2 Issues with the existing arrangement

The existing access arrangement has several deficiencies in the current two-lane configuration that could not support the planned four lane highway configuration to be

delivered as part of the Great Western Highway Upgrade Program (GWHUP). The following deficiencies and issues are noted:

- The existing highway pedestrian refuge is substandard and has a crash history which includes FSI crashes involving pedestrians. The refuge is the priority location used for pedestrian access across the highway in the community, so safety incidents involving traffic would continue to occur and likely increase in frequency over time as growth occurs
- The existing at grade pedestrian refuge connects at a constrained section of the highway corridor between rail and the local heritage listed Hydro Majestic Road Bar. The provision of four lanes plus the refuge would require direct impact on the rail corridor or the Hydro Majestic Road Bar structure due to the limited corridor width at this location
- The pedestrian level crossing across the railway tracks has a documented history of reported rail safety incidents involving pedestrians and trains. The removal of at grade level crossings is a priority initiative of Transport for NSW to improve railway safety
- The gradient of the ramp that connects the rail level crossing and the platform does not meet current accessibility standards. The station is not currently accessible or compliant with Disability Standards for Accessible Public Transport (DSAPT) requirements
- The bridge at the northern end of the platform does not meet current accessibility standards as it only provides stair access (no mobility provisions). The northern bridge is also located away from the desire line for most users, as such it's use is limited to pedestrians accessing the Café, Station Street or Coachhouse Lane. There is no defined footpath on Railway Parade south of the existing footbridge, and uncontrolled parking occurs along this area. Formalised commuter parking is not provided at Medlow Bath Station
- The existing school bus stop was placed in Railway Parade in response to safety concerns with students accessing buses on the highway. This stop prevents students exchanging between buses from having to cross the highway
- Existing bus stops are substandard facilities that are located on routes that have accessibility restrictions in all paths of travel to the Medlow Station
- Via level crossing – varies between 140m and 200m to centre of platform
- Via northern bridge – varies between 194m and 399m to centre of platform
- Via Station Street TCS – up to 575m to centre of platform
- Tourism and inter village active transport connections with the Great Blue Mountains Trail are limited, with few reasons or opportunities to cross to the eastern side of Medlow Bath. The railway line and the highway create elements that in lieu of improved connection creates a barrier that limits the urban amenity of eastern parts of Medlow Bath.

Figure 2 shows the existing features and desire lines for public access.

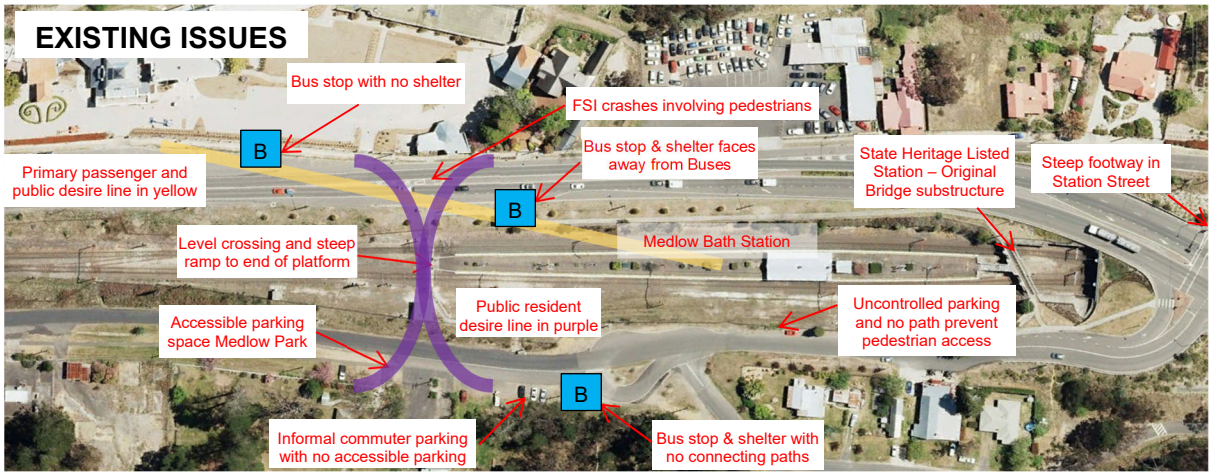


Figure 2-Existing transport related desire lines

2.3 Pedestrian Data

Pedestrian and transport user data has been collected for review from a range of source locations. The raw data from a range of sources is available in Appendix A.

Pedestrian and transport user data can be summarised as follows:

- Historical data from 2004 to 2019 gives a broad baseline of the commuter and tourist generated passenger volume which can be used to give a reliable growth baseline for passenger use, given the impact the COVID 19 Pandemic.
- Based on barrier count data and video pedestrian surveys undertaken, the level crossing was the preferred access point for 76% of passengers getting on, and 66% of passengers getting off the train.
- Safety Data analysis demonstrates FSI crashes and rail safety incidents involving pedestrians at the pedestrian crossing south of Medlow Bath Station.

2.4 Transport Accessibility DSAPT findings

The station precinct was audited by a consultant to assess its current accessibility. Medlow Bath Station was deemed not accessible, for the following reasons:

- stairs or very steep ramp being the sole access to the platform
- platforms, access paths of travel and ramps have narrow widths, limited circulation area and passing spaces
- Station facilities including help points, information points, and poster cases need to be relocated so that they are accessible
- Platforms have narrow sections ranging from 1000mm to 1050mm and steep gradients up to 1:30 and 1:31 respectively at Boarding Assistance Zones
- Stairs with non-compliant features are the sole means of access from the existing pedestrian bridge to the platform (at the country end)
- Ramp on city end of platform is non-functional due to steep gradient, missing handrails and kerb rails
- Pathways between the station and existing bus stops are non-existent or non-compliant, and exceed 60m without rest areas
- Accessible kiss and ride, and parking facilities are not available at Medlow Bath station.

3 Future Planning

3.1 Planned upgrade of the Great Western Highway

The Great Western Highway Upgrade Program proposes to deliver 34 kilometres of four lane divided highway between Katoomba and Lithgow. The NSW Government has committed $2.5 billion in funding towards the planning and construction of the duplication.

In November 2019, the strategic corridor for the proposed upgrade between Katoomba and Lithgow was put to the community for feedback. This included the previously reserved corridor from Mount Victoria to Lithgow and a new corridor between Katoomba and Mount Victoria.

The Government prioritised Medlow Bath as the first section of the Great Western Highway to be upgraded because:

- known safety concerns can be addressed sooner
- ongoing safety and accessibility benefits can be provided for local traffic and pedestrians while the remaining corridor is developed
- the corridor is well defined so the highway can be widened with minimal property and environmental impacts
- upgrading the township first prevents congestion when the links between towns are built.

3.2 Design requirements

To meet the objectives of the Government commitment, the following key points were observed in developing and considering options for pedestrian access at the Medlow Bath Station precinct:

- Highway is being upgraded to 4 lanes
- Consider where people currently choose to cross the road
- There is no space to retain or relocate the highway pedestrian refuge
- Without the pedestrian refuge, the rail level crossing no longer links to anything
- Could pedestrians be directed to the Great Western Highway/Station St/Railway Pde signalised crossing instead?
- People will need to cross the road at new and desired locations
- To meet the objectives a new link is needed that connects the primary desire lines and the public transport interchange
- The new link needs to connect with relocated & upgraded bus stops to suit the new widened highway
- Pedestrian data demonstrated primary desire line is refuge & rail level crossing; this also provides the shortest links to the public transport interchange
- Heritage considerations – infrastructure visual impact & space requirements

- Any new piece of state infrastructure that connects the township and the public transport interchange, needs to be DSAPT complaint (it needs to be accessible)
- If providing a safe grade separated rail crossing, the level crossing is made redundant and must be removed in alignment with the level crossing policy; this would also improve safety at the station
- Current and relevant highway and railway safety standards must be met by any option crossing their respective corridors.

3.3 Future Desire Lines

New crossings of both the highway and railway would be required to serve multiple desire lines in the future state. Upgrades would need to facilitate crossing of four lanes, improve pedestrian connectivity, improve urban amenity and improve transport access over both road and rail corridors for people of all abilities.

The southern end of the station platform is the area that remains common to most projected desire line paths in the future state. While the northern bridge and signals at Station Street may attract some pedestrians, the difficulties on this route would be much less desirable to users of all abilities. Regardless of engineering design options, the dominant public desire lines will remain towards the south end of the station.

The Great Western Highway Upgrade Program aims to upgrade the Great Blue Mountains Trail to a higher standard active transport link between Katoomba and Blackheath as part of implementing NSW Government and BMCC strategic plans. Specifically, Project 7 of the NSW Government Sydney's Western Green Grid Strategy aims to create a major east-west link between Penrith and Blackheath, while Action 2 and 6 of Councils Integrated Transport Strategic Plan both aim to separate users from traffic with dedicated facilities.

Future new pathway connections between Medlow Bath and Blackheath on the eastern side of the railway, would connect with Park Street feeding these active transport users through the Medlow Bath Station precinct to reach the western side of the Great Western Highway.

Future desire lines are shown by Figure 3.

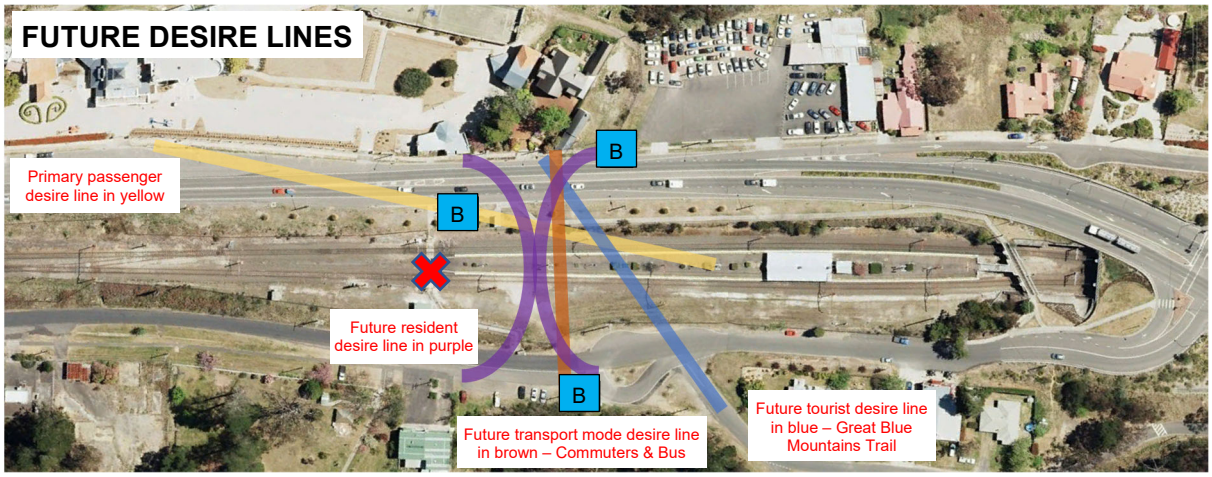


Figure 3-Future transport precinct desire lines

4 Strategic Design Approach

The first step taken was identifying design scenarios with the potential to meet the program objectives and design requirements. The different approaches were discussed and considered through a feasibility lens.

At grade and grade separated options were reviewed strategically, with consideration given to each. Strategic options for a new crossing could loosely fall into 4 strategic approaches:

- At grade pedestrian signals or diversion to the Station Street traffic signals
- Retrofits to the northern pedestrian bridge with connecting elements via Station Street traffic signals
- New underpass pedestrian tunnel with connecting elements
- New pedestrian bridge with connecting elements

Options that were not suited to the site constraints and could not meet the objectives were not progressed to design.

4.1 At Grade Signalised Crossing

The existing road crossing facilities are unsuitable in an upgraded highway design as design standards do not permit such a narrow treatment on a four lane divided highway. A compliant pedestrian refuge could not be provided at the desired location without risking impact to heritage buildings due to the constrained roadway width between the Hydro Majestic Road Bar (locally heritage listed) and the station.

While the existing refuge and level crossing is close to the desire line for the users in the future state, an uncontrolled pedestrian crossing facility would not be consistent with other treatments in other lower Blue Mountains townships where treatments assure pedestrians can safely cross the Great Western Highway.

A narrow unprotected and uncontrolled pedestrian refuge does not meet current road design standards and would not prevent future crashes involving pedestrians with highway traffic. To meet design standards, a fully signalised pedestrian crossing would be needed with sufficient crossing time for all users to cross the highway without stopping.

The desired location, at less than 300m from the Station Street / Railway Parade TCS intersection, could create signal timing issues due to the operational nature of both sites. This could generate uncontrolled delay conditions during peak periods which then generates knock on increase in noise and emissions due to increased need for vehicles stopping and starting.

The impact that this type of at grade signalised crossing would have on highway traffic flow would directly contradict GWHUP objectives and benefit realisation.

From a rail safety perspective, the at grade level crossing would also need accessibility improvement to meet current standards if the existing refuge location were to be maintained as the design crossing location.

Decision Statement

Based on safety concerns (road and rail), heritage constraints (Hydro Majestic Road Bar) and poor traffic performance outcomes, an at grade pedestrian crossing was not progressed through strategic design.

4.2 Diversion to Station Street

Closing the pedestrian refuge on the highway and redirecting users to the Station Street signals was also considered. This would take users well away from desire lines on a much longer detour.

The trip distance between key points could reach 600m which offers no improvement to the existing site deficiencies. Hydro Majestic visitors travelling by train would be the worst affected.

This would likely lead to ongoing user compliance issues with uncontrolled crossing of the highway near the rail level crossing. Pedestrian fencing or lengthy physical barriers would be needed to redirect pedestrians toward Station Street.

Increasing pedestrian demand at the Station Street traffic signals would only further reduce the efficiency of this intersection, while steep grades in Station Street would also require accessibility improvements. With limited space to accommodate changes switch back ramps to address grade issues would only further increase distance for users.

Other transport infrastructure such as commuter parking, bus stops and kiss & ride spaces could not be provided at the constrained Station Street intersection.

By directing users away from the desire line pedestrian accessibility objectives are not met. As a result, this type of at grade redirected approach was considered a poor outcome for highway traffic, local traffic, pedestrians and transport users across the board.

Decision Statement

Due it's poor location relative to transport elements such as bus stops and desire lines, redirecting pedestrians to cross at the existing Station Street traffic signals was not progressed through strategic design.

4.3 Northern Bridge Diversion

The potential to install a lift at the northern pedestrian bridge was considered in early strategic optioneering. Users would be directed via the Medlow Station northern pedestrian bridge (which would need to be upgraded, replaced and/or supplemented with lifts to provide equitable access with users then crossing the highway at Station Street.

As is the case with the Station Street at grade diversion scenario, other transport infrastructure such as commuter parking, bus stops and kiss & ride spaces could not be provided at the constrained Station Street intersection.

In the future state via the northern pedestrian bridge, users would experience a 150m increase in journey length to reach the Railway Parade transport infrastructure and at least a 220m increase in journey length to highway bus facilities (measured from the existing centre of platform). Hydro Majestic visitors travelling by train would be the worst affected.

By directing users away from the desire line pedestrian accessibility objectives are not met.

The travel paths of a northern bridge diversion are shown by Figure 4.

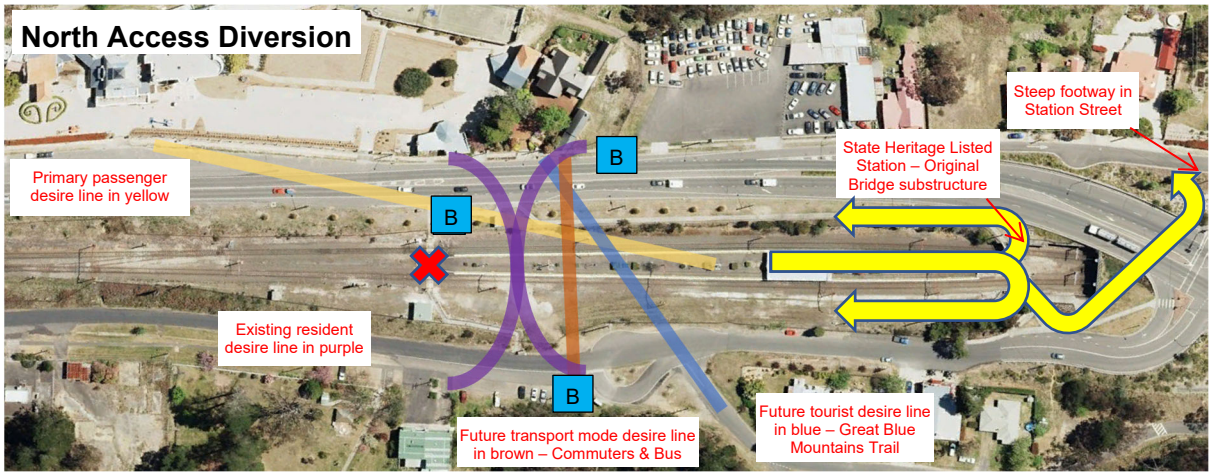


Figure 4 - Northern access pathways and desire lines

Lift access from the existing footbridge location would facilitate access to the platform only. This would not account for access to the wider station precinct including bus stops and any future accessible parking or kiss and ride facilities, as there is not enough space to co-locate these with the footbridge.

Engineering constraints were also confirmed during the concept phase due to limited width between the railway tracks at this location and the close proximity of the rail underpass below Station Street. Installation of a lift would require track relocation, platform extension and the modification of the road over rail bridge structure including its retaining walls. These impacts are all well beyond the scope of the highway upgrade project. These constraints meant a lift was not feasible at this location.

Concourse sub-option

To meet the engineering constraint, a substantial new concourse structure could be extended toward the existing station building over the northern end of the platform to provide a lift down to the platform.

Any extension of this structure over the platform would detrimentally impact on the heritage elements of the state heritage listed station due to the substantial width required to maintain circulation. An extended concourse structure over top of the station platform would permanently change the physicality of the Station as a whole.

In either scenario substantial modification of the existing northern pedestrian bridge would be required.

Heritage concerns weighed heavily on this as a strategic option, as the existing pedestrian bridge is still supported by the original substructure of the early 1900 era pedestrian bridge and the station buildings are located closer to the northern stairs. Any options that place the state heritage listing at risk were not progressed.

The principal of avoiding impact on the northern pedestrian bridge structure was later seen as desirable through preliminary discussions with Heritage NSW, due to the extensive impacts this kind of approach would generate.

Decision Statement

Based on poor accessibility outcomes, heritage constraints (Medlow Bath Station), rail track constraints, and limitations at the Station Street traffic signals, extending or modifying the northern bridge to incorporate a lift and concourse was not progressed through strategic design.

4.4 Pedestrian Underpass

During the strategic phase, the potential to install an underpass was considered. This was also raised by the community during the July 2020 public display of the strategic design. While this treatment would generally be inconsistent with other pedestrian grade separations of the existing highway between Emu Plains and Katoomba, the scenario was considered.

In the future state, users of the southern underpass would experience a minimum 100 metre increase in journey length to all transport facilities (measured from the existing centre of platform). This option could generally follow the primary passenger to Hydro Majestic desire line as shown in Figure 5.

The Railway Parade side could exit at road level, however this is a low volume pedestrian movement offering little net benefit. Positioning the underpass away from residential properties would also limit passive surveillance increasing CPTED issues (*Crime Prevention Through Environmental Design*).

While the underpass option is better suited to desire lines than the northern bridge and Station Street diversion options, by directing users away from other transport element desire lines, accessibility objectives are not met.

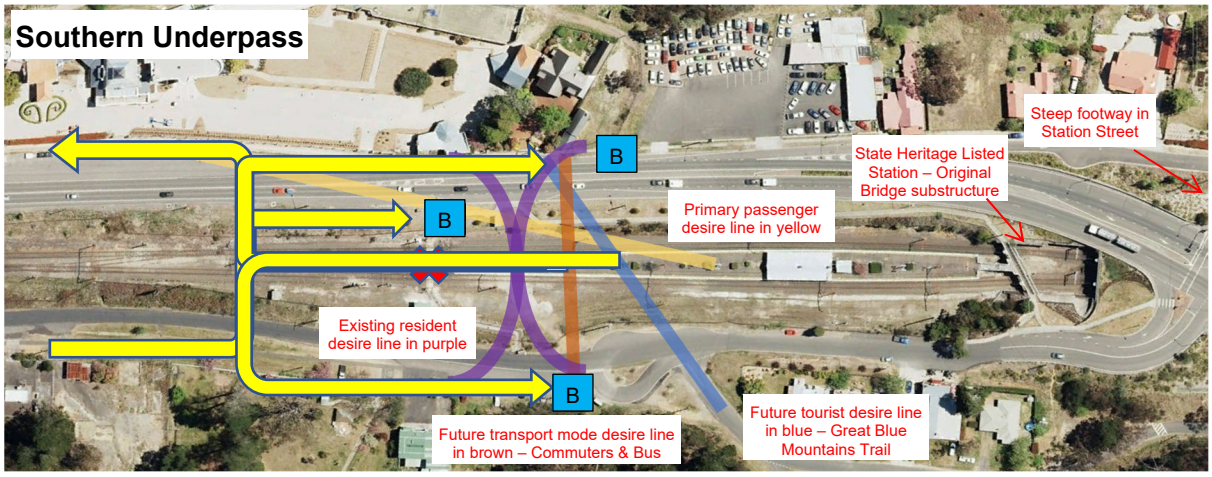


Figure 5 – Underpass access pathways and desire lines

Long gently graded ramps, lifts or escalators for users to return to the surface level on both sides of the highway would also need to be considered, including the physical impacts on utilities, drainage and private property impact that these would generate.

Heritage concerns subsequently weighed on this option, as any tunnel ramp, lift or escalators would need to surface on the western side of the highway in front of the Hydro Majestic Hotel and/or at the Hydro Majestic Road Bar while also impacting on the original sandstone wall. This would likely have a detrimental impact on the locally heritage listed tourist destination.

Engineering constraints also arose due to the strict rail safety requirements for constructing pedestrian tunnels under active railway tracks. The high complexity of construction staging, limitations of rail standards and poor outcomes for user security limited the effectiveness of an underpass at this location.

Decision Statement

Based on poor accessibility outcomes, security concerns for users, heritage constraints (Hydro Majestic Hotel, Stone wall and Road Bar), and highly complex rail constructability requirements, an underpass option was not progressed through strategic design.

4.5 Pedestrian Bridge

A pedestrian bridge scenario could meet the objectives of accessibility and safety, while best fitting with desire lines, subsequently improving access across the precinct. This was due a bridges ability to connect with all adjoining transport elements and desire lines in the shortest possible distance.

The northern bridge and Station Street connection could remain in this scenario as a supplementary access point, while primary access would be directed via the pedestrian bridge to access all transport elements via lifts at each location.

The proximity to desire lines is shown in Figure 6.

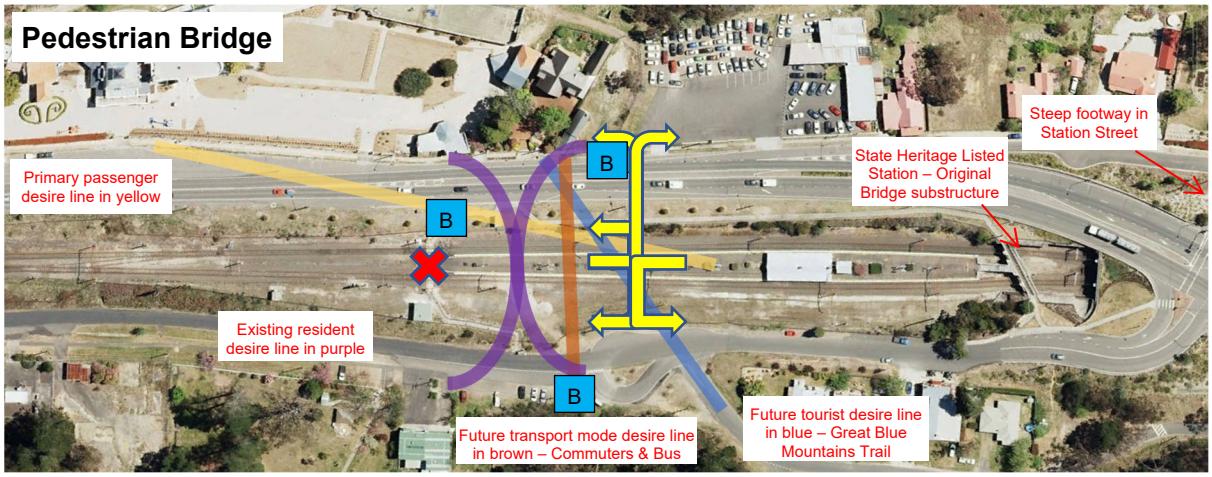


Figure 6 -Existing transport facilities and desire lines

A pedestrian bridge could offer the most flexibility to achieve the GWHUP accessibility objectives by providing opportunities for improved urban amenity, placemaking, improved surveillance and accessibility across the precinct for all users.

Heritage impact on both Medlow Bath Station and the Hydro Majestic remained a substantial factor in considering the feasibility and structural elements of this scenario. By limiting the bridge to lift and stair arrangements, the accessibility aspects could be optimised, while also limiting the physical footprint and visual impact on these heritage sites.

Direct impact could be completely avoided on the Hydro Majestic curtilage, while station impacts would be concentrated on the southern end of the station away from the main station buildings and northern footbridge.

This option would generally be consistent with other treatments on the Great Western Highway, however the structure type and engagement with the community would play a key role in public acceptance of the outcome as some bridges have generated higher visual impacts than others.

If progressed, the type of structure would need careful consideration in design due to the visual impact a pedestrian bridge would generate at Medlow Bath. The greater visual impact of a bridge option within a heritage area and the indirect impacts it could generate would need further attention as part of design development and the environmental assessment.

Decision Statement

Based on optimal accessibility outcomes, least impact potential on heritage sites and consistency with other locations in the Blue Mountains a pedestrian bridge option was progressed through strategic design.

4.6 The Preferred Strategic Option

The primary benefit which led to selection of a pedestrian bridge as the preferred strategic option, was the ability to best fit with desire lines in both the existing and future state. Comparative access distances for the respective options are shown in the following table with the preferred strategic option highlighted in green.

Transport Element	Station to eastbound bus	Station to westbound bus	Station to Railway Pde school bus	Station to commuter parking
New Pedestrian Bridge	116m	86m	97m	95m
Existing Condition	140m	196m	183m	180m
Southern Underpass	259m	235m	313m	283m
Via Northern Bridge & Station St	366m	471m	312m	310m

Other factors which influenced the selection and subsequent refinement of the preferred strategic option included:

- Optimising safety for all users including removal of the railway level crossing to improve pedestrian rail safety
- Maintaining the operation and functionality of the Great Western Highway
- Consideration of Great Western Highway regional context and the Urban Design Strategy applied between Emu Plains and Lithgow to date
- Opportunities for surrounding views afforded by a bridge (place making)
- Minimising impacts to Heritage based on both the Hydro Majestic (Locally Listed) and Medlow Bath Station (State Listed) through reducing structure form and footprint, considering circulation, physical heritage element impact and adjoining interfaces
- Security and safety - bridges are 'open' structures which allow users to see and be seen
- Making best opportunity of GWHUP to address DSAPT requirements as part of the Medlow Bath project through an integrated transport solution developed to limit the impact on community. One project delivery – rather than coming back for future TAP upgrades after the highway works are complete.
- Optimising accessibility in the future state for all users including those impaired by vision, hearing, mobility and other means as part of one project

5 Concept Design Options

Development of the concept design for the pedestrian bridge then focussed on how to minimise the visual impact and select a structure type best suited to the urban amenity of Medlow Bath.

Structural options excluded during initial discussions due to excessive or poor visual impact outcomes at Medlow Bath were:

- Standard TfNSW / RMS Tied arch bridge and steel arch designs
- Super T structure with deep supporting girders supporting thin deck with balustrades
- Suspension bridges and complex variants of this design

Ramps were also ruled out due the physical, visual and property impact these would generate. A lift and stair arrangement could provide the least visual and footprint impact while meeting all accessibility needs.

5.1 Design requirements

Any bridge option, while meeting transport standards in terms of anti-throw screens, lighting, CCTV and maintenance access would need to span the full width of the highway and each rail span with slender deck lines which would minimise visual impact.

Strict rail safety standards limit the use of paint over live tracks due to maintenance restrictions and fire safety ratings. Structural load supporting elements would need to be either weathered steel or concrete which must also be capable of withstanding derailment impact loads, substantial fire condition and meet full electrical earthing / bonding requirements.

5.2 Location considerations

The selection of a suitable location for the bridge was chosen after considering; space on the platform for stairs and lifts, proximity to Railway Parade bus stop and car parking and possible kiss and ride set-down and pick-up location; available land on the western side of Great Western Highway for lift and stairs and proximity to the proposed bus stops on the highway.

The height over the highway and rail both played a major factor in determining the final location of the bridge as any design needed to assure that BCA requirements for stairs balanced carefully with height requirements to clear highway traffic as the highway rises towards Station Street.

Figure 7 shows the access arrangement and optimised bridge location.

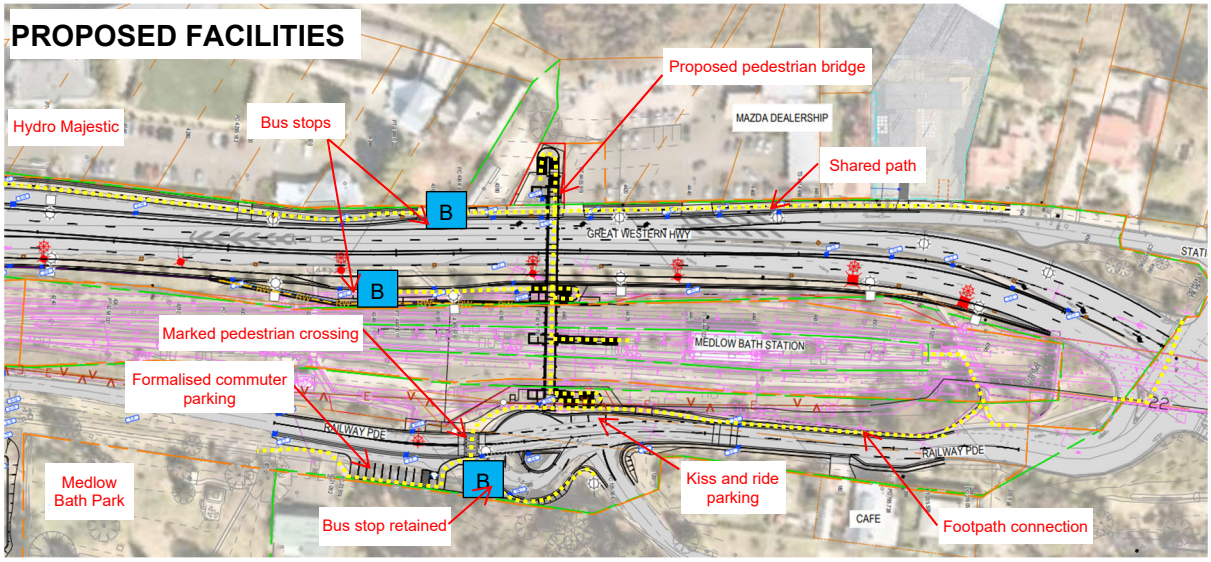


Figure 7 - Enhanced access links provided by proposed bridge

5.3 Choosing a bridge form

From the beginning of bridge optioneering, structural form and deck thickness had a big influence over the options presented. The location of the bridge and its surrounding environment required the bridge to be as slender as possible, maximising see through visibility while also considering other elements required such as hand rails, lighting, anti-throw screens and drainage.

Three structure types were considered during concept bridge design assessment:

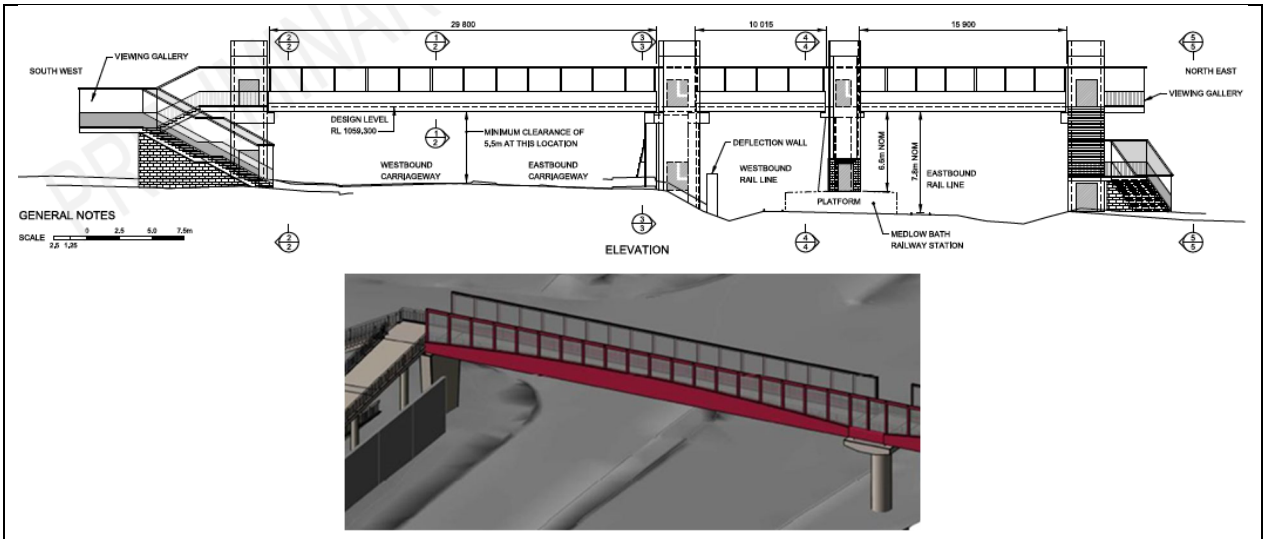
A. Concrete Through Girder a slim deck with solid concrete walls and attached anti throw screens and potentially a roof

B. Pratt Truss – A steel truss design with vertical, horizontal and angle elements tied together to sustain the loads (similar to Hazelbrook)

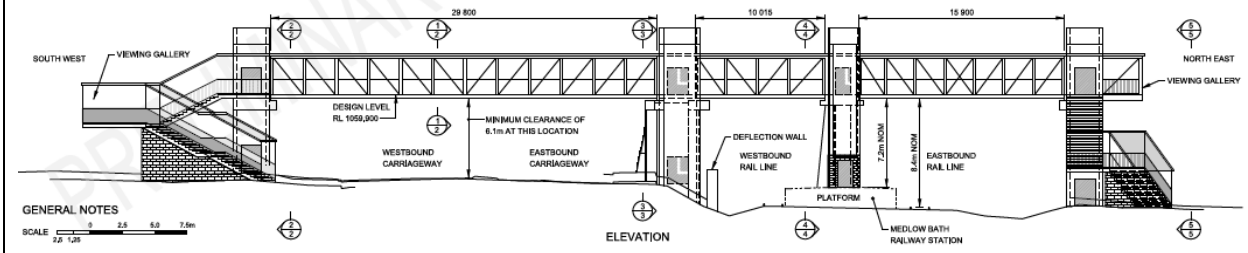
C. Vierendeel Truss – A steel truss without the angular members of the Pratt design. Thicker steel elements carry the load.

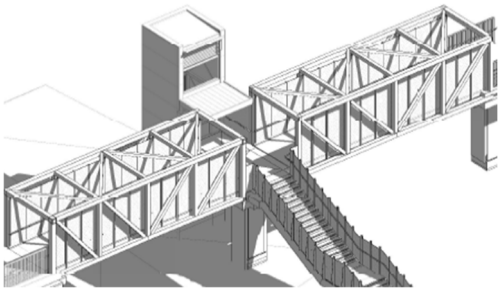
TfNSW considered various alternatives for a bridge solution as illustrated in Figure 8.

Concrete Through Girder Option



Pratt Truss Option





Vierendeel Truss Option

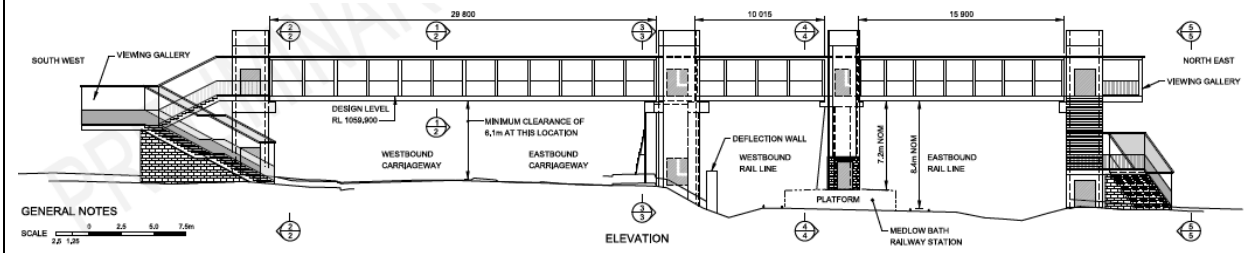


Figure 8 - Bridge forms considered

The three bridge options were developed for formal structural assessment and the production of a preferred concept structures report. The assessment matrix and findings are presented in Figure 9.

	Option 1 – Virendeel Truss	Option 2 – Pratt Truss	Option 3 – Concrete Through Girder
Spatial Arrangement and Cross-Section	Rigid connections provide a more robust truss structure vs Option 2. Uniform steel member size based on the critical span (Span 1) can provide fire design capacity for the other spans. Heavier steel sections required, compared with Pratt Truss (350SHS vs 200SHS) The full truss depth lies within the safety screens. Higher vertical clearance required above GWH compared with Concrete option Most flexibility in spacing of vertical members to provide even spacing	Lighter weight truss structure compared to Option 1. Uniform steel member size based on the critical span (Span 1) can provide fire design capacity for the other spans. The full truss depth lies within the safety screens. Higher vertical clearance required above GWH compared with Concrete option. More restrictions in spacing of verticals due to consideration of diagonal members	More robust and less sensitive to wind effects compared to Options 1 and 2. Fire rating can be easily achieved by increasing the cover. Lower vertical clearance required compared to Options 1 and 2. Inefficient span-to-depth ratios for the shorter spans. Safety screen will sit outside main superstructure members
Durability	Low corrosivity category environment for steel (C2)	Low corrosivity category environment for steel (C2)	Exposure classification A
Construction Issues	Superstructure will be lighter than Option 3, but heavier than Option 2	Lightest superstructure, therefore smallest mobile crane required to lift spans into place	Heaviest superstructure; large mobile crane required to lift superstructure into place.
Maintenance	Painting of superstructure will be required several times during the design life, necessitating encapsulation and temporary scaffolding. Other maintenance will include replacement of bearings	Painting of superstructure will be required several times during the design life, necessitating encapsulation and temporary scaffolding Other maintenance will include replacement of bearings	100 year design life can be achieved with minimal maintenance of concrete. Bearings will require replacement over the design life of the structure. Jacking loads will be larger than for steel options
Utilities and Drainage	May be possible to provide small diameter conduits within concrete deck	May be possible to provide small diameter conduits within concrete deck	More scope to accommodate conduits within superstructure More scope to accommodate drainage within superstructure
Work Health and Safety	Similar hazards during construction and maintenance	Similar hazards during construction and maintenance	Similar hazards during construction and maintenance
Departures from Standard	BCA Performance Solution Report required due to more than 36 stairs required on a straight alignment	BCA Performance Solution Report required due to more than 36 stairs required on a straight alignment	Fewer stairs required due to lower headroom, but departure from BCA requirements still required
Urban Design	Simplest and most elegant appearance. Open bay configuration (i.e. no diagonals) provides visual continuity across the piers, where users need to walk 'through' the truss.	Less elegant appearance; diagonals produce an asymmetric appearance in spans which have an uneven number of bays. Interruption of diagonals at the piers is visually discontinuous.	More robust structure detracts from surroundings
		Arrangement of diagonals for Pratt Truss non-symmetrical	
Capital and Whole Life Costing	Higher capital cost than Pratt Truss Option. Periodic painting less awkward than Pratt Truss Option due to flatter, larger surfaces.	Least amount of materials. More ongoing maintenance cost due to requirement for periodic painting.	Largest capital cost, lowest ongoing maintenance cost

Figure 9 - Bridge forms considered

The preferred option selected was a 3 span Vierendeel truss bridge with spans of 28m, 11m and 15m respectively. Each span simply supported on reinforced concrete piers.

The preference for a Vierendeel truss was primarily based on its visual advantages. The square truss bays are simple and the overall steel structure will be visually

elegant and sympathetic to the surrounding urban environment and landscape. The open bay configuration allows users to walk ‘through’ the truss when accessing it at the piers, providing additional opportunities to provide access to stairs and lifts away from supports.

The Pratt truss option would have diagonal members in elevation, which would be more visually intrusive than the Virendeel option. The arrangement of diagonals on a Pratt Truss is irregular due to the requirement for all diagonals to be in tension. Accordingly, the closest diagonal to the support is orientated in the opposite direction to the adjacent diagonals. Where there are an odd number of bays, a double arrangement of diagonals is required at the centre bay. A number of dummy members would be required at the supports to ensure the structure remains statically determinate and all diagonals remain in tension under all load cases.

The concrete through girder option offered a lower headroom than the steel options due to less onerous requirements for maintenance during the service life of the structure. However, due to the large span across the main carriageway, construction would be significantly more challenging, as individual element weights would be significantly larger. The through girder option would not adhere to the urban design principles stated in the Urban Design Strategic Report, by providing a ‘hard’, visually intrusive superstructure.

The key differentiators were:

- A concrete through girder option would not adhere to the urban design principles stated in the Urban Design Strategic Report, since it provided a ‘hard’, visually intrusive superstructure. This structure would also lead to heavier elements making construction much more challenging. While the main supporting structure could be a relatively simple form, the addition of anti-throw screens, and lighting would quickly lead to a very bulky physical form overall.
- A Pratt truss option would have had diagonal members in elevation including dummy members and supporting members leading to busier structural form. From an Urban Design perspective, despite a Pratt Truss having lighter structural members, the structure would appear more cluttered than a Vierendeel Truss Option leading to greater visual impact. Learnings from the Hazelbrook Pedestrian Bridge were also considered in the assessment of this option.
- The Vierendeel Option was found to be most feasible whilst providing the optimal urban design outcomes as it required the least structural elements, giving it a greater permeability and as such less visual impact. The simpler construction methodology compared to the through girder offered reduced impact on the road and rail operations.

The Vierendeel Truss option was progressed as the preferred structure type based on the assessment conclusions within the Concept Structures Report.

6 Detailed refinement of the preferred option

As design development progressed to the public display of the Review of Environmental Factors the project team engaged in a series of architectural challenge workshops. Specialists involved in this process included:

- Urban Designers
- Heritage Specialists
- Architectural Specialists
- Transport Access Program Engineers
- Civil & Structural Design Engineers
- The Project Manager

The workshops challenged a range of key issues in the design to assure the design was optimised before being presented to the community. The architectural challenge workshops examined a number of key refinement areas.

Weathering Steel

Weathering steel was chosen for the superstructure material. The provision of weathering steel simplifies the maintenance requirements, compared to ordinary structural steel. Weathering steel also reduces the need for periodic maintenance of the superstructure compared to painted steelwork.

Figure 10 – Image of 'Red Hands Cave'

The stable oxide 'patina' that forms on weathering steel obviates the need to paint the steelwork. The selection of a material with a red patina took inspiration from 'Red Hands Cave' near Glenbrook shown on the left; which fits naturally into the surrounding World Heritage Listed national park.

Further consideration and engagement would be applied through detailed heritage interpretation processes as design progresses.

The use of weathered steel was ultimately seen as an opportunity to best meet structural fire rating and maintenance requirements, while being visually appealing and sympathising with the surrounding village and heritage environment.

The use of weathered steel also allowed the level of the bridge to be lowered through the thinner deck and supporting structure it requires. This lowering of the soffit generated a number of other benefits, including minimising the visual impact of the bridge from its overall height, and deck thickness, while also reducing the number of stairs required to ground level.

Stair Layout

Extensive consideration was given to the layout of the stairs, lift wells and forecourt areas to assure circulating areas were clear, walking pathways most direct and the number of steps reduced. Consideration of maximising accessibility was consistently applied during all design iterations and workshops held.

A number of changes were made to the bridge, lifts and stair arrangement. These include:

- Moving the bridge 4 metres to the north, where the station platform had greater width to accommodate the stairs
- The stairs on the western side of the bridge were reversed to create a common entry space for the stairs and lift
- Lift shafts were repositioned to make them more visible at ground level
- Changing the lower section of the stairs to a built-in arrangement to eliminate the hard to maintain area under the treads

These refinements have led to the arrangement illustrated in **Figure.**11. The bridge provides safe access across the Great Western Highway, the rail tracks and also provides access to the Medlow Bath station platform by way of stairs and lifts.

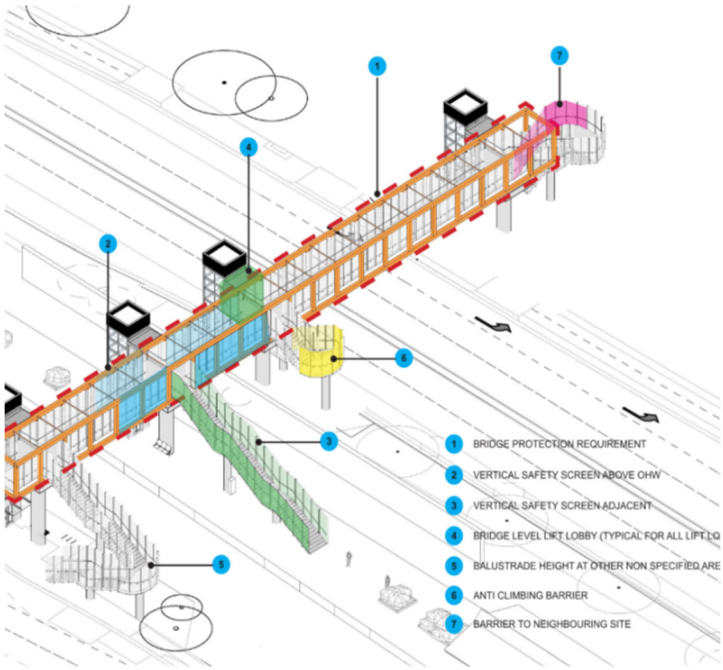


Figure 11 - Chosen bridge form

Workshop Outcomes

In its chosen form, the bridge is part of a package of improvements to provide accessible connections through Medlow Bath township. These improvements include:

- Safe grade separated crossings of the rail tracks and Great Western Highway
- DSAPT compliant accessible routes incorporating lighting to improve night-time security
- Improved connectivity by a new shared user path along the highway to Bellevue Crescent and beyond to Station Street
- Path connections to bus stops, parking and kiss and ride facilities
- Improved connections along Railway Parade
- Integration of landscaping and furniture such as benches and bicycle parking to provide an improved user experience

7 Next Steps

Following public feedback and the establishment of mitigation measures from the REF, further refinements would be incorporated through the later stages of design seeking to further reduce the visual impact of the structure.

Engagement with Heritage NSW is also required to gain formal approval of all aspects of work on the state listed Medlow Bath Station.

Cultural Interpretation Strategy

Surface treatments and interpretive aspects will also be considered further through a broader Great Western Highway Upgrade Program public engagement initiative.

Specialists in both Aboriginal and Non-aboriginal cultural heritage interpretation have been engaged to conduct a public engagement capturing heritage themes along the length from Katoomba to Lithgow for artistic representation and interpretation.

This process aims to capture and integrate artistic representations of the many historical stories capturing ‘Crossings’ of the Blue Mountains through all perspectives of the experience.

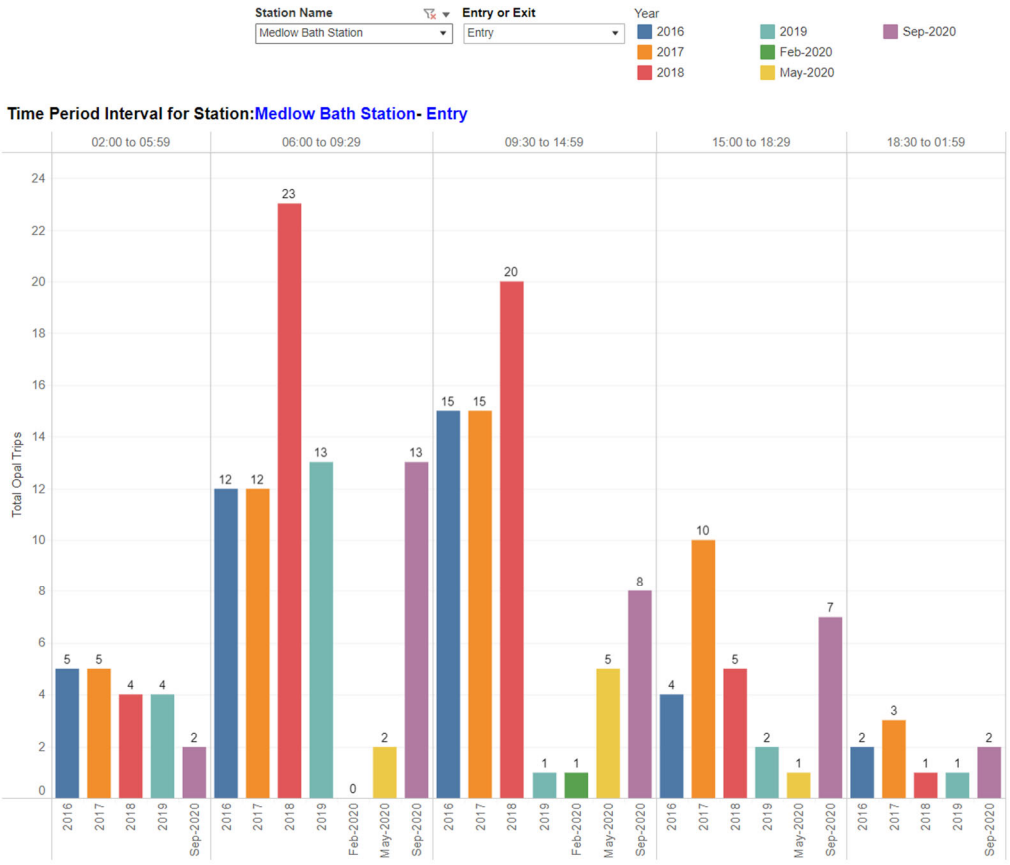
8 Appendix A

Pedestrian and Passenger Data

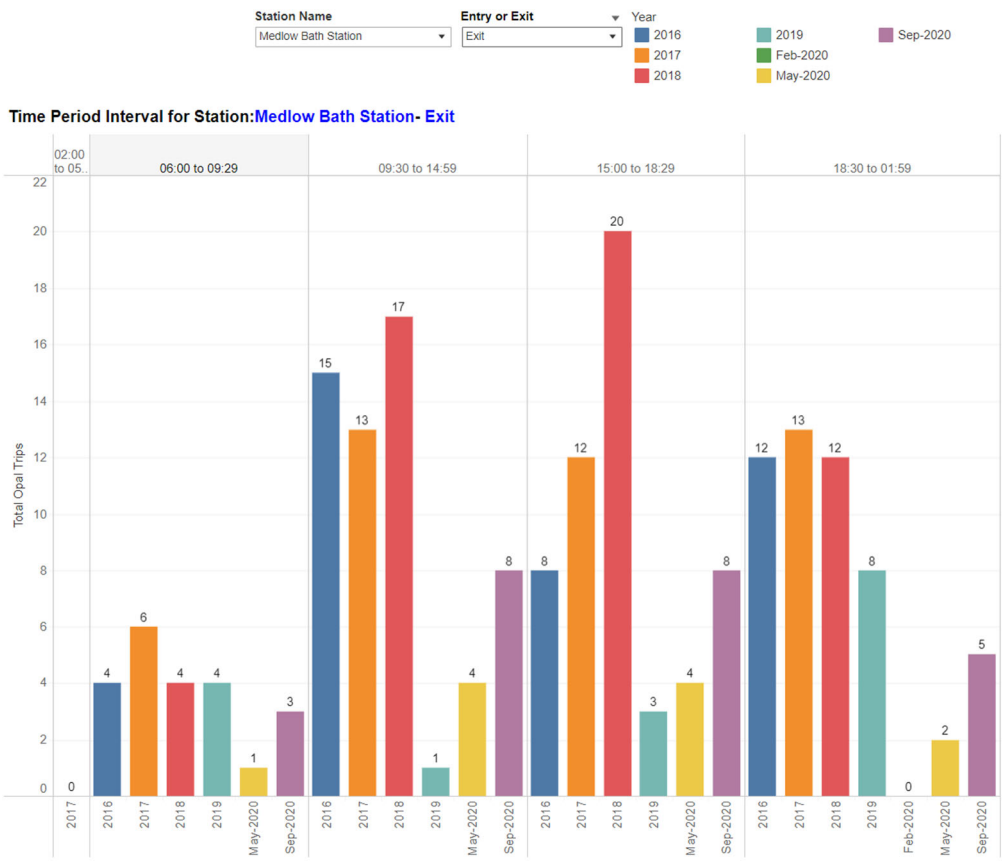
Available data from a range of sources is presented below. This data has informed the desire lines, future growth scenarios and design requirements.

8.1 Existing Station Passenger Data Sets (TfNSW)

OPAL Data Average Daily Use During Peak Time Periods 2016-2020



Average Time Period Opal Tap On Passengers 2016-2020



Average Time Period Opal Tap Off Passengers 2016-2020

The average daily rail passengers using Medlow Bath Station is provided by both Opal count and prior ticketing data in the table below. The impact of the Hydro Majestic remodelling on rail passenger trends can be clearly seen through the four year period 2011 to 2014.

Hydro Remodelling Closure Late 2010

Hydro Majestic Re-opening October 2014

Station	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Medlow Bath	20	60	60	60	120	120	140	80	80	80	60	-	77	-	81	117

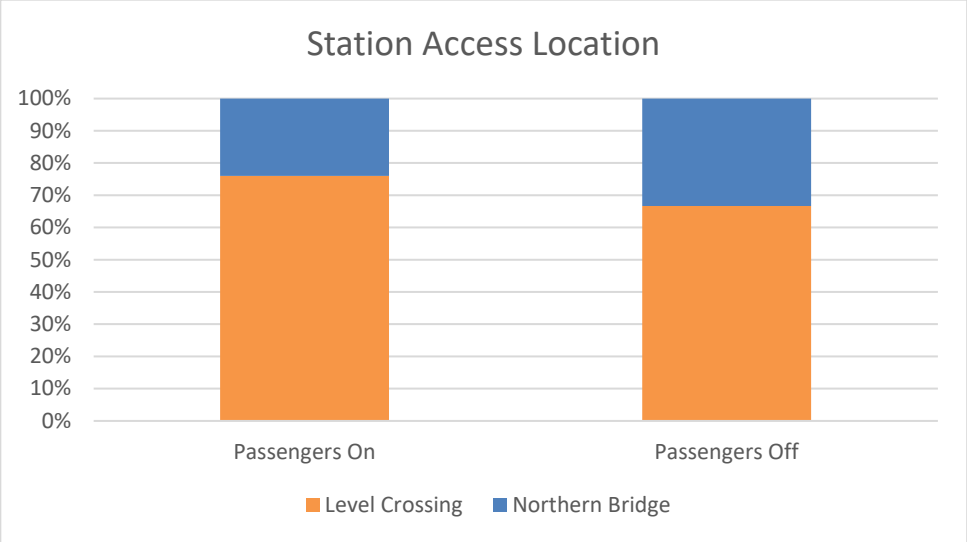
Average Daily Train Passengers 2004 – 2019

Data sources beyond 2019 show substantial variability due to the impacts of the Covid 19 pandemic on public transport use. The historical data from 2004 to 2019 gives a broad baseline of the commuter and tourist generated passenger volume split which can be used to give a reliable growth baseline for passenger use.

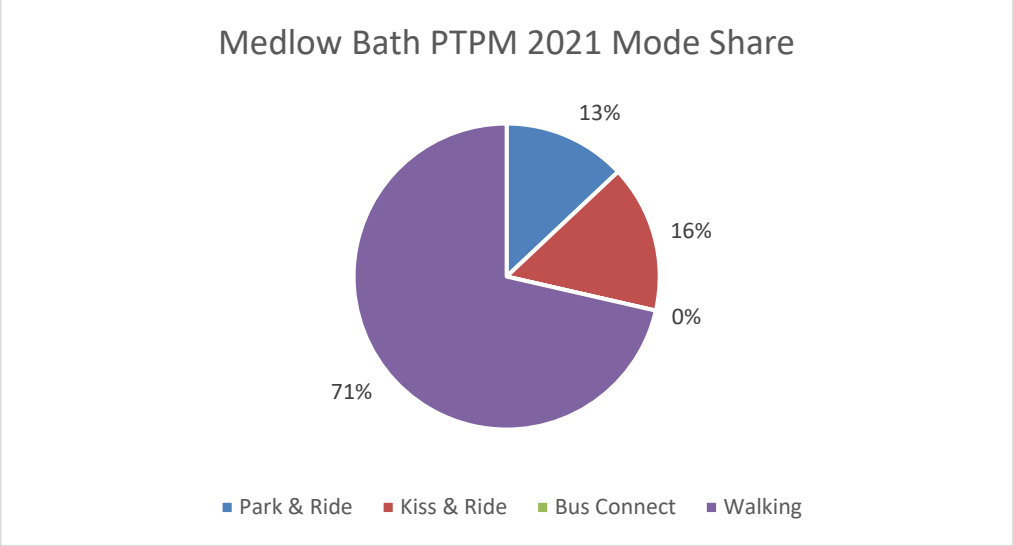
8.1.1 Patterns of Use

The Medlow Bath Station precinct is supported by a north and south connecting elements linking pedestrians to the Hydro Majestic Hotel, Mazda, United Service Station and residential areas west of the highway as well as the residential village, Café, Parks and nature area east of the highway and rail corridor.

Pedestrian count surveys taken in December 2020 demonstrated a split that favours the southern at grade pedestrian level crossing. Based on barrier count data and video pedestrian surveys undertaken in December 2020, the level crossing was the preferred access point for 76% of passengers getting on, and 66% of passengers getting off the train.



Despite relatively low volumes of use, hourly arrival of passengers does observe a basic mode split in the existing state. The PTPM Station Access / Egress – AM Peak 1hr data set by TFNSW for the 2021 base year (M019) model assumes a mode split at Medlow Bath as described below.



Based on mode split, transport node locations, barrier counts and pedestrian surveys the pedestrian desire line for rail passengers favours the southern level crossing for the majority of users.

8.2 Existing Bus Passenger Data (TfNSW)

Bus passenger data collected from TfNSW public transport CDC bus routes show monthly bus patronage at Medlow Station over the 2019 year. This data does not include passengers using Lithgow Coachlines or other Coach Services.

Tap ON Location	J	F	M	A	M	J	J	A	S	O	N	D	2019 Total
GWH Medlow Station (northbound)	24	32	10	23	30	17	17	31	18	21	38	13	274
GWH Medlow Station (southbound)	59	104	102	84	127	58	63	80	82	72	79	74	984
Railway Pde opposite Medlow Station (2 services only 3pm)	3	16	23	18	15	9	5	13	6	7	14	6	135
GWH at Foy Avenue	0	0	7	1	1	1	0	0	0	2	0	0	12

Tap OFF Location	J	F	M	A	M	J	J	A	S	O	N	D	2019 Total
GWH Medlow Station (northbound)	14	40	42	17	22	37	33	34	40	31	64	33	407
GWH Medlow Station (southbound)	22	16	25	32	29	8	14	28	56	33	39	16	317
Railway Pde opposite Medlow Station (2 services only 3pm)	0	23	25	9	29	17	9	16	2	11	18	10	169
GWH at Foy Avenue	2	11	9	3	5	3	4	2	6	4	3	2	54

Bus Data by Month OPAL Tap On & Tap Off – 2019

Bus patronage is relatively low, with a noticeable gap in tap off compared to tap on which is directly attributed to school student missing tap off data. Monthly use shows the most frequented bus stop is the southbound stop at Medlow Bath Station. This stop requires users accessing the stop to cross either the highway or the rail corridor.

8.3 Safety Data

Safety Data analysis demonstrates crashes and incidents involving pedestrians at pedestrian level crossing south of Medlow Bath Station. Safety data is further expanded in the following sections.

8.3.1 Rail Safety Data

Rail Safety Data captures incidents within the rail corridor including incidents of pedestrians gaining access to the tracks from the Level Crossing, and near misses with trains.

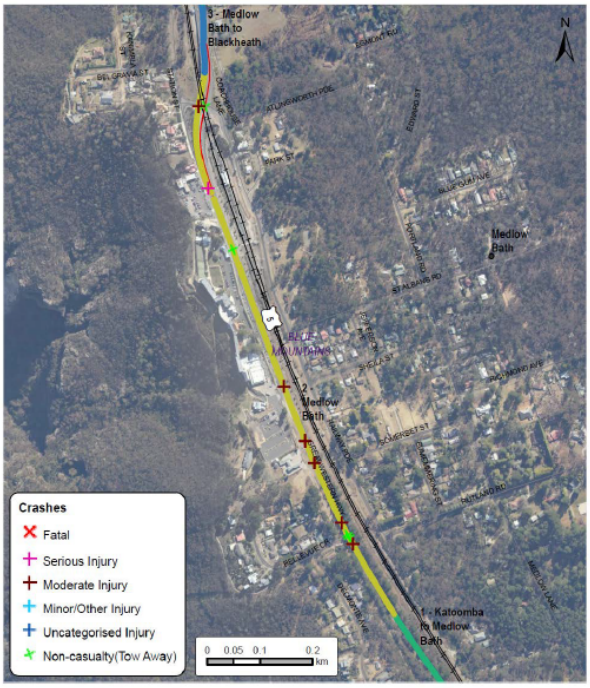
The severity of a pedestrian and train interaction risk is of fatal consequence for the pedestrian. Each reportable incident also carries with it significant trauma to the train driver, which often requires support depending on the severity of the reportable near miss.

Rail Safety Data extracts demonstrated 3 reportable incidents at the level crossing involving pedestrians and trains over a short six-month period from July to December 2019.

The Medlow Bath pedestrian level crossing represents a regular and reoccurring safety risk for the rail corridor, which can be fully mitigated by the removal of the level crossing.

8.3.2 Road Crash Data

Road safety data from both four year periods 2009-2013 and 2014-2018 identified FSI crashes involving pedestrians at the pedestrian refuge connecting with the Medlow Bath Station level crossing. The severity of the crashes on both occasions although not fatal was severe enough to generate a life-threatening injury.



- 2009-2013
  - 2 rear end crashes and 1 pedestrian crash near the Hydro Majestic Entrance / Medlow Bath Train Station
- Increase in casualty crashes
  - 3 crashes 2009-2014
  - 8 crashes 2014-2018 (picture left)
- 2014-2018 (post reopening of Hydro)
  - 1 FSI crash (2014-2018) pedestrian serious injury 2018
  - a higher number of mid-block rear end crashes,
  - rear end crashes around the Bellevue Crescent intersection
  - opposing turn crash at one of the entrances to the *Hydro Majestic hotel

*Hydro Majestic reopened after restoration in October 2014

Road Crash Summary Involving Pedestrians 2009-2018

8.4 Future State Predictions

8.4.1 Rail Passenger Growth – Without GWHUP (Baseline)

Existing rail passenger data 2004-2019 was used in conjunction with the planning provisions of the Transport for NSW 2056 Master plan, to predict passenger growth using Medlow Bath Station out to 2056.

During the 2019 strategic project design phase, Transport for NSW Rail Strategy Branch identified a 2hr AM peak of 95 passengers entering and 21 alighting in 2056. This represents over a 4-fold increase compared to 2018 2hr peak passenger use without factors influenced by the proposed Great Western Highway Upgrade Program.

Based on the 2056 projection, rail passenger volume at Medlow Bath Station could approach 500 total daily passenger trips, without the proposed Great Western Highway Upgrade at Medlow Bath.

This projected passenger growth demonstrated two key priorities from both road and rail perspectives. Firstly, connecting elements on the highway and local road network would need to be considered as part of the Highway Upgrade process.

Secondly, the ageing population trends coming from Census Data, demonstrate that a future upgrade to accessiblity would be warranted under the Transport Access Program (TAP).

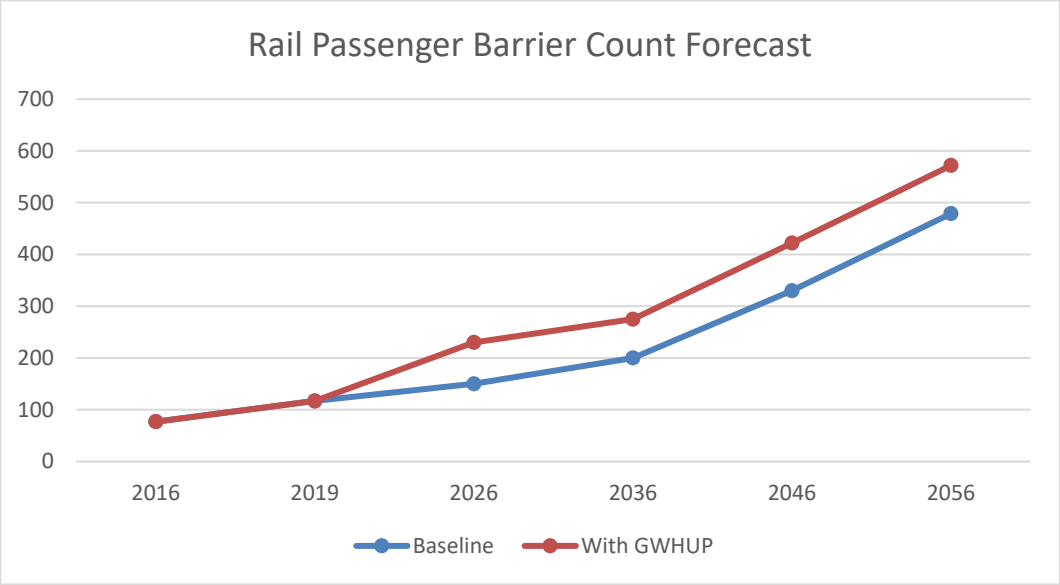
8.4.2 Rail Passenger Growth – With GWHUP

A completed upgrade of the Medlow Bath Station precinct with accessibility, commuter parking, improved bus connections, kiss & ride spaces, cycle infrastructure and improvements made by the new Mariyung Train Fleet is projected to lift the attractiveness and viability of public transport at Medlow Bath. Facility improvement aims to encourage mode shift for both commuters and tourists accessing rail services at Medlow Bath.

As the existing Medlow Bath Station offers no formal interchange facilities, it is projected that current rail passenger would increase from day of opening, as a direct result of the accessibility improvements at the Station.

Medlow Bath Station would become a more attractive alternative for Blue Mountains users in particular for ageing residents of Medlow Bath. Demand would be further reinforced by growing regional toursim at the Hydro Majestic as shown by the influence the venue has over historic rail passenger data trends.

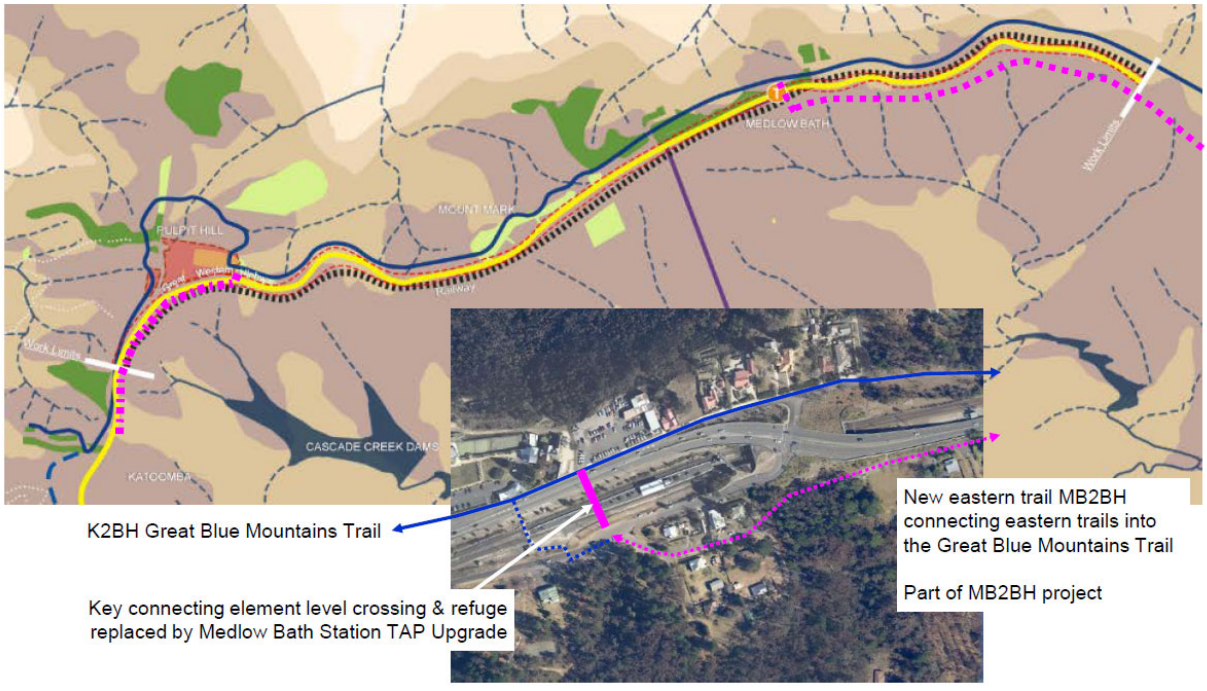
It is reasonable to determine that an initial sharp growth over existing volumes is warranted, and that these volumes would then increase over time at a steady rate in line with existing baseline growth rate.



8.4.3 Active Tourism Expansion

Another key consideration taking influence over the future state considerations is the tourism and inter community connection for active transport along the Great Blue Mountains Trail (GBMT). The Great Western Highway Upgrade Program is planning to upgrade the existing GBMT between Katoomba and Medlow Bath, while also creating a new section between Medlow Bath and Blackheath.

The presence of the bridge as both active transport enabling element, tourist destination element and transport connection provides a key link between the escarpment and highway on the west to the National Park and Cascade Dam Catchment on the east. These facilities will promote growth of active transport in and around Medlow Bath for a range of user groups.



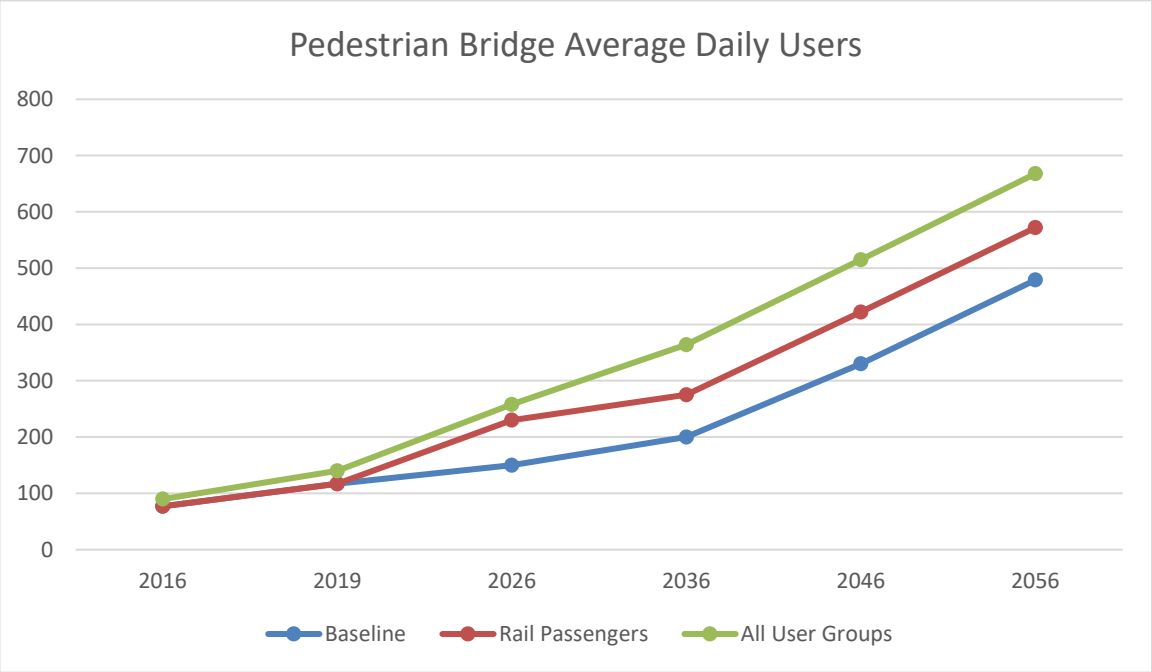
GWHUP - Future Great Blue Mountains Trail Alignment

8.4.4 Data Projections Medlow Bath

The consideration of all sources of potential users for the proposed pedestrian bridge collates user volume predictions from bus patronage, rail passengers, tourism growth, Great Blue Mountains Trail users and local resident users.

Based on the prediction table below, the initial growth rate of combined users of the bridge would peak to 2036 as mode shift to rail increases demand making use of the improved public transport elements at Medlow Bath. The presence of the highway upgrade work between Katoomba and Lithgow is also likely to contribute to rail passenger growth at this time.

The tourism growth may be somewhat delayed until works on the broader Great Western Highway Upgrade Program are completed. This sharp uptake to 2036 is largely attributed to Hydro Majestic expansion plans combined with the opening of news sections of the Great Blue Mountains Trail connecting the eastern side of Medlow Bath directly with Evans Lookout Road at Blackheath along side the upgraded highway and Blue Mountains National Park.



8.4.5 Peak Capacity & Performance

A Fruin Analysis performed by MRB Technical Services in 2021, found that the proposed Medlow Bath Upgrade provides capacity to accommodate predicted peak train demand to 2036 and beyond.

A sensitivity test to prove capacity for increased train services also demonstrates connecting elements will operate Level of Service C or better up to a service peak of 314 passengers per hour (Service frequency 4 trains per hour).

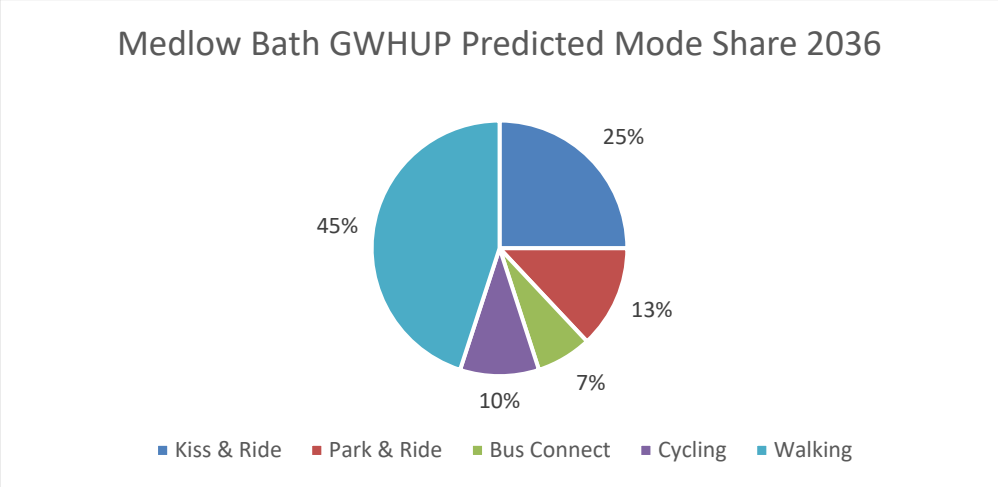
8.4.6 Projected Mode Distribution

The Medlow Bath Upgrade will redistribute mode share due to improved facilities around the station and upgrade of connecting elements. The inclusion of formal commuter parking, kiss & ride facilities, bus stop upgrades, cycle facilities, shared

path connections and the pedestrian bridge as safe grade separated crossing will influence the way all users connect with Medlow Bath Station.

Comparing to the 2021 PTPM data, cycling and bus interchanging is anticipated to occur making use of new improved facilities. A similar proportion of park & ride would occur in line with local commuters from Medlow Bath, while kiss & ride would increase through improved facilities making it more attractive for a range of school children around the area.

The highest proportion of users accessing the station precinct are expected to be on foot. This represents the observed patterns of rail passenger tourists visiting the location, local recreational walking, passengers commuting from the Medlow Bath village, and the newly predicted users of the expanded Great Blue Mountains Trail.



8.5 Movement and Place Assessment

A Movement and Place Assessment was conducted by Crossley Group. The assessment confirmed the existing state movement and place classification for the respective sections between Katoomba and Blackheath as shown below.

	Segment ID	Segment Descriptions		Length (KM)	Classification		Street Typology
		From	To		Movement	Place	
EAST SECTION	ES1	Nellies Glen Rd	United Petroleum Medlow Bath	3.2	5	A	Main Road
	ES2	United Petroleum Medlow Bath	Great Western Highway / Station St	0.5	5	C	Main Street
	ES3	Great Western Highway/Station St	East Tunnel Portal	2.4	5	A	Main Road

The following then further expands on mode user volumes and mode choice, demonstrating the existing state users on the Great Western Highway corridor between Katoomba and Blackheath.

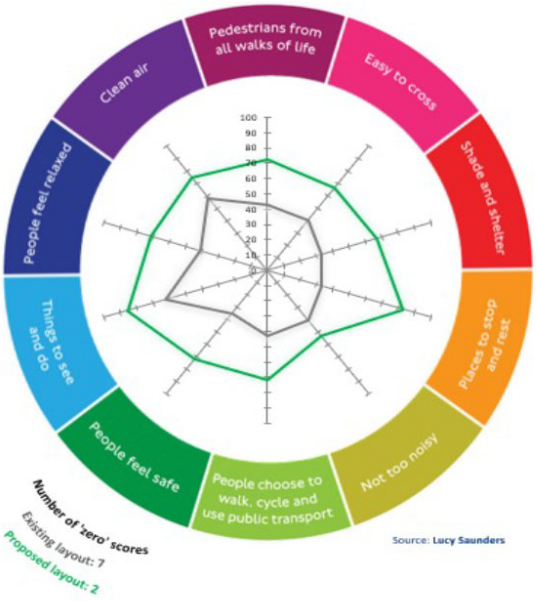
Table 11 . Existing customers and mode choice

Ref	Daily No. Vehicles (ADT)	Heavy Vehicles (%)	Medlow Station Daily entry/exit*	Daily buses	No. People cycling*	Level of pedestrian activity
ES1	26,911	15%	N/A	<1	Low (51-300)	Low
ES2	24,700	14%	234	3	Low	Medium
ES3	Not Available	Not Available	N/A	2	Low	Low

Note: * The data in the table below represents a typical day (Tuesday, Wednesday, and Thursday) average of entry and exits at station based on Opal card tap on and tap off (2016-2019). Number of people cycling is taken from Strava data only and is not representative of all cyclists.
Source: Traffic Count Survey (April 2021), Strava Data, Daily Buses - Medlow Bath Preferred Concept Design and Detailed Design REF, TfNSW Open Data Portal, Train Station Entries and Exists

By considering a range of inputs and assessment metrics the existing corridor is then assessed to rate the corridor across 10 indicators and 7 metrics. From there the pre-existing condition can be measured to determine a health streets score.

The proposed design state can then be assessed against the same criteria and metrics to determine the improvement of healthy streets score. This gives substantial weight to user group experience and safety, which reinforces the benefits of the project beyond a simple direct user volume approach.



	Existing layout	Proposed layout
Pedestrians from all walks of life	43	72
Easy to cross	41	67
Shade and shelter	33	67
Places to stop and rest	33	83
Not too noisy	40	53
People choose to walk, cycle and use public transport	43	72
People feel safe	35	71
Things to see and do	62	86
People feel relaxed	41	71
Clean Air	58	75
Overall Healthy Streets Check score	42	72
Number of 'zero' scores	7	2
(Proposed layout score from applicable metrics)		57.45%

The proposed upgrades include corridor widening, new bicycle and walking connections and amenity upgrades.

At Medlow Bath the proposed treatments result in an improved Healthy Streets Score, increasing from 42 to 72. This includes eliminating five high risk safety scores.

The remaining risks associated with high two-way volumes and traffic speeds will remain due to the high movement function of the corridor through Medlow Bath. The impact of the high-speed environment is mitigated with buffer treatments and grade-separated crossing points.