LESSON 5
A WALK FROM WESTMINSTER TO TOWER BRIDGE

THE BIG IDEA

A walking tour along a stretch of the River Thames between Westminster and Tower Bridge to research the history, technology, design and use of some of the most iconic bridges in the world.

LEARNING OBJECTIVES

Could research by photographing or sketching other features that show similar design features.

Should be able to explain why particular designs were used in particular circumstances. They should also be able to take photographs of key features to use in their display material in order to communicate design ideas.

Must know the structural elements of different types of bridge and be able to allocate particular examples to different categories.

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RESOURCES

Resource 5.1: Route guide and map section one: Westminster Bridge to Blackfriars Bridge

Resource 5.2: Route guide and map section two: Blackfriars Bridge to Tower Bridge

Resource 5.3: A view from the river

Resource 5.4: Minibridges

Resource 5.5: Bridges and living things

Resource 5.6: Bridges in the landscape

Resource 5.7: How busy?

YOU WILL ALSO NEED:

- Clipboards
- Cameras

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ACTIVITIES

PREPARING FOR THE VISIT

A pre-visit to the area is strongly recommended, so you can ensure your students' time is as focused as possible on the day. Walking the tour prior to the excursion will also enable you to check timings and stopping points. Please ensure that the appropriate risk assessment has been undertaken.

To walk the complete distance from Westminster station to Tower Hill station would take about three hours, if allowing time for research and recording. So the guides and maps provided divide the route into two separate sections, each of approximately one and a half hours.

Section one is from Westminster to Blackfriars; Resource 5.6 (page 62)

Section two is from Blackfriars to Tower Bridge; Resource 5.7 (page 63)

Each route includes suggested stopping points, convenient, wide and relatively quiet areas where groups can congregate and the information provided in the route guide shared and discussed.

Activities

Explain to students that their task during the walking tour is to collate information and images to enrich their exhibitions. It is suggested that students are divided into groups of around six. Provide each group with:

- equipment for photographing, sketching and recording
- one copy of the relevant route guide per group (you may wish to nominate a group leader to be the tour guide)
- Resources 5.1 – 5.5 (pages 57 – 61), designed to help structure their recording. You may wish to choose a selection of these resources depending on the focus of their research. Students should be asked to look for features that will both explain their bridge displays, and also bring them to life.

Homework idea

Collate the material recorded during the walk, ready for display in the exhibition.

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OTHER POSSIBLE SITES

Museum visits

A number of London museums provide an opportunity to supplement students' study of bridges.

The Science Museum

South Kensington, SW7 2DD

The Science Museum has a range of displays, activities and outreach visits that bring bridge design to life.

www.sciencemuseum.org.uk/visitmuseum/Plan_your_visit/exhibitions/challenge_of_materials.aspx

The Museum of London

150 London Wall, EC2Y 5HN

Collections explore the history of the Thames and its bridges.

www.museumoflondon.org.uk/london-wall/

Tower Bridge

Tower Bridge Road, SE1 2UP

A visit to the Tower Bridge Museum offers a chance to see the impressive engineering behind moving the bascules.

www.towerbridge.org.uk/

The Brunel Museum

Railway Avenue, SE16 4LF

The Brunel Museum in Rotherhithe, has models of Brunel bridges.

www.brunel-museum.org.uk/

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WALKING TOUR: SECTION 1 WESTMINSTER TO BLACKFRIARS STATION

THE LONDON EYE

Point 1: The riverside steps up from Westminster Bridge

From this point you can see Westminster Bridge, the upstream Queens Golden Jubilee Footbridge and Hungerford Railway Bridge. There is a good view of the London Eye, which is another kind of example of cantilevering. (The downward force of the wheel's weight is countered by the cables on the other side of the pivot.) You can also see a statue of a large white lion on the far side of Westminster Bridge, which is made of Coade stone; Coade stone was an artificial stone produced by Eleanor Coade, a remarkable scientist and entrepreneur.

Westminster Bridge has seven arches and is 252 meters long. This bridge was built in 1862, replacing the 1759 structure (which features in Wordsworth's poem, *Composed Upon Westminster Bridge, September 3rd, 1802*).

The Queen's Golden Jubilee Footbridges are cable-stayed, but the towers are cantilevered out from the pillars of Hungerford Railway Bridge.

The piers for the river-boats are also examples of bridges, mainly of beams, but of interest as the decks are reinforced with railings. They are not fixed because of the need to move up and down with the tide.

Leave point 1 and walk east along the north bank of the Thames (along the Embankment away from Westminster). Cross the Embankment before reaching the junction with Northumberland Avenue – as you walk by Victoria Embankment Gardens you pass a memorial to Samuel Plimsoll, inventor of the Plimsoll line. The memorial was erected by the National Union of Seamen in gratitude for the lives saved by the Plimsoll line, a mark placed on the sides of ships to show how much cargo they could contain and still float safely in different water conditions.

Cross Northumberland Avenue and go up the steps onto the Jubilee Footbridge. Stop mid-way across the bridge.

Point 2: The Queen's Golden Jubilee Footbridge

From here you can look back to Westminster Bridge with the Houses of Parliament beyond. The London Eye is to your left, with a good view of the cabling necessary to keep the wheel upright. The cable-staying on the footbridge is very obvious, as is the fact that the bridge is built onto the original structure of the railway bridge. The Queen's Golden Jubilee Footbridge was opened in 2002 to commemorate the 50th year of Queen Elizabeth's reign (Golden Jubilee).

The railway bridge was built in 1859, but was a replacement for a suspension bridge that was on the site before. The suspension bridge had two brick piers in the river and chains suspended across the towers built on the piers. You can still see the brick piers – they have been incorporated into the structure of the railway bridge. Originally both piers were situated in the river, but the river has been narrowed by the construction of the Embankment (by Joseph Bazalgette; a memorial to him can be seen opposite the Plimsoll memorial, set in the Embankment wall). The northern pier is now adjacent to the Embankment. The designer of the railway bridge, Sir John Hawkshaw, wanted a beam bridge, so additional piers were built to take the weight of the beams and their strengthening girders. Railway bridges need to be fairly rigid, so that the rails don't move under a train and derail it, so most railway bridges are beam/girder bridges or brick arches. If a train crosseswhile you are there you can watch the rails deflect under its weight.

Continue across the bridge and descend to the south bank. Walk east towards, then under Waterloo Bridge. As you walk you can see the downstream Jubilee Footbridge, and, across the river, Cleopatra's Needle, a gift to England from Egypt after the Napoleonic Wars. The obelisk was left in Egypt for over forty years, because of the difficulty of moving it. Eventually a special craft was built to hold the obelisk, which was then towed (with difficulty) back to England. The needle was set up on the Embankment in 1878.

Once past the National Theatre, stop.

Point 3: Embankment by National Theatre

From here you can see Waterloo Bridge to the left and Blackfriars Bridge to the right.

Waterloo Bridge is interesting from a number of different viewpoints. It is a replacement bridge for the original, which was designed by John Rennie that was opened in 1817. Originally called the Strand Bridge, it was then named Waterloo to commemorate the battle of that name. The bridge began to subside in the 1920s, and was closed (a temporary bridge was built to replace it). The replacement wasn't begun until the second world war, when many of the work force that constructed it were women – hence the nick name 'The Ladies Bridge'.

Waterloo Bridge is designed to look like an arch bridge (as the original was an arch bridge) but is in fact a box girder beam bridge, disguised to look like a series of arches. It is clad in Portland stone so that it washes clean in the rain, as concrete would have stained.

Blackfriars Bridge is far simpler. It has five wrought iron arches and is 291m long. It was opened in 1869 and replaced an earlier bridge that had 9 arches. The piers of the road bridge are aligned with those of the following two railway bridges, so that river traffic can move more easily through them. The red columns are all that the remains of one railway bridge, its rail deck removed in 1985.

One other thing you will almost certainly see from here is a crane. There are many working on building sites in central London. Cranes are a very visible way to explain cantilevering – the long (and heavy) arm of the jib is balanced by the heavy weights that are suspended on the opposite site of the pivot point.

Continue along the Embankment under Blackfriars road and rail bridges. The point between the road and first rail bridge was the site of Albion Mill, the first steam powered mill in London, with engines designed by Boulton and Watt. The mill only lasted for five years before it was mysteriously burnt down in 1791 .

If you are only completing Walking Tour: Section 1, stop here, just beyond Blackfriars station.

NATIONAL THEATRE
© Kois Maih

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WALKING TOUR: SECTION 2 BLACKFRIARS STATION TO TOWER HILL

If you are starting the tour here, leave Blackfriars Station by the Southbank exit. Turn right on leaving the station.

Point 4: South Bank at Blackfriars Station

From here Blackfriars Railway Bridge and station is to your left and the Millennium Bridge to your right.

Blackfriars Railway Bridge (originally called St. Pauls) was opened in 1886, and was designed by Henry Marc Brunel, the son of Isambard Kingdom Brunel. It was redesigned in 2012 to extend Blackfriars Station and has a roof of solar panels (it is currently the largest solar bridge in the world). It also has sun pipes and rainwater collection, putting at the forefront of sustainable design.

The Millennium Bridge is a suspension bridge. The suspension chains form a very low arc, so that the views from the bridge are unimpeded. At the time it was built, it was the lowest profile suspension bridge in the world. However, this meant it had little

THE MILLENIUM BRIDGE

lateral stability, and, when it opened, it had a tendency to wobble as crowds walked over it. The bridge was closed a few days after opening in 2000, and redesigned with features to stop the wobbling effect. The most noticeable of these are the hydraulic shock absorbers, which allow the bridge to move, but only very slowly as the piston pushes against the hydraulic fluid. Once these modifications were made the bridge was reopened in 2002.

Continue along the riverside path under Southwark Bridge (originally built in 1819 to a design by John Rennie, rebuilt in 1921). The path moves away from the river on reaching Cannon Street Railway Bridge, built in 1869 by John Hawkshaw, the builder of Hungerford Railway Bridge. (As you turn to go under the railway there is a very small metal cover set in the pavement marked LHPC – London Hydraulic Power Company, which is worth noting/pointing out to your audience in preparation for talking about Tower Bridge). The walk continues past the tourist sites of The Clink, Winchester Palace and The Golden Hind. Turn left on reaching Southwark Cathedral and follow the road under London Bridge. About 100 metres after London Bridge, turn left on a path that leads under offices to regain the riverbank. The main route is to the right, but by turning left you will find a widening of the path where you can stop and talk to your audience.

Point 5

South Bank by London Bridge. London Bridge is to your left, but this spot marks the position where Old London Bridge reached the south bank of the Thames. Opposite you can see the church of St. Magnus-the-Martyr. The original bridge, that lasted from 1209 to 1830, ran in front of the church to the point where you are now standing. The bridge had 19 stone arches, as medieval technology could only cross fairly small gaps. In order to generate an income for maintenance and repair, the bridge also had houses on it (these were demolished between 1758 and 1762 to improve traffic flow over the bridge). The number of piers impeded the flow of the river so much that the slow moving water to the west of the bridge could freeze over in winter (and Londoners then held 'Frost Fairs' on the ice). Since the demolition of the old bridge in 1830, the river has never frozen over.

A new London Bridge was opened in 1830, by King William and his wife Adelaide (the white building on the northern bank to the right of the bridge is Adelaide House; it was London's first "skyscraper" – i.e. a building using the steel frame construction techniques that had become commonplace in New York). This bridge was replaced in 1973 by the present structure, and sold to Robert McCulloch of McCulloch Oil. The old bridge was re-erected on Lake Havasu in Arizona, where it was the centrepiece of a new township he was developing. Today it is one of the most visited free tourist attractions in the US.

Continue to walk towards Tower Bridge. You will pass HMS Belfast (guns trained on London Gateway services on the M1). Stop beside The Scoop, an outdoor theatre by the side of City Hall.

OLD LONDON BRIDGE, 1710
{{PD-UK-unknown}} Wikimedia Commons

Point 6: Outside City Hall

Tower Bridge is to your right, the Tower of London directly across the river. The bridge takes its name from its proximity to the Tower, not because there are towers in its structure. You can find the times of opening of the bridge at:

www.towerbridge.org.uk/lift-times/

Tower Bridge was opened in 1894 to ease traffic congestion on London Bridge. At the time, the Pool of London (the part of the river between London and Tower Bridges) was still a very busy port area, with many sailing vessels operating to the wharfs. So that these vessels could still access the Pool, the bridge was built with opening bascules, with a walkway across the top so that pedestrian traffic was not interrupted.

The bascules were operated hydraulically – steam engines pumped water into pistons which were loaded with heavy weights. When the bascules were raised the weights pushed down on the water, which moved the bascules through pistons at the other end of the system. (You can show how the system worked using two syringes connected by plastic tubing – although as air is the material in the tube, this a pneumatic system. Hydraulic systems have water, and nowadays mineral oil, in them). You can see the old machinery if you visit the museum in the bridge:

www.towerbridge.org.uk

Hydraulics was a popular way of transmitting power around the end of the nineteenth century. The London Hydraulic Power Company was set up in 1883 to transmit hydraulic power around London through cast iron water mains. LHPC provided a back-up system for Tower Bridge, and to many offices and shops. Theatre curtains were raised by hydraulic power, as were the lifts in Selfridges.

Eventually the system was replaced by electricity, which is more flexible and has a greater number of uses. Tower Bridge operated its own hydraulic system until 1974 when a new hydraulic motors powered by electricity were installed.

Tower Bridge is also a suspension bridge – the chains on either side support the deck of the bridge running out to the bascules.

Continue east to Tower Bridge. Go up the stairs, over the bridge, then follow the pedestrian path by the side of the Tower and under the roadway to Tower Hill station. Follow the path to the area above the station.

THE SCOOP

Point 7: Above Tower Hill Station

This space can be used for recording research made on the final section of the walk after City Hall. There is a sun-dialin front of the station.

With the history of London on a circular time-line. Also of engineering interest is Trinity House, the building with the ornate tower and statue at the top. Trinity House is responsible for light-houses around the English coast.

Homework idea

Collate the material recorded during the walk, ready for display in the exhibition.

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RESOURCE 5.1: EXPLORING THAMES BRIDGES

Your task is to consider the various bridges on the Thames from boat's point of view

Answer these questions for each bridge:

1. Which section of the bridge is used by boats traveling west (upstream)?
2. Which section is used by boats traveling east (downstream)?
3. How is river traffic directed to the correct section of the bridge?
4. How is each bridge protected from river traffic?
5. What type of boats did you see on the river today? What was the main purpose of their movement?

How could you use this information to enhance the Bridge Exhibition you are designing?

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RESOURCE 5.2: MINI-BRIDGES

The main bridges span all the way across the Thames. However, as you walk along the river you will see smaller constructions, designed to bridge between boats and the shore. These are normally described as piers or landing stages, but they can also be thought of as bridges in miniature. Your task is to record these bridges and make a note of their design features.

Answer these questions for each 'mini-bridge':

1. What is the purpose of this? Who uses it? How often?
2. How is the bridge section designed to cope with the fact that the level of the river rises and falls.
3. Why does the river level rise and fall?
4. How are the bridge sections designed to be safe, even though they may sometimes be steep and slippery?
5. How are the piers designed to protect waiting passengers?
6. What other devices can you see along the river to enable boats to moor (stop by the side of the river)?

How could you use this information to enhance the Bridge Exhibition you are designing? How could you design a model to show how landing stages cope with the rise and fall of the river?

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RESOURCE 5.3: BRIDGES AND LIVING THINGS

A hundred years ago, the Thames was a smoggy and smoky environment, which was very hostile to living things. But now it is a clean and natural environment with many kinds of animal and plant life. Your task is to look for, and record, evidence of living things found on or around Thames Bridges.

BUSH GROWING ON LONDON BRIDGE

Answer these questions for each bridge:

1. Is there any evidence that birds land on this bridge? What measures have been taken to stop them landing? Why do you think this is?
2. Are there any types of plant growing on the bridge? Can you recognise any particular species? You could photograph them and try to identify them back at school.
3. What type of conditions makes the best environments for plants to grow? Do you find as many plants on brick surfaces as on metal? On railway bridges as on road-bridges? On the east side of bridges or the west?
4. Is there any evidence of plant growth on the piers supporting the bridge? Again, what conditions provide the best environment for algae and mosses to grow?

Take some pictures of the living things you find. Can you think of different ways of presenting your findings in your bridge exhibition?

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RESOURCE 5.4: BRIDGES IN THE LANDSCAPE

London has one of the best river frontages in the world. The bridges along the Thames, especially in central London, are not merely designed to carry people and vehicles across the river – they must look good as well. Your task is to look at the various ways London bridges have been designed so that they enhance the centre of the city.

Answer these questions for each bridge:

1. Are there any statues or other ornaments on the bridge?
2. Is the bridge painted to enhance it's appearance?
3. Is the bridge decorated in any other way?
4. Is there any evidence the bridge is lit up at night? (You might have to use the internet to check)
5. How is the bridge kept clean?
6. Is there any evidence of graffiti? How is the bridge designed to minimise graffiti?

Take some pictures of the bridge enhancements that you find. Can you turn your pictures into a quiz, where people have to recognise the bridge from a detail of the decoration. What would be a good way of presenting such a quiz in your bridge exhibition?

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RESOURCE 5.5: HOW BUSY

The bridges over the Thames carry a huge amount of traffic, whether by road vehicle, by train or by foot. This traffic can vary hugely throughout the day. Your task is to survey the amount of traffic crossing each bridge.

You could exchange data with other schools that do this survey at different times of day and different times of year, to build up a more accurate picture of the complex traffic flows.

To survey the traffic on your bridge:

1. Time a five minute period.
2. Count the number of people, cars or trains passing during that time.
3. If there are a number of people in your team, divide the tasks so that some measure northward flow and some measure southward.
4. If you cannot see all the cars on a bridge from your observation point, try and get a measure of traffic density by counting the number of double-decker buses.
5. Average your data if you have made a number of observations, then calculate the traffic flow/hour.

How could you present your results in an interesting way as part of your bridge exhibition?

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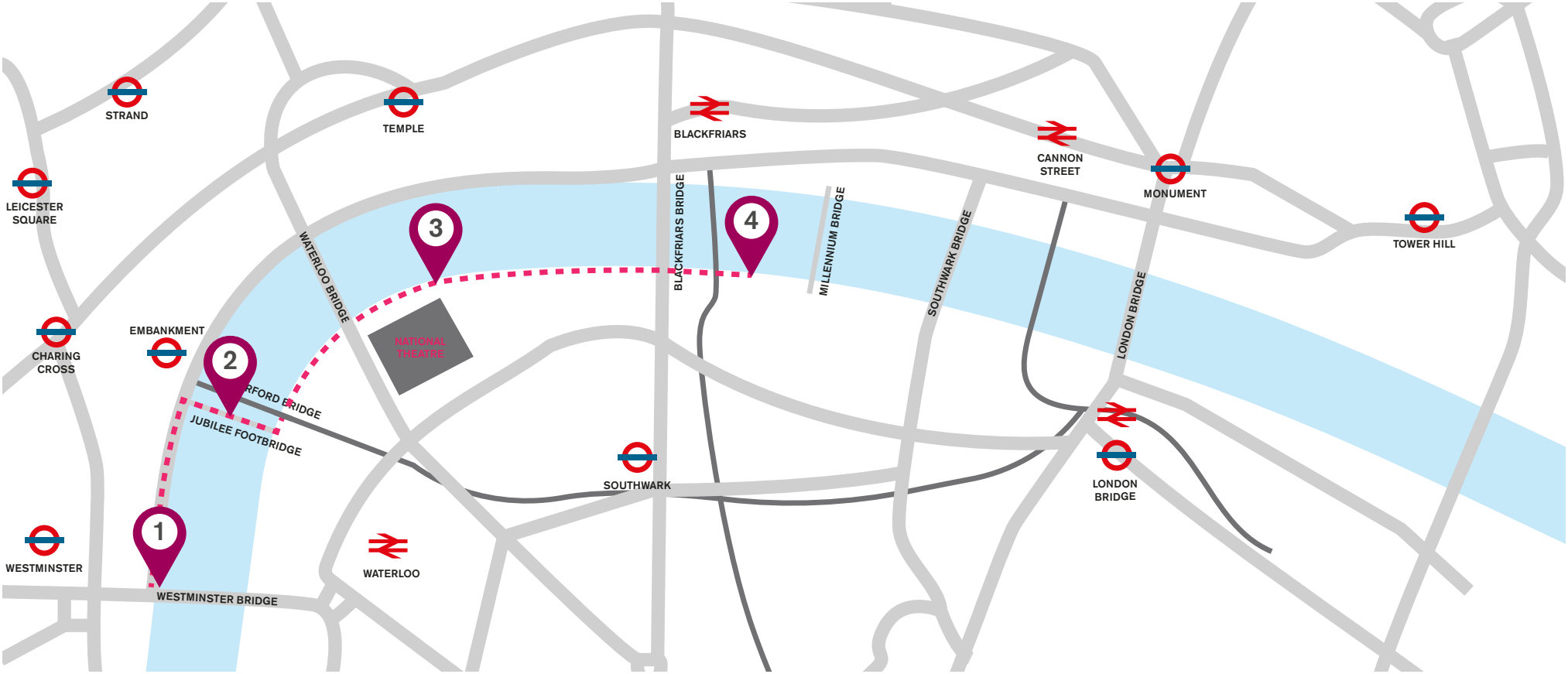
RESOURCE 5.6: WESTMINSTER BRIDGE TO BLACKFRIARS BRIDGE MAP



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RESOURCE 5.7: BLACKFRIARS BRIDGE TO TOWER HILL BRIDGE MAP