



Rampion Offshore Wind Farm



ES Section 3 – Alternatives Appendix 3.1

Moore Marine Services Ltd

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E.ON Climate & Renewables UK Rampion Offshore Wind Limited

APPENDIX 3.1 Alternatives Supporting Information

1. Grid Connection Options

Distribution System

The distribution system around the landfall options identified is primarily served by the Bolney 400kV substation, which feeds the local distribution network from a 132kV ring running via Steyning, Worthing and Southern Cross substations. From this ring, radial 132kV links run to Fishergate, Moulsecroomb and Brighton Local substations from Southern Cross. Only Southern Cross is a 132kV substation, with all other substations 33kV. The 400MW embedded generation provided by Shoreham Power Station connects to Southern Cross substation at 132kV.

The Bolney 132kV ring is linked to the 132kV ring served by Ninfield 400kV substation by a single 132kV overhead line route running via Lewes and Polegate substations, with a 132kV radial link to Eastbourne (see Figure 1).

When considering the potential for a distribution connection for the wind farm, Southern Cross 132kV substation was identified as the optimum potential connection point due to it being a substation proximate to the coast and near the likely wind farm landfall. Also, being the only 132kV substation in the area, a connection at Southern Cross would not require significant substation replanting to upgrade from 33kV to 132kV in order to accommodate the wind farm 132kV export cables.

A summer demand of approximately 257MW is served from Southern Cross substation, therefore, when Shoreham Power Station is at full output (400MW), approximately 143MW of generation will spill from Southern Cross substation. This excess power will be shared across the three 132kV circuits running from Southern Cross – two running to Bolney substation and the 132kV circuit running from Southern Cross to Lewes. The combined summer transfer capability of the Southern Cross - Bolney (434MW) and Southern Cross – Lewes (111MW) circuits is 544MW, which is adequate capacity to accommodate these flows.

If an additional 700MW of generation from the Rampion Project was connected in at Southern Cross, the potential excess generation at Southern Cross would increase to 843MW in low demand conditions. This level of excess generation cannot be accommodated on the existing 132kV links to Bolney and Lewes, triggering the need for additional capacity on the 132kV circuits running from Southern Cross.

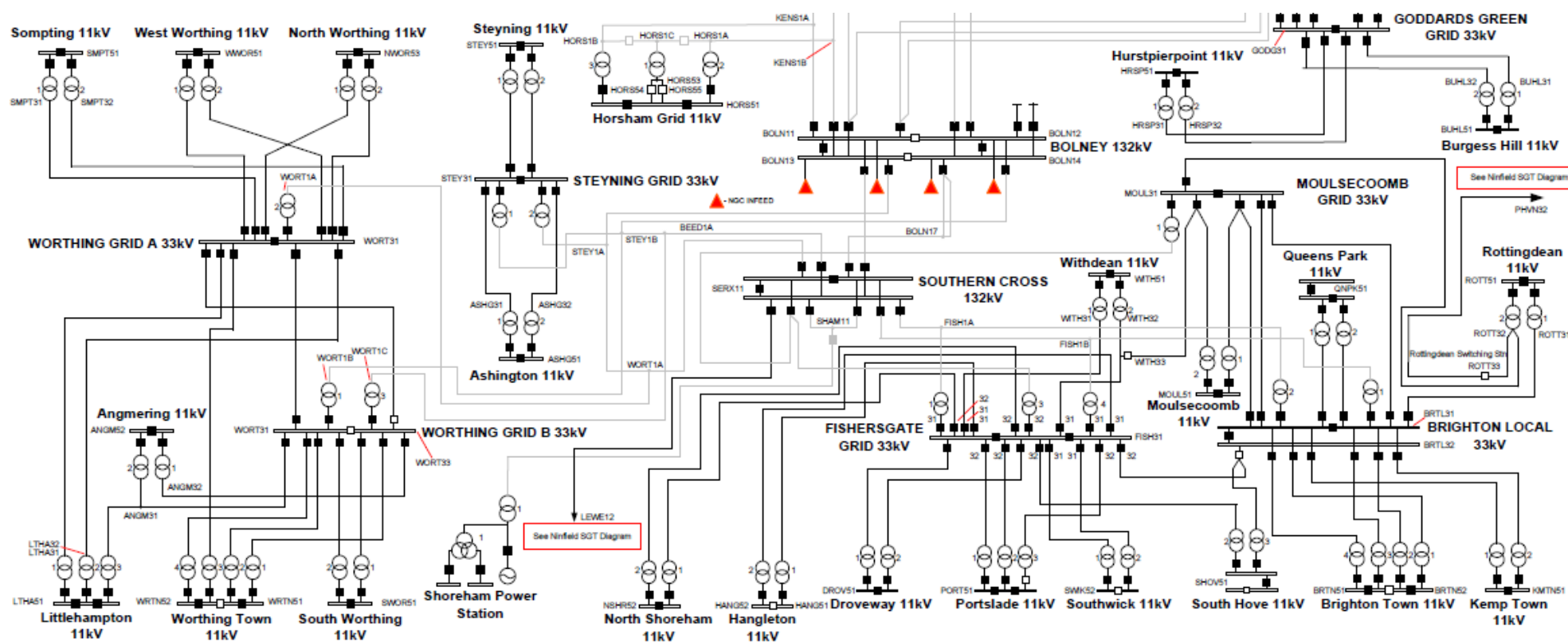


Figure 1: Electricity Distribution and Transmission system along South Coast

Given that the circuit to Lewes would be feeding a finite demand that is also served by Ninfield, the vast majority, if not all of this additional generation will flow back towards Bolney 400kV substation. Additionally, the export limit on the circuits running from Lewes would also make Newhaven an unsuitable connection point as, in addition to the upgrades to on the circuits up to Bolney, the Lewes – Southern Cross circuits would require extensive reinforcement.

The connection point at Southern Cross would therefore require the transfer capacity on the Bolney - Southern Cross 132kV circuit to be almost doubled from the current summer rating of 434MW to close to 843MW. It is therefore clear that a distribution connection at a single point would not be possible without very significant reinforcement of the 132kV network between Southern Cross and Bolney, or by reducing the wind farm size to around 250-300MW, which would make the scheme uneconomic.

Multiple Distribution Connections

Once the option of a single distribution system connection point was deemed infeasible, the possibility of multiple distribution connection points was considered in an attempt to distribute the power from the wind farm across a wider network area.

A search of the substations near the potential landfall locations identified Worthing Grid and Fishersgate substations as potential additional connection points.

Both Worthing Grid and Fishersgate substations are 33kV substations, meaning that any connection would require extensive expansion and reinforcement in order to accommodate a 132kV connection from the wind farm. More significantly, both substations are served by Southern Cross 132kV substation. This would mean that, even if the connection challenges could be overcome and multiple distribution connections achieved, it would not remove the requirement for a significant increase in transfer capacity between Southern Cross and Bolney. In fact, the likely additional requirement to upgrade the Worthing – Southern Cross and the Fishersgate - Southern Cross circuits, would make the overall impact of this solution less favourable than a single connection option at Southern Cross.

On this basis, the option of a distribution connection for the wind farm was not considered further.

Transmission System

There is no 275kV transmission network in and around the Sussex area, therefore a transmission connection would need to be onto the southern 400kV network running from Sellindge to Lovedean.

The output of the proposed wind farm can be comfortably accommodated on the existing 400kV transmission substations at Bolney or Ninfield without any significant reinforcement to the wider 400kV transmission system. Lovedean was discounted as an option as it is significantly further from the Rampion site and would involve more extensive offshore and onshore cable sections. Of the remaining options of Bolney and Ninfield, National Grid

concluded that the Bolney connection with a landfall east of Worthing was the most economically efficient connection option. The Ninfield connection would require a significantly longer offshore cable route and corresponding major increase in the connection cost, which would make the project uneconomic, as shown in Table 1 below.

Table 1: Comparison of 400kV connection points

Connection Point	Offshore distance	Onshore Cable length estimate	Budget Cost of Connection	Conclusion
Lovedean	15-19km	50-60km	Not considered – cost prohibitive	Not economically viable due to onshore and offshore cable route length
Bolney	15-19km	19-20km	Baseline	Identified by NGET to be most economic and efficient connection option
Ninfield	54km	6km	+ £132m to £138m	Not economically viable 60km on the limits of AC technology, HVDC could add further £17m overall

Connection Types

The decision to underground the entire cable route was made very early in the development process, following initial discussions with the South Downs National Park Authority (SDNPA) and Natural England, in order to minimise permanent impacts from the installation of additional large pylons across the South Downs.

While the approach of undergrounding the cables is significantly more expensive than the equivalent overhead line option, it was considered necessary to avoid any permanent visual impact across these environmentally sensitive areas.

Further to the decision to underground the cables, further work was done to develop a construction methodology using ducted cable circuits, as opposed to direct burial, which has significant benefits in terms of allowing quicker reinstatement of the cable working area. A comparison of connection types is presented in Table 2.

Table 2: Comparison of connection types

Methodology	Advantages	Disadvantages
Overhead Line	Most Cost Effective Easier to install over difficult terrain (hills, etc.) Potential to re-string to increase capacity if necessary to upgrade/increase rating	Visual impact More at risk from adverse weather (ice load, wind)
Underground: Direct burial	No permanent visual impact Marginally cheaper than ducted burial solution	Trench reinstatement linked to cable delivery/installation programme Fault repair would require excavation to recover/repair the cable
Underground: Ducted	No permanent visual impact Quicker trench reinstatement than direct burial approach	More expensive than direct buried cables Requirement for small joint bays to be excavated at cable installation stage

2. Landfall Options

Prior to selecting Brooklands Park in East Worthing as the preferred landfall location, other landfall options in the vicinity of Shoreham were originally considered. The original long list of options for a connection at Bolney is as presented in Table 3.

Table 3: Long list of potential landfall options for a connection at Bolney

Option	Location	Description	Initial screening
1	Brooklands, East of Worthing	Brooklands Pleasure Park - golf course, park, lake and other leisure amenities	Considered feasible landfall option.
2	Airport West	Landfall east of Widewater Lagoon	Initially identified as good beach landing site, but no break in the built environment. Would require demolition of substantial number of homes and issues with immediate onward cable route. Not pursued further.
3	Widewater Lagoon East	Landfall east of Widewater Lagoon	No clear gap in built up area but relatively narrow part of urban coastline. Assessed further as below.
4	Norfolk Bridge	Landfall at Beach Road play area	Break in the urban environment but includes established house boat community in the Adur as well as beach huts and childrens' play area. Assessed further as below.
5	Shoreham Port and up the River Adur	Cable installed through port entrance and up the River Adur	Would result in significant disruption to port operations and environmental impact due to ploughing/jetting 4 marine cables in the riverbed of the Adur Estuary SSSI. Not pursued further.
6	Portslade/Shoreham Port	HDD drill under the harbour wall and tunnel across to harbour	Would result in significant disruption to port operations and no clear technical solution to cross harbour and onward cable route. Not pursued further.

The two options other than Brooklands Park with most potential from the initial screening exercise, namely the Widewater Lagoon and Norfolk Bridge options, are described below in more detail.

Widewater Lagoon

Figure 2 shows the Widewater Lagoon landfall option, which would come ashore west of Shoreham Beach, although this option in practice is heavily constrained due to the presence of residential properties between the lagoon and the A259. A long horizontal directional drill (HDD) would be required underneath the lagoon and the A259. The indicative corridor shown in red in Figure 2 is approximately 40m in width (requiring greater separation of circuits than the standard trenching method of cable installation due to the nature of the HDD methodology). Even this alignment of the corridor, which manages to avoid direct conflict with properties on the north side of the road by taking an angled route, would be in conflict with a number of existing properties on the south side.

Industry practice does not permit the laying of major electricity transmission cables underneath permanent dwellings for a number of reasons including the risk of causing structural problems to the properties, the inaccessibility of cables in the event of fault and the perception of potential health issues associated with electromagnetic fields (EMFs).

This option was discounted due to the requirement to compulsorily acquire and demolish an estimated 6-7 homes on the south side of the A259 as well as land to the north of the road.

As a socially responsible developer, E.ON did not believe such an impact to be acceptable. An initial meeting in November 2010 with senior officers from Adur & Worthing Councils, where the three shortlisted landfalls (Brooklands Park, Widewater Lagoon and Norfolk Bridge) were discussed, supported the conclusion that Widewater Lagoon would not be an acceptable landfall location.



Figure 2: Potential landfall location at eastern end of Widewater Lagoon, showing indicative HDD corridor requirement (red)

Norfolk Bridge

Figure 3 shows the Norfolk Bridge landfall option, which would come ashore at Beach Green in Shoreham. A relatively straightforward HDD would be required for the shore landing into an area currently used as a childrens' play area, but would then require an additional HDD of approximately 700-800m across the Adur Estuary, emerging in the Adur Recreational Ground.

As can be seen in Figure 3, situated along the south bank of the Adur is an established riverside settlement of houseboats. The indicative HDD corridor shown in red is approximately 40m in width (requiring greater separation of circuits than the standard trenching method of cable installation).

Since major electricity transmission cables cannot be laid underneath permanent dwellings, as with the Widewater Lagoon option, this would require a significant number of compulsory acquisitions and the removal of an estimated 8-10 houseboats from this established river-based community. E.ON did not consider this to be an acceptable solution and this was the consensus in the meeting to discuss landfall options with Adur & Worthing Councils in November 2010.

In addition to the challenges of a long drill under the tidal Adur Estuary, the estuary is designated as a SSSI, which would require significant disruption during the drilling period.



Figure 3: Potential landfall location south of Norfolk Bridge, showing indicative HDD corridor requirement (red)

3. Cable Route Options

Route from Brooklands to the River Adur

Heading north from the selected landfall at Brooklands Park the cable route enters the South Downs National Park (SDNP) north of the A27. The cable is then routed eastwards around difficult topography and a Site of Nature Conservation Importance (SNCI) at Steep Down, whilst also avoiding complex topography further north at Winding Bottom (see Figure 4). Existing overhead lines pass further north, but running in parallel with this route would not be feasible for trenched underground cables.

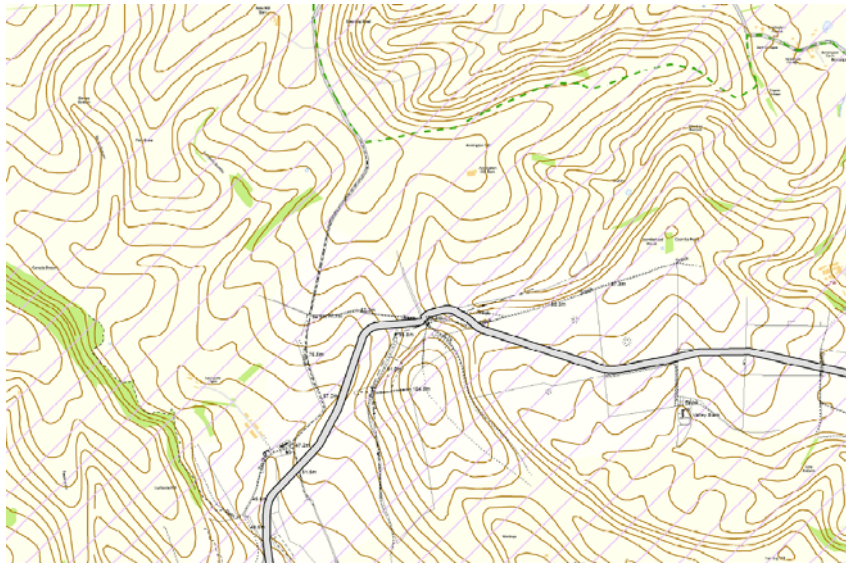


Figure 4: Cable routing eastwards between challenging terrain of Steep Down SNCI to the south and Winding Bottom to the north

River Crossing Point

The preferred crossing point of the River Adur (see Figure 5) has been selected for a number of reasons. Firstly, it is at a point where the river and the A283 run relatively close to one another, reducing the overall length of the drill. Secondly, with most of the terrain to the east of the A283 being extremely steep and not possible to cable up, the chosen route has a flat section of sufficient area to allow a HDD site to be established, with a relatively shallow gradient for the ongoing cable route.

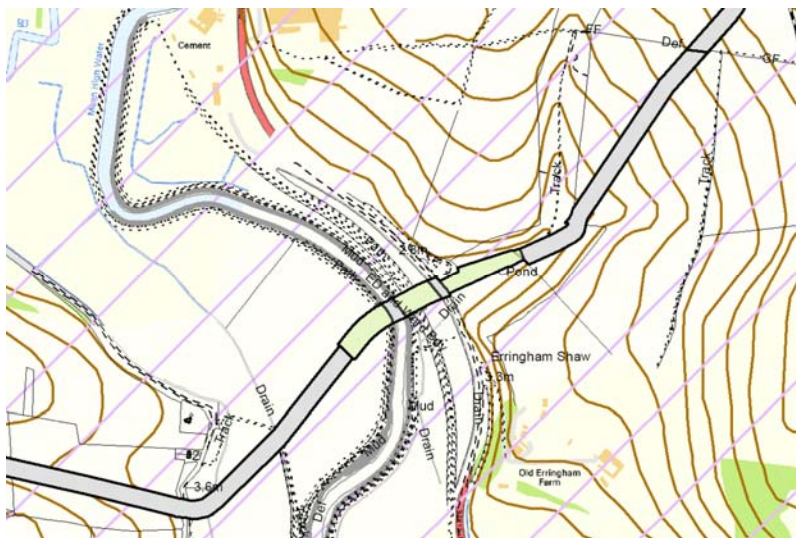


Figure 5: Selected crossing point under River Adur

Other points along the A283 either have no room for a HDD area to be established or, where there is room, the surrounding terrain is so steep as to make an onwards cable route not feasible, as shown in Figure 6.



Figure 6: Typical steep escarpment on east side of the River Adur constraining locations for crossing the river

Adur Valley

Although a cable corridor running along the Adur Valley (along the disused railway and/or the riverbed) for part of the cable route was also considered, a number of constraints were identified with this option including:

- The tidal part of the Adur Estuary is a SSSI of favourable condition noted for its littoral sediments. Disturbance to these and the river embankments would cause environmental impact to the SSSI (note that the ruling out of Norfolk Bridge landfall made a route running along this southern part of the Adur could not be pursued in any case);
- The route would run along a disused railway line for some distance; this is significantly narrower (approximately 6-8m, see Figure 7) than the corridor width required for the construction area and permanent cable easement, and in fact is insufficiently wide for the cable easement and haul road required to install the cables, even if some means of temporarily storing topsoil and subsoil offsite were practical;
- The disused railway is lined on both sides with mature trees, vegetation and valuable habitats, approximately 3km of which would need to be removed to accommodate the construction corridor;
- Embankments along the disused railway line would be unsuitable for extensive trenching to accommodate the four cable circuits, therefore extensive major re-sculpting of the landform would be required to bring the railway line elevation

back down to the level of the valley and losing evidence of the former railway which may not be acceptable in heritage terms;

- The disused railway is also in use as a public right of way, the 'Downslink'. The cabling works would require the closure of this route for a significant period of time;
- There are a number of issues preventing the cables being installed under the riverbed itself. The installation would be similar to an offshore installation requiring specialist vessels and large cable laying equipment, which would cause major disruption to other users of the river. Also, the installation would be highly constrained by the width and depth of the river, as well as the clearance to bridges. Installation of cables alongside the river presents its own problems due to it being within the floodplain. In addition to the installation difficulties caused by the ground conditions, the risk associated with a cable or joint failure due to ingress of moisture is elevated in these floodplain areas; and
- A lack of suitable crossing locations and very steep gradients/residences on the eastern side of the Adur would prevent a crossing point further north than the selected route proposed.

Further north the route is highly constrained by the adjoining settlements Bramber and Upper Beeding, therefore a crossing of the Adur south of this built up area would be required in order for the route to continue north towards Bolney (see, 'Route exiting Adur Valley to the north' below).



Figure 7: Typical section of the Downslink path with mature trees approx 3km from southernmost extent to point at which the former railway crossed the River Adur

Route exiting Adur Valley to the north

Instead of the route heading across higher ground to the east of the Adur and ascending Tottington Mount, options were explored to establish a route either between the settlements of Steyning, Bramber and Beeding, or circumnavigating to the west or east of the built up area.

The previous comments about issues of laying underground cables in the flood plain (see 'Adur Valley' above) should be noted.

Such a route could potentially deliver a shorter cable length through the SDNP as well as avoiding the most challenging section (in both environmental and engineering terms) of the route at Tottington Mount.

Figure 8 highlights the built up areas in blue, with Steyning in the west, Bramber in the centre (including Bramber Castle on an elevated mound highlighted in green) and Upper Beeding to the east. These settlements nestle in the valley between steep and complex topography of the South Downs. Arrows show the three indicative routes for passing through this area:

- To the west of Steyning through complex and steep topography would have no benefit in reducing the length of cable route within the SDNP and would elongate the River Adur flood plain crossing and the overall cable length, this was therefore discounted;
- To the east of Upper Beeding presents challenging topography in terms of being able to safely trench and effectively reinstated steep slopes (with slopes perpendicular to the direction of cable route being especially difficult to traverse), potential small reduction in distance of cable through the SDNP; and
- Routing by/under Bramber Castle (which would be the route which minimises cable length through the SDNP).



Figure 8: Settlements of Steyning, Bramber and Upper Beeding at the head of the Adur Valley

East of Upper Beeding

There are effectively two sub-options if routing to the east of Beeding.

Sub-option 1

Keeping east of the A2037 presents prolonged steep side slopes and complex topography which would be very difficult to safely lay trenches using typical cable laying techniques. This can only be done using 'zig-zag' techniques that would mean route length saving in SDNP would not be as great as if it was 'as the crow flies'. Cable trenches would require significant 'benching' into the hillside which are more likely to create prominent scars, as well as making effective reinstatement more difficult (and prone to wash out during long periods of rain).

Sub-option 2

Taking a route via Windmill Hill would require a HDD through the hill, as the topography would make trenching over the top or around this hill challenging, or routing on side slopes would have the same practical and safety issues as noted above. In addition to these challenges, the onward route either side of Windmill Hill is highly constrained due to presence of residential properties, roads and other steep gradients. This means that, even if a methodology for traversing of Windmill Hill was identified, the onward the overall route would still not be viable.

Four HDD drills of approximately 600m each would be required to cross under Windmill Hill. The main challenge would be the effective drill depth of at least 30m and resultant thermal de-rating of the cable. Essentially, the ground has a thermal insulating effect around the cable which, along with the depth that cable is buried to, limits how much current each cable can carry without overheating. Certain soils including chalk, have a particularly high thermal resistance. This would require additional drills, cables and likely require cooling systems to achieve the ratings required for the circuits. For cable circuits laid at this depth, typically a tunnel with forced air cooling is used to ensure the cable ratings are maintained (e.g. Elstree – St Johns Wood National Grid 400kV circuit). This would be cost prohibitive for such a short section.

Due to the technical constraints identified above, these options were discounted.

Via Bramber Castle

Bramber Castle is a Scheduled Monument and Grade 1 listed building. The castle is owned by the National Trust and managed by English Heritage. Due to the presence of adjacent St Nicholas Church and graveyard (the oldest Norman church in Sussex) and nearby residential properties, the only way to pass through this area would be a very long and deep HDD route. A route starting south of the A283 roundabout (see Figure 9) under the castle mound would be the only potential means way of continuing the cable route north of Bramber and Upper Beeding.



Figure 9: A283/A2037 roundabout looking towards Bramber Castle and St Nicholas Church

Subsidence on a large scale led to the ruin of the castle during the 16th century, this could be a risk factor of drilling several large cable circuits under what now remains of the castle. The same issues apply as noted above for Windmill Hill in relation to thermal rating problems of cables buried at significant depths.

If a HDD were feasible and acceptable, the cable route would need to then progress through a large flood plain area which is also designated as a SNCI and also features a Scheduled Monument (group of salterns low grassy mounds which are the remains of salt-making in the Middle Ages and earlier).

On the basis of significant technical uncertainties and environmental issues, this option was discounted.