nationalgrid

Western Gas Network Upgrade Project

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Western Gas Network Upgrade Project

Non-technical Summary

Introduction

National Grid Gas plc (National Grid) is the owner and operator of the gas National Transmission System (NTS). The NTS is an interconnected network comprising around 8000km of buried pipeline (along with various other facilities) that transports bulk supplies of gas around the UK. National Grid has identified a need to undertake important reinforcement works to the gas network between Milford Haven in Pembrokeshire and Churchover in Warwickshire (The Western Gas Network Upgrade Project – 'The Project'). This Strategic Option Report describes the identification and appraisal of alternative strategic options for this work which has led to the identification of a preferred strategic proposal which will require reinforcement work to the existing transmission network in both Wales and in England.

What is the NTS?

A single gas market serves the whole of Great Britain and in this competitive wholesale market, shippers and traders supply gas to end customers. Gas comes into the NTS at various entry points from a variety of sources including from: gas fields on the UK Continental Shelf (such as in the north sea); Norway; Liquid Natural Gas (LNG) Imports; European Interconnectors; and from storage. The NTS connects these entry points with offtakes where gas is taken out of the NTS. The offtakes connect the NTS to distribution networks (delivering gas to users such as households and businesses), transmission-connected demand customers (e.g. large industrial customers such as gas fired power stations), and to storage facilities and interconnectors.

National Grid's Legal Duties

The Gas Act 1986 (Gas Act) is the main UK legislation that governs the transport and supply of natural gas within Great Britain. In particular National Grid has duties under the Gas Act (Section 9) to develop and maintain an efficient and economical pipe-line system (the NTS) for the conveyance of gas and to comply, so far as it is economical to do so, with any reasonable request to connect to that system.

The development of the NTS responds to Government policy and changing patterns of supply and demand to ensure that competition (which maintains lower prices for consumers) and resilience of supply (as a result of supply disruptions affecting a particular gas source) are maintained. System planning scenarios, responding to these changing circumstances, are published annually (these are termed Future Energy Scenarios (FES)) and guide investment to ensure the NTS meets the UK's evolving needs.

FES 2019 is the latest version for which detailed modelling scenarios are available and reflects the ongoing change of the country's energy sources to 'net zero carbon emissions'. At least for the foreseeable future the FES scenarios expect there to be a continued requirement for the use of gas to meet the Nations' energy needs with an increased proportion of gas likely to come from imported LNG.

Which application to supply gas onto the NTS is this project responding to?

National Grid's duties under the Gas Act require it to consider applications by those looking to supply gas to the UK market. These applications are known as Planning and Advanced Reservation of Capacity Agreement (PARCA) applications. National Grid's Gas Transporter Licence in respect of the NTS (the Licence)[1] mandates that it responds to competent Planning and Advanced Reservation of Capacity Agreement (PARCA) applications.

South Hook Gas Company Limited (SHGCL) has submitted a PARCA application for 163 GWh/d of gas (approximately 15million cubic metres per day) to enter the NTS (referred to as NTS Entry Capacity) at the Milford Haven Aggregate System Entry Point (MH ASEP). The PARCA was considered in the context of the FES, National Grid's legal duties, obligations and the capacity of the existing NTS. It was considered to meet requirements and an offer was therefore made to the applicant for the entry capacity they had applied for. The entry capacity is available to SHGCL for a release date of 1st January 2026[2].

Why does the PARCA application require new infrastructure?

Analysis of gas flows around the network show that the additional gas coming into the MH ASEP can only be accommodated under some flow conditions. Restrictions to gas flow occur at other times due to constraints on the existing NTS infrastructure principally between Tirley (Gloucestershire) and Honeybourne (Worcestershire), and near Churchover compressor station (Warwickshire). As such there is therefore a need to reinforce the existing network to meet the PARCA requirement.

This SOR outlines the approach that National Grid has taken to develop a range of possible solutions to achieve this reinforcement. It concludes with the identification of National Grid's preferred strategic proposal to increase the capability of the NTS to meet the requested capacity in accordance with National Grid's licence duties and obligations.

What process does National Grid follow to identify the most appropriate solution?

An options appraisal process has been undertaken in accordance with National Grid's options appraisal guidance (National Grid – Our Approach to Options Appraisal 2012 [3]). Options Appraisal is a robust and transparent process used by National Grid to compare options and to assess the positive and negative effects they may have across a wide range of criteria including environmental, socio-economic, technical and cost factors. Typically, options appraisal is undertaken at the following points during the development of major new infrastructure projects:

- where strategic options are compared (this is the stage relevant to this report);
- where broad corridors or general locations are looked at as alternative means to implement the preferred strategic proposal;

[1] https://www.ofgem.gov.uk/licences-industry-codes-and-standards/licences/licence-conditions
2 This is referred to as the Registration Date under the PARCA arrangements.
3 https://www.nationalgridgas.com/document/81076/download

- where the proposed detailed alignment or location of any infrastructure is considered; and
- where consultation has been undertaken and alternative options have been identified.

This SOR reports the findings of the first stage of options appraisal and documents the process of investigation, analysis and review that has been undertaken to identify the strategic proposal that provides the most economical and efficient solution to safely provide the reserved capacity.

Which potential Strategic Options have been considered?

Options to increase the capacity of the NTS to allow more gas to enter at MH ASEP include options using one, or a combination of the following mechanisms and measures:

- Commercial Mechanisms. Various of these are available to National Grid to seek to either constrain or boost supply and demand, although there are limitations on the extent of the network over which these mechanisms are effective.
- System Management. The amount of gas within the system at any time is known as 'linepack' and is provided by raising pressures above minimum supply pressures. This provides some inherent buffering to respond to fluctuating levels of supply and demand across the system whilst ensuring that gas pressures are maintained above agreed minimum supply levels.
- Modification of Existing Infrastructure by Uprating of Operational Pressures. The NTS operates at a range of pressures between approximately 25barg and 94barg with some NTS pipelines operating at lower pressures than their capability would allow. System modelling has shown that a substantial contribution to the additional capacity needed can be achieved by operation of some sections of pipeline at higher pressures, referred to as uprating. As pressure is increased by uprating there may be a requirement (subject to risk assessments) for pipeline diversions, pipeline strengthening or additional pipeline protection (e.g. through use of concrete slabs laid above the pipelines to prevent impact) to ensure safety standards continue to be met.

- Additional Infrastructure & other measures. Achieving additional capacity by the construction of new infrastructure provides the final means of potentially meeting the reserved capacity. Various approaches exist:

    - New buried pipelines (with associated infrastructure such as sites or equipment for compression and AGIs) provide one solution to moving more gas past the constraint areas either to new markets or to connect elsewhere on the NTS. Options may include onshore pipeline, offshore pipeline and combinations of these.

    - Above ground onshore pipelines provide an alternative to buried pipelines.

- Compression. Where equipment is used to increase pressure and flow rates within existing pipeline infrastructure.

- The use of other transport modes (ship, road or rail) to transport LNG to other locations. LNG requires 1/600th the storage volume of natural gas at standard atmospheric pressure so represents significantly lower volume than even highly compressed natural gas. This lower volume reduces the number of movements required and increases feasibility of transporting large quantities of LNG compared with transporting compressed natural gas.

- Storage. A facility to hold the gas at an entry point or elsewhere on the NTS to provide a means to distribute flows from periods of constraint to periods when flow capacity may be available. Storage may be as LNG or compressed natural gas (CNG).

How does National Grid narrow down the options?

Using one or combinations of the above mechanisms and measures a comprehensive long list of potential strategic options (identified before consideration of factors such as capital cost or practicality at this initial stage) was developed to consider alternative means to achieve the PARCA entry capacity. This long list was then reviewed against technical and benefit filters to create a shortlist for more detailed options appraisal.

The technical filter initially considered whether the option could or should be discounted because:

- They fell outside the scope of National Grid's licenced activities,
- They would not achieve the gas flows needed to meet the PARCA,
- Specific factors were identified which rendered the option undeliverable or unable to meet technical or safety specifications,
- The option could not be built or achieved within the required timescale.

The remaining options were then considered against a benefit filter. This removed options which facilitated the release of the requested NTS Entry Capacity but which did not offer any material benefit over other options or may have performed very poorly in another aspect e.g. options to bypass the constraint with much longer pipeline lengths were removed where options to bypass the constraint with much shorter pipeline length were available.

The results of applying the technical and benefit filters

The outcome of the application of these filters on the potential strategic options is summarised as:

- Do Nothing
    - Discounted because it does not comply with National Grid's legal duties under the Gas Act to consider applications and to comply, so far as it is economical to do so, with any reasonable request to connect to the NTS.
- Use of Commercial and System Management Mechanisms

  - Discounted because whilst they provide an important mechanism for effective short-term management of a competitive gas supply market. they do not provide a mechanism to consistently respond to the NTS entry capacity in an efficient or economic manner.

- New Demand Customer (e.g. major new user of gas)
  - Discounted because National Grid is not allowed, by its licence under the Gas Act 1986, to generate demand itself and is not aware (at the time of SOR preparation) of any new consumer demands nor hydrogen economy (that may use gas as a feedstock) of sufficient scale in the relevant area to respond to the PARCA to offset the requirement for works.
- Utilise existing 3rd party infrastructure
  - Discounted because whilst various 3rd parties have existing (operational and disused) pipeline infrastructure in the relevant geographical area, appraisal has concluded that none would be extensive enough, nor have sufficient capacity, to meet the NTS entry capacity of the PARCA to offset the requirement for works.
- New storage (LNG and / or natural gas)
  - Discounted because, notwithstanding the fact that National Grid's Licence (under the Gas Act) does not allow it to use storage in this way, it is concluded that the scale of storage necessary to seek to use peaks and troughs in supply do not provide an economic, efficient or environmentally appropriate solution to meet the PARCA requirement.
- Connect to new markets (offshore pipelines to Ireland and France outside the NTS)
  - Discounted because, excluding any uncertainty over access to the other markets, these options require considerably more additional new infrastructure at greater cost and with greater environmental effects than other options. There is also a legal conflict preventing National Grid holding its licence to operate the NTS at the same time as it would need to hold a Shipper licence to commercially take gas off the system,
- LNG transfer past the area of constraint
  - Various strategic options to introduce the LNG onto the wider NTS by moving it as LNG to points beyond the constraint area were considered but discounted. It was concluded that there are unacceptable commercial and residual risks to the diversion of LNG to other terminals. A new dedicated LNG pipeline (approximately 300km from Milford Haven) would lead to greater environmental effects and at a much higher capital cost. Neither road nor rail tankers were considered capable of consistently providing certainty of transfer given the potential for transport network disruption.
- Uprating with MOP above equipment classification limits
  - This was discounted following review of the challenges associated with uprating with maximum operating pressure (MOP) above equipment classification levels. This option is viable and gave increased gas flow

capability compared with uprating with MOP below equipment classification limits. However it does not reduce the amount of new pipeline required (to meet the NTS entry capacity) compared with MOP below equipment class limits and also presents additional technical (safety case), programme and operational challenges to be overcome compared with MOP below equipment class limits.

- Connect into more northern / central parts of the NTS
    - Various options to increase the gas flow by reinforcing part of the existing network using combinations of uprating, compression and new pipelines were progressed to options appraisal.
    - Other new onshore and offshore pipeline connections were discounted on the basis of the benefit filter as they required: much longer pipelines, to increase capacity; required compression as well as pipeline compared with options requiring the same pipeline without compression; or involved pressure uprating with greater additional changes compared with other similar options that were progressed
- Connect into more eastern / south eastern parts of the NTS
    - Two options to increase capacity by connecting into more eastern / south eastern parts of the NTS were progressed to options appraisal but an option entirely allowing the avoidance of a 2km section through the Cotswolds AONB was discounted due to being considerably longer (at least 50km longer) with greater environmental effects and greater costs.
- Connect into south western parts of the NTS
    - A range of options incorporating various start points and combinations of reinforcement of the existing NTS, new onshore and offshore pipeline and potentially the use of existing River Severn crossings were considered to increase capacity by bypassing the constraint area into the south west part of the NTS. Compared with other options all performed more poorly on various grounds (including longer pipelines, greaster cost, technical factors and environmental effects) and were discounted.
- Other options
    - Above ground pipelines were discounted because they present a variety of challenges compared with buried pipelines (e.g. restricting access, preventing restoration and re-use of land, in addition to safety and security risks) that outweigh any small reduction in cost of construction.
    - Localised bypass of the Wormington area of constraint was considered however, under most circumstances the demand and supply patterns mean that gas flow is actually in opposite directions in the two sections of pipe making the option ineffective.

The shortlist of options for detailed appraisal

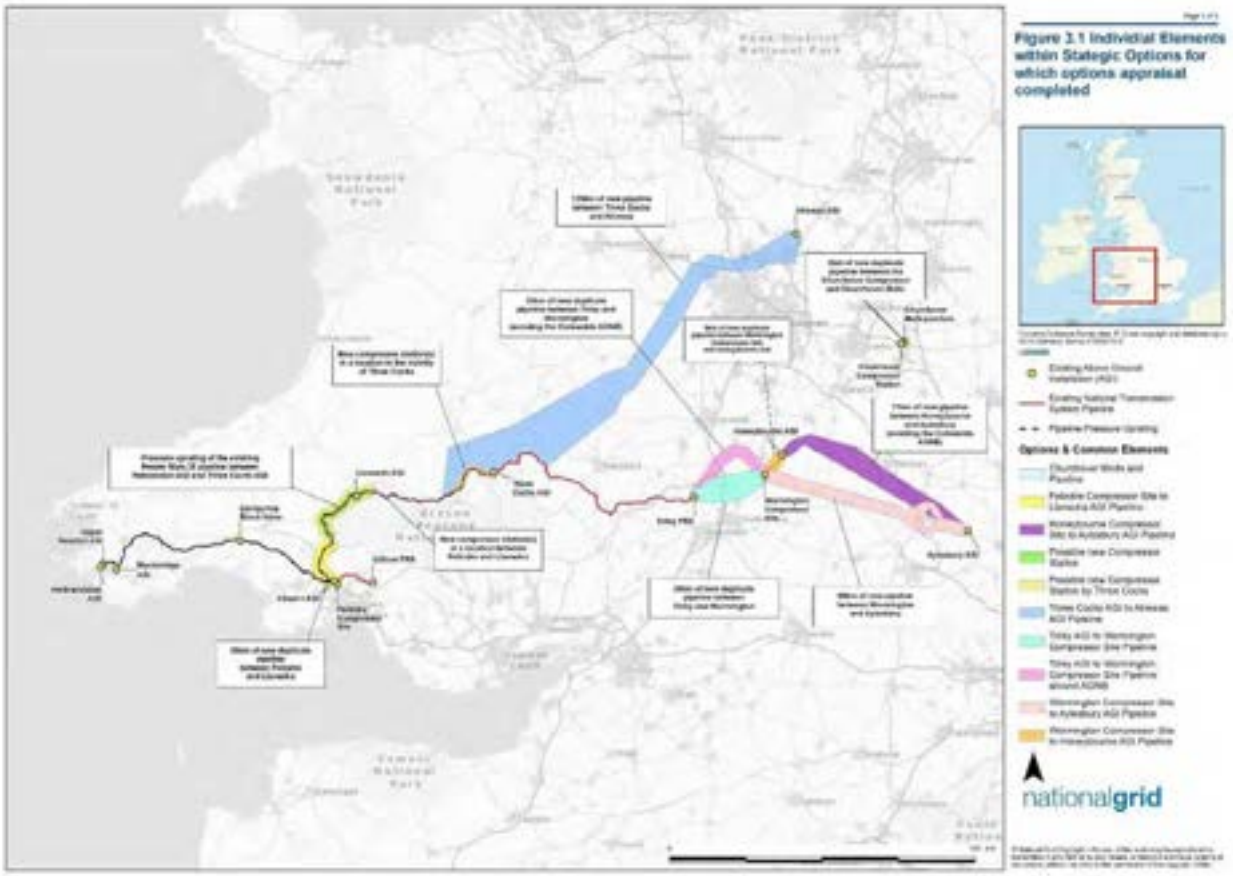
The shortlist of strategic options comprised onshore options including the following in combinations summarised in Table 1 and Figure 1 below:

- Pressure uprating i.e. increasing the Maximum Operating Pressure (MOP) of existing NTS pipelines,
- NTS reinforcement e.g. the construction of new pipelines (in some cases in addition to existing NTS capacity) and/ or additional compressor stations,
- New pipeline connections to other parts of the NTS.

Table 1 - Summary details of strategic options progressed to options appraisal

Option ref	Option short name	New pipeline (km)	Pressure uprating	New compressor site	Modifications to existing compression site	Extension to existing AGI	New AGI	Notes
F3.1	New compression between Felindre and Llanwdra AGI with ~37km of new pipelines	37	No	Yes	Yes	Yes	Yes	Pipeline from Tirley to Wormington compressor site (of which ~3km is within the Cotswolds AONB), Wormington compressor site to Honeybourne AGI and between Churchover multijunction and compressor sitest
F3.2	New compression between Felindre and Llanwdra AGI with ~44km of new pipelines	44	No	Yes	Yes	Yes	Yes	Pipeline as F3.1 but with a route between Tirley and Wormington outside the Cotswolds AONB
F3.3	New compression in the vicinity of Three Cocks AGI with ~11km of new pipelines	11	No	Yes	Yes	Yes	No	Pipeline from Wormington compressor site to Honeybourne AGI and between Churchover multijunction and compressor sitest
F4.1	New pipeline of ~92kms	92	No	No	Yes	Yes	Yes	Pipeline as F3.1 plus ~55km from Felindre towards Llanwdra s
F4.2	New pipeline of ~99kms	99	No	No	Yes	Yes	Yes	Pipeline as F3.2 (a route outside the Cotswolds AONB) plus ~55km from Felindre towards Llanwdras
F6.1	Uprating below MOP limit from Milford Haven to Three Cocks with ~37km new pipelines	37	Yes	No	Yes	Yes	Yes	Pipeline as F3.1 s
F6.2	Uprating below MOP limit from Milford Haven to Three Cocks with ~44km new pipelines	44	Yes	No	Yes	Yes	Yes	Pipeline as F3.2
F6.6	Uprating below MOP limit from Milford Haven to Three Cocks with ~11km new pipeline s	11	Yes	No	Yes	Yes	No	Pipeline as F3.3
F7.1	New ~125km pipeline from Three Cocks area to Alrewas s	125	No	No	Yes	Yes	Yes	Pipeline from the Three Cocks area to Alrewas routeing to the west of Birmingham s
G1.1	New pipeline of ~95km from Tirley to Aylesbury via Wormingtons	95	No	No	Yes	Yes	Yes	Pipeline from Tirley to Wormington compressor site and on to Aylesbury AGI with a minimum of ~16km through the Cotswolds AONB s
G1.3	New pipeline of ~104km from Tirley to Aylesbury via Honeybournes	104	No	No	Yes	Yes	Yes	Pipeline from Tirley to Honeybourne AGI and on to Aylesbury AGI with a minimum of ~5km in the Cotswolds AONBs

Figure 1 Individual elements within strategic options for which options appraisal was completed



The options appraisal of the shortlisted options

The options appraisal is underpinned by a set of guiding principles designed for this project to ensure compliance with various policies and duties including those regarding the reduction of environmental and socio-economic impacts and the economic and efficient operation of the NTS. The guiding principles are:

- GP1 Options will be safe and comply with relevant safety standards.
- GP2 Options using, extending or adapting existing infrastructure, or which can be implemented using existing rights held by National Grid, are generally preferable to creating new infrastructure or establishing new sites or new routes unless there is strong reason to suspect that options comprising less infrastructure could be less sustainable.
- GP3 Shorter routes for new pipelines are generally preferable to longer routes.
- GP4 Financially cheaper or more cost beneficial options are generally preferable to more expensive or less cost beneficial ones.
- GP5 Options where routeing and siting can be used to avoid or reduce impacts on environmental and socio-economic receptors are generally preferable to those where this is less viable.

- GP6 Options will be preferred where, after consideration of routeing and siting, any significant effects which may occur can be mitigated more easily and with greater certainty over those where such mitigation is more difficult or uncertain.
- GP7 Options, including innovative solutions, which provide technically less complex solutions or which enhance system resilience or flexibility are generally preferable to those which do not.

The information required to make comparisons between different strategic options generally relates to constraints or issues of at least national importance for which existing data is readily obtained from desk study review. More detailed assessment, supported by fieldwork, occurs in subsequent stages of study when the effort can be focussed efficiently and take account of the potential for siting, routeing and other environmental measures to influence the decision-making process.

The options appraisal considered a breadth of topics to ensure that decision-making is based on a broad understanding of the implications of National Grid's projects. It considered:

- environmental (biodiversity, landscape and historic constraints and physical aspects such as flooding);
- socio-economic (related to existing property assets);
- technical (complexity, delivery and construction issues, sustainability and network capability);
- capital cost and cost benefit analysis (weighing capital and lifetime costs against reduced system constraint costs).
- other considerations including programme.

National Grid's Preferred Option

Following the options appraisal, taking all factors into account, the balanced overall decision is that the preferred strategic proposal is option F6.6 (in Table 1 above) which comprises the following elements:

- Pressure uprating (with maximum operating pressure below equipment class limit) of the existing Feeder 28 pipeline between Milford Haven (Pembrokeshire) and Three Cocks (Powys);
- 9km of new pipeline between Wormington and Honeybourne and 2km of new pipeline between Churchover Compressor and Churchover Multijunction; and
- Related works at several existing AGI sites to facilitate the pressure uprating, connection of new pipelines and effective compression at existing stations.

The preferred strategic proposal has been selected because:

- It requires the least new infrastructure therefore minimising the impact of the project on communities and the environment,
- Has the lowest capital cost with the greatest consumer benefit; and represents the most economic and efficient solution for UK consumers,

- It complies most strongly with GP2 by maximising the use, extension and adaptation of existing NTS infrastructure, utilising some existing easements, and minimising new infrastructure requirements. Analysis also shows this option performs well in sustainability terms and has the lowest carbon budget of the strategic options. It also complies more strongly than other options with GP3 by requiring a much shorter length of new pipeline,

- Of all options within the options appraisal it complies best with GP4 being both the best performing in cost benefit assessment terms and the lowest capital cost,

- Whilst some environmental effects can be expected to arise from the new works associated with the option, these are in greater compliance with GP5 and GP6 than are the case with the other options,

- Although it involves uprating and is technically more complex and a divergence from current practice, initial assessments by National Grid indicate that the uprating continues to be safe (i.e complies with GP 1) and any remaining challenges can be resolved and the option successfully delivered. Other options themselves are more complex in other terms for example some present additional construction challenge due to additional transport infrastructure crossings and a more congested urban edge alignment.

Next Steps

The preferred strategic proposal will be reviewed regularly as the project progresses through routeing, siting, environmental appraisal and consultation to ensure it continues to represent the option that best fulfils the requirements of the PARCA and balances National Grid's various duties, obligations and guiding principles.

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1 INTRODUCTION

1.1 This Document

1.1.1 National Grid Gas plc (National Grid) is the owner and operator of the gas National Transmission System (NTS). National Grid received a Planning and Advanced Reservation of Capacity Agreement (PARCA) application from South Hook Gas Company Limited (SHGCL) to provide for 163 Gigawatt hours per day (GWh/d)[4] of gas to enter the National Transmission System (NTS) (referred to as NTS Entry Capacity) from the South Hook Liquified Natural Gas (LNG) Terminal at Milford Haven (MH) Aggregated System Entry Point (ASEP).

1.1.2 This Western Gas Network Upgrade Strategic Options Report (the "SOR") has been prepared by National Grid, as part of the PARCA pre-application procedures it adopts for major infrastructure projects. National Grid has investigated the options to meet the PARCA need and has prepared this SOR to document the evidence-led process that has been followed and to provide this information to statutory consultees and other stakeholders.

1.1.3 The SOR report has been structured to provide:

- Background to the project;
- National Grid's role and obligations;
- An overview of potential strategic options and construction methods;
- A filter of the potential strategic options and rationale for either discounting them or progressing them for more detailed options appraisal;
- An overview of the options appraisal methodology;
- An overall assessment of options progressed considering technical, cost, environmental and socio-economic considerations;
- Summary and identification of the preferred strategic proposal; and
- Next steps.

1.2 An Overview of UK Gas Supply

1.2.1 A single gas market serves the whole of Great Britain. Demand varies during and between years but in National Grid's winter outlook 2019/2020[5] peak demand was forecast to be 499 mcm/d. In this competitive wholesale market, shippers and traders trade gas on a daily basis. Gas is supplied from a variety of sources, including the UK Continental Shelf, Norway, LNG Imports, European Interconnectors and storage. Suppliers purchase gas in the wholesale market and supply to end customers. The NTS transports bulk supplies of gas from entry points to demand centres.

1.2.2 The development of National Grid's NTS began in the 1960s with subsequent incremental changes to the transmission system being made to meet increasing consumer demand and to connect new supply sources and interconnectors with

[4] The volume of gas depends on factors such as temperature and pressure but for context this equates to around 15 million cubic metres per day (mcm/d).
[5] https://www.nationalgridgas.com/document/128521/download

other transmission systems. The NTS (in 2019) consisted of just under 8000 km of pipelines with 75 compressor units at 24 compressor sites and over 500 above ground installations (data from 2019 gas ten year statement [6]). These pipelines connect entry points (where gas is put into the NTS) and offtakes (where gas is taken out of the NTS) to distribution networks, transmission-connected demand customers (e.g. large industrial customers), storage facilities and interconnectors.

1.2.3 System management is complex with the combination of: the competitive wholesale market; the combined capacity of all the ASEPs connected to and/or using the NTS being greater than the peak demand and; fluctuating daily and seasonal demand patterns. Flow direction and volume at any location can vary considerably. System changes must be carefully considered to ensure that supplies are maintained in line with relevant standards.

1.2.4 The Overarching National Policy Statement (NPS) for Energy (EN-1)[7] explicitly recognises that the "UK is highly dependent on natural gas" and that "gas will continue to play an important part in the UK's fuel mix for many years to come" (paragraph 3.8.1). It is therefore relevant to the consideration of need to note that EN-1 states that "Great Britain's gas supply infrastructure must, amongst other things, be sufficient to:

- meet 'peak' demand. This is a much more demanding requirement than meeting annual demand. Some redundancy is required to manage the risk that other capacity may not be available (for example, if undergoing maintenance); and
- allow for a sustained delivery of large volumes of gas, such as could be required during a particularly cold winter;" (paragraph 3.8.5).

1.2.5 EN-1 continues "Great Britain needs a diverse mix of gas storage and supply infrastructure (including gas import pipelines and terminals) to respond effectively in future to the large daily and seasonal changes in demand, and to provide endurance capacity during a cold winter." (paragraph 3.8.7).

1.2.6 The NPS for Gas Supply Infrastructure and Gas and Oil Pipelines (EN-4)[8] also recognises that "The efficient import, storage and transmission of natural gas and oil products is crucial to meeting our energy needs during the transition to a low carbon economy. We cannot achieve national objectives relating to security of supply without enabling investment in new infrastructure" (paragraph 1.1.1). EN-4 refers to the use of various standards which include TD-1 'Steel pipelines and associated installations for high pressure gas transmission' which is discussed further at paragraph 1.3.12 below.

1.2.7 National and local planning policy is also relevant to the development of this project. This includes the National Planning Policy Framework (NPPF), Planning Policy Wales (PPW) and local development plans.

[6] https://www.nationalgrid.com/uk/gas-transmission/document/128886/download
[7] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/47854/1938-overarching-nps-for-energy-en1.pdf
[8] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/37049/1941-nps-gas-supply-oil-en4.pdf

1.3 National Grid Duties and the Need Case

1.3.1 The Gas Act 1986 is the primary UK legislation that governs the transport and supply of natural gas within Great Britain. National Grid holds a Gas Transporter Licence ("the Licence") which is granted and administered by the Gas and Electricity Markets Authority ("the Authority"), established by the Utilities Act 2000. The Licence requires that National Grid shall enter into transportation arrangements which are in conformity with any relevant provisions of a network code, and National Grid discharges this obligation through the Uniform Network Code (UNC)[9]. Under the provisions of the UNC, Shipper Users of the NTS can request the release of NTS Entry Capacity at any NTS ASEP. Such capacity requests will be considered against the provisions of National Grid's statutory Licence obligations and in accordance with its published methodologies[10].

1.3.2 In the planning and development of their system, section 9 of the Gas Act 1986 states that a Gas Transporter has general duties, which are:

a. "To develop and maintain an efficient and economical pipe-line system for the conveyance of gas; and
b. Subject to paragraph (a) above, to comply, so far as it is economical to do so, with any reasonable request"
   i. "To connect to that system, and convey gas by means of that system to, any premises, or
   ii. To connect to that system a pipe-line system operated by an authorised transporter."

1.3.3 South Hook Gas Company Limited (SHGCL) has submitted a PARCA application which was deemed competent on 4th May 2018, meaning all necessary information has been provided and the application meets the relevant requirement. In responding to SHGCL, National Grid is obliged to outline, indicatively, to what extent, when and how the application request can be accommodated.

1.3.4 In accepting the PARCA as competent, National Grid has been bound by the terms of Section 9 of the Gas Act (as noted above) and the Licence. The Licence contains several Standard, Standard Special and Special Conditions that National Grid must comply with in developing and operating the network including:

- Standard Special Condition A9: Pipe-Line System Security Standards – This condition sets out the security standard for the NTS in terms of meeting the 1-in-20 peak aggregate daily demand.
- Special Condition 7A2: Long Term Development Statement - Under this obligation, National Grid NTS must publish an annual LongTerm Development Statement for the NTS that sets out the likely use of the NTS, the likely developments of the NTS and any other facilities or pipeline systems that may be affected.
- Special Condition C8D: NTS gas entry incentives, costs and revenues - The NTS entry condition sets out various arrangements relating to new entry capacity. Importantly, National Grid can only permanently increase

[9] https://www.gasgovernance.co.uk/UNC
[10] https://www.nationalgridgas.com/capacity/capacity-methodology-statements

the level of entry capacity at an ASEP having first assessed how much entry capacity may be substituted to meet the increase as a result of applying its Entry Capacity Substitution Methodology. This is the process of substituting Unsold Firm entry capacity from one or more ASEPs to another ASEP where demand for entry capacity exceeds the available capacity quantities for the relevant period.

- Special Condition C8E: NTS gas exit incentives, costs and revenues. National Grid NTS can only permanently increase the level of exit capacity at an exit point having first assessed how much exit capacity may be substituted to meet the increase as a result of applying its Exit Capacity Substitution Methodology. Exit Capacity substitution is the process of substituting Unsold Firm exit capacity from one or more exit points to another exit point where demand for exit capacity exceeds the available capacity quantities for the relevant period.

1.3.5 National Grid recognises that its own and the UK government's commitments to net zero emissions by 2050 will reduce national reliance on fossil fuels including natural gas. The transition in energy use is ongoing and gas continues to form an important source of energy. In its decision making on the SOR, National Grid has considered sustainability, which is inherent in the options appraisal process, and the need to maintain flexibility to meet the future needs of the NTS.

1.3.6 Considering its duties, obligations and the capacity of the existing NTS, National Grid notes that:

- Future Energy Scenarios 2019 (FES 2019)[11] forecast a need for gas entry to the NTS for the foreseeable future. All four FES require import of gas and Milford Haven ASEP is an existing component of the system for such gas imports;
- National Grid's understanding of pre-existing entry and exit capability do not provide a basis for rejecting the PARCA. On this basis, National Grid's statutory and Licence obligations require it to plan to meet the requested additional capacity; and
- A PARCA offer was made to the applicant to reserve the full quantity of additional NTS Entry Capacity for a release date of 1st January 2026.

1.3.7 Network analysis shows that the additional NTS entry capacity to meet the PARCA requirement cannot be met by the existing NTS infrastructure due to constraints on the NTS principally between Tirley and Honeybourne, and near Churchover compressor station under certain flow conditions. As such, other measures will be required through a combination of commercial rules, tools (incurring constraint costs) or asset changes to provide additional flow capability.

1.3.8 On this basis, the SOR has been prepared to outline the approach that National Grid has taken to develop a range of possible solutions to address the competent PARCA. It also outlines National Grid's preferred solution to increase the

[11] Future Energy Scenarios create a range of credible futures which allow the development of the energy system that is robust against different outcomes. FES 2019 was the most upto date available for the SOR, National Grid will back check the project as FES updates occur and the supporting detailed scenarios that allow a review of network modelling are released. More information is available at this link: http://fes.nationalgrid.com/media/1409/fes-2019.pdf.

capability of the NTS to facilitate the release of the requested capacity in accordance with National Grid's obligations and incentives under the Licence.

1.3.9 In taking forward the preparation of the SOR, National Grid's Stakeholder, Community and Amenity Policy (SCA Policy)[12] sets out how the company will meet the duties to the environment placed upon it. These commitments include:

- only seeking to build new pipelines, compressor stations, pressure reduction installations and other above ground gas installations where the existing transmission infrastructure cannot be upgraded technically or economically to meet transmission security standards;
- where new infrastructure is required, seek to avoid areas nationally or internationally designated for their landscape, wildlife or cultural significance; and
- reducing the effects of new infrastructure on other sites valued for their amenity.

1.3.10 The SCA Policy also refers to methods to assess the environmental impacts of proposals and identify appropriate mitigation and/or offsetting measures.

1.3.11 National Grid generally considers options to be preferable if:

- they are shorter, compared with longer routes;
- they are financially less expensive or more cost beneficial;
- they avoid, reduce or mitigate environmental and / or socio-economic impacts; or
- they are less technically complex or enhance system resilience or flexibility.

1.3.12 Further guidance that relates to the development of new gas infrastructure that has informed the SOR is provided in:

- The Transmission Planning Code (TPC) of 2019[13]. This is a document published by National Grid in accordance with Special Condition 7B of National Grid's Gas Transporter Licence (the Licence). The TPC describes the methodology to determine the physical capability of the system that National Grid must comply with in planning and developing the NTS.
- TD/1 Edition 5 July 2016. A document produced by the Institute of Gas Engineers & Managers for 'Steel pipelines and associated installations for high pressure gas transmission'. This provides the standard for the design, construction, inspection, testing, operation and maintenance of pipelines and associated infrastructure at the time of preparation of the SOR.

1.3.13 In early 2020 the National Infrastructure Commission (NIC) published Design Principles[14] intended to be considered by the promoters of major infrastructure

[12] https://www.nationalgridgas.com/document/81026/download
[13] https://www.nationalgridgas.com/document/128221/download
[14] https://www.nic.org.uk/wp-content/uploads/NIC-Design-Principles-Final.pdf

projects Whilst more applicable at subsequent detailed routeing, siting and design stages, the commitments and approach used for the SOR, as summarised in paragraph 1.3.7 are consistent with the NIC design principles.

1.4 The Strategic Options Report

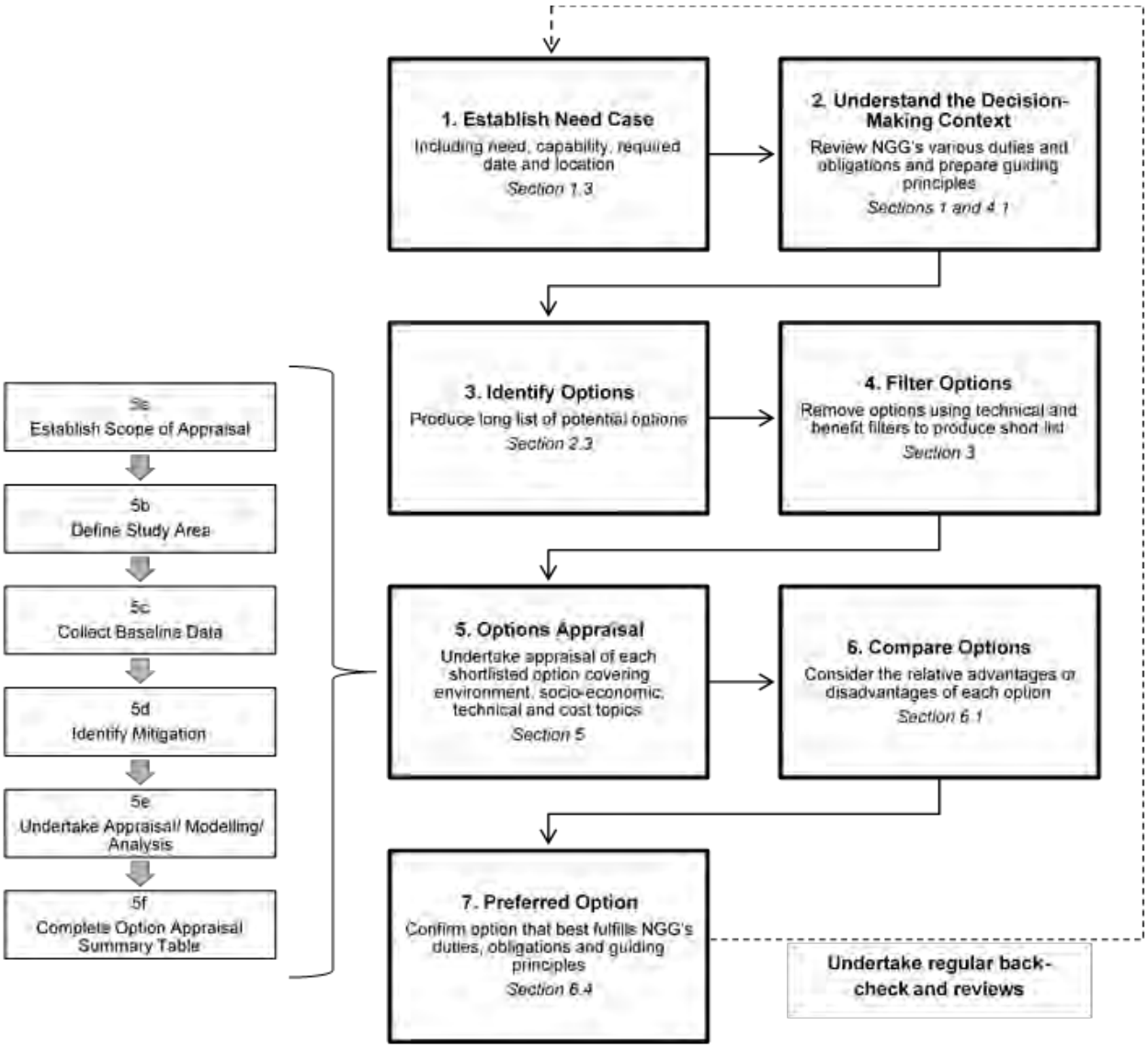
1.4.1 Options Appraisal is a robust and transparent process used by National Grid to compare options and to assess the positive and negative effects they may have across a wide range of criteria including environmental, socio-economic, technical and cost factors. The detail of the approach adopted varies on a case by case basis, to respond efficiently to the specific scale and nature of individual projects, but comprise a staged process of options appraisal. Typically, options appraisal is undertaken at the following points during the development of major new infrastructure projects:

- where strategic options are compared (this is the stage relevant to this report);
- where broad corridors or general locations are looked at as alternative means to implement the preferred strategic proposal;
- where the proposed detailed alignment or location of any infrastructure is considered; and
- where consultation has been undertaken and alternative options have been identified.

1.4.2 This SOR reports the findings of the first stage of options appraisal and documents the process of investigation, analysis and review that has been undertaken to identify the strategic proposal that provides the most economical and efficient solution to safely provide the reserved capacity, requested in the competent PARCA from SHGCL, in line with National Grid's various duties, obligations and guiding principles. Subsequent Route Corridor Studies and Siting Studies will report on the outcome of later stages of options appraisal activities, noting that stages may be combined if appropriate to do so based on the specific project circumstances.

1.4.3 Figure 1.1 provides a flow diagram of the strategic optioneering process that has been followed in relation to this project and where each stage is documented in the rest of this report.

Figure 1.1 Western Gas Network Upgrade Strategic Options Appraisal Process Flow Diagram



2 OVERVIEW OF POTENTIAL STRATEGIC OPTIONS AND CONSTRUCTION METHODS

2.1 Overview of NTS

2.1.1 Figure 2.1 shows the localised NTS in proximity to the Milford Haven ASEP and South Hook Terminal along with this area in the wider context of the NTS throughout the UK.

2.1.2 Network analysis has identified a series of sequential constraints which mean that the existing NTS cannot meet the NTS Entry Capacity requirement from Milford Haven ASEP. The main constraints relate to:

- Capacity between the compressor site at Wormington and the Above Ground Installation (AGI) at Honeybourne.
- Capacity between the Churchover compressor site and Churchover Multijunction.
- Capacity between the Tirley Pressure Reduction Station (PRS) and the Wormington compressor site.
- Capacity of Feeder 28 in South Wales.

2.2 Increasing System Capacity

2.2.1 Additional system capacity can be achieved by one, or a combination of, mechanisms and measures as described below.

Commercial Mechanisms

2.2.2 Various commercial mechanisms are available to National Grid to seek to either constrain or boost supply and demand, although there are limitations on the extent of the network over which these mechanisms are effective.

Operational Management

2.2.3 Operational management of the NTS is complex and involves balancing changing levels of supply and demand across the system. The amount of gas within the system at any time is known as 'linepack'. Linepack is used to maximise efficiency of the system and meet demand requirements. This process allows gas to be moved around the pipeline system, which increases or reduces the pipeline pressures, providing some inherent capacity buffering. This gas can then be used to meet demand, with pressures dropping at higher demand times of day. This ensures that gas pressures are maintained above agreed minimum supply levels but below agreed safety limits for the specific pipeline and equipment. Since this mechanism is already extensively and continuously used to maximise operational efficiency, it could not contribute to realising additional capacity.

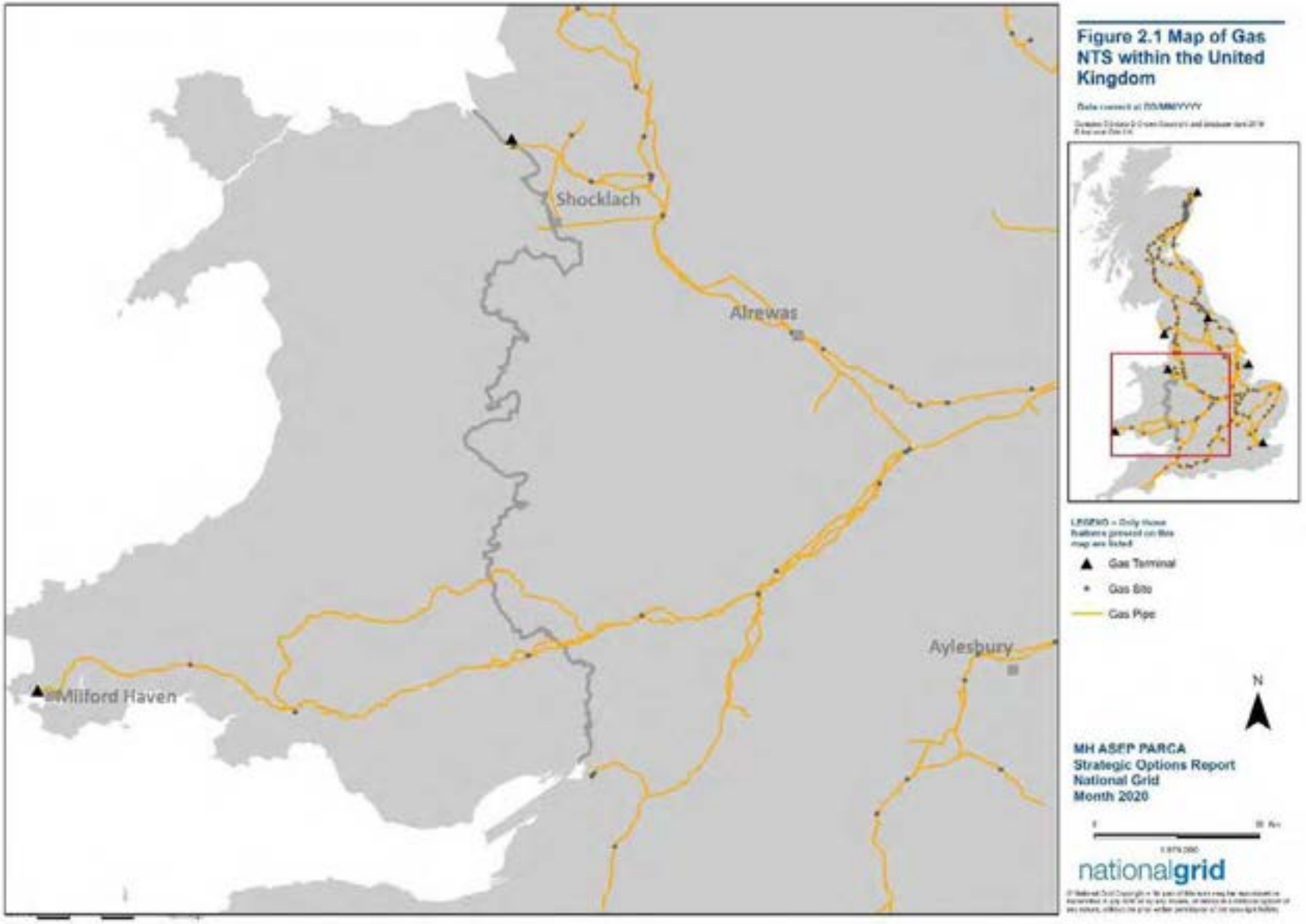


Figure 2.1 Map of Gas NTS within the United Kingdom

Modification of Existing Infrastructure by Uprating of Operational Pressures

2.2.4 The NTS currently operates at a range of pressures between approximately 25barg[15] and 94barg with some NTS pipelines operating at lower pressures than their capability would allow. System modelling has demonstrated that a substantial contribution to the additional capacity needed can be achieved by changing the operational parameters to facilitate operation at higher pressures, referred to as uprating.

2.2.5 National Grid follows an established process in these circumstances, used elsewhere in the UK, that enables redeclaring of the maximum operating pressure (of the system in question) to a higher level than the current value. Two levels of uprating have been considered. Uprating with maximum operating pressure[16] (MOP) below equipment class limits and uprating with MOP above equipment class limits.

2.2.6 National Grid would expect to uprate only those sections where it was necessary to do so and only to the pressure necessary to meet the required capacity. This means that different sections of pipeline may be uprated to different pressures and the exact level of pressure uprating would vary depending on the specific system configuration.

2.2.7 Establishing the acceptability of the uprating in safety terms may be achieved by technical review and/or physical replacement of components. The uprating process would consider the results of structural reliability assessments, quantitative risk assessment and other technical studies to confirm the continued suitability and safety of the transmission system. Suitability and safety would be confirmed with the Health & Safety Executive (HSE) (the relevant regulatory body) before pressures were physically raised.

2.2.8 The activities associated with implementing different uprating options varies. Uprating with MOP below equipment class limits is anticipated to be achievable through technical review with little requirement for physical component replacement. Should it be desirable to uprate where MOP exceeds equipment class limits, it is more likely that physical replacement of major components (for alternatives with higher ratings) would be required.

2.2.9 As pressure is increased by uprating there may be a requirement (subject to risk assessments) for pipeline diversions, pipeline strengthening or additional pipeline protection (e.g. through use of concrete slabs laid above the pipelines to prevent impact). Additionally, pressure reduction equipment may be required at boundaries between the uprated system and non-uprated pipelines and installations.

2.2.10 Pressure uprating presents technical, operational and programme challenges which generally increase as the uprated pressure increases. Some sections of pipeline are easier to uprate than others with a key influence being the number

[15] Barg The bar is a metric unit of pressure, the notation bar(g) or barg represents gauge pressure, i.e., pressure in bars above ambient or atmospheric and used by National Grid.

[16] MOP is the normal upper pressure limit of operation. Pressure may intermittently exceed this level (by between 1% to 6% is typical) (known as maximum incidental pressure) for example when compressors start due to the friction within pipes slowing the equalisation of pressure by gas movement from higher (near the source of compression) to lower pressure areas.

of offtake points. Where pressure is uprated all such offtakes need to be modified or confirmed as capable of being technically uprated. Feeder 28 uprating has been confirmed as viable in principle following technical viability review.

2.2.11 Any additional consents and approvals required to operate at the higher pressures or replace equipment required by uprating will be sought via the appropriate consent regime.

Additional Infrastructure & other measures

2.2.12 Achieving additional capacity by the construction of new infrastructure provides the final means of potentially meeting the reserved capacity. Various approaches exist:

- New pipelines (with associated infrastructure such as sites or equipment for compression and AGIs) provide one solution to moving more gas past the constraint areas either to new markets or to connect elsewhere on the NTS. Options may include onshore pipeline, offshore pipeline and combinations of these.
- Compression. Where equipment is used to increase pressure and flow rates within existing pipeline infrastructure.
- The use of other transport modes (ship, road or rail) to transport Liquified Natural Gas (LNG) to other locations. LNG requires 1/600th the storage volume of natural gas at standard atmospheric pressure so represents significantly lower volume than even highly compressed natural gas. This lower volume reduces the number of movements required and increases feasibility of transporting large quantities of LNG compared with transporting compressed natural gas.
- Storage. A facility to hold the gas at an entry point or elsewhere to provide a means to distribute flows from periods of constraint to periods when flow capacity may be available. Storage may be as LNG or compressed natural gas (CNG).

2.2.13 A brief overview of these approaches is provided below:

Onshore Pipeline

2.2.14 New pipelines provide additional capacity for gas movement. For all onshore pipeline options the use of above-ground cross country pipelines was considered but discounted at the outset for a combination of reasons including: additional safety and security risks; visual impact; effect of sterilising land use preventing its continued use for agriculture and other purposes; and because of the potential to restrict access across the pipeline alignment. The use of buried cross-country pipelines was therefore taken forward for all onshore pipeline options as they provide the safest, most secure and practical method of transporting gas in such circumstances.

2.2.15 Buried pipelines installed using trench excavation would therefore be the main technique used for onshore pipelines. This involves the establishment of a working corridor followed by the digging of a trench into which the pipeline is lowered (with at least 1.2m cover) and subsequently backfilled with the

excavated soil. All pipelines are cleaned and tested for integrity (normally by hydraulic pressure test) before being commissioned with gas. Restoration of working areas then follows.

2.2.16 Other trenchless techniques such as horizontal directional drilling, auger boring, pipe jacking or micro-tunnelling may be used to cross under obstacles such as roads, railways and watercourses. The effects associated with specific techniques are not considered determinative for decision-making at this strategic option stage but adjustments to capital cost and cost benefit assessment comparisons have been made to reflect the additional costs associated with some types of crossings. AGIs are required approximately every 16km along a pipeline, although they are relatively low profile and flexibility on location (which allows avoidance or reduction of potential adverse effects) means they are also not considered determinative at this strategic option stage.

2.2.17 Tunnels may occasionally be utilised or constructed for pipelines where longer crossings, e.g. of estuaries, may be required and where other techniques may not be available, and have been considered in the development of strategic options.

Offshore Pipeline

2.2.18 As with onshore pipelines, new offshore pipelines provide additional capacity for gas movement. Offshore pipeline installation techniques vary but typically involve pipes being laid beneath the seabed for protection either into trenches ploughed onto the seabed with material then cast back over the laid pipe or using a technique called jetting where the pipe sinks into a temporarily liquefied substrate. In some conditions rock mattresses or rock armour may be required over the pipe to provide the protection or to prevent the pipeline from floating. Crossing of other pre-existing infrastructure may require the use of various specialist structures. Where pipelines come ashore there may also be a need for trench excavation and pulling of pipes onto or from shore along with any onward works to a connection point on the NTS.

Compression

2.2.19 Gas flow through a pipeline is reduced by friction. Compressor stations increase the pressure of gas within the pipeline to enable it to be transported effectively and achieve necessary pressures at the offtakes. Power is provided by gas turbines or electric motors. Compressors are specified to operate across different pressure ranges or flow conditions and this compression ‘envelope’ can be adjusted by ‘re-wheeling’. Larger increases in flow require either the addition of new compression units at an existing site or at a new compression site or sites. Most sites incorporate three units at a single site to allow for maintenance and as back up though it is possible for multiple sites to achieve the same pressure increase whilst incorporating redundancy and hence resilience.

Storage

2.2.20 Gas can be stored either as LNG, after being cooled until it becomes a liquid, or as compressed natural gas (CNG). LNG is stored in insulated tanks at normal atmospheric pressure and low temperatures. Natural gas can be stored in vertical gas holders (typically at around 10barg) or at higher pressure in

specialised structures (similar to large diameter pipes). The UK also has extensive gas storage facilities in underground caverns, though these are restricted to certain geographical locations and not in locations beneficial to this project.

Transport Modes

2.2.21 In addition to transport by pipeline, gas (as LNG) can be transported by road, rail or sea using insulated tanks. This transport would need to be to an appropriate facility where the LNG can be regassed (converted from liquid to gas form) and injected into the existing NTS at necessary pressures (unless used directly as LNG by a demand customer).

2.3 Potential Strategic Options

2.3.1 A list of potential strategic options was developed to consider alternative means to achieve the reserved capacity. For the initial identification of options, these were deliberately unconstrained by consideration of factors such as cost or practicality. These were developed by National Grid staff from various departments with additional input by external contractors. Subsequently the potential strategic options were collated and structured into the following main themes:

- Do Nothing
- Use of Commercial Tools
- New Demand Customer
    - E.g. major user of gas (e.g. new gas fuelled power station) as well as potential for conversion into hydrogen
- Utilise existing 3rd party infrastructure
    - Considering whether existing (operational or disused) pipeline infrastructure owned or operated by 3rd parties may be available to meet the additional capacity.
- New storage (LNG and / or natural gas)
    - Considering whether temporary storage may be able to make use of less constrained periods.
- Connect to new markets (outside the NTS)
    - Offshore pipelines to Ireland and France outside the NTS
- LNG transfer past the area of constraint
    - Reviewing whether transport as LNG, including by non-pipeline means (redirected ships, or road / rail tanker beyond the constraint areas), provided an appropriate solution.
- Connect into more northern / central parts of the NTS
    - Options to increase the flow through the existing network using combinations of uprating, compression and new pipelines.

- Various new onshore and offshore pipeline connections to increase capacity by bypassing the constraint area into more northerly parts of the NTS.

- Connect into more eastern / south eastern parts of the NTS
  - Onshore options to increase capacity by connecting into more eastern / south eastern parts of the NTS
- Connect into south western parts of the NTS
  - Onshore options to increase capacity by upgrading the existing NTS or using other existing infrastructure to direct flows through the south western NTS
  - Various onshore and offshore pipeline options and combinations of options to cross the Bristol channel to increase capacity by connecting into the constraint area into the south west NTS.
- Other options
  - Localised bypass of other gas flows past the Wormington area of constraint.

2.3.2 The implementation of some options would require revisions to legislation, and/or regulations. The time required to secure legislative or regulatory change would be incompatible with project timescales so these options have been discounted. Any future Licence changes will trigger a back-check.

2.3.3 Appendix B provides a list of the potential strategic options considered. This does not include every possible combination of modifications where it is apparent, from initial modelling, that it would fail to meet the PARCA requirement (i.e fail to meet the NTS entry capacity).

2.3.4 Figure 2.2 provides a diagrammatic illustration of the potential strategic options that would involve physical works. The figure in top left illustrates consideration of various solutions using mainly offshore connections including movement to other markets (Ireland or France) or to connect into different parts of the NTS to bypass the constraint area. The figure at top right shows the range of predominantly onshore infrastructure options considered to move gas beyond the existing constraint area into more north eastern, eastern or southwestern parts of the NTS. The lower figure illustrates options incorporating storage (either as LNG or natural gas at Milford Haven or as natural gas elsewhere on the network) or movement as LNG either onshore (in a pipeline or using road or rail tankers) or by redirecting LNG ships to other facilities (to the other UK facility as shown or to other international facilities (not shown).

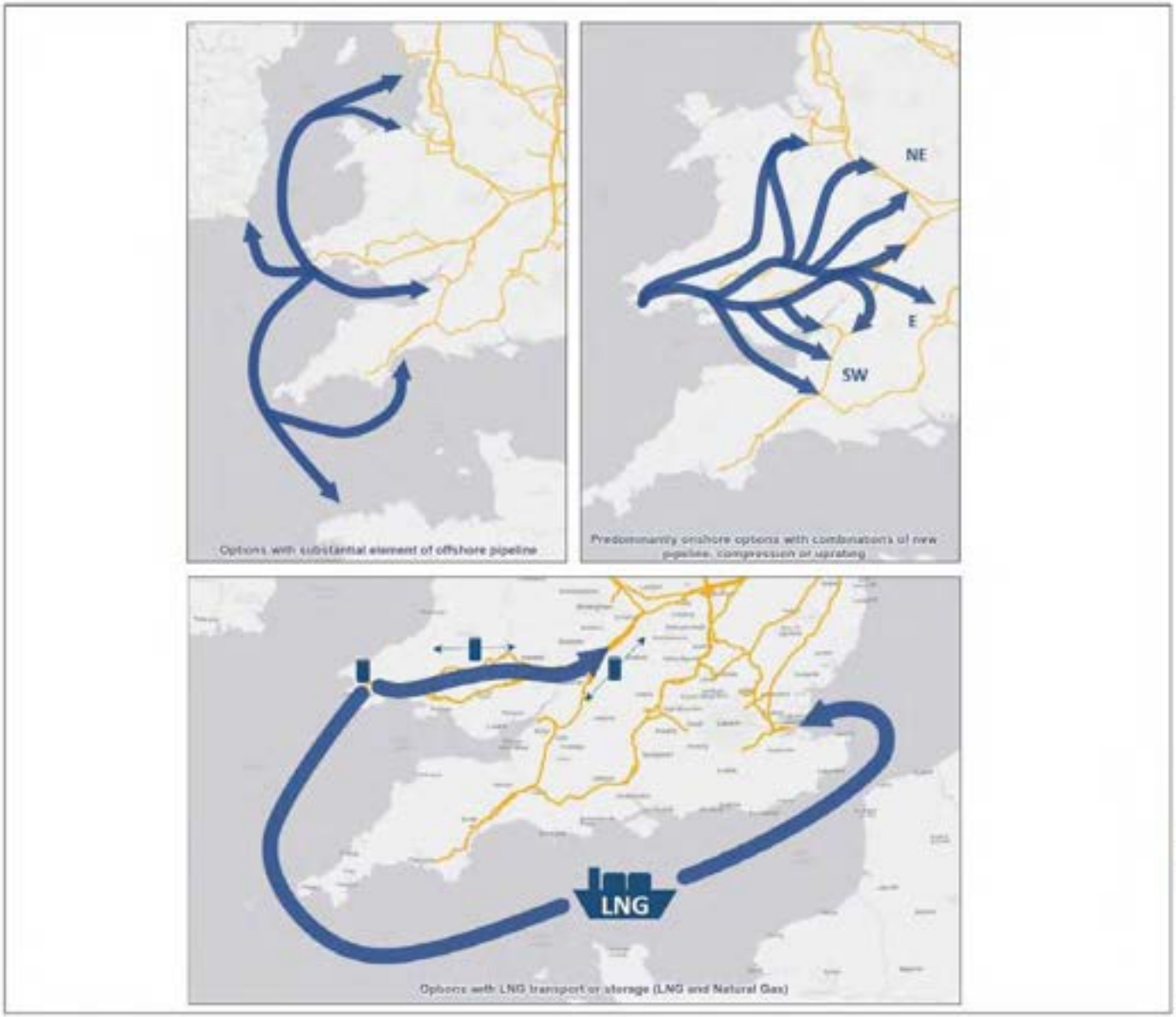


Figure 2.2 Geographic Illustration of Options

Data correct at DD/MM/YYYY

3 REVIEW OF POTENTIAL STRATEGIC OPTIONS

3.1 Technical and Benefit Filter

3.1.1 Extensive network modelling analysis has been carried out to identify the extent to which options may be able to meet the NTS entry capacity. In several cases the initial concept of the strategic option was refined, following the modelling, in order to define a deliverable solution for the strategic option to allow evaluation and comparison. This included considering the potential for combinations of options, to achieve the reserved capacity, particularly where initial appraisal suggested the option did not achieve the necessary capacity. For example, an option to connect from Milford Haven ASEP to Barrow (bypassing the constraint area and allowing connection into more northern parts of the NTS) could not achieve necessary flows without including additional compression part way along the route. This compression was therefore included within the option before it was subject to further review.

3.1.2 The list of refined strategic options was then subject to a technical filter. The technical filter considered whether options had to be discounted for various reasons including:

- They fell outside the scope of National Grid's licenced activities or were changes that could not be made within project timescales);
- They would not meet the NTS entry capacity;
- There were specific factors identified that were considered to render the option undeliverable or unable to meet technical or safety specifications;
- The option could not be developed or built within the required timescale.

3.1.3 The options were also assessed against a benefit filter. This removed options which met the need case but which would not offer any material benefit (e.g. in reduced environmental effects) over other options but which may, in comparison, have performed substantially more poorly on one or more aspect (e.g. landscape effects) with all other things being equal. This prevented the need to assess multiple options where the potential for much greater impact, from one or more otherwise similar options was readily apparent. Where some uncertainty existed, a precautionary approach was taken and options were taken forward to options appraisal to allow for additional appraisal to be undertaken.

3.1.4 Capital costs form part of the consideration within the benefit filter stage[17]. For comparisons between variations of the same general option, any operational costs appear in both variants and are therefore not determinative. Cost benefit analysis requires a level of detail about the options that is not available at this point, but which was completed for those options taken forward to the options appraisal.

3.1.5 The output of the technical and benefit filters was a shortened list of 11 potential strategic options to be taken forward to full options appraisal. The finalisation of

[17] For consistency, all capital cost comparisons have been made with reference to the lowest capital cost option that meets the NTS entry capacity for the PARCA. This is option F6.6 comprising uprating within MOP below equipment classification limits of Feeder 28 with 11km of new pipeline.

the options was arrived at through an iterative process providing the opportunity to review and refine options from the different evaluation perspectives (e.g. environment, technical, consents etc) prior to final comparative appraisal.

3.2 Discounted Options

3.2.1 After application of the Technical and Benefit filters several potential strategic options were discounted from further consideration. The reasons for this are summarised briefly below and described in detail in Appendix C.

Do Nothing

3.2.2 National Grid has a duty (under the Gas Act) to consider applications and to comply, so far as it is economical to do so, with any reasonable request to connect to the NTS. Do nothing options (option J1.1 and J1.2) are therefore discounted as an option on the basis of being non-compliant with National Grid's legal duties.

Use of Commercial and System Management Mechanisms

3.2.3 National Grid can use, at its discretion, a variety of commercial and system management mechanisms to manage the demand and supply balance and flow rate changes on the network. National Grid concluded that there were no other suppliers expected to cease activities within a relevant part of the network that would offset the NTS entry capacity sought. National Grid can use constraint payments as another mechanism to modify imbalances in supply and demand but concluded that whilst commercial and supply management mechanisms provide an important mechanism for effective short-term management of a competitive gas supply market. they do not provide a mechanism to consistently respond to the NTS entry capacity in an efficient or economic manner.

New Demand Consumer

3.2.4 National Grid is not allowed, by its licence[18], to generate demand itself and is not aware (at the time of SOR preparation) of any new consumer demands of sufficient scale in the relevant area to offset the requirement for works[19]. Similarly, no hydrogen economy (for which gas is a possible feedstock and which can be integrated with carbon capture technology) is yet established, nor is anticipated to be established within the timescales and at the scale required to respond to the PARCA.

[18] The Gas Act 1986 (Section 7, 7A and 8H) specifies that a holder of a gas transporters licence may not also hold either a gas suppliers or gas shippers licence. These are required to take gas onto and off the NTS and as a result, National Grid cannot become a source of demand. Equally, the gas act incorporates European legislation on ownership unbundling requirements that prohibits transmission system operators (TSOs) from owning or controlling assets for the production or supply of energy, or being controlled by persons that own or control such interests. The aim of this is to avoid conflicts of interest, the potential for discrimination among network users and uncompetitive behaviour.

[19] A proposed gas peaking plant near Felindre does not provide sufficient scale of demand. Further detail is provided in Appendix C.

Utilise existing 3rd party infrastructure

3.2.5 Various 3rd parties have existing (operational and disused) pipeline infrastructure in the relevant geographical area which has the potential to be used to provide the additional flow capacity in place of the construction of new pipeline (option B3.1). In addition, various mechanisms (referred to as 'flow swap') exist for National Grid to work with the local transmission system (LTS) of the Distribution Network Operators (DNO) to manipulate gas flows through different parts of the integrated NTS and LTS network to achieve higher flow rates than use of the NTS alone (options B1.1 and B2.1). Appraisal has concluded that no 3rd party infrastructure exists that would be extensive enough, nor have sufficient capacity, for flow swap arrangements to meet the NTS entry capacity.

New storage (LNG and / or natural gas)

3.2.6 These strategic options considered whether storage, over an extended period to allow smoothing of the flow of the reserved capacity over a number of days or weeks, would avoid the need for new capacity to be achieved by the construction of new infrastructure (new pipelines, compression etc). Notwithstanding the fact that National Grid's Gas Transporters Licence does not allow it to use storage in this way[20], it is concluded that depending on peaks and troughs in supply rather than new transmission capability, does not provide an economic, efficient or environmentally appropriate solution to meet the additional NTS entry capacity.

Connect to new markets (outside the NTS)

3.2.7 There is an inherent conflict that may prevent adoption of any of these options which prevents National Grid holding both a Gas Transmission licence (which it has to operate the NTS) and a Shipper licence which is required to commercially take gas off the system. Notwithstanding that, these strategic options to connect to new markets outside the NTS, to southern Ireland (option D1.1) and to northwest France (option D1.2), were considered. Both options were discounted as, excluding any uncertainty over access to the other markets, they require considerably more additional new infrastructure at greater cost and with greater environmental effects that other options.

LNG transfer past the area of constraint

3.2.8 The constraint on the reserved capacity is the ability to move the natural gas into the wider NTS beyond the constraint area around Wormington. These strategic options therefore considered whether it was possible to introduce the LNG onto the wider NTS by moving it as LNG to points beyond the constraint area. National Grid concluded that there are unacceptable commercial and residual risks to the diversion of LNG to other terminals. National Grid discounted a new dedicated LNG pipeline from MH ASEP (option E2.3) on the basis of leading to greater

[20] The Gas Act 1986 (Section 7, 7A and 8H) specifies that a holder of a gas transporters licence may not also hold either a gas suppliers or gas shippers licence. Whilst National Grid can utilise storage to manage peak and short-term issues (as previously when it operated storage at Avonmouth), it would not be allowed to operate storage that could be seen as potentially affecting the market. Managing market driven flows over long periods of constraint is considered to be potentially capable of doing this and therefore outwith National Grid's Licence.

environmental effects and at a much higher capital cost. National Grid also discounted the use of either road tankers (option E2.1) or rail tankers (option E2.2) as neither were considered capable of consistently providing certainty of transfer of the NTS entry capacity required.

Uprating with MOP above equipment classification limits

3.2.9 Following review of the challenges associated with uprating, National Grid concluded that uprating with MOP above equipment classification is viable. However, whilst this gave increased capability compared with uprating with MOP below equipment classification limits, it does not reduce the amount of new pipeline required (to meet the NTS entry capacity) compared with MOP below equipment class limits so offers no benefits in terms of meeting the NTS entry capacity of the PARCA. Given that there are also additional technical (safety case), programme and operational challenges to be overcome, options uprating with MOP above equipment classification limits (F5.1 to F5.9) were discounted from further consideration.

Connect into more northern and central parts of the NTS

3.2.10 In addition to the options progressed, several other strategic options based on enhancing Feeder 28 were considered to bypass the area of constraint by connecting into more northerly / central parts of the NTS. Several predominantly pipeline options (onshore and offshore) were discounted on the basis of the benefit filter as they: required much longer new pipelines (e.g. options F1.1, F1.2, F7.2, F7.3, F7.4); required compression as well as pipeline compared with options requiring the same pipeline without compression (e.g. F3.4, F3.4, F6.4 and F6.4); or involved pressure uprating with additional changes (e.g. F6.7 to F6.12) compared with other similar options that were progressed. An alternative to upgrade Feeder 2 (running to the south of the Brecon Beacons National Park) was also considered but discounted as it would be through considerably more challenging terrain (unavoidably crossing numerous south Wales valleys) and required additional new infrastructure due to pressure differences. Various bypass and minor changes to connection points were also considered but were discounted as ineffective or less beneficial.

Connect into more eastern parts of the NTS

3.2.11 Options to increase capacity by connecting from the vicinity of the area of constraint (at or to the west of Wormington) into more eastern parts of the NTS around Aylesbury were considered. Two were taken forward but an option entirely allowing the avoidance of a 2km section through the Costwolds AONB was discounted due to being considerably longer (at least 50km longer) with consequently greater environmental effects and greater costs.

Connect into south western parts of the NTS

3.2.12 A variety of options (H1.1 to H1.5, H2.1 and H2.2, H3.1 and H3.3, H4.1 and H4,2) incorporating various starting points and combinations of onshore and offshore pipeline and potentially the use of existing River Severn crossings were considered to increase capacity by bypassing the constraint area into the south west part of the NTS. Compared with other options all performed more poorly on various grounds and were discounted.

Localised bypass of the Wormington area constraint by other gas flows

3.2.13 Whilst not forming a full solution, consideration was given to whether a localised bypass of the Wormington area to connect from north east to south west (option I1.1) may provide some additional capacity to allow more flows from South Wales. However, under most circumstances the demand and supply patterns mean that gas flow is actually in opposite directions in the two sections of pipe rendering the option ineffective.

3.3 Strategic Options Progressed to Options Appraisal

3.3.1 Table 3.1 below provides a summary of the strategic options progressed to options appraisal. The options comprise various combinations of pressure uprating, new compression sites and new pipeline and have been presented grouped into those main themes (and in ascending order of the length of new pipeline required within themes). Some options reinforce the capability of the existing NTS infrastructure (including by adding additional pipelines on the general location / alignment of existing NTS pipelines – referred to as duplication) whilst others require new infrastructure in locations where no NTS infrastructure exists nearby. Options require various additional works which may include: the requirement for pressure reduction sites (as extensions to existing AGI facilities where uprating is proposed); some changes to offtakes (at existing AGI facilities) on uprated sections of pipeline; or a need for new AGI (approximately every 16 km) along new sections of pipelines. Figure 3.1 shows the geographical location of the differing elements that are used in different combinations depending on the option.

3.3.2 The approximate pipeline lengths referred to are the straight-line distances with sensible adjustments to route around settlements or other readily avoidable constraints. In any cost comparisons, a contingency was added to the costs to allow acceptable and achievable alignments following detailed route alignment studies and to allow a realistic comparison between options. Based on National Grid experience the costs for pipeline distances above 30km are increased by approximately 15% with an increase of 7.5% used on shorter connections.

Table 3.1 Summary details of strategic options progressed to options appraisal

Option Ref	Option short name	New pipeline (km)	Pressure uprating	New compressor site	Modifications to existing compression sites	Extension to existing AGI	New AGI	Notes
F3.1	New compression between Felindre and Llanwdra AGI with ~37km of new pipeline	37	N	Y	Y	Y	Y	Pipeline from Tirley to Wormington compressor site (of which ~3km is within the Cotswolds AONB), Wormington compressor site to Honeybourne AGI and between Churchover multijunction and compressor sites
F3.2	New compression between Felindre and Llanwdra AGI with ~44km of new pipeline	44	N	Y	Y	Y	Y	Pipeline as F3.1 but with a route between Tirley and Wormington outside the Cotswolds AONB
F3.3	New compression in the vicinity of Three Cocks AGI with ~11km of new pipeline	11	N	Y	Y	Y	N	Pipeline from Wormington compressor site to Honeybourne AGI and between Churchover multijunction and compressor sites
F4.1	New pipeline of ~92km	92	N	N	Y	Y	Y	Pipeline as F3.1 plus ~55km from Felindre towards Llanwdra
F4.2	New pipeline of ~99km	99	N	N	Y	Y	Y	Pipeline as F3.2 (a route outside the Cotswolds AONB) plus ~55km from Felindre towards Llanwdra
F6.1	Uprating below MOP limit from Milford Haven to Three Cocks[21] with ~37km new pipeline	37	Y	N	Y	Y	Y	Pipeline as F3.1
F6.2	Uprating below MOP limit from Milford Haven to Three Cocks with ~44km new pipeline	44	Y	N	Y	Y	Y	Pipeline as F3.2
F6.6	Uprating below MOP limit from Milford Haven to Three Cocks with ~11km new pipeline	11	Y	N	Y	Y	N	Pipeline as F3.3 as a result of assuming higher uprating pressure (still below MOP equipment class limits) compared with F6.1 and F6.2
F7.1	New ~125km pipeline from Three Cocks area to Alrewas	125	N	N	Y	Y	Y	Pipeline from the Three Cocks area to Alrewas routeing to the west of Birmingham
G1.1	New pipeline of ~95km from Tirley to Aylesbury via Wormington	95	N	N	Y	Y	Y	Pipeline from Tirley to Wormington compressor site and on to Aylesbury AGI with a minimum of ~16km through the Cotswolds AONB
G1.3	New pipeline of ~104km from Tirley to Aylesbury via Honeybourne	104	N	N	Y	Y	Y	Pipeline from Tirley to Honeybourne AGI and on to Aylesbury AGI with a minimum of ~5km in the Cotswolds AONB

[21] For F6.1, F6.2 and F6.6 This comprises a Milford Haven to Felindre section (which includes the pipeline through to Clfrew PRS) and a Felindre to Three Cocks section with pressure uprating potentially being to different pressures in these two sections

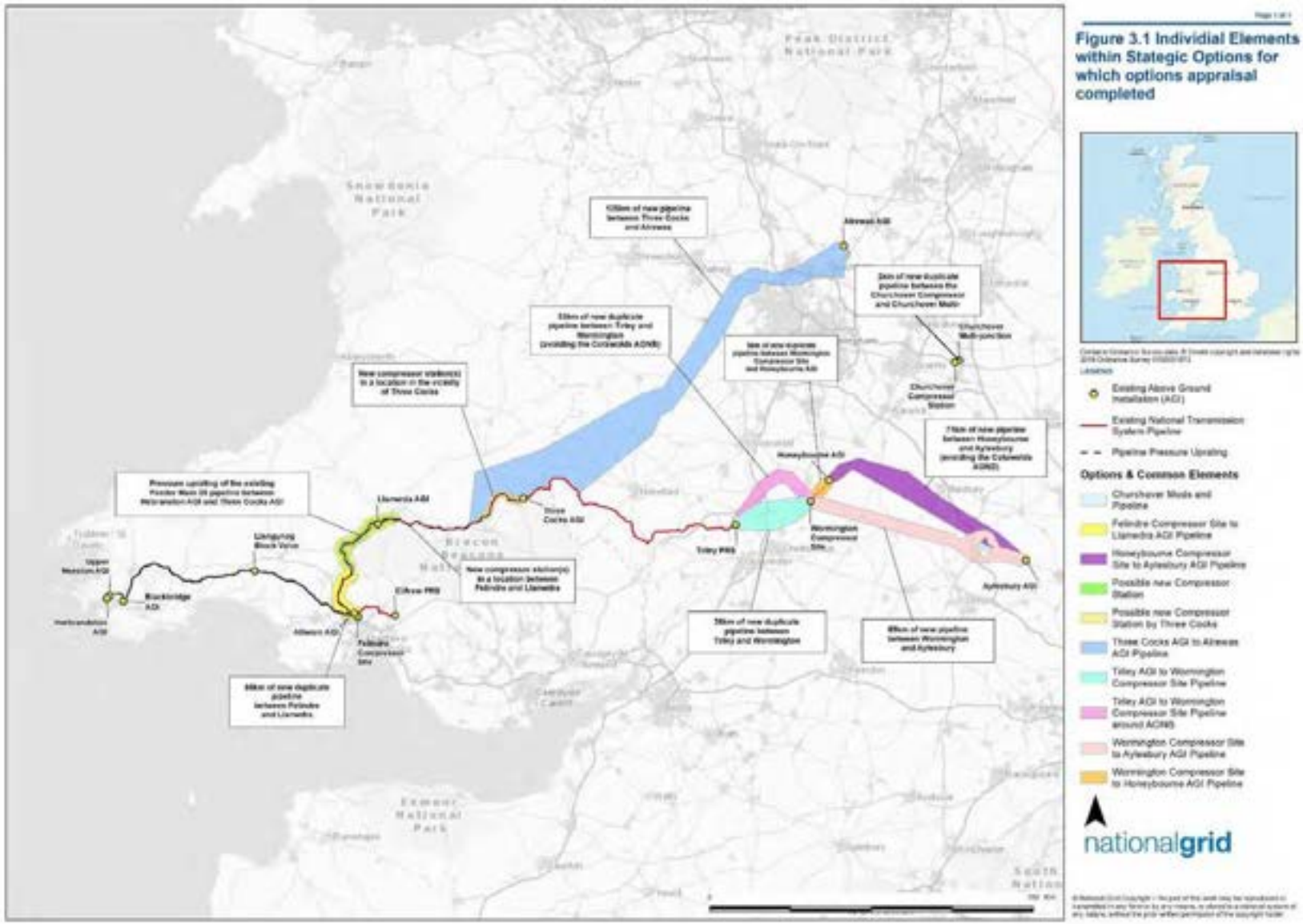


Figure 3.1 Individial Elements within Stategic Options for which options appraisal completed
Existing Above Ground Installation (AGI)
Existing National Transmission System Pipeline
Pipeline Pressure Uprating
Options & Common Elements
Churchover Mods and Pipeline
Felindre Compressor Site to Llanarda AGI Pipeline
Honeybourne Compressor Site to Aylesbury AGI Pipeline
Possible new Compressor Station
Possible new Compressor Station by Three Cocks
Three Cocks AGI to Abwest AGI Pipeline
Tirley AGI to Wormington Compressor Site Pipeline
Tirley AGI to Wormington Compressor Site Pipeline around AONB
Wormington Compressor Site to Aylesbury AGI Pipeline
Wormington Compressor Site to Honeybourne AGI Pipeline
nationalgrid

4 OVERVIEW OF OPTIONS APPRAISAL METHODOLOGY

4.1 Guiding Principles

4.1.1 The Options Appraisal has been completed in line with National Grid's Approach to Options Appraisal, 2012, and is underpinned by a set of guiding principles. These principles are the starting point for the decision-making process and define good performance. The guiding principles have been designed for this project to ensure compliance with various policies and duties including those regarding the reduction of environmental and socio-economic impacts and the economic and efficient operation of the NTS. This includes National Grid's various statutory duties (see Section 1), National Grid's SCA policy and guidance in IGEM TD/1, the National Planning Policy Framework (NPPF), Planning Policy Wales and National Policy Statements EN-1 and EN-4. The guiding principles are:

- GP1 Options will be safe and comply with relevant safety standards.
- GP2 Options using, extending or adapting existing infrastructure, or which can be implemented using existing rights held by National Grid, are generally preferable to creating new infrastructure or establishing new sites or new routes unless there is strong reason to suspect that less infrastructure could be less sustainable.
- GP3 Shorter routes for new pipelines are generally preferable to longer routes.
- GP4 Financially cheaper or more cost beneficial options are generally preferable to more expensive or less cost beneficial ones.
- GP5 Options where routeing and siting can be used to avoid or reduce impacts on environmental and socio-economic receptors are generally preferable to those where this is less viable.
- GP6 Options will be preferred where, after consideration of routeing and siting, any significant effects which may occur can be mitigated more easily and with greater certainty over those where such mitigation is more difficult or uncertain.
- GP7 Options, including innovative solutions, which provide technically less complex solutions or which enhance system resilience or flexibility are generally preferable to those which do not.

4.1.2 In addition to these general guiding principles other topic specific considerations have been adopted to ensure that important factors relevant to strategic option selection have been included.

4.1.3 There is no fixed hierarchy or weighting between the principles (or their sub-topics) and different options will be aligned with different combinations of the guiding principles. There may also be opposing assessment within individual components of each guiding principles necessitating a balance to be sought. The Strategic Options Appraisal process, and subsequent more detailed stages, do not make decisions but provide the information to support decision-making. National Grid have made judgements about the project which best balance all its duties and obligations. In later stages of the project National Grid will continue to make judgements, taking into account the advice of consultees.

4.2 Aim of the Strategic Options Appraisal

4.2.1 The aim of this Strategic Options Appraisal, is to help identify a preferred strategic proposal, based on an understanding of strategic considerations. The information required to make comparisons between different options generally relates to constraints or issues of national importance (or above) which would be of sufficient importance to influence decision-making at this strategic level. As such several topics, sub-topics or specific features, that may need to be considered at a detailed level, are not part of this strategic assessment. For example pipeline routeing may seek to avoid small areas of woodland however, at this strategic stage, because such areas could potentially be avoided during detailed routeing (with little change to overall route lengths) and are not part of NPS EN-1 or EN-4, this sub-topic is not considered to be material in determining the overall viability of the option relative to others.

4.2.2 The strategic information utilised is readily obtained through desk study review of existing information. More detailed assessment, supported by fieldwork, occurs in subsequent stages of study when the effort can be focussed efficiently and take account of the potential for siting, routeing and other environmental measures to influence the decision-making process.

4.2.3 The topics considered in options appraisal are: environment; socio-economics; technical and cost. Other considerations (including programme to delivery) have also been included for this project because the date by which the NTS entry capacity can be delivered relative to the PARCA offer is an important consideration. These topics have been identified to specifically ensure that decision-making is based on a broad understanding of the implications of National Grid's projects.

4.2.4 A flow diagram, included earlier as Figure 1.1, illustrates the options appraisal process

4.3 Constraints Considered and Data Sources

Environment

4.3.1 In respect of the environment topic the Strategic Options Appraisal has assessed the following sub-topics:

- Biodiversity;
- Landscape and Visual;
- Physical Environment (including flood zones, source protection zones, Main Rivers, Canals, Air Quality Management Areas, Geological SSSIs, Geoparks and Noise Important Areas); and
- Historic Environment.

4.3.2 The issues of national importance (or above) that have been considered in the environmental appraisal are summarised in Table 4.1 which also identifies the data sources for the information.

Table 4.1 Environmental Appraisal Data Sources

Feature	Data Sources
Biodiversity	
Special Area of Conservation (SAC)	Natural England / Natural Resources Wales
Possible SAC	Natural England / Natural Resources Wales
Candidate SAC	Natural England / Natural Resources Wales
Special Protection Area (SPA)	Natural England / Natural Resources Wales
Potential SPA	Natural England / Natural Resources Wales
Ramsar Site	Natural England / Natural Resources Wales
Proposed Ramsar Site	Natural England / Natural Resources Wales
SSSI	Natural England / Natural Resources Wales
National Nature Reserve	Natural England / Natural Resources Wales
Ancient Woodland	Natural England / Natural Resources Wales
RSPB Important Bird Areas	RSPB
Veteran Trees	Woodland Trust
Landscape and Visual	
National Park	Natural England / Natural Resources Wales
AONB	Natural England / Natural Resources Wales
World Heritage Site	Historic England / Cadw
Biosphere Reserve	Natural England / Natural Resources Wales
National Trail	Natural England / Natural Resources Wales
Settlement	OS Mapping

Physical Environment	
Flood Zones	Environment Agency / Natural Resources Wales
Main Rivers	Environment Agency / Natural Resources Wales
Source Protection Zones	Environment Agency / Natural Resources Wales
Canals	Canal and River Trust
Air Quality Management Areas	Defra / Welsh Government
Geological SSSIs	Natural England / Natural Resources Wales
Geoparks	Brecon Beacons National Park Authority
Noise Important Areas	Defra / Welsh Government
Historic Environment	
Scheduled Monuments	Historic England / Cadw
Grade I and II* Listed Buildings	Historic England / Cadw
Registered Historic Parks and Gardens	Historic England / Cadw
Registered Battlefields	Historic England / Cadw

Socio-economics

4.3.3 In respect of the socio-economics topic the issues of national importance (or above) that have been considered in the socio-economic appraisal are summarised in Table 4.2 which also identifies the data sources for the information.

Table 4.2 Socio-economic Appraisal Data Sources

Feature	**Data Sources**
National Trust Inalienable Land	National Trust
National Trust Open Land	National Trust

Countryside and Rights of Way Open Access Land	Natural England
Military sites, airfields, military practice areas	OS mapping
Airports	OS mapping
National Grid Infrastructure	National Grid
National Cycle Routes	Sustrans

Technical

4.3.4 Strategic Options progressing to options appraisal were appraised against the following technical sub-topics:

- Technical complexity (including operational flexibility and resilience);
- Delivery & Construction issues including resource use, waste and construction duration;
- Technology issues (innovation required to deliver, operational, and maintenance risks and safety issues);
- Capacity Issues (system capability achieved and system flexibility benefits); and
- Network efficiency / benefits (including energy efficiency)

Cost

4.3.5 Capital cost estimates were derived from estimated route lengths (with costs adjusted in line with paragraph 3.3.2), equipment quantities and generic unit costs. Capital costs were refined as part of the iterative refinement of options to ensure comparison is made on a fair basis. Operational costs are incorporated within the cost benefit analysis (CBA) (see below).

4.3.6 A CBA[22] was also used to inform decision making to ensure consideration of the different benefits that each option provides to UK consumers (reflecting that different options reduce likely future constraint costs by different amounts). The CBA is based on the Future Energy Scenarios (FES). The FES 2019 identifies Steady Progression (SP) and Two Degrees (TD) scenarios as the two most likely.

4.3.7 A full lifecycle scenario (out to a 45 year assumed asset life) includes the value of any benefits that may accrue in the future from capability that may be provided by an option that exceeds that required to meet the PARCA capacity offered. FES include a credible range of future scenarios but uncertainty increases with time, and therefore the extent to which benefits will materialise is uncertain. A constrained CBA provides an alternative scenario which reduces the influence of

[22] The CBA method adopted has been used previously in relation to Industrial Emissions Directive related funding requests approved by OFGEM. CBA allows for costs such as operational costs and constraint costs to be factored in to allow comparison for example between a high capital / low running cost option and a low capital / high running cost alternative.

such uncertain future benefits. For the purposes of this options appraisal a constrained (to 2035) TD scenario has been used as the CBA measure informing the comparative review of options.

4.3.8 The actual cost or CBA values have not been shown in this report and appendices as they are commercially sensitive and could influence any future construction tender process. To provide a means of relative comparison, the costs have been presented as a multiple of the lowest capital cost option taken through to options appraisal. CBA performance has been presented as a relative descending rank order with the first ranked option having the best cost benefit.

Other considerations

4.3.9 Finally, consideration is given to several further factors: alignment with planning policy, impact on stakeholders, consenting regime (including consenting programme and its effect on release of the NTS entry capacity).

5 OPTIONS APPRAISAL

5.1 Search Area Maps

5.1.1 The iterative development of the strategic options that were progressed to options appraisal, allowed identification of the expected infrastructure and indicative locations for such infrastructure. By applying the infrastructure requirement in combination with the guiding principles and some generalised assumptions (see below), search areas for new infrastructure were established. The search areas used are shown on the constraints maps (see section 5.2 for details) with option specific comments in Section 5.3.

5.1.2 The general assumptions were that:

- The search area for a new compressor site extended 1km around existing AGI or compressor sites. It also extended out to 1km to either side of existing NTS pipeline infrastructure along identified sections of pipeline appropriate to different options as identified below.
- Search areas along Feeder 28 for new compressor sites and the search area for the connection for option F7.1 were centred on a 'sweetspot' identified by network modelling, to maximise the capability increase achieved. For option F7.1, a location within 25km either side of the 'sweetspot' was used at this strategic option stage. For option F3.1 a location within 25km of the sweetspot was also used but was constrained to the east to remain outside the BBNP (within which the pipeline is routed). For option F3.3 a more restricted search area was used because the site needed to be at or to the west of the existing Three Cocks AGI but the extent to the west was also constrained to be outside the BBNP. For option F3.3 a search area around the Three Cocks AGI and within 20km to the west was therefore adopted at the strategic option stage.
- Search areas for new pipeline routes were established based on a corridor extending approximately 2km either side of a straight line from identified start and end points. Sensible adjustments were then made to avoid various AONBs, National Parks, larger urban areas and substantive settlements (where possible). Search areas were sensibly reduced where the start and end points were much closer together.

5.1.3 Uprating with MOP below equipment classification limits is not expected to involve significant physical works to the pipeline itself and therefore there would be very limited environmental effects. Some modifications are expected at some existing AGI sites and on other existing compressor sites along with extensions to existing facilities for the installation of pressure reduction equipment. A 1km search area, in line with the above, has been utilised around the relevant existing facility.

5.1.4 It is possible, though not certain, that the uprating to an MOP below equipment classification limits may lead to a requirement for additional pipeline protection to be installed in certain areas (for example by excavating and overlaying the pipeline with concrete slabs to prevent damage to them) where the pipeline is in closer proximity to existing occupied property. Initial indications are that this may be required for only one or two short sections of pipeline. The requirement and location for this is dependent on the exact level of pressure uprating required for

each section of pipeline and the associated characteristics of these sections and the surrounding areas. This information will not be confirmed until later stages of project development following the completion of complex risk assessments. Any such work would be expected to be completed directly above and in immediate proximity to the existing pipeline within the easements forming operational land within previously disturbed working corridors. As such the environmental effects are expected to be limited and are not expected to lead to effects on designated areas. They are therefore not a material factor in differentiating between strategic options.

5.1.5 The search areas provide a basis for strategic comparison of the relative merits of the options based on a sensible interpretation of where infrastructure may be sited and thus the consequences of that infrastructure. It should be noted that subsequent more detailed study at the stage of defining route corridors and sites for a preferred option or options has the potential to include areas outside these search areas. This would be in response to constraints identified at a more local scale and in line with guidance for that stage. Any such deviation is not expected to be inconsistent with this strategic option stage but would be backchecked.

5.2 Constraints Maps

5.2.1 Constraints maps have been produced to show the main constraints for the environmental and socio-economic sub-topics along with the infrastructure search areas. These maps have been used to aid the appraisal of individual options and comparison between options. Features have been combined across four plans:

- Plan A shows biodiversity features.
- Plan B shows landscape features.
- Plan C shows physical environment features.
- Plan D shows historic environment features.
- Plan E shows socio-economic constraints

5.2.2 Constraints plans are included in **Appendix D.** Due to their geographic overlap a number of options have been combined onto single sets of plans notably F3.1 with F3.2 and F3.3, F4.1 with F4.2, F6.1 with F6.2 and F6.6, G1.1 with G1.3. F7.1 is on a separate plan.

5.3 Options Appraisal Summary

5.3.1 An Option Appraisal Summary Table (OAST) has been prepared for each strategic option progressed to options appraisal (see section 3.3). The OAST captures the implications of the option for the sub-topics considered. The OASTs are included in **Appendix D** with a summary of the main conclusions provided below (in ascending option number order). Table 3.1 contains full descriptions of the Strategic Options.

Option F3.1 New compression (Llanwdra area) with 37km of new pipeline

5.3.2 The OAST concludes that this option complies less well with the guiding principles than some other options on grounds of capital cost and CBA rank (GP4) being just over four and a half times the capital cost of option F6.6 which

has the lowest capital cost. The option is ranked 7th of 11 in CBA terms. The option also brings additional operational complexity because it presents significant delivery and construction challenge (GP7). It also, by requiring the construction and operation of a new compressor, will be energy intensive throughout its lifecycle and performs less well in terms of using, adapting or extending existing equipment (GP2) compared with options not requiring a new compressor site.

5.3.3 There remains a potential indirect effect to European Sites associated with the Tirley to Wormington pipeline and with the new compressor site in the Llanwdra area that may require further consideration at routeing/siting and Habitats Regulations Assessment (HRA) Screening.

5.3.4 Whilst there are potential landscape constraints (the BBNP and the Cotswolds AONB) it should be possible to avoid direct effects on BBNP through careful siting of the compressor site although appropriate mitigation/screening may be needed dependent upon future siting work to reduce indirect effects on the BBNP and its users. For this strategic option the Tirley to Wormington pipeline passes through the Cotswolds AONB, therefore there is the potential for effects on this national designation during construction. The option is anticipated to require a DCO due to pipeline length and potential effects, though this is subject to confirmation.

Option F3.2 New compression with 44km of new pipeline avoiding the Cotswolds AONB

5.3.5 This option is the same as option F3.1 with the exception that a longer new pipeline is required to avoid construction works within the Cotswolds AONB. The OAST concludes that this option complies less well with the guiding principles than option F3.1 primarily on grounds of capital cost and CBA rank (GP4) with the option just over five times the capital cost of option F6.6 which has the lowest capital cost. The option is ranked 8th of 11 in CBA terms.

5.3.6 Whilst there are landscape constraints in the vicinity (the BBNP and the Cotswolds AONB) it should be possible to avoid direct effects through avoidance and careful siting of new pipelines and the compressor site and the route outside the Cotswolds AONB is more compliant with GP5 than that of F3.1. As with F3.1 there remains a potential indirect effect to European Sites associated with the new compressor site that requires further consideration at routeing and may also require HRA Screening. The option would require DCO due to the pipeline length.

5.3.7 It is generally poorer performing than various other non-compression options because of additional operational complexity (GP7). It also, by requiring the construction and operation of a new compressor site, which would be energy intensive throughout its lifecycle, performs less well in terms of using, adapting or extending existing equipment (GP2) compared with options not requiring a new compressor site. Whilst pipelines are operationally simple the additional length of works associated with option F3.2 means it performs less well against GP3 than either F3.1 or F3.3.

Option F3.3 New compression (at or within 20km to the west of Three Cocks AGI) with 11km of new pipeline

5.3.8 This option is similar to F3.1 and F3.2, but, by utilising a more easterly location for the compressor site (at or within approximately 20km to the west of the Three Cocks AGI), requires a shorter length of new pipeline to achieve the required capacity. The additional pipeline is required between Wormington compressor site and Honeybourne AGI (approximately 9km, all of which is outside the Cotswolds AONB) and at Churchover (approximately 2km).

5.3.9 The OAST concludes that this option complies more favourably with the guiding principles than options F3.1 and F3.2 primarily on grounds of capital cost and CBA rank (GP4) being around three and a quarter times the capital cost of option F6.6 which has the lowest capital cost and ranked 4th of 11 in CBA terms. Its use of locations and routes outside the Cotswolds AONB also make it more compliant with GP5 than that of F3.1.

5.3.10 It is generally poorer performing than various other non-compression options because of additional operational complexity (GP7). It also, by requiring the construction and operation of a new compressor site, which will be energy intensive throughout its lifecycle, performs less well in terms of using, adapting or extending existing equipment (GP2) compared with options not requiring a new compressor site. Nonetheless the shorter length of new pipeline works associated with option F3.3 means it is considered more favourable than option F3.1 and option F3.2 in terms of GP3.

5.3.11 There remains a potential indirect effect to European Sites associated with the new compressor site that may require further consideration at the siting stage and also require HRA Screening. Whilst there are landscape constraints (the BBNP and the Cotswolds AONB are nearby) there would be no direct effect on these assets. The option may not require DCO given the nature of the physical works and the pipeline length so could be progressed using Permitted Development rights and under TCPA. This is subject to environmental determination from the Department for Business, Energy & Industrial Strategy (BEIS).

Option F4.1 A total of around 92km of new pipeline

5.3.12 The OAST concludes that this option complies less well with the guiding principles than other options which include uprating with MOP below equipment classification limits. These other options involve a greater use and adaptation of existing infrastructure (GP2) and less new pipeline (GP3). However, this option complies more strongly with the guiding principles than other options (F4.2, F7.1, G1.1 and G1.3) which involve a longer length of new pipeline (i.e. F4.1 performs better against GP3) and on the basis of lower capital cost and better CBA outcome (GP4) being over five times the capital cost of option F6.6, which has the lowest capital cost and 5th out of 11 in CBA terms.

5.3.13 The option is considered to be relatively poorer performing against GP7 through additional construction complexity. The pipeline length required for this option presents substantial challenges to the construction programme and is poorer performing than many other options for resource use and waste. Constructability is also impacted by a high number of crossings including major rivers, motorways

and railways with the general topography and ground conditions for construction of Felindre to Llanwrda being shown to be challenging in past projects.

5.3.14 There remains a risk to the Afon Tywi/River Tywi SAC and SSSI as this would need to be crossed. Therefore, HRA Screening would be required and appropriate mitigation including trenchless methods to cross the watercourse. This option routes the pipeline through the Cotswolds AONB therefore there is the potential for direct effects on this national level designation during construction. However, during operation, permanent above ground infrastructure could be sited outside of very sensitive sites and screening provided if necessary - reducing effects to an acceptable level. The BBNP would be avoided through pipeline routeing. This option would require a DCO due to pipeline length

Option F4.2 A total of 99km of new pipeline of which 55km is in addition to Feeder 28 from Felindre with other new pipeline avoiding the Cotswolds AONB

5.3.15 This option is the same as option F4.1 with the exception that a longer new pipeline between Tirley and Wormington is required as a result of routeing around the north of the Cotswolds AONB.

5.3.16 The OAST concludes that this option complies less well with the guiding principles than other options which include uprating where there is greater use and adaptation of existing infrastructure (GP2) and a shorter length of new pipeline (GP3). However, it complies more strongly with the guiding principles than other options (F7.1, G1.1and G1.3) involving longer lengths of new pipeline (i.e. F4.2 performs better against GP3) and on the basis of lower capital cost and better CBA outcome (GP4) (relative to the lowest capital cost option F6.6 it is over five and a half times the capital cost and 6th of 11 in CBA terms). Whilst it is a longer route (GP3) and poorer performing in terms of capital cost and CBA performance (GP4) than option F4.1 it would avoid the AONB.

5.3.17 The option is considered to be relatively poorer performing against GP7 through additional construction complexity. The pipeline length required for this option of 99km presents substantial challenges to the construction programme and is poorer performing than many other options for resource use and waste. Constructability is also impacted by a high number of crossings including major rivers, motorways and railways with the general topography and ground conditions for construction of Felindre to Llanwrda being shown to be challenging in past projects.

5.3.18 There remains a risk to the Afon Tywi/River Tywi SAC and SSSI as this would need to be crossed. Therefore, HRA Screening would be required and appropriate mitigation including trenchless methods to cross the watercourse. The BBNP would be avoided and this option would avoid direct impacts on the Cotswolds AONB. This option will require a DCO due to pipeline length.

Option F6.1 Uprating with MOP below equipment classification limits of Feeder 28 with 37km of new pipeline

5.3.19 The OAST concludes that this option complies more strongly with the guiding principles than several other pipeline options (F7.1, G1.1 and G1.3) by requiring less new pipeline (GP3) but less well than option F6.6 which requires only 11km of new pipeline. It also performs more strongly than all but one option in respect

of GP4 having a relatively lower capital cost (2nd lowest) and better CBA outcome (2nd best).

5.3.20 It performs more poorly against GP5 than option F6.2 (and option F6.6) by adopting a route through the Cotswolds AONB. There remain some unresolved technical and operational challenges to uprating with MOP below equipment classification limits under ongoing review by National Grid but these are expected to be resolvable. There may be a requirement for HRA Screening for a single SAC dependent upon detailed routeing/siting for the Tirley to Wormington pipeline. Due to the length of new pipeline and potential environmental effects the option is anticipated to require a DCO, though this is subject to confirmation with BEIS.

Option F6.2 Uprating with MOP below equipment classification limits of Feeder 28 with 44km of new pipeline avoiding the Cotswolds AONB

5.3.21 This option is the same as option F6.1 with the exception that a longer new pipeline between Tirley and Wormington is required as a result of routeing further northwards so that it routes around the Cotswolds AONB.

5.3.22 The OAST concludes that this option complies more strongly with the guiding principles than several other pipeline options (F7.1, G1.1 and G1.3) by requiring less new pipeline (GP3) but not as well as option F6.6 which requires a much shorter pipeline length (11km). It also performs more strongly than all but two options in respect of GP4, having a relatively lower capital cost (3rd lowest) and better CBA outcome (3rd best).

5.3.23 This is a longer route (GP3) and poorer performing in terms of capital cost and CBA performance (GP4) than Option 6.1. It performs more strongly against GP5 than option F6.1 by adopting a route around the Cotswolds AONB. There remain some unresolved technical and operational challenges to uprating with MOP below equipment classification limits under ongoing review by National Grid however these are expected to be resolvable. Due to the length of new pipeline the option will require an application for a DCO.

Option F6.6 Uprating with MOP below equipment classification limits of Feeder 28 with 11km of new pipeline

5.3.24 This option is similar to option F6.1 but requires a shorter length of new pipeline as a result of assuming a slightly higher level of uprating (still with NOP below equipment class limits). For this option new pipeline of 11km is required comprising 9km between Wormington and Honeybourne AGI and a further approximately 2km at Churchover.

5.3.25 The OAST concludes that this option performs more strongly than all other options in terms of compliance with GP2 by maximising the use, extension and adaptation of existing infrastructure and minimising the need for new infrastructure. It complies more strongly with GP3 than all other pipeline options (F4.1, F4.2, F6.1, F6.2, F7.1, G1.1 and G1.3) by requiring less new pipeline. It also performs more strongly than all options in respect of GP4 having the lowest capital cost and best CBA performance.

5.3.26 It doesn't perform quite as well as options for only new pipeline on technical complexity (GP7) but this is offset by greater compliance with GP5 and GP6 than those alternative pipeline only options (as a result of shorter length and compared

with some options no direct effects on AONB). There remain some unresolved technical and operational challenges to uprating that are under ongoing review by National Grid but these are expected to be resolvable. There is the potential for pipeline works to be undertaken as permitted development and for any compressor upgrades and above ground infrastructure to be progressed by applications under TCPA. This is subject to environmental determination from BEIS.

Option F7.1 New 125km pipeline to Alrewas

5.3.27 The OAST concludes that this option complies more poorly with the guiding principles compared with many other options on various grounds. It provides a much longer route (GP3) than options such as F6.1, F6.2, F6.3, F4.1, F4.2, G1.1 and G1.3. It allows for a lower level of re-use or adaptation of the existing NTS (GP2) than options such as F6.1, F6.2 and F6.6. It has much higher capital costs and poorer CBA (GP4) than others being the highest cost option at around seven times the capital cost of option F6.6 which has the lowest capital cost. The option is 11th best out of 11 in CBA terms.

5.3.28 It also adds substantial complexity arising from construction challenges (GP7) with routes to the west and north of Birmingham presenting an extremely challenging construction environment due to the extent of urban areas and many complex obstacle crossings. It is also one of the longest pipeline routes and therefore a greater resource intensity to deliver.

5.3.29 There remains a risk to the River Wye SAC and SSSI together with the River Lugg SSSI and River Teme SSSI as these constraints would need to be crossed by the new pipeline. Therefore HRA Screening would be required for the SAC and appropriate mitigation including trenchless methods to cross all the watercourses. Direct effects on the Shropshire Hills AONB and the Brecon Beacons National Park would be expected to be avoided through careful routeing. It may also be possible to minimise routeing through the Cannock Chase AONB, however, the combination of the constraint of the urban areas as well as the designated features to the north of Birmingham may mean that it is not possible to rule out construction within the Cannock Chase AONB at this stage. The option will require DCO due to the pipeline length.

Option G1.1 New 95km pipeline Wormington to Aylesbury

5.3.30 The OAST concludes that in terms of compliance with the guiding principles this option complies more poorly than option F3.1. F3.2 and F3.3, F4.1, F4.2 and F6.1, F6.2 and F7.1 in respect of GP4 (costs and CBA performance). The option is around five times the capital cost of option F6.6 which has the lowest capital cost and the option is 9th best out of 11 in CBA terms.

5.3.31 It performs less well than other options either avoiding or adopting a route through the Cotswolds AONB (F3.1, F4.1, F4.2, F6.1, G1.3) as a result of a greater length of new pipeline within the AONB (GP5 and GP6). It would not be possible to avoid the Cotswolds AONB within the search area for this option with the proposed route from Wormington to Aylesbury requiring between approximately an additional 16km to 25km of pipeline within the AONB depending on route.

5.3.32 Overall the option is judged to perform poorly against GP7 as whilst pipeline solutions are more favourable than uprating (i.e normally more favoured than F6.1, F6.2, F6.6) or compression, the combination of additional construction challenge from the long length of pipeline as well as some system performance challenges under some patterns of supply[23] means the option presents considerable additional complexity and challenge. There may be a requirement for HRA Screening for an SAC dependent upon detailed routeing/siting for the Tirley to Wormington section of pipeline. Due to the length of new pipeline a DCO will be required.

Option G1.3 New 106km pipeline Honeybourne to Aylesbury

5.3.33 This is similar to option G1.1 but with the connection to Aylesbury made from Honeybourne. For this option, the change to a connection point at Honeybourne allows for a reduction in the length of new pipeline within the AONB compared with option G1.1.

5.3.34 The OAST concludes that in terms of compliance with the guiding principles this option complies more poorly than all options except F7.1 in respect of GP4 (costs and CBA performance) being just over five and a half times the capital cost of option F6.6 which has the lowest capital cost and 10th best out of 11 in CBA terms. Overall it performs poorly against GP2 due the length of new pipeline relative to most options, though does not have the same enduring energy costs as those options that require additional compression.

5.3.35 It would not be possible to avoid the Cotswolds AONB within the search area for this option so it performs less well options not affecting the AONB and also less well than most other options adopting a route through the Cotswolds AONB (F3.1, F4.1, F4.2, F6.1) as a result of a greater length of new pipeline within the AONB (GP5 and GP6). However, it performs more strongly on this than option G1.1 by reducing the overall length within the Cotswolds AONB. It performs much less well than option F3.1, F3.2, F3.3, F6.1, F6.1 and F6.6 in terms of GP3 as it requires a considerably greater length of new pipeline to be constructed.

5.3.36 As with G1.1 the option is judged to perform poorly against GP7 as whilst pipeline solutions are more favourable than uprating (i.e normally more favoured than F6.1, F6.2, F6.6) or compression, the combination of additional construction challenge from the long length of pipeline as well as some system performance challenges under some patterns of supply for connections to Aylesbury means the option presents considerable additional complexity and challenge. There may be a requirement for HRA Screening for a single SAC dependent upon detailed routeing/siting for the Tirley to Wormington section of pipeline. Due to the length of new pipeline a DCO will be required.

[23] For example if the combined supply from Bacton and Isle of Grain was relatively elevated, there would be no capacity to take the gas from the new connection. This would require the gas from the new connection to be moved north. Additional system modifications would be required to be made to allow such flows.

6 SELECTING THE PREFERRED STRATEGIC PROPOSAL

6.1 Clustered Comparisons

6.1.1 A structured series of comparisons were undertaken to derive the preferred option based on a balanced decision across the various topics (section 4.2.3). This approach allowed an initial comparison to be made between options predominantly focussed on increasing the capability of the existing NTS (options F3.1, F3.2, F4.1, F4.2, F6.1, F6.2, F6.6). Following this the best of these options was compared with other options which provided increased capability through new pipeline connections to other parts of the NTS (options F7.1, G1.1 and G1.3).

Comparing existing NTS upgrade options

6.1.2 This comparison considers options involving a new compressor site (options F3.1, F3.2 and F3.3) with options including uprating with MOP below equipment classification limits (F6.1, F6.2 and F6.6) and with options based on additional new pipeline only (F4.1 and F4.2).

6.1.3 Of the compression site options, an initial review confirmed that there was a clear preference to take forward option F3.3. The reasons for this being that option F3.3 shows much greater compliance with GP2, GP3, GP4 and GP5 as a result of a greatly reduced requirement for new pipeline. Option F3.3 requires 11km compared with 37km and 44km for F3.1 and F3.2 respectively.

6.1.4 On the same basis, of the options for uprating with MOP below equipment classification limit, there was a clear preference to take forward option F6,6 as it also shows much greater compliance with GP2, GP3, GP4 and GP5 as a result of a greatly reduced requirement for new pipeline. Option F6.6 requires 11km compared with 37km and 44km for F3.1 and F3.2 respectively.

6.1.5 Comparison is therefore made between F3.3, F4.1, F4.2 and F6.6. The balanced overall decision between these four alternatives is a preference for option F6.6. The main reasons for this are:

- Option F6.6 requires less overall new infrastructure than other options and is therefore more compliant with GP2 and GP3.
- Option F6.6 also has lower environmental effects than other options and is therefore more compliant with GP5. Whilst some additional compression is needed (longer running time of existing compressors) the effects are expected to be lower than those associated with the establishment and operation of a new compression site (required for F3.3). The option also requires considerably less new pipeline than options F4.1 and F4.2 with an expected reduction in environmental effects from construction. In addition, options F4.1 and F4.2 would potentially require Habitats Regulations Assessment as a new pipeline would require crossing of the Afon Tywi / River Tywi Special Area of Conservation (SAC). Whilst it should be possible to implement appropriate mitigation to reduce the likelihood of effects on this site, it does present an additional environmental risk compared to an option where impacts on European Sites could be wholly avoided.

- Option F6.6 also incurs lower capital costs and performs more strongly in CBA terms than either F3.3, F4.1 or F4.2 so performs more strongly against GP4. On a capital cost basis, F6.6 is the lowest capital cost (and the lowest of all options progressed to options appraisal) whereas, option F4.2 (closely followed by option F4.1) is the most expensive (at just over five times the capital cost of F6.6) whereas option F3.3 is just over three times the capital cost of F6.6. Options F3.3 and F6.1 both have enduring energy requirements (and running costs) through the operational period to power the compressors (as does F6.6 but to a lesser degree), however overall in CBA terms F6.6 is favoured over F3.3 which is favoured over F4.1.
- Option F6.6 also performs best against GP7 (technical complexity) as this requires least new infrastructure and is technically a straightforward solution albeit there remain some unresolved technical and operational issues associated with uprating with MOP below equipment classification limits (albeit these are considered resolvable). Option F3.3 is considered the poorest performing against GP7 as it is a more complex design solution than the alternative of additional pipeline associated with F4.1 and F4.2 though does provide some additional system resilience.

Final comparisons

6.1.6 The final comparison was then made between:

- Option F6.6 Uprating with MOP below equipment classification limits with 11km new pipeline from Wormington to Honeybourne and at Churchover
- Option F7.1 new 125km pipeline from Three Cocks area to Alrewas
- Option G1.1 new 95km pipeline comprising 26km Tirley PRS to Wormington Compressor and 69km Wormington compressor to Aylesbury AGI.
- Option G1.3 new 106km pipeline comprising 26km Tirley PRS to Wormington compressor, 9km Wormington compressor to Honeybourne AGI and 71km Honeybourne AGI to Aylesbury AGI.

6.1.7 Option F6.6 complies most strongly with GP2 by maximising the use, extension and adaptation of existing NTS infrastructure and minimising new infrastructure requirements. Analysis also shows this option performs well in sustainability terms and has the lowest carbon budget when combining embedded carbon in the pipeline, that used during construction, along with operational emissions including from additional compressor hours to move the additional gas. Option F6.6 also complies far more strongly than others with GP3 by requiring a much shorter length of new pipeline.

6.1.8 Option F6.6 complies best with GP4 being both the best performing in CBA terms and the lowest capital cost of all options within the options appraisal. The next best of these final comparison options is around three times the capital cost of option F6.6.

6.1.9 Whilst some environmental effects can be expected to arise from the new works associated with F6.6, these are in greater compliance with GP5 and GP6 than are the case with the other pipeline options in this final comparison. All of options

F7.1, G1.1 and G1.3 are expected to have some direct short-term construction effects on part of areas designated as AONB.

6.1.10 Overall there is little to differentiate compliance with GP7 between these final comparison options and overall it is not a determining factor. Because it involves uprating option F6.6 is technically more complex than others. However, initial assessments by National Grid indicate that the uprating with MOP below equipment classification limits, whilst a divergence from current practice, is safe (i.e complies with GP 1) and any remaining challenges can be resolved and the option successfully delivered. Some system complexity is also evident in some supply scenarios for G1.1 and G1.3 compared with other options. It is also apparent that the complexity of routes and length of new pipeline involved for F7.1, G1.1 and G1.3 brings additional construction challenge. Option F7.1 for example has additional transport infrastructure crossings and a more congested urban edge alignment around Birmingham.

6.1.11 Taking all factors into account, the balanced overall decision between these four alternatives is a preference for option F6.6 which comprises uprating with MOP below equipment classification limits along with a total of 11km of new pipeline. This is shown in Figure 6.1.

6.2 Back-check

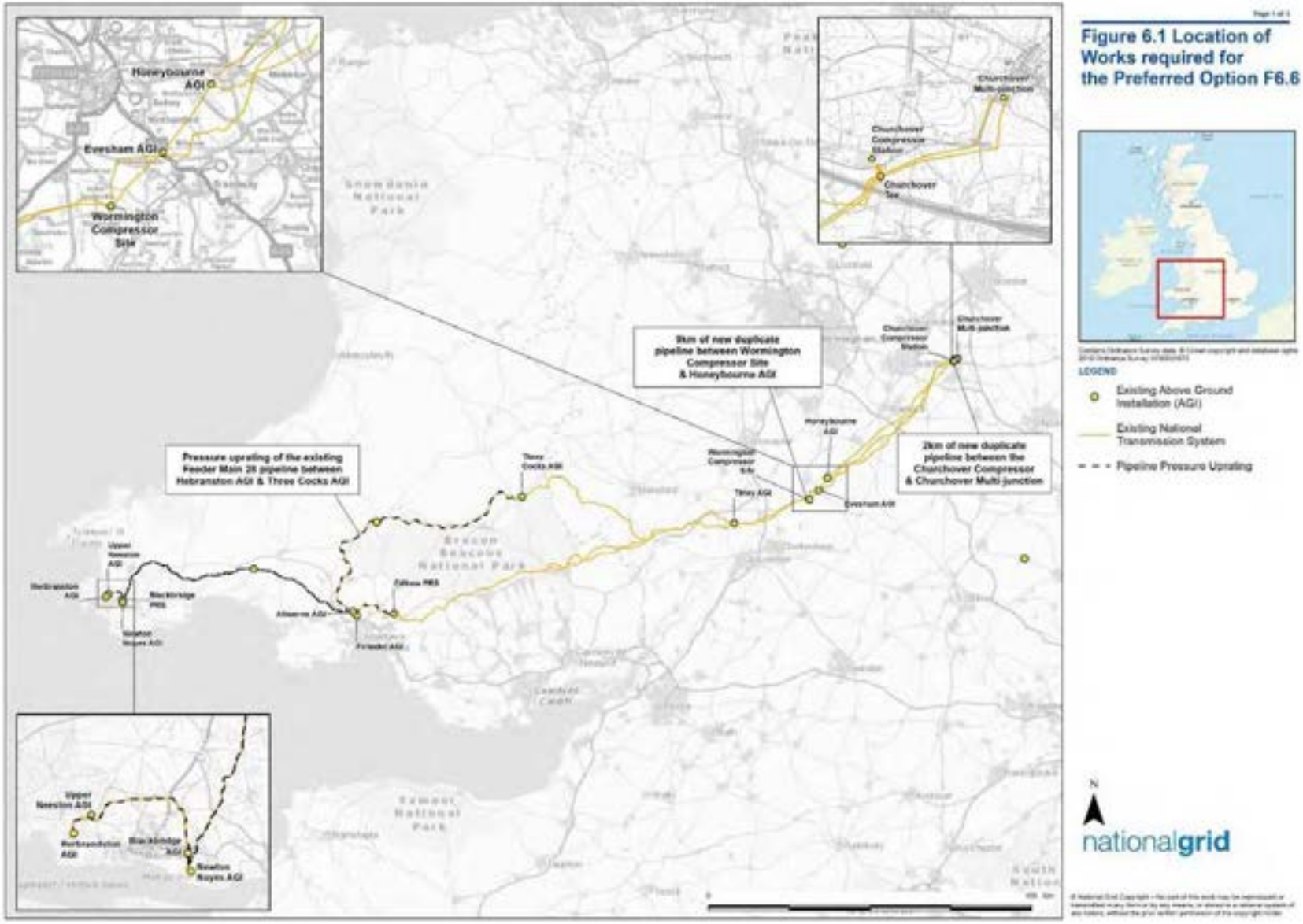
6.2.1 Prior to finalisation of the recommendation by National Grid, a back-check review of various aspects was completed. This confirmed that:

- No suitable 3rd party infrastructure was available that provided sufficient additional capacity to avoid the need for new pipeline connections as proposed by the first to fourth preferences identified above.
- Further review of the use of commercial tools as a partial solution was considered as a back check following the conclusion of the strategic options appraisal. Partial solutions (such as pressure uprating only with no new pipeline infrastructure) fall substantially below the flow required to meet the NTS entry capacity of the PARCA offer (this includes allowing for offtake for the operation of the Abergelli Power gas peaking plant near Felindre) and would therefore lead to higher constraint costs. Commercial measures to constrain flow requirements do not therefore provide a more economical or efficient approach to the preference for option F6.6 identified above.
- No other new information was available regarding new demand customers, or other combinations of options capable of meeting the reserved capacity.
- FES 2020 scenarios had been released but not the detail behind them to allow a revisit of the modelling.

6.3 National Grid Decision

6.3.1 Following careful consideration National Grid has concluded that option F6.6 is the preferred strategic proposal which comprises of:

- Pressure uprating (with maximum operating pressure below equipment class limit) of the existing Feeder 28 pipeline between Milford Haven and Three Cocks AGI;
- Approximately 9km of new pipeline between Wormington and Honeybourne and 2km of new pipeline between Churchover Compressor and Churchover Multijunction; and
- Related works at several existing AGI sites to facilitate the pressure uprating, connection of new pipelines and effective compression at existing stations.


Honeybourne AGI
Evesham AGI
Wormington Compressor Site
Churchover Multi-junction
Churchover Compressor Station
Churchover Site
9km of new duplicate pipeline between Wormington Compressor Site & Honeybourne AGI
2km of new duplicate pipeline between the Churchover Compressor & Churchover Multi-junction
Pressure uprating of the existing Feeder Main 28 pipeline between Hebranston AGI & Three Cocks AGI
Three Cocks AGI
Tirley AGI
Upper Newton AGI
Blackbridge PRS
Alrewas AGI
Clifton PRS
Hebranston AGI
Newton Regis AGI
Figure 6.1 Location of Works required for the Preferred Option F6.6
LEGEND
Existing Above Ground Installation (AGI)
Existing National Transmission System
Pipeline Pressure Uprating
N
nationalgrid

6.3.2 The preferred strategic proposal has been selected following the options appraisal process as: it requires the least new infrastructure therefore minimising the impact of the project on communities and the environment; has the lowest capital cost with the greatest consumer benefit; and represents the most economic and efficient solution for UK consumers. This option fulfils the requirements of the PARCA and is in line with National Grid's various duties, obligations and guiding principles.

7 NEXT STEPS

7.1.1 Following the conclusions of this work and based on the preferred strategic proposal, National Grid will undertake route corridor, siting studies and uprating investigations for the relevant elements of infrastructure. National Grid will also begin to engage with relevant consultees and undertake public consultation.

7.1.2 Feedback received and the findings of backcheck reviews against FES updates will help inform the final project design and subsequent applications to the relevant decision-making bodies.

7.1.3 The preferred strategic proposal will be reviewed regularly as the project progresses to ensure it continues to represent the option that best fulfils the requirements of the PARCA and balances National Grid's various duties, obligations and guiding principles.

Appendix A Glossary and Abbreviations

Above Ground Installation (AGI) – A term to describe a compound where various elements of infrastructure may be located above ground to facilitate operation or maintenance activities.

Area of Outstanding Natural Beauty (AONB)

Aggregate System Entry Point (ASEP) - A term used to refer to a gas supply terminal or group of gas supply terminals for which NTS Entry Capacity is sold.

Barg- The unit of pressure that is approximately equal to atmospheric pressure (0.987 standard atmospheres). Where bar is suffixed with the letter g, such as in barg or mbarg, the pressure being referred to is gauge pressure, i.e. relative to atmospheric pressure. One millibar (mbar) equals 0.001 bars.

Brecon Beacons National Park (BBNP)

Compressor Station - An installation that uses gas turbine or electricity driven compressors to boost pressures in the pipeline system. Used to increase transmission capacity and move gas through the network.

Development Consent Order (DCO)

Distribution Network (DN) - An administrative unit responsible for the operation and maintenance of the Local Transmission System (LTS) and <7barg distribution networks within a defined geographical boundary.

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Distribution Network Operator (DNO) - The operator of a Distribution Network (DN)

Future Energy Scenarios (FES)

Habitat Regulations Assessment (HRA) - A Habitats Regulations Assessment (HRA) refers to the several distinct stages of Assessment which must be undertaken in accordance with the Conservation of Habitats and Species Regulations 2017 (as amended) and the Conservation of Offshore Marine Habitats and Species Regulations 2017 (as amended) to determine if a plan or project may affect the protected features of a habitats site before deciding whether to undertake, permit or authorise it. European Sites and European Offshore Marine Sites identified under these regulations are referred to as 'habitats sites' in the National Planning Policy Framework.

Liquefied Natural Gas (LNG) - Gas stored and / or transported in liquid form. Liquified by cooling.

Local Transmission System (LTS) - A pipeline system operating at >7barg that transports gas from NTS offtakes to distribution system low pressure pipelines. Some large users may take their gas direct from the LTS.

Million cubic metres per day (mcm/d)

Maximum Incidental Pressure (MIP)

Maximum Operating Pressure (MOP)

National Policy Statement (NPS)

National Transmission System (NTS) - A high-pressure system consisting of terminals, compressor stations, pipeline systems and offtakes. The NTS operates at pressures up to 94 barg. NTS pipelines transport gas from terminals to NTS offtakes.

National Transmission System Offtake - An installation defining the boundary between NTS and LTS or a very large consumer. The offtake installation includes equipment for metering, pressure regulation, etc.

NTS Entry Capacity – The level of new gas introduction required to meet the PARCA application and PARCA offer capacity of 163Gwh/d and equating to approximately 15mcm/d.

Options Appraisal Summary Tables (OAST)

Peak Day Demand (1 in 20 Peak Demand) - The 1 in 20 peak day demand is the level of demand that, in a long series of winters, with connected load held at the levels appropriate to the winter in question, would be exceeded in one out of 20 winters, with each winter counted only once.

Planning and Advanced Reservation of Capacity Agreement (PARCA) — A PARCA is a multi-phased bilateral contract between National Grid and a customer, which would allow Firm Quarterly System Entry Capacity and / or Firm Enduring Annual NTS Exit (Flat) capacity to be reserved for the customer, whilst they develop initial phases of their own project. It is designed to provide National Grid with the financial security to undertake works such as planning activities prior to physical construction and ordering of materials, such as network analysis, project optioneering, engineering design and wider stakeholder consultation.

Planning Inspectorate (PI)

Stakeholder, Community and Amenity Policy (SCA Policy)

South Hook Gas Company Limited (SHGCL)

Site of Special Scientific Interest (SSSI)

Special Area of Conservation (SAC)

Strategic Options Report (SOR)

Appendix B Potential Strategic Options Long List

The following table provides a list of the potential strategic options considered. Those options progressing to full options appraisal after consideration of technical and benefit filters (and in some cases following additional National Grid review) are highlighted in grey. All distances are approximate.

Option ref			Overall Concept	Potential Strategic Option Summary Description
A			**New Demand Customer**	
A	1	1		**New demand consumer to reduce flow requirement through Felindre (the first constraint point on Feeder 28 on the existing network)**
A	2	1		**New demand customer to convert LNG to Hydrogen for use in a Hydrogen network**
B			**Utilise existing 3rd party infrastructure**	
B	1	1		**Modify the management rules for the existing network by renegotiating assured offtake pressures with downstream DN's**
B	2	1		**Use existing DN offtakes to flow swop to address gas flow constraint areas.**
B	3	1		**Take over existing third party pipeline infrastructure in place of new build pipelines**
C			**New Storage to smooth flows**	
C	1	1		**750,000 m3 of new LNG gas storage at Milford Haven to buffer flows for up to 30 days.**
C	1	2		**New natural gas storage downstream of Milford Haven on Feeder 28.**
C	1	3		**Natural Gas storage to provide additional buffering in place of new 26km Tirley to Wormington pipeline.**
D			**Interconnector to other markets**	
D	1	1		**125km offshore interconnector to south east Ireland.**

Option ref			Overall Concept	Potential Strategic Option Summary Description
D	1	2		**450km offshore interconnector to north west France**
E			**LNG transfer past constraint**	
E	1	1		**Redirect LNG ships to offload at another UK Terminal**
E	1	2		**Redirect LNG ships to offload at another continental Europe Terminal**
E	2	1		**LNG transport by road tanker to less constrained parts of the network**
E	2	2		**LNG transport by rail tanker to less constrained parts of the network**
E	2	3		**New 300km LNG pipeline beyond the Churchover constraint area**
F			**Connect into more northern and central parts of the NTS**	
F	1	1		**380km offshore pipeline to north Wales / Merseyside with 20km onshore pipeline and new compression.**
F	1	2		**370km offshore pipeline to Cumbria with new compression.**
F	2	1		**Approximately 97km new onshore pipeline comprising 60 Km in addition to Feeder 2 from Cilfrew to Gilwern, with further 37km Tirley to Wormington and on to Honeybourne and at Churchover with various compression modifications**
F	2	2		**Approximately 104km new onshore pipeline (some to avoid AONB) comprising 60km in addition to Feeder 2 from Cilfrew to Gilwern with further 44km Tirley to Wormington and on to Honeybourne and at Churchover with various compression modifications**
F	3	1		**New Feeder 28 compressor (westerly location - Llanwrda area) and 37km new pipeline (Tirley to Wormington to Honeybourne and at Churchover and various compressor modifications**
F	3	2		**New Feeder 28 compressor (westerly location – llanwdra area) and 44km new pipeline (Tirley to Wormington avoiding AONB and on to Honeybourne and at Churchover) and various compressor modifications**

Option ref			Overall Concept	Potential Strategic Option Summary Description
F	3	3		**New Feeder 28 compressor (more easterly location – at or within 20km to west of Three Cocks AGI) and 11km new pipeline (Wormington to Honeybourne and at Churchover) with various compressor modifications**
F	3	4		**New Feeder 28 compressor (more easterly location – at, or within 20km to west of, Three Cocks AGI) with below class limit MOP uprating and various compressor modifications**
F	3	5		**New Feeder 28 compressor (more easterly location – at, or within 20km to west of, Three Cocks AGI) with below class limit MOP uprating, 11km new pipeline (Wormington to Honeybourne and at Churchover) and various compressor modifications**
F	4	1		**Network upgrade to achieve gas flow northeastwards by 92km of new onshore pipeline comprising approx. 55km parts of Feeder 28 (Felindre to approx. Llanwdra) plus 37 km (Tirley to Wormington to Honeybourne and Churchover) with various compressor modifications**
F	4	2		**Network upgrade to achieve gas flow northeastwards by 99km of new onshore pipeline comprising approx. 55km parts of Feeder 28 (Felindre to approx. Llanwdra) plus 44 km (Tirley to Wormington avoiding AONB to Honeybourne and Churchover) with various compressor modifications**
F	5	1		**Above class limit MOP uprating of parts of network by physical interventions and technical design by analysis with 11km new pipeline (Wormington to Honeybourne and at Churchover) and various compressor modifications**
F	5	2		**Above class limit MOP uprating of parts of network by technical design by analysis with 11km new pipeline (Wormington to Honeybourne and at Churchover) and various compressor modifications**
F	5	3		**Above class limit MOP uprating of parts of network by physical interventions and technical design by analysis with 11km new pipeline (Wormington to Honeybourne and at Churchover), additional compressors at Felindre and various compressor modifications**
F	5	4		**Above class limit MOP uprating of parts of network by technical design by analysis with 11km new pipeline (Wormington to Honeybourne and at Churchover), additional compressors at Felindre and various compressor modifications**
F	5	5		**Above class limit MOP uprating of parts of network (Milford Haven to Tirley) by physical uprating (equipment replacement) along with below class limit MOP uprating (Tirley to Wormington, Wormington to Honeybourne and through to Churchover) with various compressor modifications**

Option ref			Overall Concept	Potential Strategic Option Summary Description
F	5	6		**Above class limit MOP uprating of parts of network (Milford Haven to Tirley) by technical design by analysis along with below class limit MOP uprating (Tirley to Wormingotn, Wormington to Honeybourne and through to Churchover) and new 11km pipeline (Wormington to Honeybourne and at Churchover) with various compressor modifications**
F	5	7		**Above class limit MOP uprating of parts of network (Milford Haven to Tirley) by technical design by analysis with 37km new pipeline (Tirley to Wormington, Wormington to Honeybourne and at Churchover) and various compressor modifications.**
F	5	8		**Above class limit MOP uprating of parts of network (Milford Haven to Tirley) by technical design by analysis with 44km new pipeline (Tirley to Wormington avoiding AONB, Wormington to Honeybourne and at Churchover) and various compressor modifications.**
F	5	9		**Above class limit MOP uprating of parts of network (Milford Haven to Tirley) by Technical design by analysis means along with below class limit MOP uprating (Tirley to Wormington, Wormington to Honeybourne and through to Churchover) with various compressor modifications**
F	6	1		**Below class limit MOP uprating of parts of network (Milford Haven to Three Cocks AGI) with 37km new pipeline (Tirley to Wormington and on to Honeybourne and at Churchover) and various compressor modifications**
F	6	2		**Below class limit MOP uprating of parts of network (Milford Haven to Three Cocks AGI) with 44km new pipeline (Tirley to Wormington avoiding AONB, Wormington to Honeybourne and at Churchover) and various compressor modifications**
F	6	3		**Below class limit MOP uprating of parts of network with 37km new pipeline (Tirley to Wormington and on to Honeybourne and at Churchover), additional compressors at Felindre and various compressor modifications**
F	6	4		**Below class limit MOP uprating of parts of network with 44km new pipeline (Tirley to Wormington avoiding AONB, Wormington to Honeybourne and at Churchover), additional compressors at Felindre and various compressor modifications**
F	6	5		**Below class limit MOP uprating of parts of the network (Milford Haven to Wormington) with various compressor modifications**
F	6	6		**Below class limit MOP uprating of parts of the network (Milford Haven to Three Cocks) with new 11km pipeline (Wormington to Honeybourne and at Churchover) and various compressor modifications**
F	6	7		**Below class limit MOP uprating of parts of the network (Milford Haven to Wormington) with new 11km pipeline (Wormington to Honeybourne and at Churchover) and various compressor modifications**

Option ref			Overall Concept	Potential Strategic Option Summary Description
F	6	8		**Below class limit MOP uprating of parts of the network (Milford Haven to Tirley) with new 11km pipeline (Wormington to Honeybourne and at Churchover), new Feeder 28 compressor (location not defined but west of Three Cocks) and various compressor modifications**
F	6	9		**Below class limit MOP uprating of parts of the network (Milford Haven to Wormington), new Feeder 28 compressor (location not defined but west of Three Cocks) and various compressor modifications**
F	6	10		**Below class limit MOP uprating of parts of the network (Milford Haven to Wormington) with new 11km pipeline (Wormington to Honeybourne and at Churchover), new Feeder 28 compressor (location not defined but west of Three Cocks) and various compressor modifications**
F	6	11		**Below class limit MOP uprating of parts of Feeder 28 (Felindre to Three Cocks only) with 37km new pipeline (Tirley to Wormington and on to Honeybourne and at Churchover) and various compressor modifications**
F	6	12		**Below class limit MOP uprating of parts of Feeder 28 (Felindre to Three Cocks only) with 11km new pipeline (Wormington to Honeybourne and at Churchover) additional compressors at Felindre, and various compressor modifications**
F	6	13		**Below class limit MOP uprating of parts of Feeder 28 (Felindre to Three Cocks only) with a new compression site (location on Feeder 28 not defined) with compressor modifications**
F	7	1		**New 125km onshore pipeline from Three Cocks area to Alrewas (avoiding AONBs) via west and north of Birmingham to achieve gas flow northeastwards with various compressor modifications**
F	7	2		**New 102km onshore pipeline from Tirley to Alrewas via south and east of Birmingham to achieve gas flow northeastwards with either uprating, new compression or further 55km onshore pipeline.**
F	7	3		**New 130km onshore pipeline plus new compression comprising 100km pipeline from Three Cocks area to Shocklach plus new 30km onshore pipeline to achieve gas flow northeastwards with various compressor modifications**
F	7	4		**New 300km pipeline Milford Haven to Shocklach and additional new pipeline to achieve gas flow with various compressor modifications**
F	8	1		**Partial solution - Direct connection Tirley to Honeybourne (not connecting directly to Wormington) along with a new compression site.**

Option ref			Overall Concept	Potential Strategic Option Summary Description
G			**Connect into more Eastern parts of the NTS**	
G	1	1		**New 95km onshore pipeline to achieve gas flow eastwards. Comprises 69km onshore pipeline Wormington to Aylesbury plus 26km of other pipeline Tirley to Wormington (through the Cotswolds AONB.**
G	1	2		**New approximately 146km pipeline to achieve gas flow eastwards avoiding the Cotswolds AONB. Comprises ~104km onshore pipeline Honeybourne to Aylesbury plus 33km of other new pipeline Tirley to Wormington avoiding Cotswolds AONB and 9km Wormington to Honeybourne**
G	1	3		**New ~106km onshore pipeline to achieve gas flow eastwards. Comprises 71km onshore pipeline Honeybourne to Aylesbury plus 26km of other new pipeline Tirley to Wormington and 9km of new pipeline from Wormington to Honeybourne**
H			**Connect into South Western part of the NTS**	
H	1	1		**475 Km new offshore pipeline around Cornwall to connect to southwest network plus 30km new onshore pipeline and various compressor modifications. Potentially also requires new compression.**
H	1	2		**170Km new offshore pipeline from Milford Haven across Bristol channel to connect to southwest network with 70km new onshore pipeline and various compressor modifications.**
H	1	3		**25km new offshore pipeline across the Bristol channel with 122km new onshore pipeline and various compressor modifications**
H	1	4		**73 km new offshore pipeline across the Bristol channel with 70km new onshore pipeline and various compressor modifications**
H	1	5		**210 km new offshore pipeline Milford Haven to Seabank with 116km new onshore pipeline and various compressor modifications**
H	2	1		**206km new onshore pipeline with 10km new offshore pipeline to Seabank and various compressor modifications**
H	2	2		**216km new onshore pipeline of which 10km within new tunnel to Seabank and various compressor modifications**

Option ref			Overall Concept	Potential Strategic Option Summary Description
H	3	1		**New 213km onshore pipeline using existing Severn Bridge crossing and various compressor modifications**
H	3	2		**New 213km onshore pipeline using existing Severn Rail Tunnels and various compressor modifications**
H	4	1		**Network upgrade to achieve flows using the network to the south west with new 199km onshore pipeline and various compressor modifications.**
H	4	2		**Network upgrade to achieve flows using the network to the south west with new 206km onshore pipeline (some to avoid AONB) and various compressor modifications.**
I			**Bypass Wormington capacity constraint area**	
I	1	1		**Bypass Wormington capacity constraint area from north east (Feeder 2, or 23) to south west (Feeder 14 or 20) with new onshore pipeline**
J			**Do Nothing & Commercial Measures**	
J	1	1		Do Nothing
J	1	2		Reject customer application as neither economic or efficient
J	1	3		Manage Constraint Risk with Commercial contracts

Appendix C Rationale for Discounting Strategic Options

After application of the Technical and Benefit filters several potential strategic options were discounted from further consideration. The reasons for this are described below.

Do Nothing

National Grid has a duty (under the Gas Act) to consider applications and to comply, so far as it is economical to do so, with any reasonable request to connect to the NTS. Do nothing options (option J1.1 and J1.2) are therefore discounted as an option on the basis of being non-compliant with National Grid's legal duties.

Use of Commercial and System Management Mechanisms

National Grid can use, at its discretion, a variety of commercial and system management mechanisms to manage the demand and supply balance and flow rate changes on the network (option J1.3).

National Grid considered whether there were opportunities within pre-existing entry and exit capability to be used to achieve the additional capacity required through the constraint areas. In summary if it was known that another potential supplier was going to cease activities this may provide the necessary capacity to meet the new request. National Grid concluded, as part of the PARCA phase 1 review, that no such opportunities existed within a relevant part of the network (i.e. that would not involve addressing the known area of constraint) and on this basis this approach was discounted.

As part of its role as facilitator of a competitive gas market, National Grid can use constraint payments as another mechanism to modify imbalances in supply and demand. In these circumstances, and where necessary arrangements have been previously established, National Grid could reduce the physical flow of gas onto the NTS through buy back arrangements. Such mechanisms have been discounted from further consideration as a complete solution for several reasons:

- The cost of such mechanisms mean they are suitable to manage short-term supply and demand imbalances (over a day or two). However, the cost of constraints for the potentially longer durations that may occur due to the physical constraints of the NTS (assumptions used in the appraisal assume up to 30 days per year) make this a financially unviable option compared with options to address the physical limitations of the NTS.

- SHGCL may also have additional limitations on their ability to respond to constraints that may occur. National Grid understands that LNG supply arrangements are booked to defined delivery dates responding to global market conditions and ship availability and SHGCL cannot easily alter these at short notice without this affecting their ability to be commercially competitive which would adversely affect UK consumers.

Overall it is concluded that whilst commercial and supply management mechanisms provide an important mechanism for effective short term management of a competitive gas supply market. they do not provide a mechanism to consistently respond to the reserved capacity in an efficient or economic manner and as such they are discounted as a full solution.

New Demand Consumer

The introduction of a new source of high gas demand (option A1.1) between the Milford Haven ASEP (MH ASEP) and the area of network constraint (Tirley through to

Honeybourne) has the potential to reduce the need for the additional capacity to flow through the area of constraint. At the time of preparation of the SOR an application for a 300MW gas fuelled peaking plant had been approved for Abergelli Power taking gas from the NTS near Felindre. Apart from being a potentially intermittent demand source (peaking plants do not create a consistent level of demand), the level of gas proposed to be utilised represents only around 5% of that envisaged by the PARCA. Whilst this may assist under certain circumstances it is not at a level that materially alters the NTS entry capacity of the PARCA offer that needs to be met (nor materially changes the acceptability of partial solutions as fall well short of the NTS entry capacity.

National Grid is not allowed, by its licence[24], to generate demand itself and is not aware (at the time of SOR preparation) of any new consumer demands of sufficient scale between Milford Haven and the the constraint areas on Feeder 28 east of Tirley.

Similarly, there is potential in the future for a hydrogen economy (option A2.1) and network to be established in the UK. Imported LNG to MH ASEP is one potential source of hydrogen for such a network. However, no such economy is yet established, nor is anticipated to be established within the timescales and at the scale required to respond to the PARCA. Proposals have been launched for the Milford Haven Energy Kingdom as a pilot project, but this anticipates a business case by 2022 but not implementation. Limited trials increasing the proportion of hydrogen within gas networks have also been undertaken (e.g. at Keele) but do not obviate the need for transport of gas. Additionally, any such hydrogen network proposal would itself potentially need a pipeline or other means of transporting the hydrogen to users (over and above some potential to use existing networks through an increased proportion of hydrogen). It therefore still, under some gas flow conditions, may require the identified constraints to be addressed to ensure a supply of gas could consistently be met by potentially flowing sufficient gas through the constraint area towards south Wales.

For these reasons, strategic options around new demand are discounted from further consideration.

Utilise existing 3rd party infrastructure

Various 3rd parties have existing (operational and disused) pipeline infrastructure in the relevant geographical area. Such infrastructure has the potential to be used to provide the additional flow capacity in place of the construction of new pipeline (option B3.1). In addition, various mechanisms (referred to as 'flow swap') exist for National Grid to work with the local transmission system (LTS) of the Distribution Network Operators (DNO) to manipulate gas flows through different parts of the integrated NTS and LTS network to achieve higher flow rates than use of the NTS alone (options B1.1 and B2.1).

[24] The Gas Act 1986 (Section 7, 7A and 8H) specifies that a holder of a gas transporters licence may not also hold either a gas suppliers or gas shippers licence. These are required to take gas onto and off the NTS and as a result, National Grid cannot become a source of demand. Equally, the gas act incorporates European legislation on ownership unbundling requirements that prohibits transmission system operators (TSOs) from owning or controlling assets for the production or supply of energy, or being controlled by persons that own or control such interests. The aim of this is to avoid conflicts of interest, the potential for discrimination among network users and uncompetitive behaviour.

Appraisal has concluded that no 3rd party infrastructure exists that would be extensive enough, nor have sufficient capacity, for flow swap arrangements to meet the additional capacity needed in its entirety. In particular:

- Distribution Network Lower Quinton to Rugby which is within the vicinity of the area of constraint near Honeybourne. This does not have the capacity to achieve the additional flows required, so even if used to meet part of the requirement, this would not overcome the need for a new pipeline to meet the remainder of the requirement. Additionally, its use by National Grid would require a variety of upgrading works, the cost of which would offset many of the benefits that may arise and would also impact on the ability of the DNO to maintain supplies.

- Distribution Network to the west of Wormington. The potential to interact with the South Wales network has been explored since there are a number of offtake connections along Feeder 2. However, the DN infrastructure does not support gas flow between any of these offtakes. Further east, there is DN infrastructure which permits flow swap from a number of offtakes in south west Engand to Fiddington offtake, which lies between Tirely and Wormington. However, even if the aggregate flow from all of these offtakes were swapped to Fiddington, this would result in only a very minor increase in entry capability for Milford Haven. Additionally, this arrangement would require a variety of upgrading works, the cost of which would offset the benefits that may arise and would also impact on the ability of the DNO to maintain supplies.

- Seabank to Pucklechurch pipeline. Whilst it may potentially be possible to establish arrangements to allow this existing pipeline to be used, which may avoid the need for around 30km of new pipeline, all options integrating this connection incorporated additional new pipeline. On its own this pipeline does not address the capacity but was considered in combinations of new onshore and offshore pipeline as discussed below.

Whilst discounted as full solutions, some 3rd party infrastructure in the vicinity of the constraint area and flow swap may have the potential to be utilised in place of the installation of certain limited sections of new pipeline proposed as part of other strategic options. On this basis, this option was discounted from further consideration but was considered further as part of the backcheck.

New storage (LNG and / or natural gas)

These strategic options considered whether storage, over an extended period to allow smoothing of the flow of the reserved capacity over a number of days or weeks, would avoid the need for new capacity to be achieved by the construction of new infrastructure (new pipelines, compression etc). For the avoidance of doubt this option does not deliver a sustained increase in capacity but provides a transient benefit. It is highly dependent on peaks and troughs in supply and demand and therefore has inherent uncertainty in effectiveness.

National Grid's Gas Transporters Licence does not allow it to use storage in this way (see footnote [25]). However, 3rd parties could potentially offer storage as a service to National Grid (similar to peaking plants and frequency response services in electricity transmission).

[25] The Gas Act 1986 (Section 7, 7A and 8H) specifies that a holder of a gas transporters licence may not also hold either a gas suppliers or gas shippers licence. Whilst National Grid can utilise storage to manage peak

Several variants of this strategic option were considered:

- LNG storage at Milford Haven (option C1.1).
- Natural gas storage on Feeder 28 or Feeder 2/14 between MH ASEP and the beginning of the area of constraint (option C1.2).
- Natural gas storage within the Tirley to Honeybourne constraint area to provide an alternative to new pipeline (option C1.3).

For new LNG storage it was considered that storage for a period of at least 30 days would be required. This reflects National Grid's experience of the periods when supply and demand balances have indicated there is most constraint to the ability of the network to transport the reserved capacity. It is also to be noted that whilst there may be some potential to use this approach to redistribute flows to less constrained periods the changing pattern of gas supply and demand creates additional uncertainty to the long-term viability of this technique.

The storage volume necessary to meet the customer requirement for such periods is estimated at up to 750,000m3 of LNG (15mcm/d for 30 days at a volume ratio of natural gas to LNG of 600:1). For context a storage vessel of 50m in diameter and 20m height has a capacity of approximately 40,000m3 and the existing South Hook facility has five (5) storage tanks with a working capacity of 155,000m3 each. Regardless of the environmental effects arising from the additional storage tanks that would be required (including landscape and visual effects and others arising from the required land take), indicative cost estimates for such storage are considerably greater than the cost of the lowest cost strategic option. Whilst no firm estimate has been sought, a conservative estimate in the order of ten times the capital cost of the lowest cost alternative. Based on the considerable environmental effects from such a scale of storage, the future uncertainty as an option and the high capital costs compared with other options, it is concluded that new LNG storage does not provide an economic or efficient solution to meet the reserved capacity and is discounted from further consideration.

Achieving such storage as natural gas requires an even more extensive storage facility. If stored in vertical gas holders (that were once relatively commonly found throughout the UK) at a typical 10barg pressure, then around 38 storage holders of 20m high by 50m diameter would be required per day of storage (requiring some 1,140 holders for 30 days storage, though the number would be reduced for individually larger holders). Storage at higher pressures comparable to the NTS network (i.e. around 90barg) was also considered in structures similar to thick walled pipes of approximately 3.6m width and 80m long. Whilst reducing the height of storage (noting that stacking is possible) the area required is still very extensive. The environmental effects of this scale of tank storage (at whichever pressure) from the visual effects and extent of physical land take required are very high compared with alternatives using other forms of infrastructure and on this basis new natural gas storage was discounted from further consideration as a strategic option.

and short term issues (as previously when it operated storage at Avonmouth), it would not be allowed to operate storage that could be seen as potentially affecting the market. Managing market driven flows over long periods of constraint is considered to be potentially capable of doing this and therefore outwith National Grid's Licence.

A further partial solution was also considered as an alternative to one of the sections of new pipeline between Tirley and Wormington required under some options. The storage volume in this case would be reduced by around half but still required 20 storage tanks per day of storage required (20m height by 50m diameter or higher pressure alternatives). This variation was discounted on the basis that the long term environmental effects (visual effects and those arising from the extensive site area required) of such a large number of gas holders far exceeded those of the alternative of a new pipeline where long term effects would be substantially reduced following a limited duration construction period.

Notwithstanding the fact that National Grid's Licence does not allow it to use storage in this manner (see comments above re storage) it is concluded that new natural gas storage does not provide an economic, efficient or environmentally appropriate solution to meet the additional capacity and the variants are discounted from further consideration as strategic options.

Connect to new markets (outside the NTS)

There is an inherent conflict that may prevent adoption of any of these options which prevents National Grid holding both a Gas Transmission licence (which it has to operate the NTS) and a Shipper licence which is required to commercially take gas off the system. The latter cannot be held in conjunction with a Gas Transporters licence. Notwithstanding that, these strategic options to connect to new markets outside the NTS were considered for completeness, comprising connections to southern Ireland (option D1.1) and to northwest France (option D1.2).

The connection to France would have required around three times the length of pipeline connection as that to Ireland along with additional (potentially offshore) compression (a new technology for National Grid and thus with enhanced risks). The combination of uncertainty of access to the French market, high additional capital cost (in the order of 15 to 20 times the capital cost of the lowest capital cost option), additional risk, and greater environmental effects relative to other strategic options meant this option to connect to France was discounted from further consideration.

At this strategic option stage (prior to contact with the relevant network operator) some uncertainty exists about the capacity of networks in south east Ireland to accommodate the reserved capacity offered into MH ASEP. However, the potential for demand in Ireland is evidenced by proposals (live when this report was prepared) for new LNG importation facilities to be established in Ireland. Analysis concluded that the expected requirement for any such connection would be for any new pipeline to provide for two-way flows (either to or from Ireland) along the pipeline (in line with EU regulations[26]). In combination with the need to respond to variable flows into Milford Haven ASEP, this requirement for two-way flow meant that the existing NTS network through the constraint areas would still need to be upgraded to allow for sustained flows to or from Ireland. As a result, this strategic option does not provide an economic or efficient solution and is discounted from further consideration.

[26] EU Regulation 994/2010 (EU Security of Gas Supply). Requires Transmission System Operators to enable bi-directional flow over interconnectors between EU Member States unless they hold an exemption to this requirement. Post Brexit and transition period arrangements are unknown.

LNG transfer past the area of constraint

The constraint on the reserved capacity is the ability to move the natural gas into the wider NTS beyond the constraint area around Wormington. These strategic options therefore considered whether it was possible to introduce the LNG onto the wider NTS by moving it as LNG to points beyond the constraint area. It is noted that the request that National Grid has received and accepted as a competent PARCA, specifically relates to additional capacity at MH ASEP. The ability for National Grid to implement options other than LNG offload by the customer at Milford Haven are uncertain and unconfirmed, nonetheless they have been considered to establish whether it may be appropriate to progress further investigation.

Other European sites for LNG offload are available (option E1.2) (with transfer by interconnector required back to the UK market) as well as a UK alternative being to offload at the Isle of Grain LNG facility (option E1.1). There are inherent complexities for National Grid to seek to establish a contract for any such arrangement. A key factor is that deliveries to terminals are driven by the same global LNG market conditions, and there is therefore a potential that terminals could be receiving imports (when LNG is commercially attractive and therefore advantageous to UK consumers) within a similar timeframe. Diverting from Milford Haven to Isle of Grain or other European facilities will therefore require National Grid to give considerable notice (when timing is inherently uncertain and unpredictable) and facilitate co-ordination between multiple independent commercial operators. Apart from these practical difficulties, National Grid expects this to also lead to elevated prices to UK consumers as the potential for intervention is built into pricing. Overall National Grid considers there are unacceptable commercial and residual risks to the diversion of LNG to other terminals and therefore this option is discounted. In addition, it is also pertinent to note that there are constraints to the onward flow of gas into the wider NTS from the Isle of Grain LNG terminal and potentially via interconnectors though these have not been investigated further.

Other strategic options considered for LNG transfer were a new dedicated LNG pipeline from MH ASEP (option E2.3) or the use of either road tankers (option E2.1) or rail tankers (option E2.2) to move the LNG to locations beyond the area of constraint to new LNG regassing facilities connected to the less constrained parts of the NTS. A new LNG pipeline was quickly discounted as it would require a new pipeline of a minimum of 300km length. This is over twice the length of new pipeline than the options with the next longest requirement that has been progressed to options appraisal. This option would lead to greater environmental effects than those others and has a capital cost in excess of 20 times the lowest capital cost option.

Road transport of LNG would require an estimated 500 road tanker movements away from the MH ASEP per day and rail transport of LNG around 15 train movements away from the MH ASEP per day. National Grid's understanding is that this amount of equipment and rolling stock is not currently available in the UK. Both modes have the potential for movements to be disrupted due to incidents / accidents and congestion creating uncertainty about their ability to meet the reserved capacity on a daily basis. This would incur constraints costs, as discussed above, should movements be disrupted. The road network to MH ASEP is also single carriageway and not considered suitable for this additional number of HGV movements. The rail connection is in parts provided by a single-track section which presents additional risks to the required level of movements given the potential for engineering failure of the track or associated embankments. For these reasons

neither road nor rail transport of LNG are considered to provide an acceptable means of providing the secure transfer of reserved capacity required and were discounted from further consideration.

Uprating with MOP above equipment classification limits

Following review of the challenges associated with uprating, National Grid concluded that uprating with MOP above equipment classification limits uprating with MOP above equipment classification limits is viable. However, there remained considerable technical (safety case), programme and operational challenges which represent a significant retrospective change from established practice and procedures. Network modelling also confirmed that whilst uprating with MOP above equipment classification limits gave increased capability compared with uprating with MOP below equipment classification limits, the latter could meet the PARCA requirement with the same amount of new pipeline. Therefore, uprating with MOP above equipment classification limits options (F5.1 to F5.9) were discounted from further consideration as it offered no benefit against the PARCA requirement for the additional challenges it gives.

It is noted that uprating with MOP below equipment classification limits is also a change in practice. However, the lower level of associated technical and operational issues (as the pressure uplift is less and within equipment classification limits) are considered resolvable within the programme requirements of the PARCA.

Connect into more northern and central parts of the NTS

In addition to the options progressed, several other strategic options were considered to bypass the area of constraint by connecting into more northerly parts of the NTS.

Options to connect via offshore pipeline towards areas to the north of the constraint were considered, with possible connections into the NTS into the north Wales / north west conurbation around Merseyside (F1.1) or into the NTS at Barrow (F1.2). Both connections require at least 370km of offshore pipeline and the installation of additional compression part way along the route. Such compression could be achieved by either a mid-sea platform (which poses additional technological risk as this is not a method used by National Grid elsewhere on the NTS) or by additional pipeline length to provide a diversion to allow compression to be provided at a site on land. The much greater length of pipeline in combination with the additional compression means that this option performs poorly in terms of overall environmental effects and capital cost (they are estimated to be in the order of 30 times more expensive than the lowest capital cost option) compared with other options progressed to options appraisal. On this basis these options were discounted from further consideration.

The NTS connections from Felindre comprise Feeder 28 routed around the north of the Brecon Beacons National Park (BBNP) and Feeder 2 routed to the south of the BBNP. Adding an approximately similar amount of each of these routes (approximately 55km) in combination with other works has the potential to achieve the additional capacity sought. However, the addition in the vicinity of Feeder 2 would be through considerably more challenging terrain (unavoidably crossing numerous south Wales valleys) than that of Feeder 28. Additional challenge was also posed by the lower operating pressure on Feeder 2 leading to an additional requirement for new infrastructure to integrate the additional pipeline. For these reasons the options involving new pipeline in the vicinity of part of

Feeder 2 were therefore discounted in favour of new pipeline in the vicinity of Feeder 28 (in combination with other works, see options F4.1 and F4.2).

Several new pipeline options were considered to connect from Feeder 28 to more northern and central parts of the NTS. An option (F7.3) to connect from the Three Cocks area to the NTS at Shocklach could be achieved at similar pipeline distance to that of F7.1. Connection at Shocklach (whilst a shorter distance) is not possible due to constraints in the NTS beyond the connection, though extending the connection with additional pipeline to Audley meets the NTS entry capacity at similar overall new pipeline length to F7.1. However option F7.1 provides additional system flexibility by the way gas flows can be managed at Alrewas compared with option F7.3. Whilst overall environmental effects would be similar to F7.1 the additional flexibility provides greater conformity to guiding principle 2 and therefore option F7.1 is preferred. A further backcheck would be completed should option F7.1 ultimately emerge as the preferred option.

A further new pipeline option (F7.2) to connect from Tirley to Alrewas was identified. This connection was potentially shorter (at approximately 102km compared with around 125km) than that from the Three Cocks area to Alrewas and would have facilitated a route to the east of Birmingham. However, compared with option F7.1, a connection point further east (i.e. at Tirley rather than closer to Three Cocks) cannot meet the additional capacity requirement without other elements of upgrade. To achieve the option either requires a total of approximately 162km of new pipeline or the 102km pipeline with additional new compression. Other options that use those elements of upgrade can achieve the necessary reserved capacity with less pipeline (between approximately 37km and 44km) leading to lower environmental effects and at lower overall capital cost. On this basis, strategic option F7.2 was discounted from further consideration.

Similarly, a new pipeline from Milford Haven directly to Shocklach was considered (option F7.4). This requires approximately 300km of new pipeline through potentially challenging terrain in proximity to various National Parks and AONB and is also expected to require additional compression. As a result of the greater environmental effects and capital costs (in the order of 15 times the capital cost of the lowest cost option) compared with other options being progressed to options appraisal this option was discounted from further consideration.

The options progressed to options appraisal use a connection point at the existing Tirley AGI (here Feeder 28 terminates and connects to Feeder 2/ 23) at the western end of the Wormington to Tirley pipeline element. A connection on Feeder 28 slightly to the west of Tirley AGI has the potential to slightly reduce the extent to which a route passing around the Cotswolds AONB adds additional environmental effects compared with a route through the Cotswolds AONB (e.g. between options F3.1 and F3.2). However, this alternative would require a new AGI with Pressure Regulation Equipment and would add additional pipeline length (approximately 20% longer) with greater environmental effects and capital cost (compared with connecting at Tirley) without increasing capacity and with a possible reduction in system flexibility. This alternative was therefore discounted from further consideration.

Various combinations of techniques (including new pipeline, new compression sites, uprating with MOP below equipment classification limits in various sections) to increase flow to more northern and central parts of the NTS were also considered and discounted for a variety of technical and benefit reasons as summarised below:

F3.4 and F3.5. New Feeder 28 compressor either with uprating with MOP below equipment classification limits on its own or in combination with 11km of new pipeline. The former was discounted as it failed to acheive the increase in capabililty required by the PARCA. The latter achieves the capability but involves more change at additional cost and programme challenge than option F3.3 (which was progressed to options appraisal) and was therefore discounted on the basis of the benefit filter.

F6.3 to F6.5 and F6.7 to F6.13. Uprating with MOP below equipment classification limits on its own on various parts of Feeder 28 or in various combinations with either 11km, 37km or 44km new pipeline, new compression site or additional compression at an existing site. Options F6.3 and F6.4 (with additional compression at existing sites) along with F6.5 below equipment class limit MOP on its own and F6.13 (uprating with a new compression site) were discounted as they failed to acheive the increase in capability required by the PARCA.. Other options, F6.7 to F6.12, achieve the required capability but involve additional infrastructure compared with options F6.1, F6.2 and F6.6 (which were progressed to options appraisal). As such these other options were discounted on the basis of the benefit filter as they were expected to incur additional cost and present greater environmental effects than the alternatives.

Finally, a partial solution to connect directly from Tirley to Honeybourne was considered (option F8.1) rather than this being achieved via Wormington. However, it was discounted as it would require an additional new compression site to be established compared with the connection via Wormington (which can use the existing Wormington compression) and on that basis performs poorly on capital cost (being around four times the capital cost of the pipeline only alternative) and would have greater environmental effects.

Connect into more eastern parts of the NTS

Options to increase capacity by connecting from the vicinity of the area of constraint (at or to the west of Wormington) into more eastern parts of the NTS around Aylesbury were considered.

An alternative providing a route completely around the Cotswolds AONB for both connections was considered (option G1.2). This provided a route from Tirley to Wormington (outside the Cotswolds AONB) and on to Honeybourne and then from Honeybourne to Aylesbury but routed completely outside the Cotswolds AONB. It leads to an overall connection length of approximately 150km, a length that is considerably longer than other options involving new pipeline connections,and would have greater environmental effects and capital costs (in excess of eight times the capital cost of the lowest capital cost option). Whilst offering some system flexibility benefits this was not considered enough for option G1.2 to progress as an alternative and it was therefore discounted from further consideration.

Two options were progressed to options appraisal. Options G1.1 and G1.3 both provided a shorter connection length than G1.2, of approximately 95km and 106km respectively, but are routed through parts of the Cotswolds AONB. Nonetheless given the potential system flexibility benefits and in light of the similarity of costs and pipeline length, compared with other pipeline options progressed to options appraisal (such as F4.1), these two options were also progressed.

Connections to eastern part of the NTS from locations further west of Wormington (i.e. towards or beyond Tirley on Feeder 2 / 23 or Feeder 28) did not reduce the overall

requirement for new pipeline (i.e. they fail the benefit filter) and were therefore not considered.

Connect into south western parts of the NTS

A variety of options (H1.1 to H1.5, H2.1 and H2.2, H3.1 and H3.3, H4.1 and H4,2) incorporating various starting points and combinations of onshore and offshore pipeline were considered to increase capacity by bypassing the constraint area into the south west part of the NTS. Compared with other options all performed more poorly on various grounds and were discounted as summarised below.

A new offshore pipeline from Milford Haven around Cornwall to the south coast to connect to Feeder 20 could be achieved (H1.1) but requires around 475km of new pipeline with new mid-way compression. In combination with an additional 30km of new onshore pipeline this option is therefore expected to perform poorly compared with others in terms of pipeline length, environmental effects and very poorly on capital cost (well in excess of 30 times the capital cost). It was therefore discounted from further consideration.

Several options to cross the Bristol Channel to a landing point on the north Cornwall / Devon / Somerset coast were considered (H1.2 to H1.5 and H2.1). Each would comprise different combinations of offshore pipeline and onshore pipeline. Variants with longer offshore elements connecting directly from Milford Haven whereas shorter offshore variants required longer onshore connection to the south Wales coast. These onshore connection sections include the need to follow the approximate route of Feeder 2 and its technically challenging crossing of various south Wales valleys in an area with extensive built development and extensive areas designated for nature conservation reasons which further complicate alignment opportunities. All options required longer overall pipeline length than other options being progressed (with varying proportions of this comprising more costly offshore connections). All were at much greater capital cost with the cheapest of being in excess of ten times the capital cost of the lowest capital cost option. In combination with the technical challenges they were therefore expected to perform poorly relative to other options progressed to options appraisal and were discounted from further consideration.

Some options considered the use of existing infrastructure. There is an existing 3rd party connection near Seabank that connects to the NTS at Pucklechurch. This has the potential to be used or duplicated with new pipeline. However, using such connection also requires substantial additions to the network to the south west in order to move flows away from the constraint area meaning that overall new pipeline lengths were in the order of 200km or above. These options therefore are expected to perform more poorly in terms of overall environmental effects and capital costs and were therefore discounted. Other alternatives were to use existing crossings of the Severn Estuary including the existing road bridges (H3.1) and rail tunnels (H3.2). In excess of 200km of new pipeline would be required and these options also presented various technical and safety related concerns which together undermine the viability of these options. This in combination with the expected greater level of environmental effects from the long length of onshore pipeline and capital costs (in the order of at least ten times the capital cost of the lowest capital cost option before additional crossing cost inclusion) meant that such options were discounted from further consideration.

Localised bypass of the Wormington area constraint by other gas flows

Whilst not forming a full solution, consideration was given to whether a localised bypass of the Wormington area to connect from north east to south west (option I1.1) may provide

some additional capacity to allow more flows from South Wales. However, under most circumstances the demand and supply patterns mean that gas flow is actually in opposite directions in the two sections of pipe rendering the option ineffective. It was therefore discounted from further consideration.

Appendix D Strategic Option Search Areas with Constraints

Constraints maps have been produced to show the main constraints for the environmental and socio-economic sub-topics along with the infrastructure search areas. These maps have been used to aid the appraisal of individual options and comparison between options. Features have been combined across five plans:

- Plan A shows biodiversity features.
- Plan B shows landscape features.
- Plan C shows physical environment features.
- Plan D shows historic environment features.
- Plan E shows socio-economic constraints

Due to their geographic overlap a number of options have been combined onto single sets of plans notably F3.1 with F3.2 and F3.3, F4.1 with F4.2, F6.1 with F6.2 and F6.6, G1.1 with G1.3. F7.1 is on a separate plan.

Plan A showing Biodiversity Designations

Data correct at 30/03/2020

LEGEND – Only those features present on this map are listed

- Existing Above Ground Installation
- Existing National Transmission System
- F3.1 and F3.2 Search Corridor
- F3.3 Search Corridor
- Ancient Woodland
- Important Bird Areas
- National Nature Reserve
- RSPB Reserve
- Site of Special Scientific Interest
- Special Area of Conservation
- Special Protection Areas

Western Gas Network Upgrade Project.
Strategic Options Report
National Grid
April 2020

N

0 10 Km

1:180,000

nationalgrid

Option F3.1, F3.2 and F3.3

Plan A showing Biodiversity Designations

Data correct at 30/03/2020

LEGEND – Only those features present on this map are listed

- Existing Above Ground Installation
- Existing National Transmission System
- F3.1, F3.2 and F3.3 Search Corridor
- F3.1 Search Corridor
- F3.2 Search Corridor
- Ancient Woodland
- National Nature Reserve
- RSPB Reserve
- Site of Special Scientific Interest
- Special Area of Conservation

Churchover Multi-junction

Honeybourne AGI

Wormington Compressor Site

0 2 Km

1:50,000

Western Gas Network Upgrade Project.
Strategic Options Report
National Grid
April 2020

N

0 8 Km

1:150,000

nationalgrid

50mm on Original

Option F3.1, F3.2 and F3.3

Plan B showing Landscape Designations

Data correct at 30/03/2020

LEGEND – Only those features present on this map are listed

- Existing Above Ground Installation
- Existing National Transmission System
- F3.1 and F3.2 Search Corridor
- F3.3 Search Corridor
- National Park

Three Cocks AGI

Llanwrda AGI

Brecon Beacons

Western Gas Network Upgrade Project.
Strategic Options Report
National Grid
April 2020

N

0 10 Km

1:180,000

nationalgrid

Option F3.1, F3.2 and F3.3 Sheet 2 of 2

Plan B showing Landscape Designations

Data correct at 30/03/2020

LEGEND – Only those features present on this map are listed

- Existing Above Ground Installation
- Existing National Transmission System
- National Trail
- F3.1, F3.2 and F3.3 Search Corridor
- F3.1 Search Corridor
- F3.2 Search Corridor
- Area of Outstanding Natural Beauty

Churchover Multi-junction

Honeybourne AGI

Wormington Compressor Site

Malvern Hills

Cotswolds

0 2 Km

1:50,000

50mm on Original

Western Area Gas Transmission Reinforcement Project
Strategic Options Report
National Grid

N

0 8 Km

1:150,000

nationalgrid

Option F3.1, F3.2 and F3.3

Plan C showing physical environment features

Data correct at 30/03/2020

LEGEND – Only those features present on this map are listed

- Existing Above Ground Installation
- Existing National Transmission System
- Canal
- Main River
- F3.1 and F3.2 Search Corridor
- F3.3 Search Corridor
- Air Quality Management Area
- Flood Zone 3
- Flood Zone 2
- Geopark
- Noise Important Area

Source Protection Zone

- Zone I - Inner Protection Zone
- Zone II - Outer Protection Zone
- Zone III - Total Catchment

Western Gas Network Upgrade Project.
Strategic Options Report
National Grid
April 2020

N

0 10 Km

1:180,000

nationalgrid

50mm on Original

Churchover Multi-junction

Honeybourne AGI

Wormington Compressor Site

Tirley PRS

0 2 Km

1:50,000

50mm on Original

Option F3.1, F3.2 and F3.3

Sheet 2 of 2

Plan C showing physical environment features

Data correct at 30/03/2020

LEGEND– Only those features present on this map are listed

- Existing Above Ground Installation
- Existing National Transmission System
- Canal
- Main River
- F3.1, F3.2 and F3.3 Search Corridor
- F3.1 Search Corridor
- F3.2 Search Corridor
- Air Quality Management Area
- Flood Zone 2
- Flood Zone 3
- Noise Important Area

Source Protection Zone

- Zone I - Inner Protection Zone
- Zone II - Outer Protection Zone
- Zone III - Total Catchment

Western Gas Network Upgrade Project. Strategic Options Report National Grid April 2020

N

0 8 Km

1:150,000

nationalgrid

Option F3.1, F3.2 and F3.3

Plan D showing historic environment features

Data correct at 30/03/2020

LEGEND – Only those features present on this map are listed

- Existing Above Ground Installation
- Listed Building - Grade I and II*
- Listed Building - Grade II
- Existing National Transmission System
- F3.1 and F3.2 Search Corridor
- F3.3 Search Corridor
- Historic Registered Park and Garden
- Scheduled Monument

Western Gas Network Upgrade Project.
Strategic Options Report
National Grid
April 2020

N

0 10 Km

1:180,000

nationalgrid

Option F3.1, F3.2 and F3.3

Plan D showing historic environment features

Data correct at 30/03/2020

LEGEND – Only those features present on this map are listed

- Existing Above Ground Installation
- Listed Building - Grade I and II*
- Listed Building - Grade II
- Existing National Transmission System
- F3.1, F3.2 and F3.3 Search Corridor
- F3.1 Search Corridor
- F3.2 Search Corridor
- Historic Registered Park and Garden
- Registered Battlefield
- Scheduled Monument

Churchover Multi-junction

Honeybourne AGI

Wormington Compressor Site

Tirley PRS

0 2 Km

1:50,000

Western Gas Network Upgrade Project.
Strategic Options Report
National Grid
April 2020

N

0 8 Km

1:150,000

nationalgrid

50mm on Original

Option F3.1, F3.2 and F3.3

Plan E showing socio-economic constraints

Data correct at 30/03/2020

LEGEND – Only those features present on this map are listed

- Existing Above Ground Installation
- Existing National Transmission System
- National Cycle Routes
- F3.1 and F3.2 Search Corridor
- F3.3 Search Corridor
- National Trust Inalienable Land
- National Trust Open Land

Western Gas Network Upgrade Project.
Strategic Options Report
National Grid
April 2020

N

0 10 Km

1:180,000

nationalgrid

Plan E showing socio-economic constraints

Data correct at 30/03/2020

LEGEND – Only those features present on this map are listed

- Existing Above Ground Installation
- Existing National Transmission System
- National Cycle Routes
- F3.1, F3.2 and F3.3 Search Corridor
- F3.1 Search Corridor
- F3.2 Search Corridor
- Countryside and Rights of Way Open Access Land
- National Trust Inalienable Land
- National Trust Open Land

Western Gas Network Upgrade Project.
Strategic Options Report
National Grid
April 2020

N

0 8 Km

1:150,000

nationalgrid

Churchover Multi-junction

Honeybourne AGI

Wormington Compressor Site

Tirley PRS

0 2 Km

1:50,000

50mm on Original

Plan A showing Biodiversity Designations

Data correct at 30/03/2020

LEGEND – Only those features present on this map are listed

- Existing Above Ground Installation
- Existing National Transmission System
- F4.1 and F4.2 Search Corridor
- Ancient Woodland
- Important Bird Area
- National Nature Reserve
- Ramsar
- RSPB Reserve
- Site of Special Scientific Interest
- Special Area of Conservation
- Special Protection Area

Western Gas Network Upgrade Project. Strategic Options Report National Grid April 2020

N

0 10 Km

1:175,000

nationalgrid

Plan A showing Biodiversity Designations

Data correct at 30/03/2020

LEGEND – Only those features present on this map are listed

- Existing Above Ground Installation
- Existing National Transmission System
- F4.1 and F4.2 Search Corridor
- F4.1 Search Corridor
- F4.2 Search Corridor
- Ancient Woodland
- National Nature Reserve
- RSPB Reserve
- Site of Special Scientific Interest
- Special Area of Conservation

Western Gas Network Upgrade Project. Strategic Options Report National Grid April 2020

N

0 8 Km

1:150,000

nationalgrid

50mm on Original

Option F4.1 and F4.2 Sheet 1 of 2

Plan B showing Landscape Designations

Data correct at 30/03/2020

LEGEND – Only those features present on this map are listed

- Existing Above Ground Installation
- Existing National Transmission System
- F4.1 and F4.2 Search Corridor
- Area of Outstanding Natural Beauty
- National Park

Western Gas Network Upgrade Project.
Strategic Options Report
National Grid
April 2020

N

0 10 Km

1:175,000

nationalgrid

Option F4.1 and F4.2

Plan B showing Landscape Designations

Data correct at 30/03/2020

LEGEND – Only those features present on this map are listed

- Existing Above Ground Installation
- Existing National Transmission System
- National Trail
- F4.1 and F4.2 Search Corridor
- F4.1 Search Corridor
- F4.2 Search Corridor
- Area of Outstanding Natural Beauty

Churchover Multi-junction

Honeybourne AGI

Wormington Compressor Site

Malvern Hills

Cotswolds

Western Gas Network Upgrade Project.
Strategic Options Report
National Grid
April 2020

N

0 8 Km

1:150,000

nationalgrid

Llanwrda AGI

Felindre Compressor Site

50mm on Original

Option F4.1 and F4.2

Plan C showing physical environment features

Data correct at 30/03/2020

LEGEND – Only those features present on this map are listed

- Existing Above Ground Installation
- Existing National Transmission System
- Canal
- Main River
- F4.1 and F4.2 Search Corridor
- Air Quality Management Area
- Flood Zone 3
- Flood Zone 2
- Geopark
- Noise Important Area

Source Protection Zone

- Zone I - Inner Protection Zone
- Zone II - Outer Protection Zone
- Zone III - Total Catchment

Western Gas Network Upgrade Project.
Strategic Options Report
National Grid
April 2020

N

0 10 Km

1:175,000

nationalgrid

Churchover Multi-junction

Honeybourne AGI

Wormington Compressor Site

0 2 Km

1:50,000

50mm on Original

Option F4.1 and F4.2

Plan C showing physical environment features

Data correct at 30/03/2020

LEGEND– Only those features present on this map are listed

- Existing Above Ground Installation
- Existing National Transmission System
- Environment Agency Main River
- Canal
- F4.1 and F4.2 Search Corridor
- F4.1 Search Corridor
- F4.2 Search Corridor
- Air Quality Management Area
- Flood Zone 2
- Flood Zone 3
- Noise Important Area

Source Protection Zone

- Zone I - Inner Protection Zone
- Zone II - Outer Protection Zone
- Zone III - Total Catchment

Western Gas Network Upgrade Project. Strategic Options Report National Grid April 2020

N

0 8 Km

1:150,000

nationalgrid

Option F4.1 and F4.2 Sheet 1 of 2

Plan D showing historic environment features

Data correct at 30/03/2020

LEGEND – Only those features present on this map are listed

- Existing Above Ground Installation
- Listed Building - Grade I and II*
- Listed Building - Grade II
- Existing National Transmission System
- F4.1 and F4.2 Search Corridor
- Historic Registered Park and Garden
- Scheduled Monument

Western Gas Network Upgrade Project. Strategic Options Report National Grid April 2020

N

0 10 Km

1:175,000

nationalgrid

Plan D showing historic environment features

Data correct at 30/03/2020

LEGEND – Only those features present on this map are listed

- Existing Above Ground Installation
- Listed Building - Grade I and II*
- Listed Building - Grade II
- Existing National Transmission System
- F4.1 and F4.2 Search Corridor
- F4.1 Search Corridor
- F4.2 Search Corridor
- Historic Registered Park and Garden
- Registered Battlefield
- Scheduled Monument

Western Gas Network Upgrade Project. Strategic Options Report National Grid April 2020

N

0 8 Km

1:150,000

nationalgrid

Churchover Multi-junction

Honeybourne AGI

Wormington Compressor Site

0 2 Km

1:50,000

50mm on Original

Option F4.1 and F4.2

Plan E showing socio-economic constraints

Data correct at 30/03/2020

LEGEND – Only those features present on this map are listed

- Existing Above Ground Installation
- Existing National Transmission System
- National Cycle Routes
- F4.1 and F4.2 Search Corridor
- National Trust Inalienable Land
- National Trust Open Land

Western Gas Network Upgrade Project.
Strategic Options Report
National Grid
April 2020

N

0 10 Km

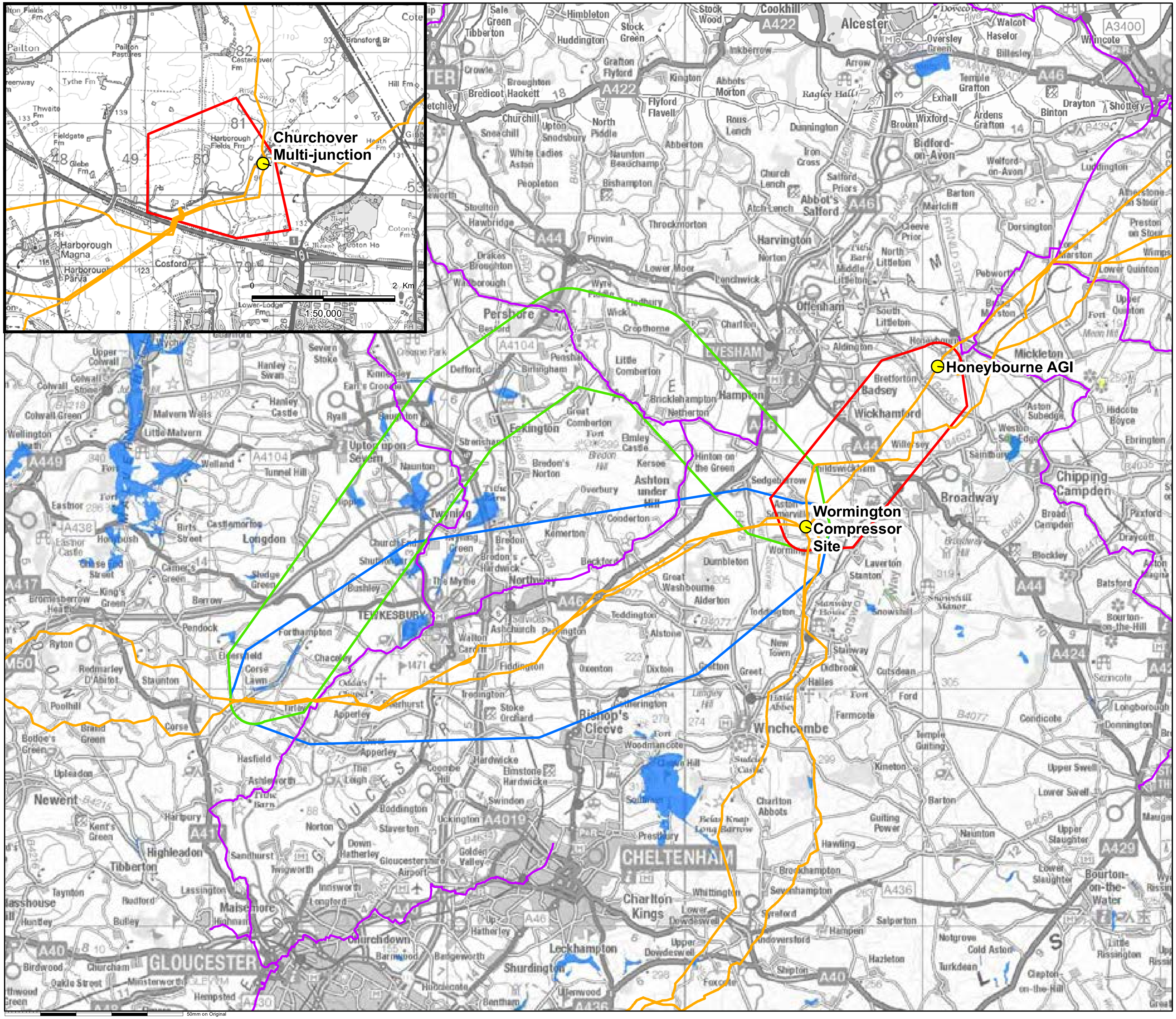
1:175,000

nationalgrid

Option F4.1 and F4.2 Sheet 2 of 2

Plan E showing socio-economic constraints

Data correct at 30/03/2020



LEGEND – Only those features present on this map are listed

- Existing Above Ground Installation
- Existing National Transmission System
- National Cycle Routes
- F4.1 and F4.2 Search Corridor
- F4.1 Search Corridor
- F4.2 Search Corridor
- Countryside and Rights of Way Open Access Land
- National Trust Inalienable Land
- National Trust Open Land

Western Gas Network Upgrade Project.
Strategic Options Report
National Grid
April 2020

N

0 8 Km

1:150,000

nationalgrid

Option F6.1, F6.2 and F6.6

Plan A showing Biodiversity Designations

Data correct at 30/03/2020

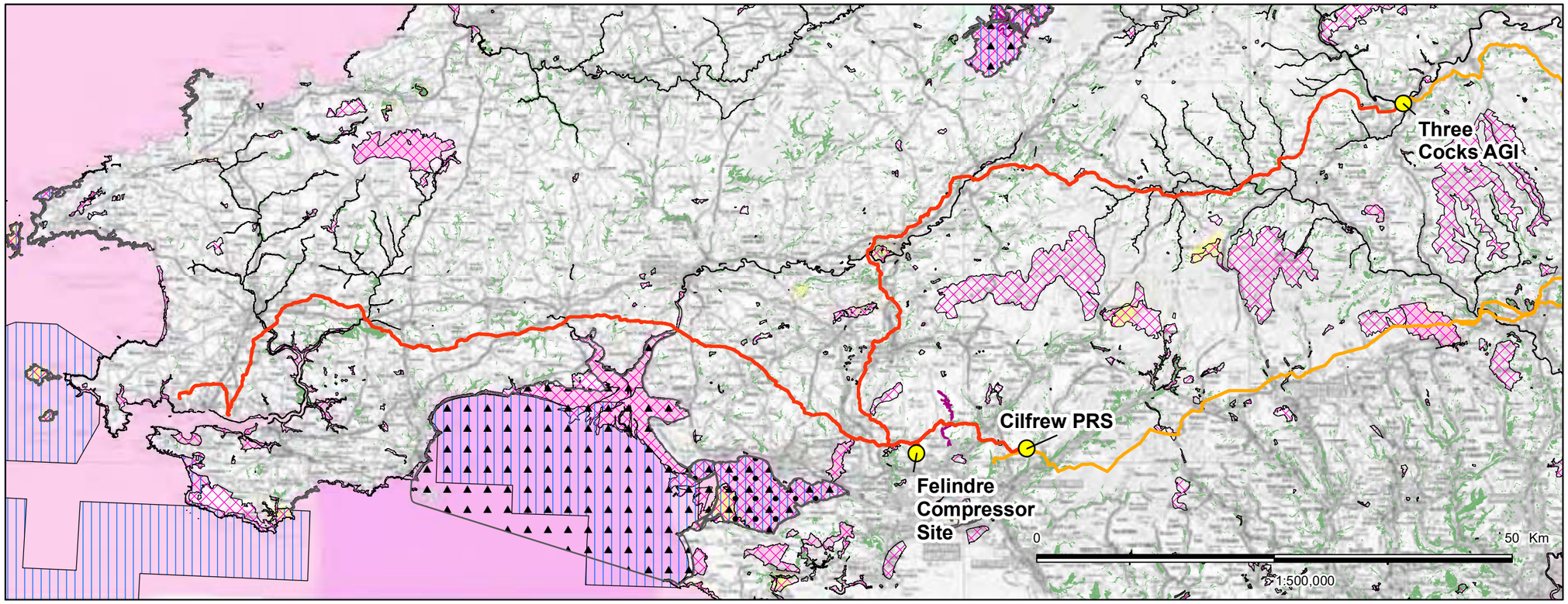
LEGEND – Only those features present on this map are listed

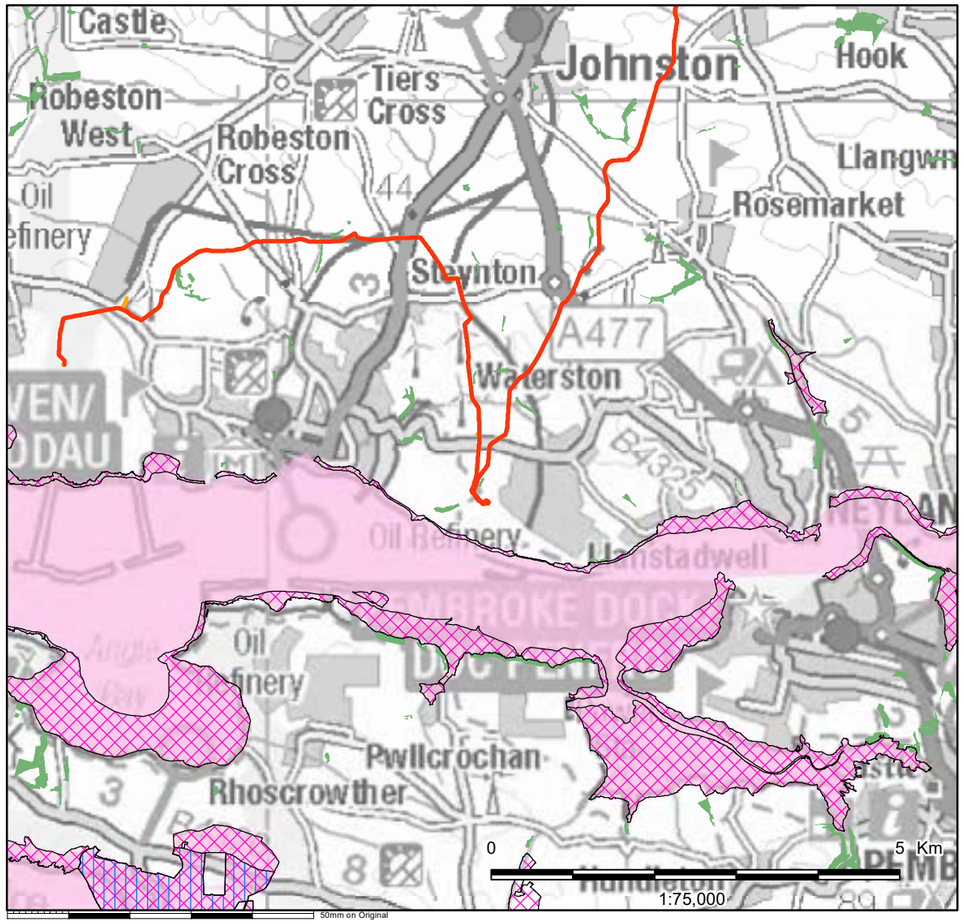
- Existing Above Ground Installation
- Uprating of pressure
- Existing National Transmission System
- Important Bird Area
- Ramsar
- Special Protection Area
- RSPB Reserve
- Ancient Woodland
- National Nature Reserve
- Site of Special Scientific Interest
- Special Area of Conservation
- Possible Special Area of Conservation

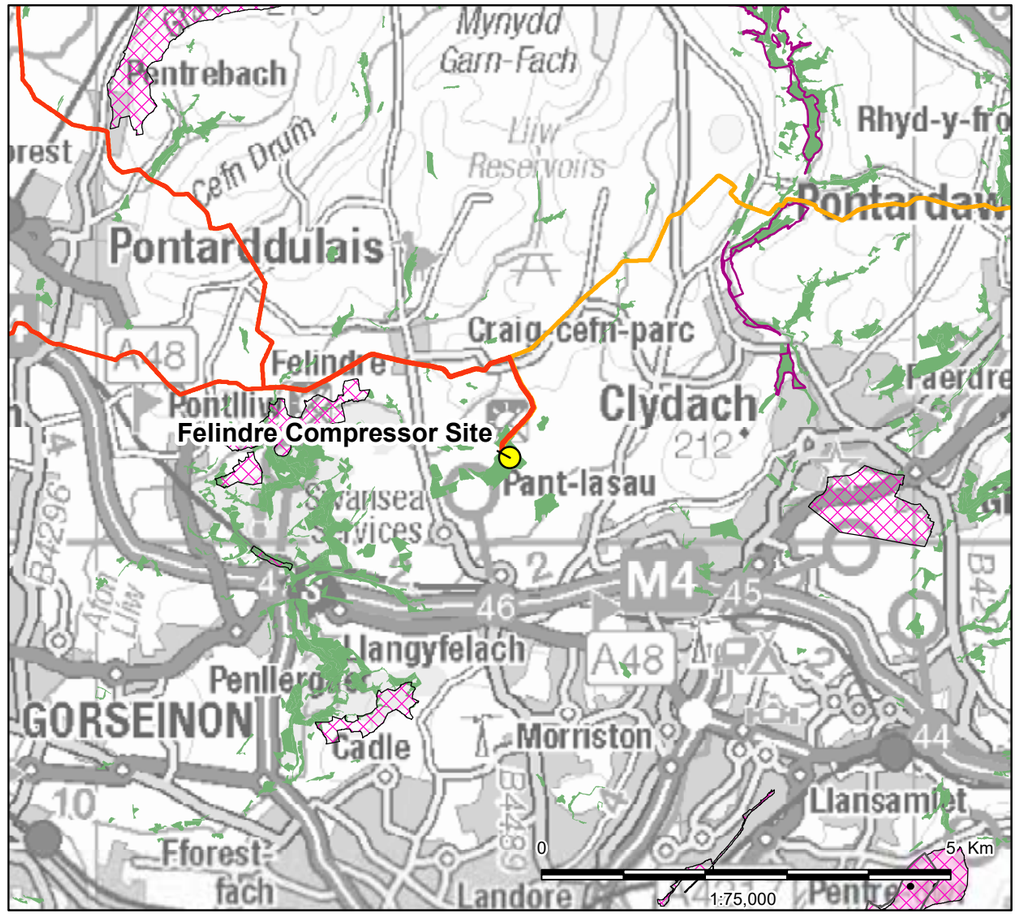
Western Gas Network Upgrade Project. Strategic Options Report National Grid April 2020

N

nationalgrid







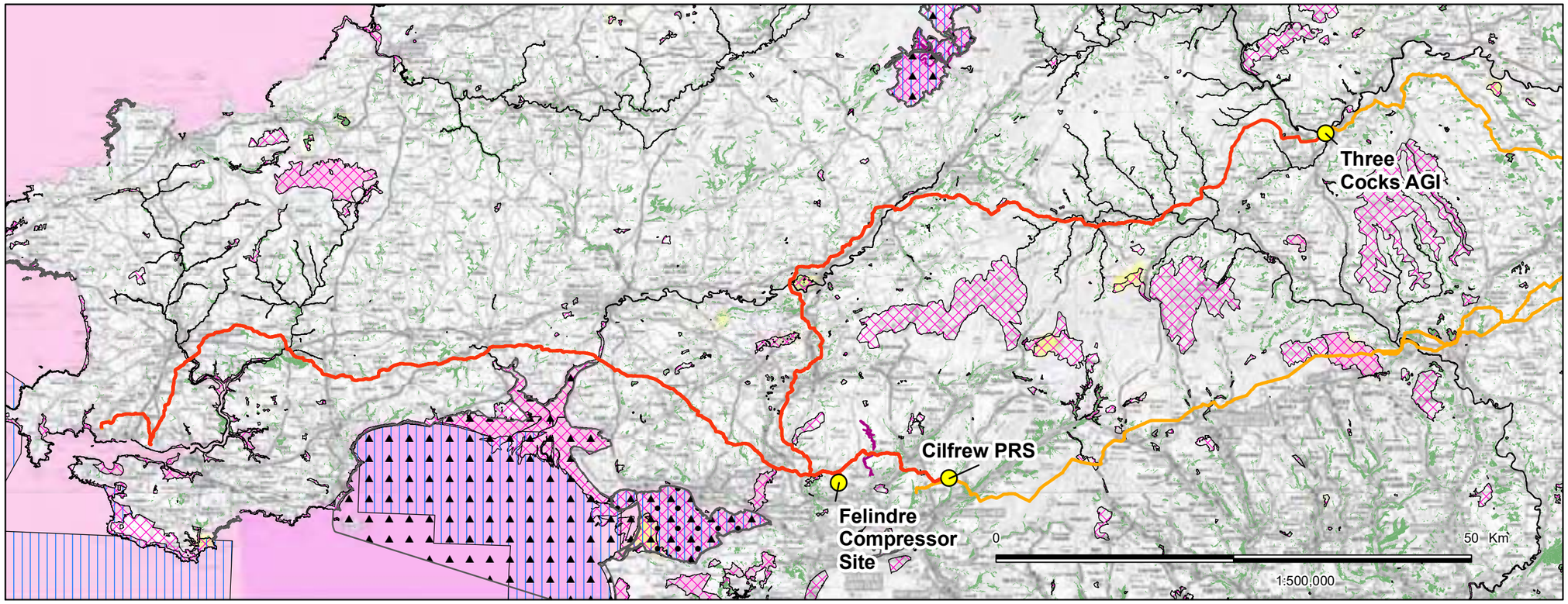
Option F6.1, F6.2 and F6.6

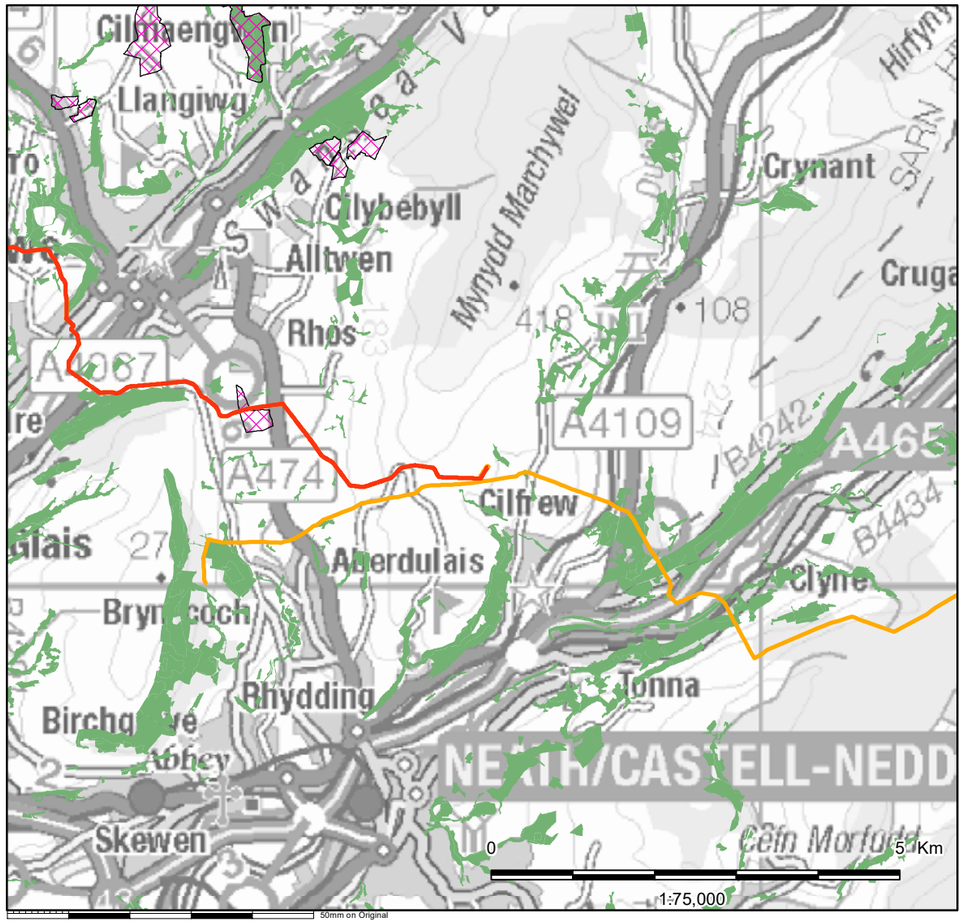
Plan A showing Biodiversity Designations

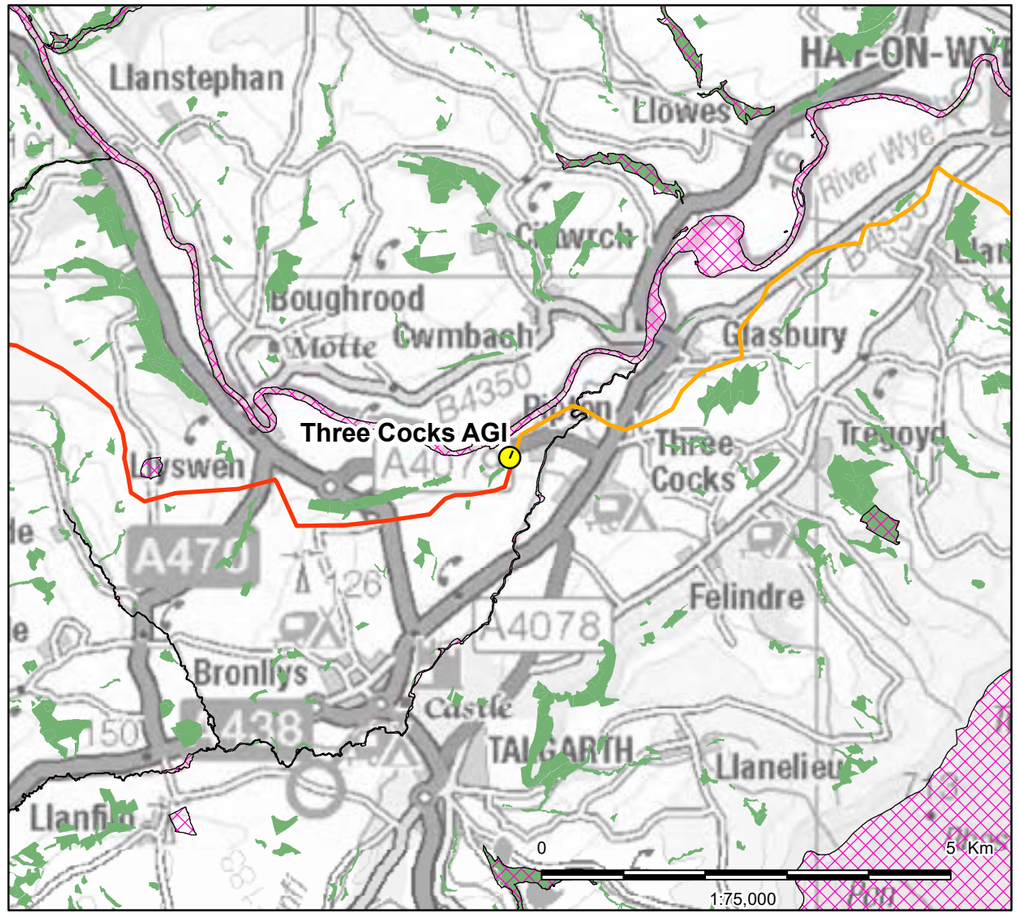
Data correct at 30/03/2020

LEGEND – Only those features present on this map are listed

- Existing Above Ground Installation
- Uprating of pressure
- Existing National Transmission System
- Important Bird Area
- Ramsar
- Special Protection Area
- RSPB Reserve
- Ancient Woodland
- National Nature Reserve
- Site of Special Scientific Interest
- Special Area of Conservation
- Possible Special Area of Conservation







Western Gas Network Upgrade Project. Strategic Options Report National Grid April 2020

N

nationalgrid

Plan A showing Biodiversity Designations

Data correct at 30/03/2020

LEGEND – Only those features present on this map are listed

- Existing Above Ground Installation
- Existing National Transmission System
- F6.1, F6.2 and F6.6 Search Corridor
- F6.1 Search Corridor
- F6.2 Search Corridor
- Ancient Woodland
- National Nature Reserve
- RSPB Reserve
- Site of Special Scientific Interest
- Special Area of Conservation

Western Gas Network Upgrade Project. Strategic Options Report National Grid April 2020

N

0 8 Km

1:150,000

nationalgrid

Churchover Multi-junction

Honeybourne AGI

Wormington Compressor Site

0 2 Km

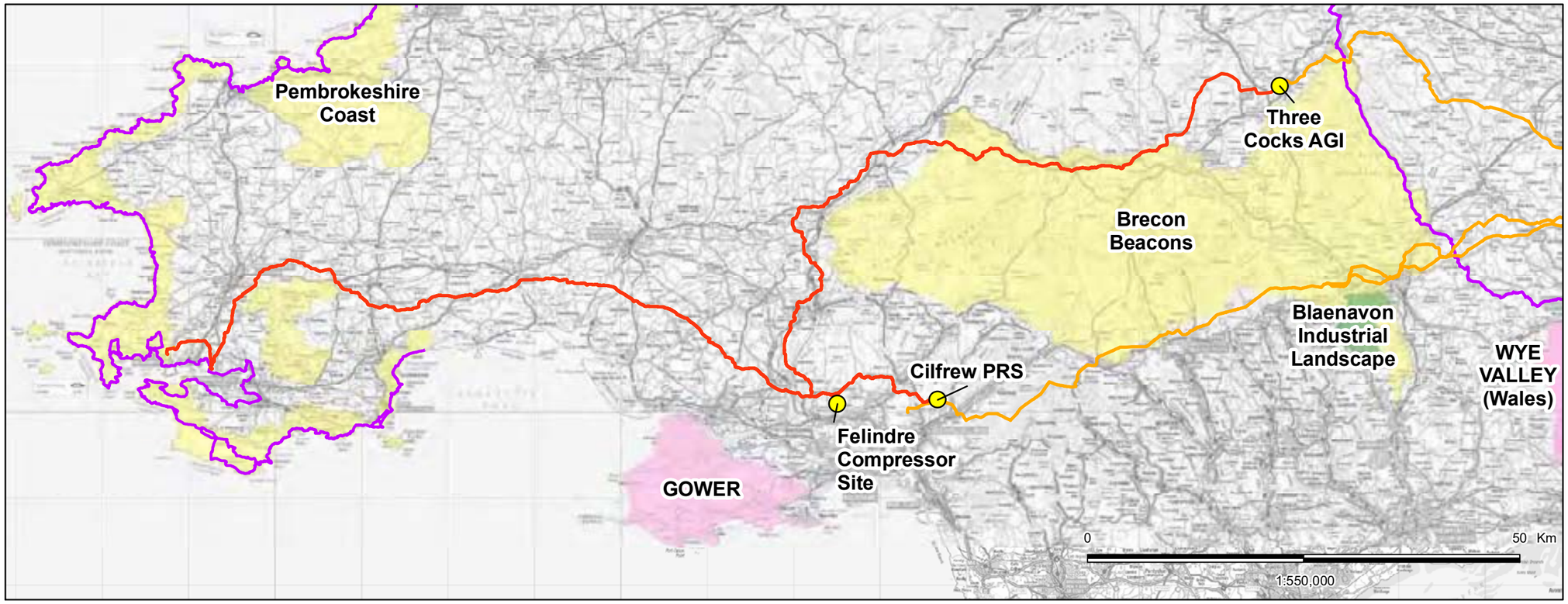
1:50,000

50mm on Original

Option F6.1, F6.2 and F6.6

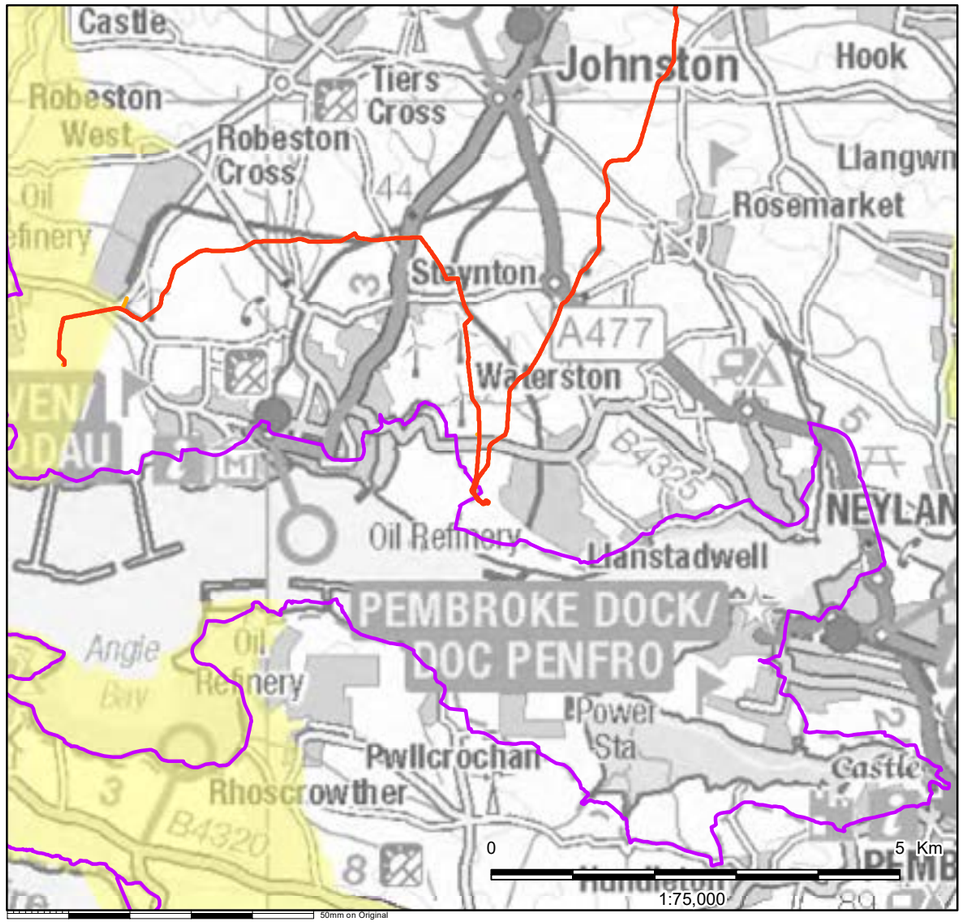
Plan B showing Landscape Designations

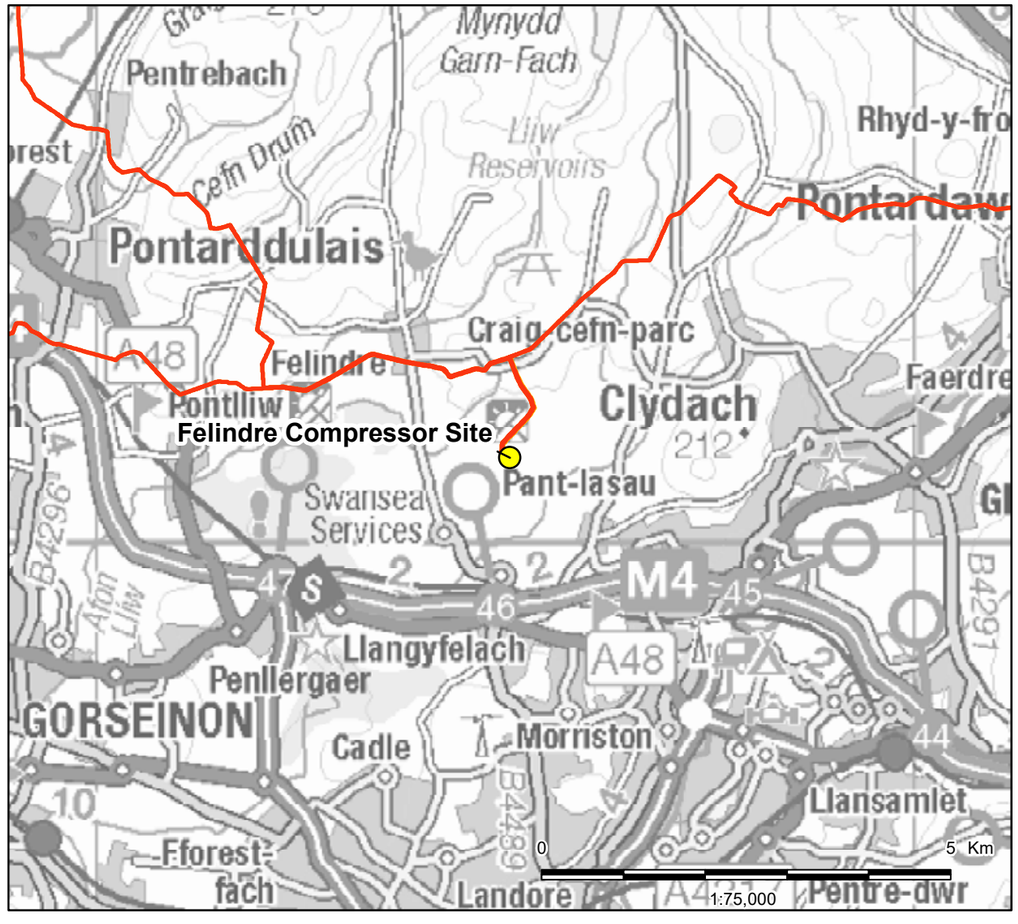
Data correct at 30/03/2020



LEGEND – Only those features present on this map are listed

- Existing Above Ground Installation
- Uprating of pressure
- Existing National Transmission System
- National Trail
- Area of Outstanding Natural Beauty
- National Park
- World Heritage Site





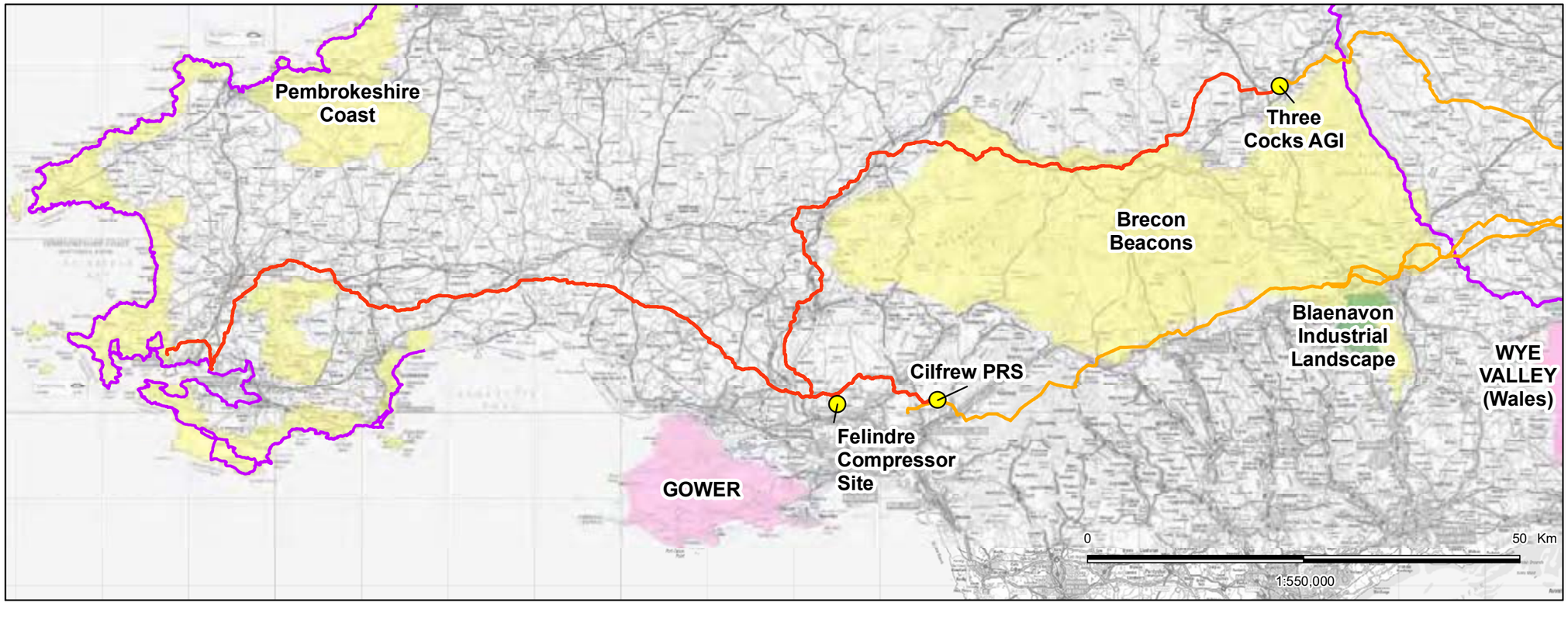
Western Gas Network Upgrade Project.
Strategic Options Report
National Grid
April 2020

N

nationalgrid

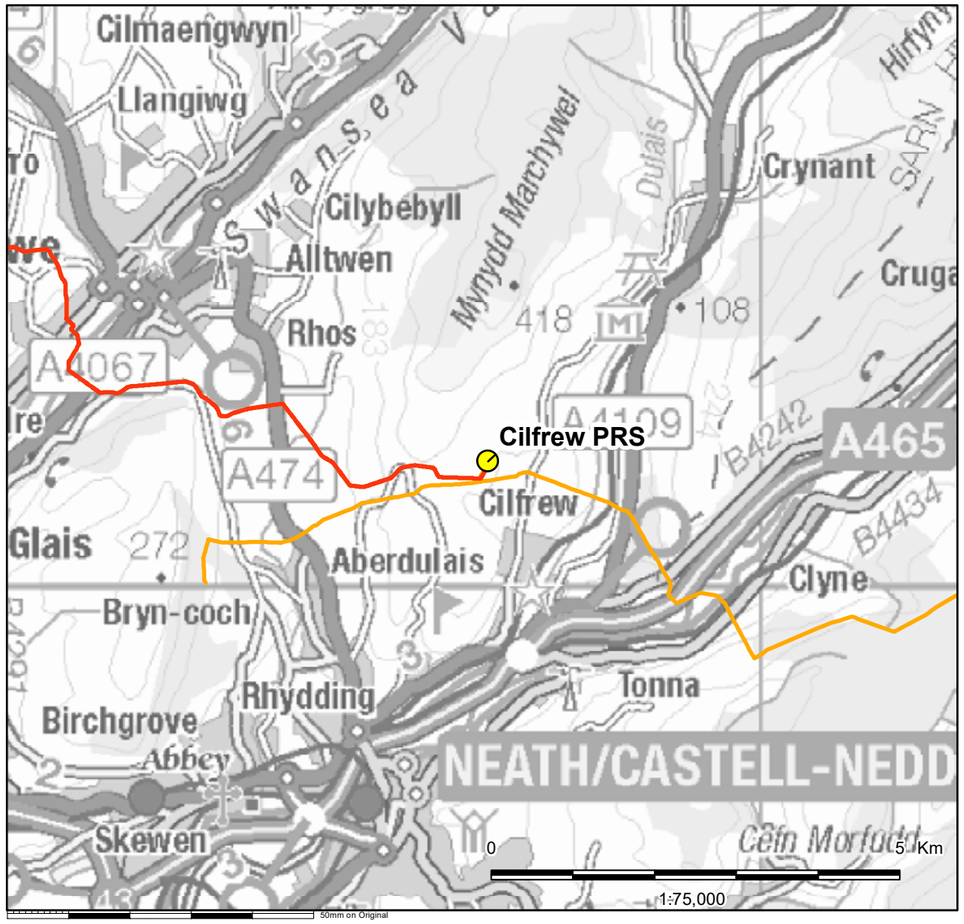
Plan B showing Landscape Designations

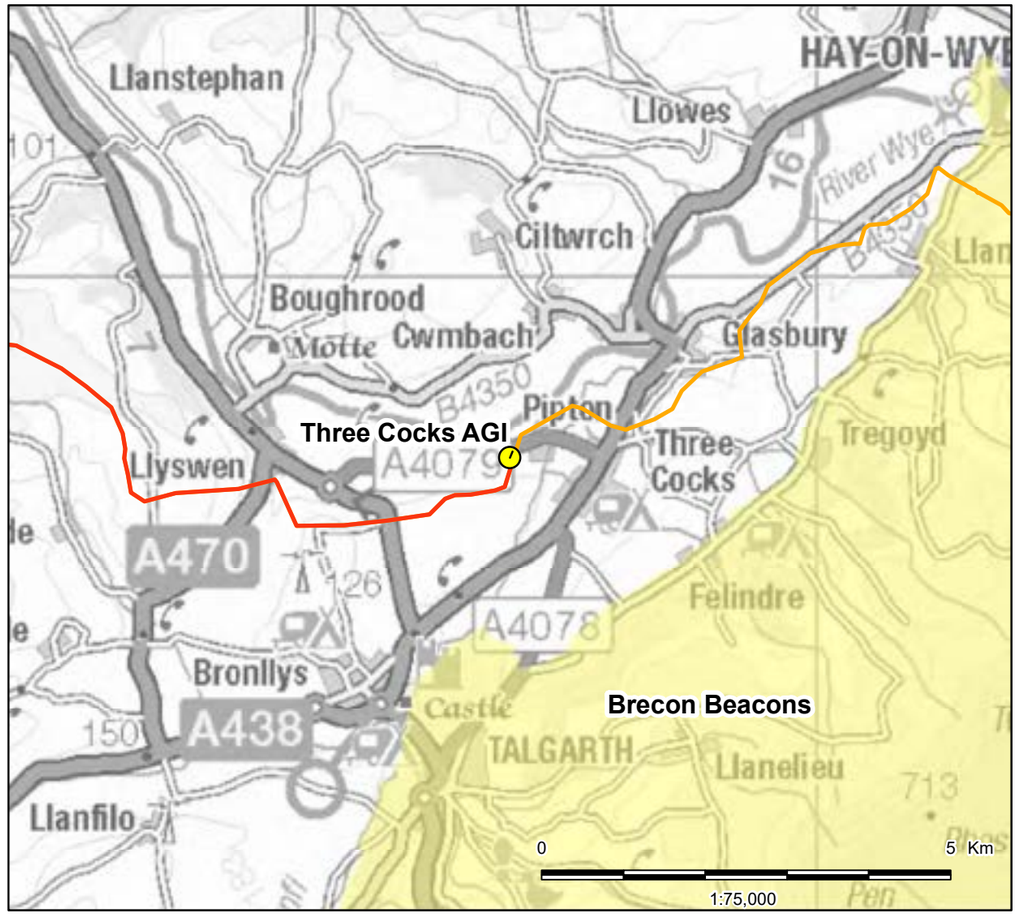
Data correct at 30/03/2020



LEGEND – Only those features present on this map are listed

- Existing Above Ground Installation
- Uprating of pressure
- Existing National Transmission System
- National Trail
- Area of Outstanding Natural Beauty
- National Park
- World Heritage Site





Western Gas Network Upgrade Project.
Strategic Options Report
National Grid
April 2020

N

nationalgrid

Plan B showing Landscape Designations

Data correct at 30/03/2020

LEGEND – Only those features present on this map are listed

- Existing Above Ground Installation
- Existing National Transmission System
- National Trail
- F6.1 and F6.2 and F6.6 Search Corridor
- F6.1 Search Corridor
- F6.2 Search Corridor
- Area of Outstanding Natural Beauty

Churchover Multi-junction

Honeybourne AGI

Wormington Compressor Site

Malvern Hills

Cotswolds

0 2 Km

1:50,000

Western Gas Network Upgrade Project. Strategic Options Report National Grid April 2020

N

0 8 Km

1:150,000

nationalgrid

Option F6.1, F6.2 and F6.6

Plan C showing physical environment features

Data correct at 30/03/2020

LEGEND – Only those features present on this map are listed

- Existing Above Ground Installation
- Uprating of pressure
- Existing National Transmission System
- Canal
- Main River
- Air Quality Management Area
- Flood Zone 2
- Flood Zone 3
- Geopark
- Noise Important Area

Source Protection Zone

- Zone I - Inner Protection Zone
- Zone II - Outer Protection Zone
- Zone III - Total Catchment

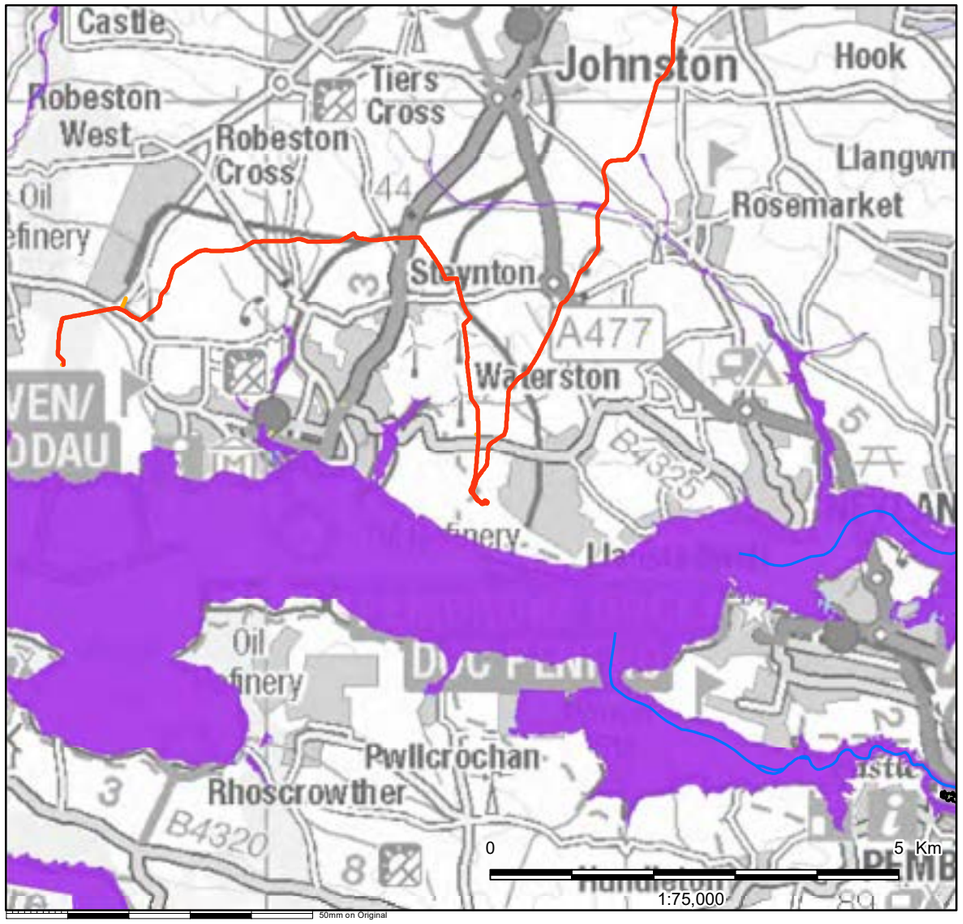
Three Cocks AGI

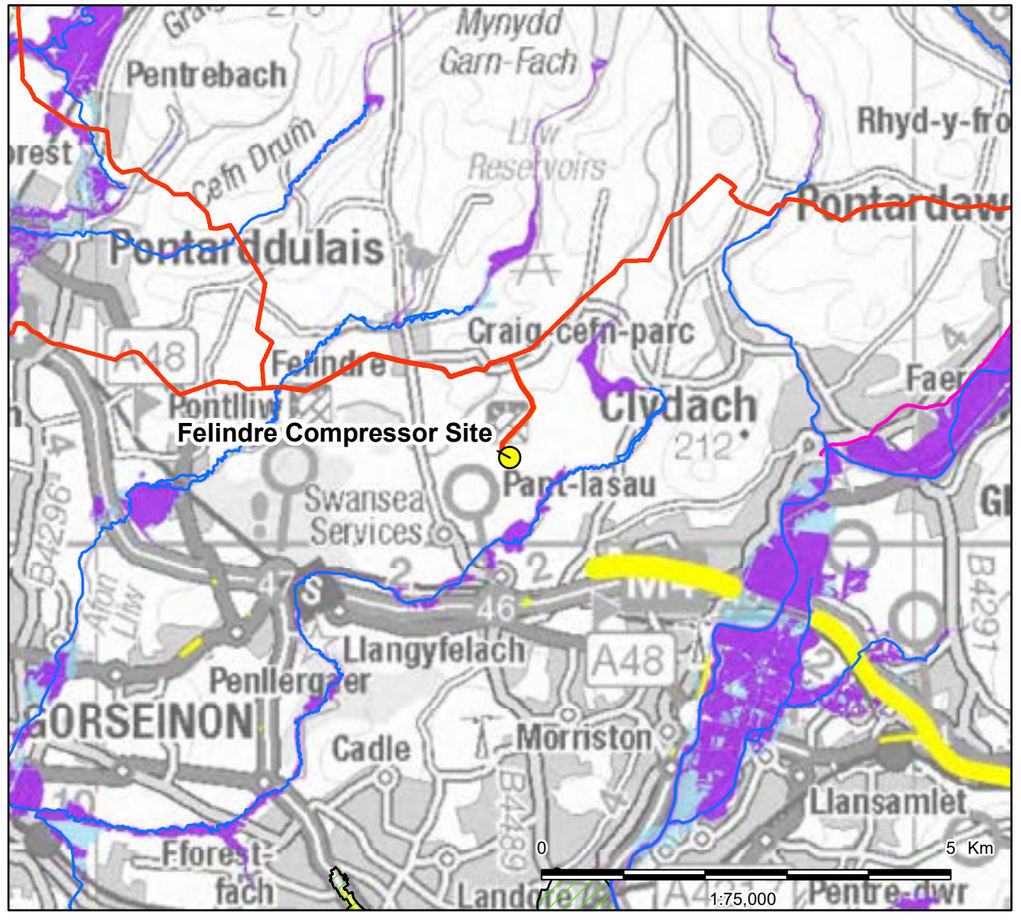
Cilfrew PRS

Felindre Compressor Site

0 50 Km

1:550,000





Western Gas Network Upgrade Project. Strategic Options Report National Grid April 2020

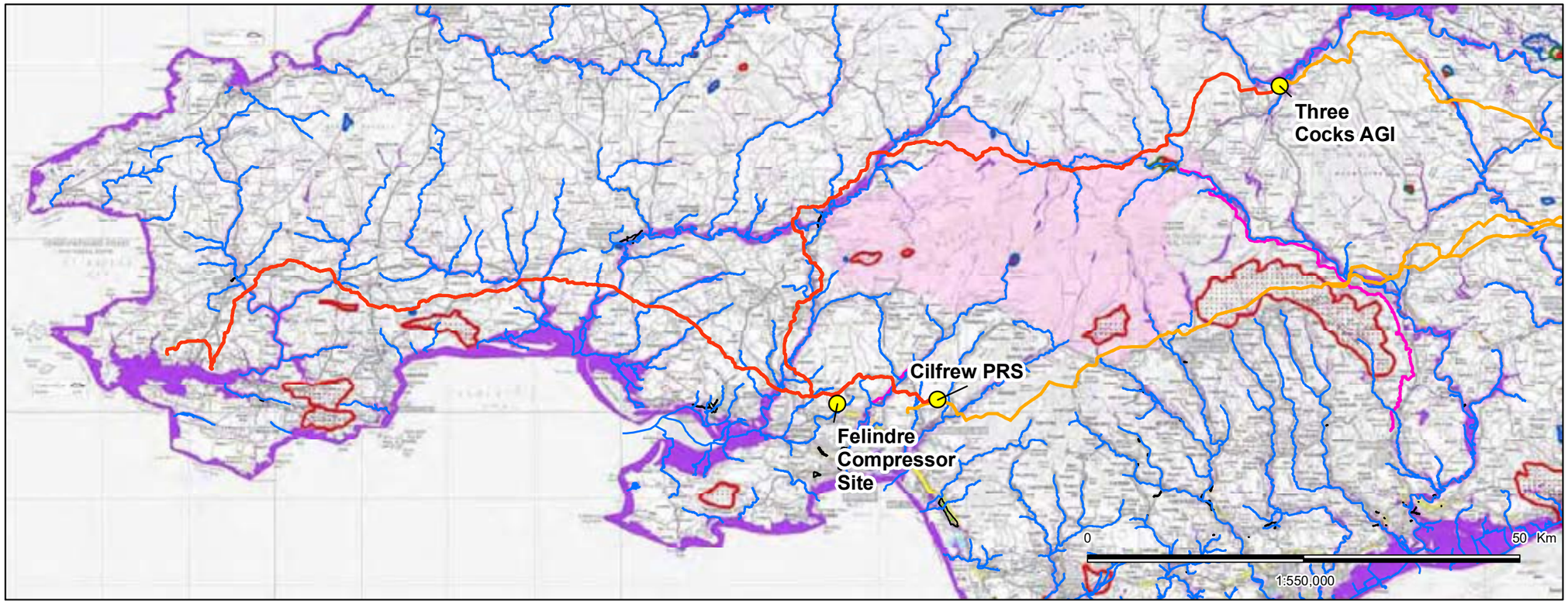
N

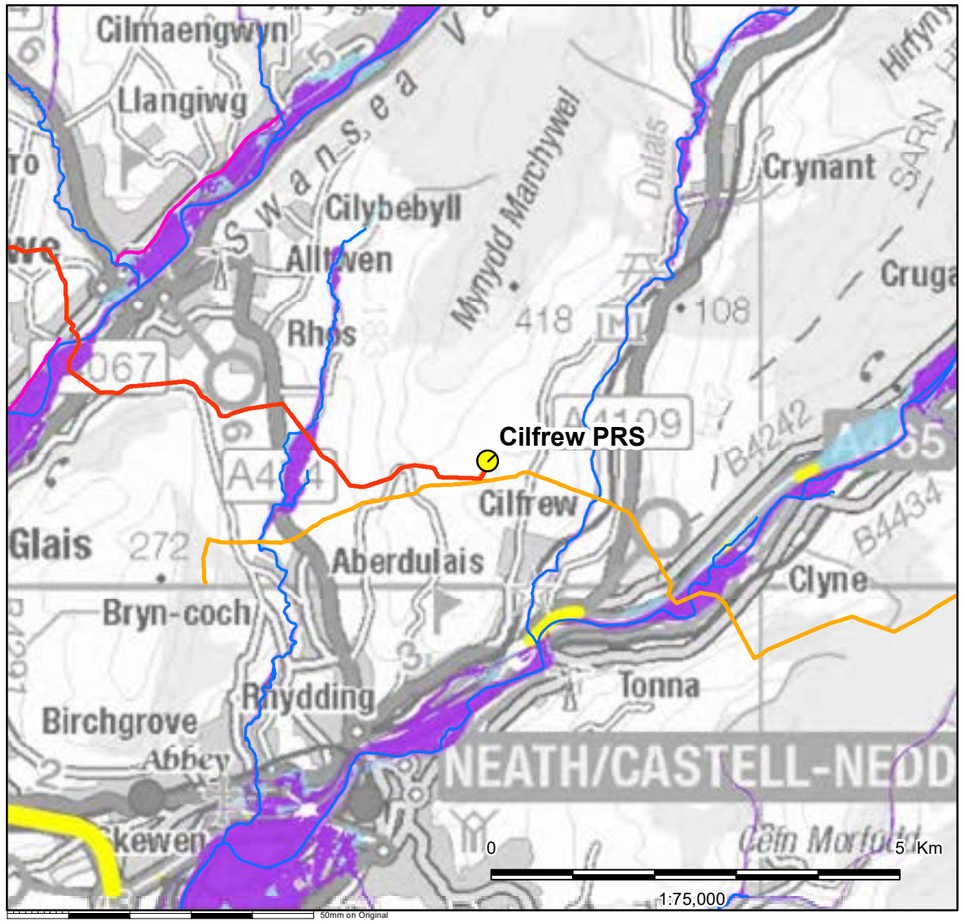
nationalgrid

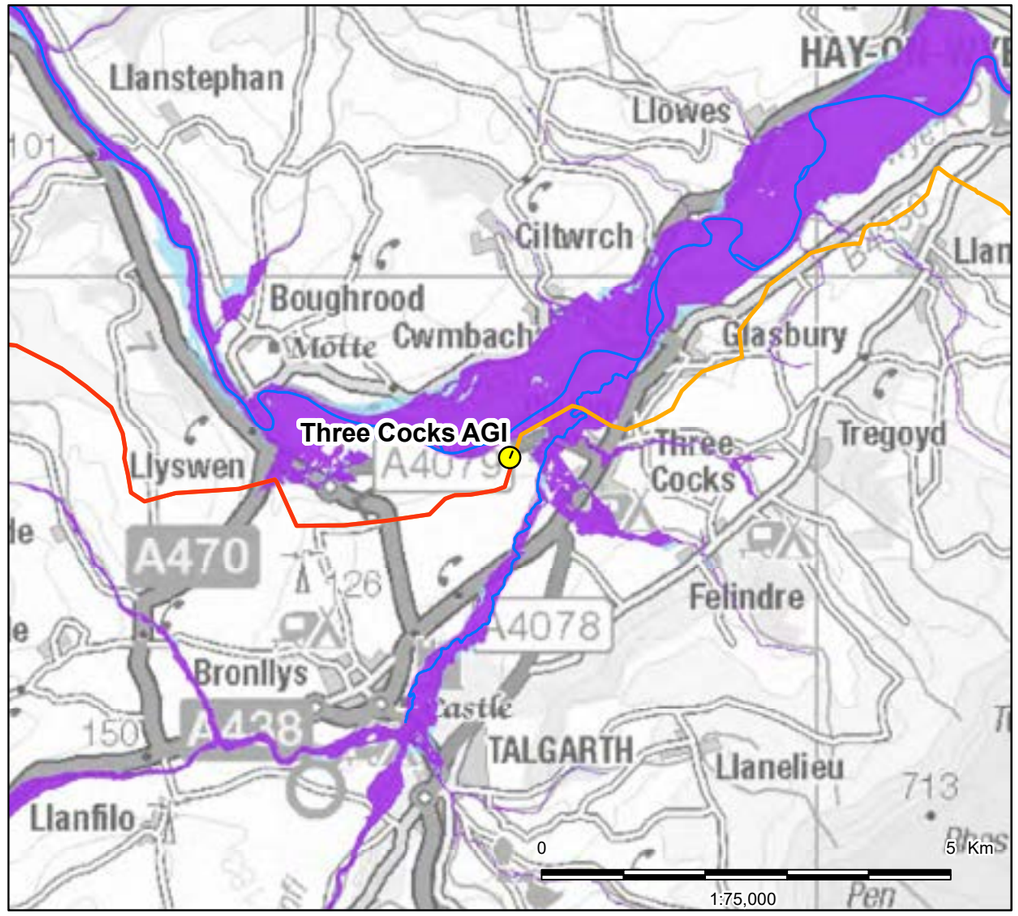
Option F6.1, F6.2 and F6.6

Plan C showing physical environment features

Data correct at 30/03/2020







LEGEND – Only those features present on this map are listed

- Existing Above Ground Installation
- Uprating of pressure
- Existing National Transmission System
- Canal
- Main River
- Air Quality Management Area
- Flood Zone 2
- Flood Zone 3
- Geopark
- Noise Important Area

Source Protection Zone

- Zone I - Inner Protection Zone
- Zone II - Outer Protection Zone
- Zone III - Total Catchment

Western Gas Network Upgrade Project.
Strategic Options Report
National Grid
April 2020

N

nationalgrid

Plan C showing physical environment features

Data correct at 30/03/2020

LEGEND – Only those features present on this map are listed

- Existing Above Ground Installation
- Existing National Transmission System
- Canal
- Main River
- F6.1, F6.2 and F6.6 Search Corridor
- F6.1 Search Corridor
- F6.2 Search Corridor
- Air Quality Management Area
- Flood Zone 2
- Flood Zone 3
- Noise Important Area

Source Protection Zone

- Zone I - Inner Protection Zone
- Zone II - Outer Protection Zone
- Zone III - Total Catchment

Churchover Multi-junction

Honeybourne AGI

Wormington Compressor Site

0 2 Km

1:50,000

Western Gas Network Upgrade Project. Strategic Options Report National Grid April 2020

N

8 Km

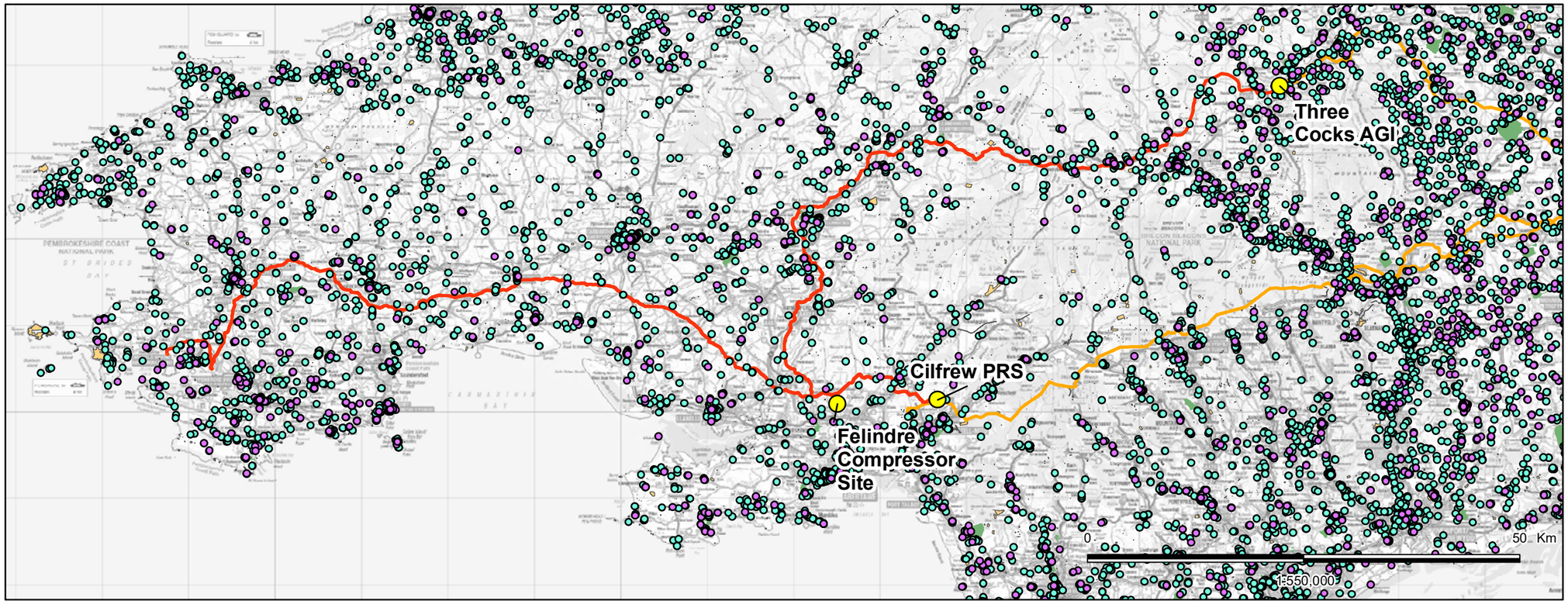
1:150,000

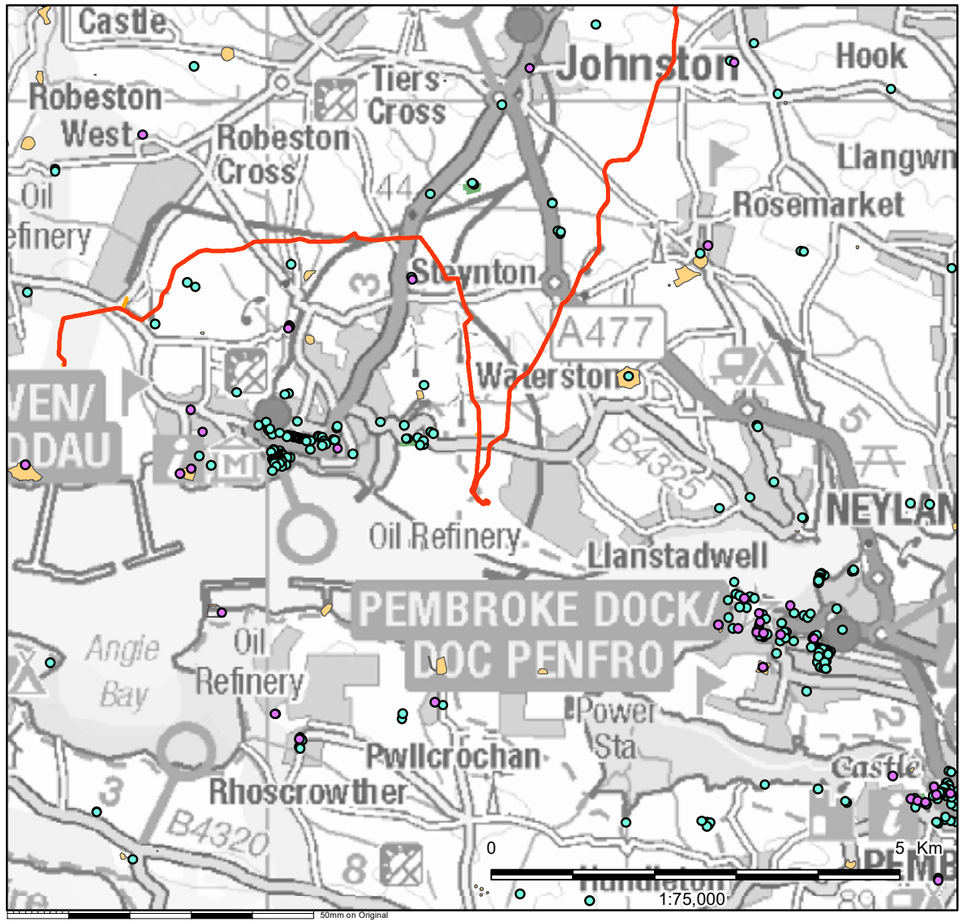
nationalgrid

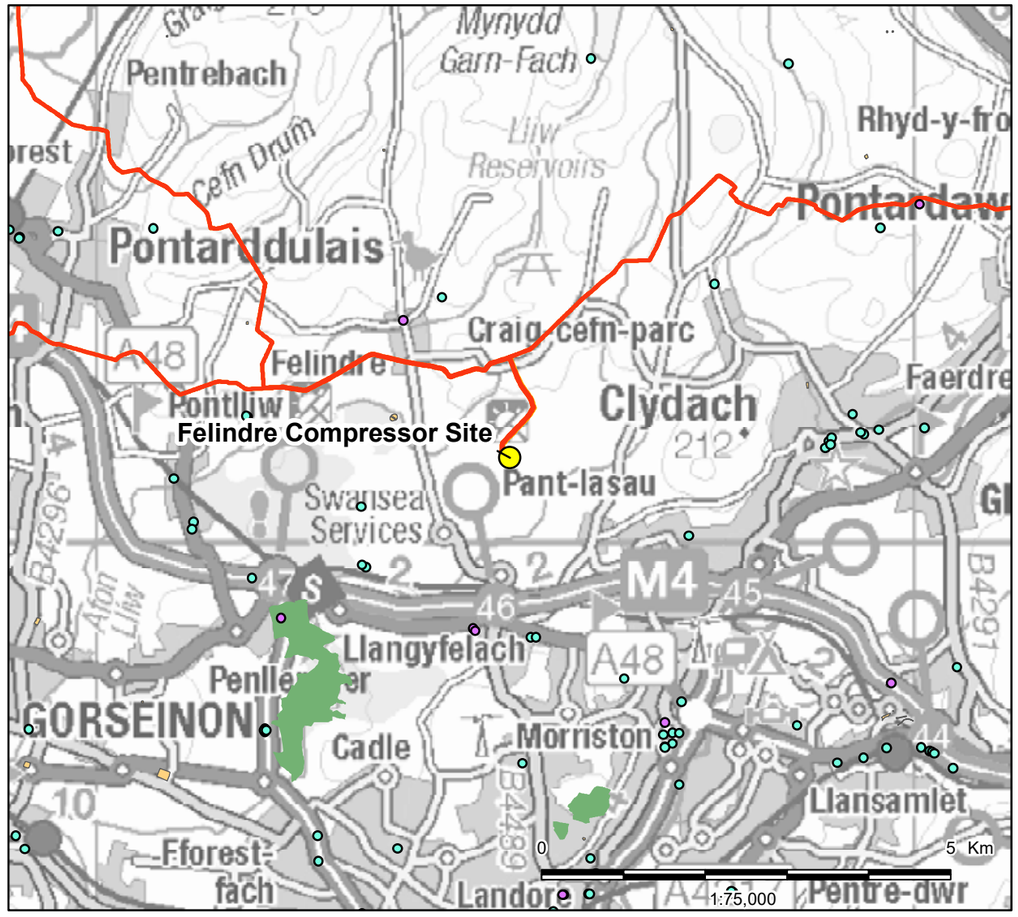
50mm on Original

Plan D showing historic environment features

Data correct at 30/03/2020







LEGEND – Only those features present on this map are listed

- Existing Above Ground Installation
- Listed Building - Grade I and II*
- Listed Building - Grade II
- Uprating of pressure
- Existing National Transmission System
- Historic Registered Park and Garden
- Registered Battlefield
- Scheduled Monument

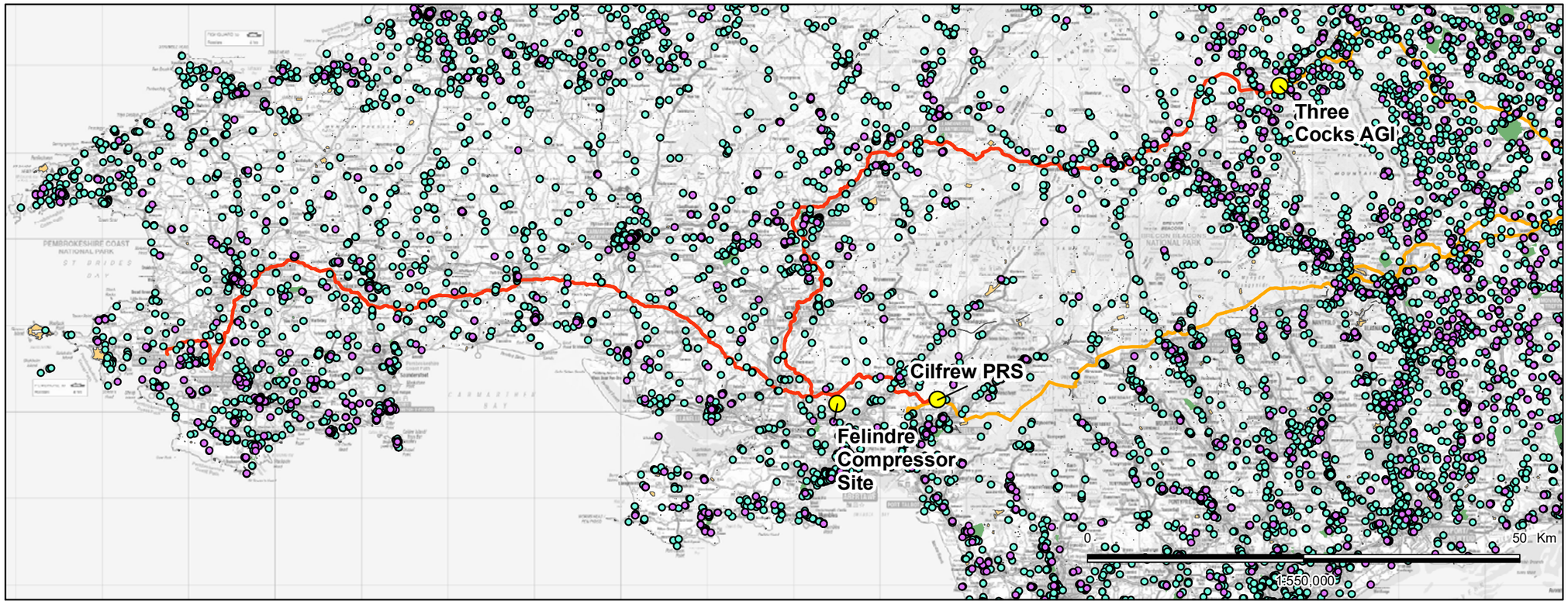
Western Gas Network Upgrade Project.
Strategic Options Report
National Grid
April 2020

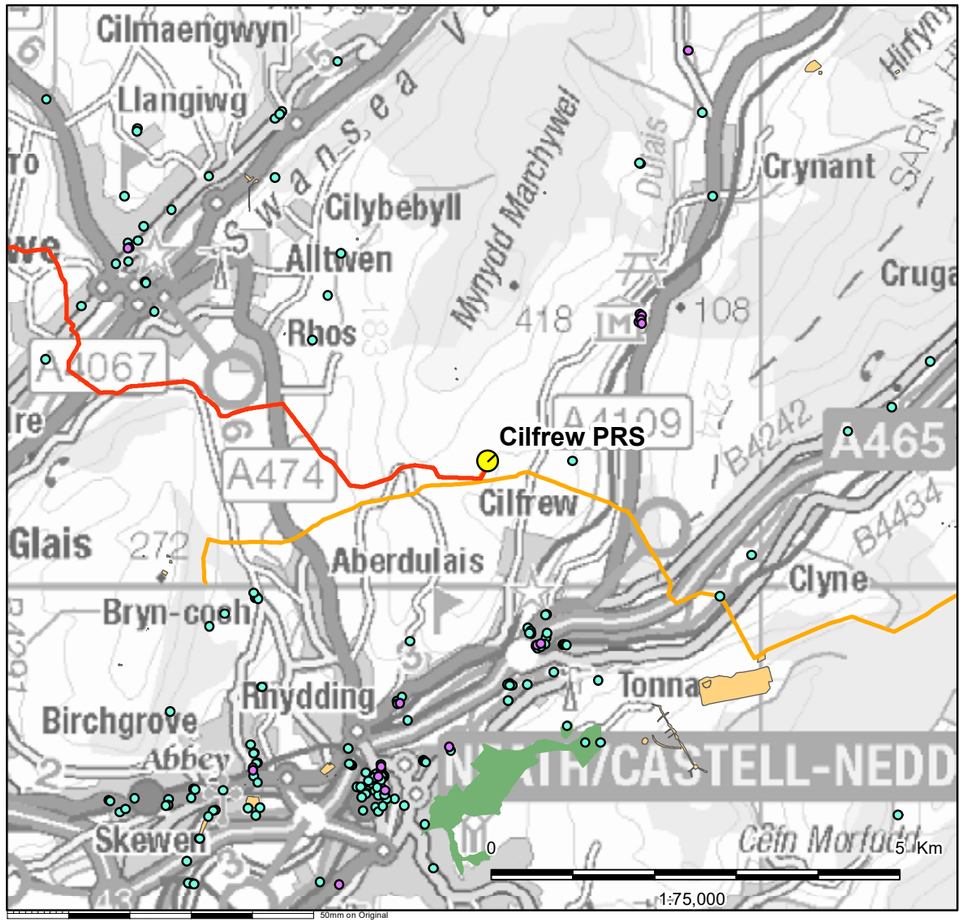
N

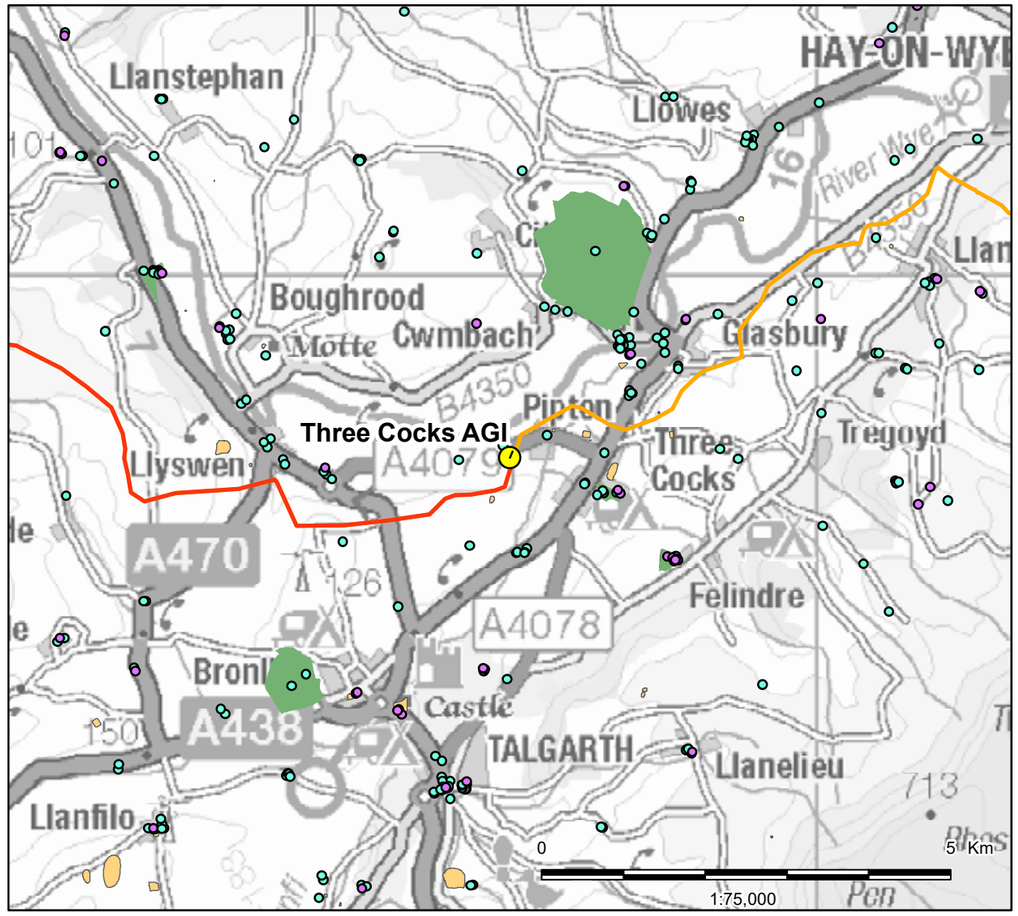
nationalgrid

Plan D showing historic environment features

Data correct at 30/03/2020







- Existing Above Ground Installation
- Listed Building - Grade I and II*
- Listed Building - Grade II
- Uprating of pressure
- Existing National Transmission System
- Historic Registered Park and Garden
- Registered Battlefield
- Scheduled Monument

Western Gas Network Upgrade Project.
Strategic Options Report
National Grid
April 2020

N

nationalgrid

Option F6.1, F6.2 and F6.6

Plan D showing historic environment features

Data correct at 30/03/2020

LEGEND – Only those features present on this map are listed

- Existing Above Ground Installation
- Listed Building - Grade I and II*
- Listed Building - Grade II
- Existing National Transmission System
- F6.1, F6.2 and F6.6 Search Corridor
- F6.1 Search Corridor
- F6.2 Search Corridor
- Historic Registered Park and Garden
- Registered Battlefield
- Scheduled Monument

Western Gas Network Upgrade Project.
Strategic Options Report
National Grid
April 2020

N

0 8 Km

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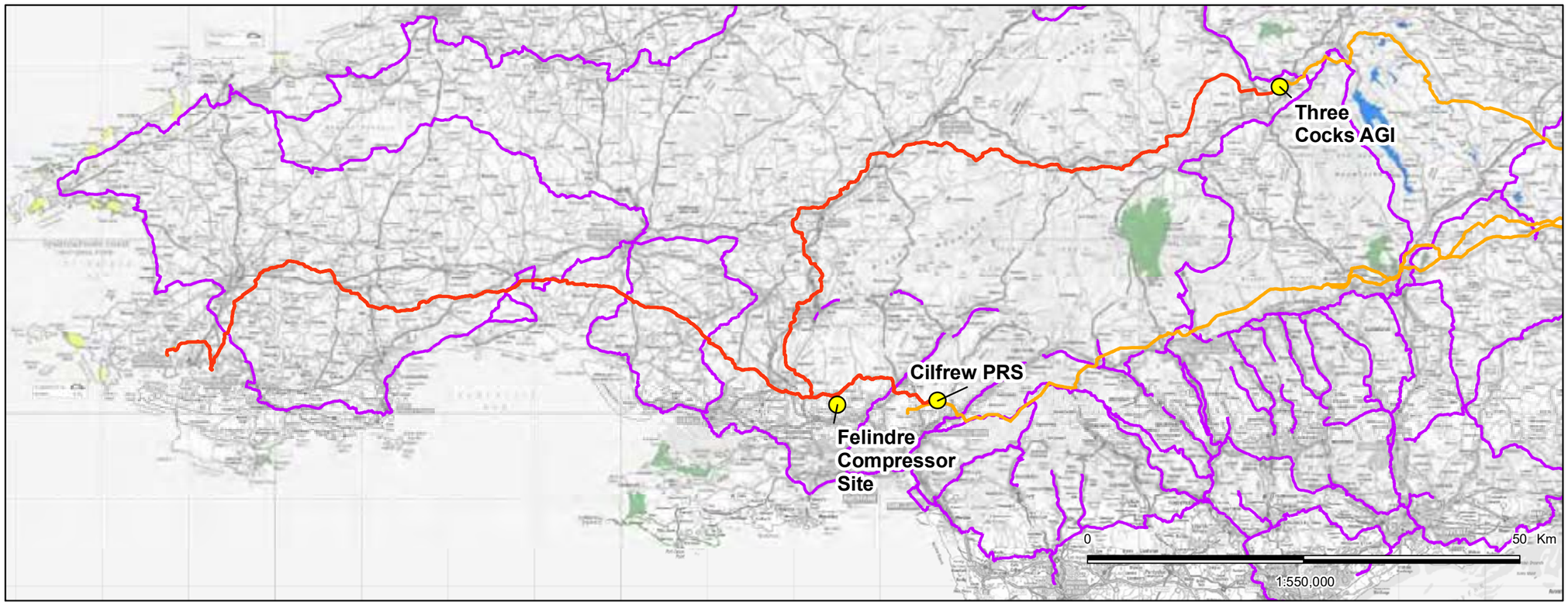
nationalgrid

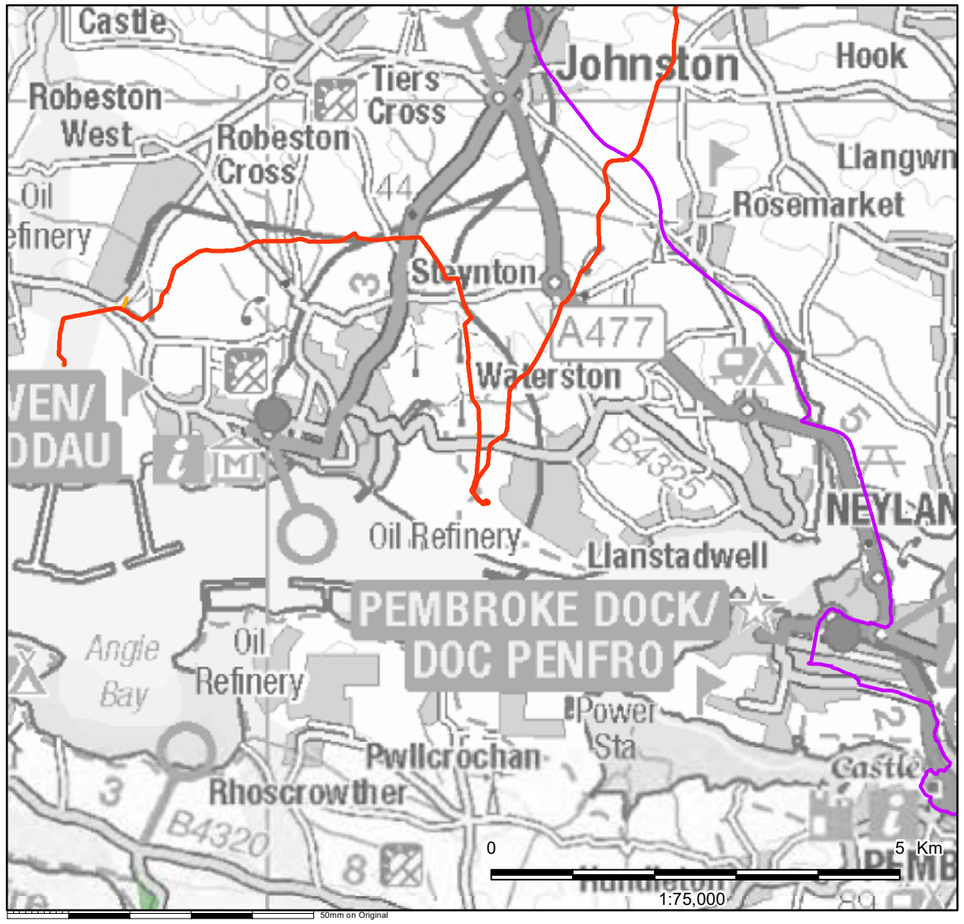
Plan E showing socio-economic constraints

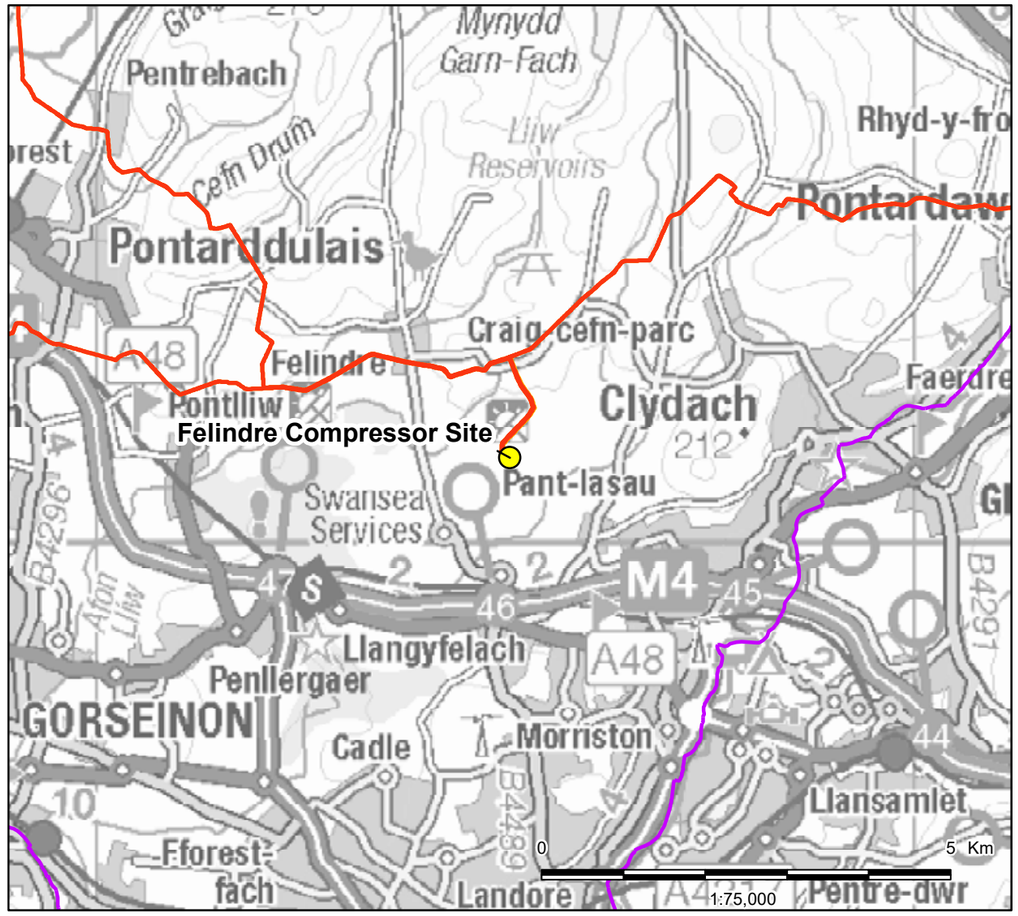
Data correct at 30/03/2020

LEGEND – Only those features present on this map are listed

- Existing Above Ground Installation
- Uprating of pressure
- Existing National Transmission System
- National Cycle Routes
- Countryside and Rights of Way Open Access Land
- National Trust Inalienable Land
- National Trust Open Land







Western Gas Network Upgrade Project.
Strategic Options Report
National Grid
April 2020

N

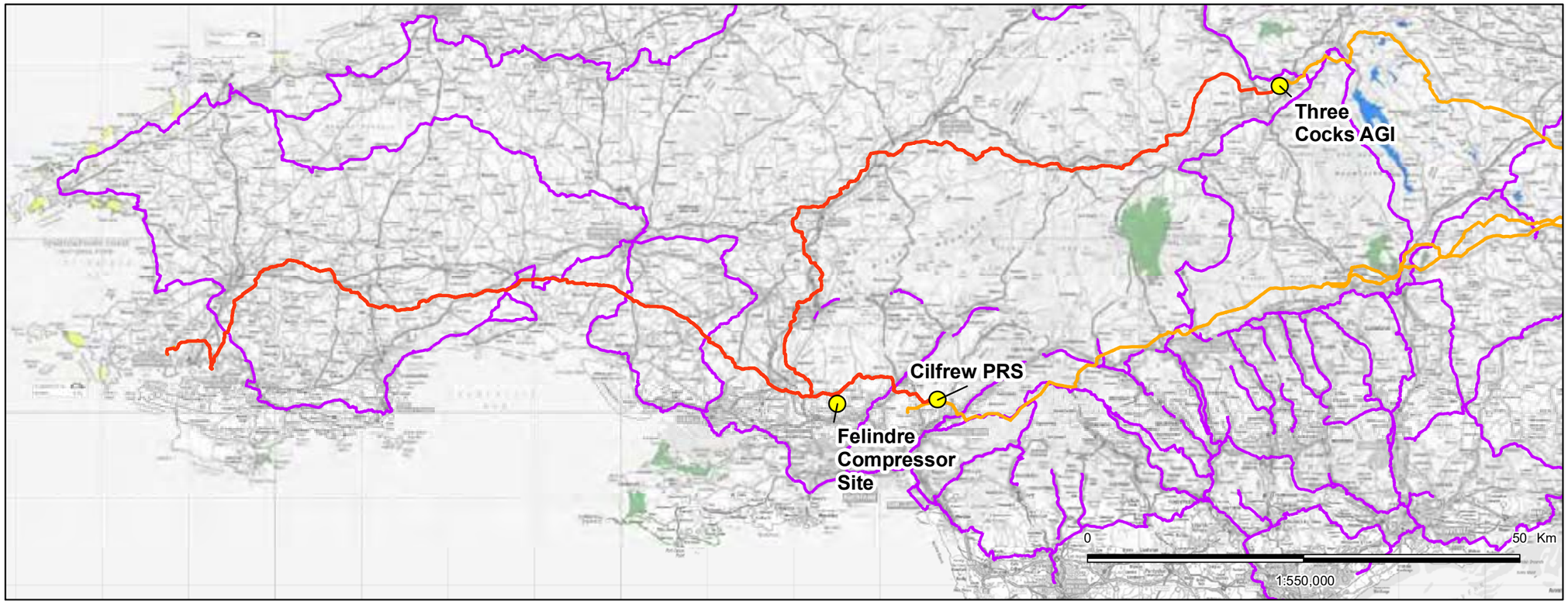
nationalgrid

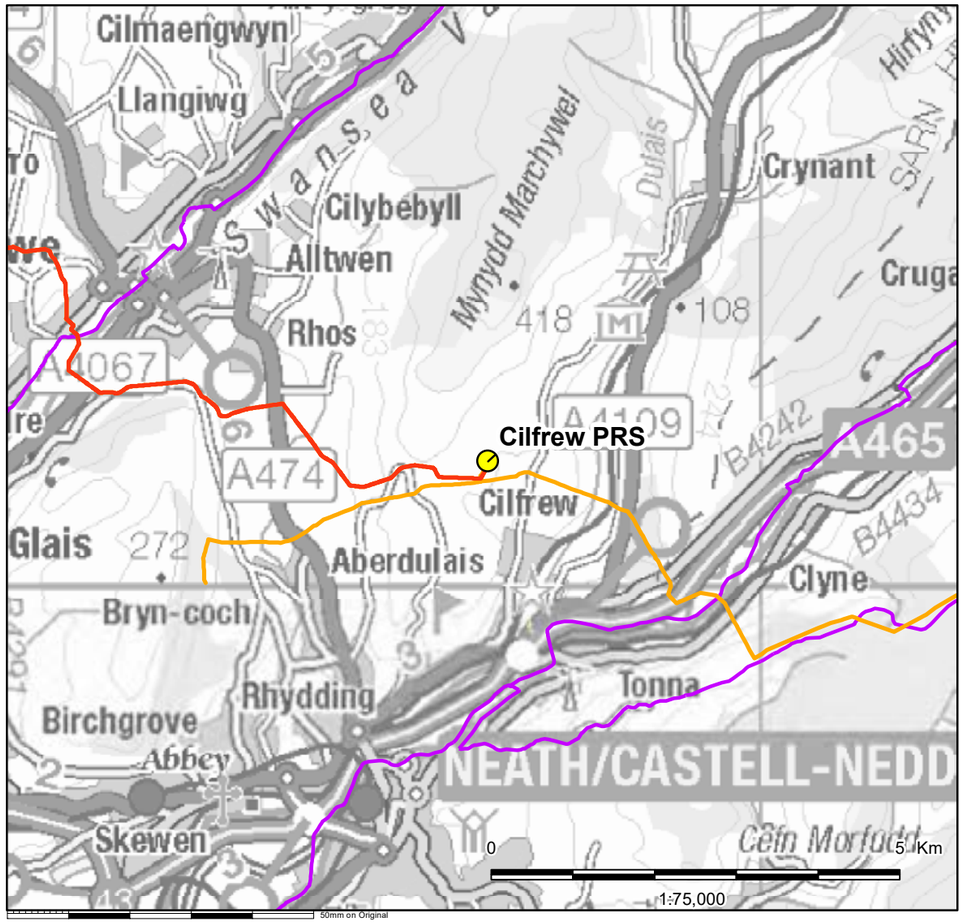
Plan E showing socio-economic constraints

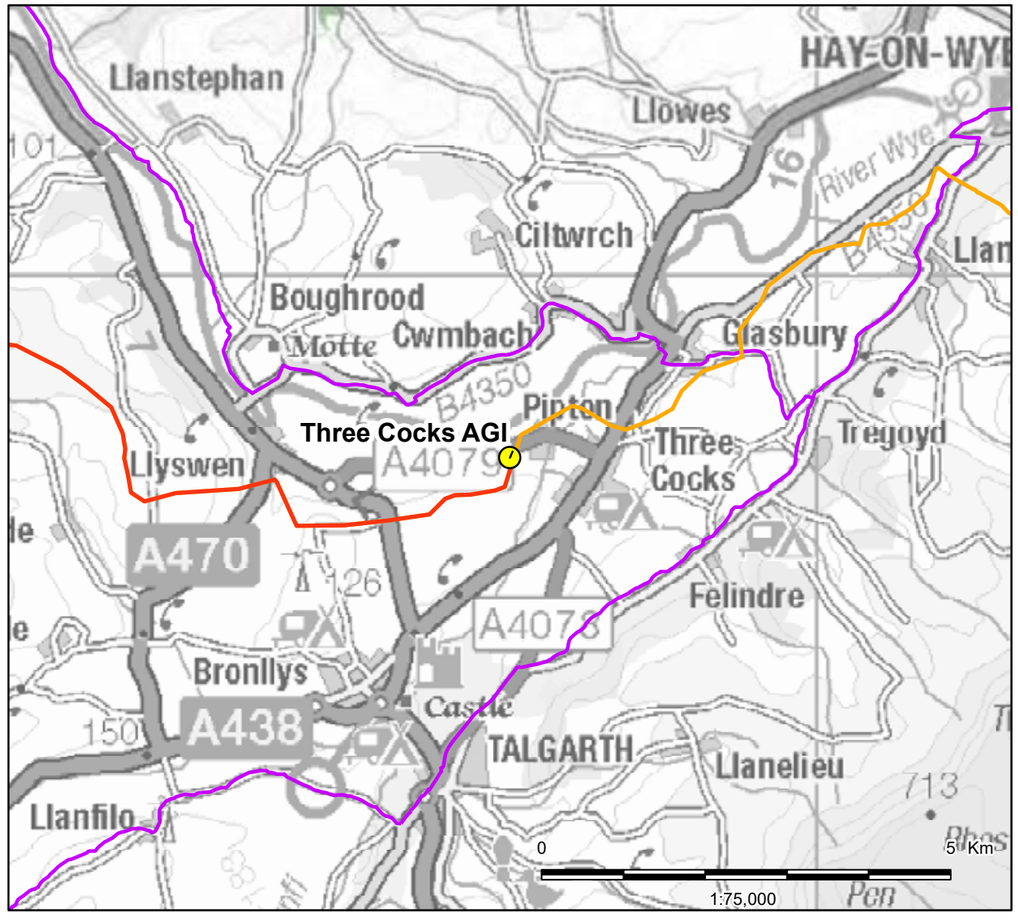
Data correct at 30/03/2020

LEGEND – Only those features present on this map are listed

- Existing Above Ground Installation
- Uprating of pressure
- Existing National Transmission System
- National Cycle Routes
- Countryside and Rights of Way Open Access Land
- National Trust Inalienable Land
- National Trust Open Land







Western Gas Network Upgrade Project.
Strategic Options Report
National Grid
April 2020

N

nationalgrid

Plan E showing socio-economic constraints

Data correct at 30/03/2020

LEGEND – Only those features present on this map are listed

- Existing Above Ground Installation
- Existing National Transmission System
- National Cycle Routes
- F6.1, F6.2 and F6.6 Search Corridor
- F6.1 Search Corridor
- F6.2 Search Corridor
- Countryside and Rights of Way Open Access Land
- National Trust Inalienable Land
- National Trust Open Land

Western Gas Network Upgrade Project.
Strategic Options Report
National Grid
April 2020

N

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nationalgrid

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Plan A showing Biodiversity Designations

Data correct at 30/03/2020

LEGEND – Only those features present on this map are listed

- Existing Above Ground Installation
- Existing National Transmission System
- F7.1 Search Corridor
- Important Bird
- Special Protection
- Site of Special Scientific Interest
- RSPB Reserve
- Ancient Woodland
- National Nature Reserve
- Special Area of Conservation

Three Cocks AGI

Western Gas Network Upgrade Project. Strategic Options Report National Grid April 2020

N

0 10 Km

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nationalgrid

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Option F7.1

Plan A showing Biodiversity Designations

Data correct at 30/03/2020

LEGEND – Only those features present on this map are listed

- Existing Above Ground Installation
- Existing National Transmission System
- F7.1 Search Corridor
- Important Bird Area
- Ramsar
- Site of Special Scientific Interest
- RSPB Reserve
- Ancient Woodland
- National Nature Reserve
- Special Area of Conservation

Western Gas Network Upgrade Project.
Strategic Options Report
National Grid
April 2020

N

0 10 Km

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nationalgrid

50mm on Original

Option F7.1

Sheet 1 of 2

Plan B showing Landscape Designations

Data correct at 30/03/2020

LEGEND – Only those features present on this map are listed

- Existing Above Ground Installation
- Existing National Transmission System
- National Trail
- F7.1 Search Corridor
- Area of Outstanding Natural Beauty
- National Park

Western Gas Network Upgrade Project.
Strategic Options Report
National Grid
April 2020

N

0 10 Km

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nationalgrid

50mm on Original

Plan B showing Landscape Designations

Data correct at 30/03/2020

LEGEND – Only those features present on this map are listed

- Existing Above Ground Installation
- Existing National Transmission System
- F7.1 Search Corridor
- Area of Outstanding Natural Beauty
- World Heritage Site

Western Gas Network Upgrade Project.
Strategic Options Report
National Grid
April 2020

N

0 10 Km

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nationalgrid

50mm on Original

Option F7.1

Plan C showing physical environment features

Data correct at 30/03/2020

LEGEND – Only those features present on this map are listed

- Existing Above Ground Installation
- Existing National Transmission System
- Canal
- Main River
- F7.1 Search Corridor
- Air Quality Management Area
- Flood Zone 2
- Flood Zone 3
- Geopark
- Noise Important Area

Source Protection Zone

- Zone I - Inner Protection Zone
- Zone II - Outer Protection Zone
- Zone III - Total Catchment

Three Cocks AGI

Western Gas Network Upgrade Project.
Strategic Options Report
National Grid
April 2020

N

0 10 Km

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nationalgrid

Option F7.1

Plan C showing physical environment features

Data correct at 30/03/2020

LEGEND – Only those features present on this map are listed

- Existing Above Ground Installation
- Existing National Transmission System
- Canal
- Main River
- F7.1 Search Corridor
- Air Quality Management
- Flood Zone 2
- Flood Zone 3
- Noise Important

Source Protection Zone

- Zone I - Inner Protection Zone
- Zone II - Outer Protection Zone
- Zone III - Total Catchment

Western Gas Network Upgrade Project.
Strategic Options Report
National Grid
April 2020

N

0 10 Km

1:225,000

nationalgrid

Plan D showing historic environment features

Data correct at 30/03/2020

LEGEND – Only those features present on this map are listed

- Existing Above Ground Installation
- Listed Building - Grade I and II*
- Listed Building - Grade II
- Existing National Transmission System
- F7.1 Search Corridor
- Historic Registered Park and Garden
- Scheduled Monument

Three Cocks AGI

Western Gas Network Upgrade Project.
Strategic Options Report
National Grid
April 2020

N

0 10 Km

1:225,000

nationalgrid

50mm on Original

Plan D showing historic environment features

Data correct at 30/03/2020

LEGEND – Only those features present on this map are listed

- Existing Above Ground Installation
- Listed Building - Grade I and II*
- Listed Building - Grade II
- Existing National Transmission System
- F7.1 Search Corridor
- Historic Registered Park and Garden
- Registered Battlefield
- Scheduled Monument

Western Gas Network Upgrade Project.
Strategic Options Report
National Grid
April 2020

N

0 10 Km

1:225,000

nationalgrid

50mm on Original

Plan E showing socio-economic constraints

Data correct at 30/03/2020

LEGEND – Only those features present on this map are listed

- Existing Above Ground Installation
- Existing National Transmission System
- National Cycle Routes
- F7.1 Search Corridor
- Countryside and Rights of Way Open Access Land
- National Trust Inalienable Land
- National Trust Open Land

Three Cocks AGI

Western Gas Network Upgrade Project.
Strategic Options Report
National Grid
April 2020

N

0 10 Km

1:225,000

nationalgrid

Option F7.1 Sheet 2 of 2

Plan E showing socio-economic constraints

Data correct at 30/03/2020

LEGEND – Only those features present on this map are listed

- Existing Above Ground Installation
- Existing National Transmission System
- National Cycle Routes
- F7.1 Search Corridor
- Countryside and Rights of Way Open Access Land
- National Trust Inalienable Land
- National Trust Open Land

Western Gas Network Upgrade Project.
Strategic Options Report
National Grid
April 2020

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0 10 Km

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nationalgrid

50mm on Original

Honeybourne AGI

Wormington Compressor Site

Aylesbury AGI

0 1:350,000 20 Km

50mm on Original

Option G1.1 and G1.3

Sheet 1 of 1

Plan A showing Biodiversity Designations

Data correct at 30/03/2020

LEGEND – Only those features present on this map are listed

- Existing Above Ground Installation
- Existing National Transmission System
- G1.1 and G1.3 Search Corridor
- G1.1 Search Corridor
- G1.3 Search Corridor
- Important Bird Area
- Ramsar
- RSPB Reserve
- Site of Special Scientific Interest
- Special Area of Conservation
- Special Protection Area

Western Gas Network Upgrade Project.
Strategic Options Report
National Grid
April 2020

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Option G1.1 and G1.3 Sheet 1 of 1

Plan B showing Landscape Designations

Data correct at 30/03/2020

LEGEND – Only those features present on this map are listed

- Existing Above Ground Installation
- Existing National Transmission System
- National Trail
- G1.1 and G1.3 Search Corridor
- G1.1 Search Corridor
- G1.3 Search Corridor
- Area of Outstanding Natural Beauty
- World Heritage Site

Honeybourne AGI

Malvern Hills

Wormington Compressor Site

Cotswolds

Aylesbury AGI

Chilterns

North Wessex Downs

0 1:350,000 20 Km

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N

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Honeybourne AGI

Wormington Compressor Site

Aylesbury AGI

0 1:350,000 20 Km

Option G1.1 and G1.3 Sheet 1 of 1

Plan C showing physical environment features

Data correct at 30/03/2020

LEGEND – Only those features present on this map are listed

- Existing Above Ground Installation
- Existing National Transmission System
- Canal
- Main River
- G1.1 and G1.3 Search Corridor
- G1.1 Search Corridor
- G1.3 Search Corridor
- Air Quality Management Area
- Flood Zone 2
- Flood Zone 3
- Noise Important Area

Source Protection Zone

- Zone I - Inner Protection Zone
- Zone II - Outer Protection Zone
- Zone III - Total Catchment

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Honeybourne AGI

Wormington Compressor Site

Aylesbury AGI

0 20 Km

1:350,000

Option G1.1 and G1.3

Sheet 1 of 1

Plan D showing historic environment features

Data correct at 30/03/2020

LEGEND – Only those features present on this map are listed

- Existing Above Ground Installation
- Listed Building - Grade I and II*
- Listed Building - Grade II
- Existing National Transmission System
- G1.1 and G1.3 Search Corridor
- G1.1 Search Corridor
- G1.3 Search Corridor
- Historic Registered Park and Garden
- Registered Battlefield
- Scheduled Monument

Western Gas Network Upgrade Project.
Strategic Options Report
National Grid
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Honeybourne AGI

Wormington Compressor Site

Aylesbury AGI

0 1:350,000 20 Km

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Option G1.1 and G1.3

Plan E showing socio-economic constraints

Data correct at 30/03/2020

LEGEND – Only those features present on this map are listed

- Existing Above Ground Installation
- Existing National Transmission System
- National Cycle Routes
- G1.1 and G1.3 Search Corridor
- G1.1 Search Corridor
- G1.3 Search Corridor
- Countryside and Rights of Way Open Access Land
- National Trust Inalienable Land
- National Trust Open Land

Western Gas Network Upgrade Project.
Strategic Options Report
National Grid
April 2020

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Appendix E Options Appraisal Summary Tables

OAST Summary Tables

The following tables capture the analysis of potential effects for the different strategic options for Environment, Socio-economic, Consenting & Programme, Technical and Cost perspectives along with an overall conclusion. The options are provided in order of F3.1, F3.2, F3.3, F4.1, F4.2, F6.1, F6.2, F6.6, F7.1, G1.1 and G1.3.

OPTION APPRAISAL SUMMARY TABLE (OAST) F3.1

Option	Option Description	Main Option Elements	Extent to which elements achieve customer requirement (if part solution possible)
F3.1	**Network upgrade to achieve gas flow northeastwards with 37km new pipeline, new Llanwrda area compression and various compressor modifications**	CE1, Felindre Mods CE2 Wormington to Honeybourne 9km pipeline CE3 Tirley to Wormington 26km pipeline CE4 Churchover 2km pipeline CE5 Llanwrda area compressor CE7 Wormington compressor mods Additionally possible impact from response to pressure change at offtakes but assume no or limited environmental implications	**Meets PARCA Requirement**

ENVIRONMENT

Sub-category	Constraints and Opportunities	Main Potential Impacts (adverse and beneficial)	Likely Mitigation Requirements	Residual Impacts and Implications	Summary and Conclusions
Biodiversity Considerations	There are a number of statutory environmental designations located within the Strategic Option F3.1 search area. These include Dixton Wood Special Area of Conservation (SAC), River Usk SAC and River Twyi / Afon Twyi SAC as well as 15 Sites of Special Scientific Interest (SSSI), one National Nature Reserve (NNR), large areas of ancient woodland and many veteran trees. There are no possible SACs, candidate SACs, Special Protection Areas (SPA), Potential SPAs, Ramsars or proposed Ramsars within the Strategic Option search area.	Common element 3 (a pipeline between Tirley and Wormington) has the potential to affect the Dixton Wood SAC and eight SSSIs. Common element 5 (a new gas compressor) has the potential to affect the River Twyi / Afon Twyi SAC, seven SSSIs and one NNR. These effects could occur due to a direct loss of habitats within these sites and/or indirect effects on potentially functionally linked land during construction. There is also the potential for these sites and their qualifying features to be affected by noise and vibration, pollution of land and water and general disturbance as a result of construction works. No potential effects recorded for other common and unique elements. There are unlikely to be any significant effects during operation.	Careful routing and siting of the pipeline, Above Ground Installations (AGIs) and required land take at Tirley and Wormington (proposed as part of common element 3) and the new control building and compressor buildings (proposed as part of common element 5) would avoid / reduce effects on sensitive features. Best practice construction methods would need to be followed to ensure the risk of disturbance or damage to species and habitats are minimised. Trenchless crossing techniques such as HDD may need to be used. Construction activities would need to be confined to a defined working area and appropriate pollution control measures implemented to reduce effects to air, noise and water.	Through careful siting of the proposed new infrastructure and the implementation of mitigation measures, the effects on statutory designated sites could be avoided / reduced to an acceptable level. For common elements 3 and 5, Habitats Regulations Assessment (HRA) Screening is likely to be required to determine if there would be any likely significant effects on the Dixton Wood SAC and the River Twyi/Afon Twyi SAC a once further detail is known.	Direct effects during construction on statutory sites could be avoided through careful routeing and siting. Construction mitigation measures such as controlling dust and pollution would also be required. However, there remains a potential indirect effect to European Sites associated with common elements 3 and 5 that may require further consideration at routeing/siting and HRA Screening. It is considered that with mitigation in place biodiversity could meet the tests within NPS - EN1. No significant effects are anticipated during operation.
Physical Environment Considerations (Geological, Water, Air Quality, Noise)	There are a number of physical environment features within the search areas for the Strategic Option, including many Main Rivers, ordinary watercourses, areas within the floodplain (e.g. Flood Zones 2 and 3), Air Quality Management Areas (AQMAs) six geological Sites of Special Scientific Interest (SSSI) and Noise Important Areas. One Main River crossing would be required for common element 2; Badsey Brook. In addition, three ordinary watercourse crossings could not be avoided. One Main River crossing would be required for common element 3: Afon Hafren / River Severn. In addition, the	A minimum of three Main River crossings would be required for this Strategic Option together with a minimum of five ordinary watercourse crossings. Therefore there is a pollution risk associated with the new pipelines and effects to flood risk associated with the temporary loss of floodplain during construction within common elements 2, 3 and 4. Air quality effects during construction are likely to be limited to construction dust effects. However, there may be effects associated with NO2 emissions from construction vehicles on the AQMA. There may also be effects associated with noise from construction sites and construction vehicles on Noise Important Areas.	Where river crossings are required specific trenchless construction methods could be used to minimise effects. Other specific construction techniques and control measures could be implemented to reduce / minimise effects on the water environment and air quality. Routeing would need to avoid geological SSSIs. Sensitive routeing of construction traffic could be used to avoid / minimise any effects on AQMAs and Noise Important Areas. Consent from the Environment Agency and Natural Resources Wales would be required for works in the floodplain or crossing a watercourse. Any works within	Adopting sensitive construction techniques at river crossings and ensuring appropriate pollution controls are in place when working close to Main Rivers and in flood zones would ensure effects to the water environment are minimised. Residual effects on the AQMAs, Noise Important Areas, geopark and geological SSSIs are likely to be negligible following mitigation.	The Strategic Option would require a minimum of eight watercourse crossings (including the River Severn) and would pass through many areas of flood zones 2 and 3. The presence of Main Rivers, ordinary watercourses and areas of flood zones 2 and 3 throughout the common elements 2, 3, 4 and 5 mean that potentially significant construction stage effects cannot be ruled out at this stage. However, through the adoption of proven mitigation measures (including the use of trenchless methods) and early consultation with the Environment Agency / Natural Resources Wales and satisfying the tests outlined in NPS EN-1 effects during construction could be mitigated. Therefore the physical

OPTION APPRAISAL SUMMARY TABLE (OAST) F3.1

	River Isbourne extends throughout common element 3 and could not be avoided. Part of this watercourse is a designated Main River and part ordinary watercourse. One Main River crossing would be required for common element 4: River Swift. The Canal Feeder ordinary watercourse could not be avoided.	The Strategic Option has the potential to affect geological SSSIs and a geopark.	flood zones would require a flood risk assessment.		environment may be a material consideration in the selection of the Preferred Option where other options have markedly different number of crossings or area of extent of flood zones 2 / 3.
Landscape and Visual Considerations	The Cotswolds Area of Outstanding Natural Beauty (AONB) lies adjacent to the common element 2 search area (Wormington to Honeybourne pipeline) and crosses the entirety of the common element 3 search area (Tirley to Wormington pipeline). The Brecon Beacons National Park lies adjacent to the area of search for a new gas compressor (common element 5). Within the search area for this Strategic Option there are no National Trails, World Heritage Sites or Biosphere Reserves.	For common element 2, during the construction phase there is the potential for localised, indirect, adverse effects on the Cotswolds AONB depending upon where the pipeline and associated construction working areas are located. Routing a new pipeline proposed as part of common element 3 would not be able to avoid the Cotswolds AONB. There is also the potential for indirect effects on the AONB as a result of the construction of the Block Valve AGIs and the works at Wormington. Therefore there would be direct effects on landscape character and visual amenity. For common element 5, there is the potential to indirectly adversely affect the landscape character and visual amenity of the Brecon Beacons National Park during construction, depending upon the location of the new control building and compressor building. Once operational, effects associated with routing a pipeline through the AONB would be very limited and would only be associated with any AGIs as the land would be restored following construction.	Owing to the limited interaction of the AONB within the common element 2 search area it should be possible to minimise effects through careful routing. It would not be possible to avoid the AONB within the common element 3 search area. Careful routing is recommended through areas of the AONB most able to tolerate change. The new compressor station for common element 5 would not be located within the National Park and careful consideration should also be given to its location outside of the Park owing to potential indirect effects on views for users of the National Park. Appropriate screening and planting should also be provided for the gas compressor site.	The potential for significant adverse residual effects on the Cotswolds AONB during construction could not be ruled out at this stage as routing a new pipeline within common element 3 could not avoid it. Additional work would need to be undertaken at the routing stage to ensure that effects are reduced to an acceptable level. Operational effects are unlikely to be significant once land is re-instated and planting re-establishes. There is also the potential for indirect effects on the Brecon Beacons National Park depending upon the siting of the compressor station although it is assumed that there would be no direct impact on the National Park.	It would not be possible to avoid the Cotswolds AONB within the common element 3 search area. Therefore there is the potential for significant effects during construction. However, during operation, AGIs could be sited outside of very sensitive sites and screening provided around permanent infrastructure reducing effects to an acceptable level. Landscape and visual amenity should be considered a material factor in the selection of the Preferred Option as AONBs are afforded very high protection within NPS EN-1. The NPS states that consent in these areas [is permitted] in exceptional circumstances. There are existing pipelines through the Cotswolds AONB which may indicate there are areas that are more able to tolerate change and this should be considered in more detail at the routeing stage. The new compressor for common element 5 would be positioned outside of the Brecon Beacons National Park but further consideration must be given at siting stage to risks associated with indirect effects on visual amenity and potential effects mitigated accordingly.
Historic Environment Considerations	Within the search area for this Strategic Option there are 20 Scheduled Monuments, over 900 Listed Buildings (many of which are Grade I and II*), four Registered Park and Gardens and one Registered Battlefield.	During construction, there is the potential for direct physical effects together with effects on the setting of designated heritage assets. During operation, there is the potential for permanent infrastructure to continue to affect the setting of heritage assets depending on where it is located.	Careful routing and siting would avoid physical effects on designated heritage assets. In addition siting permanent infrastructure away from designated assets would reduce potential effects on their setting. Planting around permanent above ground infrastructure could provide visual screening and minimise effects over time on the setting of heritage assets.	Through careful routing and siting, physical effects on designated heritage assets could be avoided. However, owing to the number of designated assets within the Strategic Option search areas there may be residual effects on the setting of heritage assets during construction. In the long-term and once operational the likelihood of significant setting effects is considered negligible although this would depend upon the final siting of a new gas compressor in relation to cultural heritage assets.	NPS EN-1 states that avoidance of Scheduled Monuments and listed buildings should be a priority and substantial harm to or loss should be wholly exceptional. It is expected that the loss of heritage assets could be avoided. However, at this stage it cannot be confirmed that all effects on the setting on heritage assets particularly during construction could be ruled out for this Strategic Option. This is due to the number of assets within the search areas for common elements 2, 3 and 5. The effects to Listed Buildings associated with the permanent works at AGIs is low owing to the distance of the heritage features from them and the ability to be able to reduce any setting effects through screening. There may be a continued risk to setting of heritage features associated with a new gas compressor building although this would depend upon siting and screening and could reduce with time as planting/screening matures.

OPTION APPRAISAL SUMMARY TABLE (OAST) F3.1

Overall Environment Summary	There are a number of European and nationally important sites for biodiversity, landscape and visual, water and historic environment within the search areas for this strategic option that have the potential to be affected. From a biodiversity perspective it is considered that through the routing process it should be possible to avoid direct impacts on SACs, ancient woodland, SSSIs and veteran trees all of which are given significant weight in NPS EN-1. However, there remains a potential indirect effect to European Sites associated with common elements 3 and 5 that may require further consideration at routing/siting and HRA Screening. Whilst there are significant landscape constraints (the Brecon Beacons National Park and the Cotswolds AONB) it will be possible to avoid direct effects on the Brecon Beacons National Park through careful siting of common element 5 although appropriate mitigation/screening may be needed dependent upon future siting work to reduce indirect effects on the site and its users. For this strategic option it would not be possible to avoid the Cotswolds AONB for the works associated with common element 3 (pipeline). Therefore' there is the potential for significant effects during construction. However, during operation, AGIs could be sited outside of very sensitive sites and screening around permanent infrastructure provided - reducing effects to an acceptable level. Landscape and visual amenity should be considered as a material factor in the selection of the Preferred Option as AONBs are afforded very high protection within NPS EN-1. It should be noted that there are also existing pipelines through the Cotswolds AONB which may indicate there are areas that are more able to tolerate change. Once operational and following the establishment of the landscape and associated planting, there would be no ongoing effects on the AONB associated with the pipeline. There are a large number of heritage assets that it should be possible to avoid during routing although there may remain risks to setting during construction and potentially once operational dependent upon the location of above ground assets in relation to designated heritage receptors. Whilst there are significant areas of Flood Zone 2 and 3 and a large number of river crossings (circa eight for this option) that could generate significant adverse effects during construction, mitigation should reduce these risks to an acceptable level.

SOCIO-ECONOMIC

Sub-category	Constraints and Opportunities	Main Potential Impacts (adverse and beneficial)	Likely Mitigation Requirements	Residual Impacts and Implications	Summary and Conclusions
Socio-Economic Considerations	There are many existing National Grid pipelines within the search area for the Strategic Option particularly around Wormington gas site. There are also a number of areas of Countryside and Rights of Way Act (CRoW) Open Access Land and National Trust Inalienable and Open Land and National Cycle Routes associated with common elements 3 and 5.	There is the potential to directly affect CRoW land, National Cycle Routes, National Trust Open and Inalienable Land depending upon where new infrastructure is sited and users of that land during construction. New infrastructure would also need to be appropriately routed in relation to existing National Grid infrastructure to ensure that existing safety standards can be maintained. Once the scheme is operational there would be no significant effects as the effects would have been mitigated during the construction phase.	Careful routeing and siting of the new infrastructure would minimise effects to socio-economic receptors as well as implementation of appropriate diversions for the affected cycle routes.	No significant residual effects anticipated following the implementation of mitigation.	It is assumed effects to the socio economic features could be avoided / minimised through careful siting and appropriate construction mitigation measures such as diversions for affected cycle routes.
Overall Socio-economic Summary	There are a number of socio-economic receptors that could be affected particularly for the pipelines for Common Elements 3 and 5. These receptors include CRoW Land, Open Access Land and National Trust Inalienable Land as well as PRoW and National Cycle Routes. During construction there is the potential for direct effects on these assets as well as amenity effects on a number of their users. Effective routeing would mitigate the risk of direct effects and short-term construction effects on amenity could be reduced through effective construction practices. There is also National Grid Infrastructure that will have a bearing on the route selection to ensure that appropriate safety standards are maintained. There would be no effects during operation.				

CONSENTING & PROGRAMME SUMMARY

Overall Consenting & Programme	The option is anticipated to require DCO due to pipeline length and effects, though this is subject to confirmation. The new compression requirement may mean difficulty to identify an appropriate site and it may attract substantial stakeholder opposition. As such the option presents a higher risk to programme than other options without compression with a risk that capacity release will be later than that offered in the PARCA.

TECHNICAL

Sub-category	Commentary for Option
Summary for Technical Complexity	Adverse. Operational complexity associated to the new compressor station is high and resilience of option is low due to it's location on the NTS and risk of reliability issues with compressors.
Summary for Delivery & Construction including Resource use and Waste	Highly adverse. Low constructability solution with long delivery programme and multiple major crossings required.
Summary for Technology Issues	Beneficial. No technology issues identified.
Summary for Capacity Issues	Generally beneficial. This option achieves additional Milford Haven entry capability equivalent to the full requested capacity increase (PARCA) across the annual demand range. Whilst the 9Km pipe reinforcement is beneficial in all technical respects, the option as a whole is neutral in terms of network flexibility and resilience due to it's placing a greater burden on a single feeder with increasing Milford Haven supply.
Summary for Network Efficiency / benefits (inc Energy Efficiency)	Adverse. Option relies heavily on compression which is inherently energy intensive on an ongoing basis and has associated emissions impacting on sustainability.
Overall Summary for Technical	Overall Adverse. Low technology issues and beneficial capacity increments but high technical complexity, low constructability and low network efficiency. Overall this option is considered operationally complex (particularly because of the additional compression) because it presents significant delivery and construction challenge and will be energy intensive throughout its lifecycle. Whilst pipelines are operationally simple the different length of works associated with option F3.1 mean it is considered less favourable technically than option F3.3, but more favourable than option F3.2.

OPTION APPRAISAL SUMMARY TABLE (OAST) F3.1	
COST	
Overall Cost Summary	The option is just over four and a half times the capital cost of option F6.6 which has the lowest capital cost. The option is ranked 7th of 11 in CBA terms.
CONCLUSION FOR OPTION F3.1	
The overall conclusion is that option F3.1 complies less well with the guiding principles than some other options on grounds of capital cost and CBA rank (GP4) and additional operational complexity (GP7). It also, by requiring the construction and operation of a new compressor site, performs less well in terms of using, adapting or extending existing equipment (GP2).	

OPTION APPRAISAL SUMMARY TABLE (OAST) F3.2

Option	Option Description	Option Elements (in sequential order if part solutions possible)	Extent to which elements achieve customer requirement (if part solution possible)
F3.2	**Network upgrade to achieve gas flow northeastwards with 44km new pipeline (some to avoid AONB), new Llanwrda area compressor and various compressor modifications**	CE1, Felindre Mods CE2 Wormington to Honeybourne 9km pipeline CE4 Churchover 2km pipeline CE5 Llanwrda area compressor CE6 Tirley to Wormington 33km pipeline avoiding AONB CE7 Wormington compressor mods Additionally possible impact from pressure change at offtakes but assume no or limited environmental implications	**Meets PARCA Requirement**

ENVIRONMENT

Sub-category	Constraints and Opportunities	Main Potential Impacts (adverse and beneficial)	Likely Mitigation Requirements	Residual Impacts and Implications	Summary and Conclusions
Biodiversity Considerations	There are a number of statutory environmental designations located within the Strategic Option F3.2 search area. These include River Twyi / Afon Twyi Special Area of Conservation (SAC), as well as 13 Sites of Special Scientific Interest (SSSI), one National Nature Reserve (NNR), large areas of ancient woodland and many veteran trees. There are no possible SACs, candidate SACs, Special Protection Areas (SPA), Potential SPAs, Ramsars or proposed Ramsars within the Strategic Option search area.	Common element 5 (a new gas compressor) has the potential to affect two statutory European sites and eight nationally designated sites including SACs, SSSIs and an NNR. Common element 6 (a new pipeline between Wormington and Tirley) has the potential to affect up to six SSSIs. These effects could occur due to a direct loss of habitats within these sites and/or indirect effects on potentially functionally linked land during construction. There is also the potential for these sites and their qualifying features to be affected by noise and vibration, pollution of land and water and general disturbance as a result of construction works. There are unlikely to be any significant effects during operation.	Careful routing and siting of the pipeline, AGI and the new control building and compressor buildings could avoid effects to sensitive features. Best practice construction management methods would need to be followed to ensure the risk of disturbance or damage to species and habitats are minimised. Trenchless crossing techniques such as HDD may need to be used. Construction activities would need to be confined to a defined working area and appropriate pollution control measures implemented to reduce effects to air, noise and water.	Through careful siting of the proposed infrastructure and the implementation of mitigation, the effects on statutory designated sites could be avoided or reduced to an acceptable level. However, for common element 5 (a new gas compressor), Habitats Regulations Assessment (HRA) screening may be required to determine if there would be any likely significant effects on the River Twyi / Afon Twyi SAC once further detail is known.	Effects during construction on statutory sites could be avoided through careful routing and siting and construction mitigation measures such as controlling dust and pollution, particularly for common elements 3 and 5. It is considered that with mitigation in place biodiversity could meet the tests within NPS - EN1. No significant effects are anticipated during operation.
Physical Environment Considerations (Geological, Water, Air Quality, Noise)	There are a number of physical environment features within the search areas for the Strategic Option, including many Main Rivers, ordinary watercourses, areas within the floodplain (Flood Zones 2 and 3), Air Quality Management Areas (AQMA), seven geological Sites of Special Scientific Interest (SSSI) and Noise Important Areas. One Main River crossing would be required for common element 2; Badsey Brook. In addition three ordinary watercourse crossings could not be avoided. One Main River crossing would be required for common element 4: River Swift. The Canal Feeder ordinary watercourse also could not be avoided. Three Main River crossings would be required for common element 6: River Severn / Afon Hafren, River Avon and River Isbourne. In addition two ordinary watercourses would be unavoidable these are Merry Brook and Ripple Brook.	A minimum of 11 river crossings would be required for this Strategic Option (five Main River Crossings and six ordinary watercourse crossings). Therefore there is a pollution risk associated with the new pipelines and effects to flood risk associated with Flood Zones 2 and 3 within common elements 2, 4 and 6. Air quality effects during construction are likely to be limited to construction dust effects. However, there may be effects associated with NO2 emissions from construction vehicles on the AQMAs. There may also be effects associated with noise from construction sites and construction vehicles on Noise Important Areas.	Where river crossings are required specific trenchless construction methods could be used to minimise effects. Other specific construction techniques and control measures could be implemented to reduce / minimise effects on the water environment and air quality. Routing would need to avoid geological SSSIs . Sensitive routing of construction traffic could be used to avoid / minimise any effects on AQMAs and Noise Important Areas. Consent from the Environment Agency/Natural Resources Wales would be required for works in the floodplain and crossing a watercourse. Any works within flood zones would require a flood risk assessment.	Adopting sensitive construction techniques at river crossings and ensuring appropriate pollution controls are in place when working close to Main Rivers and in flood zones would ensure effects to the water environment are minimised, however adverse effects cannot be ruled out at this stage for common elements 2, 4 and 6. Residual effects on the AQMA and Noise Important Areas are likely to be negligible following mitigation.	The Strategic Option would require a minimum of 11 watercourse crossings (including the River Severn) and would pass through many areas of flood zones 2 and 3. The presence of Main Rivers, ordinary watercourses and areas of flood zones 2 and 3 throughout the common elements 2, 4, 5 and 6 mean that potentially significant construction stage effects cannot be ruled out at this stage. However, through the adoption of proven mitigation measures (including the use of trenchless construction methods) and early consultation with the Environment Agency/Natural Resources Wales and satisfying the tests outlined in NPS EN-1 effects during construction could be mitigated. Therefore the physical environment may be a material consideration in the selection of the Preferred Option where other options have markedly different number of crossings or area of extent of flood zones 2 / 3.

OPTION APPRAISAL SUMMARY TABLE (OAST) F3.2					
Landscape and Visual Considerations	There are small areas of the Cotswolds Area of Outstanding Natural Beauty (AONB) adjacent to the search area for common element 2 and the AONB lies in close proximity to the search area for the Tirley to Wormington pipeline (common element 6). The Brecon Beacons National Parklies adjacent to the search area for common element 5 (new gas compressor). Within the search area for this Strategic Option there are no National Trails, World Heritage Sites or Biosphere Reserves.	For common elements 2 and 6, during the construction phase there is the potential for localised indirect adverse effects on the Cotswold AONB, and for there to be impacts on landscape character and visual amenity. During operation there may be indirect impacts on the AONB as a result of the new pig trap associated with common element 2. For common element 5, there is the potential to indirectly adversely affect the landscape character and visual amenity of the Brecon Beacons National Park during construction, depending upon the location of the new control building and compressor buildings during construction and operation.	Routing of the new pipelines for common elements 2 and 6 should avoid the AONB. Following construction, planting around permanent infrastructure (e.g. block valves/AGIs) would provide some visual screening and minimise indirect effects over time on the AONB if required. Siting of the new control building and gas compressor for common element 5 would avoid the Brecon Beacons National Park and consideration should be given to the visibility of the infrastructure from key viewpoints within the National Park. For all new infrastructure an appropriate level of screening should be provided to reduce long-term effects once operational.	Through effective routing and siting and appropriate planting/screening, it should be possible to reduce the long-term effects of the infrastructure on the AONB. Any effects would be short-term and occur during construction. Residual effects on the Brecon Beacons National Park as a result of a new compressor station would be dependent upon where the new facility is located but it should be possible to reduce effects to an acceptable level with appropriate screening/planting in the long-term.	It is anticipated the Brecon Beacons National Park would be wholly avoided through careful siting of permanent infrastructure. However, there would need to be careful siting of the new compressor station to ensure that it is sufficiently screened to ensure there are no long-term indirect effects on the setting of the National Park. This option could avoid direct impacts on the Cotswolds AONB although there may be a risk of short-term, indirect adverse effects depending upon visibility from elevated locations within the AONB. AONBs and National Parks are afforded very high protection within NPS EN-1.
Historic Environment Considerations	Within the search area for this Strategic Option there are 25 Scheduled Monuments, over 700 Listed Buildings (many of which are Grade I and II*), and four Registered Park and Gardens. There are no Registered Battlefields.	During construction, there is the potential for both direct physical effects and effects on the setting of designated heritage assets. During operation, there is the potential for the Block Valve AGIs, and the new control building and the new compressor buildings to continue to affect the setting of heritage assets depending where they are located.	Careful routing and siting would avoid physical effects on designated heritage assets. In addition, siting permanent infrastructure away from designated assets would reduce potential effects on their setting. Planting around permanent above ground infrastructure could provide visual screening and minimise effects over time on the setting of heritage assets.	Through careful routing and siting, physical effects on designated heritage assets could be avoided. However, owing to the number of designated assets within the Strategic Option search areas there may be residual effects on the setting of heritage assets during construction. In ther long-term and once operational the likelihood of significant setting effects is considered negligible although this would depend upon the final siting of a new gas compressor in relation to cultural heritage assets.	NPS EN-1 states that avoidance of Scheduled Monuments and Listed Buildings should be a priority and substantial harm to or loss should be wholly exceptional. It is expected that the loss of heritage assets could be avoided. However, at this stage it cannot be confirmed that all effects on the setting on heritage assets particularly during construction could be ruled out for this Strategic Option. This is due to the number of assets within the search areas for common elements 2, 5 and 6. The effects to Listed Buildings associated with the permanent works at AGIs is low owing to the distance of the heritage features from them and the ability to be able to reduce any setting effects through screening. There may be a continued risk to setting of heritage features associated with a new gas compressor building although this would depend upon siting and screening and could reduce with time as planting/screening matures.
Overall Environment Summary	There are a number of European and nationally important sites for biodiversity, landscape and visual, water and historic environment within the search areas for this strategic option that have the potential to be affected. From a biodiversity perspective, through the routing process it should be possible to avoid direct impacts on SACs, ancient woodland, SSSIs and veteran trees all of which are given significant weight in NPS EN-1. However, there remains a potential indirect effect to European Sites associated with common element 5 that requires further consideration at routing and may also require HRA Screening. Whilst there are significant landscape constraints (the Brecon Beacons National Park and the Cotswolds AONB) it should be possible to avoid direct effects through avoidance and careful siting of common elements 2, 5 and 6. However, there remains the potential for indirect effects on these resources and their users dependent upon visibility of construction works (which would be a temporary effect) and long-term visibility associated with new above ground infrastructure although this should be possible to reduce to acceptable levels through siting, screening and effective engagement with appropriate stakeholders. There are a large number of heritage assets that it should be possible to avoid during routing although there may remain risks to setting during construction and potentially once operational dependent upon the location of above ground assets in relation to designated heritage receptors. Whilst there are significant areas of Flood Zone 2 and 3 and a large number of river crossings (circa 11 for this option) that could generate significant adverse effects during construction, mitigation should reduce these risks to an acceptable level.				
SOCIO-ECONOMIC					
Sub-category	**Constraints and Opportunities**	**Main Potential Impacts (adverse and beneficial)**	**Likely Mitigation Requirements**	**Residual Impacts and Implications**	**Summary and Conclusions**
Socio-Economic Considerations	There are many existing National Grid pipelines within the search area for the Strategic Option particularly around the Wormington gas site. In addition there are a number of areas of Countryside and Rights of Way Land (CRoW) Open Access Land and National Trust Inalienable and Open Land and National Cycle Routes.	There is the potential to directly affect National Cycle Route 45, CRoW Open Access Land and National Trust Open and Inalienable Land depending upon where the pipelines are routed and above ground infrastructure is located. New infrastructure would also need to be appropriately routed in relation to existing National Grid infrastructure to ensure that existing safety standards can be maintained. Once the scheme is operational there would	Through careful routeing and siting of the new pipelines and infrastructure associated with this Strategic Option, effects to National Cycle Routes, National Trust Open and Inalienable Land could be avoided or minimised.	No significant residual effects anticipated.	It is assumed that effects on socio-economic receptors could be avoided through careful routeing and siting, or mitigated through sensitive construction techniques.

OPTION APPRAISAL SUMMARY TABLE (OAST) F3.2					
		be no significant effects as the effects would have been mitigated during the construction phase.			
Overall Socio-economic Summary	There are a number of socio-economic receptors that could be affected including CRoW Land, Open Access Land and National Trust Inalienable Land as well as PRoW and National Cycle Routes 41 and 45. During construction there is the potential for direct effects on these assets as well as amenity effects on a number of their users. Effective routeing would mitigate the risk of direct effects and short-term construction effects on amenity could be reduced through effective construction practices and appropriate diversions, for example for NCN 45. There is also National Grid Infrastructure that will have a bearing on the route selection to ensure that appropriate safety standards are maintained. There would be no effects during operation.				
CONSENTING & PROGRAMME					
Overall Consent & Programme Summary	The option is anticipated to require DCO due to a combination of the pipeline length and likely effects including from the new compression requirement. The new compression requirement may create difficulty in identifying an appropriate site and it may attract substantial stakeholder concern. As such the option presents a higher risk to programme than other options without compression with a risk that capacity release will be later than that offered in the PARCA.				
TECHNICAL					
Sub-category	**Commentary for Option**				
Summary for Technical Complexity	Adverse. Operational complexity associated to the new compressor station is high and resilience of option is low due to it's location on the NTS and risk of reliability issues with compressors.				
Summary for Delivery & Construction including Resource use and Waste	Highly adverse. Low constructability solution with long delivery programme and multiple major crossings required.				
Summary for Technology Issues	Beneficial. No technology issues identified.				
Summary for Capacity Issues	Generally beneficial. This option achieves additional Milford Haven entry capability equivalent to the full requested capacity increase (PARCA) across the annual demand range. Whilst the 9Km pipe reinforcement is beneficial in all technical respects, the option as a whole is neutral in terms of network flexibility and resilience due to it's placing a greater burden on a single feeder with increasing Milford Haven supply.				
Summary for Network Efficiency / benefits (inc Energy Efficiency)	Adverse. Option relies heavily on compression which is inherently energy intensive on an ongoing basis and has associated emissions impacting on sustainability.				
Overall Technical Summary Consolidating the above	Overall this option is operationally complex (principally because of the additional compression), presents significant delivery and construction challenge, and will be energy intensive throughout its lifecycle. Whilst pipelines are operationally simple the additional length of works associated with option F3.2 means it is considered less favourable technically than option F3.1 and F3.3.				
COST					
Overall Cost Summary	The option is just over five times the capital cost of option F6.6 which has the lowest capital cost. The option is ranked 8th of 11 in CBA terms.				
CONCLUSION					
The overall conclusion is that option F3.2 complies less well with the guiding principles than option F3.1 primarily on grounds of capital cost and CBA rank (GP4) though its route outside the Cotswolds AONB is more compliant with GP5 than that of F3.1. It is generally poorer performing than various other non-compression options because of additional operational complexity (GP7). It also, by requiring the construction and operation of a new compressor site, performs less well in terms of using, adapting or extending existing equipment (GP2).					

OPTION APPRAISAL SUMMARY TABLE (OAST) F3.3

Option	Option Description	Option Elements (in sequential order if part solutions possible)	Extent to which elements achieve customer requirement (if part solution possible)
F3.3	**Network upgrade to achieve gas flow northeastwards with 11km new pipeline, new west of Three Cocks compression and various compressor modifications**	CE1, Felindre Mods CE2 Wormington to Honeybourne 9km pipeline duplication CE4 Churchover comp mods and 2km pipeline duplication CE5 West of three cocks compressor (within 20km and outside BBNP) CE7 Wormington compressor mods Additionally possible impact from pressure change at offtakes and at Tirley but assume no or limited environmental implications and all works within existing sites	**Meets PARCA Requirement**

ENVIRONMENT

Sub-category	Constraints and Opportunities	Main Potential Impacts (adverse and beneficial)	Likely Mitigation Requirements	Residual Impacts and Implications	Summary and Conclusions
Biodiversity Considerations	There are a number of statutory environmental designations located within the Strategic Option F3.3 search area. These include the River Usk SAC and the River Wye SAC as well as five Sites of Special Scientific Interest (SSSI), large areas of ancient woodland and many veteran trees. There ere are no possible SACs, candidate SACs, Special Protection Areas (SPA), Potential SPAs, Ramsars, proposed Ramsars or National Nature Reserves within the Strategic Option search area.	Common element 5 (a new gas compressor) has the potential to affect the River Wye SAC and River Usk SAC and five SSSIs. These effects could occur due to a direct loss of habitats within these sites and/or indirect effects on potentially functionally linked land during construction / operation. There is also the potential for these sites and their qualifying features to be affected by noise and vibration, pollution of land and water and general disturbance as a result of construction works. No potential effects recorded for other common and unique elements. There are unlikely to be any additional effects during operation.	Careful routing and siting of the pipeline, Above Ground Installation works (AGIs) and the new control building and compressor buildings (proposed as part of common element 5) would avoid / reduce effects to sensitive features. Best practice construction methods would need to be followed to ensure the risk of disturbance or damage to species and habitats is minimised. Construction activities would need to be confined to a defined working area and appropriate pollution control measures implemented to reduce effects to air, noise and water.	Through careful siting of the proposed new infrastructure and the implementation of mitigation measures, the effects on statutory designated sites could be avoided / reduced to an acceptable level. For common element 5, Habitats Regulations Assessment (HRA) Screening may be required depending upon the location of the new compressor to determine if there would be any likely significant effects on the River Wye and River Usk SACs once further detail is known.	Direct effects during construction on statutory sites could be avoided through careful routeing and siting. Construction mitigation measures such as controlling dust and pollution would also be required. However, there remains a potential indirect effect to European Sites associated with common element 5 that may require further consideration at the siting stage and HRA Screening. It is considered that with mitigation in place biodiversity could meet the tests within NPS - EN1. No significant additional effects are anticipated during operation.
Physical Environment Considerations (Geological, Water, Air Quality, Noise)	There are a number of physical environment features within the search areas for the Strategic Option, including many Main Rivers, ordinary watercourses, areas within the floodplain (e.g. Flood Zones 2 and 3), one Air Quality Management Area (AQMA) a geopark, and Noise Important Areas. One Main River crossing would be required for common element 2; Badsey Brook. In addition three ordinary watercourse crossings could not be avoided. One Main River crossing would be required for common element 4: River Swift. The Canal Feeder ordinary watercourse could not be avoided.	A minimum of two Main River crossings would be required for this Strategic Option together with a minimum of four ordinary watercourse crossings. Therefore there is a pollution risk associated with the new pipelines and effects to flood risk associated with the temporary loss of floodplain during construction within common elements 2 and 4. Air quality effects during construction are likely to be limited to construction dust effects. However, there may be effects associated with NO2 emissions from construction vehicles on the AQMA. There may also be effects associated with noise from construction sites and construction vehicles on Noise Important Areas. The Strategic Option has the potential to affect a geopark.	Where river crossings are required specific trenchless construction methods could be used to minimise effects. Other specific construction techniques and control measures could be implemented to reduce / minimise effects on the water environment and air quality. Routeing would need to avoid the Geopark. Sensitive routeing of construction traffic could be used to avoid / minimise any effects on the AQMA and Noise Important Areas. Consent from the Environment Agency and Natural Resources Wales would be required for works in the floodplain or crossing a watercourse. Any works within flood zones would require a flood risk assessment.	Adopting sensitive construction techniques at river crossings and ensuring appropriate pollution controls are in place when working close to Main Rivers and in flood zones would ensure effects to the water environment are minimised. Residual effects on the AQMA, Noise Important Areas and geopark are likely to be negligible following mitigation.	The Strategic Option would require a minimum of six watercourse crossings and would pass through many areas of flood zones 2 and 3. The presence of Main Rivers, ordinary watercourses and areas of flood zones 2 and 3 throughout the common elements 2, 4 and 5 mean that potentially significant construction stage effects cannot be ruled out at this stage. However, through the adoption of proven mitigation measures (including the use of trenchless methods) and early consultation with the Environment Agency / Natural Resources Wales and satisfying the tests outlined in NPS EN-1 effects during construction could be mitigated. Therefore the physical environment may be a material consideration in the selection of the Preferred Option where other options have markedly different number of crossings or area of extent of flood zones 2 / 3.
Landscape and Visual Considerations	The Cotswolds Area of Outstanding Natural Beauty (AONB) lies adjacent to the common element 2 search area (Wormington to Honeybourne pipeline). The Brecon Beacons National Park lies adjacent to the area of search for a new gas compressor (common element 5). A Registered Historic Landscape,	For common element 2, during the construction phase there is the potential for localised, indirect, adverse effects on the Cotswolds AONB depending upon where the pipeline and associated construction working areas are located. For common element 5, there would be no direct effects on the Brecon Beacons National	Owing to the limited interaction of the AONB within the common element 2 search area it should be possible to minimise effects through careful routing. Consideration should be given to the location of a new compressor outside of the National Park owing to potential indirect effects on views for users of the National	Residual effects on the Cotswolds AONB as a result of a new pipeline and infrastructure at Honeybourne and Wormington within the common element 2 search area would be dependent upon where the works are located, however through careful siting / routing could be reduced. Residual effects on the Brecon Beacons National Park would also be minimise through careful siting in	A new compressor site, any works to existing AGIs and the pipeline routeing would be sited outside of very sensitive sites and screening provided around the permanent infrastructure reducing effects to an acceptable level. Landscape and visual amenity should be considered a material factor in the selection of the Preferred Option as AONBs and National

OPTION APPRAISAL SUMMARY TABLE (OAST) F3.3

	designated by Powys County Council runs through the common element 5 search area to the east near Three Cocks. Within the search area for this Strategic Option there are no National Trails, World Heritage Sites or Biosphere Reserves.	Park, however, there is the potential to adversely affect the landscape character and visual amenity of the park during construction, depending upon the location of the new control building and compressor. There is also the potential to directly affect a Registered Historic Landscape located within the common element 5 search area. Once operational effects would only be associated with any AGIs / new compressor site.	Park. Appropriate screening and planting / mounding should also be provided for the gas compressor site. Direct effects the Registered Historic Landscape could be avoided through careful siting of the compressor station outside of this feature.	addition to planting / mounding around the new compressor site. There would be no direct residual effects on the Registered Historic Landscape if this feature was avoided through careful siting. Following successful mitigation / reinstatement effects on landscape over time are likely to be reduced to acceptable levels as planting matures.	Parks are afforded very high protection within NPS EN-1.
Historic Environment Considerations	Within the search area for this Strategic Option there are eight Scheduled Monuments, 129 Listed Buildings (many of which are Grade I and II*) and one Registered Park and Garden.	During construction, there is the potential for direct physical effects together with effects on the setting of designated heritage assets. During operation, there is the potential for permanent infrastructure to continue to affect the setting of heritage assets depending on where it is located.	Careful routeing and siting would avoid physical effects on designated heritage assets. In addition siting permanent infrastructure away from designated assets would reduce potential effects on their setting. Planting / mounding around permanent above ground infrastructure could provide visual screening and minimise effects over time on the setting of heritage assets.	Through careful routeing and siting, physical effects on designated heritage assets could be avoided. However, owing to the number of designated assets within the Strategic Option search areas there may be residual effects on the setting of heritage assets during construction. In the long-term and once operational the likelihood of significant setting effects is considered negligible although this would depend upon the final siting of a new gas compressor in relation to cultural heritage assets.	NPS EN-1 states that avoidance of Scheduled Monuments and Listed Buildings should be a priority and substantial harm to or loss should be wholly exceptional. It is expected that the loss of heritage assets could be avoided. However, at this stage it cannot be confirmed that all effects on the setting on heritage assets particularly during construction could be ruled out for this Strategic Option. This is due to the number of assets within the search areas for common elements 2 and 5. The effects to Listed Buildings associated with the permanent works at AGIs is low owing to the distance of the heritage features from them and the ability to be able to reduce any setting effects through screening. There may be a continued risk to setting of heritage features associated with a new gas compressor building although this would depend upon siting and screening and could reduce with time as planting/screening matures.
Overall Environment Summary	There are a number of European and nationally important sites for biodiversity, landscape and visual, water and historic environment within the search areas for this strategic option that have the potential to be affected. From a biodiversity perspective it is considered that through the routing process it should be possible to avoid direct impacts on SACs, ancient woodland, SSSIs and veteran trees all of which are given significant weight in NPS EN-1. However, there remains a potential indirect effect to European Sites associated with common element 5 that may require further consideration at the siting stage and also require HRA Screening. Whilst there are landscape constraints (the Brecon Beacons National Park and the Cotswolds AONB) there would be no direct effect on these assets. It should be possible to minimise indirect effects on both assests through careful routeing and siting of common elements 2 and 5 although appropriate mitigation/screening may be needed dependent upon future work to reduce indirect effects on the sites and its users. Landscape and visual amenity should be considered as an important factor in the selection of the Preferred Option as AONBs and National Parks are afforded very high protection within NPS EN-1. There are a large number of heritage assets that it should be possible to avoid during routing although there may remain risks to setting during construction and potentially once operational dependent upon the location of above ground assets in relation to designated heritage receptors. Whilst there are large areas of Flood Zone 2 and 3 and a number of river crossings (circa six for this option) that could generate significant adverse effects during construction, mitigation should reduce these risks to an acceptable level.				

SOCIO-ECONOMIC

Sub-category	**Constraints and Opportunities**	**Main Potential Impacts (adverse and beneficial)**	**Likely Mitigation Requirements**	**Residual Impacts and Implications**	**Summary and Conclusions**
Socio-Economic Considerations	There are many existing National Grid pipelines within the search area for the Strategic Option particularly around Wormington gas site. There is also an area of National Trust Open and Inalienable Land at Bretforton within the search area for common element 2.	New infrastructure would also need to be appropriately routed in relation to existing National Grid infrastructure to ensure that existing safety standards can be maintained. Once the scheme is operational there would be no significant effects as the effects would have been mitigated during the construction phase. There is also the potential to affect a small area of National Trust Open and Inalienable Land at Bretforton within the search area for common element 2.	Careful routeing and siting of the new infrastructure would minimise effects to socio-economic receptors.	No significant residual effects anticipated following the implementation of mitigation.	It is assumed effects to the socio economic features could be avoided / minimised through careful siting / routeing.
Overall Socio-economic summary	There is also National Grid Infrastructure that will have a bearing on the route selection to ensure that appropriate safety standards are maintained. There is also an area of National Trust Open and Inalienable Land at Bretforton within the search area for common element 2. However, it is assumed effects to the National Trust Open / Inalienable Land at Bretforton could be avoided / minimised through careful siting / routeing. There would be no effects during operation.				

OPTION APPRAISAL SUMMARY TABLE (OAST) F3.3	
CONSENTING & PROGRAMME	
Overall Consenting & Programme Summary	The option may not require DCO given the nature of the physical works and the pipeline length but is subject to environmental determination from the Department for Business, Energy & Industrial Strategy (BEIS). The new compression requirement may create difficulty in identifying an appropriate site and it may attract substantial stakeholder concern. As such the option presents a lower risk to programme than other new compression options but represents a higher consenting risk than other options without compression. There is the potential for pipeline works to been undertaken as permitted development and for any compressor upgrades and above ground infrastructure to be progressed by applications under the Town & Country Planning Act (TCPA). The option (assuming the project is not progressed as a DCO project) may achieve a programme for capacity release in line with the PARCA.
TECHNICAL	
Sub-category	**Commentary for Option**
Summary for Technical Complexity	Adverse. Operational complexity associated to the new compressor station is high and resilience of option is low due to it's location on the NTS and risk of reliability issues with compressors.
Summary for Delivery & Construction including Resource use and Waste	Adverse. Low constructability solution with long delivery programme.
Summary for Technology Issues	Beneficial. No technology issues identified.
Summary for Capacity Issues	Generally beneficial. This option achieves additional Milford Haven entry capability equivalent to the full requested capacity increase (PARCA) across the annual demand range. Whilst the pipe reinforcement is beneficial in all technical respects, the option as a whole is neutral in terms of network flexibility and resilience due to it's placing a greater burden on a single feeder with increasing Milford Haven supply.
Summary for Network Efficiency / benefits (inc Energy Efficiency)	Adverse. Option relies heavily on compression which is inherently energy intensive on an ongoing basis and has associated emissions impacting on sustainability.
Overall Technical Summary Consolidating the above	Overall this option is operationally complex (principally because of the additional compression), presents significant delivery and construction challenge, and will be energy intensive throughout its lifecycle. Whilst pipelines are operationally simple the reduced length of works associated with option F3.3 means it is considered more favourable technically than option F3.1 and option F3.2
COST	
Overall Cost Summary	The option is around three and a quarter times the capital cost of option F6.6 which has the lowest capital cost. The option is ranked 4th of 11 in CBA terms.
CONCLUSION	
The overall conclusion is that option F3.3 complies more favourably with the guiding principles than options F3.1 and F3.2 primarily on grounds of capital cost and CBA rank (GP4). Its use of locations and routes outside the Cotswolds AONB also make it more compliant with GP5 than that of F3.1. It is generally poorer performing than various other non compression options because of additional operational complexity (GP7). It also, by requiring the construction and operation of a new compressor site, performs less well than uprating with MOP below equipment classification limits with 11km pipeline (option F6.6) in terms of using, adapting or extending existing equipment (GP2).	

OPTION APPRAISAL SUMMARY TABLE (OAST) F4.1

Option	Option Description	Option Elements (in sequential order if part solutions possible)	Extent to which elements achieve customer requirement (if part solution possible)
F4.1	**Network upgrade to achieve gas flow northeastwards by 92km of new onshore pipeline comprising duplication of approx 55km of Feeder 28 (Felindre to approx Llanwdra) plus 37 km (Tirley to Wormington, Wormington to Honeybourne and at Churchover) with various compressor modifications**	**List summary of elements in sequential order** **CE1 Felindre compressor mods** **CE2 Wormington to Honeybourne pipeline 9km** **CE3 Tirley to Wormington pipeline 26km** **CE4 Churchover mods and 2km pipeline** **CE7 Compressor mods at Wormington** **UE1 55km new pipeline Felindre to Llanwdra area**	**Full PARCA requirement met**

ENVIRONMENT

Sub-category	Constraints and Opportunities	Main Potential Impacts (adverse and beneficial)	Likely Mitigation Requirements	Residual Impacts and Implications	Summary and Conclusions
Biodiversity Considerations	There are a number of statutory environmental designations located within the search areas for this Strategic Option including four Special Areas of Conservation (SAC), 23 Sites of Special Scientific Interest (SSSI), two National Nature Reserves (NNR), large areas of ancient woodland and many veteran trees. One river crossing would be required for unique element 1: Afon Tywi / River Tywi (SAC/SSSI). There are no candidate SACs, possible SAC, Special Protection Areas (SPA), potential SPAs, Ramsar sites or proposed Ramsar sites	Common element 3 (Tirley to Wormington pipeline) has the potential to affect the Dixton Wood SAC and eight SSSIs. Unique element 1 (duplicate Feeder 28) has the potential to affect the Afon Tywi / River Tywi SAC/SSSI, Cernydd Carmel SAC and Caeau Mynydd Mawr SAC. The Afon Tywi / River Tywi SAC would be unavoidable in the routeing of a new pipeline. Unique element 1 also has the potential to affect up to 15 SSSIs and two NNRs. Potential affect to the sites noted above include a direct loss of habitats together with indirect effects on potentially functionally linked land during construction. There is also the potential for these sites and their qualifying features to be affected by noise and vibration, pollution of land and water and general disturbance as a result of construction works.	Specific trenchless construction methods such as Horizontal Directional Drilling (HDD) could be used to minimise effects to required river crossings particularly for the Afon Twyi/River Tywi SAC and SSSI. Effects on other SACs, SSSIs, ancient woodland and veteran trees could be avoided through careful routing of a new pipeline, AGIs and works at Tirley and Wormington associated with common element 3. Best practice would need to be followed to ensure the risk of disturbance or damage to species and habitats are minimised, including developing appropriate access arrangements.	There remains risks associated with potential adverse effects on the qualifying habitats and species of the Afon Tywi / River Tywi SAC, Dixton Wood SAC, Cernydd Carmel SAC and Caeau Mynydd Mawr SAC that would require further assessment at the corridor stage. A Habitats Regulations Assessment (HRA) screening would also need to be undertaken. Residual effects on SSSIs, NNRs, ancient woodland and veteran trees would be limited.	This option would require crossing the Afon Tywi / River Tywi SAC and SSSI. This constraint could not be avoided therefore potentially significant construction effects cannot be ruled out. Although using standard mitigation measures to cross the watercourse and early consultation with Natural Resources Wales to agree other mitigation requirements should reduce risks to an acceptable level. Direct effects on three other SACs as well as SSSI and NNRs could be reduced through avoidance at the routeing stage and then implementation of pollution control measures to reduce the risk of indirect effects. It is considered that with mitigation in place biodiversity could meet the tests within NPS - EN1. Biodiversity may be a material consideration in the option selection process where other options have markedly different numbers of crossing SACs.

OPTION APPRAISAL SUMMARY TABLE (OAST) F4.1

Physical Environment Considerations (Geological, Water, Air Quality, Noise)	There are a number of physical environment features within the search areas for the Strategic Option including a number of Main Rivers, ordinary watercourses areas of Flood Zone 2 and 3, three Air Quality Management Areas (AQMA), 15 Noise Important Areas, nine geological Sites of Special Scientific Interest (SSSI) and one geopark. A number of river crossings would also be needed which comprise: One Main River crossing would be required for common element 2; Badsey Brook. In addition three ordinary watercourse crossings could not be avoided. One Main River crossing would be required for common element 3: Afon Hafren / River Severn. In addition the River Isbourne extends throughout common element 3 and could not be avoided. Part of this watercourse is a designated Main River and part ordinary watercourse. One Main River crossing would be required for common element 4: River Swift. The Canal Feeder ordinary watercourse could not be avoided. Six Main River crossings would be required for unique element 1: River Towy / Afon Tywi (two crossings would be required), Dulais (Rhosmaen) / River Towy / Afon Tywi, Dulais on Loughor, River Lougher / Llwchr and River Lougher / Llwchr / Lash on Lougher. In addition two ordinary watercourses would need to be crossed, the Afon Lliw (part Main River and part ordinary watercourse) and Fferrws Brook / Nant Arw. There are no Source Protection Zones (SPZs) within the Strategic Option.	A minimum of 16 river crossings (nine Main Rivers and seven ordinary watercourses) would be required for this Strategic Option. Therefore there is a pollution risk associated with the new pipelines and effects to flood risk associated with flood zones 2 and 3 within common element 2, 3, 4 and unique element 1 search areas. Air quality effects during construction are likely to be limited to construction dust effects. However, there may be effects associated with NO2 emissions from construction vehicles on the AQMAs. There may also be effects associated with noise from construction sites and construction vehicles on noise important areas. There is the potential to affect up to seven statutory designated Geological SSSIs.	Where river crossings are required specific trenchless construction methods could be used to minimise effects. Other specific construction techniques and control measures could be implemented to reduce / minimise effects on the water environment and air quality. Routing would need to avoid geological SSSIs and the Geopark. Sensitive routing of construction traffic could be used to avoid / minimise any effects on AQMAs and Noise Important Areas. Consent from the Environment Agency / Natural Resources Wales would be required for works in the floodplain or crossing a watercourse and any works within flood zones would require a flood risk assessment.	Adopting sensitive construction techniques at river crossings and ensuring appropriate pollution controls are in place when working close to Main Rivers, ordinary watercourses and in flood zones would ensure effects to the water environment are minimised, however adverse effects cannot be ruled out at this stage. Residual effects on the AQMAs and Noise Important Areas are likely to be negligible following mitigation. There would be no effects on the Geological SSSIs and the Geopark following mitigation.	A minimum of 16 river crossings (nine Main Rivers and seven ordinary watercourses) would be required for this option (including crossing the River Severn) together with routing through flood zones 2 and 3 associated with these rivers. The presence of Main Rivers, ordinary watercourses and areas of flood zones 2 and 3 throughout the common elements 2, 3, 4 and unique element 1 mean that potentially significant construction stage effects cannot be ruled out at this stage. However, using specific methods for crossings such as trenchless techniques would reduce effects during construction combined with completion of Flood Risk Assessments and implementation of appropriate mitigation. Therefore the physical environment may be a material consideration in the selection of the Preferred Option where other options have markedly different number of crossings and / or extent of flood zones 2 and 3. Effects on the Geopark, geological SSSIs and the AQMAs and Noise Important Areas could be appropriately avoided and mitigated.
Landscape and Visual Considerations	The Cotswolds Area of Outstanding Natural Beauty (AONB) lies adjacent to common element 2 search area and crosses the entirety of common element 3 search area. The Brecon Beacons National Park lies adjacent to the proposed area of search for the duplicate pipeline (it is assumed that the area of search would not require physical pipeline works in the National Park). There are no National Trails, World Heritage Sites or Biosphere Reserves associated with the Strategic Option search areas.	There would be potential significant adverse construction stage effects on the visual amenity and the character of the Cotswolds AONB by routing a pipeline through part of this designated site. There is also the potential for adverse effects on the AONB from the construction of new AGIs and works at Wormington - depending on their location / scale. Owing to the distance of the existing Honeybourne AGI to the AONB (in excess of 2.5km) potential effects would also be limited. However, there may be the potential for indirect effects on landscape character and visual amenity of the AONB as a result of works at the Wormington gas site. Following construction, the new pipeline would be buried therefore landscape effects would be limited.	It would not be possible to avoid the Cotswolds AONB. Therefore careful routing would be required through areas of the AONB most able to tolerate change. Sensitive construction techniques would also need to be considered. Through careful siting of the Block Valve AGI, it should be possible to avoid locating it within the AONB. Screening could also be used during construction of the AGI and works at Wormington. It is assumed that the pipeline would be routed outside of the Brecon Beacons National Park and that AGIs would also be sited appropriately to minimse long-term landscape and visual amenity impacts as well as being appropriately screened.	Significant adverse residual effects on the Cotswolds AONB during construction could not be ruled out at this stage as part of the pipeline would be routed through it. Additional work would need to be undertaken at the routeing stage to ensure that effects are reduced to an acceptable level. Operational effects are unlikely to be significant once land is re-instated and planting re-establishes. There is also the potential for indirect effects on the Brecon Beacons National Park depending upon the routeing of the pipeline and associated AGIs although it is assumed that there would be no direct impact on the National Park.	It would not be possible to avoid the Cotswolds AONB. Therefore there is the potential for significant effects during construction on landscape character and visual amenity. However, during operation, permanent infrastructure could be sited outside of very sensitive sites and screening provided if necessary - reducing effects to an acceptable level. Whilst direct effects on the Brecon Beacons AONB would be avoided, there may be potential indirect setting effects during construction. It is assumed that with appropriate siting and screening of AGIs associated with the duplicate pipeline that operational effects would be reduced to an acceptable level.

OPTION APPRAISAL SUMMARY TABLE (OAST) F4.1

		A new pipeline routed adjacent to the Brecon Beacons National Park has the potential to have landscape and visual amenity effects during the construction phase. Effects once operational would depend upon the location of AGIs etc and their visibility from the Brecon Beacons National Park.			NPS EN-1 states that consent in these areas is permitted in exceptional circumstances. However, it should be noted that there are existing pipelines through the Cotswolds AONB and Brecon Beacons National Park which may indicate there are areas that are more able to tolerate change than others.
Historic Environment Considerations	There are 17 Scheduled Monuments, 1,224 Listed Buildings, four Registered Park and Gardens and one Registered Battlefield within the search areas for this Strategic Option.	During construction, there is the potential for direct physical effects together with effects on the setting of designated heritage assets associated with the construction of new sections of pipeline and construction of AGIs and works adjacent to existing National Grid sites. During operation, there is the potential for permanent infrastructure to continue to affect the setting of heritage assets depending where it is located. There would be no ongoing effects following construction of the pipeline as the land would be reinstated.	Careful routing and siting to avoid physical effects on designated heritage assets. In addition siting permanent infrastructure away from designated assets would reduce potential effects on their setting. Planting around permanent above ground infrastructure could provide visual screening and minimise effects over time on the setting of heritage assets, depending on where it is sited.	Through careful routing and siting, physical effects on designated heritage assets could be avoided. There may be temporary effects on the setting of designated heritage assets during construction. Following construction, there may be residual effects on the setting of heritage assets depending upon where AGIs are located.	NPS EN-1 states that avoidance of Scheduled Monuments and Listed Buildings should be a priority and substantial harm to or loss should be wholly exceptional. It is expected that the loss of heritage assets could be avoided. However, at this stage it cannot be confirmed that all effects on the setting on heritage assets particularly during construction could be ruled out for this Strategic Option. This is due to the number of assets that are present. It is expected that AGIs and permanent infrastructure could be sited away from sensitive sites and screened with planting - reducing effects to an acceptable level during operation.
Overall Environment Summary	There are a number of European and nationally important sites within the search areas for this strategic option that have the potential to be affected. Whilst it should be possible to avoid direct impacts on most SACs, ancient woodland, SSSIs and veteran trees all of which are given significant weight in NPS EN-1 there remains a risk to the Afon Tywi/River Tywi SAC and SSSI as this constraint would need to be crossed for the pipeline associated with Unique Element 1. Therefore HRA Screening would be required and appropriate mitigation including trenchless methods to cross the watercourse combined with early consultation with Natural Resources Wales to reduce potential construction effects. It would not be possible to avoid the Cotswolds AONB for the pipeline for common element 3. Therefore there is the potential for significant effects during construction. However, during operation, permanent infrastructure could be sited outside of very sensitive sites and screening provided if necessary - reducing effects to an acceptable level. The Brecon Beacons National Park would be avoided through pipeline routing although there may be some indirect effects on setting during construction. Landscape and visual effects should be considered as a material factor in the selection of the Preferred Option. NPS EN-1 states that consent in these areas is permitted in exceptional circumstances. However, it should be noted that there are existing pipelines through the Cotswolds AONB and Brecon Beacons National Park which may indicate there are areas that are more able to tolerate change than others. Direct effects on the large number of designated heritage assets that could be affected should be possible to avoid although there remains a risk of indirect setting effects during the construction phase. There would be circa 16 river crossing and effects during construction on flood zones 2 and 3 which would require appropriate mitigation and assessment.				

SOCIO-ECONOMIC

Sub-category	Constraints and Opportunities	Main Potential Impacts (adverse and beneficial)	Likely Mitigation Requirements	Residual Impacts and Implications	Summary and Conclusions
Socio-Economic Considerations	There is existing National Grid Infrastructure, National Trust Open and Inalienable Land, National Cycle Route 41 and Countryside Right of Way (CRoW) Open Access Land within this Strategic Option. These constraints are primarily issues for the pipelines associated with common element 3 and unique element 1. There are no military sites or airports.	There is the potential to directly affect National Cycle Route 41, CRoW Open Access Land and National Trust Open and Inalienable Land depending upon where the pipelines are routed and above ground infrastructure is located. New infrastructure would also need to be appropriately routed in relation to existing National Grid infrastructure to ensure that existing safety standards can be maintained. Once the scheme is operational there would be no significant effects as the effects would have been mitigated during the construction phase.	Through careful routeing and siting of the new pipelines and infrastructure associated with this Strategic Option, effects to National Cycle Route 41, National Trust Open and Inalienable Land could be avoided or minimised. Sensitive construction technqiues would also minimise amenity effects to users of this land.	No significant residual effects anticipated.	It is assumed that effects on socio-economic receptors could be avoided through careful routeing and siting, or mitigated through sensitive construction techniques.
Overall Socio-economic summary	There are a number of socio-economic receptors that could be affected particularly for the pipelines for Common Elements 3 and unique element 1. These receptors include CRoW Land, Open Access Land and National Trust Inalienable Land as well as PRoW and National Cycle Routes. During construction there is the potential for direct effects on these assets, for example National Cycle Route 41 as well as amenity effects on a number of their users. Effective routeing would mitigate the risk of direct effects and short-term construction effects on amenity could be reduced through effective construction practices. There is also National Grid Infrastructure that will have a bearing on the route selection to ensure that appropriate safety standards are maintained. There would be no effects during operation.				

CONSENTING & PROGRAMME

Overall consent & programme Summary	This option would require a DCO due to pipeline length . There is additional complexity around consenting due to the presence of sections of new pipeline in both England and Wales. Additional challenge from stakeholders can be expected due to the extent of physical works some of which is within the Cotswolds AONB and in proximity to the BBNP. Together this presents a relatively higher risk to programme than other options which require considerably less new pipeline with a risk that capacity release will be later than that offered in the PARCA.

OPTION APPRAISAL SUMMARY TABLE (OAST) F4.1	
TECHNICAL	
Sub-category	**Commentary for Option**
Summary for Technical Complexity	Beneficial. Technical complexity considered low since most of the modifications are to existing compression and do not increase complexity substantially. Pipeline elements have low technical complexity.
Summary for Delivery & Construction including Resource use and Waste	Adverse. Total length of 92km of pipeline presents substantial challenges to construction programme and is assessed adversely for resource use and waste. Constructability is impacted by a high number of crossings including major rivers, motorways and railways. The general topography, ground conditions, drainage, proximity to other below ground services and river development in the Towy valley proved challenging for routing and construction of Felindre to Llanwrda in past projects.
Summary for Technology Issues	Beneficial. No innovation is required and no significant safety issues, which cannot be mitigated, are perceived.
Summary for Capacity Issues	Generally beneficial. This option achieves additional Milford Haven entry capability equivalent to the full requested capacity increase (PARCA) across the annual demand range. The 9Km pipe reinforcement is beneficial in all technical respects The option as a whole is neutral in terms of network flexibility and resilience since although it places a greater burden upon most of Feeder 28, resilience is increased for the duplicated section of the feeder.
Summary for Network Efficiency / benefits (inc Energy Efficiency)	Beneficial. This option relies on reduced restriction to flow, rather than additional compression to generate additional capacity and hence can be considered efficient in high flow scenarios but also during more regular operation of the network.
Overall Technical Summary Consolidating the above	The pipeline length required for this option of 92km presents substantial challenges to the construction programme and is poorer performing than many other options for resource use and waste. Constructability is impacted by a high number of crossings including major rivers, motorways and railways. The general topography and ground conditions for construction of Felindre to Llanwrda (where duplication would be required) have been shown to be challenging in past projects. Generally this provides an efficient solution once operational, but with constructability and programme challenges prior to commissioning.
COST	
Overall cost Summary	The option is over five times the capital cost of option F6.6, which has the lowest capital cost. The option is 5th out of 11 in CBA terms..
CONCLUSION	
The overall conclusion is that option F4.1 complies less well with the guiding principles than other options which envisage some form of uprating or new compression. However it complies more strongly with the guiding principles than other options involving longer length of new pipeline on the basis of lower capital cost. The overall conclusion is that this option complies less well with the guiding principles than other options which include uprating with MOP below equipment classification limits. These other options involve a greater use and adaptation of existing infrastructure (GP2) and less new pipeline (GP3). However, this option omplies more strongly with the guiding principles than other options (F4.2, F7.1, G1.1 and G1.3) involving longer length of new pipeline (i.e. F4.1 performs better against GP3) and on the basis of lower capital cost and better CBA outcome (GP4).	

OPTION APPRAISAL SUMMARY TABLE (OAST) F4.2

Option	Option Description	Option Elements	Extent to which elements achieve customer requirement (if part solution possible)
F4.2	**Network upgrade to achieve gas flow northeastwards by 99km of new onshore pipeline comprising duplication of approx 55km of Feeder 28 (Felindre to approx Llanwdra) plus 44 km (Tirley to Wormington avoiding AONB, Wormington to Honeybourne and at Churchover) with various compressor modifications**	**List summary of elements in sequential order** **CE1 Felindre compressor mods** **CE2 Wormington to Honeybourne pipeline 9km** **CE4 Churchover mods and 2km pipeline** **CE6 Tirley to Wormington pipeline 33km** **CE7 Compressor mods at Wormington** **UE1 55km new pipeline Felindre to Llanwdra area**	**Meets PARCA requirement**

ENVIRONMENT

Sub-category	Constraints and Opportunities	Main Potential Impacts (adverse and beneficial)	Likely Mitigation Requirements	Residual Impacts and Implications	Summary and Conclusions
Biodiversity Considerations	There are a number of statutory environmental designations located within this Strategic Option. These comprise three Special Areas of Conservation (SAC) (Afon Tywi / River Tywi SAC, Cernydd Carmel SAC and Caeau Mynydd Mawr SAC), 21 Sites of Special Scientific Interest (SSSI), two National Nature Reserves (NNR), large areas of ancient woodland and many veteran trees. One river crossing would be required for unique element 1: Afon Tywi / River Tywi (SAC/SSSI). There are no candidate SACs, possible SAC, Special Protection Areas (SPA), potential SPAs, Ramsar sites or proposed Ramsar sites.	Unique element 1 has the potential to affect the Afon Tywi / River Tywi SAC/SSSI, Cernydd Carmel SAC and Caeau Mynydd Mawr SAC. The Afon Tywi / River Tywi SAC would have to be crossed for the routing of a new pipeline. Unique element 1 also has the potential to affect up to 15 SSSIs and two NNRs. Potential affect to the sites noted above include a direct loss of habitats together with indirect effects on potentially functionally linked land during construction. There is also the potential for these sites and their qualifying features to be affected by noise and vibration, pollution of land and water and general disturbance as a result of construction works.	Specific trenhcless crossing methods such as Horizontal Directional Drilling (HDD) could be used to minimise effects for the required river crossing. Effects on other SACs, SSSIs, ancient woodland and veteran trees could be avoided through careful routing. Best practice would need to be followed to ensure the risk of disturbance or damage to species and habitats are minimised, including developing appropriate access arrangements.	There remains risks associated with potential adverse effects on the qualifying habitats and species of the Afon Tywi / River Tywi SAC, Cernydd Carmel SAC and Caeau Mynydd Mawr SAC that would require further assessment at the corridor stage. A Habitats Regulations Assessment (HRA) screening would also need to be undertaken. Residual effects on SSSIs, NNRs, ancient woodland and veteran trees would be limited.	This option would require crossing the Afon Tywi / River Tywi SAC and SSSI. This constraint could not be avoided therefore potentially significant construction effects cannot be ruled out. Although using standard mitigation measures such as HDD methods to cross the watercourse, early consultation with Natural England, and satisfying the tests outlined in NPS EN-1 (HRA screening) effects during construction could be mitigated. A further three SACs could also be affected however, careful routing could avoid these constraints. Biodiversity may be a material consideration in the selection of the Prefered Option where other options have markedly different numbers of crossing SACs.
Physical Environment Considerations (Geological, Water, Air Quality, Noise)	There are a number of physical environment features within the search areas for the Strategic Option, including many Main Rivers, ordinary watercourses, areas of Flood Zone 2 and 3, Air Quality Management Areas (AQMA), Noise Important Areas, geological SSSIs and geoparks. One Main River crossing would be required for common element 2; Badsey Brook. In addition three ordinary watercourse crossings could not be avoided. One Main River crossing would be required for common element 4: River Swift. The Canal Feeder ordinary watercourse also could not be avoided. Three Main River crossings would be required for common element 6: River Severn / Afon Hafren, River Avon and River Isbourne. In addition two ordinary watercourses would be unavoidable these include Merry Brook and Ripple Brook. Six Main River crossings would be required for unique element 1: River	A minimum of 19 river crossings (11 Main River crossings and eight ordinary watercourse crossings) would be required for this Strategic Option. Therefore there is a pollution risk associated with the new pipelines and affects to flood risk associated with Flood Zones 2 and 3 within common element 2, 4 and 6 and unique element 1 search areas. Air quality effects during construction are likely to be limited to construction dust effects. However, there may be effects associated with NO2 emissions from construction vehicles on the AQMA. There may also be effects associated with noise from construction sites and construction vehicles on Noise Important Areas. There is the potential to affect up to seven statutory designated geological SSSIs.	Where river crossings are required specific trenchless construction methods could be used to minimise effects. Other specific construction techniques and control measures could be implemented to reduce / minimise effects on the water environment and air quality. Sensitive routing of construction traffic could be used to avoid / minimise any effects on AQMAs and Noise Important Areas. Routing should also avoid direct impacts on geological SSSIs. Consent from the Environment Agency / Natural Resources Wales would be required for works in the floodplain or crossing a watercourse and any works within flood zones would require a flood risk assessment.	Adopting sensitive construction techniques at river crossings and ensuring appropriate pollution controls are in place when working close to Main Rivers, ordinary watercourses and in flood zones would ensure effects to the water environment are minimised, however adverse effects cannot be ruled out at this stage. Residual effects on the AQMAs and Noise Important Areas are likely to be negligible following mitigation. Effects on the geological SSSIs should also be avoided.	A minimum of 19 watercourse crossings (11 Main River crossings and eight ordinary watercourse crossings) would be required for this option together with routing through flood zones 2 and 3 associated with them. The presence of Main Rivers, ordinary watercourses and areas of flood zones 2 and 3 throughout the common elements 2, 4, 6 and unique element 1 mean that potentially significant construction stage effects cannot be ruled out at this stage. However, using specific trenchless construction methods for crossings would reduce effects during construction combined with completion of Flood Risk Assessments and implementation of appropriate mitigation. Therefore, the physical environment may be a material consideration in the selection of the Preferred Option where other options have markedly different number of crossings and / or extent of flood zones 2 and 3. Effects on the geological SSSIs and the AQMAs and Noise Important Areas could be appropriately avoided and mitigated.

OPTION APPRAISAL SUMMARY TABLE (OAST) F4.2

	Towy / Afon Tywi (two crossings would be required), Dulais (Rhosmaen) / River Towy / Afon Tywi, Dulais on Loughor, River Lougher / Llwchr and River Lougher / Llwchr / Lash on Lougher. In addition two ordinary watercourses would need to be crossed, the Afon Lliw (part Main River and part ordinary watercourse) and Fferrws Brook / Nant Arw.				
Landscape and Visual Considerations	The Cotswolds Area of Outstanding Natural Beauty (AONB) lies adjacent to common element 2 and 6 search areas. The Brecon Beacons National Park lies adjacent to the proposed area of search for the duplicate pipeline (it is assumed that the area of search would not require physical pipeline works in the National Park). There are no National Trails, World Heritage Sites or Biosphere Reserves associated with the Strategic Option search areas.	A new pipeline routed adjacent to the Brecon Beacons National Park has the potential to have landscape and visual amenity effects during the construction phase. Effects once operational would depend upon the location of AGIs etc and their visibility from the National Park. For common elements 2 and 6 during construction there is the potential for indirect adverse effects on landscape character and visual amenity of the AONB depending upon the location of the new infrastructure and views of the works from elevated locations. Following construction effects would be limited.	The pipeline would be routed outside of the Brecon Beacons National Park and that AGIs would also be sited appropriately to minimise long-term landscape and visual amenity impacts as well as being appropriately screened. Owing to the limited interaction of the AONB with the proposed works it should be possible to minimise effects through careful routing / siting. Following construction, planting around permanent infrastructure would provide some visual screening and minimise indirect effects over time on the AONB if required.	There is the potential for indirect effects on the Brecon Beacons National Park depending upon the routing of the pipeline and associated AGIs although it is assumed that there would be no direct impact on the National Park. Residual effects on the AONB as a result of a new infrastructure would be dependent upon where the works are located, however through careful siting / routing effects could be reduced.	Whilst direct effects on the Brecon Beacons National Park and the Cotswolds AONB would be avoided, there may be potential indirect setting effects and effects on visual amenity during construction. It is assumed that with appropriate siting and screening of AGIs associated with new pipelines that operational effects would be reduced to an acceptable level.
Historic Environment Considerations	Within the search area for this Strategic Option there are 22 Scheduled Monuments and 993 Grade I and II* Listed Buildings.	During construction, there is the potential for direct physical effects together with effects on the setting of designated heritage assets. During operation, there is the potential for permanent infrastructure to continue to affect the setting of heritage assets depending where they are located.	Careful routing and siting would avoid physical effects on designated heritage assets. In addition siting permanent infrastructure away from designated assets would reduce potential effects on their setting. Planting around permanent above ground infrastructure could provide visual screening and minimise effects over time on the setting of heritage assets, depending on where it is sited.	It is anticipated that through careful routing and siting, physical effects on designated heritage assets could be avoided. However, there remains a risk owing to the number of designated assets within the Strategic Option search areas that there may be residual effects on the setting of many heritage assets.	NPS EN-1 states that avoidance of Scheduled Monuments and listed buildings should be a priority and substantial harm to or loss should be wholly exceptional. It is expected that the loss of heritage assets could be avoided. However, at this stage it cannot be confirmed that all effects on the setting on heritage assets particularly during construction could be ruled out for this Strategic Option. This is due to the number of assets within the search areas for common elements 2, 6 and unique element 1. It is expected that AGIs and permanent infrastructure could be sited away from sensitive sites and screened with planting - reducing effects to an acceptable level during operation.
Overall Environment Summary	There are a number of European and nationally important sites for biodiversity, landscape and visual, water and historic environment within the search areas for this strategic option that have the potential to be affected. Whilst it should be possible to avoid direct impacts on most SACs, ancient woodland, SSSIs and veteran trees all of which are given significant weight in NPS EN-1 there remains a risk to the Afon Tywi/River Tywi SAC and SSSI as this constraint would need to be crossed for the pipeline associated with Unique Element 1. Therefore HRA Screening would be required and appropriate mitigation including trenchless methods to cross the watercourse combined with early consultation with Natural Resources Wales to reduce potential construction effects. The Brecon Beacons National Park and the Cotswolds AONB would not be directly affected but there is the potential for indirect setting effects and effects on visual amenity during construction. Direct effects on the large number of designated heritage assets that could be affected should be possible to avoid although there remains a risk of indirect setting effects during the construction phase. There would be circa 19 river crossing and effects during construction on flood zones 2 and 3 which would require appropriate mitigation and assessment.				

SOCIO-ECONOMIC

Sub-category	Constraints and Opportunities	Main Potential Impacts (adverse and beneficial)	Likely Mitigation Requirements	Residual Impacts and Implications	Summary and Conclusions
Socio-Economic Considerations	There are many existing National Grid pipelines within the search area for the Strategic Option particularly around Wormington gas site. In addition there are a number of areas Countryside Rights of Way (CRoW) Open Access Land and National Trust Inalienable and Open Land and National Cycle Routes 41 and 45.	There is the potential to directly affect National Cycle Route 45 as it could not be avoided as well as CRoW Open Access Land and National Trust Open and Inalienable Land depending upon where the pipelines are routed and above ground infrastructure is located. New infrastructure would also need to be appropriately routed in relation to existing National Grid infrastructure to ensure that existing safety standards can be maintained. Once the scheme is operational there would be no significant effects as the effects would	Through careful routeing and siting of the new pipelines and infrastructure associated with this Strategic Option, effects to National Cycle Routes, National Trust Open and Inalienable Land could be avoided or minimised.	No significant residual effects anticipated.	It is assumed that effects on socio-economic receptors could be avoided through careful routeing and siting, or mitigated through sensitive construction techniques.

OPTION APPRAISAL SUMMARY TABLE (OAST) F4.2					
		have been mitigated during the construction phase			
Overall Socio-economic summary	There are a number of socio-economic receptors that could be affected including CRoW Land, Open Access Land and National Trust Inalienable Land as well as PRoW and National Cycle Routes 41 and 45. During construction there is the potential for direct effects on these assets as well as amenity effects on a number of their users. Effective routeing would mitigate the risk of direct effects and short-term construction effects on amenity could be reduced through effective construction practices and appropriate diversions, for example for NCN 45. There is also National Grid Infrastructure that will have a bearing on the route selection to ensure that appropriate safety standards are maintained. There would be no effects during operation.				
CONSENTING & PROGRAMME					
Overall Consent & Programme Summary	This option will require a DCO due to pipeline length. There is additional complexity around consenting due to the presence of sections of new pipeline in both England and Wales. Additional challenge from stakeholders can be expected due to the extent of physical works some of which is within proximity of the Cotswolds AONB and to the BBNP. Together this presents a relatively higher risk to programme than other options which require considerably less new pipeline with a risk that capacity release will be later than that offered in the PARCA.				
TECHNICAL					
Sub-category	**Commentary for Option**				
Summary for Technical Complexity	Beneficial. Technical complexity considered low since most of the modifications are to existing compression and do not increase complexity substantially. Pipeline elements have low technical complexity.				
Summary for Delivery & Construction including Resource use and Waste	Adverse. Total length of 92km of pipeline presents substantial challenges to construction programme and is assessed adversely for resource use and waste. Constructability is impacted by a high number of crossings including major rivers, motorways and railways, further complicated in comparison to option F4.1 by a longer route with more motorway and other major crossings, around Cotswolds AONB. The general topography, ground conditions, drainage, proximity to other below ground services and river development in the Towy valley proved challenging for routing and construction of Felindre to Llanwrda have been shown to be challenging in past projects.				
Summary for Technology Issues	Beneficial. No innovation is required and no significant safety issues, which cannot be mitigated, are perceived.				
Summary for Capacity Issues	Generally beneficial. This option achieves additional Milford Haven entry capability equivalent to the full requested capacity increase (PARCA) across the annual demand range. The 9Km pipe reinforcement is beneficial in all technical respects The option as a whole is neutral in terms of network flexibility and resilience since although it places a greater burden upon most of Feeder 28, resilience is increased for the duplicated section of the feeder.				
Summary for Network Efficiency / benefits (inc Energy Efficiency)	Beneficial. This option relies on reduced restriction to flow, rather than additional compression to generate additional capacity and hence can be considered efficient in high flow scenarios but also during more regular operation of the network.				
Overall Technical Summary Consolidating the above	The pipeline length required for this option of 99km presents substantial challenges to the construction programme and is poorly performing than many other options for resource use and waste. Constructability is impacted by a high number of crossings including major rivers, motorways and railways. The general topography and ground conditions for construction of Felindre to Llanwrda have been shown to be challenging in past projects. Generally an efficient solution once operational, but with constructability and programme challenges prior to commissioning. The option is less favourable in comparison to F4.1 due to the longer pipeline requirement.				
COST					
Overall Cost Summary	The option is over five and a half times the capital cost of option F6.6 which has the lowest capital cost. The option is 6th of 11 in CBA terms.				
CONCLUSION					
The overall conclusion is that option F4.2 complies less well with the guiding principles than other options which include uprating with MOP below equipment classification limits where there is greater use and adaptation of existing infrastructure (GP2) and less new pipeline (GP3). However, it complies more strongly with the guiding principles than other options (F7.1, G1.1and G1.3) involving longer lengths of new pipeline (i.e. F4.2 performs better against GP3) and on the basis of lower capital cost and better CBA outcome (GP4). Whilst it is a longer route (GP3) and poorer performing in terms of capital cost and CBA performance (GP4) than option F4.1 it would avoid the AONB. However based on the potential to mitigate construction effects within the AONB overall option F4.2 is considered less favourable than F4.1				

OPTION APPRAISAL SUMMARY TABLE (OAST) F6.1

Option	Option Description	Option Elements (in sequential order if part solutions possible)	Extent to which elements achieve customer requirement (if part solution possible)
F6.1	**Below class limit MOP uprating parts of network with network upgrade to achieve gas flow northeastwards with 37km new pipeline, and various compressor modifications**	CE1 Felindre compressor mods CE2 Wormington to Honeybourne pipeline duplication 9km CE3 Tirley to Wormington pipeline duplication 26km CE4 Churchover comp mods and 2km pipeline duplication CE7 Wormington compressor mods UE1 Below class limit MOP uprate Feeder 28 from Milford Haven to Three Cocks UE2 Assumes south hook and dragon can achieve higher pressures	**Meets PARCA Requirement**

ENVIRONMENT

Sub-category	Constraints and Opportunities	Main Potential Impacts (adverse and beneficial)	Likely Mitigation Requirements	Residual Impacts and Implications	Summary and Conclusions
Biodiversity Considerations	There are a number of statutory designations located within the Strategic Option F6.1 search area. These include Dixton Wood Special Area of Conservation (SAC), eight Sites of Special Scientific Interest (SSSI), large areas of ancient woodland and many veteran trees. There are no possible SACs, candidate SACs, Special Protection Areas (SPA), Potential SPAs, Ramsars or proposed Ramsars within the Strategic Option search area.	Common element 3 (Tirley to Wormington pipeline) has the potential to affect the Dixton Wood SAC and eight SSSIs. Effects are potentially due to a direct loss of habitats within these sites and indirect effects on potentially functionally linked land during construction. There is also the potential for these sites and their qualifying features to be affected by noise and vibration, pollution of land and water and general disturbance as a result of construction works. No potential effects recorded for other common and unique elements.	Careful routing and siting of the pipeline, AGIs and required land take at Tirley and Wormington (proposed as part of common element 3) would avoid / reduce effects to sensitive features. Best practice construction management would be needed to ensure the risk of disturbance or damage to species and habitats is minimised. Construction activities would need to be confined to a defined working area and appropriate pollution control measures implemented to reduce effects to air, noise and water.	Through careful siting of the proposed new infrastructure and the implementation of mitigation, the effects on statutory designated sites could be avoided / reduced to an acceptable level for all common and unique elements. However, for common elements 3 it is anticipated that Habitats Regulations Assessment (HRA) screening may be required to determine if there would be any likely significant effects on the Dixton Wood SAC once further detail is known. No specific mitigation proposed for other common / unique elements.	During construction effects on statutory sites could be avoided through careful routing and siting - particularly for common element 3. No European sites would be required to be crossed for this Strategic Option. However, HRA screening may be required once further detail is known. No significant effects are anticipated during operation. It is considered that with mitigation in place biodiversity could meet the tests within NPS - EN1.
Physical Environment Considerations (Geological, Water, Air Quality, Noise)	There are a number of physical environment features within the search areas for the Strategic Option, including many Main Rivers, ordinary watercourses, areas within the floodplain (e.g. Flood Zones 2 and 3), two Air Quality Management Areas (AQMAs), two geological Sites of Special Scientific Interest (SSSI) and Noise Important Areas. One Main River crossing would be required for common element 2; Badsey Brook. In addition three ordinary watercourse crossings could not be avoided. One Main River crossing would be required for common element 3: Afon Hafren / River Severn. In addition the River Isbourne extends throughout common element 3 and could not be avoided. Part of this watercourse is a designated Main River and part ordinary watercourse. One Main River crossing would be required for common element 4: River Swift. The Canal Feeder ordinary watercourse also could not be avoided.	A total of three Main River crossings (and five ordinary watercourse crossings) would be required for this Strategic Option. Therefore there is a pollution risk associated with the new pipelines and effects to flood risk associated with the floodplain within common elements 2, 3 and 4. Air quality effects during construction are likely to be limited to construction dust effects. However, there may be effects associated with NO2 emissions from construction vehicles on the AQMA. There may also be effects associated with noise from construction sites and construction vehicles on Noise Important Areas. The Strategic Option has the potential to directly affect geological SSSIs.	Where river crossings are required specific trenchless construction methods could be used to minimise effects. Other specific construction techniques and control measures could be implemented to reduce / minimise effects on the water environment and air quality. Sensitive routing of construction traffic could be used to avoid / minimise any effects on AQMAs, Noise Important Areas and routing should avoid geological SSSIs. Consent from the Environment Agency would be required for works in the floodplain or crossing a watercourse. Any works within flood zones would require a Flood Risk Assessment.	Adopting sensitive construction techniques at river crossings and ensuring appropriate pollution controls are in place when working close to Main Rivers, ordinary watercourses and in flood zones would ensure effects to the water environment are minimised, however adverse effects cannot be ruled out at this stage. Residual effects on the AQMA, Noise Important Areas and geological SSSIs are likely to be negligible following mitigation.	The Strategic Option would require a minimum of eight watercourse crossings (three Main Rivers and five ordinary watercourses) and would pass through many areas of flood zones 2 and 3. The presence of Main Rivers, ordinary watercourses and areas of flood zones 2 and 3 throughout the common elements 2, 3 and 4 mean that potentially significant construction stage effects cannot be ruled out at this stage. However, through the adoption of proven mitigation measures (including the use of trenchless construction methods) and early consultation with the Environment Agency and satisfying the tests outlined in NPS EN-1 effects during construction could be mitigated. Therefore the physical environment may be a material consideration in the selection of the Preferred Option where other options have markedly different number of crossings or area of extent of flood zones 2 / 3.

OPTION APPRAISAL SUMMARY TABLE (OAST) F6.1					
Landscape and Visual Considerations	The Cotswolds Area of Outstanding Natural Beauty (AONB) lies adjacent to the common element 2 search area and crosses the entirety of the common element 3 search area. Within the search area for this Strategic Option there are no National Parks, National Trails, World Heritage Sites or Biosphere Reserves.	For common element 2, during the construction and operation phases there is the potential for localised indirect adverse effects on the Cotswolds AONB depending upon where the pipeline and associated construction working areas are located. It would not be possible to avoid the Cotswolds AONB when routing the pipeline between Tirley and Wormington. There is also the potential for indirect effects on the AONB as a result of the construction of the Block Valve AGIs and the works at Wormington. Once operational, effects associated with routing a pipeline through the AONB would be very limited and would only be associated with any AGIs as the land would be restored following construction.	Careful routing is recommended, through areas of the AONB most able to tolerate change. Appropriate screening and planting should also be used for Block Valve AGIs and works at Wormington.	Significant adverse residual effects on the Cotswolds AONB during construction could not be ruled out at this stage. Additional work would need to be undertaken at the routing stage to ensure that effects are reduced to an acceptable level. Operational effects are unlikely to be significant once land is re-instated and planting re-establishes.	It would not be possible to avoid the Cotswolds AONB in this option. Therefore there is the potential for significant, direct effects during construction. However, during operation, AGIs could be sited outside of very sensitive sites and screening around permanent infrastructure provided - reducing effects to an acceptable level. Landscape and visual amenity should be considered a material factor in the selection of the Preferred Option as AONBs are afforded very high protection within NPS EN-1. The NPS states that consent in AONBs and National Parks is permitted in exceptional circumstances. There are existing pipelines through the Cotswolds AONB which may indicate there are areas that are more able to tolerate change and therefore this would be an important factor during the routeing stage.
Historic Environment Considerations	Within the search area for this Strategic Option there are 23 Scheduled Monuments, over 900 Listed Buildings (many of which are Grade I and II*), two Registered Park and Gardens and one Registered Battlefield.	During construction, there is the potential for direct physical effects together with effects on the setting of designated heritage assets. During operation, there is the potential for permanent infrastructure to continue to affect the setting of heritage assets depending where they are located.	Careful routing and siting would avoid physical effects on designated heritage assets. In addition siting permanent infrastructure away from designated assets would reduce potential effects on their setting. Planting around permanent above ground infrastructure could provide visual screening and minimise effects over time on the setting of heritage assets, depending on where it is sited.	Through careful routing and siting, physical effects on designated heritage assets could be avoided. However, there remains a risk owing to the number of designated assets within the Strategic Option search areas and therefore there may be residual effects on the setting of heritage assets. The effects to Listed Buildings associated with the permanent works at AGIs is low owing to the distance of the heritage features from them and the ability to be able to reduce any setting effects through screening.	NPS EN-1 states that avoidance of Scheduled Monuments and listed buildings should be a priority and substantial harm to or loss should be wholly exceptional. It is expected that the loss of heritage assets could be avoided. However, at this stage it cannot be confirmed that all effects on the setting on heritage assets particularly during construction could be ruled out for this Strategic Option. This is due to the number of assets within the search areas for common elements 2, 3 and 5. The effects to Listed Buildings associated with the permanent works at AGIs is low owing to the distance of the heritage features from them and the ability to be able to reduce any setting effects through screening.
Overall Environment Summary	There would be no significant effects on designated biodiversity sites as any potential effects could be avoided through routing. However, there may be a requirement for HRA Screening for a single SAC dependent upon detailed routing/siting for common element 3 (Tirley to Wormington pipeline). It would not be possible to avoid the Cotswolds AONB within the common element 3 search area. Therefore there is the potential for significant effects during construction. However, during operation, AGIs could be sited outside of very sensitive sites and screening around permanent infrastructure provided - reducing effects to an acceptable level. Landscape and visual amenity should be considered a material factor in the selection of the Preferred Option as AONBs are afforded very high protection within NPS EN-1. However, the NPS states that consent in these areas is permitted in exceptional circumstances. It should be noted that there are also existing pipelines through the Cotswolds AONB which may indicate there are areas that are more able to tolerate change. There are a large number of Scheduled Monuments and Listed Buildings that could be affected but it should be possible to avoid direct effects on them through careful siting although there would remain a risk of indirect effects on their setting during construction and potentially during operation dependent upon the location of AGIs although this could be managed through mitigation such as screening as well as effective siting. There would be a need for approximately eight river crossings as well as works within or in close proximity to flood zones 2 and 3. It should be possible through the use of trenchless crossing techniques such as HDD, as well as Flood Risk Assessments and implementation of appropriate requirements to reduce this risk to an acceptable level.				
SOCIO-ECONOMIC					
Sub-category	**Constraints and Opportunities**	**Main Potential Impacts (adverse and beneficial)**	**Likely Mitigation Requirements**	**Residual Impacts and Implications**	**Summary and Conclusions**
Socio-Economic Considerations	There are many existing National Grid pipelines within the search area for the Strategic Option particularly around Wormington gas site. There are also a number of areas of Countryside and Rights of Way Act (CRoW) Open Access Land and National Cycle Route 41 associated with common element 3. There is a parcel of National Trust Inalienable and Open Land with the search area for CE2.	There is the potential to directly affect CRoW land, National Cycle Route 41, National Trust Open and Inalienable Land depending upon where new infrastructure is sited and users of that land during construction. New infrastructure would also need to be appropriately routed in relation to existing National Grid infrastructure to ensure that existing safety standards can be maintained. Once the scheme is operational there would be no significant effects as the effects would have been mitigated during the construction phase.	Careful routeing and siting of the new infrastructure would minimise effects to socio-economic receptors.	No significant residual effects anticipated following the implementation of mitigation.	It is assumed effects to the socio economic features could be avoided / minimised through careful siting and appropriate construction mitigation measures such as diversions for affected cycle routes.

OPTION APPRAISAL SUMMARY TABLE (OAST) F6.1	
Overall Socio-economic Summary	There are a number of socio-economic receptors that could be affected particularly for the pipeline for Common Element 3. These receptors include CRoW Land and National Cycle Route 41. There is a Parcel of National Trust Inalienable and Open Land within the search area for common element 2. During construction there is the potential for direct effects on these assets as well as amenity effects on a number of their users. Effective routeing would mitigate the risk of direct effects and short-term construction effects on amenity could be reduced through effective construction practices. There is also National Grid Infrastructure that will have a bearing on the route selection to ensure that appropriate safety standards are maintained. There would be no effects during operation.
CONSENTING & PROGRAMME	
Overall Consenting and programme Summary	Due to the length of new pipeline and potential environmental effects the option is anticipated to require an application for a DCO, though this is subject to confirmation with BEIS. The capacity release is expected to be in line with that offered by the PARCA
TECHNICAL	
Sub-category	**Commentary for Option**
Summary for Technical Complexity	Adverse. Overall this option has high technical complexity since it will require design by analysis to justify uprating. National Grid has no experience of this however uprating viability assessments have shown innovative uprating proposals are viable, subject to fulfilment of structural reliability assessment, quantitative risk assessment and design by analysis studies.. Boundary control and/or High Integrity Pressure Protection would be required to protect parts of the network not uprated from additional pressure.
Summary for Delivery & Construction including Resource use and Waste	Beneficial. Most elements of this option have high constructability. There are challenges associated to the Wormington to Tirley pipeline section including multiple river crossings and known difficult ground conditions but the project is achievable within PARCA timescales.
Summary for Technology Issues	Adverse. Uprating is considered innovative. Structural reliability assessment and quantitative risk assessment of infringements would be required as part of the uprating proposals and, where appropriate, engineering interventions could be required to reduce risk to as low as reasonably practicable levels.
Summary for Capacity Issues	Generally beneficial. This option achieves additional Milford Haven entry capability equivalent to the full requested capacity increase (PARCA) across the annual demand range. The pipe reinforcement is beneficial in all technical respects. The option as a whole is slightly detrimental in terms of network flexibility and resilience since it places a greater burden upon Feeder 28, whilst providing no redundancy.
Summary for Network Efficiency / benefits (inc Energy Efficiency)	Beneficial. Network efficiency would be very incrementally increased under normal operating conditions, since the 37km of pipeline reduces resistance to flow in the midlands. Commercial issues surrounding the requirement for both South Hook and Dragon to operate at higher pressure must be clarified before option is pursued further, but initial indications suggest modification scope is reasonable.
Overall Technical Summary Consolidating the above	Some unresolved technical and operational challenges to uprating with MOP below equipment classification limits remain under review by National Grid. Assuming these are resolved (as is expected) the option is still considered less favourable than other options in terms of technical complexity and technology issues. It does however require less new pipeline and other infrastructure than options such as F4.1, F4.2, F6.2, F7.1, G1.1 and G1.3) but more than option F6.6
COST	
Overall Cost Summary	This option is approximately 2 and a half times more expensive than the least capital cost option.
CONCLUSION	
The overall conclusion is that option F6.1 complies more strongly with the guiding principles than most other pipeline options (F4.1, F4.2, F6.2, F7.1, G1.1 and G1.3) by requiring less new pipeline (GP3). It also performs more strongly than all but one option in respect of GP4 having a relatively lower capital cost (2nd lowest) and better CBA outcome (2nd best). In view of the fact that it is a shorter route (GP3), better performing in terms of capital cost and CBA performance (GP4), along with the evidence from previous successful routeing through the AONB that parts of the AONB may have some capacity to absorb change reducing the differential with F6.2 in terms of compliance with GP5 and GP6, option F6.1 is overall more favourable than F6.2. There remain some as yet unresolved technical and operational challenges to uprating with MOP below equipment classification limits under ongoing review by National Grid however these are expected to be able to be resolved.	

OPTION APPRAISAL SUMMARY TABLE (OAST) F6.2

Option	Option Description	Option Elements (in sequential order if part solutions possible)	Extent to which elements achieve customer requirement (if part solution possible)
F6.2	**Below class limits MOP Uprating parts of network with network upgrade to achieve gas flow northeastwards with 44km new pipeline (some to avoid AONB), and various compressor modifications**	CE1 Felindre compressor mods CE2 Wormington to Honeybourne pipeline duplication 9km CE6 Tirley to Wormington pipeline around AONB duplication 33km pipeline CE4 Churchover comp mods and 2km pipeline duplication CE7 Wormington compressor mods UE1 Below class limit MOP uprate Feeder 28 from Milford Haven to Three Cocks UE2 Assumes south hook and dragon can achieve higher pressures	**Meets PARCA requirement**

ENVIRONMENT

Sub-category	Constraints and Opportunities	Main Potential Impacts (adverse and beneficial)	Likely Mitigation Requirements	Residual Impacts and Implications	Summary and Conclusions
Biodiversity Considerations	There are a number of statutory designations located within the Strategic Option F6.2 search area. These include, six Sites of Special Scientific Interest (SSSI), large areas of ancient woodland and many veteran trees. There are no Special Areas of Conservation (SACs), possible SACs, candidate SACs, Special Protection Areas (SPA), Potential SPAs, Ramsars or proposed Ramsars within the Strategic Option search area.	Effects are due to a direct loss of habitats within these sites and indirect effects during construction. There is also the potential for these sites and their qualifying features to be affected by noise and vibration, pollution of land and water and general disturbance as a result of construction works. No potential effects recorded for other common and unique elements.	Careful routing and siting of the pipeline, AGIs and required land take at Tirley and Wormington (proposed as part of common element 6) would avoid / reduce effects to sensitive features. Best practice construction management would be needed to ensure the risk of disturbance or damage to species and habitats is minimised. Construction activities would need to be confined to a defined working area and appropriate pollution control measures implemented to reduce effects to air, noise and water.	Through careful siting of the proposed new infrastructure and the implementation of mitigation, the effects on statutory designated sites could be avoided / reduced to an acceptable level for all common and unique elements. No specific mitigation proposed for other common / unique elements.	Effects during construction on statutory sites could be avoided through careful routing and siting. There are no European sites within the area of search for the Strategic Option. No significant effects are anticipated during operation.
Physical Environment Considerations (Geological, Water, Air Quality, Noise)	There are a number of physical environment features within the search areas for the Strategic Option, including many Main Rivers, ordinary watercourses, areas within the floodplain (e.g. Flood Zone 2 and 3), one Air Quality Management Areas (AQMAs), three geological Sites of Special Scientific Interest (SSSI) and Noise Important Areas. One Main River crossing would be required for common element 2; Badsey Brook. In addition three ordinary watercourse crossings could not be avoided. One Main River crossing would be required for common element 4: River Swift. The Canal Feeder ordinary watercourse could not be avoided. Three Main River crossings would be required for common element 6: River Severn / Afon Hafren, River Avon and River Isbourne. In addition two ordinary watercourses would be unavoidable these include Merry Brook and Ripple Brook.	A total of five Main River crossings and six ordinary watercourse crossings would be required for this Strategic Option. Therefore there is a pollution risk associated with the new pipelines and effects to flood risk associated with the floodplain within common elements 2, 4 and 6. Air quality effects during construction are likely to be limited to construction dust effects. However, there may be effects associated with NO2 emissions from construction vehicles on the AQMA. There may also be effects associated with noise from construction sites and construction vehicles on Noise Important Areas. The Strategic Option has the potential to affect geological SSSIs.	Where river crossings are required specific trenchless construction methods could be used to minimise effects. Other specific construction techniques and control measures could be implemented to reduce / minimise effects on the water environment and air quality. Sensitive routing of construction traffic could be used to avoid / minimise any effects on AQMAs, Noise Important Areas and routing of the pipeline to avoid geological SSSIs. Consent from the Environment Agency would be required for works in the floodplain or crossing a watercourse. Any works within flood zones would require a flood risk assessment.	Adopting sensitive construction techniques at river crossings and ensuring appropriate pollution controls are in place when working close to Main Rivers, ordinary watercourses and in flood zones would ensure effects to the water environment are minimised, however adverse effects cannot be ruled out at this stage. Residual effects on the AQMA, Noise Important Areas and geological SSSIs are likely to be negligible following mitigation.	A minimum of 11 watercourse crossings would be required for this option (five Main River crossings and six ordinary watercourse crossings) together with routing through flood zones 2 and 3 associated with them. The presence of Main Rivers, ordinary watercourses and areas of flood zones 2 and 3 throughout the common elements 2, 4 and 6 mean that potentially significant construction stage effects cannot be ruled out at this stage. However, using specific trenchless construction methods for crossings would reduce effects during construction combined with completion of Flood Risk Assessments and implementation of appropriate mitigation. Therefore, the physical environment may be a material consideration in the selection of the Preferred Option where other options have markedly different number of crossings and / or extent of flood zones 2 and 3.

OPTION APPRAISAL SUMMARY TABLE (OAST) F6.2					
Landscape and Visual Considerations	The Cotswolds Area of Outstanding Natural Beauty (AONB) lies adjacent to the search area for common elements 2 and 6. Within the search area for this Strategic Option there are no National Parks, National Trails, World Heritage Sites or Biosphere Reserves.	For common elements 2 and 6, during the construction and operation phases there is the potential for localised indirect adverse effects on the Cotswolds AONB depending upon where the works are located. Operational effects would be very limited as the pipeline would be buried and above ground works such as AGIs/block valves would be limited.	Ensure the routing of the pipeline avoids the Cotswolds AONB and ensure appropriate siting and screening of above ground infrastructure.	Through effective routing and siting and appropriate planting/ screening, it should be possible to reduce the long-term effects of the infrastructure on the AONB. Any indirect effects on setting and visual amenity would be short-term and occur during construction.	The Cotswolds AONB could be wholly avoided through careful routing and siting of permanent infrastructure. Appropriate planting and screening of AGIs/block valves would also ensure that there are no long-term effects on landscape and visual amenity of the AONB.
Historic Environment Considerations	Within the search area for this Strategic Option there are 23 Scheduled Monuments, over 650 Listed Buildings (many of which are Grade I and II*). There are no Registered Park and Gardens or Registered Battlefields.	During construction, there is the potential for direct physical effects together with effects on the setting of designated heritage assets. During operation, there is the potential for permanent infrastructure to continue to affect the setting of heritage assets depending where they are located.	Careful routing and siting would avoid physical effects on designated heritage assets. In addition siting permanent infrastructure away from designated assets would reduce potential effects on their setting. Planting around permanent above ground infrastructure could provide visual screening and minimise effects over time on the setting of heritage assets, depending on where it is sited.	Through careful routing and siting, physical effects on designated heritage assets could be avoided. However, there remains a risk owing to the number of designated assets within the Strategic Option search areas that there may be residual effects on the setting of many heritage assets during the construction phase.	NPS EN-1 states that avoidance of Scheduled Monuments and Listed Buildings should be a priority and substantial harm to or loss should be wholly exceptional. It is expected that the loss of heritage assets could be avoided. However, at this stage it cannot be confirmed that all effects on the setting on heritage assets particularly during construction could be ruled out for this Strategic Option. This is due to the number of assets within the search areas for common elements 2 and 6. It is expected that AGIs and permanent infrastructure could be sited away from sensitive sites and screened with planting - reducing effects to an acceptable level during operation.
Overall Environment Summary	There would be no significant effects on designated biodiversity sites as any potential effects could be avoided through routing. This option would also avoid direct effects on the Cotswolds AONB although there may be a risk of indirect, temporary setting effects for the site and its users during construction depending upon the routing of the pipeline for common element 2 and 6. Whilst there are a large number of Scheduled Monuments and Listed Buildings that would need to be avoided this should be possible at routing stage although there may be risks to setting of assets during the construction phase that would require assessment and where possible mitigation. There would be a need for approximately 11 river crossings as well as works within or in close proximity to flood zones 2 and 3 it should be possible through the use of techniques such as HDD, as well as Flood Risk Assessments and implementation of appropriate requirements to reduce this risk to an acceptable level.				
SOCIO-ECONOMIC					
Sub-category	**Constraints and Opportunities**	**Main Potential Impacts (adverse and beneficial)**	**Likely Mitigation Requirements**	**Residual Impacts and Implications**	**Summary and Conclusions**
Socio-Economic Considerations	There are many existing National Grid pipelines within the search area for the Strategic Option particularly around Wormington gas site. In addition there are a number of areas of Countryside Rights of Way (CRoW) Open Access Land and National Cycle Routes 41 and 45 within the search area for common area 6. There is a single area of National Trust Open and Inalienable Land within the Wormington to Honeybourne pipeline search area.	There is the potential to directly affect National Cycle Route 45, CRoW Open Access Land and National Trust Open and Inalienable Land depending upon where the pipelines are routed and above ground infrastructure is located. New infrastructure would also need to be appropriately routed in relation to existing National Grid infrastructure to ensure that existing safety standards can be maintained. Once the scheme is operational there would be no significant effects as the effects would have been mitigated during the construction phase.	Through careful routeing and siting of the new pipelines and infrastructure associated with this Strategic Option, effects to National Cycle Routes, National Trust Open and Inalienable Land could be avoided or minimised.	No significant residual effects anticipated.	It is assumed that effects on socio-economic receptors could be avoided through careful routeing and siting or mitigated through sensitive construction techniques.
Overall Summary	There are a number of socio-economic receptors that could be affected including CRoW Land, Open Access Land and National Trust Inalienable Land as well as PRoW and National Cycle Routes 41 and 45. During construction there is the potential for direct effects on these assets as well as amenity effects on a number of their users. Effective routeing would mitigate the risk of direct effects and short-term construction effects on amenity could be reduced through effective construction practices and appropriate diversions, for example for NCN 45. There is also National Grid Infrastructure that will have a bearing on the route selection to ensure that appropriate safety standards are maintained. There would be no effects during operation.				
CONSENTING & PROGRAMME					
Overall Consent and programme Summary	Due to the length of new pipeline the option will require an application for a DCO. The capacity release is expected to be in line with that offered by the PARCA				

TECHNICAL	
Sub-category	**Commentary for Option**
Summary for Technical Complexity	Adverse. Overall this option has high technical complexity since it will require design by analysis to justify uprating. National Grid has no experience of uprating however uprating viability assessments have shown innovative uprating proposals are viable, subject to fulfilment of structural reliability assessment, quantitative risk assessment and design by analysis studies.. Boundary control and/or High Integrity Pressure Protection would be required to protect parts of the network not uprated from additional pressure.
Summary for Delivery & Construction including Resource use and Waste	Beneficial. Most elements of this option have high constructability. There are challenges associated to the Wormington to Tirley pipeline section including multiple river crossings and known difficult ground conditions but the project is achievable within PARCA timescales.
Summary for Technology Issues	Adverse. Uprating is considered innovative. Structural reliability assessment and quantitative risk assessment of infringements would be required as part of the uprating proposals and, where appropriate, engineering interventions could be required to reduce risk to as low as reasonably practicable levels.
Summary for Capacity Issues	Generally beneficial. This option achieves additional Milford Haven entry capability equivalent to the full requested capacity increase (PARCA) across the annual demand range. The 9Km pipe reinforcement is beneficial in all technical respects. The option as a whole is slightly detrimental in terms of network flexibility and resilience since it places a greater burden upon Feeder 28, whilst providing no redundancy.
Summary for Network Efficiency / benefits (inc Energy Efficiency)	Beneficial. Network efficiency would be very incrementally increased under normal operating conditions, since the 37km of pipeline reduces resistance to flow in the midlands. Commercial issues surrounding the requirement for both South Hook and Dragon to operate at higher pressure must be clarified before option is pursued further, but initial indications suggest modification scope is reasonable.
Overall Technical Summary Consolidating the above	Uprating viability assessments have shown innovative uprating proposals are viable, subject to fulfilment of structural reliability assessment, quantitative risk assessment and design by analysis studies. Technical complexity is high but overall infrastructure requirements are reasonable and hence constructability is high.
COST	
Overall Cost Summary	The option is achieved at around 20% higher capital cost than option F6.1 and is the 3rd lowest capital cost. The option performs 3rd best out of 11 in CBA terms
CONCLUSION	
The overall conclusion is that option F6.2 complies more strongly with the guiding principles than most other pipeline options (F4.1, F4.2, F7.1, G1.1 and G1.3) by requiring less new pipeline (GP3) but not as well as options F6.1 or F6.6. It also performs more strongly than all but two options in respect of GP4, having a relatively lower capital cost (3rd lowest) and better CBA outcome (3rd best). This is a longer route (GP3) and poorer performing in terms of capital cost and CBA performance (GP4) than Option 6.1. Whilst this option would avoid routeing through the Cotswolds AONB unlike option F6.1, there have been previous pipelines routed through the AONB suggesting there may be some capacity to absorb change which reduces the differential with F6.1 in terms of compliance with GP5 and GP6. There remain some as yet unresolved technical and operational challenges to uprating with MOP below equipment classification limits under ongoing review by National Grid however these are expected to be able to be resolved.	

OPTION APPRAISAL SUMMARY TABLE (OAST) F6.6

Option	Option Description	Option Elements (in sequential order if part solutions possible)	Extent to which elements achieve customer requirement (if part solution possible)
F6.6	**Below class limit MOP uprating parts of network with network upgrade to achieve gas flow northeastwards with 11km new pipeline, and various compressor modifications**	**Technical Uprating** **CE1 - Compressor mods at Felindre** **CE2 - Wormington to Honeybourne 9km pipeline** **CE4 - Churchover comp mods and 2km pipeline duplication** **CE7 - Mods to Wormington compressor** **UE1 – Below class limit MOP uprating of feeder 28 from Felindre to Three Cocks assumed that design by analysis with existing infrastructure able to accommodate** **UE2 – Below class limit MOP uprate from Milford Haven to Felindre.** **UE3 - Requires PRS extensions at Blackbridge and Cilfrew** **UE4 - Assume south hook and dragon can achieve higher pressure requirement**	**Meets PARCA requirement**

ENVIRONMENT

Sub-category	Constraints and Opportunities	Main Potential Impacts (adverse and beneficial)	Likely Mitigation Requirements	Residual Impacts and Implications	Summary and Conclusions
Biodiversity Considerations	There are no statutory designations associated with this Strategic Option. There are areas of ancient woodland and a number of veteran trees within the search areas for common elements 1, 2 and 7 and unique element 4.	During the construction phase there is the potential for direct effects on ancient woodland and veteran trees depending on where the pipeline is routed and infrastructure is sited. There may also be indirect effects associated with pollution and construction dust.	It is assumed that ancient woodland and veteran trees could be avoided through careful routing and siting of new permanent infrastructure. Best practice construction methods would also need to be followed.	There would be no adverse residual effects.	Effects on ancient woodland and veteran trees could be avoided through careful routing of the new pipeline and new permanent above ground infrastructure. It is considered that biodiversity is not a relevant decision-making factor for this Strategic Option.
Physical Environment Considerations (Geological, Water, Air Quality, Noise)	There are a number of physical environment features within the search areas for the Strategic Option, including many Main Rivers, ordinary watercourses, areas within the floodplain (e.g. flood zones 2 and 3), Air Quality Management Areas (AQMA) and Noise Important Areas. There are no Source Protection Zones (SPZs), geological SSSIs or geoparks. One Main River crossing would be required for common element 2; Badsey Brook. In addition, three ordinary watercourse crossings could not be avoided. One Main River crossing would be required for common element 4: River Swift. The Canal Feeder ordinary watercourse could not be avoided.	For this Strategic Option a minimum of two Main River crossings and four ordinary watercourse crossings would be required. Therefore there is a pollution risk associated with a new pipeline within the common element 2 and 4 search area to rivers. There may also be effects associated with flood risk due to the swaths of areas of flood risk 2 and 3 within the common element 2 and 4 search area. Air quality effects during construction are likely to be limited to construction dust effects. However, there may be effects associated with NO2 emissions from construction vehicles on the AQMA. There may also be effects associated with noise from construction sites and vehicles on the noise important areas.	Where features of the water environment cannot be avoided, specific trenchless construction methods could be used to minimise effects. Other specific construction techniques and control measures could be implemented to reduce / minimise effects on the water environment and air quality. Consent from the Environment Agency would be required for works in the floodplain and crossing a watercourse. Works within Flood Zones would require a flood risk assessment. Sensitive routeing of construction traffic could be used to avoid / minimise any effects on AQMAs and Noise Important Areas.	Where features of the water environment cannot be avoided, specific trenchless construction methods could be used to minimise effects. Other specific construction techniques and control measures could be implemented to reduce / minimise effects on the water environment and air quality. Consent from the Environment Agency would be required for works in the floodplain and crossing a watercourse. Works within Flood Zones would require a flood risk assessment. Sensitive routeing of construction traffic could be used to avoid / minimise any effects on AQMAs and Noise Important Areas.	Adopting sensitive construction techniques at river crossings and ensuring appropriate controls are in place when working in areas close to Main Rivers and ordinary watercourses would ensure effects to the water environment are minimised. Residual effects on the AQMA and noise important areas are likely to be negligible following mitigation.
Landscape and Visual Considerations	There are two very small parts of the Cotswolds AONB adjacent to the common element 2 search area (pipeline from Wormington to Honeybourne). The Pembrokeshire National Trail is located approximately 200m to the west of the Blackbridge AGI. There are no National Parks, World Heritage Sites or Biosphere Reserves associated with the Strategic Option.	During construction phase there is the potential for indirect adverse effects on landscape character and visual amenity of the AONB depending upon the location of the new infrastructure proposed as part of common element 2 and views of the works from elevated locations. However, following construction the pipeline would be buried and therefore long-term landscape and visual effects would be very limited. There is the potential for direct and indirect effects on the Pembrokeshire National Trail depending on the works proposed at Blackbridge AGI.	Land take within the AONB could be avoided through careful siting and routeing owing to the limited interaction of the AONB within the common element 2 search area. Good practice during construction would help to minimise any indirect effects. In addition, planting around the potential new pig trap at Wormington would provide some visual screening and minimise any indirect effects over time on the AONB if required. Avoiding the Pembrokeshire National Trail would avoid direct effects on this asset. Careful siting of works at the Blackbridge AGI would minimise indirect effects.	Residual effects on the AONB as a result of a new pipeline and infrastructure at Honeybourne and Wormington within the common element 2 search area would be dependent upon where the works are located. However, through careful siting/routeing it should be possible to minimise these effects as far as possible post construction and in the long-term. There are unlikely to be any significant adverse effects once the pipeline is operational as the infrastructure would be buried. There would be limited residual effects on the Pembrokeshire National Trail.	There is the potential for short-term indirect adverse effects during construction on the Cotswolds AONB, depending on visibility from elevated locations of the construction works associated with common element 2. It is assumed effects could be minimised / avoided through careful siting / routeing. There would be no long-term / operational landscape and visual amenity effects.

OPTION APPRAISAL SUMMARY TABLE (OAST) F6.6

		No potential effects identified for other common and unique elements.	No mitigation proposed for any other common and unique elements.	No other residual effects identified for any other common and unique elements.	
Historic Environment Considerations	Within the search area for this Strategic Option there is one Scheduled Monument and 87 Listed Buildings (many of which are Grade I and II*). There are no Registered Park and Gardens or Registered Battlefields.	There is the potential for direct physical effects on designated heritage assets; a Scheduled Monument and 87 Listed Buildings. There is also the potential for effects on the setting of these heritage assets during construction. Long-term operational impacts are unlikely as the pipeline between Wormington and Honeybourne would be buried and works at Wormington and Honeybourne are likely to be limited in extent.	Through careful routeing it should be possible to avoid physical effects on high value designated heritage assets. During construction it may also be possible to minimise effects on the setting of heritage assets at a local scale through screening etc. Although effects on setting are considered a low risk issue owing to the distance of the Listed Buildings from the existing National Grid sites. Planting around the works required at Wormington and Honeybourne could provide visual screening and minimise effects over time on the setting of heritage assets.	Through careful routeing and siting to avoid direct physical impacts and the use of appropriate screening and planting it should be possible to reduce the risk of significant adverse heritage effects.	Whilst there are a high number of designated heritage assets associated with common element 2. Those present can be avoided through careful routeing and siting of the proposed infrastructure. Whilst there may be a risk of impacts to the setting of heritage assets during construction they would be temporary and in the long-term as planting re-establishes effects on heritage assets would be of negligible significance.
Overall Environment Summary	For the majority of environmental receptors it should be possible to mitigate effects to an appropriate level either through avoidance at the routing/siting stage, appropriate construction mitigation measures such as screening, completion of relevant studies such as Flood Risk Assessments and the implementation of their recommendations. Whilst there are areas of ancient woodland and veteran trees that could be affected it should be possible to avoid them. Similarly whilst there are a large number of designated heritage assets (Listed Buildings) associated with the potential pipeline works avoidance should again be possible. There remains a residual risk associated with indirect effects on the setting of heritage assets during construction but they would not be long-term and would reduce as land is restored and any planting for site based works matures. There are potential water environment constraints associated with river crossings and working in the floodplain that will also require mitigation but this should reduce this risk to an acceptable level. The key national level constraint with significant NPS weight associated with this strategic option is the presence of the Cotswolds AONB. There is the potential during construction for indirect adverse effects on landscape character and visual amenity depending upon the location of new infrastructure and views of the works from elevated locations within the AONB. However, following construction the new pipeline would be buried therefore landscape and visual effects would be negligible. Owing to the distance of the existing Honeybourne AGI from the AONB (in excess of 2.5km) potential effects associated with works in this location are also unlikely and it is also considered unlikely that there would be significant effects on landscape and visual amenity as a result of the minor works at the Wormington gas site. Notwithstanding there will be further need for careful routing and siting work to minimise impacts on the AONB as far as possible and for appropriate screening as necessary.				

SOCIO-ECONOMIC

Sub-category	Constraints and Opportunities	Main Potential Impacts (adverse and beneficial)	Likely Mitigation Requirements	Residual Impacts and Implications	Summary and Conclusions
Socio-Economic Considerations	There is existing National Grid Infrastructure and a small area of National Trust Open and Inalienable Land within this Strategic Option. There are no Countryside and Rights of Way Open Access Land, National Cycle Routes, military sites or airports.	There is the potential to directly affect a very small area of National Trust Open and Inalienable Land within this Strategic Option. New infrastructure would also need to be appropriately routed in relation to existing National Grid infrastructure to ensure that existing safety standards can be maintained.	Through careful routeing of the pipeline and siting of the additional infrastructure required as part of common element 2 effects on the National Trust Open and Inalienable Land could be avoided.	No significant residual effects anticipated following the implementation of mitigation.	It is assumed effects to the socio economic features could be avoided / minimised through careful siting.
Overall Socio-economic Summary	There is one area of National Trust Open and Inalienable Land that could be affected by this strategic option. This receptor could be avoided through careful routeing. There is also National Grid Infrastructure that will have a bearing on the route selection to ensure that appropriate safety standards are maintained. There would be no effects during operation.				

CONSENTING & PROGRAMME

Overall Consent and Programme Summary	This option may not require DCO, given the nature of the physical works and length of new pipeline proposed, but is subject to environmental determination from BEIS. Alternative to that is the potential for pipeline works to be undertaken as permitted development and for any compressor upgrades and above ground infrastructure to be progressed by applications under TCPA. The option (assuming the project is not progressed as a DCO project) may allow capacity release earlier than that offered in the PARCA

TECHNICAL

Sub-category	Commentary for Option
Summary for Technical Complexity	Adverse. Overall this option has high technical complexity since it will require design by analysis to justify pressure uprating. National Grid has no experience of doing this however uprating viability assessments have shown innovative uprating proposals are viable, subject to fulfilment of structural reliability assessment, quantitative risk assessment and design by analysis studies.. Boundary control and/or High Integrity Pressure Protection would be required to protect parts of the network not uprated from additional pressure.
Summary for Delivery & Construction including Resource use and Waste	Beneficial. This option keeps physical intervention to an absolute minimum. Modifications could be done mostly without large outages since assets could be constructed with sites operational and only tied-in under outages. This option carries the highest confidence of delivery within the PARCA timescales.

OPTION APPRAISAL SUMMARY TABLE (OAST) F6.6	
Summary for Technology Issues	Adverse. Uprating is considered innovative. Structural reliability assessment and quantitative risk assessment of infringements would be required as part of the uprating proposals and, where appropriate, engineering interventions could be required to reduce risk to as low as reasonably practicable levels
Summary for Capacity Issues	Generally beneficial. This option achieves additional Milford Haven entry capability equivalent to the full requested capacity increase (PARCA) across the annual demand range. The pipe reinforcement is beneficial in all technical respects. The option as a whole is slightly detrimental in terms of network flexibility and resilience since it places a greater burden upon Feeder 28, whilst providing no redundancy. The pressure uprate also creates a challenge in terms of managing the impact of compressor trips, due to the large pressure drop
Summary for Network Efficiency / benefits (inc Energy Efficiency)	Neutral. Network efficiency would be very incrementally increased under normal operating conditions, since the 9km of pipeline reduced resistance to flow in the midlands. Commercial issues surrounding the requirement for both South Hook and Dragon to operate at higher pressure must be clarified before option is pursued further, but initial indications suggest modification scope is reasonable.
Overall Technical Summary Consolidating the above	Uprating viability assessments have shown innovative uprating proposals are viable, subject to fulfilment of structural reliability assessment, quantitative risk assessment and design by analysis studies. Technical complexity is high but overall infrastructure requirements are minimal and hence constructability is very high. The option is less favourable than other options in terms of technical complexity and technology issues, but require less new pipeline and other infrastructure than all other options
COST	
Overall Cost Summary	This option is the lowest capital cost option and is 1st (i.e. best performing) of 11 in CBA terms.
Conclusion	
The overall conclusion is that option F6.6 performs more strongly than all other options in terms of compliance with GP2 by maximising the use, extension and adaptation of existing infrastructure and minimising the need for new infrastructure. It complies more strongly with GP3 than all other pipeline options (F4.1, F4.2, F6.1, F6.2, F7.1, G1.1 and G1.3) by requiring less new pipeline. It also performs more strongly than all options in respect of GP4 having the lowest capital cost and best CBA performance and therefore provides the most economic and efficient solution for UK consumers. It doesn't perform quite as well as options for only new pipeline on technical complexity (GP7) but this is offset by greater compliance with GP5 and GP6 than those alternative pipeline only options. There remain some as yet unresolved technical and operational challenges to uprating with MOP below equipment classification limits under ongoing review by National Grid however these are expected to be able to be resolved.	

OPTION APPRAISAL SUMMARY TABLE (OAST) F7.1

Option	Option Description	Option Elements (in sequential order if part solutions possible)	Extent to which elements achieve customer requirement (if part solution possible)
F7.1	**New 125km onshore pipeline from Three Cocks to Alrewas (avoiding AONBs) via west and north of Birmingham to achieve gas flow northeastwards with various compressor modifications**	CE1 Compressor mods at Felindre UE1 -new approx 125km pipeline Three cocks to Alrewas routed to bypass AONB, Cannock Chase and B'Ham urban area. Requires Block Valve AGI's every 16km (25m by 25m) UE2 Mods at Alrewas to configure to existing compressors - no new land take - UE3 Mods for flow control at Three Cocks and for additional pig trap 50m by 50m "	**Meets PARCA Requirement**

ENVIRONMENT

Sub-category	Constraints and Opportunities	Main Potential Impacts (adverse and beneficial)	Likely Mitigation Requirements	Residual Impacts and Implications	Summary and Conclusions
Biodiversity Considerations	There are a number of statutory designated sites located within the search areas for this Strategic Option including the River Wye Special Area of Conservation (SAC), River Usk SAC, Cannock Extension Canal SAC, Rhos Goch SAC, Mynydd Epynt SAC, many Sites of Special Scientific Interest (SSSI), two National Nature Reserves (NNR), large areas of ancient woodland and many veteran trees. There are also three river crossings that cannot be avoided as part of unique element 1; River Wyre SAC / SSSI, the River Lugg SSSI and the River Teme SSSI. There are no Special Protection Areas (SPA) or Ramsar sites within the search areas for the Strategic Option.	Unique element 1 (new pipeline) has the potential to affect the River Wye SAC / SSSI, the River Lugg SSSI and the River Teme SSSI due to a direct loss of habitats within these sites together with indirect effects on potentially functionally linked land during construction. There is also the potential for these sites and their qualifying features to be affected by noise and vibration, pollution of land and water and general disturbance as a result of construction works. Unique element 3 has the potential to affect statutory designated sites dependent upon where the new pig trap is located. Potential effects were not recorded for other unique and common elements.	Specific construction methods such as Horizontal Directional Drilling (HDD) / trenchless techniques could be used to minimise effects on river crossings. Careful routing and siting to avoid sensitive features would minimise impacts. In particular ensuring a new pig trap (as proposed by unique element 3) is not located on or close to a SAC or SSSI would avoid effects on these receptors. No other specific mitigation identified.	Given the European importance of the River Wye (a SAC) which would need to be crossed as part of unique element 1 it would be necessary to demonstrate the project does not have an adverse effect on the integrity of the SACs qualifying features (most notably habitats and fish). Following the implementation of mitigation it is anticipated that biodiversity effects of a new pig trap within the unique element 3 search area could be reduced to an acceptable level through careful siting. Habitats Regulations Assessment (HRA) screening may be needed depending upon the location of the pig trap.	The River Wye SAC (River Lugg SSSI and River Teme SSSI) cannot be avoided when routing a pipeline within unique element 1. HRA Screening would be required. However, it is understood that effects could be reduced during construction through the use of trenchless crossing techniques such as HDD methods and early consultation with Natural England. There is a residual risk that direct effects on the Chasewater and Southern Staffordshire Coalfield Heaths SSSI could not be avoided owing to the limited options available and the proximity of settlements and the M6 toll. No significant effects are anticipated during operation.
Physical Environment Considerations (Geological, Water, Air Quality, Noise)	There are a number of physical environment features within the search areas for the Strategic Option including many Main Rivers, ordinary watercourses, Canals, areas of Flood Zone 2 and 3, Source Protection Zones (SPZ), an Air Quality Management Area (AQMA) in Wolverhampton, Fforest Fawr geopark and Noise Important Areas. Unique element 1 also crosses four Main Rivers; River Wye, River Lugg, River Teme and River Severn/Afon Hafren. There are other ordinary watercourses within the search area that would be unavoidable, these comprise: River Rea (part Main River and part ordinary watercourse) and Borle Brook. Three canals would also be unavoidable including, the Shropshire Union Canal, Staffordshire and Worcestershire Canal and Trent and Mersey / Coventry Canal.	A minimum of four Main River crossings, two ordinary watercourse crossings and three Canal crossings would be required for unique element 1 and many SPZs would need to be crossed. Unique elements 2 and 3 may also affect Main Rivers depending on where infrastructure is located. Therefore there is a pollution risk to rivers, canals and ground water supplies. There may also be effects associated with flood risk due to the areas of Flood Zones 2 and 3. Air quality effects during construction are likely to be limited to construction dust effects. However, there may be effects associated with NO2 emissions from construction vehicles on the AQMA. There may also be effects associated with noise from construction sites and construction vehicles on Noise Important Areas. Potential effects were not recorded for other unique and common elements.	Where watercourse crossings are required specific trenchless construction methods could be used to minimise effects. Other specific construction techniques and control measures could be implemented to reduce / minimise effects on the water environment and air quality. Sensitive routing of construction traffic could be used to avoid / minimise any effects on the Wolverhampton AQMA and Noise Important Areas. Consent from the Environment Agency or Natural Resources Wales would be required for works in the floodplain or crossing a watercourse and any works within flood zones would require a flood risk assessment. Careful siting would ensure modifications to Alrewas and the new pig trap are located outside Flood Zones 2 and 3. No other specific mitigation identified.	Adopting sensitive construction techniques at watercourse crossings and ensuring appropriate pollution controls are in place when working in areas that are SPZs and when working close to Main Rivers, ordinary watercourses and canals would ensure effects to the water environment are minimised, however adverse effects cannot be ruled out at this stage. Siting the modifications at Alrewas and the new pig trap away from sensitive features would avoid / minimise to acceptable levels effects on the physical environment. Residual effects on the AQMA and Noise Important Areas are likely to be negligible following mitigation.	A minimum of four Main River crossings, two ordinary watercourse crossings and three Canal crossings would be required for this option together with routing through flood zones 2 and 3 associated with them and many SPZs. The presence of Main Rivers, ordinary watercourses and areas of flood zones 2 and 3 throughout the unique elements mean that potentially significant construction stage effects cannot be ruled out at this stage. However, using specific trenchless construction methods for crossings would reduce effects during construction combined with completion of Flood Risk Assessments and implementation of appropriate mitigation. Therefore, the physical environment may be a material consideration in the selection of the Preferred Option where other options have markedly different number of crossings and / or extent of flood zones 2 and 3.

OPTION APPRAISAL SUMMARY TABLE (OAST) F7.1					
Landscape and Visual Considerations	Small parts of the Cannock Chase Area of Outstanding Natural Beauty (AONB), Shropshire Hills AONB, the Brecon Beacons National Park and Offas Dyke Path (a National Trail) are located within the search areas for this Strategic Option.	For unique element 1 during the construction phase there is the potential for localised direct and indirect adverse effects on landscape character and visual amenity on the Cannock Chase AONB and the Brecon Beacons National Park. There is also the potential for direct impacts on the Offa's Dyke Path. During operation there may be indirect impacts on landscape character and visual amenity associated with the AONB and National Park as a result of the Block Valve AGIs. Unique element 3 has the potential to affect statutory designated sites dependent upon where the new pig trap is located. Potential effects were not recorded for other unique and common elements.	Owing to the limited interaction of the AONB and the National Park within the unique element 1 search area it should be possible to minimise effects through careful routing and screening. The routing of a new pipeline within the unique element 1 search area would also cross Offa's Dyke Path. Therefore different construction techniques would need to be considered to minimise disruption. Careful routing and siting to avoid sensitive features would minimise impacts. In particular ensuring a new pig trap (as proposed by unique element 3) is not located on or close to the National Park. Planting around the Block Valve AGIs and pig trap would provide visual screening and minimise indirect effects over time on the National Park and AONB. No other specific mitigation identified.	Following the implementation of mitigation it is considered that construction effects could be reduced to not significant though careful routing and siting of infrastructure. During operation with planting and screening it is consider that effects could be reduced to negligible / minor adverse.	There are small areas of the Cannock Chase AONB and the Brecon Beacons National Park within unique element 1. However, through careful siting / routing these sensitive features could be directly avoided. This would result in limited effects on the AONB and National Park. Whilst there may be indirect effects on setting during construction dependent upon routing there would be no long term operation effects with appropriate siting and screening and so the policy tests of NPS EN-1 should be met.
Historic Environment Considerations	Within the search area for this Strategic Option there are many Scheduled Monuments, Registered Parks and Gardens, and Grade 1 and II* listed buildings. There are no Registered Battlefields within the search areas for the Strategic Option.	During construction there is the potential for direct physical effects on designated heritage assets; Scheduled Monuments, Listed Buildings and Registered Parks and Gardens. There is also the potential for effects on the setting of a large number of heritage assets. During operation unique elements 1, 2 and 3 may continue to effect the setting of heritage assets depending where they are sited / located. Potential effects were not recorded for other unique and common elements.	Through careful routing it should be possible to avoid many physical effects on high value designated heritage assets. During construction it may also be possible to minimise effects on the setting of heritage assets at a local scale through planting and screening etc. During operation planting around the Block Valve AGIs, pig trap and works at Alrewas would provide visual screening and minimise effects over time on the setting of any affected heritage assets. No other specific mitigation identified.	It may be possible to reduce physical direct adverse effects to negligible by avoiding heritage assets. However, owing to the number of heritage assets within the unique element 1 search area and unique element 3 search area there is risk that adverse residual effects on the setting of heritage assets may remain following the implementation of mitigation. Effects on the setting of heritage assets would remain during operation but may reduce over time as planting establishes for unique elements 1, 2 and 3.	NPS EN-1 states that avoidance of Scheduled Monuments and listed buildings should be a priority and substantial harm to or loss should be wholly exceptional. It is expected that the loss of heritage assets could be avoided. However, at this stage it cannot be confirmed that all effects on the setting on heritage assets particularly during construction could be ruled out for this Strategic Option. This is due to the number of assets within the search areas for unique elements 1, 2 and 3. It is expected that AGIs and permanent infrastructure could be sited away from sensitive sites and screened with planting - reducing effects to an acceptable level during operation.
Overall Environment Summary	There are a number of European and nationally important sites within the search areas for this strategic option that have the potential to be affected. Whilst it should be possible to avoid direct impacts on most SACs, ancient woodland, SSSIs and veteran trees all of which are given significant weight in NPS EN-1 there remains a risk to the River Wye SAC and SSSI together with the River Lugg SSSI and River Teme SSSI as these constraints would need to be crossed for the pipeline associated with Unique Element 1. Therefore HRA Screening would be required for the SAC and appropriate mitigation including HDD methods to cross all the watercourses combined with early consultation with Natural England to reduce potential construction effects. Direct effects on the large number of designated heritage assets that could be affected should be possible to avoid although there remains a risk of indirect setting effects during the construction phase. There would be circa six watercourse crossing (and three Canal crossings) and effects during construction on flood zones 2 and 3 which would require appropriate mitigation and assessment together with effects on Source Protection Zones. Whilst direct effects on the Cotswolds AONB and the Cannock Chase AONB should be avoided through routing there may be temporary effects on the setting of these features during construction.				
SOCIO-ECONOMIC					
Sub-category	**Constraints and Opportunities**	**Main Potential Impacts (adverse and beneficial)**	**Likely Mitigation Requirements**	**Residual Impacts and Implications**	**Summary and Conclusions**
Socio-Economic Considerations	There are many existing National Grid pipelines within the search area for the Strategic Option particularly around the existing facilities at Felindre, Alrewas and Three Cocks. In addition there are a number of National Cycle Routes that pass through the Strategic Option search areas and areas of National Trust Open and Inalienable Land, most of which lie with the search area for unique element 1. There are also areas of CRoW Access Land including a cluster of land located to the east and south east of Burntwood.	There is potential for direct effects on National Cycle Routes, CRoW Access Land and National Trust Open and Inalienable Land depending upon where the pipeline, AGIs, modifications and pig trap are located. There is also the potential for amenity effects on users of those sites during the construction phase. Existing National Grid infrastructure would have a bearing on route selection to ensure appropriate safety standards are maintained.	Careful routeing of the new pipeline and siting of modifications / AGIs / pig trap could avoid direct effects on the National Trust Open and Inalienable Land and the airfields and aerodromes. There would need to be diversions implemented to avoid impacts on three National Cycle Routes for works associated with unique element 1. Whilst a lot of the CRoW Open Access Land could be avoided there are a number of areas in the vicinity of Burntwood where there may be challenges posed by the presence of other	For most receptors the implementation of mitigation should reduce the risk of significant residual effects although there is a possibility that it may not be possible to avoid all CRoW land in the vicinity of Burntwood and so there may be some loss of land.	Through careful routeing and siting, National Trust Open and Inalienable Land, airfields and aerodromes can be avoided. It is assumed that the direct effects to National Cycle Routes could be mitigated to acceptable levels through diversions and careful construction techniques. Even with careful routeing there is a potential risk that some CRoW Open Access Land could be lost owing to the complexity of the constraints in the vicinity of the urban area of Burntwood and this issue should be considered in the decision-making process.

OPTION APPRAISAL SUMMARY TABLE (OAST) F7.1					
	There are also six airfields and aerodromes located within the unique element 1 search area.		designations (AONB and SSSIs) as well as extensive urban areas.		
Overall Socio-economic Summary	There are many existing National Grid pipelines within the search area for the Strategic Option particularly around the existing facilities at Felindre, Alrewas and Three Cocks. In addition there are a number of National Cycle Routes and areas of National Trust Open and Inalienable Land, most of which lie with the search area for unique element 1. There are also areas of CRoW Access Land including a cluster of land located to the east and south east of Burntwood. Potential effects include direct loss of land within the sites as well as effects on the amenity value of them during construction. Careful routeing of the new pipeline and modifications to AGIs etc could avoid direct effects on most receptors although there is potentially a challenge associated with avoiding impacts on the CRoW Open Access Land around Burntwood owing to the proximity of a number of other constraints in this area including AONB, SSSIs and urban areas and therefore there may be adverse residual effects. This needs to be considered in the decision-making process. There would also need to be diversions of three National Cycle Routes.				
CONSENTING & PROGRAMME					
Overall Consent and Programme Summary	The option will require DCO due to the pipeline length and anticipated environmental effects. There is also potential for additional complexity to consenting due to the possible presence of sections of new pipeline in both England and Wales (presence in the former is certain and possible in the latter depending on connection point and route alignment). Additional challenge from stakeholders can be expected due to the extent of physical works some of which is within proximity to the Brecon Beacons National Park as well as to two AONBs. The coalescence of designations and urban areas to the north of Birmingham also increase the potential for stakeholder challenge and present a relatively higher risk to programme than other options which require less than half the length of new pipeline. This means that there is a risk that capacity release will be later than that offered in the PARCA				
TECHNICAL					
Sub-category	**Commentary for Option**				
Summary for Technical Complexity	Highly beneficial. This option represents a significant improvement in Operational Flexibility by introducing redundancy into the system.				
Summary for Delivery & Construction including Resource use and Waste	Highly adverse. Delivery and construction is very resource intensive and unlikely to be achieved within the PARCA contract timescales. Likely routes in vicinity of Birmingham city represent an extremely challenging construction environment with many complex obstacle crossings and extremely constrained routes due to building proximity distances. Substantial reconfiguration required at Alrewas, but associated complexity is manageable.				
Summary for Technology Issues	Beneficial. Option does not require innovative technology, does not present unusual operational or maintenance risk and would be configured, maintained and safely operated in a similar way to the existing NTS.				
Summary for Capacity Issues	Generally beneficial. This option achieves additional Milford Haven entry capability equivalent to the full requested capacity increase (PARCA) across the annual demand range and goes well beyond this at low demands. The option as a whole is beneficial in terms of network flexibility and resilience since it reduces reliance on the existing network between Felindre and Wormington (and on Wormington compressor itself). The option provides a strong basis for further increases in capability in the future due to the extra capacity the new feeder offers and the opportunity to move gas to the centre of the network.				
Summary for Network Efficiency / benefits (inc Energy Efficiency)	Beneficial. Post-construction, this represents a straightforward and sustainable system to operate and maintain.				
Overall Technical Summary Consolidating above	Overall Beneficial. Whilst very challenging to construct, this option differentiates itself from the others by creating redundancy in the system and an alternative route for gas flows. This would improve system access in the future, create a more robust network and provide the foundation for further incremental capacity improvements if flows from South Wales endure. However, the pipeline would be extremely challenging to construct, particularly through the constrained areas around Birmingham, which reduces overall assessment. It is also one of the longest pipeline routes and therefore a greater resource intensity to deliver.				
COST					
Overall Cost Summary	The option is the higher cost option at around seven times the capital cost of option F6.6 which has the lowest capital cost. The option is 11th best out of 11 in CBA terms				
CONCLUSION					
The overall conclusion is that this option complies more poorly with the guiding principles compared with other options due to the combination of: a much longer route (GP3); lower re-use or adaptation of the existing NTS (GP2); potential residual effects on designated areas (GP5 and GP6); higher capital costs and poorer CBA (GP4) and substantial complexity arising from construction challenges (GP7).					

OPTION APPRAISAL SUMMARY TABLE (OAST) G1.1

Option	Option Description	Option Elements (in sequential order if part solutions possible)	Extent to which elements achieve customer requirement (if part solution possible)
G1.1	**New 95km onshore pipeline to achieve gas flow eastwards. Comprises 69km onshore pipeline Wormington to Aylesbury plus 26km of other new pipeline Tirley to Wormington.**	**List summary of elements in sequential order** **1) Felindre mods (CE1)** **2) Tirley to Wormington 26km pipeline (CE2)** **3) 69km Wormington to Aylesbury UE1** **5) Mods at Wormington (CE7) with Steppingley and Huntingdon reconfiguration**	**Meets PARCA Requirement**

ENVIRONMENT

Sub-category	Constraints and Opportunities	Main Potential Impacts (adverse and beneficial)	Likely Mitigation Requirements	Residual Impacts and Implications	Summary and Conclusions
Biodiversity Considerations	There are a number of statutory environmental designations located within the Strategic Option search area. These include Dixton Wood Special Area of Conservation (SAC) as well as 18 Sites of Special Scientific Interest (SSSI), large areas of ancient woodland and many veteran trees. There are no possible SACs, candidate SACs, Special Protection Areas (SPA), Potential SPAs, Ramsars or proposed Ramsars within the Strategic Option search area.	Common element 3 (a pipeline between Tirley and Wormington) has the potential to affect the Dixton Wood SAC and eight SSSIs. Unique Element 1 has the potential to affect 10 SSSIs. These effects could occur due to a direct loss of habitats within these sites and/or indirect effects on potentially functionally linked land during construction. There is also the potential for these sites and their qualifying features to be affected by noise and vibration, pollution of land and water and general disturbance as a result of construction works. No potential effects recorded for other common or unique elements. There are unlikely to be any significant effects during operation.	Careful routeing and siting of the pipeline and Above Ground Installations (AGIs) would avoid / reduce effects to sensitive features. Best practice construction methods would need to be followed to ensure the risk of disturbance or damage to species and habitats are minimised. Trenchless crossing techniques may need to be used. Construction activities would need to be confined to a defined working area and appropriate pollution control measures implemented to reduce effects to air, noise and water.	Through careful siting of the proposed new infrastructure and the implementation of mitigation measures, the effects on statutory designated sites could be avoided / reduced to an acceptable level. For common element 3 , Habitats Regulations Assessment (HRA) Screening is likely to be required to determine if there would be any likely significant effects on the Dixton Wood SAC once further detail is known.	Effects during construction on statutory sites (one SAC and 18 SSSIs) could be avoided through careful routeing and siting together with implementing suitable construction mitigation measures such as controlling dust and pollution, particularly for common element 3 and unique element 1. It is considered that with mitigation in place biodiversity could meet the tests within NPS - EN1. No significant effects are anticipated during operation.
Physical Environment Considerations (Geological, Water, Air Quality, Noise)	There are a number of physical environmental features within the search areas for the Strategic Option, including many Main Rivers, ordinary watercourses, areas within the floodplain (e.g. Flood Zones 2 and 3), Air Quality Management Areas (AQMAs), geological Sites of Special Scientific Interest (SSSI) and Noise Important Areas. One Main River crossing would be required for common element 3: Afon Hafren / River Severn. In addition the River Isbourne extends throughout common element 3 and could not be avoided. Part of this watercourse is a designated Main River and part ordinary watercourse. Two Main River crossings would be required for unique element 1 - River Ray and River Cherwell. The Oxford Canal Feeder could also not be avoided. However, many more may need to be crossed depending upon routeing. There are six Source Protection Zones	A minimum of four Main River crossings, one canal crossing and SPZ crossing would be required for this Strategic Option. Therefore there is a pollution risk associated with the new pipelines and effects to flood risk associated with the temporary loss of floodplain during construction within common elements 3 and unique element 1. Air quality effects during construction are likely to be limited to construction dust effects. However, there may be effects associated with NO2 emissions from construction vehicles on the AQMA. There may also be effects associated with noise from construction sites and construction vehicles on Noise Important Areas.	Where river crossings are required specific trenchless construction methods could be used to minimise effects. Other specific construction techniques and control measures could be implemented to reduce / minimise effects on the water environment and air quality. Routeing would need to avoid geological SSSIs. Sensitive routeing of construction traffic could be used to avoid / minimise any effects on AQMAs and Noise Important Areas. Consent from the Environment Agency would be required for works in the floodplain or crossing a watercourse. Any works within flood zones would require a flood risk assessment.	Adopting sensitive construction techniques at river crossings and ensuring appropriate pollution controls are in place when working close to Main Rivers, SPZs and in flood zones would ensure effects to the water environment are minimised. Residual effects on the AQMAs, Noise Important Areas, and geological SSSIs are likely to be negligible following mitigation.	The Strategic Option would require a minimum of four Main River crossings and would pass through many areas of flood zones 2 and 3, and an area of SPZ. The presence of Main Rivers, ordinary watercourses and areas of flood zones 2 and 3 throughout the common element 3 and unique element 1 mean that potentially significant construction stage effects cannot be ruled out at this stage. However, through the adoption of proven mitigation measures (including the use of trenchless methods) and early consultation with the Environment Agency and satisfying the tests outlined in NPS EN-1 effects during construction could be mitigated. Therefore the physical environment may be a material consideration in the selection of the Preferred Option where other options have markedly different number of crossings or area of extent of flood zones 2 / 3.

OPTION APPRAISAL SUMMARY TABLE (OAST) G1.1					
	within the unique element 1 search area, two of which are unavoidable.				
Landscape and Visual Considerations	The Cotswolds Area of Outstanding Natural Beauty (AONB) crosses common element 3 search area (Tirley to Wormington pipeline) once and unique element 1 (Wormington to Aylesbury) twice. The AONB could not be avoided. The Cotswold National Trail crosses unique element 1 in its entirety and could not be avoided. Within the search area for this Strategic Option there are no World Heritage Sites or Biosphere Reserves.	Routeing a new pipeline proposed as part of common element 3 and unique element 1 would not be able to avoid the Cotswolds AONB which would have effects on landscape character and visual amenity during the construction phase. Whilst most of these effects would be during the construction phase and would continue until the land has been reinstated there would also be some potential for permanent effects associated with the presence of any new block values or AGIs associated with the new pipelines. Therefore, there would be potential direct effects on landscape character and visual amenity. Unique element 1 would also result in adverse effects on visual amenity for users of the Cotswolds Way National Trail.	It would not be possible to avoid the AONB within the common element 3 and unique element 1 search areas. Careful routing is recommended through areas of the AONB most able to tolerate change. AGIs could be sited outside of very sensitive sites and screening around permanent infrastructure provided e.g. planting. Unique element 1 would not be able to avoid the Cotswold National Trail. There would need to be appropriate diversions implemented.	Significant adverse residual effects on the Cotswolds AONB during construction could not be ruled out at this stage as routeing a new pipeline within common element 3 and unique element 1. Work would need to be undertaken at the routeing stage to identify a route that is potentially less sensitive and to minimise as far as possible the length of the pipeline within the AONB. Operational effects are unlikely to be significant following the careful siting of Block Valve AGIs and once land is re-instated and planting establishes / re-establishes. There would need to be engagement with relevant stakeholders during the routeing stage and to agree appropriate mitigation.	It would not be possible to avoid the Cotswolds AONB within the common element 3 search area. Therefore there is the potential for significant effects during construction. However, during operation, AGIs could be sited outside of very sensitive sites and screening around permanent infrastructure provided - reducing effects to an acceptable level. Landscape and visual should be considered a material factor in the selection of the Preferred Option as AONBs are afforded very high protection within NPS EN-1. The NPS states that consent in these areas [is permitted] in exceptional circumstances. Whilst there are also existing pipelines through the Cotswolds AONB (within common element 3) which may indicate there are areas that are more able to tolerate change, there is no precedent set within unique element 1 which may present a consenting risk.
Historic Environment Considerations	Within the search area for this Strategic Option there are 40 Scheduled Monuments, 1,887 Listed Buildings (many of which are Grade I and II*), two Registered Park and Gardens and one Registered Battlefield.	During construction, there is the potential for direct physical effects together with effects on the setting of designated heritage assets. During operation, there is the potential for permanent infrastructure to continue to affect the setting of heritage assets depending on where it is located.	Careful routeing and siting would avoid physical effects on designated heritage assets. In addition siting permanent infrastructure away from designated assets would reduce potential effects on their setting. Planting around permanent above ground infrastructure could provide visual screening and minimise effects over time on the setting of heritage assets.	Through careful routeing and siting, physical effects on designated heritage assets could be avoided. However, owing to the number of designated assets within the Strategic Option search areas there may be residual effects on the setting of heritage assets during construction. In the long-term and once operational the likelihood of significant setting effects is considered negligible although this would depend upon the final siting of above ground infrastructure in relation to heritage assets.	NPS EN-1 states that avoidance of Scheduled Monuments and listed buildings should be a priority and substantial harm to or loss should be wholly exceptional. It is expected that the loss of heritage assets could be avoided. However, at this stage it cannot be confirmed that all effects on the setting on heritage assets particularly during construction could be ruled out for this Strategic Option. This is due to the number of assets within the search areas for common elements 3 and unique element 1. Once operational it is assumed that any long-term effects could be minimised through careful siting and appropriate screening.
Overall Environment Summary	There are a number of European and nationally important sites for biodiversity, landscape and visual, water and historic environment within the search areas for this strategic option that have the potential to be affected. From a biodiversity perspective it is considered that through the routeing process it should be possible to avoid direct impacts on SACs, ancient woodland, SSSIs and veteran trees all of which are given significant weight in NPS EN-1. However, there remains a potential indirect effect to a European Site associated with common element 3 that may require further consideration at routing/siting and HRA Screening. For this strategic option it would not be possible to avoid the Cotswolds AONB for the works associated with common element 3 and unique element 1 (pipelines). Significant lengths of the pipeline would need to be routed through this national level designation. Whilst there is scope to minimise effects through careful routeing and appropriate screening of Above Ground Infrastructure, and there are existing pipelines within parts of the AONB which suggests that some areas may be more able to tolerate change/disruption, this is not necessarily the case for some of all areas of the AONB affected by this option. It is considered that this potential level of impact, albeit largely short-term, should be considered as a material factor in the selection of the Preferred Option as AONBs are afforded very high protection within NPS EN-1. There are a large number of heritage assets that it should be possible to avoid during routeing although there may remain risks to setting during construction and potentially once operational dependent upon the location of above ground assets in relation to designated heritage receptors. Whilst there are significant areas of Flood Zone 2 and 3 and a large number of river crossings (a minimum of four for this option) that could generate significant adverse effects during construction, mitigation should reduce these risks to an acceptable level.				
SOCIO-ECONOMIC					
Sub-category	**Constraints and Opportunities**	**Main Potential Impacts (adverse and beneficial)**	**Likely Mitigation Requirements**	**Residual Impacts and Implications**	**Summary and Conclusions**
Socio-Economic Considerations	There are many existing National Grid pipelines within the search area for the Strategic Option particularly around Wormington gas site. In addition, there are a number of areas of Countryside and Rights of Way Act (CRoW) Open Access Land and National Trust Inalienable and Open Land and National Cycle Routes.	There is the potential to directly affect CRoW land, National Cycle Routes, National Trust Open and Inalienable Land depending upon where new infrastructure is sited and users of that land during construction. New infrastructure would also need to be appropriately routed in relation to existing National Grid infrastructure to ensure existing safety standards can be maintained. Once the scheme is operational there would	Careful routeing and siting of the new infrastructure would minimise effects to socio-economic receptors.	No significant residual effects anticipated following the implementation of mitigation.	It is assumed effects to the socio economic features could be avoided / minimised through careful siting. It is considered that socio-economics are not a relevant decision-making factor for this common element.

OPTION APPRAISAL SUMMARY TABLE (OAST) G1.1					
		be no significant effects as the effects would have been mitigated during construction.			
Overall Socio-economic Summary	There are a number of socio-economic receptors that could be affected particularly for the pipelines for Common Element 3 and Unique Element 1. These receptors include CRoW Land, Open Access Land and National Trust Inalienable Land as well as PRoW and National Cycle Routes. During construction there is the potential for direct effects on these assets as well as amenity effects on a number of their users. Effective routeing would mitigate the risk of direct effects and short-term construction effects on amenity could be reduced through effective construction practices. There is also National Grid Infrastructure that will have a bearing on the route selection to ensure that appropriate safety standards are maintained. There would be no effects during operation.				
CONSENTING & PROGRAMME					
Overall Consent and Programme Summary	Due to the length of new pipeline and potential environmental effects the option will require an application for a DCO. Substantial stakeholder challenge can be anticipated for this option relative to other options with similar overall pipeline length due to the greater extent of construction required within the Cotswolds AONB. The option is nonetheless expected to allow the capacity release to be in line with that offered in the PARCA				
TECHNICAL					
Sub-category	**Commentary for Option**				
Summary for Technical Complexity	Beneficial. Provides additional operational flexibility and resilience by bridging across the centre of the network and creating an additional flow path. This may aid system access in the future by introducing redundancy				
Summary for Delivery & Construction including Resource use and Waste	Highly adverse. Very long length, long construction duration and high number of expected crossings reduce constructability of this option.				
Summary for Technology Issues	No significant technological issues perceived. The maintenance requirement is high but relatively straightforward. Neutral.				
Summary for Capacity Issues	Highly beneficial. Achieves the PARCA requirement whilst providing additional network resilience and a basis for further capacity increase, though by avoiding any reinforcements of feeder 28 it does increase reliance on a single feeder.				
Summary for Network Efficiency / benefits (inc Energy Efficiency)	Highly beneficial. Network efficiency and sustainability is high given the effective use of pipelines rather than reliance on compression power.				
Overall Technical Summary Consolidating the above	Low Technical complexity and absence of technology issues is highly beneficial. Similarly, network efficiency and capacity is also highly beneficial since the PARCA requirements are satisfied whilst reducing reliance on compression power, reducing restrictions to gas flows, and introducing system resilience through alternate flow paths and redundancy. Conversely, the construction and delivery aspects are highly adverse, predominantly a factor of the length of the pipeline. This option is considered less favourable than those associated with uprating with MOP below equipment classification limits (F6.1, F6.2 and F6.3) in terms of constructability since the total length of pipeline for the option is greater. It is also marginally less favourable than option F4.1 as the pipeline length is slightly longer for G1.1 Therefore, on balance, this option performs adversely.				
COST					
Overall Cost Summary	The option is around five times the capital cost of option F6.6 which has the lowest capital cost. The option is 9th best out of 11 in CBA terms				
Conclusion					
The overall conclusion is that in terms of compliance with the guiding principles this option complies more poorly than option F3.1. F3.2 and F3.3, F4.1, F4.2 and F6.1, F6.2 and F7.1 in respect of GP4 (costs and CBA performance). It performs less well than other options adopting a route through the Cotswolds AONB (F3.1, F4.1, F4.2, F6.1, G1.3) as a result of a greater length of new pipeline within the AONB (GP5 and GP6).					

OPTION APPRAISAL SUMMARY TABLE (OAST) G1.3

Option	Option Description	Option Elements	Extent to which elements achieve customer requirement (if part solution possible)
G1.3	**New 106km onshore pipeline to achieve gas flow eastwards. Comprises 71km onshore pipeline Honeybourne to Aylesbury plus 26km of other new pipeline Tirley to Wormington and plus 9km Wormington to Honeybourne.**	**1) Felindre mods (CE1)** **2) Wormington to Honeybourne 9km pipeline (CE2)** **3) Tirley to Wormington 26km pipeline (CE3)** **4) 71km Honeybourne to Aylesbury (UE1)** **5) Mods at Wormington with Steppingley and Huntingdon reconfiguration (CE7+)**	**Meets PARCA requirement - 163GWh/day**

ENVIRONMENT

Sub-category	Constraints and Opportunities	Main Potential Impacts (adverse and beneficial)	Likely Mitigation Requirements	Residual Impacts and Implications	Summary and Conclusions
Biodiversity Considerations	There are a number of statutory environmental designations located within the Strategic Option search area. These include Dixton Wood Special Area of Conservation (SAC) as well as 12 Sites of Special Scientific Interest (SSSI), large areas of ancient woodland and many veteran trees. There are no possible SACs, candidate SACs, Special Protection Areas (SPA), Potential SPAs, Ramsars or proposed Ramsars within the Strategic Option search area.	Common element 3 (a pipeline between Tirley and Wormington) has the potential to affect the Dixton Wood SAC and eight SSSIs. Unique Element 1 has the potential to affect four SSSIs. These effects could occur due to a direct loss of habitats within these sites and/or indirect effects on potentially functionally linked land during construction. There is also the potential for these sites and their qualifying features to be affected by noise and vibration, pollution of land and water and general disturbance as a result of construction works. No potential effects recorded for other common or unique elements. There are unlikely to be any significant effects during operation.	Careful routeing and siting of the pipeline and Above Ground Installations (AGIs) would avoid / reduce effects to sensitive features. Best practice construction methods would need to be followed to ensure the risk of disturbance or damage to species and habitats are minimised. Trenchless crossing techniques may need to be used. Construction activities would need to be confined to a defined working area and appropriate pollution control measures implemented to reduce effects to air, noise and water.	Through careful siting of the proposed new infrastructure and the implementation of mitigation measures, the effects on statutory designated sites could be avoided / reduced to an acceptable level. For common element 3, Habitats Regulations Assessment (HRA) Screening is likely to be required to determine if there would be any likely significant effects on the Dixton Wood SAC once further detail is known.	Effects during construction on statutory sites (one SAC and 12 SSSIs) could be avoided through careful routeing and siting together with implementing suitable construction mitigation measures such as controlling dust and pollution, particularly for common element 3 and unique element 1. It is considered that with mitigation in place biodiversity could meet the tests within NPS - EN1. No significant effects are anticipated during operation.
Physical Environment Considerations (Geological, Water, Air Quality, Noise)	There are a number of physical environmental features within the search areas for the Strategic Option, including many Main Rivers, ordinary watercourses, areas within the floodplain (e.g. Flood Zones 2 and 3), Air Quality Management Areas (AQMAs), geological Sites of Special Scientific Interest (SSSI) and Noise Important Areas. One Main River crossing would be required for common element 3: Afon Hafren / River Severn. In addition the River Isbourne extends throughout common element 3 and could not be avoided. Part of this watercourse is a designated Main River and part ordinary watercourse. Three Main River crossings would be required for unique element 1 - Badsey Brook, River Ray and River Cherwell. Three crossings of ordinary watercourses would also be required. The Oxford Canal Feeder could also not be avoided. However, many more may need to be crossed depending upon routeing. There are five Geological SSSIs within this Strategic Option comprising Alderton Hill Quarry, Beckford Gravel Pit in common element 3 search area, and Stratton Audley Quarries, Ardley Cutting and Quarry and Ardley Trackways in unique element 1	A minimum of four Main River crossings and one canal crossing would be required for this Strategic Option as well as a number of ordinary watercourse crossings. Therefore there is a pollution risk associated with the new pipelines and effects to flood risk associated with the temporary loss of floodplain during construction within common element 3 and unique element 1. Air quality effects during construction are likely to be limited to construction dust effects. However, there may be effects associated with NO2 emissions from construction vehicles on the AQMA. There may also be effects associated with noise from construction sites and construction vehicles on Noise Important Areas.	Where river crossings are required specific trenchless construction methods could be used to minimise effects. Other specific construction techniques and control measures could be implemented to reduce / minimise effects on the water environment and air quality. Routeing would need to avoid geological SSSIs. Sensitive routeing of construction traffic could be used to avoid / minimise any effects on AQMAs and Noise Important Areas. Consent from the Environment Agency would be required for works in the floodplain or crossing a watercourse. Any works within flood zones would require a flood risk assessment.	Adopting sensitive construction techniques at river crossings and ensuring appropriate pollution controls are in place when working close to Main Rivers, SPZs and in flood zones would ensure effects to the water environment are minimised. Residual effects on the AQMAs, Noise Important Areas, and geological SSSIs are likely to be negligible following mitigation.	The Strategic Option would require a minimum of four Main River crossings and would pass through many areas of flood zones 2 and 3. The presence of Main Rivers, ordinary watercourses and areas of flood zones 2 and 3 throughout the common element 3 and unique element 1 mean that there is a risk of construction stage effects. However, through the adoption of proven mitigation measures (including the use of trenchless methods) and early consultation with the Environment Agency and satisfying the tests outlined in NPS EN-1 effects during construction could be mitigated. Therefore the physical environment may be a material consideration in the selection of the Preferred Option where other options have markedly different number of crossings or area of extent of flood zones 2 / 3.

OPTION APPRAISAL SUMMARY TABLE (OAST) G1.3

	search area. There are 27 Noise Important Areas within this Strategic Option. There is one Air Quality Management Area within this Strategic Option. There are 25 historic landfills within this strategic option and four registered waste sites.				
Landscape and Visual Considerations	The Cotswolds Area of Outstanding Natural Beauty (AONB crosses common element 3 search area (Tirley to Wormington pipeline) once and unique element 1 (Wormington to Aylesbury) once. The AONB could not be avoided. The AONB partially intersects common element 2 twice and unique element 1 once. Within the search area for this Strategic Option there are no World Heritage Sites, National Parks, National Trails or Biosphere Reserves.	Routeing a new pipeline proposed as part of common element 3 and unique element 1 would not be able to avoid the Cotswolds AONB. Therefore there is the potential for direct adverse effects within the AONB on its landscape character, tranquillity and visual amenity resulting from the loss of field boundary features, disruption to farmland and the noise from construction activities. Construction activities would be visible from both properties and Public Rights of Way. Whilst most of these effects would be during the construction phase and would continue until the land has been reinstated there would also be some potential for permanent effects associated with the presence of any new block values, AGIs associated with the new pipelines and in the installation of permanent red and white marker poles.	It would not be possible to avoid the AONB within the common element 3 and unique element 1 search areas. The temporary land take and working area within the AONB required to install the pipe should be kept to a minimum and reinstated as soon as possible. Careful construction techniques and routeing through areas of the AONB most able to tolerate change would be required to minimise effects on the special qualities of the AONB as far as possible. Siting of AGIs and construction compounds within or immediately adjacent to the AONB should be avoided. Night-time working should be avoided to prevent light and noise pollution.	Significant adverse residual effects on the Cotswolds AONB during construction could not be ruled out at this stage. Work would need to be undertaken at the routeing stage to identify a route that is potentially less sensitive and to minimise as far as possible the length of the pipeline within the AONB. Operational effects are unlikely to be significant following the careful siting of Block Valve AGIs and once land is re-instated and planting establishes / re-establishes. There would need to be engagement with relevant stakeholders during the routeing stage and to agree appropriate mitigation.	There is the potential for adverse residual effects on the Cotswolds AONB arising from physical works of laying a pipeline. Temporary land take and the working area within the AONB should be kept to a minimum and reinstated as soon as possible. Careful siting of construction compounds outside and away from the AONB boundary would limit residual effects. After construction, there may be short-term effects on the AONB resulting from views of the reinstatement works in the short-term as planting requires time to mature. Residual effects are likely to result from the permanent red and white marker poles that are required to be installed to mark the location of the gas pipeline. Landscape and visual should be considered a material factor in the selection of the Preferred Option as AONBs are afforded very high protection within NPS EN-1. The NPS states that consent in these areas [is permitted] in exceptional circumstances. Whilst there are also existing pipelines through the Cotswolds AONB (within common element 3 and unique element 1) which may indicate there are areas that are more able to tolerate change.
Historic Environment Considerations	Within the search area for this Strategic Option there are 28 Scheduled Monuments, 2,281 Listed Buildings (many of which are Grade I and II*), eight Registered Park and Gardens and one Registered Battlefield.	During construction, there is the potential for direct physical effects together with effects on the setting of designated heritage assets. During operation, there is the potential for permanent infrastructure to continue to affect the setting of heritage assets depending on where it is located.	Careful routeing and siting would avoid physical effects on designated heritage assets. In addition siting permanent infrastructure away from designated assets would reduce potential effects on their setting. Planting around permanent above ground infrastructure could provide visual screening and minimise effects over time on the setting of heritage assets.	Through careful routeing and siting, physical effects on designated heritage assets could be avoided. However, owing to the number of designated assets within the Strategic Option search areas there may be residual effects on the setting of heritage assets during construction. In the long-term and once operational the likelihood of significant setting effects is considered negligible although this would depend upon the final siting of above ground infrastructure in relation to heritage assets.	NPS EN-1 states that avoidance of Scheduled Monuments, Listed Buildings, Registered Battlefields and Conservation Areas should be a priority and substantial harm to or loss should be wholly exceptional. It is expected that the loss of heritage assets could be avoided. However, at this stage it cannot be confirmed that all effects on the setting on heritage assets particularly during construction could be ruled out for this Strategic Option. This is due to the number of assets within the search areas for common elements 3 and unique element 1. Once operational it is assumed that any long-term effects could be minimised through careful siting and appropriate screening.

OPTION APPRAISAL SUMMARY TABLE (OAST) G1.3

Overall Environment Summary	There are a number of European and nationally important sites for biodiversity, landscape and visual, water and historic environment within the search areas for this strategic option that have the potential to be affected. From a biodiversity perspective it is considered that through the routeing process it should be possible to avoid direct impacts on SACs, ancient woodland, SSSIs and veteran trees all of which are given significant weight in NPS EN-1. However, there remains a potential indirect effect to a European Site associated with common element 3 that may require further consideration at routeing/siting and HRA Screening. For this strategic option it would not be possible to avoid the Cotswolds AONB for the works associated with common element 3 and unique element 1 (pipelines). Significant lengths of the pipeline would need to be routed through this national level designation. Whilst there is scope to minimise effects through careful routeing and appropriate screening of Above Ground Infrastructure, and there are existing pipelines within parts of the AONB which suggests that some areas may be more able to tolerate change/disruption, this is not necessarily the case for some of all areas of the AONB affected by this option. It is considered that this potential level of impact, albeit largely short-term, should be considered as a material factor in the selection of the Preferred Option as AONBs are afforded very high protection within NPS EN-1. There are a large number of heritage assets that it should be possible to avoid during routeing although there may remain risks to setting during construction and potentially once operational dependent upon the location of above ground assets in relation to designated heritage receptors. Whilst there are significant areas of Flood Zone 2 and 3 and a large number of river crossings (a minimum of four for this option) that could generate significant adverse effects during construction, mitigation should reduce these risks to an acceptable level.

SOCIO-ECONOMIC

Sub-category	Constraints and Opportunities	Main Potential Impacts (adverse and beneficial)	Likely Mitigation Requirements	Residual Impacts and Implications	Summary and Conclusions
Socio-Economic Considerations	There are many existing National Grid pipelines within the search area for the Strategic Option particularly around Wormington gas site. In addition there are five areas of Countryside and Rights of Way Act Open Access Land and and one area of National Trust Inalienable and Open Land and National Cycle Routes.	There is the potential to directly affect CRoW land, National Cycle Routes, National Trust Open and Inalienable Land depending upon where new infrastructure is sited and users of that land during construction. New infrastructure would also need to be appropriately routed in relation to existing National Grid infrastructure to ensure that existing safety standards can be maintained. Once the scheme is operational there would be no significant effects as the effects would have been mitigated during the construction phase.	Careful routeing and siting of the new infrastructure would minimise effects to socio-economic receptors.	No significant residual effects anticipated following the implementation of mitigation.	It is assumed effects to the socio economic features could be avoided / minimised through careful siting. It is considered that socio-economics are not a relevant decision-making factor for this common element.
Overall Socio-economic Summary	There are a number of socio-economic receptors that could be affected particularly for the pipelines for Common Element 3 and Unique Element 1. These receptors include CRoW Land, Open Access Land and National Trust Inalienable Land as well as PRoW and National Cycle Routes. During construction there is the potential for direct effects on these assets as well as amenity effects on a number of their users. Effective routeing would mitigate the risk of direct effects and short-term construction effects on amenity could be reduced through effective construction practices. There is also National Grid Infrastructure that will have a bearing on the route selection to ensure that appropriate safety standards are maintained. There would be no effects during operation.				

CONSENTING & PROGRAMME

Overall Consent and Programme Summary	Due to the length of new pipeline the option will require an application for a DCO. Stakeholder challenge can be anticipated for this option relative to other options such as F6.1 and F4.1 due to the greater amount of construction required within the Cotswolds AONB. The option is expected to allow the capacity release to be in line with that offered in the PARCA

TECHNICAL

Sub-category	Commentary for Option
Summary for Technical Complexity	Beneficial. Provides additional operational flexibility and resilience by bridging across the centre of the network and creating an additional flow path. This may aid system access in the future by introducing redundancy
Summary for Delivery & Construction including Resource use and Waste	Highly adverse. Very long length, long construction duration and high number of expected crossings reduce constructability of this option.
Summary for Technology Issues	No significant technological issues perceived. The maintenance requirement is high but relatively straightforward. Neutral.
Summary for Capacity Issues	Highly beneficial. Achieves the PARCA requirement whilst providing additional network resilience and a basis for further capacity increase, though by avoiding any reinforcements of feeder 28 it does increase reliance on a single feeder.
Summary for Network Efficiency / benefits (inc Energy Efficiency)	Highly beneficial . Network efficiency and sustainability is high given the effective use of pipelines rather than reliance on compression power.
Overall Technical Summary Consolidating the above	**Low Technical complexity and absence of technology issues is highly beneficial. Similarly, network efficiency and capacity is also highly beneficial since the PARCA requirements are satisfied whilst reducing reliance on compression power, reducing restrictions to gas flows, and introducing system resilience through alternate flow paths and redundancy. Conversely, the construction and delivery aspects are highly adverse, predominantly a factor of the length of the pipeline. Therefore, on balance, this option performs adversely.**

OPTION APPRAISAL SUMMARY TABLE (OAST) G1.3	
COST	
Overall Cost Summary	The option is just over five and a half times the capital cost of option F6.6 which has the lowest capital cost. The option is 10th best out of 11 in CBA terms
CONCLUSION	
The overall conclusion is that in terms of compliance with the guiding principles this option complies more poorly than all options except F7.1 in respect of GP4 (costs and CBA performance) though does not have the same enduring energy costs as those options that require new compressor sites. It performs less well than most other options adopting a route through the Cotswolds AONB (F3.1, F4.1, F4.2, F6.1) as a result of a greater length of new pipeline within the AONB (GP5 and GP6) but is better in this respect than G1.1. It performs much less well than option F3.1, F3.2, F3.3, F6.1, F6.1 and F6.6 in terms of GP3 as it requires a considerably greater length of new pipeline to be constructed albeit is more compliant with GP7 by being less complex than uprating or new compression options	