2019

STRATEGIC ENVIRONMENTAL ASSESSMENT FOR THE IDENTIFICATION OF ENERGY CORRIDORS AS WELL AS ASSESSMENT AND MANAGEMENT MEASURES FOR THE DEVELOPMENT OF A PHASED GAS PIPELINE NETWORK IN SOUTH AFRICA

PART 2

Identification of Gas Pipeline Corridors

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PART 2. IDENTIFICATION OF THE PHASED GAS PIPELINE CORRIDORS

2.1 Introduction

This section of the report describes the process undertaken to identify the Phased Gas Pipeline Corridors. The Phased Gas Pipeline Corridors are founded on a set of nine phased gas pipeline routings, based on a conceptual Phased Gas Pipeline Network identified as part of the Operation Phakisa Offshore Oil and Gas Lab held from July to August 2014 (Refer to Figure 1). The SEA undertook to identify the Preliminary Corridors and refine them to ensure optimal placement in support of sustainable development, as well as the consideration of environmental and engineering constraints, together with the needs of authorities and key stakeholders. The approach undertaken for refining the corridors was developed in line with the context and study objectives described in Part 1 of the report. The approach is broadly based on an integrated spatial analysis of the best available data at the time.

As noted in Part 1 of this report, Phase 2 of the SEA Process consists of four tasks, which are focused on identifying and refining the Preliminary Corridors. Task 1 is the confirmation of the Preliminary Corridors, which are approximately 100 km wide, focused on linking specific supply and demand areas. As part of the process to refine and confirm the Preliminary Corridors, a series of meetings were held with key stakeholders and sectors, major gas users, and important business and government stakeholders. In addition, an initial Public Outreach was undertaken in this regard.

Task 2 involved negative mapping to determine areas of environmental sensitivities and engineering constraints in the context of gas transmission pipeline development. This phase included the completion of a wall to wall sensitivity delineation assessment to determine areas where gas pipeline infrastructure is likely to have a negative impact on the environment (environmental sensitivities) and areas where the environment and other linear infrastructure such as high voltage power lines and railway lines are likely to have a negative impact on gas pipeline infrastructure (engineering constraints). This mapping exercise indicates areas to be avoided (Very High sensitivity), areas which are sensitive for various reasons (High-Medium sensitivity), and areas which demonstrate no sensitivity (Low sensitivity).

Task 3 is referred to as the Corridor Refinement phase, and it entailed the refinement of the corridor positions further to minimise the occurrence of environmental sensitivities and engineering constraints inside of the corridors. This phase involves aggregating the digital information captured in Tasks 1 and 2 to determine optimal placement of the corridors from both an “opportunities” and “constraints” perspective i.e. where opportunities are maximized whilst ensuring suitable routing alternatives are available from a constraints perspective (both environmental and engineering). The outputs of this task were the Draft Refined Corridors and Draft Corridor Environmental Sensitivities Maps.

Task 4 includes the specialist studies, which were commissioned in order to review, validate and enhance the sensitivity delineations defined within the Draft Corridor Environmental Sensitivities Map. Based on the inputs from the specialists and key stakeholders, the preliminary corridors will be adjusted and finalised for consideration by Cabinet. The results of this task will be used to inform the final sensitivity maps as well as the Development Protocols, Generic Environmental Management Programme (EMPr), and Standards or Minimum Information Requirements.

2.2 Identification of Preliminary Corridors

As discussed in Part 1 of this report, pre-planned national gas transmission pipeline corridors are a means to accelerate gas development within South Africa. Linked to this, the Operation Phakisa Oceans Economy Lab mandated a State-Owned-Company to oversee the Phased Gas Transmission Pipeline Network planning under the A1 Workgroup, including:

- Engaging with the DEA in terms of commissioning the SEA for the Phased Gas Pipeline Network, the output of which is this current report (as well as other outputs described further in this document);
- Using the outcomes of the SEA to engage with land owners and secure servitudes as required;
- Undertaking Route Engineering studies for the various phases of the Phased Gas Pipeline Network, excluding sections already completed; and
- Engaging with Independent Power Producers (IPPs) and Eskom for gas offtake negotiations as power generation is the most likely anchor client for these projects.

Therefore, the Department of Energy (DoE), Department of Environmental Affairs (DEA) and Department of Public Enterprises (DPE), together with iGas, Transnet and Eskom, were mandated to oversee the implementation of the SEA Process. The identification of the initial Phased Gas Pipeline Network is discussed in the next section.

2.2.1 Initial Phased Gas Pipeline Network (Based on the Operation Phakisa Offshore Oil and Gas Lab – 2014)

As noted above, the Preliminary Corridors were identified based on the Phased Gas Pipeline Network as envisaged during the Operation Phakisa Offshore Oil and Gas Lab held between July and August 2014 (refer to Figure 1).

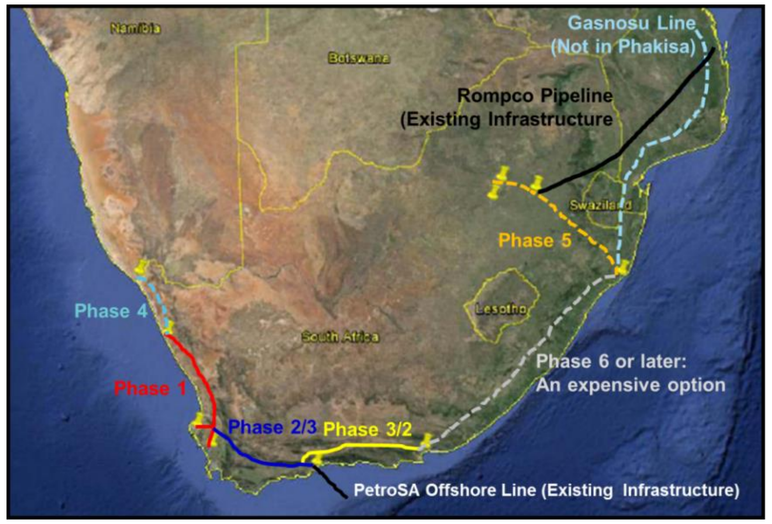


Figure 1: Proposed Phased Gas Pipeline Network for South Africa (Operation Phakisa Offshore Oil and Gas Lab, 2014)

The following Phases were <u>envisaged:</u>

- **Phase 1** extends from Abraham Villiers Bay to Saldanha/Atlantis, and would serve the Ibhubesi Gas field and other West Coast gas finds, transporting gas from the landing point in Abraham Villiers Bay down to Saldanha and the Ankerlig Power Station in Atlantis. The route engineering for this section has been completed. Sunbird Energy/Umbono, the Ibhubesi Gas field developer, has opted for a subsea pipeline to Saldanha or Grotto Bay. Should the landing point be located at Saldanha, then only the section of Phase 1 from Saldanha to Atlantis would be required. If the landing point is located at Grotto Bay, this phase will not be required until additional gas reserves are discovered off the West Coast of South Africa.
- **Phase 2** extends from Saldanha to Mossel Bay, and **Phase 3** extends from Mossel Bay to Coega. The technical pre-feasibility study has been completed. These two phases would transport gas to the PetroSA Gas-to-Liquid Refinery (GTLR) and the Gourikwa

Power Station in Mossel Bay. These phases are interchangeable, depending on where the gas will originate, i.e. if more and significant gas finds originate on the West Coast of South Africa then the pipeline from Saldanha to Mossel Bay is proposed to proceed first. However, if gas is found on the South Coast, then it will most likely land in Mossel Bay to service the existing PetroSA GTLR and Gourikwa markets. If the gas can service more than the Mossel Bay market, then it can service the Saldanha and Coega markets via Phases 2 and 3, the phasing being dependent on the commercial viability of each of those markets.

- **Phase 4** extends from Oranjemund (at the border of Namibia) to Abraham Villiers Bay, and was contemplated to bring in Kudu gas from Namibia to markets in South Africa. This Phase may proceed if positive and enabling agreements are reached. This is at conceptual stage.
- **Phase 5** links Richards Bay to the Gauteng market, unlocking opportunities for gas off the east coast of South Africa, specifically the Tugela Basin.
- **Phase 6** links Coega to Richards Bay. This Phase is expensive and unlikely to proceed, except into the long term future. This is primarily due to the significant length of the pipeline; the absence of major markets in-between; the fact that the gas markets will be developed at the point it is landed rather than transporting the gas to a market far away; and, the existence of better options to supply gas at either end, i.e., Coega and Richards Bay.
- The Gasnosu/Rovuma North-South pipeline that is conceptually considered to be from Palma in the north of Mozambique to Richards Bay in the south was not envisaged to be a part of this program because it did not enable offshore gas exploration in South Africa.

2.2.2 Revised Initial Phased Gas Pipeline Network (Subsequent to the 2014 Operation Phakisa Offshore Oil and Gas Lab)

The above description of the initial identification of the Phased Gas Pipeline Network emanated from the Operation Phakisa Oceans Economy Offshore Oil and Gas Lab held from July to August 2014. **However, shortly after the initiation of the A1 Workgroup, the State Owned Companies forming part of the A1 Workgroup, i.e. iGas, Transnet and Eskom were requested to ensure strategic alignment of the Phased Gas Pipeline Network. In addition, the Workgroup requested a prioritisation of the phases.**

The strategic alignment and re-numbering of the phases is presented in this section (Figure 2) and carried forward into the SEA. This alignment takes into consideration the current opportunities to supply indigenous gas to existing power plants (Ankerlig and Gourikwa Power Stations), the prospects for greenfield power plants in Saldanha, Richards Bay and Coega, as well as other developments outside of Operation Phakisa, i.e. the 2015 Electricity War Room; imported Liquefied Natural Gas (LNG); Karoo Shale Gas; and Eskom's targets for the Gasnosu (Mozambique North-South) pipeline in Mozambique.

Refer to Part 1 of the SEA Report for additional background, as well as for the information on the specific gas development projects referred to in the following sub-sections.

2.2.2.1 Phase 1a: Saldanha to Ankerlig

Given the limited reserves of the Ibhubesi Gas field, the pipeline between Saldanha/Grotto Bay and Ankerlig can be viewed as a strategically sensible precursor to LNG import at Saldanha if no additional gas is found on the West Coast. This is therefore targeted as Phase 1a of the Phased Gas Pipeline Network.

2.2.2.2 Phase 1b: Saldanha to Mossel Bay

Further exploration for gas reserves on the West Coast may be promoted with the forthcoming construction of the Sunbird Energy subsea pipeline for the development of the Ibhubesi gas field. Sunbird Energy/Umbono received Environmental Authorisation for this project on 3 August 2017. The Environmental Authorisation approved the following infrastructure 1) Offshore Production Facility; 2) Offshore Production Pipeline to Grotto Bay; 3) Offshore Production Pipeline to St. Helena Bay East; 4) Grotto Bay Southern Shore Crossing and Production Pipeline; 5) St Helena East Northern Shore Crossing and Production Pipeline; and 6) Onshore Gas Receiving Facility at Ankerlig. According to the Addendum Report compiled for the Sunbird Energy Ibhubesi Project, the St. Helena Bay East pipeline link to industrial activities in the region would depend on end-user locations[1]. Exploration on the South Coast has also been targeted, signalled by the arrival of the Total drill ship in South African waters late in 2018. Refer to Part 1 of the SEA Report for feedback on the gas find made by Total in February 2019. This would service the Mossel Bay and south coast markets. However, if these finds are large enough, they could also supply the Saldanha/Ankerlig/Cape Town market via a pipeline between Saldanha and Mossel Bay.

Alternatively, if gas finds (beyond Ibhubesi) off the West Coast are not forthcoming, LNG is anticipated in Saldanha. This will also target the Gourikwa Power Station and the PetroSA GTLR once the indigenous gas off the South Coast of South Africa is depleted and if there are no other gas opportunities off-shore of the South African coast. The pipeline between Saldanha and Mossel Bay is therefore prioritised as Phase 1b.

2.2.2.3 Phase 2: Mossel Bay to Coega

The gas pipeline from Mossel Bay to Coega adds to the linkages of industrial requirements for gas along the coastal areas. In the same way that Mossel Bay and Saldanha are target markets for South and West Coast gas, so is Coega, which can access the gas via a pipeline between Mossel Bay and Coega. Additionally, any gas off the coast of Coega can service the Mossel Bay and Saldanha markets. LNG imports at Coega, as contemplated in the 2016 DoE IPP Office Project Information Memorandum (PIM) could also service the Mossel Bay market. The pipeline between Mossel Bay and Coega is therefore prioritised as Phase 2.

2.2.2.4 Phase 3: Richards Bay to Secunda, and Gauteng

Richards Bay and Secunda are currently linked via the Lilly Pipeline owned by Transnet SOC Limited and operated by Sasol. However, this pipeline is currently operating at 70% capacity and may not be sufficient to supply the target markets in Gauteng should sufficient gas be found of the East Coast of South Africa or if LNG import to Richards Bay proceeds. The pipeline between Richards Bay and Secunda is therefore prioritised as Phase 3 to unlock gas off the east coast, particularly considering that, currently, ENI anticipates the start of a drilling program off the coast of Richards Bay in 2019. A final Environmental Impact Assessment (EIA) Report was compiled by ERM for the ENI project in December 2018 and submitted to PASA for decision-making. A decision is currently pending. Refer to Part 1 of the SEA Report for additional feedback on this project.

2.2.2.5 Phase 4: Mozambique (Southern Border) to Richards Bay

iGas has undertaken a conceptual evaluation on the Gasnosu / North-South pipeline in Mozambique from Palma to Maputo and extending down to Richards Bay. However, as the focus for Operation Phakisa is on infrastructure within South Africa's perimeter, the Gasnosu pipeline is noted as an opportunity but not considered within this work stream. Additionally, as one of the objectives of the A1 Workgroup is to negotiate and secure servitudes, the servitude for the Gasnosu pipeline will be a single negotiation with the Mozambican Government as there is no private land ownership in Mozambique. Hence, in order to support South Africa's aspiration for investment in the Gasnosu / North-South pipeline; focus should only be on the section of pipeline from Mozambique's southern border to Richards Bay.

It should be noted that this phase of the Phased Gas Pipeline Network is introduced to access Mozambican gas coming from the Rovuma Basin. If the pipeline proceeds, it is a way of introducing gas from an established gas reserve to South Africa and is therefore prioritised as Phase 4.

[1] CAA Environmental (2017). Proposed Development of the Ibhubesi Gas Project Final EIA Report: Addendum Report. Prepared for Sunbird Energy (Ibhubesi) (PTY) Ltd.

2.2.2.6 Phase 5: Abraham Villiers Bay to Saldanha and Ankerlig

From an Electricity War Room perspective, gas to Ankerlig was seen as a short to medium term (3 to 5 years) objective for gas supply. The gas pipeline from Saldanha to Ankerlig is a critical part of the ongoing supply of gas to Ankerlig. If no gas beyond the Ibhubesi gas field on the West Coast is commercially viable, LNG supply at Saldanha, either via a Floating Storage Regasification Unit (FSRU) or a land based terminal (LNGT), can be the long term solution. The overall solution for Ankerlig as described here could therefore be: 1) gas from the Ibhubesi Gas field in the medium term; and 2) LNG import at Saldanha in the long term, if additional gas is not discovered off the West Coast.

The pipeline between Abraham Villiers Bay and Ankerlig is therefore prioritised as Phase 5.

2.2.2.7 Phase 6: Abraham Villiers Bay to Oranjemund

With Namibia's intention to utilise Kudu Gas in country via a gas fired power station, there is currently limited opportunity for the monetisation of Kudu gas in South Africa. Nevertheless, with the power station contemplated, the Kudu gas field will be depleted within 20 years of commissioning. The opportunity then exists for the supply of gas from the possible West Coast gas opportunities or Saldanha LNG, whichever proves to be viable. Phase 5 of the Phased Gas Pipeline Network, partway to the Namibian border could be a part of that West Coast opportunity; hence the extension from Phase 5 to the Namibian border is prioritised as Phase 6. However, this decision can be revisited if the possibility develops to bring Kudu gas to South Africa.

2.2.2.8 Phase 7: Coega to Richards Bay

This phase contemplates transporting gas between Coega and Richards Bay, targeting markets at either end. For reasons discussed in Section 2.2.1 above, this is an expensive and unlikely scenario due to the significant length of the pipeline and the absence of substantial markets (except domestic use) between the two ends. However, should gas reserves prove to be large enough that it warrants linking these two markets, then the construction of this phase of the pipeline would be justified. Therefore, the Pipeline between Coega and Richards Bay is prioritised as Phase 7.

2.2.2.9 Shale Gas Corridor and Inland Corridor from Saldanha to Coega

As noted above, the Operation Phakisa Phased Gas Pipeline Network was initially contemplated to unlock offshore exploration in South African waters. However, the possibilities of shale gas in the Karoo are noted and, in consultation with the Project Partners, and relevant stakeholders, a link from the shale gas "sweet spot" in Beaufort West to Phase 2 was included in the SEA. The shale gas "sweet spot" referred to above was based on the findings of the CSIR Shale Gas SEA (2017).

Additionally, an inland corridor from Saldanha to Coega was also required and justified as the coastal corridor (i.e. Phase 2) was indicated by stakeholders to have a more intensive and complex land use than the inland option running through the Karoo. This inland corridor coincides with the shale gas area and can create potential synergies for shale gas utilisation. The inland corridor is also aligned with portions of the gazetted central and eastern EGI corridors. In addition to bypassing the high land usage area of the Phase 2 corridor, the inland corridor also links the shale gas area to the coast at Saldanha, Mossel Bay and Coega.

2.2.2.10 Rompco Pipeline Corridor

The Rompco Mozambique to Secunda Pipeline (MSP) crosses the South African – Mozambique border at Komatipoort and then proceeds in an almost straight line to Secunda in Mpumalanga Province. With the advent of Rovuma gas coming to the south of Mozambique via the Gasnosu North-South pipeline, the possibility of additional gas to Mpumalanga and Gauteng provinces via the Rompco MSP becomes a future possibility. However, except for a small percentage, the MSP essentially has no spare capacity, and additional capacity via additional loop lines would be required. The South African and Mozambican governments have been in discussions via the Bi-National Commission and on this basis; the DoE requested that the Rompco MSP corridor be included in the SEA to accommodate this expansion for additional tranches of gas from Mozambique to the Mpumalanga and Gauteng provinces.

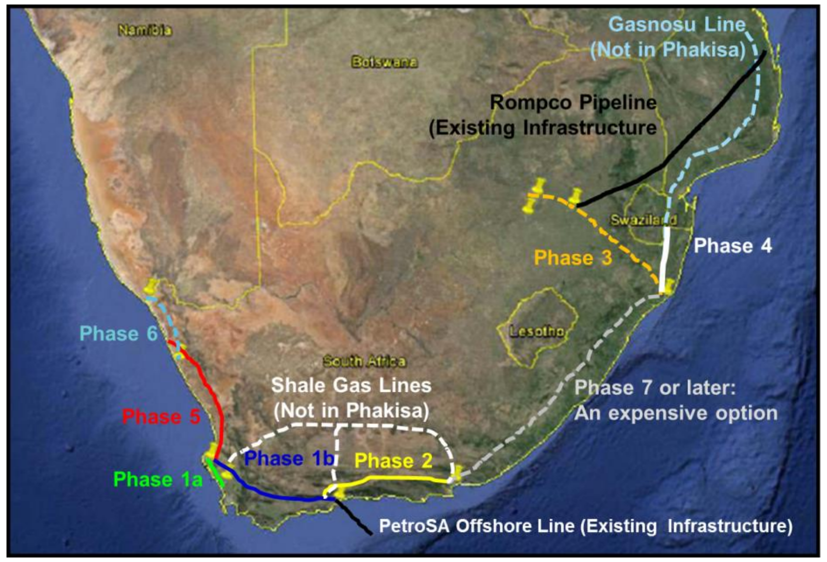
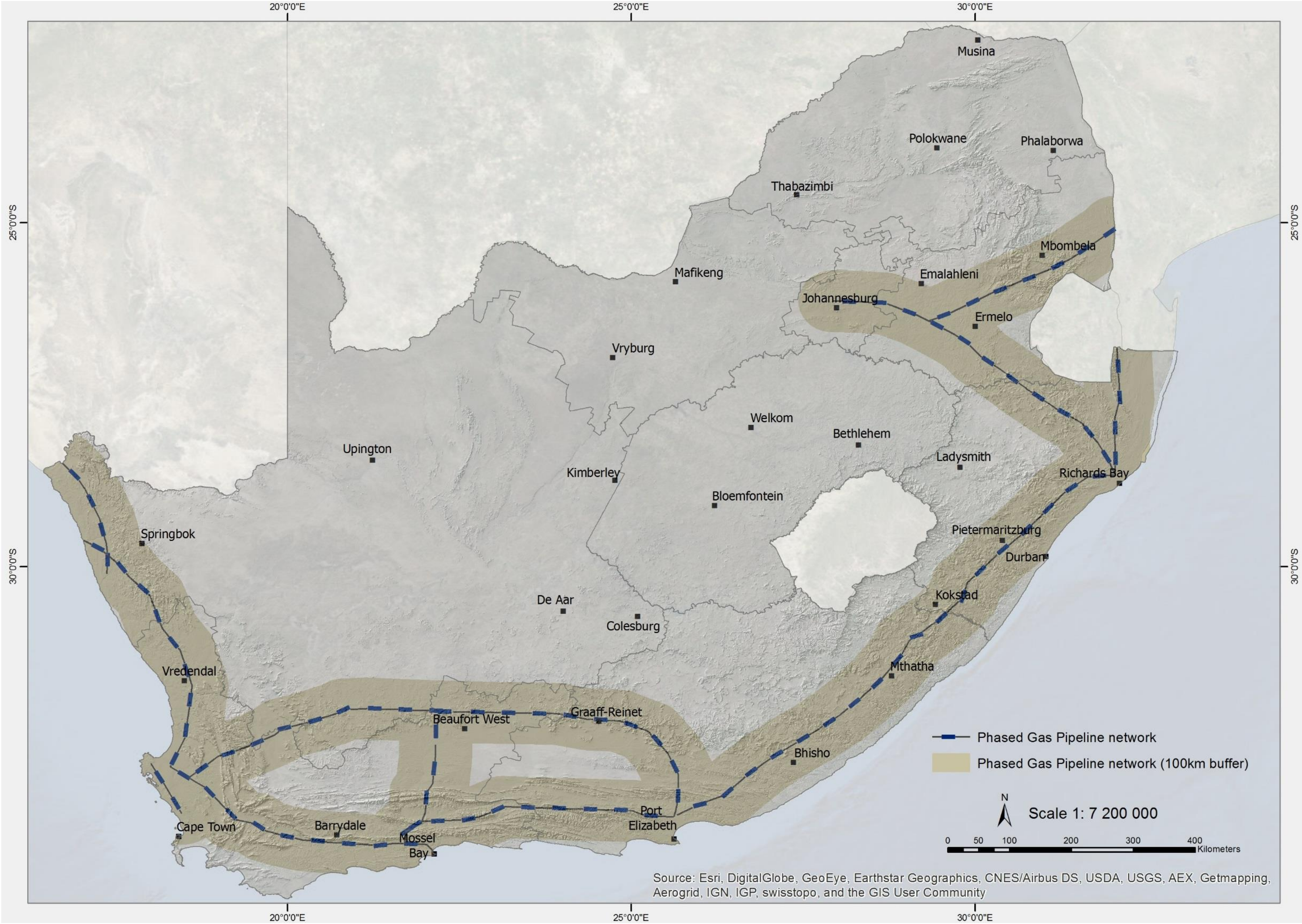


Figure 2: CEF Group-Eskom-Transnet Strategically Aligned Phased Gas Pipeline Network

Linked to Figure 2 and the preceding information, it must be noted that, although these phases have been prioritised in order of anticipated construction, they will not necessarily be developed in this order. Rather, they will be developed according to economic viability, i.e. a source of supply and a guaranteed offtake comprising a viable business case for each phase of the Phased Gas Pipeline Network.

As part of this SEA Process, using Geographic Information System (GIS) software, ArcMap 10.4, the Phased Gas Pipeline Networks described above (and shown in Figure 2) were buffered by 50 km on either side to produce 100 km wide corridors. The 100 km wide corridors were guided by and encompassed the Phased Gas Pipeline Network. These are referred to as the Preliminary Corridors, which are indicated in Map 1 below.



Map 1: Preliminary Corridors

2.3 Project Description

It is also important to describe the technical aspects of gas transmission pipeline infrastructure. The information provided in this section has been provided by the Project Partners.

2.3.1 Specifications

- <u>Pipeline Location (Onshore versus offshore):</u>

With a pipeline around the South African coast, two technology options are possible, i.e. onshore and offshore pipelines. However, the costs of offshore pipelines are approximately 40% more than that of onshore pipelines. In addition, offshore pipelines will limit the ability to expand easily to accommodate new customers. They will also require landing points and transmission networks from these landing points to the market demand centres. This could eventually lead to almost parallel onshore networks. Therefore, only onshore pipelines are considered in this SEA Process.

- <u>Pipeline Pressure:</u>

This SEA is only focused transmission pipelines (main trunk lines), with a pressure of more than 15 bar as defined in the Gas Act. The suppliers of the gas into the pipeline are usually responsible for compressing the gas before supplying it at the inlet flange. Distribution pipelines (branch lines to industrial areas and reticulation offtake points) with a pressure range of 2 to 15 bar and reticulation (lines to homes and small industry) pipelines, with pressures less than 2 bar, are not considered in this SEA Process.

- <u>Pipeline Depth, Above-Ground Infrastructure and Crossing of Waterbodies:</u>

The pipelines will be below-ground. The top of the proposed pipeline would be approximately 1 m underground all along the route, with pigging stations above ground approximately every 130 km but possibly as far apart as 250-500 km (based on new technology options for pigging). The limitations linked to the distance between pigging stations are mainly based on the capability of the PIG (Pipeline Intelligent Gauge) in terms of battery life and on-board memory storage. Pigging stations are generally 30 x 80 m in size. Block valves will also be required every 30 km along the pipeline route, which will consist of a concrete slab on the surface that will cover a concrete valve chamber below ground. The valves can be automated, i.e., remotely activated to close a specific section of the line in the event of a leak (i.e. close two valves on either side of the leak). If the line needs to be repaired, the remaining gas within the line may be vented off. However, technology exists to repair "live" lines with pressurised gas still inside, and this is the preferred option for repairs and modifications for pipeline expansion.

When the crossing of a waterbody is required for the Phased Gas Pipeline, trenching, pipe-jacking or horizontal directional drilling will be undertaken. Sub-surface flow below the river bed can be corrosive. Therefore, the pipe must be deep enough under the river bed with corrosion protection. Attaching the gas pipeline to a suspension bridge is not considered as the safest option, therefore this will not be considered in the SEA Process. Additional detail regarding the pipeline crossing of water bodies is included in the Biodiversity Assessment specialist studies.

- <u>Pipeline Diameter and Wall Thickness:</u>

Transmission pipelines can typically range in size anywhere from 6 to 48 inches in diameter, depending on the economics and their function. The typical pipeline diameter, for purposes of this SEA, is estimated at 26 inches (660 mm), similar to that of the Rompco MSP. Thickness of the pipeline wall is estimated to range between 10 – 17 mm, depending on the proximity to human settlements.

- <u>Pipeline Material, Specification and Sourcing:</u>

The Phased Gas Pipeline Network will be designed in accordance with the latest editions of internationally accepted standards, e.g., ASME B31.8 and the line pipe material should be in accordance with API 5L (latest edition) or an equivalent international material specification. The pipeline will be composed of steel. The material grade should be either X65 or X70 or possibly higher grades. X65 is more conducive to manual welding. X70 is a higher strength material than X65. The calculated wall thicknesses are therefore thinner. As such the benefit is a lighter pipe which is beneficial for both transport and material handling. A possible disadvantage is that, while it can be manually welded, it is more conducive to automatic welding. Welders experienced in welding this grade of material are scarcer, but can be qualified by a competent construction contractor. The final decision on the material grade will be made during engineering of the pipeline phases. The pipes will need to be supplied in 18 m lengths. While mills capable of producing 12 m lengths of pipe are more readily available, 12 m pipes will require 50% more welding during construction. This creates more scope and opportunity for weld failures.

The acceptable manufacturing processes are:

- Electric resistance or induction welded
    - HFW High Frequency electric welding
- Submerged arc welding
    - LSAW longitudinal weld seam
    - HSAW Helical weld seam (spiral welded pipe)

LSAW is the most expensive of the three processes because it is made from plate material. HSAW is the cheapest and is made from coil material. HFW pipe is also made from coil material but has a longitudinal weld seam. The cost is marginally higher than HSAW pipe material. Operators prefer longitudinally welded pipe as it is easier to tie-in to at a later stage than spirally welded pipe. As long as the appropriate inspection plan is in place and all defects are addressed or rejected, any one of the three processes will be acceptable. The decision for a specific type should therefore be cost and schedule (availability) driven.

The pipeline will be an all-welded system, so there is no possibility of leaking from flanges or failed gaskets.

In general, the pipelines are also covered with a specialised coating to ensure that it does not corrode once placed in the ground. The purpose of the coating is to protect the pipe from moisture, which causes corrosion. There are a number of different coating techniques. In the past, pipelines were coated with specialised coal tar enamel. Today, pipes are often protected with what is known as a fusion bond epoxy. In addition, cathodic protection is often used; which is a technique of running a low voltage electric current (typically equal to or less than 3V) through the pipe to ward off corrosion.

- <u>Local Opportunity for Pipeline Fabrication:</u>

If South Africa is to build a Phased Gas Pipeline Network in excess of 3500 km, the opportunity exists to develop the local mills and to ensure that they reach international standards. There is also the opportunity for investment by international pipe fabricators in these mills or in new local mills. Any of these options will establish a South African capability for world class pipe manufacturing and coating and should be pursued as part of Operation Phakisa's objectives before resorting to international pipe mills. However, it must be noted that, globally, there may be an excess capacity for pipeline manufacturing and coating. A thorough marketing exercise, considering global supply and demand will need to be undertaken by the developer once a phase of the pipeline network would be proposed to be constructed. This is therefore not considered as part of this SEA.

- <u>Compression:</u>

Reservoir gas is generally at a high pressure or compressed at the production facility to transport the gas to onshore locations. An inlet pressure of between 100 bar and 125 bar is generally sufficient to transport gas up to 500 km. After that, compression becomes necessary to increase throughput. As an example, the first expansion project for the Rompco MSP was a compressor station installed at Komatipoort, approximately 500 km from the Central Processing Facility (CPF). Compression will be required if the network has a single source input transporting gas over long distances. However, if there are multiple inputs 500 km apart, then compression will generally not be required, unless an increase in throughput is required. The installation of compressor stations will be considered during the engineering studies for each phase of the pipeline network. As a design principle, compression along the pipeline route should be avoided in the initial construction and should be left for capacity increase during later stages of the pipeline operation when market demand increases, requiring increased throughput. Therefore, compressor stations have not been considered as part of this SEA Process, and should be considered on a project specific basis.

- **Access Roads:**

During the construction phase, access roads will be required to the pigging stations, camp site and construction right-of-way. It is estimated that the access roads will extend about 8 – 10 m in width. A service road along the pipeline route is not planned, however some level of access to the pipeline will be required during maintenance. As such, a number of access roads will be kept.

2.3.2 Construction Activities

- **Skills and Labour Requirement**

With this SEA and other initiatives to increase the role of natural gas in the country's energy mix, skills will be required on a national scale to enable implementation. From a gas infrastructure design and construction perspective, the following skills will be required:

- A knowledge of local and international standards for the design of gas pipelines, together with the ability to design the pipelines and develop dynamic models of the pipelines using computer software. This competence must reside with both the pipeline owners / operators as well as with engineering contractors and consultants. South Africa does currently have this level of skill within the engineering contractors and at least one operator (Sasol Gas).

- An in-depth understanding of large Engineering Construction and Procurement Management (EPCM) and Engineering, Construction and Procurement (EPC) contracts. Core competencies required are in Project and Contract Management and administration. Large EPCM and EPC contracts have been undertaken in the country both for petrochemical facilities and pipelines. Major international engineering contractors with experience in this field have offices in the South Africa capable of executing these projects. These companies can also draw on experience and personnel from their international offices, giving them the benefits of both a knowledge of the local regulatory and business environment as well as an international experience base. Smaller South African companies have the competency and experience to execute EPCM contracts of this nature. However, it is doubtful that they have the financial resources to execute an EPC project.

- Construction Contractors: South Africa has the competence for the implementation of large pipeline construction projects, developed in the civil and water pipeline construction industries. However, experience in petrochemical pipelines is limited to the few projects executed over the past decade.

- Welders: South Africa has a skills shortage of suitably qualified welders capable of welding high strength gas transmission pipeline material. Currently, this requirement is filled by the construction contractors from a pool of international welders that are willing to travel abroad, living in construction camps for between 6 and 8 weeks at a time while working on petrochemical pipeline projects. South Africa can train welders to meet this requirement. However, it should be noted that if around 150 km of pipelines are not constructed in a year, these welders may be lost to the international pool. However, on a positive note, they will then gain international experience in this case.

- Servitude Negotiations: The South African legal fraternity should be well versed in the area of servitude negotiations, as this has been an ongoing process for Eskom's power transmission lines; and water, sewerage and other pipelines. The notable difference for gas pipelines is that product is flammable and even explosive within a range of gas to air mixtures. Safety aspects will be dealt with in the design of the pipelines and those negotiating with landowners for the servitudes must be able to deal with concerns regarding safety and the responsibility placed on land owners for non-interference with the pipeline. However, the current existence of thousands of kilometres of gas pipelines in the country without major incidents should serve to alleviate concerns.

- Pipeline Operators: There are a few gas pipeline operators in South Africa, e.g., Sasol Gas, Transnet Pipelines, Egoli Gas, Virtual Gas Network, Novo Energy, Reatile Gastrade, Easigas, and Tetra4. However, most of their experience is limited to distribution and reticulation pipeline operations. Gigajoule, a South Africa company is a shareholder in and the operator of the Moamba Pipeline in Mozambique. If South Africa is to develop a gas transmission pipeline network, pipeline operators need to be developed and enter this space to promote effective gas on gas competition.

- **Construction Processes**

During pre-construction, when servitudes and construction areas (including laydown areas) are determined and mapped, the Pipeline Owner needs to undertake the following:

- Identification of the type of vegetation and trees within the servitude area, and its conservation status, and ensure rehabilitation is undertaken as per the EMPr;
- Aerial photographs of the servitudes noting and tagging all buildings and human usage of the areas for record purposes;
- Communication with the provincial government noting the sensitivity of the servitudes for future provincial planning;
- Interaction with neighbouring communities, and provincial and municipal authorities for temporary labour requirements;
- Agreement with local government structures in terms of the type of labour required and the percentage use of local labour and necessary training;
- Provide information to the surrounding affected communities (including formal structures such as provincial government) on the details of the construction process, such as the purpose and duration of the construction work;
- Identification of borrow pits (for bedding and padding soil) if required and completing the permitting process for use of the pits;
- Identification of water sources for hydro-testing;
- Planning for rehabilitation;
- Agreement with land owners regarding permanent or temporary fencing or access;
- Engineering and construction teams to be mobilised; and
- Ensure that all necessary permits are in place prior to the commencement of construction, including work permits for expatriates and import/export permits for equipment. This also includes following the outcomes of the SEA Process such as the Standards/Minimum Information Requirements, EMPr, and Protocols to ensure that the necessary environmental approvals are obtained before construction commences.

Once the above tasks are completed, the construction process is generally ready for commencement. The establishment of the gas pipeline will entail the following steps and processes:

- Construction camp site and laydown area establishment;
- Access road construction;
- Pipe laydown area establishment;
- Preparation for construction right-of-way and ground preparation;
- Survey and staking;
- Front-end clearing;
- Right-of-way grading;
- Stringing pipe;
- Bending pipe;
- Line-up, initial weld;
- Final Welding and weld inspection;
- Trenching;
- Field joint coating and inspection;
- Lowering pipe into trench;
- Pad, backfill, rough grade;
- Testing and final tie in;
- Final clean up and full rehabilitation; and
- Team debriefings, demobilise temporary workers and commission the operating team.

The above steps are detailed below, as applicable:

- **Construction Camps and Work Fronts**

Experience indicates that for an approximately 100 km long pipeline, one single construction camp is sufficient. In general, construction camps are set up in the middle of the pipeline length so that construction starts in the middle and proceeds in a single work front towards one end and then reverting to the middle and proceeding towards the other end. For pipelines of the length considered in the Phased Gas Pipeline Network, more than one construction camp will be required. These can be about 50 km from the start of one end and then spaced 100 km apart. Depending on the schedule, a single camp and work front can be used, moving the camp as construction proceeds. If the schedule is more critical, multiple construction camps and work fronts can be used, proceeding from the two ends of the pipe until they meet in the centre.

All aspects of the site camp need to be signed off by the relevant parties, prior to the commencement of construction. This includes the approval of the camp design, including the acceptable quartering for all site personnel, obtaining certificates of compliance for generators and other site equipment, ensuring potable water supply is suitable and sufficient, ensuring waste disposal and sewage treatment is operational, finalising plans for medical care on site, as well as ensuring that catering supply and facilities are in place. In addition, spare parts for equipment and basic Personal Protection Equipment (PPE) needs to be in place prior to commencement of construction. In places where there is no mobile network coverage, radio communication will be used at the work fronts. In addition, internet connection will be set up at the site camp.

In general, about 20 experienced personnel from the contractor and 3 – 10 pipeline owner personnel will be on site during pipeline construction from an EPC Management perspective. At peak times, about 550 construction personnel could be on site, with an average of 300 personnel ranging from welders to cathodic protection specialists and third party inspectors.

- **Construction Right-of-Way and Work Space**

A 30 m to 50 m wide construction right-of-way will be required during the construction phase. Space is required for trenching and other construction activities listed above, as well as for the storage and stockpiling of soil, pipes and equipment. The overall footprint required for the pipeline includes the right-of-way and the temporary work space. Figure 3 below provides an illustration of the construction right-of-way and work space.

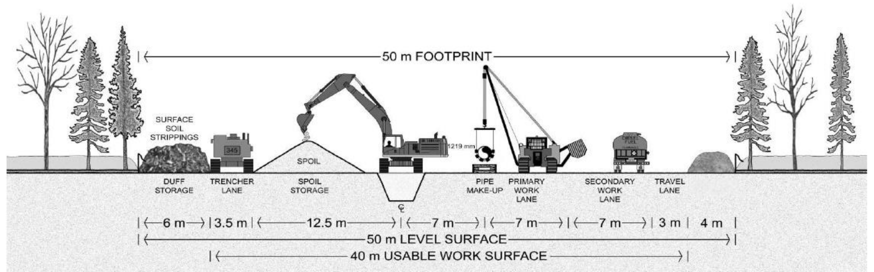


Figure 3: Cross-sectional View of the Right-of-Way and Work Space

- **Pipe Material Receipt, Transport to Site and Stockpiling**

As noted above, it is anticipated that the pipes will be imported and received at the relevant Port. It will then be offloaded and transported to the site via trucks. Once it reaches the site, it will be stockpiled in an area close to the pipeline right-of-way. The stockpile area will be cleared of vegetation.

- **Pipe Stringing, Bending, Line-Up, Welding, Inspection and Coating**

Once the right-of-way is completed, the pipe stringing and bending will take place. This will be followed by lining up of the pipes and welding, as described above. Once the welding is complete, inspection will be undertaken (i.e. Automatic Ultrasonic Testing in line with the applicable standards and codes), and this will be followed by field joint coating, which will either include heat shrink or painting.

- **Trenching**

Trenches will be dug using mechanical trench diggers or excavators. Depending on the pipe diameter, an approximately 1 - 2 m wide section will be trenched. The excavated soil and topsoil will be stockpiled separately adjacent to the trench for infilling and rehabilitation purposes.

- **Lowering of Pipeline, Bedding and Padding**

Once the trenching is complete, the pipeline will be lowered into the trench and bedding and padding will be completed. Where rocky substrate occurs within the trench, it is possible that imported soft soil (from a borrow pit) will be placed within the trench. Alternatively, the material excavated from the trench could be sieved in-situ to ensure better padding and bedding.

- **Pipeline cleaning and hydrostatic testing**

Thereafter, the pipe will be cleaned and tested.

- **Reinstatement and Rehabilitation**

The right-of-way will be rehabilitated progressively as the construction of the pipeline advances. A 10 m wide servitude should ideally be maintained during the operational phase, however, shallow rooted vegetation will be allowed to re-establish within the servitude. Deep rooted vegetation will not be allowed to establish within the 10 m operation servitude as they pose a risk to the underground pipeline and a constraint to future maintenance of the pipeline. Shallow rooted crops over the servitude will be cultivated at the land owners risk should it be required to remove for maintenance purposes. However, in cultivating these shallow rooted crops, land owners must be aware of the depth of the pipeline and the ploughing equipment.

2.3.3 Operational Activities

The operation activities for the phased gas pipeline network will include transmission of gas in the pipeline within the 10 m wide registered servitude and maintenance activities. The servitude agreement with the land owner will specify the requirements of the Pipeline Operator. Maintenance activities will include pigging, cleaning and inspections. The pigging stations will be accessed on a regular basis for maintenance of the stations (generally 4 to 6 times per year).

Pigging is essentially used for cleaning, maintaining and inspecting the pipelines, as well as to detect areas of degradation, corrosion and defects in order to prevent leaks. The smart robotic PIG is inserted into a "pig launcher" which is then closed and the pressure-driven flow of the product in the pipeline is used to push the pig along the pipe until it reaches the receiving trap or "receiving station". PIGS can also test pipe thickness, and roundness, inspect for signs of corrosion, and any other defect along the interior of the pipeline that may either impede the flow of gas, or pose a potential safety risk to the operation of the pipeline. Pigs can also assess the state of the external coating of the pipeline. The pigging exercise usually does not interrupt production, though some product can be lost when the PIG is extracted.

During the operational phase, pipelines are usually monitored through a suitable system to manage and monitor the transmission of the gas through the pipeline. These systems are essentially sophisticated communications systems that take measurements and collect data along the pipeline and transmit it to the control centre. Flow rates through the pipeline, operational status, pressure, and temperature readings may all be used to assess the status of the pipeline at any one time. These systems also work in real time, meaning that there is little lag time between the measurements taken along the pipeline and their transmission to the control station. This enables quick reactions to equipment malfunctions, leaks, or any other unusual activity along the pipeline.

In addition to inspection and monitoring listed above, there are a number of safety precautions and procedures that can be used to minimise the risk of accidents. A few of the safety precautions associated with gas pipelines may include:

- Aerial Patrols – Helicopters surveys are used to ensure no construction activities are taking place too close to the route of the pipeline, particularly in residential areas. Unauthorised construction and digging is considered a huge threat to pipeline safety.
- Odour - In its natural form, gas is odourless, colourless and tasteless. Mercaptan, a harmless chemical added to natural gas contains sulfur, which makes it detectable by smell. However, Mercaptan is generally not added at the transmission level, only at the distribution and reticulation levels.
- Leak Detection – Natural gas detecting equipment is periodically used by pipeline personnel on the surface to check for leaks. This is especially important in areas where the natural gas is not odourised, as discussed above.

- Pipeline Markers – Signs on the surface above gas pipelines indicate the presence of underground pipelines to the public, to reduce the chance of any interference with the pipeline. Pipeline markers will be installed every 1 km aboveground to indicate the presence of the pipeline so that future developers and adjacent land users are aware of its location.
- Preventative Maintenance – This involves the testing of valves, repairing of defects, repairs of washaways and the removal of surface impediments to pipeline inspection. Pigging every 5 years also forms part of the preventative maintenance activities.
- Emergency Response – Emergency response teams that are prepared for the possibility of a wide range of potential accidents and emergencies.

2.3.3.1 Fire Risk

In terms of operational risks to the gas pipeline, fires are a concern, whether this is controlled burning for crops or veld fires. Discussions were held with the Cape Nature Disaster Management teams to determine the potential risk in areas that are prone to fire. The team confirmed that during normal veld fires, the soil below ground returns to normal temperatures from about 10 cm below ground level. Therefore, since the pipeline would be 1 - 2 m underground, these fires would not pose a risk. Root fires may have a different impact, however, deep rooted vegetation will not be allowed to establish above the pipeline within the registered servitude. In addition, forest areas will be avoided for the development of the pipeline.

2.3.3.2 Climate Change Risk

According to the Intergovernmental Panel on Climate Change (IPCC) (2007[2], pg 30), climate change refers to any change in climate over time, whether due to natural variability or as a result of human activity. Climate change influences the global population and it is anticipated to eventually impact numerous industries (Nursey-Bray et al., 2013[3]).

The causes of climate change may be due to natural or anthropogenic processes. Natural processes include periodic changes in the earth's orbit, volcanoes and solar variability; whereas changes linked to anthropogenic activities include increasing emissions of greenhouse gases (such as CO_2), land use change and/or emissions of aerosols (CSIR, 2011[4]). During the last 100 years, a measurable increase in global temperature has become evident and this can only be explained if human activities are taken into consideration (IPCC, 2007 in CSIR, 2011). The rate of anthropogenic emissions of greenhouse gases has been increasing over time, which has resulted in an increase in temperatures, which in turn has resulted in various other changes to the climate system (CSIR, 2011).

According to the IPCC, climate change will cause low-lying coastal areas to be inundated, thereby resulting in impacts on coastal settlements (Boko et al., 2007 in CSIR, 2011). Satellite data indicates that the sea level rise from 1993 to 2006 was 3.3±0.4 mm per year (Theron, 2011 in CSIR, 2011). It is predicted that even with the stabilisation of greenhouse gas concentrations, sea level rise will continue to occur (IPPC, 2007 in CSIR, 2011).

This SEA and associated specialist assessments have looked at the broad climate change models, which generally show shifts in biomes and indicate at a broad scale where biomes would change, and what to expect in terms of features. Some of the Specialist studies do factor in climate change in terms of impact and spatial relation to climate change. Critical Biodiversity Areas (CBAs) factor in climate resilience and adaptability to changes as a result of climate change. Climate change prediction models will for example show a shift in the range of a particular biome, but not at a finer scale than that. Therefore, the sensitivity assigned to that specific biome will apply, regardless of where the shifts have occurred. These changes also happen slowly, over time and the prediction models have changed drastically over the last 10 years, and therefore may change again in the next 10 years.

From an operational perspective, if the climate gets drier, this is not a concern for the gas pipeline development. However, if the climate gets wetter, buoyancy issues would prevail, requiring additional design measures to address the constraint. These measures may include concrete weights or saddles over the pipeline to prevent them from floating as floating may induce bending stresses with the potential to cause fatigue on the pipeline increasing the risk of failure to the pipeline. If the air temperature increases or decreases within a few degrees Celsius (and not in the extreme), it is unlikely that this will affect the soil temperature at the depth of the pipeline and is not likely to be a concern to the gas pipeline.

2.3.3.3 Greenhouse Gas Emissions

As noted in Part 1 of the SEA Report, the Draft 2018 Integrated Resources Plan (IRP) (released in August 2018 by the DoE for public comment) presents the future energy mix which includes an additional 8 100 MW of energy from gas/diesel by 2030 (totalling to 11 930 MW or 16% of the total installed capacity mix by 2030) (DoE, 2018[5]). The Draft 2018 IRP considered the following four scenarios and their impact on the future energy mix: electricity demand scenario; a gas scenario; a renewables scenario; and an emissions constrained scenario. The updated report was focused on ensuring security of supply, as well as reduction in the cost of electricity, negative environmental impact (emissions) and water usage (DoE, 2018).

Based on feedback received during the Authority and Public outreaches conducted during the SEA Process, the use of natural gas in the energy mix is perceived by stakeholders to result in excessive Greenhouse Gas (GHG) emissions, with some organisations taking a stand against **any** Oil and Gas development, including Exploration. These concerns are duly noted by the SEA Project Team. Research indicates that natural gas (Methane (CH_4)), although having a global warming potential that is greater than Carbon Dioxide (CO_2), is the cleanest-burning hydrocarbon with an emission factor for combustion of 56g of CO_2 per MJ, and it has lower polluting potential than oil (77g of CO_2 per MJ) and coal (96g of CO_2 per MJ) (PWC, 2012[6]; EThekwini Municipality Energy Office, 2015[7]). It is however still associated with GHG emissions and this is largely the basis of concern from stakeholders.

It must firstly be reiterated that the scope of this SEA only covers the assessment of 100 km wide onshore corridors at a strategic level. The impacts associated with the exploration and extraction of gas, its transmission to the landing points as well as the usage of gas (e.g. generation of power using natural gas via a power station) fall outside the scope of work of this study and will need to be subjected to separate Environmental Assessment Processes.

As indicated above, in order to cover the major anchor points and ports, the corridors have been routed along the coast with an additional inland link from Richards Bay to the Gauteng and Secunda regions, as well as a link to Gauteng from the Mozambican border via Mpumalanga. This SEA does not therefore consider specific gas pipeline route(s) but instead pre-assesses the proposed corridors in term of environmental sensitivities and engineering constraints to optimise their location. This will ensure that these corridors are the most suitable (with the least possible environmental impact) for the potential establishment of gas transmission pipelines from landing points to customers.

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[2] IPCC (2007). Climate Change 2007: Synthesis Report. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.

[3] Nursey-Bray, E., Blackwell, B, Brooks B, Campbell, M. L., Goldsworthy, L., Pateman, H., Rodrigues, I., Roomeb, M., Wright, J. T., Francis, J. and Hewitt, C. L. (2013). Vulnerabilities and Adaptations of Ports to Climate Change. Journal of Environmental Planning and Management, 56, 7: 1021-1045.

[4] Council for Scientific and Industrial Research (CSIR) (2011). Climate Risk and Vulnerability: A Handbook for Southern Africa. Council for Scientific and Industrial Research, Pretoria, South Africa, pp 92.

[5] Department of Energy (August 2018). Integrated Resource Plan 2018 (Draft). Pretoria

[6] PWC (2012). The Gas Equation: An analysis of the potential of the natural gas industry in South Africa. https://www.pwc.co.za/en/assets/pdf/the-gas-equation-june-2012.pdf [on-line]. Accessed 25 February 2019.

[7] EThekwini Municipality Energy Office (2015). Natural Gas Position Paper: EThekwini Municipality. Paper developed by Price Waterhouse Coopers Incorporated, Sunninghill. http://www.durban.gov.za/City_Services/energyoffice/Documents/Natural_Gas_Position_Paper_eThekwini_Municipality_2015.pdf [on-line]. Accessed August 2017.

The information required for the undertaking of a full life cycle assessment (LCA) with respect to GHG emissions can only be finalised at a project specific level, once a specific transmission gas pipeline route has been determined and a detailed design analysis undertaken (i.e. once there is a viable business case, meaning a guaranteed supply of gas and sufficient demand). In addition, a full LCA requires several details such as the source of gas, quantity of gas transported, usage of gas, location of take offs, location of compressor stations (if any), etc. This level of information is unknown at this stage. There are still currently uncertainties regarding the likelihood and the timeframe for the construction of such pipelines and no real guarantee whether they will be constructed.

The following sub-sections briefly discusses potential GHG emissions associated with the construction and operation of gas transmission pipelines. Assumptions had to be made given that details such as pipeline engineering design, supply, demand etc. are not yet available.

- <u>Construction Phase</u>

During the construction phase of the proposed gas pipeline development, GHG emissions are likely to occur as a result of the operation of construction vehicles and equipment (such as diesel generators, pumps, excavators, etc.). These emissions, associated with any large scale construction project, are anticipated to be temporary and of low environmental significance. Nonetheless, adequate management actions, detailed in the Norms/Standards/Minimum Information Requirements, will be implemented to reduce GHG emissions during the construction phase, such as ensuring construction vehicles and equipment are maintained sufficiently.

- <u>Pipeline Commissioning</u>

Commissioning of gas pipelines involves complete displacement of air in the pipeline by natural gas before pressure is increased to the required operation level. Inert gas (usually nitrogen) is used to displace the air before displacement of nitrogen by natural gas. According to the American Gas Association (AGA), "it is usually necessary to use at least 1.5 to 2.5 volumes of inert gas per volume of free space in purging. When purging a pipeline, the area of contact may be so small that little mixing will occur. Advantage can be taken of this condition to conduct an inert purge by use of a quantity of inert gas that is only a fraction of the volume of combustible gas or air to be replaced. It is possible to introduce just enough inert gas to form a "slug" or piston between the original gas (or air) content and the entering air (or gas) [cushioned between foam pigs]. This slug and the original gas or air ahead of it, is pushed along the pipe to the end of the section being purged by air or gas introduced after it" (AGA, 2011[8]). For a 26" pipeline, the calculated natural gas released at each pigging station ranges between 5 kg and 6 kg during that operation. As a comparison, this is the quantity of gas in a typical gas bottle used for camping.

This release may result in the formation of an explosive vapour cloud, which could present a threat to those situated close to the venting. It is therefore important to know the flammable limits of the combustible gas in air when undertaking purging operation. The gas must also be vented via vent stack with an outlet in excess of 10 m above ground level to allow the gas to disperse quickly before forming a combustible vapour cloud.

The following mitigation measures have been recommended in the EIA Report compiled for the installation, commissioning and operation of a high-pressure natural gas transmission pipeline from Sasol Synfuels in Secunda to Sasol Chemical Industries in Sasolburg (Niemand et al. 2009[9]):

- The relevant authorities must be notified in writing prior to the venting being undertaken.
- As best as possible, ensure that the volume of methane vented is kept as low as possible.
- It is recommended that venting is undertaken during suitable atmospheric conditions, such as during windy conditions and at an elevated ambient temperature.
- As best as possible, venting must be avoided at night.
- Venting must be closely monitored and controlled. Ensure that all possible sources of ignition are eliminated or controlled.

- <u>Operational Phase under Normal Conditions</u>

During the operational phase, GHG emissions are most likely to occur as a result of the following:

- Pigging operations; and
- Compressor station operations.

As noted in Section 2.3.1 of this chapter, compressor stations are not being considered within the scope of this SEA Process. Compressor stations are generally required to assist with the transmission of gas over long distances, in areas with varying topography and to maintain an adequate pressure profile within the pipeline. In general, compressor stations are fuelled from the gas contained within the pipeline (EThekwini Municipality Energy Office, 2015). Compressor stations also include liquid separators to ensure that potential water and hydrocarbon condensate emanating from the gas during transport are removed (EThekwini Municipality Energy Office, 2015).

If a compressor station is required, then a separate Environmental Authorisation Process will need to be undertaken in accordance with the relevant EIA Regulations in force at the time. This EIA Process would therefore need to consider the potential GHG emissions of compressor stations, as well as any relevant cumulative impacts based on the energy mix and surrounding developments at the time.

During pigging operations, an estimated 5 kg of methane would typically be released in the atmosphere during removal of the pig for each pig run (iGas, 2018, Personal Communication[10])[11]. This is equivalent to 125 kg of CO_2 equivalent (IPCC, Fourth Assessment Report, 2007[12]; Greenhouse Gas Protocol[13]) per pig run for each pigging station. Pigging is undertaken once every five years and there is approximately one pigging station every 130 km along the pipeline route (but possibly 250 km to 500 km apart depending on whether newer technology will be used). For purposes of this calculation, it is assumed that pigging stations will be constructed every 250 km along the route (i.e. 4 stations/1000 km of pipeline). Assuming that 6 pig runs are carried out for each pigging station, approximately 750 kg of CO_2 equivalent would be released at each pigging station (i.e. 6 pig runs * 125 kg of CO_2 equivalent per pig run). Based on the above, it is estimated that approximately 3000 kg of CO_2 equivalent would be vented to the atmosphere per 1000 km of pipeline length every 5 years. Figure 4 provides an example of a pigging station.

It must be noted that although the proposed gas transmission pipeline network presented in this study runs over approximately 5000 km along the coast, it is still to be determined if all of the corridor phases will be constructed. Each phase (or section of a phase) would only be constructed based on its own viable business case (i.e. availability of gas and sufficient demand).

By way of comparison, according to the US Environmental Protection Agency (US EPA), an average car (i.e. typical passenger vehicle) emits about 4 – 5 tons of CO_2 per year (US EPA, 2018[14], Ashwoods Lightfoot

[8] American Gas Association, 2001. Purging Principles and Practice. 3rd edition.

[9] Niemand, A., Conradie, D., Duff, A., Maphathe, N., and Niemand II, A. (2009). Environmental Impact Report and Environmental Management Plan for the installation, commissioning and operation of a high-pressure natural gas transmission pipeline from Sasol Synfuels in Secunda to Sasol Chemical Industries in Sasolburg, via Balfour. Report compiled for Sasol Gas Limited. DEA Project Reference Number 12/12/20/1067.

[10] iGas (2018). Personal Communication.

[11] Assumptions: Pipe Diameter = 26 inches, Pig length= 10m, Pressure = 2 bars

[12] IPCC Fourth Assessment Report. Forster, P., V. Ramaswamy, P. Artaxo, T. Berntsen, R. Betts, D.W. Fahey, J. Haywood, J. Lean, D.C. Lowe, G. Myhre, J. Nganga, R. Prinn, G. Raga, M. Schulz and R. Van Dorland, 2007: Changes in Atmospheric Constituents and in Radiative Forcing. In: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M.Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. Accessed: https://www.ipcc.ch/site/assets/uploads/2018/02/ar4-wg1-chapter2-1.pdf

[13] Greenhouse Gas Protocol: Global Warming Potential Values. Accessed: https://ghgprotocol.org/sites/default/files/ghgp/Global-Warming-Potential-Values%20%28Feb%2016%202016%29_1.pdf

[14] United States Environmental Protection Agency (US EPA) (2018). Greenhouse Gas Emissions from a Typical Passenger Vehicle.

Limited 2019[15]). This estimate, however, may vary based on the distance travelled, the type of fuel used, and the fuel consumption economy (US EPA, 2018). Based on the latest live vehicle population as per the National Traffic Information System – eNaTIS (2019[16]), 12 506 592 vehicles (light, heavy, trailers, motorcycles, etc.) have been registered in South Africa with the Department of Transport (as at January 2019). Therefore, using the above estimates for CO_2 emissions for an average car, it can be derived that the release of CO_2 from motor vehicles in South Africa is 48 – 60 million tons per year. Research indicates that in 2009, road transport activities resulted in a total of 43.5 million tons of CO_2 equivalent in South Africa, whereby motor vehicles and trucks formed 70.6 % of the total emissions (Tongwane *et al*. 2015[17]).

Figure 4: Example of a pigging station (Photo from Mr N Ephraim, iGas).

- <u>Operational Phase under Abnormal Conditions</u>

Compared with other methods for transporting hazardous chemicals, such as rail or road, transmission pipelines can be very safe, and transmission pipeline accidents are relatively rare and have caused few fatalities. However, if product releases (leaks or ruptures) occur during the operational phase, it may constitute a considerable safety risk for the surrounding community.

In South Africa, Sasol Gas operates a network of Gas Transmission and Distribution Pipelines. Based on feedback provided in the year 2000, Sasol documented the following incidents over a 30 year period and over approximately 1 260 km of pipeline (Niemand et al. 2009; Page 7.37):

- One incident caused by the rupture of a high-pressure pipeline and ignition of gas caused by a bulldozer ripper while excavating for adjacent road construction. This resulted in severe injury of the operator of the bulldozer.
- Thirty-five incidents of damage by third parties resulting in leaks.
- Twenty-five incidents of valve failure and corrosion resulting in leaks.
- Sixteen incidents of mechanical defects resulting in minor leaks.
- Three leaks due to other causes.

The Pipeline Operator will ensure that the pipeline is designed to relevant international and national standards, taking into consideration the lessons learnt from previous regional operations. Leaks are normally detected by abnormal pressure drops and a loss of transported volumes. Risk Based Inspection (RBI) via scheduled intelligent pigging of the pipeline sets an initial baseline and thereafter monitors the condition of the pipeline. If a section of the pipeline needs to be repaired, the remaining gas within the isolated section can be vented off. This methodology has been successfully employed on the Rompco Pipeline, detecting corrosion and signalling maintenance and repair long before failure actually occurs. As has been previously mentioned, technology exists to isolate and/or perform maintenance and tie-ins on "live" pipelines that are still under pressure. This technology is available in South Africa and has been successfully employed on the Rompco Pipeline for tie-ins.

Research indicates[18] that the main causes of gas pipeline leaks or spillages in Europe include third party accidents, mechanical failure, and corrosion, followed by natural hazards on a smaller scale. Third party accidents generally occur by parties other than the Pipeline Operator, for example excavating equipment being used to maintain or construct adjacent services without consideration of pipeline markers or existing service plans from the municipalities. Mechanical failures generally include failures of the pipeline infrastructure for various reasons, ranging from excessive operating pressure to welding failure. These types of mechanical failures will be avoided by ensuring that adequate mitigation and maintenance measures are taken into consideration in the design and operation of the pipeline. It is thus imperative that careful, coordinated and integrated planning must take place when considering the development of a gas transmission pipeline, ensuring that the location maps of the servitudes are readily available. It is also important to ensure that third parties do not have access to the pipeline servitude without prior notification.

In addition, regular pipeline monitoring will be implemented, along with stringent emergency response procedures. These mitigation measures will be included in the EMPr that is being compiled as part of this SEA.

As noted in Section 2.3.1 of this chapter, block valves will be installed at set intervals (30 km) along the gas pipeline route in order to isolate sections of the lines in the event of leaks and to undertake pipeline repairs. In order to illustrate an example of emissions if a major leak occurs within one section of the pipeline, the following assumptions are made:

- Pipeline Length (one section between block valves) = 30 000 m;
- Pipeline Diameter = 26 inches = 0.66 m;
- Pipeline Radius = 13 inches = 0.33 m;
- Pipeline Volume (in one section between block valves) = 10 263.58 m^3;
- Natural Gas Specifications = Generic;
- Natural Gas Composition = Generic and not exact specifications (Methane = 94.240%; Ethane = 2.046%; Nitrogen = 1.804%; Water = 0.006%; and [Propane; Butane; Pentane; Hexane; Heptane; Octane and Other] = 1.904%)
- Leak = Assume all gas molecules from the 30 km long pipeline section will be lost.

Based on the above, natural gas density was determined using the AGA8 detailed characterization equation (i.e. AGA8-92DC)[19].

The calculations confirmed that if the pipeline is operating at atmospheric conditions (i.e. 1.01325 bar and 15 °C), then 7.308 tonnes of natural gas would be emitted from the 30 km long pipeline section. Furthermore, if the pipeline is operating at its maximum pressure (i.e. 100 bar and 20 °C), then 858.774 tonnes of natural gas would be emitted from the 30 km long pipeline section. However; it is important to re-iterate that the amount of **methane** emitted to the atmosphere will be <u>**less than**</u> 7.308 tonnes (if the pipeline is operating at atmospheric conditions) and **less than** 858.774 tonnes (if the pipeline is operating at maximum pressure) because its composition (in terms of molecular %) accounts for 94.24% of the total constituents of natural gas.

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2.4 Constraints and Opportunities Mapping

Constraints refer to environmental features which gas pipeline developers seek to avoid, where possible, due to the additional time and cost incurred when developing infrastructure in these areas. In the context of the constraints mapping exercise, constraints were mapped according to two categories, namely environmental constraints or sensitivities and engineering constraints.

During Phase 2 of the SEA Process, several workshops, meetings and engagement processes were undertaken with authorities, the general public, sector specific and key stakeholders, and representatives on the Project Steering Committee (PSC) and Expert Reference Group (ERG). One of the objectives of the consultation process was to seek feedback from the authorities, general public and key stakeholders (including sector specific stakeholders) on potential constraints and opportunities, including any major infrastructure projects that needed to be considered in the corridor refinement process. In addition, a dedicated consultation process was undertaken from 1 November 2017 to 13 November 2017 with provincial authorities to discuss the proposed corridors and their alignment with provincial and regional planning. A second round of authority meetings were undertaken from 8 October 2018 to 22 October 2018. The opportunity was used to identify additional information and potential concerns from provincial departments that needed to be taken into consideration in the SEA Process.

2.4.1 Environmental Constraints/Sensitivities

Environmental constraints/sensitivities in the context of the study refer to environmental features negatively impacted by the construction and or maintenance of gas pipelines. The mapping exercise was undertaken for the entire country and involved identifying high level environmental constraints/sensitivities for gas pipeline infrastructure development based on the best available data at a national scale. The identification of sensitive features, applicable buffers and datasets was undertaken in consultation with the relevant authorities and key stakeholders. In instances where data for certain environmental aspects was not available, indicative sensitive areas were provided by relevant key stakeholders in consultation with the specialist fraternity. Further environmental constraints/sensitivities considered during the analysis included various environmental features such as protected areas, wetlands and recognised heritage sites. Also included were existing and future conflicting planned land uses such as mining activities and the Square Kilometre Array (SKA). Projects which encroach upon these features are considered more likely to encounter delays, appeals or a negative decision for environmental authorisation.

2.4.2 Engineering Constraints

Engineering constraints in the context of the SEA refers to technical challenges posed by the landscape and surrounding environment to the construction and operation of gas pipeline infrastructure. The mapping exercise was undertaken for the entire country and based on the best available data at a national scale. The identification of features and delineation of constraint level (sensitivity) for each engineering feature was done in consultation with engineering representatives from iGas and Transnet, as well as Eskom. Typical engineering related features include steep slopes, coastal areas and deep river gorges. The level of constraint attributed to each feature (f_n) was determined according to a crude cost assessment. The cost assessment considered the impact of each feature on an optimal cost effective Baseline Scenario (BS) (x). The BS in this instance was the construction and maintenance of a 1 X km of 26" gas transmission pipeline in optimal conditions for construction. Therefore, by introducing each engineering feature into the BS individually, the impact of each feature on the BS was determined.

Level of constraint (c) associated with a feature in the context of the BS (x) was therefore represented as $(c) = (x)*(f_n)$.

2.4.3 Constraints Criteria

The list of features, buffers and associated level of constraint (Very High, High, Medium and Low) as well as the originating datasets used to map environmental and engineering constraints at a national scale are detailed in Table 1 and Table 2, respectively. From an engineering constraints perspective, the following datasets/parameters should be considered during the project specific stage and when the pipeline routes are determined. These are mainly related to the highly variable nature of expected geological conditions and associated constraints, which may change over short distances, which would require detailed mapping and planning of routes:

- Soil type and salt content to determine overall suitability of the soil from a salt content perspective to understand the corrosion risk;
- Rock outcrops in order to gauge the risk in terms of excavations considering the local changes in geology and topography. This will have an implication on associated costs in terms of excavation and importing piping and bedding material. Rock outcrops or shallow rock is often associated with steep slopes; and
- Slope stability, which is considered to be localised and can be engineered to eliminate or avoid based on severity.

Furthermore, the American Standard ASME B38.1-2016 could not be utilised at this strategic level of the SEA, however it will be recommended for use during the pipeline route planning stage in order to consider building structure types and pipeline wall thickness required.

Table 1: Features and datasets used to prepare high level draft environmental constraints/sensitivities map

Feature Category/Factor	Source/Dataset	Features	Mapping Sensitivity (Environmental Constraint)	Feature/Buffer
Protected Areas	South African Protected Areas Database (SAPAD) - Q4, 2018 , South African National Parks (SANParks) and Provincial	Marine Protected Areas	N/A	feature
		National Parks	Very high	feature
		Nature Reserves	Very high	feature
		World Heritage Sites (Core)	Very high	feature
		Mountain Catchment Areas	High	feature
		Protected Environments	High	feature
		Forest Nature Reserve	Very high	feature
		Forest Wilderness Area	Very high	feature
		Special Nature Reserve	Very high	feature
Protected Areas Buffers	SAPAD - Q4, 2018 and South African Conservation Areas Database (SACAD) - Q1,2017	10 KM buffer around National Parks or buffers received from SANPARKS	High	feature
		5KM buffer around Provincial Nature Reserves	N/A	feature
		1KM buffer around Local Nature Reserves	N/A	feature
		1KM buffer around Special Nature Reserves	N/A	feature
		Buffer around World Heritage Sites (Buffers are Site Specific)	High	feature
		5 km buffer around protected forests	N/A	feature
Conservation Areas	South African Conservation Areas Database (SACAD) -Q1,2017 (DEA)	Biosphere reserves (Buffer area of the biosphere reserve, core areas are already protected)	Medium	feature
		Botanical gardens	Medium	feature
		Ramsar Sites (not already protected)	Very high	feature
		1 km Buffer around National Botanical gardens	N/A	feature
		5km Buffer around Ramsar Sites	N/A	feature
	UNESCO Website / SAHRA	UNESCO tentative sites	High	feature
National Protected Areas Expansion Strategy	Priority Areas for Protected Area Expansion, 2017 (including updated Northern Cape Priorities) Department of Environmental Affairs (DEA)	Protected Areas Expansion Priority Areas (Primary)	High	feature
Natural Forests	National Forest Inventory (NFI), sourced 2016, Department of Agriculture, Forestry and Fisheries (DAFF)	National Forest Inventory	Very high	feature
Critical Biodiversity Areas	Provincial datasets (GP- 2014, EC- 2018, FS-2016, KZN- 2012, Limp- 2013, MP- 2013, NW- 2014, WC-2017, NC- 2016)	CBA	Very high	feature
		ESA	Medium	feature
Threatened Ecosystems	DEA and the South African National Biodiversity Institute (SANBI) 2010	CR	Very high	feature
		EN	High	feature
		VU	Medium	feature
Thicket	Thicket Vegetation, SANBI Vegetation Map, 2012 and the STEP Remnant Layer, 2003	Thicket Vegetation Types	Very high	N/A
Species of conservation concern	Endangered Wildlife Trust (EWT), SANBI and BirdLife South Africa (2017)	Critical Habitat for highly restricted Species Global Extent of Occurrence < 10 km^2	Very high	feature
		Confirmed occurrences of rare and threatened species	High	feature
		Suitable unsurveyed habitat for threatened, rare and data deficient species.	Medium	feature
		No known or expected threatened or rare species.	Low	feature
Bats	Roost dataset from the South African Bat Assessment Advisory Panel (SABAAP), 2017	Colony of 1 – 50 Least Concern bats + colony of 1 – 50 Low Risk Conservation Important bats	Very high	N/A
		Colony of 50 – 500 Least Concern bats + colony of 50 - 500 Low Risk Conservation Important bats + Colony of 1 – 50 Med-High Risk Conservation Important bats	Very high	N/A
		Colony of >500 High Risk Least Concern bats + colony of 50 - 500 Med-High Risk Conservation Important bats + colony of 500 - 2000 Low Risk Conservation Important bats	Very high	N/A

Feature Category/Factor	Source/Dataset	Features	Mapping Sensitivity (Environmental Constraint)	Feature/Buffer
		Colony of 500 - 2000 Med-High Risk Conservation Important bats	Very high	N/A
		Colony of >2000 Bats of any status or risk level	Very high	N/A
	Ecoregions (for bats), SABAAP, 2017	KwaZulu-Cape coastal forest mosaic	Medium	feature
		Maputaland-Pondoland bushland and thickets	Medium	feature
		Maputaland coastal forest mosaic	Medium	feature
		Zambezian and Mopane woodlands	Medium	feature
	Dolomite and Limestone, 2013, CSIR (Phase 1 REDZ)	Dolomite and Limestone	N/A	N/A
	Rivers - 1:50 000 scale river lines from the Department of Water Affairs, 2015; Wetlands, updated National Biodiversity Assessment Wetland Layer, SANBI, 2017	Rivers and Wetlands	N/A	N/A
Birds	BirdlifeSA exclusions Phase 1 SEA	Priority colonies	High	feature
		Transkei vulture IBA	High	feature
		Amur nests	High	feature
		Bearded vulture nest	High	feature
		Verloernvlei Flyway	High	feature
		Lesser Kestrel	High	feature
		Potberg Cape Vulture	High	feature
		Saldanha Flyway	High	feature
	Vulture Data, 2017, VULPRO	VULPRO Cape Vulture colonies	High	feature
		VULPRO Cape Vulture roosts	High	feature
		VULPRO Cape Vulture restaurants	High	feature
	Vulture Roost Sites, 2017, NMMU	NMMU Cape Vulture roost sites	High	feature
	Bearded Vulture Risk Model, 2017, KZN Wildlife	Bearded Vulture collision risk model	High	feature
	Important Bird Areas for South Africa, Bird Life, 2016	Important Birds Areas (Formally Protected)	Very high	feature
		Partially protected	High	N/A
		Unprotected	Medium	N/A
Estuaries	Estuaries, including flood plains, 2011, National Biodiversity Assessment, SANBI	All estuaries	Very high	feature
Freshwater Features	Rivers - 1:50 000 scale river lines from the Department of Water Affairs, 2015; Wetlands, updated National Biodiversity Assessment wetland layer, SANBI, 2017	Wetlands	Very high	feature
		Rivers	Very high	feature
Freshwater Feature Buffers	Buffered Rivers and Wetlands	500m buffer around Wetlands	N/A	N/A
		32 m buffer around Rivers	Very high	32m buffer and feature
Strategic Water Source Areas (SWSAs) - Surface and Groundwater	Council for Scientific and Industrial Research (CSIR) April 2018	SWSAs (Natural Areas)	High	feature
Land Cover	National Land Cover 2013/2014, DEA Habitat Modification Layer (Improved Land Cover) SANBI 2017	Natural areas	Low	feature
		Modified areas	Low	feature
		Old fields (mapped from imagery)	Low	feature
Agricultural Land Capability	Land Capability Layer, 2016, DAFF	Land capability features with values ranging from 11-15	Very high	feature
		Land capability features with values ranging from 8-10	High	feature
		Land capability features class 6 to 7	Medium	feature
		Land capability features class 1 to 5	Low	feature
Field Crop Boundaries	Field Crop Boundaries, 2017, DAFF	Irrigated Areas (pivot agriculture)	Very high	feature
		Shadenet	Very high	feature
		Viticulture	Very high	feature

Feature Category/Factor	Source/Dataset	Features	Mapping Sensitivity (Environmental Constraint)	Feature/Buffer
		Horticulture	Very high	feature
		Other cultivated areas	High	feature
Coastline	Coastline, 2015, SANBI and Department of Rural Development and Land Reform	Buffered coastline (1km)	Very high	1km
Karoo Central Astronomy Advantage Area (KCAAA)	KCAAA Footprint, obtained via CSIR (2017)	Karoo Central Astronomy Advantage Area	Medium	feature
Square Kilometre Array (SKA) Area	SKA Core Area, 2017, from SKA via CSIR	Square Kilometre Array (SKA) study area	Very high	Feature
		SKA Telescopes with 20km buffer	Very high	0-20km
Defence	Defence Data, 2017, South African National Defence Force	Forward Airfield	Very high	1 km
		Air Force Bases	Very high	1 km
		High Sites	Very high	1 km
		Operational Military Bases	Very high	1 km
		Military Training Areas	Very high	2km
		Bombing Ranges	Very high	1km
			High	2km
			Medium	5km
		Shooting ranges	Very high	1km
		Border Posts	Very high	1km
		Ammunition Depots	Very high	10 km
		All Other DoD features (Including Naval Bases, Housing, Offices etc.)	Very High	1km
Airports (major, landing strips, small aerodromes)	REDZs 1 SEA Dataset and EGI SEA Dataset, 2017	Major Airports	Medium	8km
		Landing strips	N/A	N/A
		Other civil aviation aerodromes (small aerodromes)	Medium	8km
	SACAA	Civil Aviation Radars	N/A	N/A
	ATNS	Air Traffic Control and Navigation Sites	N/A	N/A
	SACAA	Danger and Restricted Airspace	N/A	N/A
Paleontological heritage resources	Palaeontological Substrate, CSIR, 2013	High sensitivity areas (*) - refer to below	High	feature
		Medium sensitivity areas (**) - refer to below	Medium	feature
Heritage	Mapped Heritage Features, SAHRA, 2018	World Heritage Sites (Core)	Very high	feature
		World Heritage Sites (Buffer)	High	feature
		Grade I sites	Very high	2km
		Grade II sites	Very high	1km
		Grade IIIa sites	High	150m
		Grade IIIb sites	High	100m
		Grade IIIc sites	High	50m
		Ungraded	Very high	100m
		Battlefields (Grade IIIb)	Very high	5 km
Visual	Modelled from Digital Elevation Model, 2015, NGI	Slopes > 25% or 1:4	Medium	feature
	NFEPA 2011	Major River	N/A	NA
	NGI, 2016	Coastal zones	Not a visual issue	1-4 km
	Provincial data sets on Game Farms and Private Reserves (2014-2017); SACAD Q2, 2017, DEA	Private reserves and game farms	High	0-2.5 km
			Medium	2.5-5 km
			Low	5-10 km
			Low	>10 km
	Location of the SAL Telescope, sourced from the CSIR, 2017	SALT	Very high	0-25 km

Feature Category/Factor	Source/Dataset	Features	Mapping Sensitivity (Environmental Constraint)	Feature/Buffer
	Mapped Heritage Features, SAHRA, 2015	Heritage feature: Grade I sites	Medium	feature- 1.5 km
		Heritage feature: Grade II sites	Medium	1- 1.5 km
		Heritage feature: Grade IIIa sites	Medium	150 m - 1.5 km
		Heritage feature: Grade IIIb sites	Medium	50 m - 1.5 km
		Heritage feature: Grade IIIc sites	Medium	30 m - 1.5 km
	Location of Towns, AfriGIS Towns – 2017	Town, villages and settlements outside large urban areas	Very high	0-500 m
			High	500 m - 1 km
			Medium	1 km-2 km
	NGI, Coastline 2016	National Roads and Scenic Routes	N/A	N/A
			N/A	N/A
			N/A	N/A
	Western Cape Department of Transport, 2013, Sourced from the CSIR	Western Cape Routes	N/A	N/A
Major Towns	Location of Towns, AfriGIS Towns – 2017	Towns, villages and settlements and urban areas	Very high	5 km
Urban Areas and High Density Rural Settlements	Eskom SPOT Building Count, 2013 (100 m x 100 m grid cell resolution).	Grid cells containing ≥ 3 dwellings	Very high	1 km
Paleontological Heritage Resources - High Sensitivity Areas (*)	Geological features and substrates of Palaeontological Importance, Geology Layer, 2014, Council for Geosciences	• ADELAIDE • ASBESTOS HILLS • BOEGOEBERG DAM • BOTHAVILLE • BRULSAND • CAMPBELL RAND • CLARENS • DRAKENSBERG • DWYKA • ECCA • ELLIOT • ENON • GHAAP • KAMEELDOORNS • KOEGAS • KUIBIS • MATSAP • MOLTENO • PRINCE ALBERT • RIETGAT • SCHMIDTSDRIF • SCHWARZRAND • STALHOEK • SULTANAOORD • TARKASTAD • VRYBURG • WHITEHILL • WITTEBERG	High	feature
Paleontological Heritage Resources - Medium Sensitivity Areas (**)	Geological features and substrates of Palaeontological Importance, Geology Layer, 2014, Council for Geosciences	• ACHAB • ALLANRIDGE • BIDOUW • BREDASDORP • CERES • CONCORDIA GRANITE • DWYKA • FORT BROWN • GESELSKAPBANK • GLADKOP • GRAHAMSTOWN • HARTEBEEST PAN GRANITE • HOOGOOR • KALAHARI • KAMIESKROON GNEISS • KAROO DOLERITE • KHURISBERG • KONKYP GNEISS • KOOKFONTEIN • KORRIDOR • MESKLIP GNEISS • MODDERFONTEIN • GRANITE/GNEISS • NAAB • NABABEEP GNEISS • NAKANAS • NARDOUW • NUWEFONTEIN GRANITE • RIETBERG GRANITE • SKOORSTEENBERG • STINKFONTEIN • STYGER KRAAL SYENITE • TABLE MOUNTAIN • TIERBERG • VOLKSRUST • WATERFORD	Medium	feature

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1 Table 2: Features and datasets used to prepare high level draft engineering constraints map

Feature category/Factor	Source/Dataset	Features	Mapping Sensitivity (Engineering Constraint)	Feature/Buffer
Coastline (including Estuaries)	SANBI 2004	Coastline & Estuaries	Very High	1 km
Slope	25m NGI DEM	>45°	Very High	feature
		25-45°	High	feature
		15-25°	Medium	feature
		0-15°	Low	feature
Access/Roads	Eskom - NGI Roads Layer 2016	Roads	Low	feature
Geology	Council for Geoscience, 1997	Dolomite (and other rock types)	High	feature
		Dolomite restricted to Gauteng and Mpumalanga	Very high	Feature
Seismicity	Seismic Hazard in South Africa 2011 (Council for Geoscience Report number: 2011-0061)	Generally confined to Cape Fold Belt region of Southern Cape	High	feature
Gully Erosion	DAFF Gully Erosion Datasets	Footprint of erosion/gully > 500 m²	Very High	feature
Soil Erodibility	DAFF Soil Erosion Hazard Classes - South Africa and Lesotho, 2010	Hazard Class - High	High	feature
		Hazard Class - Medium	Medium	feature
		Hazard Class - Low	Low	feature
Settlements	AfriGIS Towns Layer	Towns, villages and settlement spatial footprints	Very high	feature
Railway Lines (All Railways)	DRDLR Topo, 2006 - Transnet	0 - 1 km around railways	Very High	1 km
		1 - 5 km around railways	High	1 - 5 km
		5 - 10 km around railways	Medium	5 - 10 km
Industrial Areas	DEA 2013/2014 land cover	Existing industrial areas	Low	feature
Industrial Expansion	SDFs, IDPs, consultation with authorities	Planned industrial activities	Low	feature
Mining	DMR, 2018 (SAMRAD Mining Applications)	(RETENTION PERMIT, RECONNAISSANCE PERMISSION/PERMIT, RECON PERMISSION, PROSPECTING RIGHT, PROSPECTING RIGHT RENEWAL, MINING_RIGHT, MINING_PERMIT, MINING RIGHT RENEWAL, EXPLORATION RIGHT, BURROW PIT, AMENDING AN EXISTING RIGHT)	Very High	feature
Mining	Transnet	Undermining. Localised areas in northern KwaZulu-Natal and Mpumalanga associated with old coal mine working	High	Feature
Major dams	DWA Dams Data	Dams	Very High	feature
Estuaries	National Biodiversity Assessment (NBA) 2017/18	All Estuaries	Very High	feature
Wetlands	Wetland Data 2017	All Wetlands	Medium	feature
Rivers	NFEPA River Data 2010 and NGI Mapped River Footprint	Drainage Lines	Very high (Order 6-7)	> 500m
			High (Order 4-5)	Between 10 and 500 m
			Medium (Order 1-3)	<10m
	NBA 2018 (South African Inventory of Inland Aquatic Ecosystems)	Valley Bottom include Stream (Exclude Northern Cape)	Very High	
WULA Agreements	NFEPA River and Wetland Data 2010	Rivers and wetlands buffered by 500 m	High	500 m buffer around feature

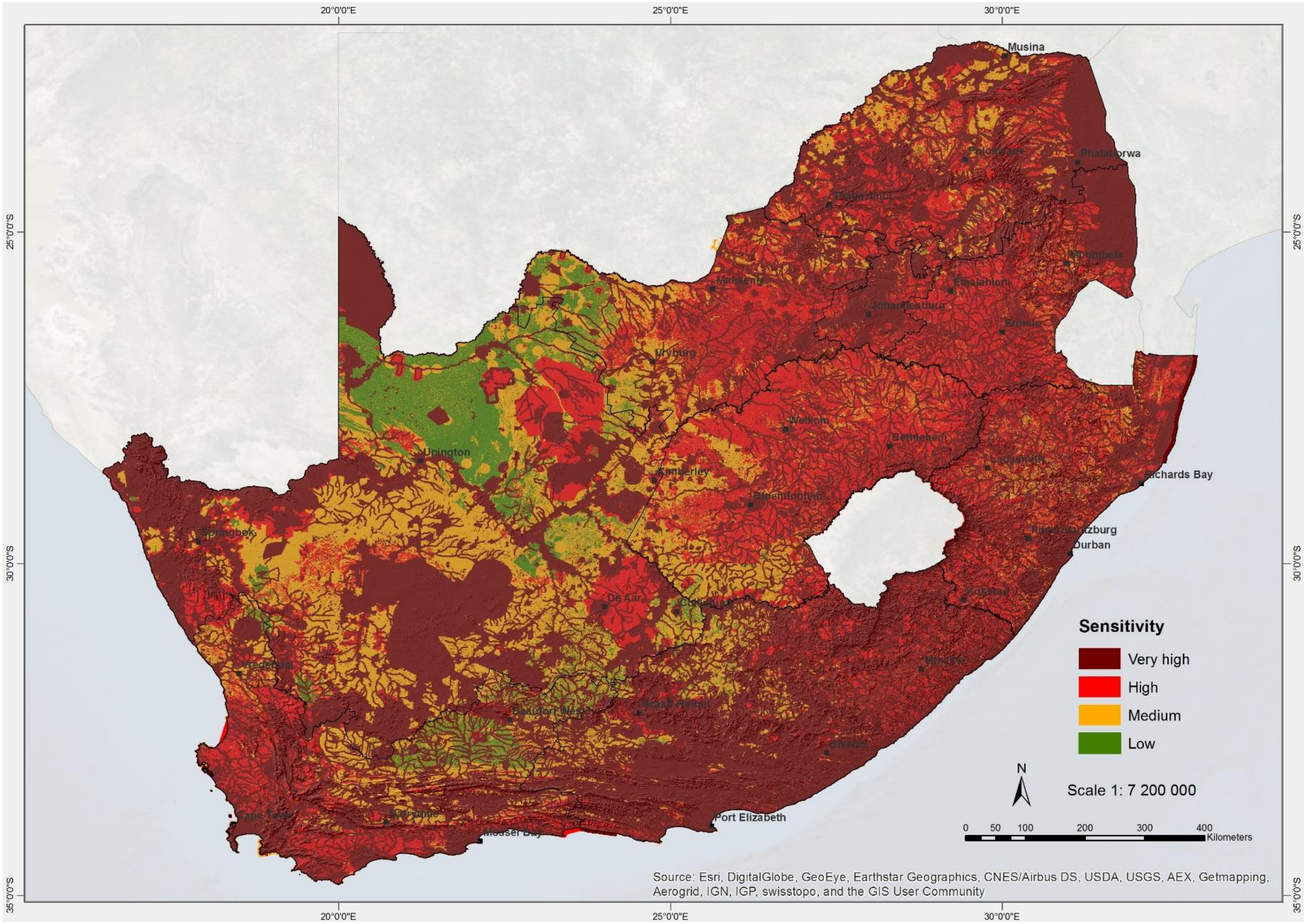
Feature category/Factor	Source/Dataset	Features	Mapping Sensitivity (Engineering Constraint)	Feature/Buffer
Natural Forests	Department of Agriculture, Forestry and Fisheries, 2017. NFI	Natural forests	Very High	feature
Forestry Potential (EC)	EC Parks and Tourism Agency 2014	Potential Areas for Forestry	Medium	feature
Thicket	Albany Thicket, SANBI Vegetation Map, 2017	National	High	feature
Sugar Cane	KZN Land Cover 2011 [Sugar cane farming and emerging farming data]	Sugar Cane Farm Boundaries	High	feature
Commercial Forestry	Data on Commercial Forestry provided by DAFF in June 2016	DAFF Commercial Forests	Very high	50 m buffer
Field Crop Boundaries (Pivot >500 m radius)	Agriculture Field Crop Boundary Data 2016	All	N/A	NA
Field Crop Boundaries (vineyards and orchards)	Agriculture Field Crop Boundary Data 2016	All	N/A	NA
Field Crop - Short term	Agriculture Field Crop Boundary Data 2016	All	Medium	feature
Field Crop - Long term	Agriculture Field Crop Boundary Data 2016	All	Very High	feature
High incidence for lightning strikes	Eskom, July 2014	Highest 10% risk areas	Low	feature
High incidence for fire	Eskom, November 2016 (2002-2017)	Highest 10% risk areas	High	feature
High incidence for wind	Eskom, July 2014	Highest 10% risk areas	Low	feature
High incidence for flooding	Eskom, 2015 (sourced in 2018)	Highest 10% risk areas	Medium	feature
High incidence for snow conditions	Eskom, July 2014	Highest 10% risk areas	N/A	N/A
High incidence for pollution	Eskom, July 2014	Highest 10% risk areas	N/A	N/A
Electrical Transmission Cables (Voltages Above 60 kV)	DRDLR Topo, 2006 - Transnet	0 - 1 Km	Very High	< 1 km
		1 - 5 km	High	1 - 5 km
		5 - 10 km	Medium	5 - 10 km
		> 10 km	Low	> 10 km
Electrical Transmission Cables (Voltages Below 60 kV)	DRDLR Topo, 2006 - Transnet	0 - 1 Km	High	< 1 km
		1 - 5 km	Medium	1 - 5 km
		5 - 10 km	Low	5 - 10 km
Cable/Telecom line/Pipelines	iGas, 2017 (Rompco Gas Pipeline) Transnet, 2018 (Future and Existing Gas and Fuel Pipelines)	Gas and Fuel Pipelines (feature)	Medium	feature
Water Pipelines	DWS, 2017 (Bulk Infrastructure)	Existing and Future Bulk Water Pipelines and Infrastructure	Medium	feature

2.4.4 Constraints Maps

The constraints mapping outputs were developed at a national scale for both environmental and engineering constraints. The four tiered wall to wall draft environmental constraints/sensitivities map and the interpretation of each tier of constraint is illustrated in Map 2 and Table 3, respectively. In addition, the four tiered wall to wall draft engineering constraints map and the interpretation of each tier of constraint is illustrated in Map 3 and Table 4, respectively. The Draft Environmental Constraints/Sensitivities Corridor Map and Draft Engineering Constraints Corridor Map are shown in Map 7 and Map 8 respectively.

Table 3: Environmental constraints/sensitivities interpretation

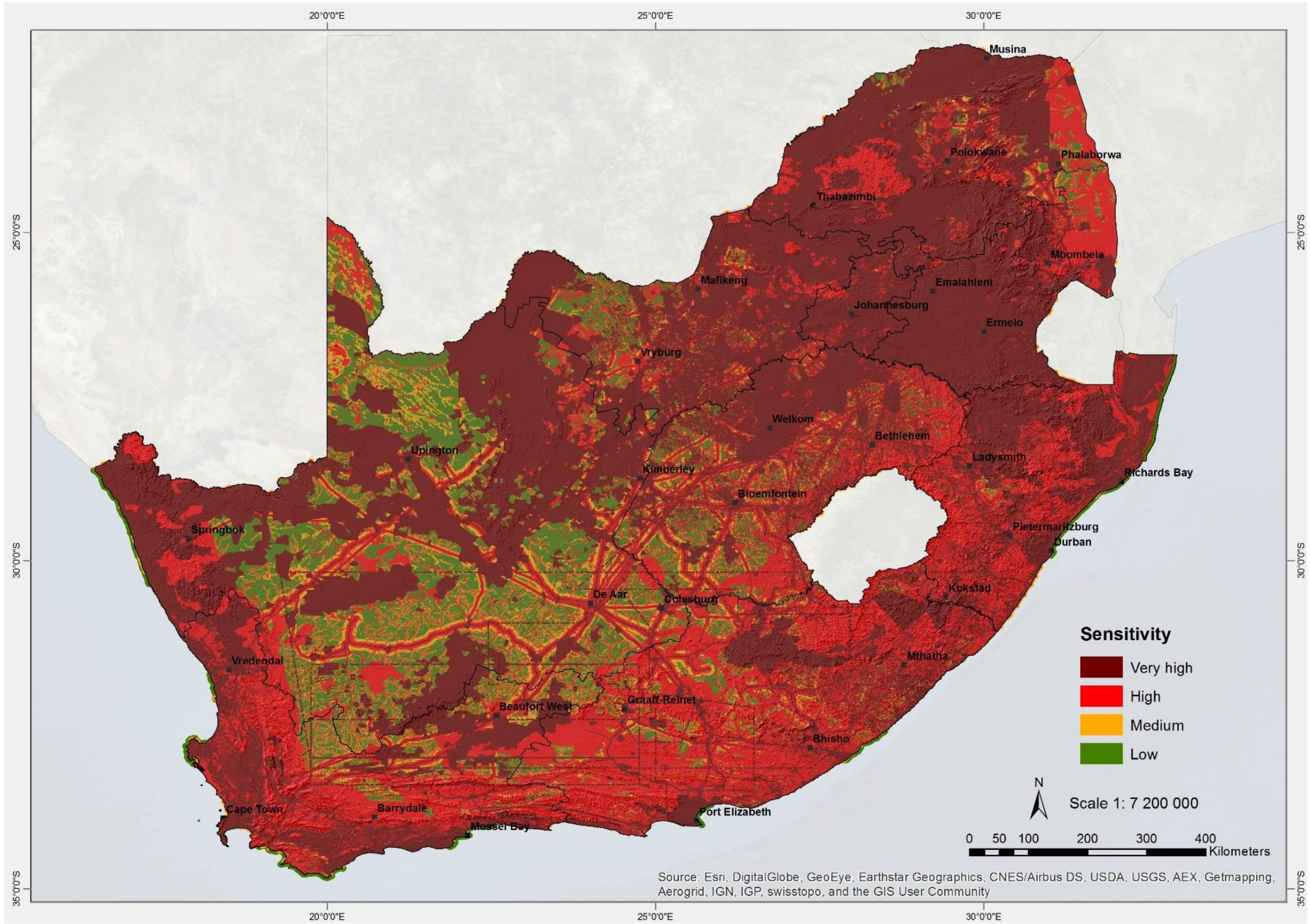
Environmental Constraints/Sensitivities	
Constraint	**Description**
Very High	The area is rated as extremely sensitive to the negative impact of gas pipeline infrastructure development. As a result, the area will either have very high conservation value, very high existing/ potential socio-economic value or hold legal protection status.
High	The area is rated as being of high sensitivity to the negative impact of gas pipeline infrastructure development. As a result, the area will either have high conservation value and or existing/potential socio-economic value.
Medium	The area is rated as being of medium sensitivity to the negative impact of gas pipeline infrastructure. As a result the area will either have medium levels of conservation value and/or medium levels of existing/potential socio-economic value.
Low	Area is considered to have low levels of sensitivity in the context of gas pipeline infrastructure.



Map 2: Draft Environmental Constraints/Sensitivities Map

Table 4: Engineering constraints interpretation

Engineering Constraints		
Constraint	**Description**	**Feature Cost**
Very High	The lifetime cost associated with development in this area is greater than 160% the baseline lifetime cost index.	c=>1.60x
High	The lifetime cost associated with development in this area is between 140% and 160% the baseline lifetime cost index.	c=>1.40x and ≤1.60x
Medium	The lifetime cost associated with development in this area is between 120% and 140% the baseline lifetime cost index.	c=1.20x and ≤ 1.40x
Low	The lifetime costs associated with development in this area is less than 120% times the baseline lifetime cost index.	c =<1.20x



Map 3: Draft Engineering Constraints Map

2.4.5 Opportunities Mapping (Pull Factors)

The opportunity mapping considered key strategic geographical areas set aside for specifically targeted economic activities through national policy, plans and programmes. In particular, the mapping exercise considered 15 Special Economic Zones (SEZs) identified by the Department of Trade and Industry (DTI) as incentivised sector-specific industrial development areas under the Special Economic Zones Act (2012). Consideration was also given to existing Industrial Development Zones (IDZ) and the spatial distribution of the relevant SIPs recognised under the IDP. The establishment and promotion of SEZs are at the centre of national industrial policy. These Zones include the existing IDZs at Coega, East London, Richards Bay and Saldanha along with the following 10 proposed SEZs:

Table 5: Proposed SEZs for South Africa

**Source: Dti (2014)*

	Province	Location	SEZ Type
1.	Kwazulu-Natal	Dube Trade Port	Agro-processing, Green Energy, trade hub
2.	Mpumalanga	Nkomazi	Agro-processing, mineral processing and trade hub
3.	Free State	Harrismith	Agro-processing, logistics hub
4.	Eastern Cape	Wild Coast	Agro-processing, tourism, leather
5.	North West	Mafikeng/Rustenburg	Agro-processing, mixed manufacturing and Platinum Hub
6.	Limpopo	Musina	Agro-processing, mineral processing and trade hub
7..	Limpopo	Burgersfort/Tubatse	Platinum and other PGMs beneficiation
8.	Gauteng	Nasrec	ICT Hub (Smart City)
9.	Northern Cape	Upington Solar Corridor	Solar Components, Electronics
10.	Western Cape	Atlantis	Renewable Energy

The aforementioned SEZs are mapped in the figure below. It is clear that they are spread throughout the country and would be well-served and facilitated by the planned gas pipeline corridors which generally run through or nearby them.

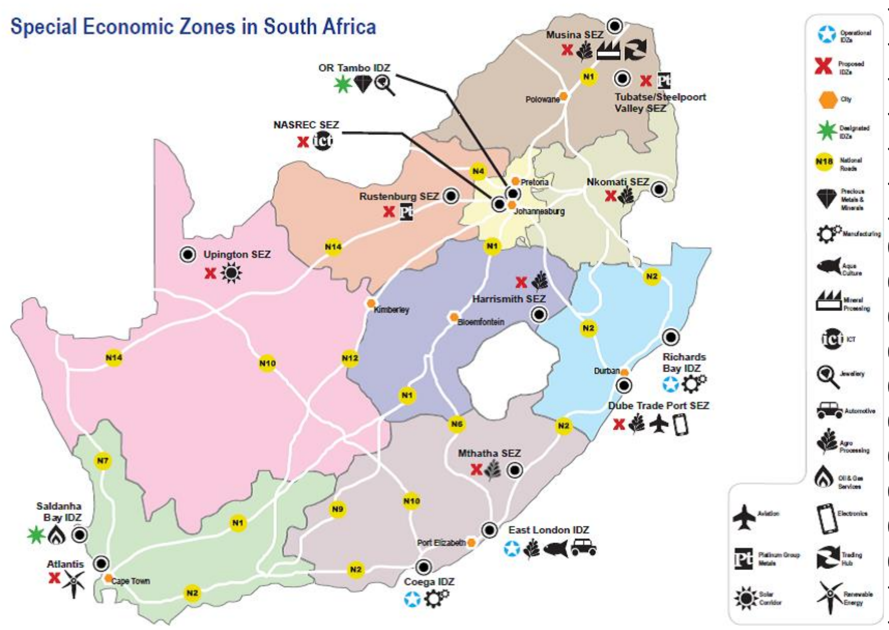


Figure 5: Map of existing IDZs and planned SEZs (Source: DTU Regional and Spatial Economic Development)

Municipalities and provinces were also provided with an opportunity to give feedback on major infrastructure that would require the use of gas (e.g. existing and proposed mining areas, Industrial expansion, and Industrial zone establishment (outside urban edges)) based on most recent plans and local knowledge.

On the other hand, infrastructure such as roads and other main servitudes have been treated as Pull factors, while urban areas and urban expansion were considered as Push factors.

2.5 Draft Pinch Point Analysis

As explained in Part 1 of this SEA Report, Task 3 of Phase 2 involved the Corridor Refinement. As noted above, there are numerous environmental features that could potentially be impacted on by the gas pipeline infrastructure development. In order to refine the 100 km wide gas pipeline corridors, an analysis was undertaken to identify areas of very high environmental sensitivity to potentially avoid. This analysis is known as a "Pinch Point Analysis". The Pinch Point Analysis is a method that identifies where "bottle necks" or "choke-points" are located within the landscape (McRae *et al*. 2008[20]). The analysis works by synthesizing and overlaying the constraints mapping (sensitive environmental and engineering features) outputs to determine where possible available routing options exist within the corridors. Multiple unique routing options, outside of Very High sensitivity areas and at all points along each of the corridors, are desirable in the context of this study as this allows developers a degree of flexibility when negotiating without having to consider development in a very sensitive area.

A draft Pinch Point Analysis was undertaken during the screening phase, prior to the commencement of the specialist assessment in order to guide and inform the location of the corridors. A final Pinch Point Analysis will be undertaken after the specialist studies and stakeholder input, to allow for potential realignment of the corridor.

The draft refinement of the preliminary corridors used outputs from the environmental and engineering constraint mapping, together with expert inputs from the gas and environmental sector. As noted above, both the environmental and engineering constraints mapping exercise identified sensitivity areas and assessed them as either Very High (VH), High (H), Medium (M) or Low (L) sensitivity.

However, for the Pinch Point Analysis only Very High sensitive areas were used for the corridor refinement. Due to their sensitivity, these Very High sensitive areas potentially impact the design of the phased gas pipeline network, and consequently the location of the corridors. Some examples of features rated with a Very High sensitivity includes the SKA, active mining areas, Protected Areas, mountainous areas, critical biodiversity areas, threatened ecosystems and water related features.

Using the Spatial Analysis suite of tools in GIS, a single layer of all Very High sensitive areas was created at a national scale. This layer was then overlaid with the preliminary 100 km wide corridors (Map 4). This process enabled the Project Team to highlight and identify bottle necks or pinch points within the landscape. Pinch points or bottle necks are defined, for the purposes of this exercise, where at least 80 % of the 100 km wide corridor is covered by Very High sensitive features. A complete pinch point had 98 - 100% of the corridor covered in Very High Sensitive features, a partial Pinch Point occurred where 80-97% of the corridor was covered in Very High sensitive features. In the event of a complete or partial pinch point, the area immediately adjacent to that point and outside the corridor was considered from an environmental and engineering constraints perspective. Where relief outside of the corridors was shown to be present, the corridor boundary was shifted in the direction of relief to allow for a minimum of five unique routing options.

However, not all the features were considered to be constraints, as some features were used as opportunity or pull factors, where the corridor was adjusted and directed towards these features (as described in Section 2.4.5). In cases where there was no need to adjust the corridors based on sensitivity, the corridor remained the same. Similarly, in cases where there

[20] McRae, B.H., Dickson, B.G., Keitt, T.H. and Shah, V.B., 2008. Using circuit theory to model connectivity in ecology, evolution, and conservation. *Ecology*, *89*(10), pp.2712-2724.

were Very High sensitive features both in and around the corridors, the corridors remained the same as there was no immediate relief outside the corridors.

The main focus area for the Phased Gas Pipeline Network is along the coast due to offshore oil and gas activities taking place. Therefore, the Project Partners advised that the refinement and adjustment process should ensure that the corridors are located as close to the coast as possible due to the escalating cost associated with developing the infrastructure away from the coast. However, because of the sensitivity of coastal areas, the corridors are set back at least 10 km from the coastline (in some cases).

As part of the draft Pinch Point Analysis, refinements and adjustments took place at the corridors within the Northern Cape and Western Cape (Phases 5 and 6), and Free State and Mpumalanga (Phase 3), as well as at the Inland Corridor near Beaufort West (Map 5). The major shifts were driven by the following:

- Protected areas; SKA; Mining areas;
- Adjustments to align with other SEA planning outputs (i.e. Shale Gas and EGI); and
- Expanding the corridors to allow a greater area for the assessment.

The draft refined corridors were made available to the specialists for assessment as part of Task 4 of Phase 2 of the SEA Process. The Draft Refined Corridors in comparison to the Preliminary Corridors (the starting point of the SEA Process) are illustrated in Map 6. The outcome of the specialist assessment and stakeholder engagement will then be used to identify any further pinch points, and a final corridor re-alignment will be undertaken to confirm the final corridors. This information will then be used to undertake a least cost path analysis that will identify routes of low sensitivity in the corridors, where there will be low environmental impact and low cost.

After the draft pinch point analysis was undertaken a 25 km assessment buffer was added, and a 125 km wide corridor was used in the specialist assessment phase. This was undertaken to make provision of potential realignment of the corridors subsequent to the specialist studies and consultation, during which the corridors will be realigned to 100 km wide corridors.

The output of the draft pinch point analysis was a draft set of refined corridors. The output of the final pinch point analysis will be a final set of refined corridors i.e. the Gas Corridors. The pinch point analysis will ensure that the final position of the corridors as a result of the SEA Process not only support areas of potential for gas pipeline development but also reduce the risk of significant impact to the environment.

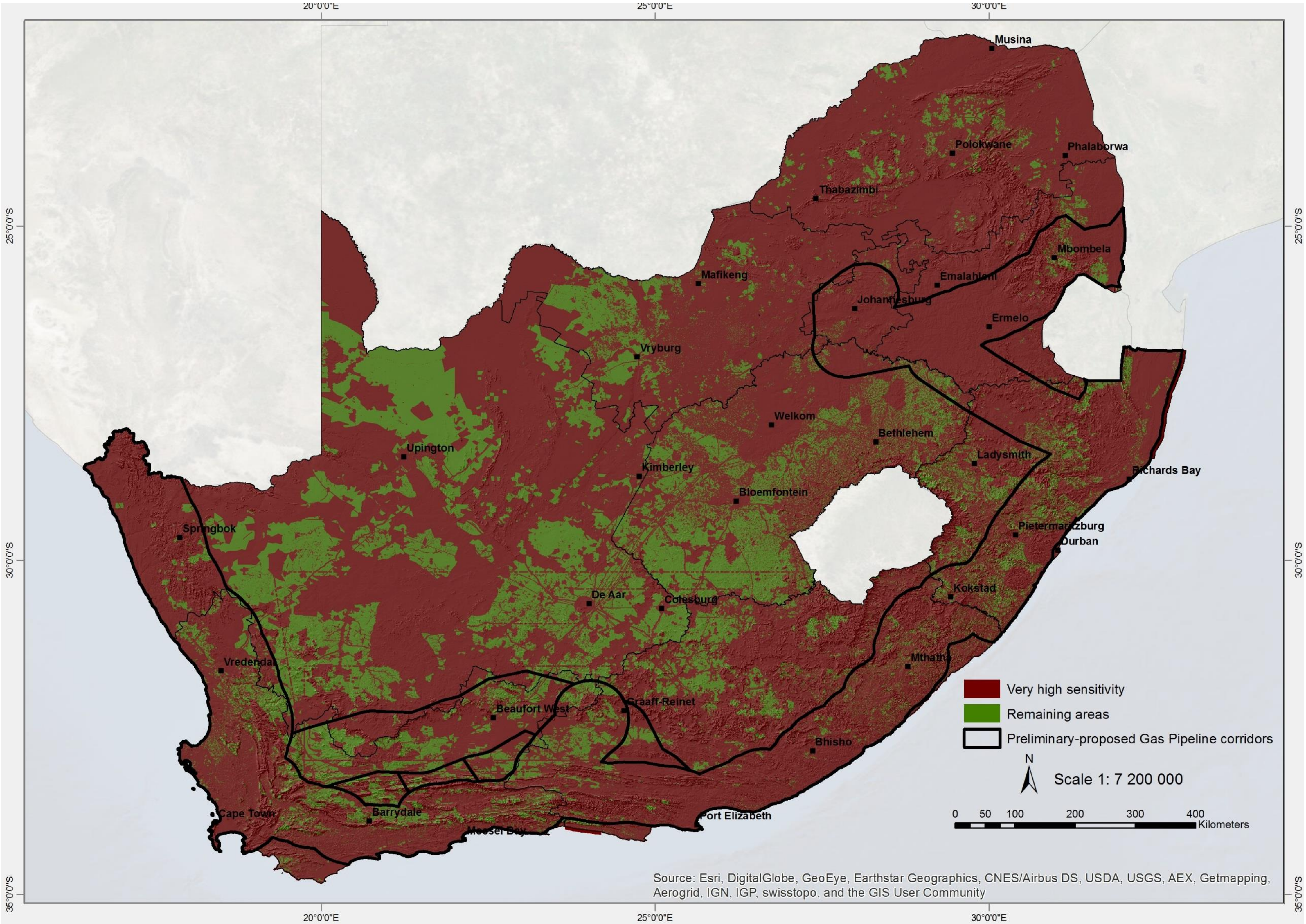
2.6 Public Consultation

As noted in Section 2.4, in addition to consulting key stakeholder groups through the ERG and PSC, as well as engagement with key and sector specific stakeholders, public consultation was conducted throughout the duration of the SEA through the exchange of information and data via a dedicated online platform (i.e. project website: https://gasnetwork.csir.co.za/). Additional public engagement was undertaken through newspaper advertisements at key stages of project delivery as well as two Public Outreach programmes. Table 6 below lists the various mechanisms used to engage the public as part of this SEA.

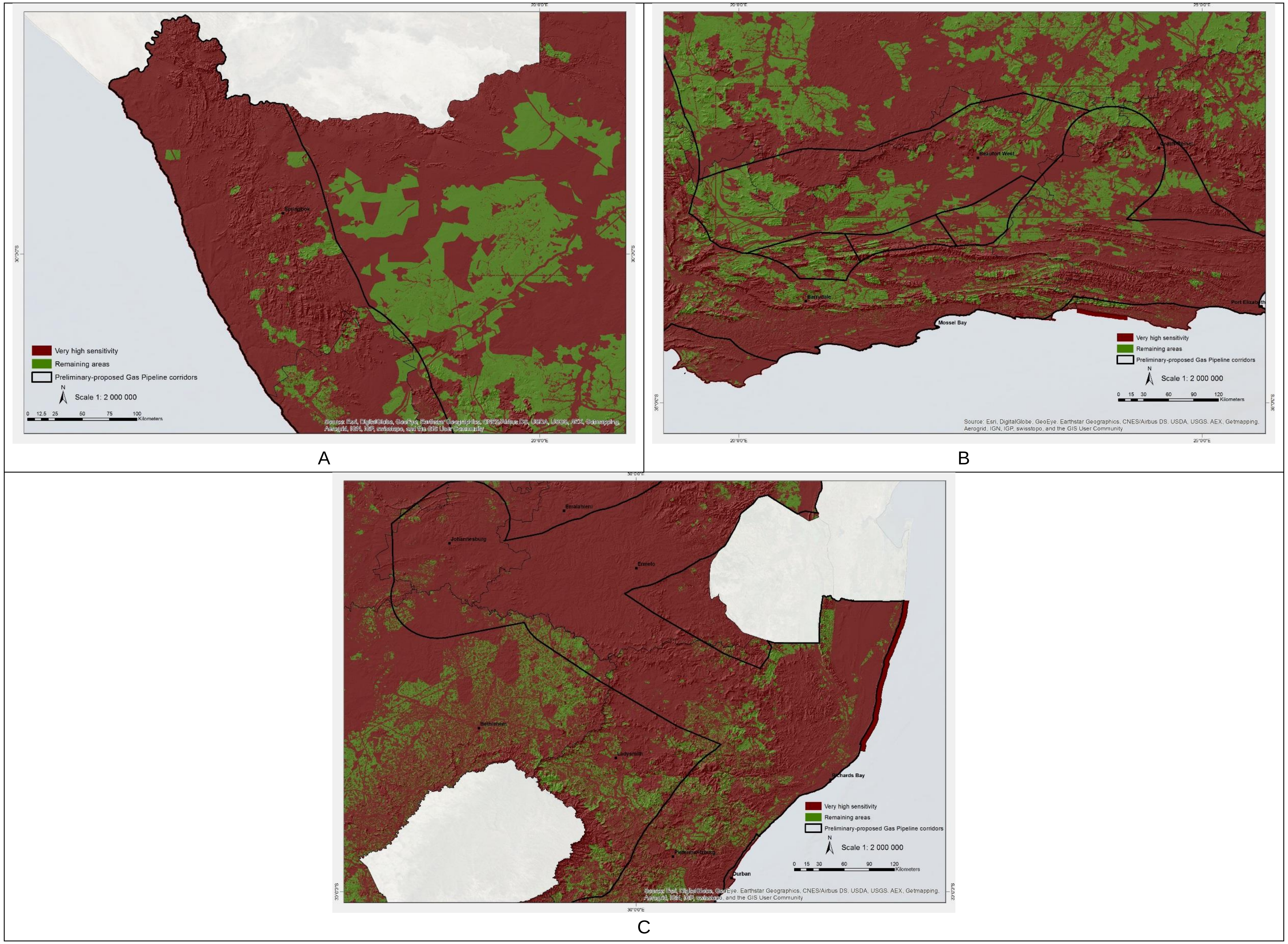
Table 6: Summary of Public Engagement undertaken during the SEA

Date	Mechanism
July 2017	Advertisements placed in the following newspapers to inform stakeholders of the SEA (as part of the Project Initiation): • The Star • Cape Argus • Diamond Fields Advertiser • Daily News • Farmers Weekly • Engineering News
October 2017	Advertisements placed in the following newspapers to notify stakeholders of the planned public meetings for the Public Outreach – Round 1: • Business Day • Cape Argus • City Press • Daily Dispatch • Daily News • George Herald • The Gemsbok • The Star
1 November 2017 to 8 November 2017	Public Outreach – Round 1 at the following locations: • Cape Town • East London • Johannesburg • Durban • Springbok • George
6 July 2018	Article published online in Engineering News provide a progress update on the SEA.
August 2018	Advertisements placed in the following newspapers to provide an update on SEA Process: • Cape Argus • Daily News • Diamond Fields Advertiser • The Star
September 2018 and October 2018	Advertisements placed in the following newspapers to notify stakeholders of the planned public meetings for the Public Outreach – Round 2: • Business Day • Cape Times • City Press • Daily Dispatch • Daily News • EP Herald_ • George Herald • The Gemsbok • The Star • Pretoria News • Diamond Fields Advertiser
8 October 2018 to 22 November 2018	Public Outreach – Round 2 at the following locations: • George • Port Elizabeth • East London • Durban • Johannesburg • Upington • Springbok • Cape Town

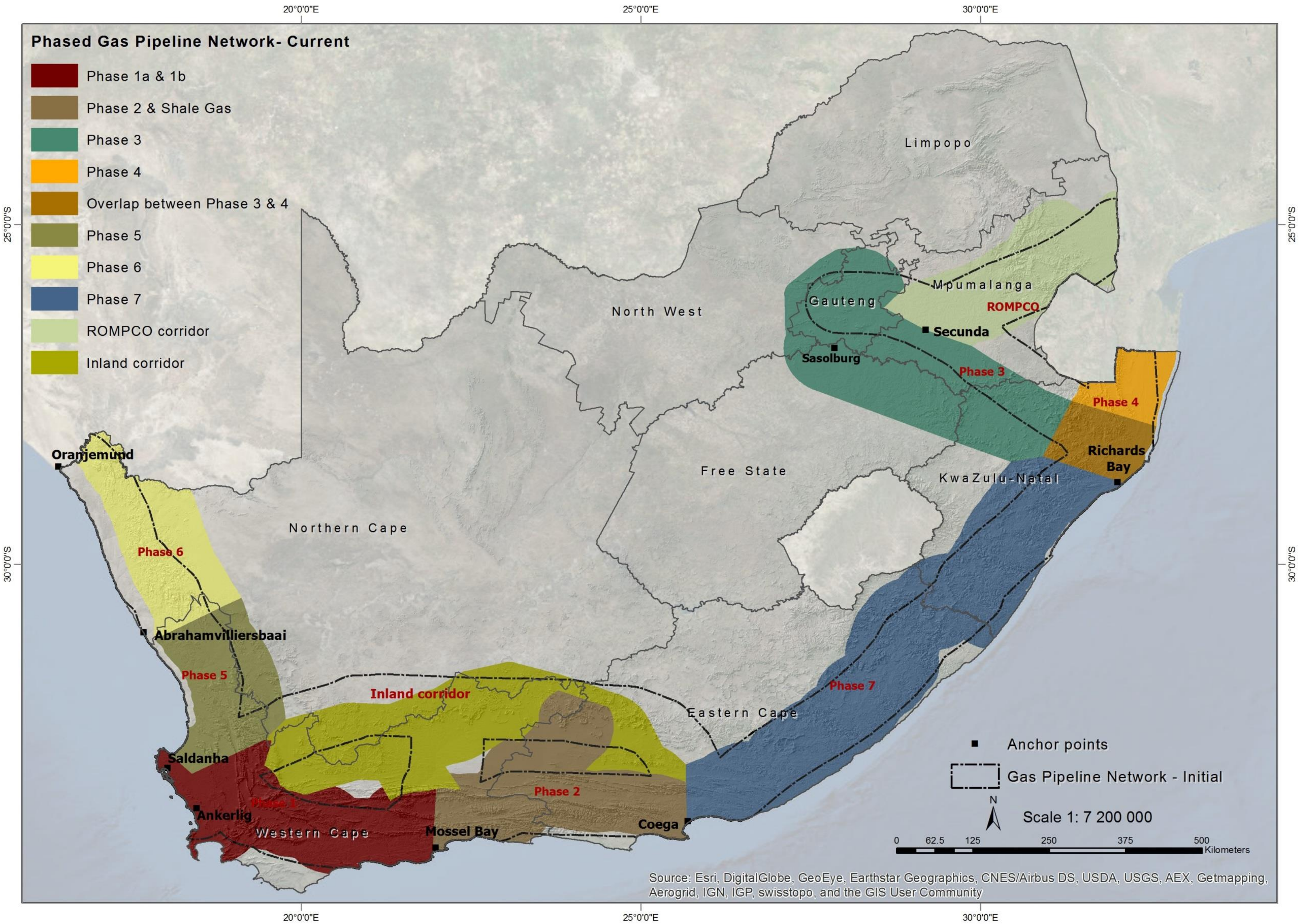
Currently, the specialist assessment reports are being released for public review. Formal comments from stakeholders are received throughout the SEA Process; however only comments received during the dedicated public commenting period will be included in the Issues and Response trails.



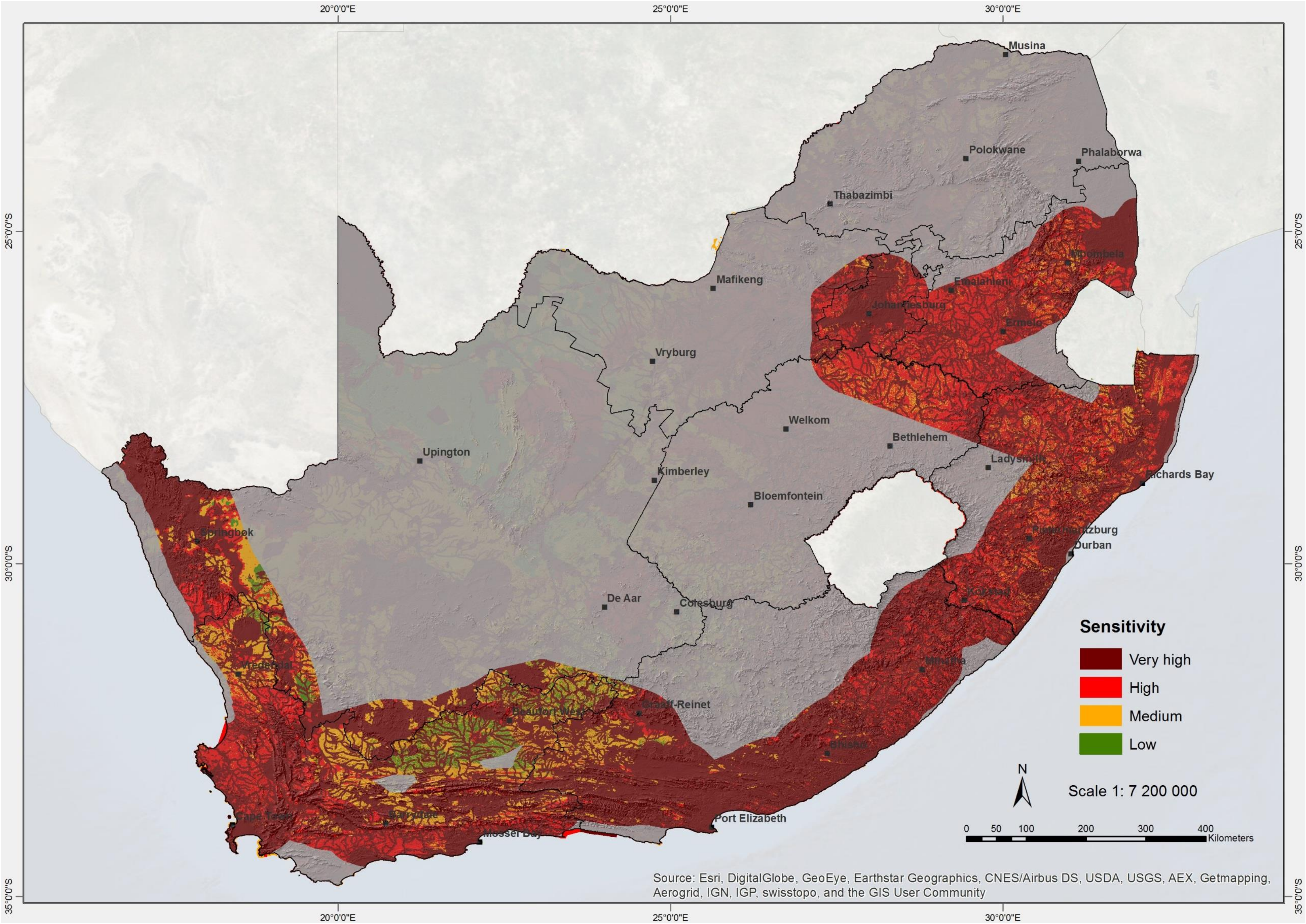
Map 4: Draft Pinch Point Analysis Results at a national scale. Rivers were excluded due to scale.



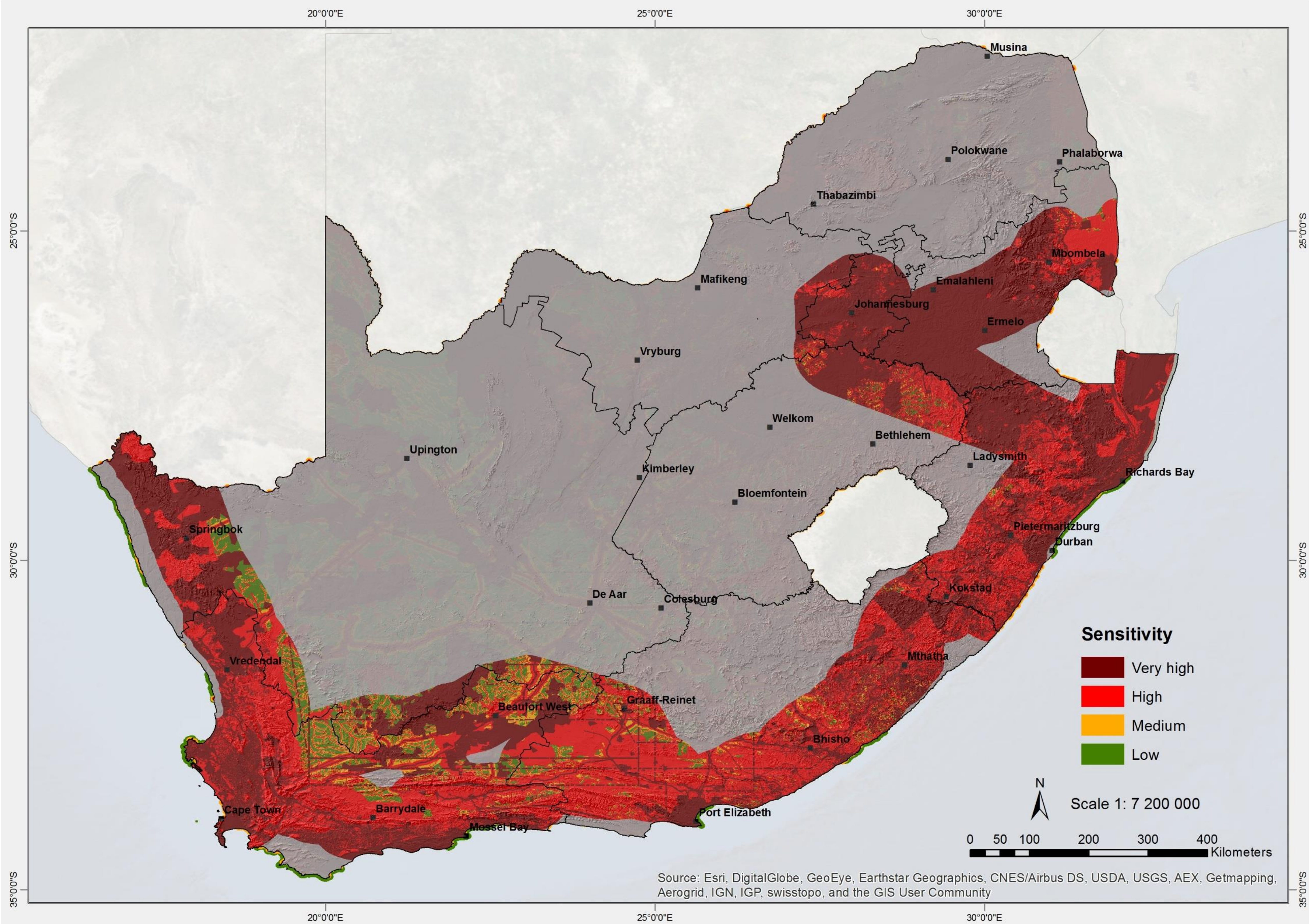
Map 5: Zoomed in map for the A) West Coast, B) Inland Corridor, and C) East Coast to show the Very High sensitive areas for the Draft Pinch Point Analysis. Rivers were excluded due to scale.



Map 6: Preliminary Corridors and Draft Refined Corridors



Map 7: Draft Environmental Constraints/Sensitivities Refined Corridor Map



Map 8: Draft Engineering Constraints Refined Corridor Map