

## Chapter 4 Project Development and Evaluation of Alternatives





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## **4 PROJECT DEVELOPMENT AND EVALUATION OF ALTERNATIVES**

### **4.1 Introduction**

This chapter describes the elements of the SCPX Project for which alternatives were assessed and explains the reasons why particular options were adopted for the proposed SCPX base case presented in Chapter 5. The alternatives are:

- The 'no development' option
- The development concept and the type and size of pipeline
- The pipeline route
- The type of river and road crossings
- The location of the facilities
- The design of the facilities
- The routing of access roads
- The location of construction camps and equipment lay-down areas
- Logistics.

Alternative options are generally evaluated with consideration given to environmental and social (E&S) and health and safety (H&S) potential impacts, technical feasibility and commercial implications.

Where kilometre points (KPs) are mentioned to describe the location of certain features, these denote the nearest kilometre point on the new 56" pipeline loop. Where reference is made to the location of CSG2 and PRMS, where there is no new SCPX pipeline, the KP denotes the nearest kilometre point on the SCP pipeline.

### **4.2 No-Development Alternative**

If the SCPX Project does not go ahead, there will be no environmental and social impacts from construction or operation, but some positive benefits would also be lost:

- There would be no export route for the additional gas produced from the Shah Deniz Full Field Development or for future gas volumes from other developments in the Caspian region
- The Georgian Government would forgo the revenue earnings from tariffs on the transfer of Shah Deniz Full Field Development gas through Georgia, which could fund continued social and environmental improvement in the country
- The additional gas that would enter the Georgian national gas system, made available from the Shah Deniz Full Field Development, would not go ahead
- Europe and Turkey would forgo the security of gas supply that transport of the gas from Shah Deniz Full Field Development through Georgia would provide
- The social benefits of the employment opportunities and economic stimulus that the Project would generate would be lost.

The lack of benefits and the potential risks associated with the no-development option were considered unacceptable by the Project proponents on financial, environmental and social grounds, and the decision was made to identify the most suitable export option for gas from the Shah Deniz Full Field Development in the Caspian Sea.

## 4.3 Development Concept Alternatives

### 4.3.1 *Export Methods*

The South Caucasus Pipeline (SCP) ESIA discussed alternative methods for exporting gas from the Sangachal Terminal in Azerbaijan, including conversion to liquefied natural gas for bulk transport and conversion to electrical power for transfer by power lines. The conclusion that gas export by pipeline is the most efficient and economic option for transport is still valid.

### 4.3.2 *Project Concept*

The existing 42"-diameter SCP pipeline has been transporting gas from the Sangachal Terminal in Azerbaijan for 690km to the border of Georgia and Turkey since 2006, with a system design capacity of 7.41 bcma (billion cubic metres annually). Further development of the Shah Deniz reservoir is planned, with the additional gas produced significantly exceeding the current capacity of the SCP.

The required flow rate can be achieved by a number of different concepts combining variations of pipeline diameter, pipeline loop length, and compression power. Increasing the diameter of the pipeline reduces the rate at which the gas pressure in the pipeline diminishes, so less compression power is needed as the pipeline diameter increases. Decreasing the pipeline loop length has the effect of increasing the compression power needed.

Various options to expand the existing SCP system, to incorporate the additional gas from the Shah Deniz FFD, were evaluated.

- A 42"-diameter pipeline
  - Option 1 – a pipeline loop through Azerbaijan to the Georgia/Turkey border and one compressor station in Georgia
  - Option 2 – a pipeline loop through Azerbaijan and for some distance in Georgia and two compressor stations in Georgia
  - Option 3 – a pipeline loop through Azerbaijan and no pipeline loop in Georgia, but three compressor stations (one in Azerbaijan, two in Georgia).
- A 56"-diameter pipeline
  - Options A and B – a partial pipeline loop for some distance in Azerbaijan and Georgia and two compressor stations in Georgia
  - Option C – a pipeline loop through Azerbaijan and for some distance in Georgia and one compressor station in Georgia
  - Option D – a pipeline loop through Azerbaijan to the Georgia/Turkey border and with one compressor station in Georgia
  - Option E – a pipeline loop through Azerbaijan to the Georgia/Turkey border.

Note all options require additional compression power at the Sangachal Terminal in Azerbaijan, which is outside the scope of this ESIA.

In each case, options were evaluated in terms of:

- H&S – accessibility, construction hazards, operational hazards
- E&S impacts
- Technical feasibility (constructability and operational constraints)
- Commercial implications (capital expenditure, operating expenditure).

The evaluation process was carried out by a multidisciplinary team that:

- Took account of the relative importance of H&S, E&S, technical and commercial considerations
- Scored the construction and operation of each option using professional judgement, previous experience and the results of early baseline surveys
- Totalled the scores for each option.

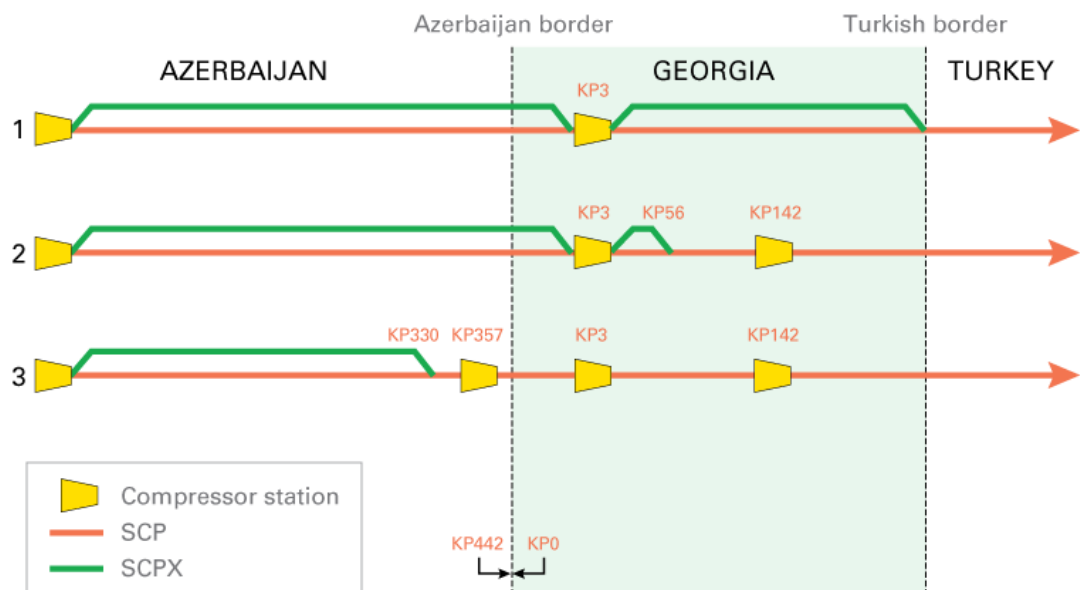
The concept with the lowest score was deemed the concept that best balanced H&S, E&S, technical and commercial constraints.

#### *42"-diameter pipeline*

The capacity of a single additional pipeline without compressor stations, i.e. a system similar to the existing SCP, would not have sufficient capacity to accommodate SCPX's additional gas volumes. Design considerations of flow assurance and resulting system energy efficiency resulted in a requirement to locate the compressor station close to the Azerbaijan /Georgia border. Three 42"-diameter pipeline and compressor station configurations presented in Figure 4-1 were considered.

Technically, Option 1 is the most difficult option, due to the mountainous terrain along some sections and difficulty accessing the high snow-covered sections of the route for construction and operation in winter. It is not clear whether a suitable route exists adjacent to the existing pipeline in these sections. Option 2 is preferable to Option 3 with regard to topography.

Commercially, Option 1 involves significantly higher capital costs and Option 2 has the lowest capital cost. Operating costs are significantly greater when more compressor stations are added.



**Figure 4-1: Schematic of 42"-Diameter Pipeline Options**

Option 3 involves operating three compressor stations with increased numbers of staff and associated risks, but its construction was on the smallest geographical scale and it avoided the need to construct (including blasting) in difficult terrain and winter conditions. Option 1 had the lowest anticipated risks during operations as it has fewer manned facilities, but needs construction (and blasting) in difficult terrain where adverse winter weather conditions increase the health and safety hazards. Option 2 represented a balance between these,

avoiding difficult terrain with adverse winter conditions, but needing to operate two compressor stations.

Option 1 has the lowest likely long-term E&S impact in the operation phase, but the highest short-term impact in the construction phase. Option 3 has the lowest construction-phase impacts because it has the smallest footprint, needs less temporary land acquisition and will cause less habitat disturbance and potential for community disturbance, but it has the highest predicted emissions and discharges and potential for community disturbance from the operation of three compressor stations. Here again, Option 2 represented a balance between the other options, with an intermediate footprint during construction and intermediate emissions during operations.

Table 4-1 summarises the assessment, with Option 2 being the preferred option. It should be noted that the results are relative and should be interpreted independently for each discipline, with a value of 'high' representing the highest potential impact, technical difficulty or cost.

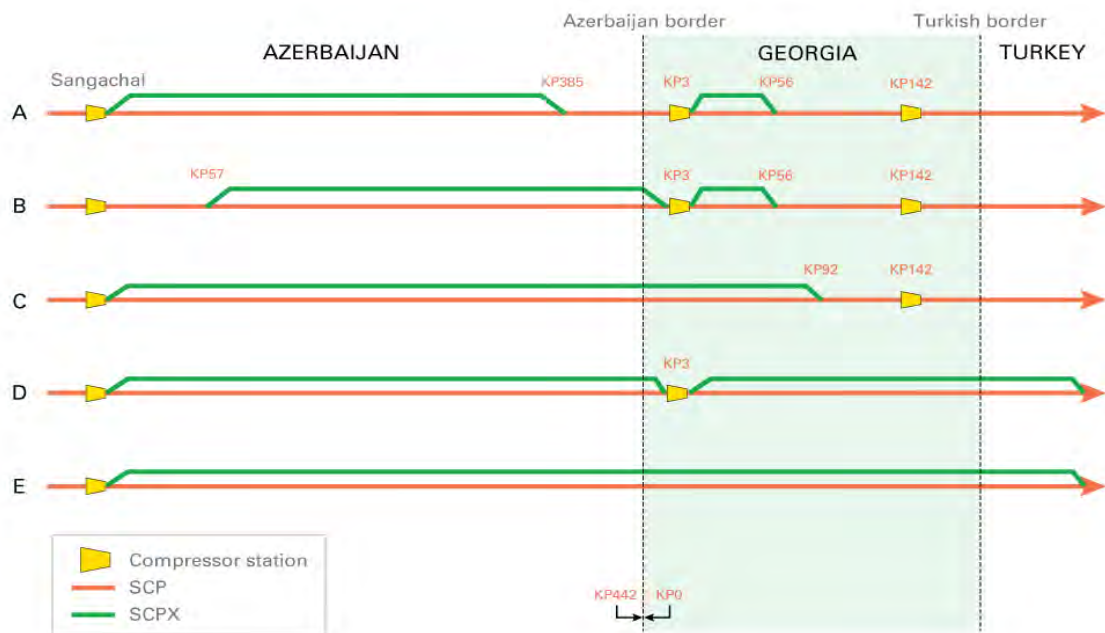
**Table 4-1: Comparison of Potential Impacts of SCPX 42"-Diameter Pipeline Options**

Option	Description	Technical	Commercial	Health and Safety	Environmental and Social
1	Full loop, minimum compression	High	High	Low	Low
2	Two compressor stations, partial looping	Moderate	Low	Moderate	Moderate
3	Three compressor stations, minimum looping	Moderate	Moderate	High	High

#### *56"-diameter pipeline*

Following engagement with the Azerbaijani State Oil Company, SOCAR the pipeline system was increased from 42 to 56-inch to consider future expansion beyond the current SCPX design. Evaluated Options A–E are presented in Figure 4-2.





**Figure 4-2: Schematic Showing the 56" Diameter Pipeline Options**

Technically, Option E does not provide sufficient extra capacity and was discounted while Option D has even larger constructability issues than the equivalent 42" option (Option 1). Technical constraints with Option C owing to low temperatures in operation exclude it as a viable option. H&S and E&S impacts for Options A and B were similar to those of the 42" concept, with shorter pipeline length and reduced numbers of compressors being preferred and providing a balance between hazards and impacts in the construction and operational phases, with Option B being the preferred option. Table 4-2 presents the results of the assessment. It should be noted that the results are relative and should be interpreted independently for each discipline, with a value of 'high' representing the highest potential impact, technical difficulty or cost.

**Table 4-2: Comparison of Potential Impacts of SCPX 56"-Diameter Pipeline Options**

Option	Description	Technical	Commercial	Health and Safety	Environmental and Social
A and B	Two compressor stations, minimum looping	Low	Low	Moderate	Moderate
C	One compressor station, partial looping	High	Moderate	Low	Low
D	Full loop, minimum compression	High	High	High	Low
E	As for the 42" selection process, a complete pipeline loop in Azerbaijan and Georgia with no additional compressor stations was considered – Option E. However, the required throughput of +16bcm/a was not met for part of the year, therefore this option did not meet the Project design criteria and was discounted from a technical perspective				

### *Comparison of 42" Option 2 and 56" Option B*

Technically, the 56" pipeline needs less compression power at each compressor station (66MW at each station compared with 80MW at the first compressor station and 70MW at the second), so it requires fewer compression trains. However, the 56" pipe needs more careful handling during construction to prevent damage or deformation. It involves more complex and technically challenging trenchless crossing techniques (e.g. micro-tunnelling or horizontal directional drilling).

Commercially, the 56" concept has higher capital cost than the 42" concept, but it also has greater potential for future expansion to accommodate additional gas volumes.

From a health and safety perspective, the need to handle heavier pipe and to use more complex lifting operations, and because of the increase in traffic movements owing to a reduction in the number of pipe sections that can be transported on one truck, increases the potential construction health and safety impacts of the 56" option.

The 56" concept offers environmental and social benefits compared with the 42" option:

- Lower fuel gas consumption and greenhouse gases (estimated at approximately 254,000 tonnes less CO<sub>2eq</sub> per year than the 42" concept) plus lower emissions of atmospheric pollutants (NO<sub>x</sub> and CO) (see Section 4.8 for further details)
- Reduction in potential operational noise emissions at compressor stations by having fewer compression trains (compressor trains being the primary source of noise on the site)
- The 56"-diameter pipeline allowed the Project to achieve the required throughput using a shorter pipeline loop in Azerbaijan, starting at SCP KP57. The selection of the 56" option, with the requirement for a shorter pipeline loop in Azerbaijan has enabled the Project to avoid the Gobustan Cultural Reserve and Buffer Zone and avoids the area currently proposed as a nationally protected area, the Gobustan National Park
- A similar physical footprint is achieved with the 56" option as although the construction ROW width of 36m is 4m wider than the 42" pipeline ROW the 57km shorter loop in Azerbaijan that can be achieved using the 56" case means that overall pipeline land requirements are approximately equal for both options. The shorter loop in Azerbaijan also avoids the semi-desert Gobustan area and several areas known as the Badlands, both of which contain fragile topsoil where reinstatement is more difficult.

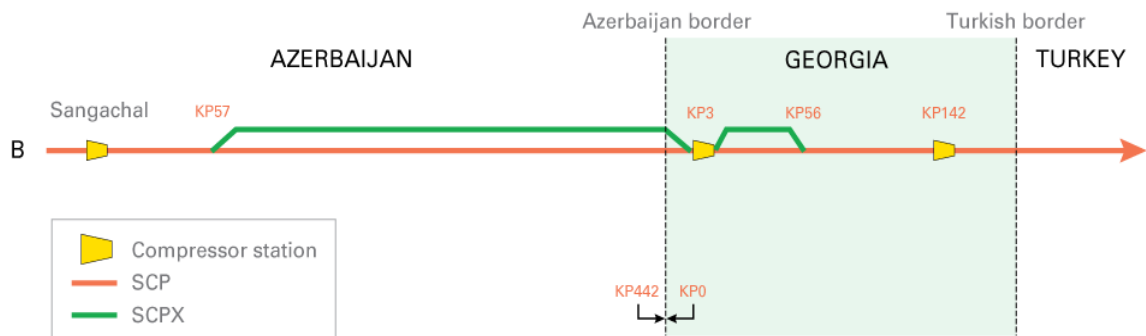
Table 4-3 presents the comparative assessment of the 42" and 56" pipeline configurations.

**Table 4-3: Comparison of Potential Impacts of SCPX 56-inch and 42-inch Diameter Pipeline Options**

Option	Description	Technical	Commercial	Health and Safety	Environmental and Social
42 inch	Two compressor stations, minimum looping	Lower	Lower	Lower	Higher
56 inch	Two compressor stations, minimum looping	Higher	Higher	Higher	Lower

### Concept selected for SCPX Project

The selected option Figure 4-3 is a 56-inch loop pipeline from a start point in Azerbaijan, some 57km from the Sangachal Terminal (Az KP57), to a point on the SCP pipeline 56km inside the border with Georgia. Two compressor stations will be developed in Georgia. This will achieve the flow rate of +16bcma in the SCPX pipeline and a combined capacity of +23 bcma by maximising the use of the existing SCP pipeline.



**Figure 4-3: Selected 56-inch Option**

## 4.4 Pipeline Routing Alternatives

### 4.4.1 Existing SCP Pipeline Route

The Project concept aims to optimise the flow through the existing SCP pipeline. The BTC and the SCP were routed following extensive engineering, environmental and social surveys and took into account an optimal secure border crossing with Azerbaijan. The Project's preferred option was to utilise the existing BTC/SCP pipeline right of way (ROW) where possible. This has considerable environmental and social advantages over the establishment of a new corridor including:

- Partial overlap with a previously disturbed corridor reduces new land take and habitat disturbance
- Relationships have been established with the local communities
- Some established access routes can be used minimising the need for new ones
- One compressor station (CSG1) and the pressure reduction and metering station (PRMS) can be collocated with the BTC pipeline's pumping station PSG1 and the SCP pressure reduction and metering station (Area 80) respectively, and the SCPX block valve can be collocated with BTC and SCP ones, reducing additional visual and landscape impacts
- Collocated facilities can share utilities to increase efficiencies.

Routing studies focused initially on the minimum safe separation distance of the SCPX ROW from the existing SCP/BTC or any other pipelines. Modelling studies (see Chapter 12) determined that the minimum separation distance between the SCPX pipeline and the BTC and SCP pipelines should generally be 20m.

#### 4.4.2 ***Southern Route Corridor***

The Project has also investigated a number of route corridors that run to the south of the current SCP pipeline route, via a southern route corridor that was also considered during the routing of the BTC and SCP pipelines. Four options were considered, each following the existing SCP for a certain distance and then diverging south to the Georgian/Turkish border before following a common route into Turkey to connect to the national gas transmission system. Table 4-4 summarises the route corridors evaluated and key constraints with each option.

**Table 4-4: Route Corridors Evaluation**

Corridor Option	Point of Divergence from SCP Route (SCP KP)	Constraints
1	114	Potential for approximately 150km of rock blasting Security and infrastructure and services issues as the route passes through Akhalkalaki region
2	4	Significant geotechnical hazards including landslides, debris flows and potential for flash floods are likely to be present Difficult construction required along narrow ridges and spurs Security and infrastructure and services issues as the route passes through Akhalkalaki region
3	54	Significant geotechnical hazards including landslides, debris flows and potential for flash floods are likely to be present Difficult construction required along narrow ridges and spurs Security and infrastructure and services issues as the route passes through Akhalkalaki region
4	113	Potential for approximately 150km of rock blasting Security and infrastructure and services issues as the route passes through Akhalkalaki region

The existing SCP route corridor was selected as the preferred option. The use of the existing route corridor minimises the area of disturbance and additional land take, avoids difficult construction terrain and geotechnical hazards by a combination of pipeline looping and compressor stations and finally it avoids the Akhalkalaki region, where there are security concerns.



**Figure 4-4: Route Corridor Options**

#### **4.4.3 Detailed Routing**

Where paralleling the BTC/SCP corridor presents technical difficulties or obstacles such as irrigation canals, topography or population encroachment, potential re-routes have been defined using remote sensing and a field walk in 2011. The following short sections of the SCPX loop have been re-routed:

- KP3 where the pipeline is re-routed into and out of CSG1 and re-joins the existing corridor at KP6
- KP25–26 (east of the Mtkvari River) where the SCPX pipeline is diverted away from the SCP pipeline by approximately 200m because the ridges where the SCP and BTC pipelines run are too narrow to accommodate a third pipeline
- KP45–46 where the pipeline has been diverted to avoid an existing culvert and track
- KP52–55 east of the Algeti River where the SCPX pipeline is diverted away from SCP to avoid a third-party gas pipeline and down a steep slope.

## **4.5 Pipeline River and Road Crossing Alternatives**

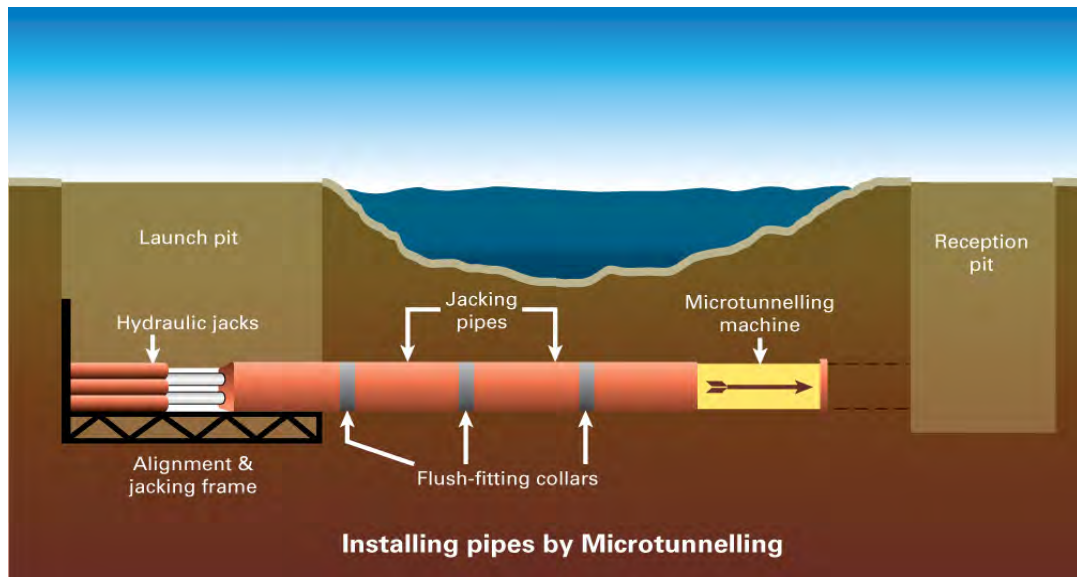
### **4.5.1 River Crossings**

The technical options for constructing river crossings are:

- Wet open-cut crossings that excavate a trench across the bed of the watercourse, install the pipe, backfill the trench and reinstate the banks, without stopping the flow of water
- Dammed open-cut crossings that dam the watercourse upstream and downstream of the crossing, pump water round the trench and release it downstream of the crossing. The pipe trench is excavated and the pre-welded pipe is installed before the trench is backfilled with the excavated material



- Flumed open-cut crossings that maintain water flow by installing suitably sized flume pipes in the bed of the watercourse to accommodate the river flow. The watercourse is dammed allowing water to flow through the pipes. The pipe trench is excavated and the pre-welded pipe is installed before the trench is backfilled with the excavated material. The flume pipes are then removed and the banks of the watercourse are reinstated
- Non-open-cut crossings that install the pipe below the watercourse by drilling or tunnelling from one bank to the other. Non-open-cut techniques include:
  - Micro-tunnelling (see Figure 4-5). Concrete pipes are lowered into a launch pit in one bank and hydraulic jacks push them behind a steerable laser guided tunnel-boring machine (TBM) to line a tunnel to a reception pit in the other bank. When the tunnel is complete, the pipeline is installed into the tunnel and the space between pipeline and tunnel wall is filled with grout
  - Guided auger boring/auger boring. A pilot hole is opened by augers from a launch pit on one bank to a reception pit on the other. The pilot hole is enlarged to accommodate the pipeline using larger augers and steel casing. The pipeline is lowered into the launch pit and welded to the steel casing. It is then propelled into the cased hole, displacing the casing that is removed in the reception pit
  - Horizontal directional drilling (HDD). An inclined drilling rig drills a small-diameter pilot hole from the surface on one bank to the surface on the other bank, using a rotating drill bit attached to the end of a string of drill pipe. The resultant borehole is reamed to a diameter suitable to accept the product pipeline. Drilling fluid is pumped repeatedly through the drill string, bit and annulus while the hole is drilled and reamed. A pulling head on a pre-formed length of pipeline is attached to the drill pipe, and the pipeline is pulled through the bore in a single operation.



**Figure 4-5: Schematic of Micro-tunnelling**

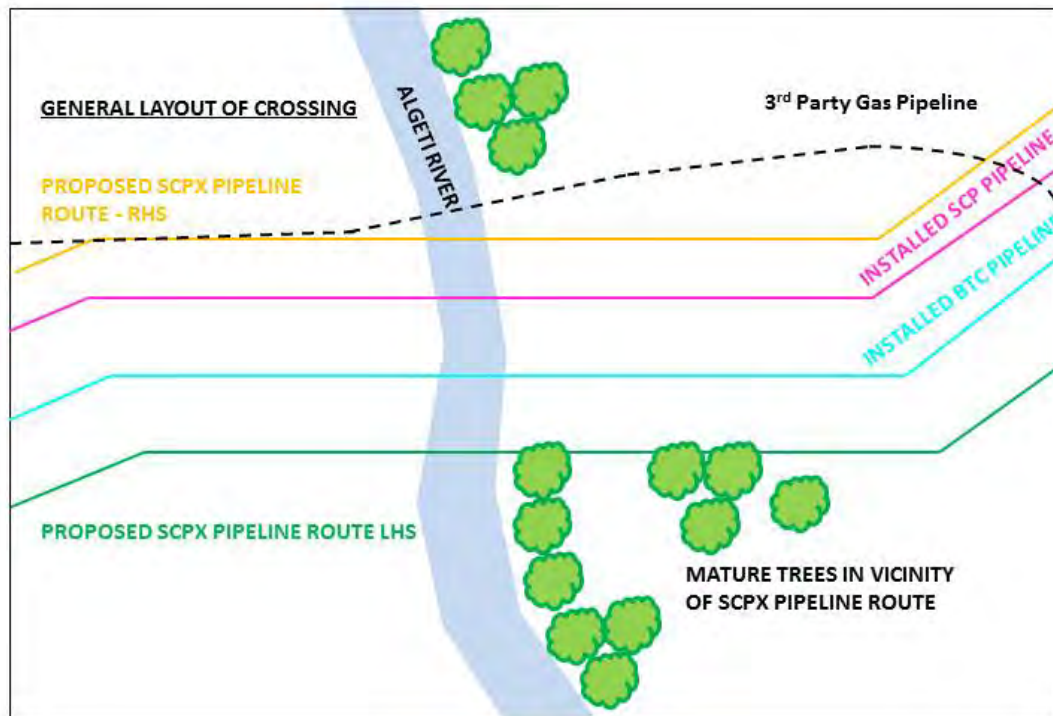
The different crossing methods are suitable for different types of watercourse. The Project has assessed the most appropriate method to use for each watercourse crossing the ROW, taking into account the geotechnical characteristics at the location and the depth of cover required. At the Algeti River crossing, detailed evaluation of alternatives was undertaken (see below); for further discussion of other crossings see Section 5.4.11.

### *Algeti River crossing*

Following the philosophy of routing the SCPX pipeline in the same corridor as the SCP and BTC pipelines, the SCPX route crosses the Algeti River in close proximity to the existing pipelines.

### **Pipeline route**

The Project evaluated two potential pipeline routes in this area, one routing to the right-hand side (north) of the existing SCP pipeline and the other to the left-hand side (south) of the existing pipeline; the indicative locations are shown on Figure 4-6.



**Figure 4-6: Proposed location of SCPX Route Options at the Algeti River**

Routing to the right-hand side of SCP would allow the SCPX pipeline route and construction ROW to take greater advantage of gaps in the riparian forest at the east side of the crossing. The riparian forest in this area contains individuals of the smooth-leaved elm (*Ulmus minor*) a Georgian Red List species. However, a third-party gas pipeline in the vicinity of the SCP pipeline represents a further constraint on the available construction area and prevented construction occurring on the right-hand side.

After selecting a route on the left hand side of the existing pipelines, further refinement to minimise the removal of trees was considered through re-routing the pipeline on the eastern bank of the crossing or narrowing the ROW, to avoid a cluster of nine mature individuals of smooth-leaved elm. The re-route would involve moving the route to the south to an area that also contains some mature individuals of smooth-leaved elm, which would also require removal (Figure 4-7).



**Figure 4-7: Proposed location of SCPX Route Options at the Algeti River**

This option was rejected, as it would result in further fragmentation of the habitat and would leave an artificial group of isolated trees between the existing BTC and SCP pipeline corridor and the SCPX corridor. Further narrowing of the ROW in this area is not possible owing to the need to maintain a separation distance of 20m between the BTC and SCPX pipelines. Thus, the preferred option was to maintain the original centre line (indicated in red in Figure 4-7) because it avoided further habitat fragmentation and the removal of mature trees could be mitigated by the implementation of offset planting (discussed in further detail in Section 10.7).

#### **Crossing methodology**

Upon finalisation of the route, the Project also considered a number of different crossing methodologies with the aim of avoiding or reducing the potential impacts on the riparian forest and smooth-leaved elms.

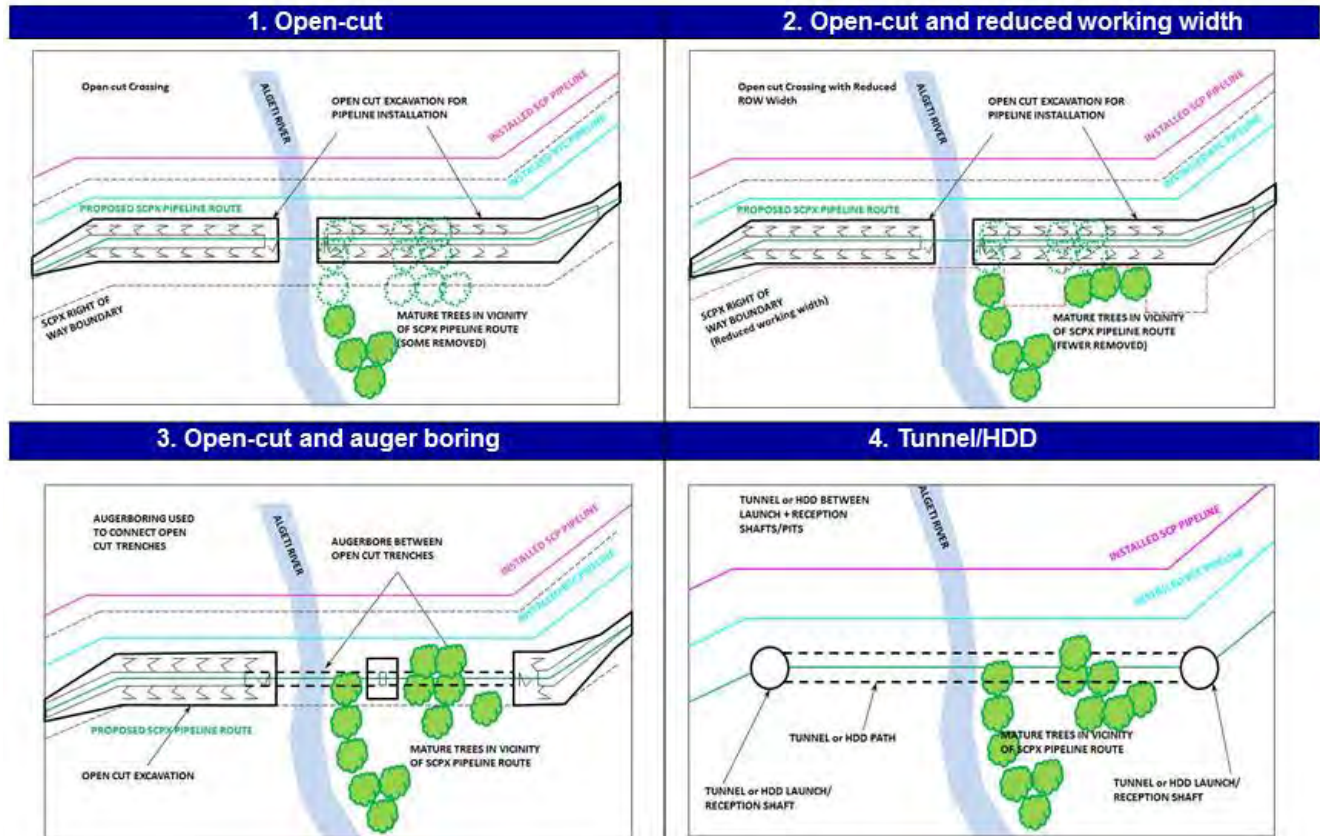
Four different crossing methodology options were considered as described below and illustrated in Figure 4-8:

1. *Open-cut crossing*: This methodology was used to install both the SCP and BTC pipelines at the Algeti River. It involves excavating the trench on the east bank, lowering the pipe and backfilling before damming or fluming the watercourse, excavating on the west bank and within the river channel, lowering the pipe and backfilling.
2. *Open-cut crossing with reduced working width*: This is similar to the open-cut method but the construction ROW is reduced through careful location of topsoil and material on the existing pipelines, use of gaps in the trees to store material and digging excavations using specialised engineering techniques to reduce the area required (e.g. trench support systems). A portion of the existing BTC and SCP pipeline ROW will be used as a running track for vehicle and equipment movements.
3. *Open-cut with auger boring*: Open-cut excavations are used outside of the area of mature trees and watercourse. A launch/reception pit is excavated on either side of



the river with a midway pit excavated in a gap between the trees (two pits on the eastern bank), with auger boring used to install the pipe below the trees and the river.

4. *Tunnelling or horizontal directional drilling (HDD)*: Tunnel or HDD entry and exist shafts are excavated on both banks, outside of the areas containing mature trees. The pipeline is installed through tunnelling or drilling under the trees and the watercourse.



**Figure 4-8: Alternative Construction Methodologies for the Algeti River Crossing**

Options were reviewed from an environmental perspective (considering impacts on both the riparian forest and the watercourse), the Project footprint requirements, a constructability perspective and a commercial perspective (Table 4-5).

**Table 4-5: Alternative Comparison of Construction Methodologies for the Algeti River Crossing**

Option	Environmental Impact on Trees/ Watercourse	Working Area Requirements	Difficulty of Construction	Commercial
Option 1 (open-cut)	Highest	Highest	Lower	Lower
Option 2 (open-cut with reduced working width)	Moderate	Moderate	Lower	Lower
Option 3 (open cut and auger bore)	Lower	Moderate	Moderate	Moderate

Option	Environmental Impact on Trees/ Watercourse	Working Area Requirements	Difficulty of Construction	Commercial
Option 4 (tunnel and HDD)	Lower	Lower	Highest	Highest

Option 4 avoids impacts on mature trees and the watercourse by tunnelling/drilling beneath these features. These options, however, are associated with the highest levels of construction difficulty and cost. Option 3 has lower impacts on the trees and watercourse, although it is still difficult from a construction perspective owing to the need for large equipment to handle heavy pipe and the need for deep entry excavations at the first entry pit. Option 1 was not preferred from an environmental perspective owing to the highest impacts on the riparian forest area and having the largest working area requirements.

Option 2 was selected as the Project's preferred crossing methodology, as the reduced ROW working width seeks to use gaps within the existing forest areas and in combination with both special construction techniques and a greater overlap with the existing BTC ROW will reduce the impacts to mature trees. The nominal ROW width at major open-cut river crossings, such as the Algeti, where deep trench excavation is required is generally 60m (30m on either side of the pipeline). This has been reduced to approximately 26m on the right-hand side of SCPX and approximately 10m on the left-hand side at the Algeti crossing to reduce the overall number of trees that require removal, with a specific focus on the Georgian Red List smooth-leaved elm species.

Impacts on the watercourse, and specifically fish species, will be further mitigated through constructing the crossing outside of the fish-spawning season (May–June). Impacts on the tree species will be further mitigated through the use of off-set planting. The mitigation measures are described more fully in Chapter 10, refer to Section 10.7.4 for more details.

#### **4.5.2 Road and Rail Crossings**

The eleven major roads and two railways crossed by the SCPX pipeline in Georgia will be crossed using one of the following non-open-cut techniques:

- Direct-burial pipe jack (carrier pipe). A carrier pipe is installed behind a protective shield using a combination of mining techniques and hydraulic jacks to drive the pipe forward. The excavated material is removed through the exposed end of the pipe. As each pipe progresses forward, another is welded on until the crossing is finished
- Micro-tunnelling. Sections of concrete carrier pipe are driven into the hole opened by a TBM by hydraulic jacks. Excavated material is removed via the exposed end of the carrier pipe. As each section of the concrete pipe progresses forward, another is connected behind it, until the hole reaches the far side of the crossing. After completion of the carrier pipe, the pipeline is installed.

## **4.6 Facilities Location Alternatives**

The SCPX Project requires the following facilities in Georgia:

- Two compressor stations (CSG1 and CSG2)
- One pressure reduction and metering station (the PRMS)
- One pigging station (pig receiver)
- One block valve station.

Alternative locations for each of the Facilities were identified from a desktop review and then finalised during a multidisciplinary site visit including engineering (geotechnical; process; pipeline), health and safety, and environmental and social representatives.

#### **4.6.1 Compressor Station 1 Location**

Pipeline hydraulics control the compressor station locations to a large extent, and for CSG1 it was also considered preferable to locate the first compressor station close to the existing BTC pump station at KP3. Collocation will allow SCPX to take advantage of synergies during operation.

Figure 4-9 shows the four options considered for locating CSG1 close to or immediately adjacent to the site of PSG1 and Area 72 (the existing Azerbaijan/Georgia SCP pressure reduction and metering station and Georgian offtake location):

- Option 1 – north-west of the existing facilities, PSG1 and Area 72
- Option 2 – south-west of the existing facilities
- Option 3 – south-east of the existing facilities
- Option 4 – north-east of the existing facilities.



Figure 4-9: Potential Options for CSG1



Option 1 is upwind of PSG1 and Area 72 (which is planned to be decommissioned) in the prevailing wind direction. This is not recommended from a health and safety perspective because there is a higher probability that in the event of an unplanned release of gas from CSG1, PSG1 would be down-wind of the source. Option 1 was therefore discounted.

Option 2 is physically separate from the existing Area 72 on the SCP pipeline and it would be necessary to relocate some or all of Area 72 to achieve maximum integration with existing SCP infrastructure. The SCP pipeline would require local re-routing and some of the support facilities west of PSG1 would need to be relocated for reasons of safety. However, the Option 2 location avoids the possible need to remediate contamination at the military base (to the north-west of Option 4) or to re-settle three families who live there; it is also the furthest from inhabited settlements, and so minimises the impacts of noise.

Locating CSG1 at site Option 3 would need complex tie-ins to the existing facility at PSG1 that cross the main road. Option 3 is overlooked by residents living on the south-western edges of Jandari village, and would interrupt open views from that position.

Option 4 is the best position to maximise synergies with the existing SCP pressure reduction and metering facilities at Area 72; it also avoids re-routing the existing SCP pipeline locally and relocation of parts of the existing PSG1 facility. However, Option 4 is likely to require the physical re-settlement of the three families living in the abandoned military base and overcoming difficult access restrictions currently imposed on that land by the military. Demolition of the abandoned military base has the potential for contaminated land to be encountered. Option 4 is closer to the community of Jandari (approximately 1km) and it would be difficult to achieve the targeted plant noise levels at the village.

#### *Selected option – CSG1 location*

Despite being more technically challenging, site Option 2 was selected as the location for CSG1.

#### **4.6.2 Compressor Station 2 Location**

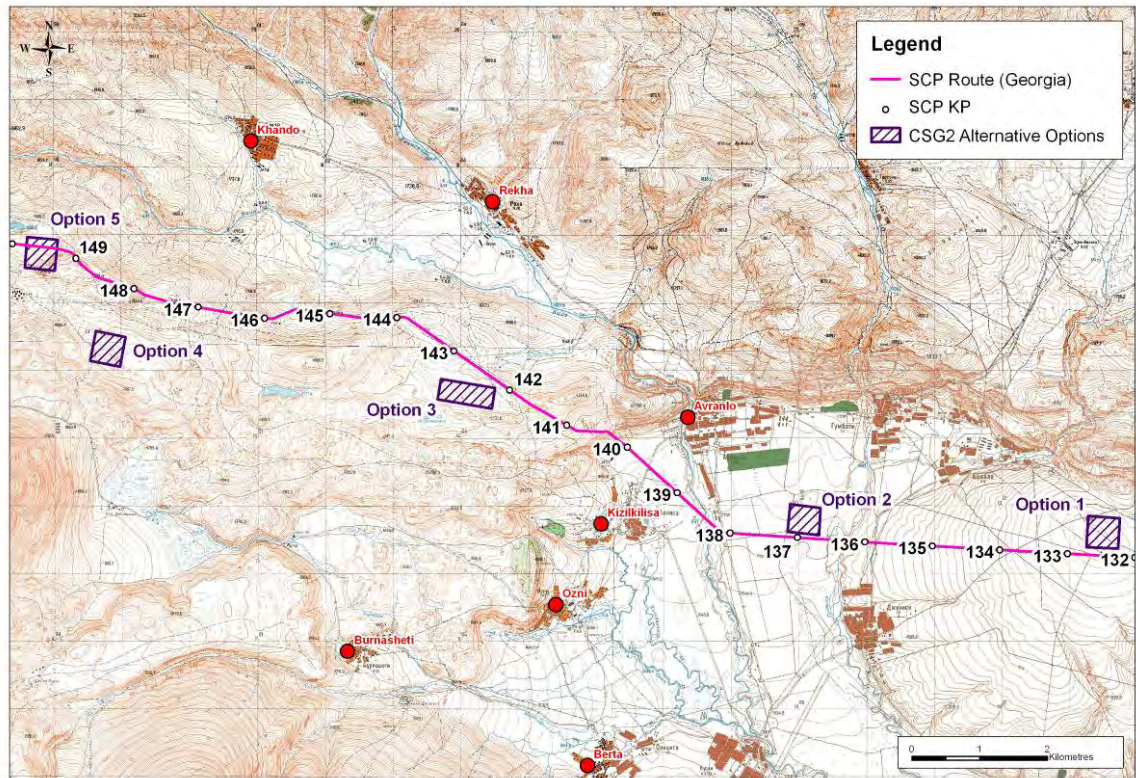
Five options were considered for the location of CSG2 (see Figure 4-10):

- Option 1 (KP135) – on agricultural land in the valley west of Lake Tsalka close to the village of Ashkala
- Option 2 (KP137) – on agricultural land in the valley west of Lake Tsalka close to the villages of Jinisi and Gumbati
- Option 3 (KP142) – in subalpine meadow at 1700m altitude close to the villages of Rekha and Avranlo
- Option 4 (KP149) – in subalpine meadow at 1880m
- Option 5 (KP151) – in subalpine meadow at 1930m.

Options 1 and 2 are in the valley, where there is good terrain for construction, but they are close to villages, would intrude on views from up to eight villages and could cause economic displacement due to the lack of availability of replacement agricultural land.

Options 3, 4 and 5 are all located in more remote subalpine meadows at increasing elevations. The sites pose challenges for construction (waterlogging, seasonal flooding) and construction would involve blasting (in the case of Option 5 the blasting would be quite close to the SCP pipeline). Access to these three sites will be increasingly challenging as altitude increases, particularly in winter when there is snow cover for several months. All three sites would need access road construction, but Options 3 and 5 require the greatest length of road. Emergency response at site Option 3 involves lower H&S risks than Options 4 and 5, and is more suitable for access by helicopter.

Option 4 is the most remote option, and has the lowest potential for disturbance and visual impact. Option 3 is approximately 1km from Avranlo and Rekha and is likely to be visible from Rekha village. Options 3 and 4 contain patches of wetland habitat, but those at Option 4 are less disturbed than those at Option 3. Small stone piles (potential burial mounds) were noted within the boundaries of Options 3, 4 and 5.



**Figure 4-10: CS2 Location Options Taking into Account Hydraulic Requirement**

Table 4-6 presents the multidisciplinary assessment of the five options for the CSG2 site.

**Table 4-6: Alternative Comparison of CSG2 Potential Locations**

Option	KP	Difficult Ground Conditions	Access Constraints	Land Constraints	Close proximity to Community	Ecological Value	Cultural Heritage	Health and Safety Concerns
1	132			Higher	Higher			
2	137			Higher	Higher	Lower		
3	142	Moderate	Moderate		Moderate	Moderate	Moderate	
4	149	Moderate	Moderate		Lower	Higher	Moderate	Moderate
5	151	Moderate	Higher		Lower	Moderate	Moderate	Moderate

#### *CSG2 options – biodiversity value*

In addition to the above evaluation, owing to the greenfield nature and the subalpine meadow habitat of the CSG2 location, a comparison of the qualitative biodiversity value of the alternative options has also been completed (Table 4-7).

**Table 4-7: Qualitative Biodiversity Assessment of CSG2 Alternative Options**

Option	KP	No. Higher Plant Species	Habitat	Anthropogenic Influences	Higher-Value Species	Higher-Value Habitat	Relative Biodiversity	Summary
1	132	51	Subalpine meadow	Used for hay harvesting	None noted	None noted	Lower	This option does not support any protected, rare or endemic plant or animal species. The habitat is a subalpine meadow with secondary vegetation used for hay harvesting and has low conservation value. This has relatively lower potential impacts on local biodiversity
2	137	83	Subalpine meadow and arable land	Used for hay harvesting, crop cultivation and autumn grazing	Euxine marsh orchid ( <i>Dactylorhiza euxina</i> ), CITES listed, nationally important	Fragments of wetland vegetation that provide important habitat for numerous vertebrate and invertebrate animals, especially amphibians	Higher	This option has some significance in terms of biodiversity conservation. Wetland fragments provide habitat for numerous vertebrate and invertebrate animal species. One plant species of conservation value, the Euxine marsh orchid (CITES species), was also recorded on the site. This option is therefore less desirable than others for siting of the proposed compressor station
3	142	43	Subalpine meadow	Heavily grazed	One individual of lesser kestrel ( <i>Falco naumanni</i> ) - species listed in the Georgian Red List, noted on similar habitat during access road survey	Wetland fragment which is affected by grazing	Moderate	This option comprises an overgrazed secondary subalpine meadow where no plant or animal species of conservation value were noted during early ecological surveys. However subsequent surveys did identify individuals of the marsh orchid ( <i>Dactylorhiza urvilleana</i> ), a CITES species, in the vicinity of wetland areas that were not apparent at the time of the site selection surveys. The habitat

Option	KP	No. Higher Plant Species	Habitat	Anthropogenic Influences	Higher-Value Species	Higher-Value Habitat	Relative Biodiversity	Summary
								is a potential foraging area for the lesser kestrel ( <i>Falco naumann</i> ) but no individuals were recorded during detailed baseline surveys at this site. The presence of a wetland fragment in the south-eastern part of the site, in addition to the presence of the marsh orchid, makes this option less favourable than some of the alternatives
4	149	31	Alpine meadow	Heavily grazed	One individual of lesser kestrel ( <i>Falco naumann</i> ), a species listed in the Georgian Red List, noted on similar habitat during access road survey	Some wetland fragments with relatively low disturbance level	Moderate	This option is occupied by plants and communities characteristic of subalpine and alpine meadows. The site is used for intensive grazing and the disturbance level is fairly high. There are some wetland fragments within this site; disturbance of these wetlands is relatively low and it is considered necessary to retain these fragments undamaged
5	151	52	Subalpine meadow	Heavily grazed	One individual of lesser kestrel ( <i>Falco naumann</i> ), a species listed in the Georgian Red List, noted on similar habitat during access road survey	None noted	Lower	This option comprises an overgrazed subalpine meadow, which does not support any plant and animal species of conservation value. Therefore, this is one of the preferred options in terms of lower potential impacts on the local biodiversity



Option 1 was most preferable from a biodiversity perspective, as it did not include any areas of higher value habitat or support any higher value species (e.g. GRL or internationally designated species).

Option 2 was least preferable from a biodiversity perspective, as it supported populations of the Euxine marsh orchid (*Dactylorhiza euxina*), a Convention on International Trade in Endangered Species (CITES) listed species and also included higher value wetland habitat fragments that supported a variety of fauna.

Options 3–5 all had the potential to provide foraging habitat for the lesser kestrel (*Falco naumanni*), a higher value GRL species. Options 3 and 4 contained wetland fragments: Option 3 was subject to heavier grazing disturbance, while the wetland at Option 4 was subject to relatively low disturbance and was considered to be of a higher habitat value.

#### *Selected option – CSG2 location*

Option 3 was selected as the location for CSG2. This represented a balance between technical issues (constructability and access) and environmental and social impacts. This option has lower potential social impact than Options 1 and 2 and similar environmental impact to Options 4 and 5. It also has more favourable health and safety and accessibility benefits when compared with 4 and 5.

Option 3 is considered of moderate biodiversity value owing to the wetland fragments existing within the site footprint. The Project has designed CSG2 to avoid building on the largest wetland fragment at the site (refer to commitment D17-01 in Chapter 10). In addition, subsequent detailed baseline surveys of the chosen option did identify individuals of the marsh orchid (*Dactylorhiza urvilleana*), a CITES-listed species, which were not apparent at the time of the site selection surveys. The Project has committed to translocating these species prior to construction (refer to commitment X7-18 in Chapter 10).

### **4.6.3 Pressure Reduction and Metering Station Location**

#### *PRMS expansion vs. stand-alone facility*

The purpose of the PRMS is to reduce the gas pressure to meet the specification for export to Turkey and to measure the quantity exported to Turkey. This facility needs to be located close to the Georgia/Turkey border. As the SCP pipeline's PRMS, known as Area 80, does not have the capacity to process additional SCPX gas volumes, it is necessary either to expand the existing PRMS or to develop a new stand-alone facility, leaving the existing facility redundant.

A stand-alone facility would have the benefit of simpler process design and control during operation, but a new greenfield site would take additional land. The existing facilities would need to be decommissioned and their benefit would not be fully realised.

Increasing the capacity of the additional site by installing parallel equipment would be more complex to design and control, but would reduce land-take, minimise the need for new equipment and use existing resources efficiently. Expanding the existing facility would present an opportunity to share the fuel gas, power generation and relief systems, and would reduce the capital cost of the development.

Expansion of the existing PRMS by the installation of additional, parallel equipment is the selected option.

### *PRMS site selection*

Two site options were considered for the expansion of the PRMS (see Figure 4-11):

- Option 1 – north-west of Area 80
- Option 2 – east of Area 80.



**Figure 4-11: Expansion Options for the PRMS**

Option 1 is sloping ground, which would need significant earthworks and perhaps rock blasting, quite close to the BTC pipeline. The site would be hemmed in between the BTC pipeline to the west and the existing facility to the east. The site would be close to the existing accommodation block, and is slightly further than Option 2 from other communities.

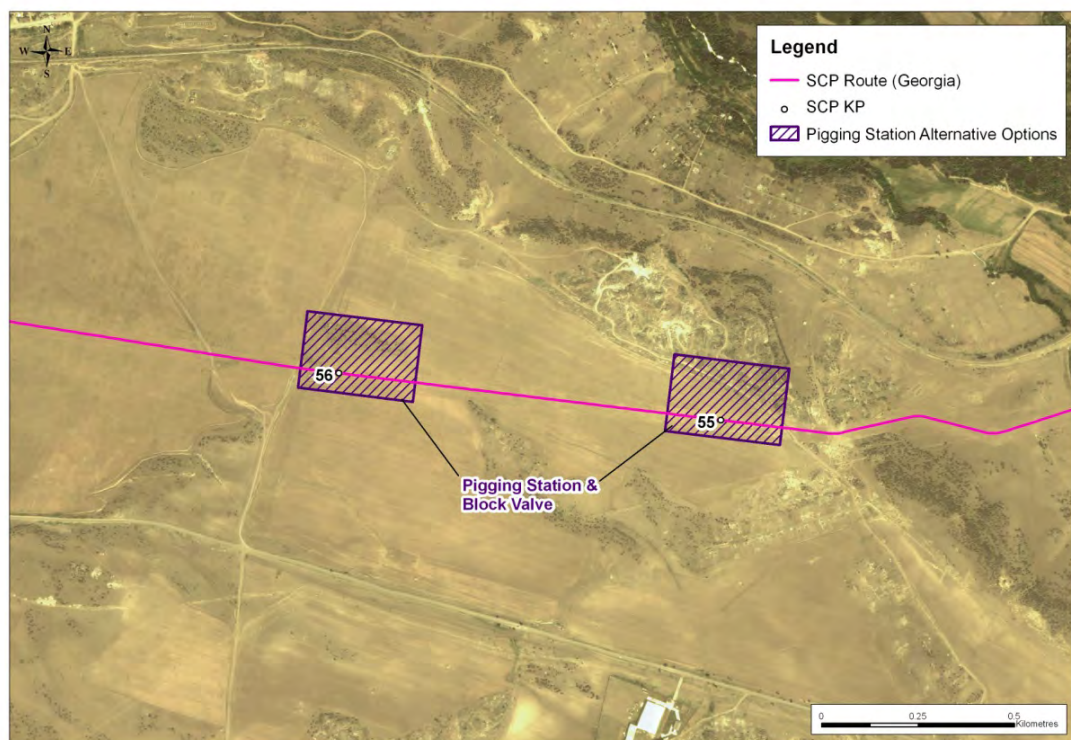
Option 2 is closer to the SCP pipeline. Tie-in to the new facility would be easier and the site would have more space for optimising the layout of equipment. Option 2 is approximately 3km from the nearest communities.

#### *Selected option – PRMS location*

Option 2 was selected as the location for the new expanded PRMS as it offers greater engineering synergies and a commercial benefit and there is no significant difference between the potential environmental and social impacts of the two options.

#### **4.6.4 Pigging Station Location**

There is a requirement for the integrity of the new pipeline to be monitored periodically using a pipeline integrity gauge (pig). In Georgia, the pig will run from CSG1 to a pigging station at the end of the 56" pipeline loop, at either KP55 or KP56 depending on the length of the pipeline loop (see Figure 4-12).



**Figure 4-12: Pigging Station Location Options**

No ecological, social or cultural heritage factors differentiate between the two sites. In the absence of environmental and social constraints at either option, pipeline hydraulics determined the best location as SCP KP55.

## **4.7 Facility Design Alternatives**

The Project has assessed options for the following facility design alternatives:

- Compressor drivers
- Waste heat recovery
- Power generation
- Turbine sizes and emissions control
- Relief systems
- Noise insulation
- Heating, ventilation and air-conditioning (HVAC) systems.

#### **4.7.1 Compressor Drivers**

SCPX considered the following primary driver options:

- Mechanical drive from gas turbines run on natural gas from the SCP/SCPX pipelines
- Electric motors.

The Project considered three alternatives for supplying electric power to run electric motors to drive compressors:

- Taking electricity from the Georgian National Transmission Grid. This was discounted owing to a lack of available reliability data that would demonstrate electricity would be available for this essential use, and also to avoid reducing the power supply to other Georgian users
- Building a central power station to supply electricity to both compressor stations via high-voltage distribution cables following the pipeline route. This option was not preferred, because:
  - It has a high cost
  - High energy losses during transmission (approximately 10%) make the concept unattractive
- Building a simple on-site electricity generation plant at each facility.

On-site generation was the preferred option for supplying electricity to the compressor driver motors, as an alternative to be considered compared with use of gas turbines to drive the compressors directly.

#### *Compressor drivers – gas turbine vs. electric motors*

Table 4-8 presents the preliminary comparative assessment of gas turbine drives and electric motors to drive the compressors.

**Table 4-8: Comparison of Compressor Driver Options**

Parameter	Gas Turbines	Electric Motor
Technical	Moderate maintenance requirements Moderate flexibility to respond to changes in system profile	Lowest maintenance requirements High flexibility to respond to changes in system profile
Cost	High cost	High cost (on-site power plant required)
Efficiency	Low efficiency, highest fuel consumption	Low efficiency (on-site power plant required)
Emissions	Low NO <sub>x</sub> emissions Moderate CO <sub>2</sub> emissions per unit of power	Low NO <sub>x</sub> emissions Moderate CO <sub>2</sub> emissions per unit of power (on-site power plant required)



Before deciding on a gas turbine or an electric motor concept, the Project investigated waste heat recovery (WHR) options that could make them more efficient and reduce CO<sub>2</sub> emissions from the compressor stations.

#### *Waste heat recovery*

The efficiency of three waste heat recovery options was compared to running a gas turbine with no waste heat recovery system:

- Option 1 – gas turbine without waste heat recovery system
- Option 2 – gas turbine with waste heat recovery system to provide heat for space heating and process heating
- Option 3 – gas turbine with organic Rankine cycle waste heat recovery system used to drive compressors and generate electricity for the site with waste heat used for building and process heating
- Option 4 – gas turbine with organic Rankine cycle waste heat recovery system used to generate electricity for electric motors driving the compressors with waste heat used to generate additional electricity.

The organic Rankine system transfers heat from the exhaust of a gas turbine used for power generation to a re-circulating fluid (typically hot oil). The hot oil vaporises an organic fluid that expands through a turbine powering an electricity generator. The vapour is re-circulated, cooled and returned to the vaporiser to be re-heated.

Table 4-9 summarises the comparative assessment of the options.

**Table 4-9: Comparative Assessment of the Waste Heat Recovery Options**

Option	Description	Energy Efficiency (%)	Incremental CO <sub>2</sub> Emissions Reduction (tonnes/year)	Incremental Capital Cost (Millions, \$)	Technical
1	Gas turbine; no WHR	34	-	-	None
2	Gas turbine; WHR	36	Moderate	Low	Minimal
3	Gas turbine; WHR and electricity	40	High	Moderate	Increased complexity in design, operation and maintenance; complex technology to remote location with no previous experience
4	Electric motors; WHR and electricity	43	Moderate	Very high	Increased complexity in design, operation and maintenance; complex technology to remote location with no previous experience

Option1 has the lowest capital cost but the lowest energy efficiency and the highest annual CO<sub>2</sub> emissions.

Option 3 has an intermediate capital cost and intermediate energy efficiency, but it has lower annual CO<sub>2</sub> emissions than the other options. This system is a more complex design than gas turbines without waste heat recovery, and is complex to operate and maintain, particularly in the remote CSG2 location. Hot oil and pentane systems involve potential safety risks.

Option 4 has the highest capital cost by far. It needs four large gas turbines at compressor station to generate the required electrical power to run the compressors, so fuel gas consumption is similar to Options 1 and 2.

Owing to the limited use of WHR, particularly at CSG2, direct drive gas turbines (Option 1) was determined to be the Project preferred option for compressor power generation, with a further study to investigate WHR from the power generation equipment.

#### *Process heating*

During more detailed design, it was determined that the power generation turbines would be more suitable for the provision of waste heat. This was partially because of a reduction in heating requirements (see Section 4.7.6) and because these turbines run continuously to provide electricity for the site whereas the operation of the compressor turbine drives is dependent on gas throughput (driven by the commercial requirements) and ambient temperature. Using the power generation turbines was therefore investigated further.

Engineering studies determined that using waste heat recovery to replace the gas-fired heater required to heat the gas that will enter the Georgian gas system at CSG1 (there is no such facility at CSG2) would reduce the CO<sub>2</sub> emissions by 3000 tonnes/year. This was, however, associated with increasing site complexity, significant capital expenditure and the potential that supplementary heating, burning additional gas, would be required during some operating cases. Gas-fired water bath heaters were therefore the selected option to heat the gas at the Georgian off-take at CSG1.

### **4.7.2 Power Generation**

#### *Primary power*

At CSG1 and CSG2 the Project evaluated two potential options, gas turbines and gas engines to generate the electricity required for the sites.

Gas turbines have the following advantages over gas engines:

- Can accept large variations in load whereas gas engines cannot
- Shorter start-up times.

However, gas engines have:

- Higher overall efficiency and therefore lower associated CO<sub>2</sub> emissions (approximately 35% lower).

Based on the technical constraints associated with gas engines and potential to fail when there are large variations in load, which currently have the potential to occur, gas turbines have been selected as the Project's preferred operation for power generation.

#### *Electricity grid connection*

The Project also evaluated the potential to install a connection to the Georgian national electricity grid to provide site power, e.g. building heating, lighting, etc., at CSG1 and the PRMS. The selected option was to install a connection at each of these sites, initially to provide back-up power, should the primary power generation be unavailable. The Project intends to gather reliability information on the electrical connection with the aim of moving to using the electricity grid as the primary source of site power in the future, provided there is no impact on the pipeline availability. Moving to using electricity from the Georgian grid at

CSG1 and the PRMS is estimated to reduce annual CO<sub>2</sub> emissions by approximately 27,200 tonnes CO<sub>2</sub><sup>1</sup>.

#### **4.7.3 Turbine Sizes and Emissions Control**

##### *Low NO<sub>x</sub> turbines*

The nitrogen oxides (NO<sub>x</sub>) from combustion processes in turbines consist primarily of nitrogen oxide (NO) with smaller amounts of nitrogen dioxide (NO<sub>2</sub>). On release to the atmosphere, most of the NO is oxidised to NO<sub>2</sub>, a potential local air quality pollutant associated with respiratory problems, particularly in children and the elderly.

Gas turbine drive units can be supplied with standard combustion systems or with dry low emissions (DLE) or dry low NO<sub>x</sub> (DLN) combustion systems designed by the turbine supplier to reduce the emission of NO<sub>x</sub> and carbon monoxide (e.g. by controlling the combustion temperature). DLE gas turbine drive units typically reduce NO<sub>x</sub> in the turbine exhaust emissions from 400mg/Nm<sup>3</sup> (for a standard combustion system) to 50mg/Nm<sup>3</sup> (above approximately 70% turbine load). However, the DLE combustion process operates only when the gas turbine is operating at approximately 70–100% load (depending on the turbine model). At lower loads, the DLE process does not operate as effectively and NO<sub>x</sub> and CO emissions increase, although they are still less than those from a standard combustion turbine.

The compressor gas turbines fitted with DLE combustion systems are technically capable of achieving relevant air emission standards determined in accordance with the host government agreement (see Chapter 6) and DLE turbines have been selected for this application. Conservative air emissions modelling showed a greater than 60% decrease in the hourly NO<sub>2</sub> concentration at the nearest receptor to CSG1, with the use of DLE turbines.

Standard gas turbines (i.e. not using DLE technology) have been selected for the power generation turbines. These turbines are much smaller than the compressor gas turbine drives and DLE technology has been assessed as not technically viable for this size of equipment. Based on the current predicted electricity demand, the smallest Project-approved turbines would be operating below 70% load during normal operation, which can lead to mechanical integrity issues resulting in a significant negative impact on reliability. Air dispersion modelling suggests that peak hourly ambient concentrations of NO<sub>2</sub> with non-DLE power generation gas turbines are approximately 33% higher than with DLE power generation gas turbines. However, they are still well within the air quality standards.

##### *Turbine sizing*

The Project considered two options for the size of turbines to drive the compressor trains (i.e. turbines and compressors taken together), taking account of factors such as variable ambient temperatures, pipeline gas arrival temperatures and pipeline throughput:

- Option 1: CSG1 and CSG2 each with 4 turbines of approximately 30MW each
- Option 2: CSG1 with 9 turbines and CSG2 with 8 turbines of approximately 15 MW each.

When the pipeline flow rate is reduced, the compressor power requirements reduce and the gas turbine power demand is also reduced. Smaller trains would be more flexible to these changes and could operate in DLE mode more frequently than larger ones, so they can theoretically achieve lower NO<sub>x</sub> emissions. But larger trains are approximately 20% more fuel efficient than small ones and emit approximately 20% less CO<sub>2</sub>. Conservative modelling of hourly and annual ambient NO<sub>x</sub> concentrations showed even if the large gas turbines

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<sup>1</sup> Assuming approximately 87% of Georgia's electricity is generated from hydroelectric power ([http://www.iea.org/stats/electricitydata.asp?COUNTRY\\_CODE=GE](http://www.iea.org/stats/electricitydata.asp?COUNTRY_CODE=GE); IEA, 2011)

operated out of DLE mode for a full year ambient NO<sub>2</sub> concentrations would not exceed the Project ambient air quality standards for NO<sub>x</sub>.

#### *Selected option for turbines*

Ambient air quality levels of NO<sub>x</sub> have been demonstrated to meet WHO standards and will not cause local air quality problems, thus the Project has concluded that:

- DLE technology should be specified as the combustion system on the compressor drive gas turbines and that standard combustion systems will be used on the power generation gas turbines
- Large gas turbines will be used as the gas compressor drive option.

#### **4.7.4 Relief System Alternatives**

The Project considered alternative systems to safely dispose of:

- Mixed nitrogen and pipeline gas leakage from the compressor gas seals
- Pipeline gas released from maintenance or emergency blowdown of equipment.

Seal gas leakage is predicted to emit twice as much greenhouse gas as maintenance and emergency blowdowns. Seal gas leakage occurs continuously while gas released during maintenance or emergency blowdown is intermittent, so a common flare system would need a continuous nitrogen/fuel gas purge to ensure complete combustion of the seal gas. It was considered inherently safer and more reliable not to discharge low-pressure seal gas to a common relief system, which could experience highly variable backpressure.

#### *Compressor seal gas management options*

The Project therefore considered three options for the management of compressor seal gas:

- Option 1 – flaring
- Option 2 – venting
- Option 3 – recovery.

Option 1 would route the seal gas leakage to a small, dedicated low-pressure flare that would combust the methane to emit CO<sub>2</sub> saving the equivalent of 6300 tonnes/yr CO<sub>2</sub> per compressor station. The flare would be purged by fuel gas with a pilot to ensure the seal gas is combusted. Option 1 would have significantly lower greenhouse gas (GHG) emissions than Option 2. Light from the flare and the pilot could intrude on views from communities.

Option 2 would route the seal gas leakage to a vent at a safe location above the compressor building and release it without ignition. This has the highest environmental impact in terms of greenhouse gas emissions, but is technically the simplest option with the lowest probability of failure.

Option 3 would collect the seal gas leakage and typically use a small compressor to return it to the fuel gas system. Technically it is the most complex option, and a safe alternative disposal route needs to be available if the seal gas leakage recovery package is out of service. However, Option 3 avoids the majority of greenhouse gas emissions (saving the equivalent of 7500 tonnes/yr CO<sub>2</sub> per compressor station) and the potential visual disturbance associated with Option 1.

#### *Maintenance and emergency depressurisation options*

The Project considered three options for the safe release of gas from maintenance and emergency depressurisation of individual sections of the compressor station:



- Option 1 – high-pressure vent
- Option 2 – high-pressure elevated flare
- Option 3 – high-pressure ground flare.

Option 1 would release methane to the atmosphere via a single high-pressure vent without combustion. Technically, this is the simplest option, has the lowest probability of failure and requires least maintenance. However, it has higher greenhouse gas emissions than the other options and noise emissions may cause community disturbance during emergency depressurisations.

Option 2 would route the gas from depressurisation to an elevated flare. This flare could either have a nitrogen purge and a continuous pilot or be ignited only in the event of maintenance of an emergency depressurisation. The not normally ignited flare would have lower GHG emissions than the flare with a continuous pilot. Either way, it would produce less GHG than Option 1, because the gas is combusted to CO<sub>2</sub>. Combustion and jet noise from the flare would make Option 2 louder than Option 1. Light from the flare would cause a visual impact, particularly at night.

Option 3 would route the gas from depressurisation to a flare at ground level. This is likely to be less noisy and have less visual impact than Option 2. However, Option 3 is inherently less safe as gas is vented at ground level, and the ground flare's valve and burner arrangement is more complex and needs more maintenance.

Table 4-10 summarises a comparative assessment of the options for maintenance and emergency depressurisation. This assumes a depressurisation frequency of once per year per compression train and once every 10 years for interconnecting pipework (for maintenance venting) and a similar frequency and event for emergencies with the addition of one full station blowdown per year.

**Table 4-10: Assessment of Emergency and Maintenance Depressurisation Options**

Option	CO <sub>2eq</sub> Emissions (tonnes/year/station)	Potential for Community Disturbance	Technical
1. High-pressure vent	7829	Moderate	Lower
2a. High-pressure flare (continuously lit)	750	Higher	Moderate
2b. High-pressure flare (not normally lit)	440	Moderate	Moderate
3. Ground flare	850	Lower	Higher

#### *Selected option for relief systems*

Based on the greenhouse gas emissions savings, the seal gas recovery system was selected as the preferred option for compressor seal gas management.

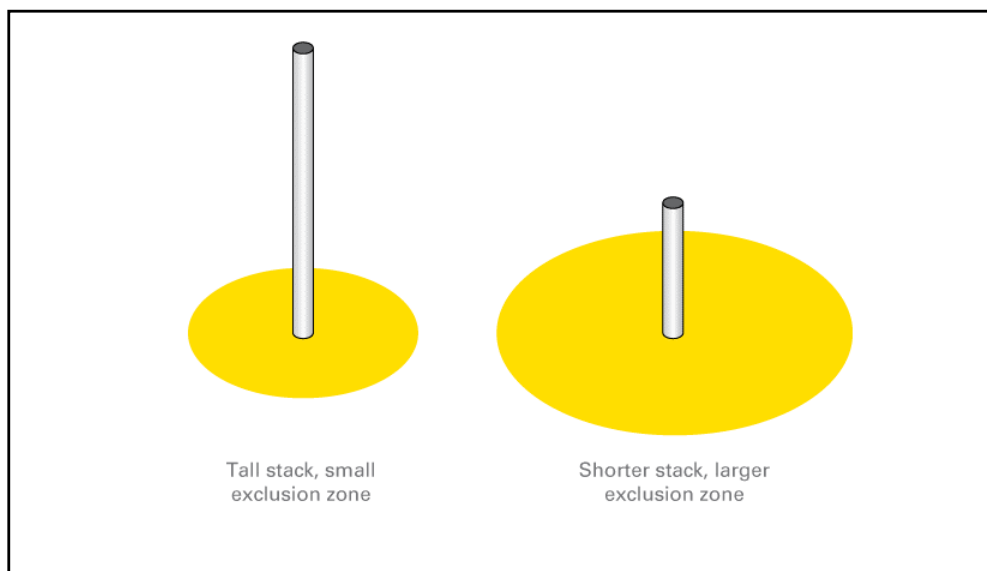
A high-pressure vent was selected for disposal of gas released during maintenance and emergency activities. This option was felt to be inherently safer than a ground flare although it has the highest GHG emissions. This option also has reduced visual impact and noise emissions.

#### *Vent stack height and exclusion zone*

Thermal radiation modelling was carried out at a variety of heights to determine a height at which unexpected ignition of vented gas would expose on-site personnel and the public to

acceptable levels of thermal radiation, and to set an exclusion zone boundary round the vent stack.

Increasing the height of the stack decreases the radius of vent exclusion zone, as acceptable levels of thermal radiation are achieved closer to the stack (see Figure 4-13). The increasing stack height therefore is associated with greater potential for visual impact and lower land take requirements.



**Figure 4-13: Relationship between Vent Stack Height and Exclusion Zone Area**

The height of the elevated vent stacks at CSG1 and CSG2 took account of the presence of public roads, railway lines and power lines, and the potential visual impact.

At CSG1, the presence of the public road from Jandari to Nazarlo south of the site, the electricity line and railway line parallel to the western site boundary and the existing PSG1 facility east of the site restricts the vent exclusion zone area. Two potential exclusion zone locations were considered: one on the current CSG1 location that would need the vent to be 120m tall, and one further north that would allow the vent to be 80m tall. The upper portions of the vent stack of both the 120m and 80m options would be visible from the villages of Jandari, Nazarlo, Kesalo, Gardabani and Mzianeti above intervening tree lines and would result in a minor change in the views.

At CSG2, the vent exclusion zone area is not constrained by existing services. Two potential options were considered for vent stacks 80m and 40m high. In the view from the village of Rekha, both vent stacks are likely to be noticeable against the backdrop of the distant mountains. The 80m-high stack would also be visible from Khando, and more distantly from the villages of Gumbati, Jinisi and Kuschi.

At the PRMS the vent exclusion zone area is not constrained by existing services. Two potential options were considered for vent stacks 80m and 40m high. In distant views from the villages of Vale, Naokhrebi, Tsinubani, Abatkhevi, Julda and Tskaltbila both the 40m and 80m options will be seen against the backdrop of hills and mountains and would result in a minor change in the views.

Figure 4-13 shows a summary of the visual impact at the alternative stack heights and the potential associated increase in required land to facilitate an expansion of the exclusion zone. Table 4-11 shows the variation in land area with stack height.

**Table 4-11: Assessment of Vent Stack Height Options**

Facility	CSG1		CSG2		PRMS	
Alternative vent heights (m)	120	80	80	40	80	40
Estimate of Additional land area (to public boundary, m <sup>2</sup> )	-	+42,000	-	+23,000	-	+23,500

The Project evaluated the possibility of maintaining as much vegetation as practicable within the exclusion zone to reduce the potential environmental impact of increasing the vent exclusion zone area to reduce vent stack height. During detailed design it was determined that apart from a track to the vent and the area required for foundations for the vent pipework, the majority of the exclusion zone would remain as vegetation.

*Selected options for vent stack heights*

Vent stack heights of 40m have been selected for CSG2 and the PRMS and a vent stack height of 80m at CSG1.

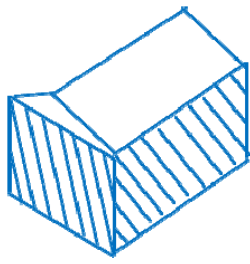
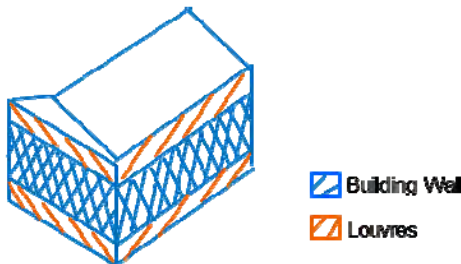
#### 4.7.5 Noise Attenuation Alternatives

The Project considered two design options to reduce noise emissions from equipment in CSG1's compressor train (gas turbine and compressors) building:

- Option 1 – a fully enclosed building
- Option 2 – a building partially clad with high performance louvres.

Table 4-12 presents the relative advantages and disadvantages of the two options.

**Table 4-12: CSG1 Compressor Train Building Options**

	Option 1 Fully Clad Building	Option 2 Partially Clad Building with Louvres
Design		
Safety	Closed building creates rigid volume Higher potential for projectiles if an explosive atmosphere is ignited	Open building design allows any ignited volume to expand and burn, which is an inherently safer design

	Option 1 Fully Clad Building	Option 2 Partially Clad Building with Louvres
CO <sub>2</sub> emissions reductions	0 tonne CO <sub>2e</sub> /yr	3000 tonnes CO <sub>2e</sub> /yr
Noise*	Estimated 44 dB(A) free-field at nearest receptor	Estimated 44 dB(A) free-field at nearest receptor

\*Estimations of noise levels at nearest receptor are based on indicative plant sound power levels for the purposes of assessment within this ESIA.

Option 2 allows for a significant reduction in the electricity needed to ventilate the building. This represents a reduction in fuel gas for power generation and a saving of 3000 tonnes of CO<sub>2eq</sub> emissions per year and noise levels remain within the Project noise standards. Option 2 is an inherently safer design as it does not create rigid confines to any explosion in the building and reduces the likelihood of projectiles in the event of an explosion.

#### *Selected options for noise insulation*

Owing to the E&S and H&S benefits, a partially clad compressor train building was selected for CSG1.

### **4.7.6 HVAC System Alternatives**

The Project considered two options for the HVAC systems needed at CSG1 and CSG2:

- Option 1: 100% fresh air mode with a minimum temperature in the buildings of 10°C
- Option 2: 20% fresh air mode with a minimum temperature in the buildings of -20°C.

Option 2 recycles 80% of the air in buildings. Option 2's lower acceptable minimum temperature means that CSG1 will not need heating in the winter, beyond the heat radiated from the turbines' lubricating oil coolers. Therefore, Option 2 needs less power to be generated, saves on fuel gas and saves approximately 7000 tonnes of CO<sub>2</sub> emission per year in total.

#### *Selected option for HVAC systems*

The Project has selected HVAC systems with 20% fresh air mode and a minimum temperature in the buildings of -20°C.

## **4.8 Summary of Selected GHG Reduction Measures**

### **4.8.1 Project Concept**

The SCPX Project concept selection process evaluated the use of a 42"-diameter pipeline and a 56"-diameter pipeline with pipeline looping and additional compressor stations. It found that the selection of the 56"-diameter pipeline allows a significant reduction in greenhouse gas emissions (see Table 4-13) because it reduces the compression power needed at each compressor station. The 42-inch option needed compression power of approximately 80MW at the first compressor station (CSG1) and 70MW at the second compressor station (CSG2), whereas the 56-inch option needs only approximately 66MW at each station. This has led to a subsequent reduction in the number of compressor trains required at CSG1 and CSG2 from 5 (4 +1 standby) to 4 (3 + 1 standby).

Table 4-13 shows preliminary estimates of combined emissions from CSG1, CSG2 and the PRMS based on a worst-case compressor loading for the 42"-diameter concept and the 56"-

diameter concept at a similar stage in the Project design. These calculations include a modified design philosophy that only requires compressor driver equipment to be sized to supply 5% more than the peak power required instead of 13%, which in turn increases the efficiency of the equipment.

**Table 4-13: Comparison of GHG Emissions for 42" and 56" Pipeline Concepts**

Concept	CO <sub>2eq</sub> Emissions (tonnes/year)
42"-diameter pipeline	1,054,000
56"-diameter pipeline	800,000

The 56"-diameter option selected by the Project reduced annual CO<sub>2eq</sub> emissions by 254,000 tonnes per year, a 24% reduction.

#### 4.8.2 Facility Design

During the early engineering phase, the Project evaluated a number of different options and technologies for further reducing GHG emissions. Table 4-14 shows the GHG reductions achieved by options that were selected and incorporated into the Project design.

**Table 4-14: Facility Design GHG Reductions**

Emissions Reduction Technique	CO <sub>2eq</sub> Emissions Reduction (tonnes/year)
<b>Seal gas recovery:</b> Recovering the gas that evolves from the compressor gas seals instead of venting to atmosphere	15,000
<b>Electricity Grid Connection:</b> Potential future movement to using the Georgian national electricity grid for site power at CSG1 and PRMS, instead of gas turbines/engines	27,200 <sup>2</sup>
<b>Partially clad buildings:</b> The use of partially clad compressor buildings at CSG1 instead of fully enclosed buildings, reducing the heating and ventilation requirements	3000
<b>Heating and ventilation system:</b> Increasing the volume of air recycled within the heating and ventilation system to 80%, reducing the heating demands	7000
Total	52,200

Refinement of the emissions estimates to allow for seasonal variation in operation plus the additional emission savings outlined above, have led to current emission forecasts of approximately 599,500 tonnes of direct CO<sub>2eq</sub> emissions per year plus 4,000 tonnes<sup>2</sup> of indirect CO<sub>2eq</sub> emissions per year (from the grid electricity supply). The Project's predicted energy intensity (the energy consumed to transport the gas expressed as a percentage of the energy contained within the 23 bcma of gas which is being exported) is 1.15%.

Further refinement of the emissions estimates will be undertaken as the Project design is developed during detailed engineering.

## 4.9 CSG2 Access Road Options

The CSG2 site is in a relatively remote location some 16km from the Millennium Road and currently can only be accessed using poorly surfaced roads and tracks that pass through several villages. The Project will need to construct an access road to transport construction

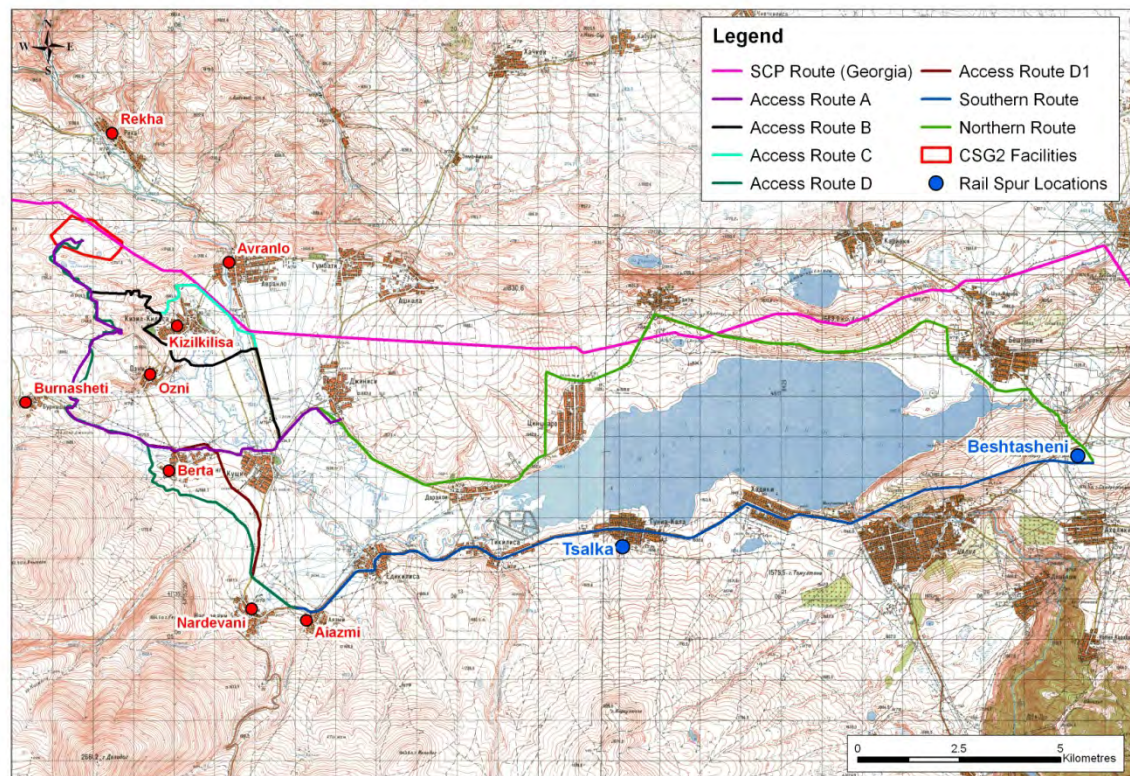
<sup>2</sup> Assuming approximately 87% of Georgia's electricity is generated from hydroelectric power ([http://www.iea.org/stats/electricitydata.asp?COUNTRY\\_CODE=GE](http://www.iea.org/stats/electricitydata.asp?COUNTRY_CODE=GE); IEA, 2011), rounded up to the nearest 500 tonnes.



materials, process equipment and personnel to and from CSG2 and to provide access to the site during operations.

A preliminary survey of the existing roads noted restrictions to turning circles, width restrictions, their suitability for wide loads and their avoidance of communities. Four route options were identified (see Figure 4-14):

- Option A: south/west from south of Jinisi, skirting to the north of Kuschi and Berta, then west towards Burnasheti, and north to CSG2
- Option B: south/west from south of Jinisi, turning north before Kuschi, then south-west round Kizilkilisa, then north/west to CSG2
- Option C: south/west from south of Jinisi, turning north before Kuschi, then north-east round Kizilkilisa, then north/west to CSG2
- Option D: north from the Millennium road between Nardevani and Aiazmi, skirting Berta/Oliangi (variant D1 going east round Berta), continues north past Burnasheti to CSG1.



**Figure 4-14: CSG2 Access Road Options from Rail Unloading area at Beshtasheni and Tsalka**

Route options C and B were rejected because of their proximity to the communities of Avranlo and Kizilkilisa including a cemetery and church. These communities could be sensitive to disturbance from the SCPX Project.

Route Option A makes greater use of existing tracks than Route Option D and needs less new land to be acquired, but as the road north from the Millennium Road at Gantiadi towards Darakovi and Jinisi was found to be unsuitable as an access road, Option A would

need an improved road to the north of Tsalka Lake to be constructed (Northern Route). This would involve upgrading approximately 17km of existing track, constructing two new bridges and constructing new road to bypass the villages of Beshtasheni and Tsintskaro.

Parts of Route Option D would be constructed on hillsides where they would have a higher visual impact than the other options, but Route Option D can be accessed from the Millennium Road. To reduce the land take and potential visual impact associated with Route D, the modified Route Option D1 was proposed, which passes east round Berta/Oliangi taking advantage of the flatter ground to the south of Kuschi (see Figure 4-15).

Table 4-15 summarises the comparative assessment of the access road route options.

**Table 4-15: Comparative Assessment of CSG2 Access Road Options**

E&S Constraint	Potential Impact				
	A	B	C	D	D1
Ecological impact	Moderate	Higher	Higher	Moderate	Moderate
Visual impact	Moderate	Moderate	Moderate	Higher	Moderate
Economic resettlement	Moderate	Moderate	Moderate	Higher	Moderate
Community, H&S and disturbance	Moderate	Higher	Higher	Lower	Lower
Cultural heritage	Moderate	Higher	Moderate	Moderate	Moderate

#### **4.9.1 Selected Option for CSG2 Access Route**

Route Option D1 (see Figure 4-15) was selected as the preferred access route to CSG2 as it has a relatively low potential to disturb communities or impact on community health and safety. Compared with all the other options it has a lower visual impact. It needs less land than Route D. Route D1 utilises existing roads where possible and is accessible from the Millennium Road.

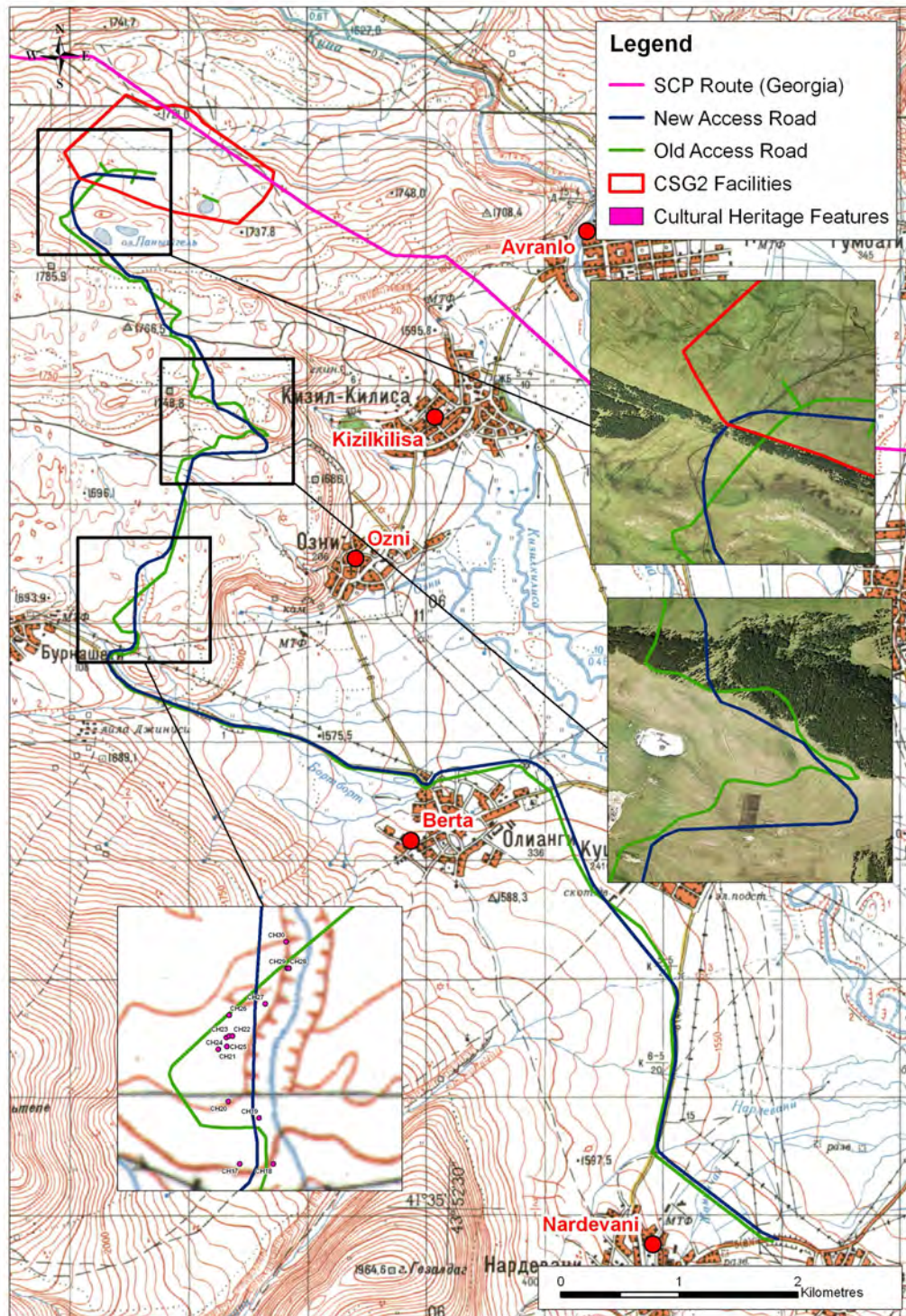
#### **4.9.2 CSG2 Access Route – Micro-Routing**

The route has been refined following site survey work to avoid the majority of wetland, sites of importance for cultural heritage and utilising gaps in the existing plantations (Figure 4-15).

Additional constraints were identified during the disclosure phase when preparing for cultural heritage works and following the implementation of follow-up ornithological surveys. These identified several large probable burial mounds within the road footprint between Kuschi and Berta villages. An area of wetland was also identified to the north of the access road route close to these cultural heritage sites, where two pairs of corncrake (*Crex crex*) were observed (Figure 4-16).

A multidisciplinary routing review was carried out with the aim of evaluating the routing options to minimise impact on the area of wetland habitat, to increase the distance from the habitat to reduce disturbance to birds and to avoid as far as practical the potential burial mounds. The access road has been re-routed to the south as shown on Figure 4-16, avoiding impacts on the visible cultural heritage features, avoiding routing the permanent or temporary footprint of the road within the wetland habitat and increasing the distance between construction activities and the wetland.





**Figure 4-15: Selected Access Road Route Option D1 showing Alignment Changes to Avoid Constraints (pine plantation and cultural heritage)**



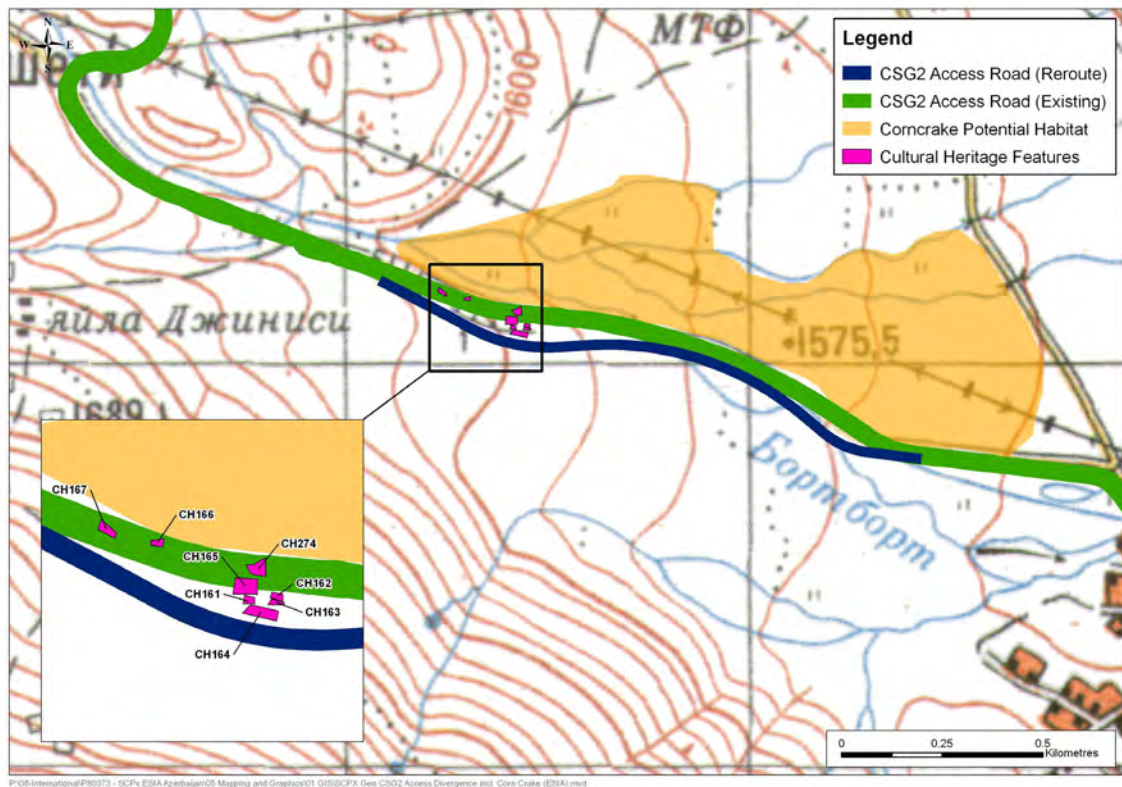


Figure 4-16: CSG2 Access Road Micro Re-Route

#### 4.9.3 CSG2 Access Road Construction

The Project will consider options relating to CSG2 access road construction including options for import of material from borrow pits; disposal of cut material; bridge design; drainage; lighting; markers; and snow clearance during detailed engineering.

### 4.10 Construction Camp and Lay-down Area Location Alternatives

The Project has considered alternatives for the location of construction camps, railheads and equipment lay-down areas.

#### 4.10.1 Construction Camp Location Options

The SCPX Project will require temporary construction camps conveniently located for construction of CSG1, CSG2, CSG2 access road, the PRMS and the pipeline. Preferentially, construction camps have been collocated adjacent to the respective construction sites. A desktop review identified location options for camps at CSG1, CSG2, CSG2 access road, the PRMS and the pipeline. The selection was finalised during a multidisciplinary site visit by representatives from engineering, H&S and E&S disciplines.

##### *Assessment of options*

Each of the sites was assessed against a range of site-specific environmental and social criteria and assigned a score based on information gained from the site visit carried out by Project environmental and social specialists and ecological and cultural heritage surveys

(where appropriate). A weighting factor was applied using the following ranking (as appropriate for each site):

- Community safety (highest)
- Proximity to houses, schools etc
- Land ownership and use
- Ecological impact
- Proximity to known wells/abstraction points
- Proximity to surface waters
- Cultural heritage
- Existing contamination
- Historic use (lowest).

#### *CSG1 construction camp options*

The Project considered six options for a construction camp location near to CSG1 (see Figure 4-17):

- Option 1 – in a field west of CSG1
- Option 2 – in a field south of CSG1
- Option 3 – in a field south of the military camp
- Option 4 – in a field north of the military camp
- Option 5 – in a field south-west of CSG1
- Option 6 – in a field north-west of CSG1.



**Figure 4-17: Construction Camp Options Locations around CSG1**

Options 1 and 5 were less favoured because they are on communal land that is used by local residents. Option 2 was not preferred, because personnel would need to cross the main public road to access the work site. Option 3 is closest to Jandari village and thus has the highest potential for disturbance. In addition, Options 2 and 3 are located on the southern side of the railway line, which presents logistical difficulties. Option 4 is state-owned land at a manageable distance from local communities, although access to this site was deemed to be complicated owing to military access. Option 6 was deemed the most suitable option from a multidisciplinary perspective, as it was not communal land, did not involve personnel crossing the public road to access the worksite and is furthest from local communities.

#### *CSG2 construction camp*

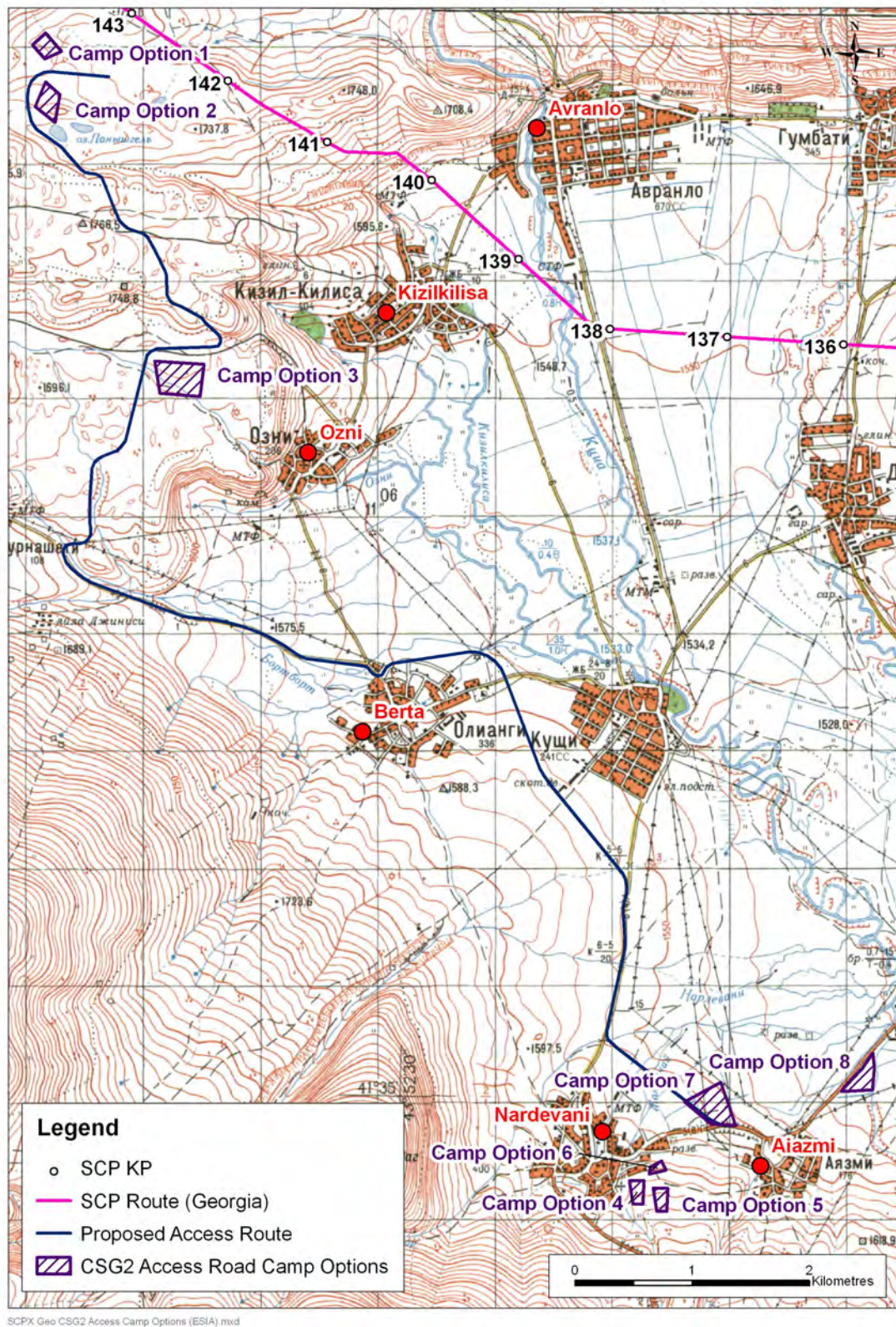
The CSG2 construction camp was required to be as close as possible to the CSG2 location to avoid excessive travel distances for vehicles and workers to the site, which would be especially problematic in severe winter conditions. The Project considered two options immediately to the south of the tree belt which borders the site; however, these were discounted owing to topographical constraints and distance from the site. The selected option to locate the CSG2 camp at the CSG2 site (Chapter 5) was deemed acceptable from an environmental and social perspective because it is not located close to communities, did not contain visible cultural heritage features, was not located on cropped land and was of similar ecological value to the CSG2 site.

#### *CSG2 access road camp options*

Eight options were considered for the location of the CSG2 access road camp, which is required to accommodate workers during the construction of the road (Figure 4-18):

- Options 1, the CSG2 construction camp
- Options 2–3, towards the end of the access road immediately adjacent to the tree belt surrounding CSG2 and further down the valley to the north-west of Ozni
- Option 4, to the west of the Millennium Road south of Nardevani village near the start of the CSG2 access road
- Option 5, to the east of the Millennium Road south of Nardevani village near the start of the CSG2 access road
- Option 6, an area to the north of Option 5 that was used as a construction camp during the Millennium Road construction
- Option 7, an area to the north of the Millennium Road between Nardevani and Aiazmi, adjacent to the start of the CSG2 access road
- Option 8, an area to the south of the Millennium Road between Aiazmi and Sakdrioni.





**Figure 4-18: Construction Camp Options Locations around CSG2 Access Road**



Options 1–3 were rejected as there are no existing access routes to these sites or the existing roads cannot readily accommodate construction plant and equipment. Option 4 was rejected owing to its location immediately adjacent to a large cultural heritage site (a Bronze Age – Mediaeval period cyclopean fortress). Within the boundaries of the Option 4 location there were many linear stone banks and small mounds thought to represent potential cultural heritage, and there was a high potential that features associated with the fortress would extend into the camp area.

Option 6 is a brownfield site that was still being used to support construction of the Millennium Road and it was uncertain whether this area would be available in advance of road construction. Option 7 was the preferred option from an engineering perspective but was rejected owing to the area being covered by a large number of small land plots, many used for crops and the potential livelihood impacts associated with using this area for a camp. Further investigations of Option 8 revealed that it was crossed by a third-party gas pipeline, so the required safety separation distances between this line and accommodation buildings meant that the area was too small to site the camp on.

Option 5 was the selected option for the CSG2 access road construction camp. It consists of a modified subalpine meadow area subject to heavy grazing and trampling. The site has been modified and artificial terraces can be observed on the site. It does not support any species of conservation value. There were several small stone piles and mounds on the surface; after further investigation, one was noted as a potential feature and is discussed further in Section 10.10.

#### *PRMS construction camp options*

The Project considered seven options for a construction camp location near to the PRMS (see Figure 4-19):

- Options 1a and 1b – on level land west of the PRMS
- Option 2 – in the next plateau 1.5km west of the PRMS
- Option 3 – in the Potskhovi River valley 2km south-east of the site
- Option 4 – south of the Potskhovi River opposite Akhaltsikhe village 24km away
- Option 5 – north of the road to the Potskhovi road bridge 1km from the site
- Option 6 – by the Potskhovi road bridge 2km south-east of the site.

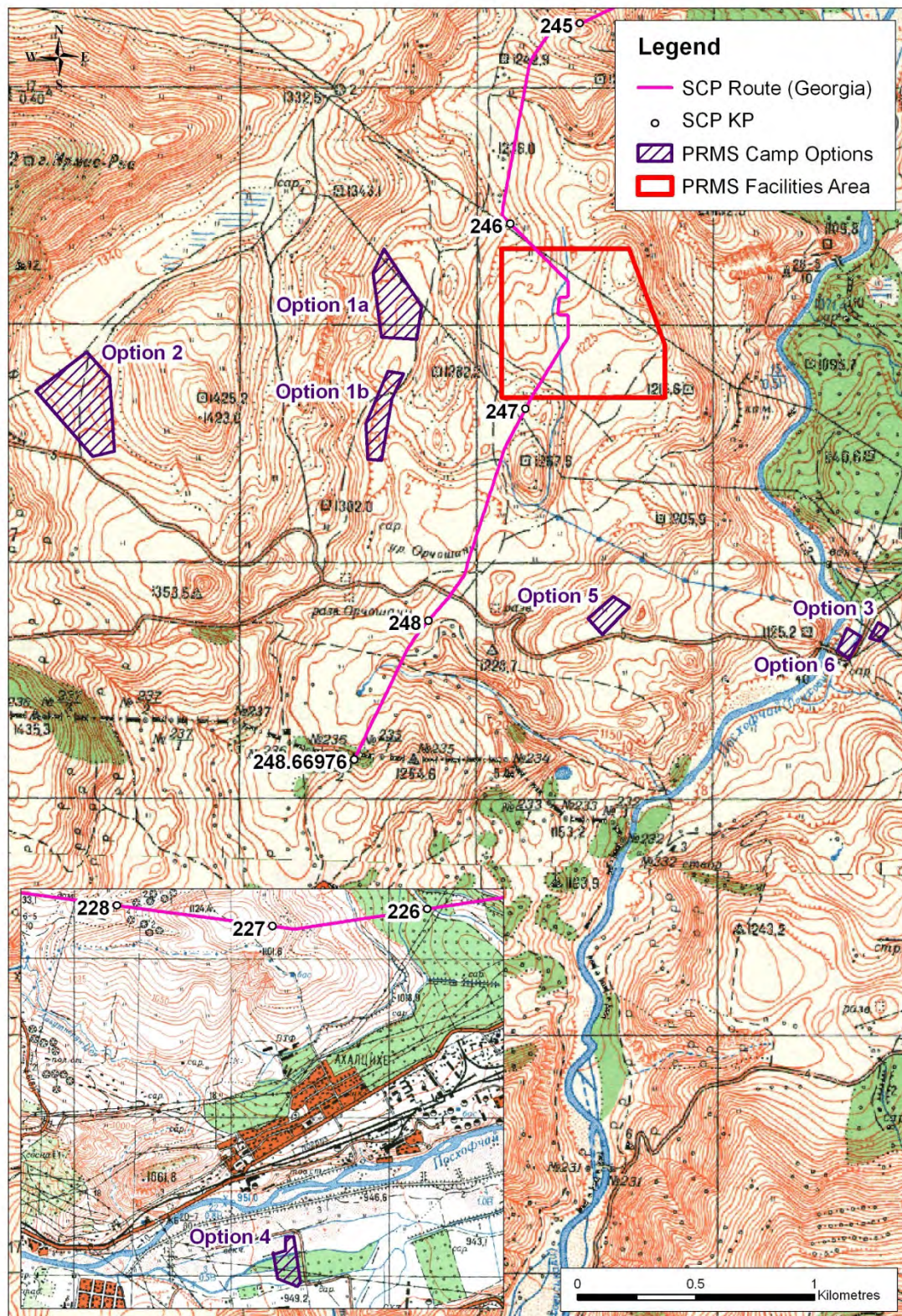


Figure 4-19: Construction Camp Options Locations around PRMS



Option 4 was located 25km away, which was deemed to involve excessive travel times and distances and the highest potential for health and safety impacts. Options 3 and 5 were located on productive agricultural land. Option 6 was not on agricultural land but was 3km from the site, which would involve additional travel and was also in an area prone to flooding. Option 2 was technically not suitable owing to topography and lack of access to the PRMS site.

Option 1a was rejected owing to the significant length of new access road that would have been required and the additional temporary footprint this would require. Option 1b and Option 5 were selected as the two potential construction camp locations. The proximity of Option 1b to the site minimises travel time and traffic movements thus reducing the potential health and safety and community disturbance impacts, and the site is not located on cropped land. However, there is the potential for the wetland adjacent to the camp to provide a habitat for fauna. Option 5 is slightly further from the site with greater travel times required and is located on cropped agricultural land. Since the ESIA Disclosure, the Project has decided to retain two potential options for the PRMS construction camp, Option 1b and Option 5, and intends to select the most appropriate camp option after undertaking seasonal ecological surveys of both options prior to construction (refer to Chapter 5, Section 5.6).

#### *Pipeline construction camp options*

The Project considered six location options close to Rustavi for a construction camp near to the pipeline that have good road access to the pipeline ROW, the pipe yard and the rail offloading area (see Figure 4-20):

- Rustavi Area 1 camp
- Rustavi Area 2 camp
- Gamarjveba Area 1 camp
- Gamarjveba Area 2 camp
- Karajalari/Gachiani camp
- Marneuli camp.

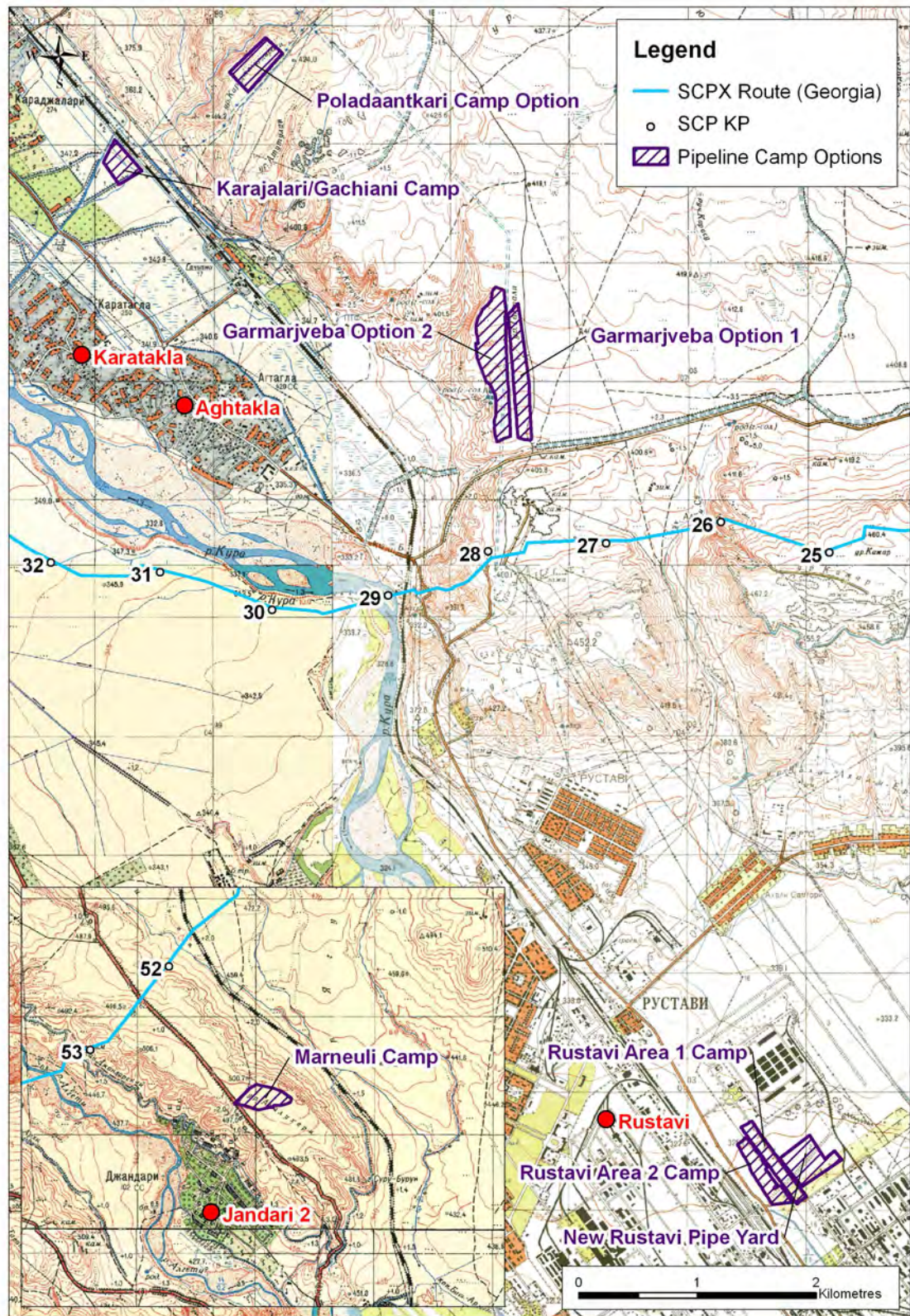


Figure 4-20: Pipeline Construction Camp Options Locations

The Karajalari/Gachiani option is a greenfield site. The other options are all brownfield sites and have some degree of land contamination, e.g. fly-tipping, that would need to be remediated; the Rustavi camp options are extensively contaminated with potential industrial waste. The Karajalari/Gachiani option was discounted as it is close to communities and is a greenfield site. The Marneuli and Rustavi options are located in areas where existing traffic is heavy and there are pedestrian users; in addition Marneuli is a considerable distance from the majority of the pipeline loop. This would complicate the management of camp traffic.

Gamarjveba Area 1 was initially chosen as the preferred site, because it is a reasonable distance from local communities and has little existing land contamination.

Since the ESIA Disclosure, the construction camp area at Gamarjveba Area 1 has been deemed unsuitable. This is because of the proximity of an existing gravel extraction plant adjacent to the proposed camp area. It became apparent during subsequent site visits that dust from the extraction operations would blow over the camp during certain meteorological conditions, leading to potential health and safety risks to the workforce.

The Project identified an alternative option in the vicinity of the village of Poladaantkari. No visible cultural heritage was observed on the site, which is a greenfield site used for pasture. The proposed camp is within approximately 200m from houses on the edge of Poladaantkari but is partially screened from view by topography and vegetation and is further from dwellings than the Karajalri/Gachiani option. The camp boundary currently encompasses part of an existing access track that some residents of Poladaantkari currently use to access their houses. As described in Chapter 05, this access track will be avoided or an alternative provided.

#### **4.10.2 Offloading and Lay-down Area Options**

A new pipe lay-down location has been identified at Rustavi (see Figure 4-20) and a rail offloading area nearby to serve the pipeline and potentially CSG1. The access route options to CSG1 are shown in Figure 4-21. Option A is the selected route that will be used for the major plant and pipeline deliveries to CSG1 and the pipeline ROW. Option B was considered less favourable, as it passes through a number of villages with the potential for increased impacts on community health and safety. Access between the Rustavi pipeline lay-down area and the pipeline ROW are described in Chapter 5.



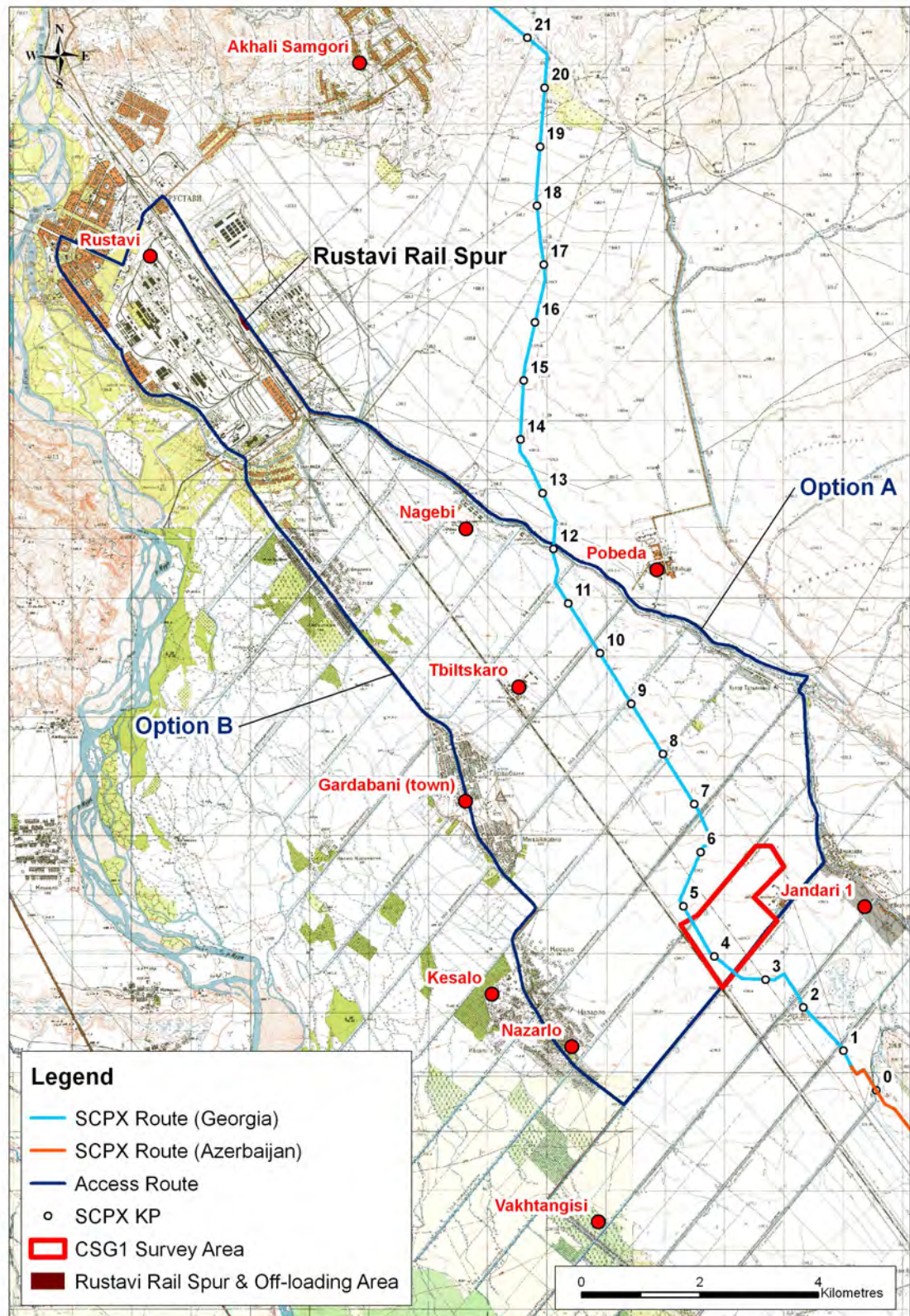


Figure 4-21: Optional Access Routes between Rustavi Rail Spur and CSG1

At CSG2, two options for the potential rail offloading area were identified one at Tsalka and a second at Beshtasheni. The facility at Beshtasheni was used during BTC/SCP construction, although neither area currently has a rail spur in place. The Beshtasheni option was selected because of overhead cables constraining access at Tsalka and the potential for health and safety impacts at Tsalka, which is currently a public station. The potential options are shown in Figure 4-14.

The potential rail offloading area at the PRMS will be located in Akhaltsikhe at the site used during BTC/SCP construction (see Chapter 5).

## **4.11 Logistics Alternatives**

### **4.11.1 *Transport of Line Pipe, Materials and Equipment***

Process equipment and line pipe will be imported into Georgia at the port of Poti (major equipment) or Batumi (line pipe). The Project has considered options for forwarding line pipe from Batumi to the pipe yard in Rustavi and process equipment from Poti to the SCPX facilities by rail and by road. Transport of materials and equipment by air has been discounted with the exception for emergency response and rapid evacuation.

Rail is a safer and more efficient mode of freight transport than road haulage. It involves less interaction with other users, is more fuel-efficient and has lower emissions, and causes less noise (due to distances from receptors) and general nuisance. Subject to the results of ongoing detailed surveys of the condition and capacity of the existing rail infrastructure, rail transport will be used to transfer line pipe from Poti and Batumi to Rustavi.

Subject to the results of ongoing detailed surveys of the condition and capacity of the existing road infrastructure, modules of major compressor station equipment will be transported to the construction sites by road to avoid damage from shunting while on rail wagons or damage from repeat handling.

Aggregates and general construction equipment will be transported within Georgia mainly by truck.

## **4.12 Conclusion**

This section has summarised some of the key Project alternatives that the Project has reviewed. A continual process of environmental and social consideration of the Project design has resulted in the adoption of the optimal base-case design for the SCPX Project. This base-case design has been described in detail in Chapter 5. The selection of preferred solutions affects the overall environmental and social impacts of the SCPX Project that are assessed in Chapter 10 and Chapter 12.