Chapter 12 Hazard Analysis and Risk Assessment (Unplanned Events)

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12 HAZARD ANALYSIS AND RISK ASSESSMENT (UNPLANNED EVENTS)

12.1 Introduction

The primary driver for the WREP-SR Project is to ensure continued safe operation of WREP. As the WREP is an operational pipeline system, the design has been subjected to risk assessments. There is an existing oil spill response plan (OSRP) and emergency response procedures in place that have been approved by GIOC (GOGC), as a representative of the Georgian Government, in accordance with the Pipeline Construction and Operating Agreement (PCOA). There is also an established network of containment sites and pollution control equipment depots. An updated Oil Spill Response Plan will cover the de-oiling, commissioning and operation of the re-commissioned line.

Despite high standards of design and operational procedures, there will be a small residual risk of loss of containment associated with the project activities. This chapter discusses the Project quantitative and environmental risk assessments, the potential effects of a spill as well as control measures that will be implemented by the project to mitigate such risks and minimise impacts.

The WREP-SR Project will result in the replacement of sections that are considered to represent a risk of potential failure due to landslides and river bed scouring. Once a new replacement section has been constructed, the redundant section will be de-oiled, cleaned and removed from service as described in Section 5.5. The following risk assessment (Section 12.2) addresses risks and impacts associated with de-oiling. Options considered for de-oiling and removal from service are described in Section 4.5.

12.2 De-oiling Risk Assessment

12.2.1 Background and Approach

Proposed de-oiling procedures (see Section 5.5) have the potential to result in an oil release to the environment during:

1. De-oiling of isolated redundant pipeline sections, e.g. due to seam-weld failure in Soviet pipe sections / landslide areas
2. Transfer of oil (via temporary break tanks) from the redundant pipeline sections to the downstream pipeline.

De-oiling of RP-001a and RR-001 pipeline is to be undertaken from the tie-in points for the replacement pipelines to minimise oil volumes. For RR-004a, de-oiling is to be undertaken between BVS44 and PRS1. De-oiling risk assessment is therefore required for these sections. It should however be noted that there is no Soviet era pipe within the section of WREP to be replaced by RR-004a; loss of containment due to seam-weld failure is not therefore a risk.

De-oiling risk assessment is also required for oil transfer activities for RP-001a, RR-001 and RR-004a.

The pipelines to be replaced at WREP and Export pipeline crossings of the River Supsa are modern pipe with minimal gradient changes. Pressure during de-oiling will be well within the maximum operating pressures. Both Supsa crossings will be de-oiled directly to the Terminal with no potential for oil leakage during product transfer. Detailed risk assessment has therefore not been undertaken for the Supsa WREP or Supsa Export crossings.

De-oiling and cleaning is anticipated to be undertaken over a period of several weeks, with an oil spill, if realised, comprising, at worst, a full bore pipeline or temporary break tank rupture and instantaneous release of calculated volumes of oil. Oil release in this scenario therefore has the potential to cause significant short-term (acute) environmental impact, with subsequent ongoing long-term (chronic) effects. Studies undertaken as part of the WREP-SR Project indicate that there are no significant differences in the probability of pipeline failure during de-oiling and current operations. Potential release volumes are lower during de-oiling than for normal operation of the pipeline.

By contrast, sealed sections of pipeline remaining *in situ* following removal from service procedures will have been be cleaned and drained and will contain only a residual film of oil and wax (see Section 5.5.4). Low points in the pipeline, where residual oil could potentially collect will be drilled and investigated using a borescope, with any excess oil drained. At the Supsa river crossings the pipeline beneath the river is level, with no anticipated collection of oil following cleaning. Any small residual amounts of hydrocarbons remaining after cleaning will be immobilised through oxidation and solidification within the pipe sections, which will be very rapid in relation to the decades-long lifespan of the *in situ* abandoned pipeline. Risks to the environment from the leaking of residual hydrocarbons from redundant pipe in such scenarios are therefore insignificant and do not require further risk assessment.

The risk assessment that has been undertaken will ensure the pipeline remains in compliance with the Host Government Agreement (HGA) and the PCOA for WREP. Specifically the PCOA (Schedule 2, Part A, 3e - 3h) requires:

- An assessment of the environmental risks associated with pipeline operations (assessed previously for WREP and therefore not considered further within this ESIA)
- A statement of the options for mitigating identified risks, including the preferred option for each risk
- The identification of any practicable mitigation measures
- The formulation of a monitoring program.

The risk assessment will also feed into the oil spill response plan and will inform the de-oiling strategy.

BP policies require all projects to implement procedures to minimise the risk of soil and groundwater pollution. In this context the risk assessment was designed to:

1. Evaluate the consequences of an oil release in terms of the potential risk posed to human health and the environment in the context of a defined ‘source–pathway–receptor’ (SPR) conceptual model
2. Quantify the actual risk posed for complete or potentially complete SPR linkages, taking into account the extent and nature (toxicity/mobility) of the source, the pathway transport characteristics and the sensitivity of the identified potential receptors
3. Development of appropriate risk-based remedial or release mitigation solutions to ensure that the risk posed is acceptable given the regulatory and operating environment.

Table 12-1: Geohazard Locations and Soviet Era Pipe Included in Risk Assessment

Replacement Section	Purpose	Aerial Marker (AM) Location	
		start	finish
RP-001a	Landslides	AM 51+900	AM 55+050
RR-001	Landslides / Soviet era pipe	AM 63+100	AM 69+100
RR-004a	Landslide	AM 225	AM 225+400

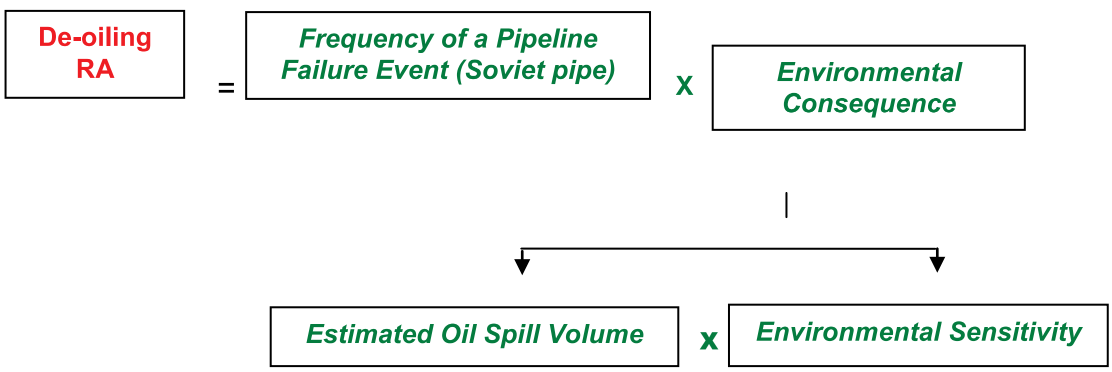
Risk assessment was undertaken at the proposed de-oiling tie-in locations for RP-001a, RR-001 and RR-004a shown in Table 12-2.

Table 12-2: De-Oiling Tie-In Locations Included in Risk Assessment

Replacement Section	Site Location	Aerial Marker (AM) Location
RP-001a	Tie-in 1	AM 51 + 850
	Tie-in 2 (oil transfer)	AM 55 + 55
RR-001	Tie-in 1	AM 63 + 90
	Tie-in 2 (oil transfer)	AM69 + 125
RR-004a	Tie-in 2	AM 225 + 450

12.2.2 Risk Assessment

Assessment of environmental risk, associated with an oil spill during de-oiling procedures, was calculated from the following model and used to generate relative risk rankings for each section of the pipeline.



Environmental sensitivity (vulnerability) was calculated for all receptors in each kilometre of RP-001a, RR-001 and RR-004a to produce a relative numerical ranking, taking account of multiple pathways and exposure scenarios. Calculations were based on professional judgement and experience and are qualitative in nature. RR-004a does not contain any Soviet-era pipe and will be de-oiled within the maximum operating pressure; loss of containment from pipe failure is therefore not a realistic scenario for this section. RR-004a has been included in the assessment solely to evaluate the consequence of any spill during the transfer of oil during de-oiling.

Oil volumes anticipated during de-oiling were applied to the environmental sensitivity ratings to provide a measure of environmental consequence.

Methodology

The method used to evaluate relative environmental sensitivity is a qualitative assessment of environmental receptors (groundwater, surface waters, humans, ecology, land use and archaeology).

The model is based on the selection of key features. For example, features that contribute to aquifer sensitivity include depth to water, net recharge, aquifer media, soil media, topography, impact of the vadose zone media and hydraulic conductivity. Numerical weightings are applied to each feature to reflect their relative importance. Each key feature is further divided into ranges (for example, a range of depth to water in metres), with numerical ratings applied to a given range based on its relative contribution to aquifer sensitivity to pollution.

An overall relative sensitivity score (index) for different locations was computed through summation of the products of rating and weights for each feature. The overall sensitivity score is a measure of relative sensitivity to pollution rather than an intrinsic value.

The use of this model approach to evaluate relative environmental sensitivity is consistent with a source–pathway–receptor risk-based approach through provision of information about the sensitivity of the pathway-receptor linkage.

Environmental sensitivity was calculated for each receptor type in each kilometre of the original pipeline that will be replaced by sections RP-001a, RR-001 and RR-004a. For each kilometre overall environmental sensitivity was calculated through summation of individual receptor sensitivities.

The features and weightings of each receptor are summarised in Table 12-3.

Table 12-3: Summary of Receptor Features and Weightings

Environmental Receptor	Feature	Weighting
Groundwater	Depth to Water	5
	Net Recharge	4
	Aquifer Media	3
	Soil Media	2
	Topography	1
	Impact of the Vadose Zone Media	5
	Hydraulic Conductivity of the Aquifer	3
Surface Waters	Pipeline crosses Surface Water	10
	Distance to Surface Water	5
	Topography/Slope	5
	Impact of the Vadose Zone Media	3
	Surface Water 'Type'	5
	Groundwater Pathway Vulnerability	3
	River Significance	5
	Distance to Transboundary River	5
Humans	Distance from Settlement/Human Activity	2
	Human Risk from Surface Waters	4
	Human Risk from Groundwater	3

Environmental Receptor	Feature	Weighting
Ecology	Distance to Designated Area of Protection	5
	Distance to Designated Protected Species	5
	Distance to Area of High Biodiversity Value/Conservation Interest	3
	Surface Water Vulnerability	2
	Distance to Azerbaijan Border (and possible ecology)	4
Land Use	Distance to Crops/Pastureland	5
	Presence of Irrigation Ditches	4
	Distance to Uncultivated Land/Scrubland	1
Archaeology	Distance to World Heritage Site	5
	Distance to Other Known Archaeology	5
Notes – Features highlighted in *italics* include sensitivity rankings calculated for other receptors		

Features were chosen for each environmental receptor to reflect the areas through which the pipeline passes. For example:

- Hydrogeological features reflect, for example, the presence of shallow aquifers, permeability of local geology, permanent and seasonal surface water features, topography and potential for trans-boundary migration of surface water impact
- Features for human receptors reflect the key pathways through which potential contact with oil is most likely, e.g. direct contact and water-based exposure pathways (groundwater and surface water). Human impact *via* consumption of oil-contaminated crops is not considered directly, although crops are evaluated as a receptor in their own right
- Ecological features are generally restricted to designated areas and species, as well as to areas of conservation interest. Surface waters are considered, regardless of the above, to have ecological importance as well as the potential for trans-boundary ecological impact (in Azerbaijan)
- The presence of crops/pasture and irrigation ditches are key features for land use, however the sensitivity of uncultivated and scrubland is also recognised
- All archaeological remains are considered to be sensitive receptors, and while direct impact by oil leaks are unlikely such areas have the potential to be impacted by clean-up operations.

A number of individual receptors are intrinsically linked, for example, surface water via groundwater (through base flow to rivers), humans via surface water (direct contact, potable abstraction and agriculture) and groundwater (potable abstraction), and ecology via surface waters. Features that incorporate the sensitivity of a linked receptor are highlighted in italics in Table 12-3. Some ‘double counting’ in the assessment of environmental sensitivity is unavoidable for some receptors; this reflects the multiple exposure scenarios considered and the relative individual receptor sensitivity scores.

Ranges and ratings were chosen for each feature to reflect the potential for local conditions to provide a pathway between the oil pipeline and environmental receptor. It is important to note that the weightings listed in Table 12-3 were derived for each environmental receptor separately, with relative weightings reflecting the comparative contribution for each feature towards the overall sensitivity of each receptor. Thus, for example, a rating score of 5 for the distance to a World Heritage Site for archaeological receptors should not be taken as being equivalent to the distance to surface waters for surface water receptors (rating score 5) in terms of their contribution to overall environmental sensitivity (total sensitivity of all environmental receptors). The relative contribution from individual environmental receptors to overall environmental sensitivity is discussed in the section below.

Features and weightings summarised in Table 12-3, and associated ranges and ratings for each receptor were based on expert judgement, experience and evaluation of printed maps and information supplied within the WREP ESIA. Satellite imagery was also used to assess some receptors and features, particularly land use and areas not covered by mapping.

Environmental sensitivity

Environmental sensitivity scores have been calculated separately for all receptors. For comparative purposes scores have been normalised so that the maximum score possible for a receptor is 100. Graphs of environmental sensitivity score for each kilometre section (denoted by the nearest aerial marker (AM) location) are provided within this chapter.

A summary of the number of individual kilometre sections exhibiting high environmental sensitivity is given in Table 12-4 to provide an indication of the risk drivers for overall environmental sensitivity within a given replacement section. It should be noted that the number of kilometre sections is also reflective of the length of the replacement section.

Table 12-4: Summary of Kilometre Sections Exhibiting High Environmental Sensitivity – De-oiling

RP/RR Location	Number of Kilometre Sections with High Environmental Sensitivity					
	Groundwater	Surface Water	Humans	Ecology	Land Use	Archaeology
RP-001a	0	1	0	2	1	0
RR-001	0	4	5	6	4	2
RR-004a	0	1	1	1	2	0

Simple summation of individual receptor sensitivity scores to provide a measure of overall environmental sensitivity for each replacement section would necessitate that the contribution to overall environmental sensitivity is equal for all receptors. Whilst all of the receptors are important it is considered that humans, for example, and the receptors directly relating to potential human exposure (e.g. surface water and groundwater) deserve a higher degree of protection than archaeology, for example.

A qualitative exercise was undertaken to assess the relative importance of each environmental receptor as a measure of their relative contribution to overall environmental sensitivity. The results of this exercise are shown below (as percentages):

- Humans 33%
- Surface water 26%
- Groundwater 20%
- Ecology 13%
- Land use 7%
- Archaeology 1%.

Calculation of overall environmental sensitivity was undertaken through summation of individual receptor sensitivities, which were weighted in accordance with the percentages listed above. These overall environmental sensitivity scores were then normalised to give a maximum possible score of 100. Overall environmental sensitivity is shown in Figure 12-1.

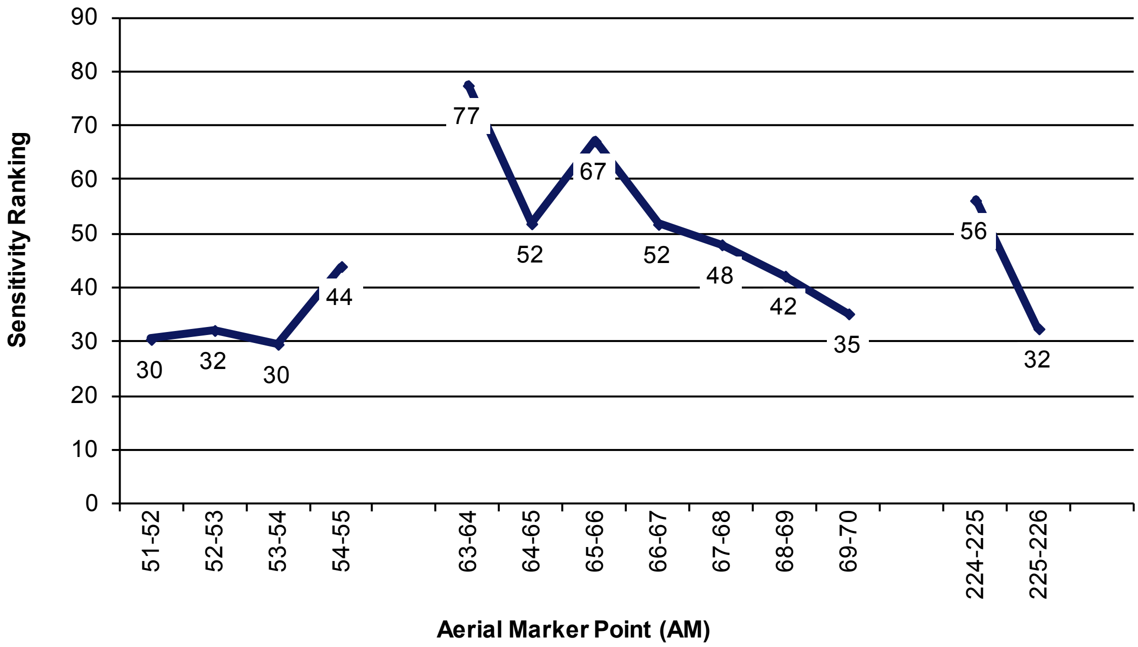


Figure 12-1: Overall Environmental Sensitivity

Highest overall environmental sensitivity is calculated for RR-001, with normalised sensitivity for the six kilometre sections ranging from 35 (AM 69-70) to 77 (AM 63-64). A summary of the highest overall environmental sensitivity for RP-001a, RR-001 and RR-004a is provided in Table 12-5.

Table 12-5: Locations with Highest Overall Environmental Sensitivity

Section	AM	Overall Environmental Sensitivity Score	Key Sensitivity Drivers
RP-001a	54-55	44	High surface water sensitivity (un-named gully at AM54+610, seasonal flow), high ecological sensitivity (GRL listed species within pipeline corridor)
RR-001	63-64	77	Medium groundwater sensitivity (aQ4), crosses R. Jokhtaniskhevi, close proximity to Gldani settlement and Tbilisi National Park (TNP)
RR-001	65-66	67	High surface water sensitivity (R. Jachviskhevi crossing), high human sensitivity (350m down-slope to houses), high ecological sensitivity (proximity to TNP), high land use sensitivity (land at KP2.0 of RR-001 fenced and being used for fruit crops and pasture)
RR-001	64-65	52	High human sensitivity (350m down-slope to houses, high ecological sensitivity (proximity to TNP), high land use sensitivity (land at KP2.0 of RR-001 fenced and being used for fruit crops and pasture)
RR-001	66-67	52	High surface water sensitivity (Gorge 6), high human sensitivity (875m to Zahesi settlement cemetery), high ecological sensitivity (proximity to TNP)

Section	AM	Overall Environmental Sensitivity Score	Key Sensitivity Drivers
RR-004a	224-225	56	High surface water sensitivity (head of stream), high human sensitivity (550m from nearest house), ecological sensitivity (arable & pasture land of limited value), high land use sensitivity (cultivated land plots)

Key factors driving environmental sensitivity are the presence of sensitive groundwater aquifers and rivers, and nearby communities which use these as a resource. A graphical summary of sensitivity scores for groundwater, surface water and humans is presented in Figure 12-2.

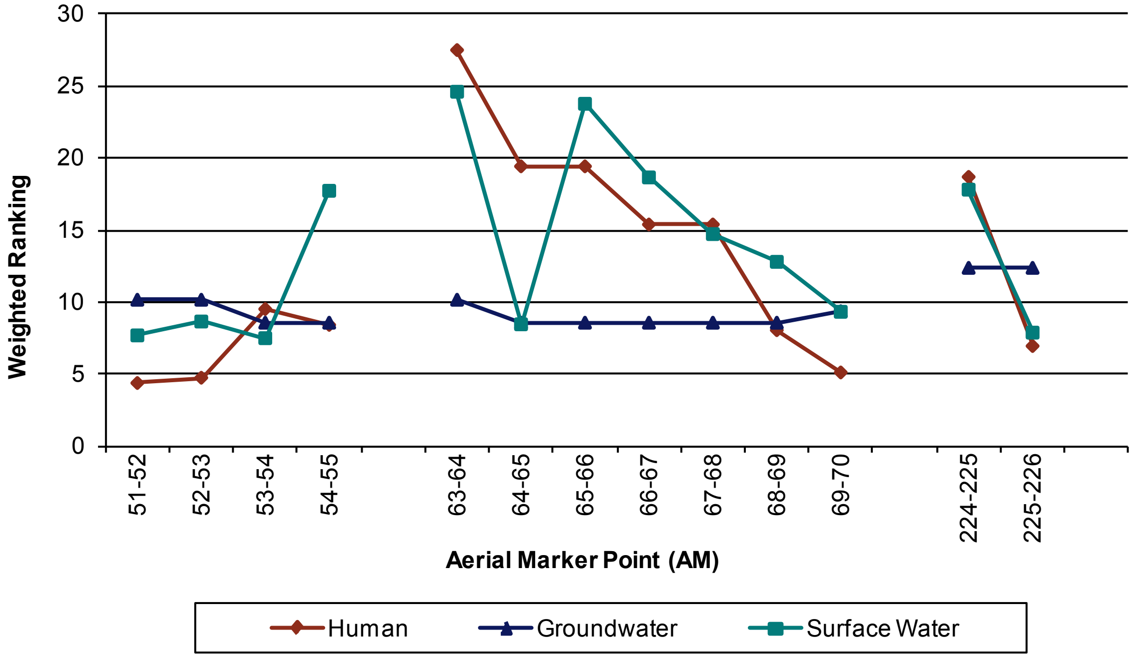


Figure 12-2: Key Environmental Sensitivity Drivers

Environmental consequence

Environmental consequence (Figure 12-4) was calculated from the product of overall environmental sensitivity (Figure 12-1) and potential worst case oil spill volumes (see Figure 12-3), which were correlated with RP and RR pipeline sections. Potential oil spill volumes for RR-004a were taken as the worst case total pipeline length volume (110 m^3).

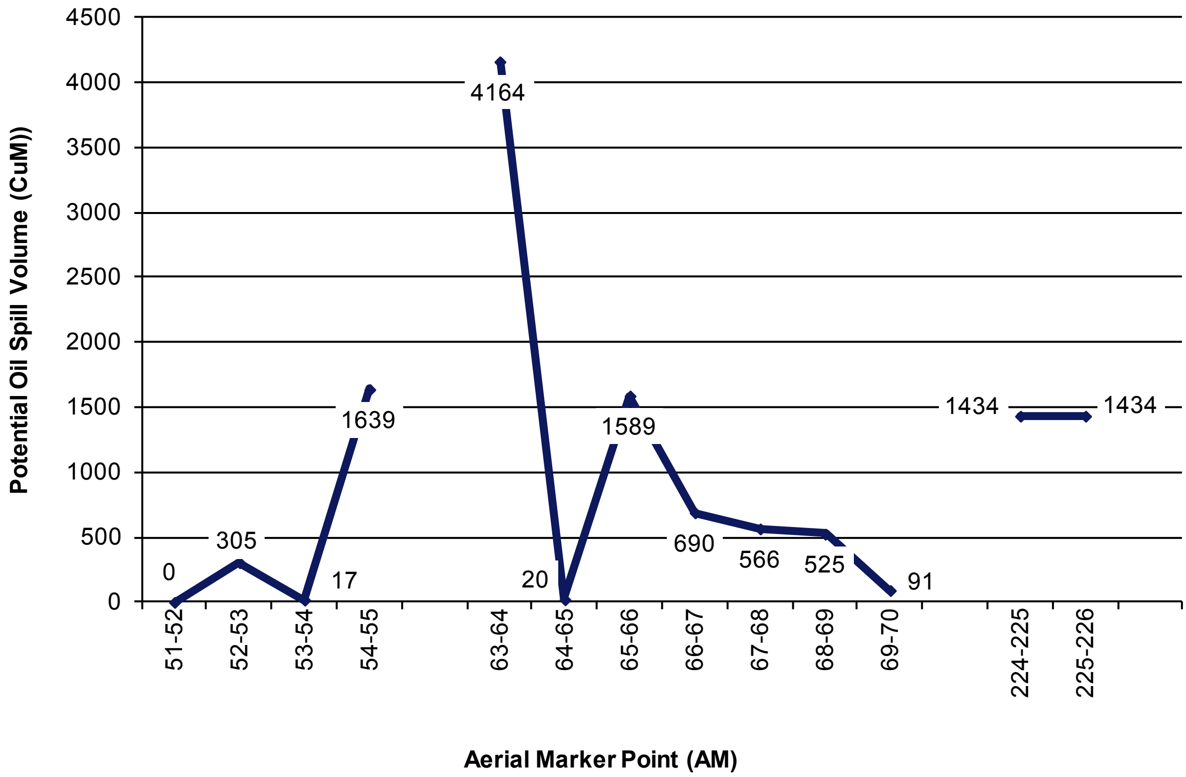


Figure 12-3: Potential (Worst Case) Oil Spill Volumes During Pipeline De-Oiling

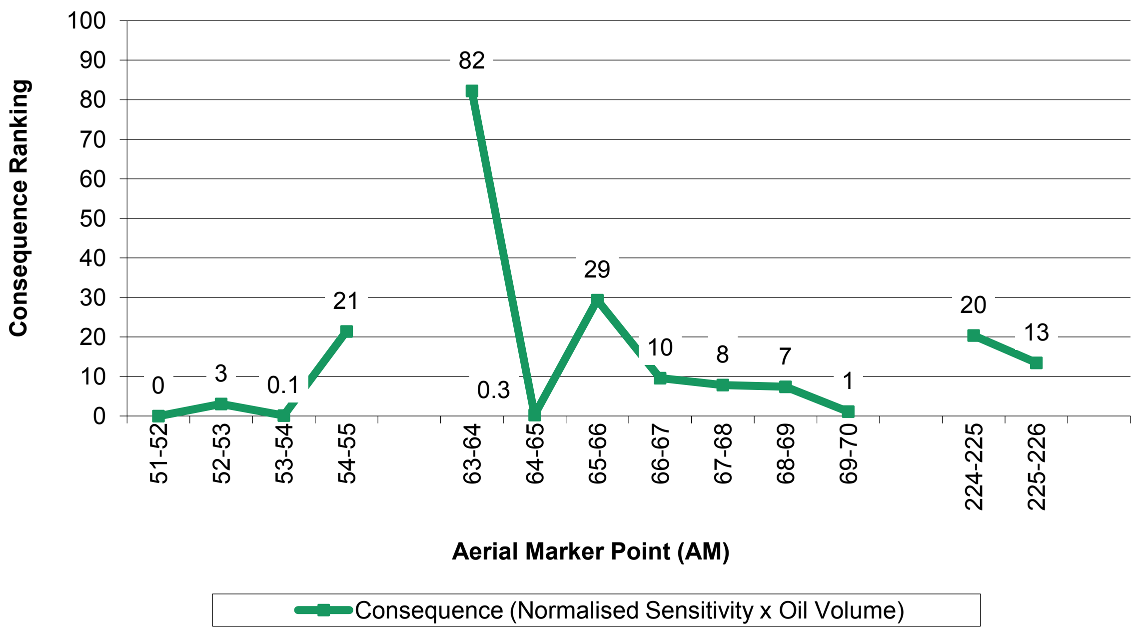


Figure 12-4: Environmental Consequence for Pipeline De-Oiling

The top locations for environmental consequence within RP-001a, RR-001 and RR-004a are shown in Table 12-6.

Table 12-6: Locations with Highest Environmental Consequence

RP/RR Location	AM	Consequence Score	Location
RR-001	63–64	82	Jokhtaniskhevi (ephemeral water course)
RP-001a	54-55	21	Gully 3 (possible ephemeral water course)
RR-004a	224-225	20	Close to start of ephemeral stream

The environmental consequence for location summarised in Table 12-6 relates principally to the presence of ephemeral surface water features.

Pipeline failure probability and environmental risk

The Project has evaluated the probability of seam weld failure of the Soviet-era pipeline during de-oiling planned operations per kilometre of pipeline. This is only relevant for Sections RR-001 and RR-001a as RR-004a and the Supsa crossings contain no Soviet-era pipe.

Overall environmental risk associated with each kilometre section of Soviet-era pipeline was calculated as the product of the average case failure probability and calculated environmental consequence.

For Soviet-era pipeline sections with no weld failure data and for all other non-Soviet era pipeline sections, the following failure probability data derived from reported oil releases between 1971 and 2009 (CONCAWE) were used (sum of) in calculations:

- Third party interference – 1.19 E-4 /year/km
- Corrosion – 7.69 E-5 /year/km
- Operational – 1.08 E-5 /year/k
- Mechanical defects – 5.52 E-5 /year/km.

Overall environmental risk (normalised) is presented for each kilometre of pipeline in Figure 12-3. Environmental sensitivity and consequence are also shown for comparison.

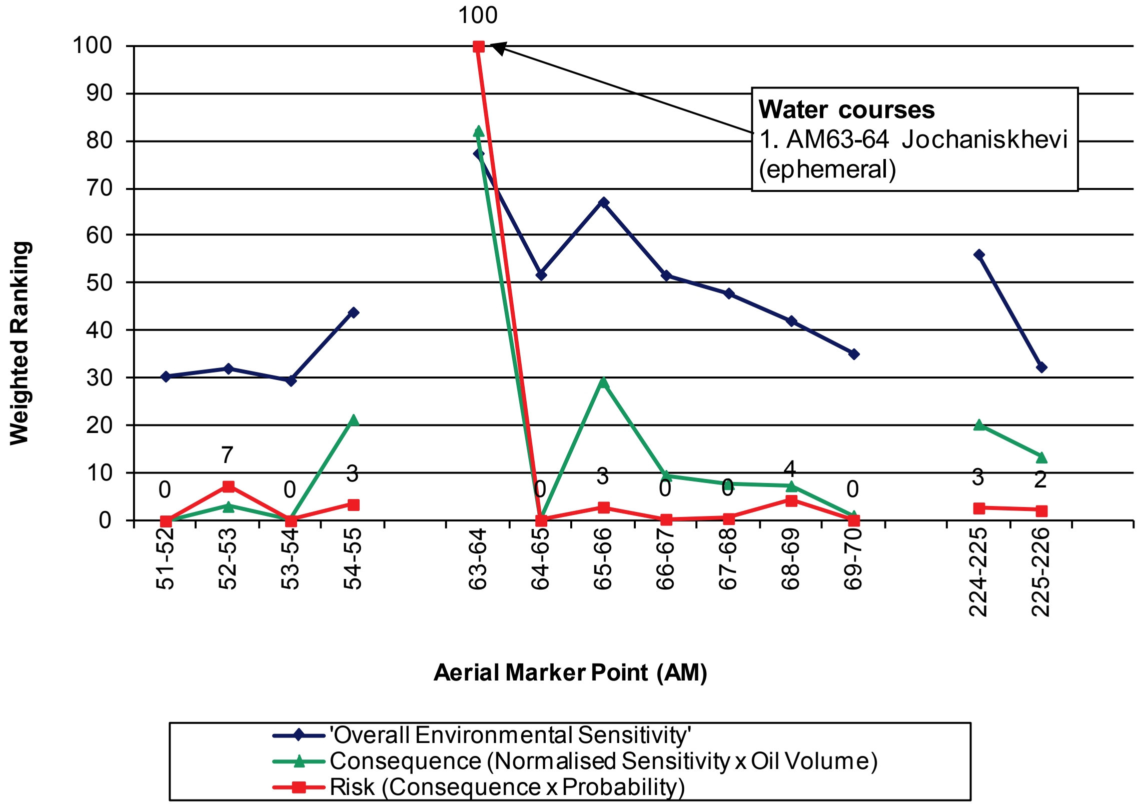


Figure 12-3: Environmental Risk for Pipeline De-Oiling

From this assessment the R Jokhtaniskhevi crossing at AM63-64 is shown to have the highest risk during de-oiling procedures due to a combination of high environmental sensitivity, oil volume and failure probability. It is noted that the R Jokhtaniskhevi is ephemeral, running only during time of melt water run-off or flash flood. During times when the river is dry the environmental sensitivity, and hence risk, is significantly lower. The same applies to all ephemeral water courses. This assessment highlights the importance of undertaking de-oiling activities during dry seasons where the likelihood for dry water courses over the full period of de-oiling is high.

Emergency response provision should prioritise this location for deployment of the oil spill response contractor during the de-oiling process.

Environmental Risk during De-oiling Oil Transfer

Tie-in locations for RP-001a, RR-001 and RR-004a are shown in Table 12-3. At up-stream tie-in locations, a stopple (see Section 5.5.3), will be inserted into the pipeline using highly controlled, standard engineering methodology. The oil volume of oil in the stopples and the likelihood for leakage of oil from these locations is very low.

The upstream tie-in site for RP-001a is located in an area of lowest environmental sensitivity (Figure 12-1) and the environmental risk associated with de-oiling related activities is low. In contrast, the upstream tie-in site for RR-001 is located in an area of higher environmental sensitivity (Figure 12-1) and the environmental risk associated with de-oiling related activities is therefore potentially high. However, due to the low volumes of oil involved, the environmental risk associated with construction of the stopple and associated works is low. Risks are further reduced if the works are undertaken during dry periods when there are no flows in the ephemeral R Jokhtaniskhevi.

At the downstream tie-in locations, oil will be transferred from the isolated pipe to the downstream (live) pipeline. Whilst the total volumes of oil to be transferred are relatively high (221 m^3 per linear kilometre), the oil is to be transferred via bunded temporary break tanks with a total volume of between 40m^3 - 60m^3 (using 2 to 3 break tanks at each site). The controlled nature and low volumes of oil being transferred at any one time are highly unlikely to result in the spillage of significant volumes of oil.

The oil transfer sites for RR-001 and RR-004a are located in areas of relatively low environmental sensitivity, but for RP-001a it is in a section (AM54-55) with higher sensitivity. Environmental sensitivity at AM54-55 is associated with an un-named gully (ephemeral with seasonal flows) at AM54+610, which is located 445m up topographic gradient from the oil transfer point (AM55+55). Environmental risk associated with a potential worst case oil transfer spill is relatively low, although undertaking the works during dry periods when there are no flows in the gully will further reduces the risks.

12.3 Potential Impacts of Oil Spills

Oil will spread once it has been released to the environment, particularly if it reaches a watercourse or groundwater. A large proportion of the lighter fractions of the oil will evaporate and some of the residual hydrocarbons will become attached to soil particles or pool at the surface. A proportion of the oil may penetrate to deeper layers of permeable soils, particularly gravels.

12.3.1 Impacts on Land and Biological Receptors

The susceptibility of organisms to oil depends on a wide range of factors, including:

- Their ability to resist contamination (physically, or by possessing the ability to metabolise contaminants)
- The degree to which they are stressed by natural factors (their physical environment and biological competition)
- Their breeding condition
- Their ability to move away from impacted areas.

The time that it takes for an oil-damaged habitat to recover varies considerably and depends on the severity and duration of the disturbance and the reproduction potential of individual species.

Survival and reproduction of plants are affected by oil, largely through a disruption of cellular biochemistry and physiology, cell membrane damage and cell leaking. These responses are accompanied by reduced biochemical performance, reduced photosynthesis, increased respiration rates and reduced translocation of materials, due in part to blocked stoma and intercellular spaces. Thinner oil fractions penetrate the stoma, disrupting cellular activity, while heavier fractions block out the light needed for photosynthesis.

After the initial effects on vegetation, oil may break down and act as a fertiliser. This is particularly significant for vegetation on nutrient-poor soils. Nutrients released as oil degrades may give some species a competitive advantage and thus alter the community composition. The stimulation may also be indirect resulting from favourable bacteria, changing soil condition or, as suggested by Baker (1971), due to suppression of flowering and seed formation making more nutrients available for shoot and leaf production.

In addition, there is the possibility that more toxic substances may be produced on release of crude oil to the environment, especially if it has been stored for long periods.

Meadows

Heavy oiling, e.g. with pools of oil in depressions, can kill meadow plants, particularly if they have shallow-root systems that tend to be concentrated in the top 200mm of soil. Deep-rooted perennials such as *Tamarix* (which has recorded rooting depths of up to 20m) are less likely to be affected by surface oiling. There could be serious effects on ephemeral species according to the time of year. Summer oiling is likely to kill plants before seeds are set, which will affect the following year's production. Oiling of seeds in late winter and early spring can reduce germination.

Forest and trees

Severe oiling with heavy penetration of the soil can kill trees by affecting the root systems. A more commonly reported effect is temporary stress (as evidenced by leaf drop) followed by recovery within a year. If the soil is very wet or flooded, tree root systems are less likely to be affected as the oil will not mix with the water.

Woodland receptors along the sections of pipe that form the WREP-SR Project include several forest fragments and, more importantly, the Saguramo SPZ of Tbilisi National Park. The ground flora in woodland will be affected in the same manner as meadow plants. However, plants that are propagated by bulbs, corms or rhizomes are less likely to be affected if oiling occurs while they are dormant. The most significant risk to this group of plants is that the bulbs, corms or rhizomes may be removed from the area during clean-up.

Wetlands

Wetlands are often dominated by robust, productive perennial plants with substantial underground root systems (Westlake, 1982). These underground systems, with their food reserves and protected buds, provide some potential for recovery from surface damage, including oil spill damage. There is an annual cycle of winter dieback, rapid growth from subterranean buds in the spring and transfer of nutrients to underground reserves in the autumn. This has a bearing on plant performance following damage to emergent shoots from oil pollution and cleanup. Regrowth from secondary buds is quick after cutting during the period of rapid growth (in spring and early summer). However, after the emergence period, cut shoots are not (or hardly) replaced and with part of the growing season lost, the crop is reduced the following year.

Wetland characteristics depend particularly on the water regime, which is subject to seasonal variations. Water regime characteristics at the time of a spill can profoundly affect the distribution of oil within a wetland, with large areas at risk during times of flood. Conversely, when water is draining down through the substratum, relatively small areas may be affected but with enhanced penetration of the substratum. This in turn may lead to longer residence times and difficult cleanup problems.

Rivers

Within rivers, free-floating plants are particularly vulnerable to oil because they live at the air–water interface, which is where most spilled oil is initially distributed and because they have no protected underground reserves from which regeneration could take place. Marginal vegetation that is oiled during a period of flood is particularly susceptible to damage if the flood rapidly subsides, allowing oil to penetrate the bank sediments and thereby contact the root systems. Small plants with shallow root systems (typically annuals, are likely to be most vulnerable. In contrast, robust emergent perennials are able to recover quickly provided they are not completely removed from the watercourses during clean-up.

Channels and ditches

Various channels and ditches are crossed by the pipeline. Generally, they have marginal vegetation that is dominated by *Phragmites* and *Typha* species of reed. As mentioned above, these plants recover well from oiling although there may be diminished productivity or species diversity, particular if oiling is a regular occurrence.

Agricultural land

It is likely that the same problems would arise with cultivated species as have been recorded for natural plant communities. These are likely to include reduction of germination for oiled seeds, relatively high mortalities for annual species, and greater tolerance of deep-rooted perennial species. Bioremediation involving addition of fertiliser and ploughing (to stimulate bacterial breakdown of oil in the soil) is likely to be a particularly appropriate remediation technique.

Developed land

Any spillage in residential and industrial areas and in parks and open spaces will require specialist cleaning methods but would be unlikely to have any significant adverse effects on ecological interests.

Fauna

The main direct effect on fauna would be coating with oil either through immersion in oil in the water or soil or brushing against oiled vegetation, burrows etc. This would affect the insulating efficiency of feathers/fur leading to hypothermia and possible death. Bird and insect flight could also be inhibited. Respiration of invertebrates could be affected through a surface coating of oil.

Owing to the toxic effects of the oil on unhatched embryos and susceptible juveniles, breeding success of individuals may be affected. The significance of this for the population would depend upon the proportion of the population affected and the severity of the effect in terms of stage of the breeding season and level of toxicity.

Oil may be ingested through the cleaning of oiled plumage and fur, water intake and oiled food items. This may have a direct toxic effect on the animal. A further effect may be on higher levels of the food chain by the removal or reduction in availability of a food source – plants, invertebrates, fish and vertebrates.

12.3.2 Impacts on Surface Waters

Contamination of water resources may directly affect water used for drinking or irrigation because of the dissolved toxic components of oil in the water. Small concentrations of oil in water may result in tainting of the water or, if the spill is on land, of agricultural produce.

Dissolved oil components in river water may have acute toxic effects on fish and invertebrates, and the adsorption of oil onto sediments may cause chronic effects over a longer period of time due to a slow but continuous release.

Oiling of water surfaces (of rivers, canals, lakes, ponds and ditches) can also affect birds, not only in terms of toxic ingestion, but also in terms of oiling of their feathers, particularly in diving species.

Any release of inventory close to flowing rivers or channels will be distributed downstream and, in the absence of spill response measures, may reach as far as the Mtkvari or Aragvi rivers or the Tbilisi reservoir. Potential receptors include those water bodies themselves, and sensitive downstream and communities.

The severity of the impact of an oil spill into any of the watercourses crossed by the new sections of the WREP will be determined by the release rate, release volume and the water flow in the river at the time of the spill. As noted in Section 7.5, the flow regime of some of these rivers is highly seasonal. If an oil spill were to happen at a time of low, or even no, flow in a river, then the spreading potential is much reduced. However, this depends on the clean-up of oil before new periods of rainfall or snow melt, in which case oil may be released from the riverbed. It must be noted that an oil spill into a dry riverbed will almost certainly lead to some level of groundwater pollution. The hydraulic conductivity of the bed materials is generally high and these materials often provide preferential migration pathways to the aquifer. In all cases, the spreading will occur at the spill location and downstream in the watercourse or canal. At times of high flow the oil will be rapidly dispersed downstream and the toxic components of the spill will be diluted, but it will affect a larger area than if the spill occurred at a time of low or no flow.

When oil is spilt onto the surface of any water body, it undergoes a number of changes as it weathers; some of these will enhance its natural dissipation, while others cause the oil to persist. Therefore, the fate and effects of any particular type of oil, as well as the clean-up requirements, will depend primarily on the combined physical and chemical properties of its components.

Other factors such as the amount of oil spilled, location, weather and water conditions, and the time of year will also all have a major influence on the fate and effects of the oil spill. For these reasons, no two spills are likely to be the same in terms of their impact or clean-up requirements.

Some freshly spilled oils may contain a high proportion of toxic hydrocarbons such as aromatic compounds. However, although these components are among the most soluble in water, they are also those that are lost most rapidly by evaporation. Lethal concentrations of toxic components leading to fish, invertebrate and plant mortalities will therefore be rare in turbulent waters and more common in calm waters, where they will be highly localised and short lived.

The key factors that affect the fate of spilled oil are:

- Biodegradation
- Spreading
- Evaporation
- Natural dispersion
- Dissolution
- Formation of water-in-oil emulsions
- Sedimentation
- Various oxidation processes.

In times of high flow, any oil entering a watercourse will be dispersed rapidly over a wide area. Large numbers of organisms may therefore be exposed to fairly low concentrations of oil that are broken down quickly.

In times of low flow, oil entering a watercourse will tend to be more concentrated at the surface, but distributed throughout the water column. In this case, it will have a more significant effect on local fish populations as the oil persists for longer in one location.

12.3.3 Impacts on Groundwater

Following a spill, oil will tend to penetrate porous sub-soils. There it will move downwards under the influence of gravity and capillary action. The amount of oil retained in soil at saturation is normally between $5l/m^3$ and $40l/m^3$, depending upon soil porosity and physiochemical characteristics.

The rate of penetration depends on the type of oil (principally its viscosity), the type of soil and the soil's saturation with water. Low-viscosity oil and coarse gravel provide the combination with the fastest penetration rate. In practice, highly viscous oils, such as some crude oils, do not penetrate to a significant extent.

In the event of an oil spill onto land, several migration pathways exist.

- On impermeable soils, oil will flow down-slope over the surface and may form a pool or enter a ditch, drain or other watercourse
- On permeable soils, migration of oil into the subsurface can be divided into three stages:
    - Seepage through the unsaturated zone
    - Spreading over the water table
    - Stability within the water capillary zone.

The Caspian crude oils that are transported in the WREP are light, with a high proportion of volatile organic fractions. The crude oil is stabilised and thermally treated before it is injected into the pipeline. It is anticipated that virtually all significant losses will be initiated at least one metre below the ground surface (though a major pipe failure may be expected to affect the ground surface). A leak from a small hole, typically over a prolonged period because of difficulties in detection (such as failure), may therefore cause subsurface pollution affecting aquifers. A larger hole or rupture is likely to cause oil to be released under pressure, cratering at the surface and the spraying of oil locally that may affect water bodies and watercourses in addition to the pooling and flow of oil over the ground surface.

12.3.4 Impacts on People

In the event of an oil spill onto land, there could be a loss of livelihood or reduced income for those who farm the affected land. While this could be a severe impact for those affected, the number of people affected by any one spill is likely to be small. Oil clean-up operations may also disrupt farming operations in the short-term, but once completed, cultivation can recommence provided any depleted soil resources are replaced. In the event of a spill, farmers will be compensated for any loss of income.

A more serious situation arises if the spill is onto land that is over an aquifer. Any contamination of an aquifer that is used for potable water could affect a large number of users. In the worst case, people may have to use an alterative water source.

Users of water downstream from a spill into a watercourse will be affected if contamination reaches the section of watercourse they use. Cattle drinking the water may ingest oil, which could cause tainting of milk as well as direct toxic effects on the animals concerned. Contaminated water would be unsuitable for irrigation; if used, there could be consequential contamination of the irrigated land and its crops. Contaminated water would be unsuitable for washing.

Remediation activities can potentially have an impact upon natural and man-made structures where heavy plant and pressure hoses are used; however, this would be mitigated during design and planning.

12.3.5 Impact Summary and Assessment of Significance

Table 12-7 provides an assessment of the significance of impacts on environmental and social receptors before and after implementation of the proposed operational controls which are discussed in the following section.

Table 12-7: Impact Assessment for Non-Routine Events

Issue		Receptor	Potential Impacts	Potential Impact Significance	Operational Controls	Residual Impact Significance
42	Spill of crude oil during de-oiling	Soil	Soil contamination	C5 High	See Section 12.6	C3 Medium
		Groundwater	Groundwater contamination	D5 High		D3 Medium
		Surface water	Surface water contamination	D5 High		D3 Medium
		Ecology	Habitat and species loss	B4 Medium		B3 Low
			Impaired breeding			
		Community health	Risk of illnesses through accidental ingestion of materials or via skin contact	D2 Medium		D1 Low

12.4 Operational Controls

12.4.1 Project Control Measures

A suite of control measures will be implemented during de-oiling in order to reduce the risk of oil spill to as low as reasonably practicable:

- The Project will develop detailed de-oiling procedures. All activities will be precisely controlled and closely monitored
- De-oiling will be undertaken in secure sites that will be manned
- De-oiling pressures in the segment of WREP between PS11 and PS 15 (which contains some Soviet-era pipe) will be controlled and monitored
- Double skinned break tanks or tank bunds sized to contain 110% of volume will be used for the temporary oil storage during de-oiling
- The operational pipe and temporary works areas will be patrolled regularly.

12.4.2 Oil Spill Response Capability

Priorities

GPC has an approved OSRP, containment sites and spill clean-up resources for the WREP pipeline system.

The BP incident management system makes the best use of the facilities and resources available to deal with emergencies.

The Georgia Operations Emergency Response Plan is based on BP's Crisis Management Framework document, which sets out a management system for crisis management and emergency response and prioritises the response in the following order:

1. People: Employees, contractors, suppliers, customers and communities
2. Environment: Air, water, land, spillages and areas of sensitivity
3. Property: BP, partners, contractors, communities and third-party facilities
4. Business: Supply, production and reputation

The approach encourages the fundamental principle of emergency response philosophy: over-reaction, assessment, response and subsequent de-escalation.

All personal are required to understand their roles and responsibilities described in the oil spill response plan (OSRP) and undertake training, instruction and information necessary to ensure that personnel are competent to carry out their roles and responsibilities as outlined in the Georgia Operations Emergency Response Plan via the annual Emergency Response Exercise Programme.

Tiered response

To assure a consistent and effective response internationally recognised tiered response is adopted.

The provision of resources to combat oil spills is divided into three categories or tiers of equipment provision. This system is internationally recognised as the most pragmatic approach, avoiding excessive costs and seeking shared resources for large, infrequent events.

Tier 1 (minor spills)

Tier 1 events are defined as small local spills requiring no outside intervention and can be dealt with on site by local staff. Tier 1 spills have the potential to arise during operations such as refuelling and PIG launching and receiving routine operations

In most cases, the clean up will be effected using the oil spill response kits held at each WREP facility. Any additional oil spill equipment (if necessary) will be provided from the nearest WREP and NRC Environmental Services oil spill response equipment stockpiles (see Figure 12-4). Although notification, support from the IMT will not be required.

Tier 2 (emergency)

Tier 2 incidents are larger spills, which require additional local (regional) resources and manpower. Tier 2 spills are likely to be resulted from integrity failure of safety and protection systems and equipment, large fuel losses, or small to medium pipeline integrity failures (hole size less than 50mm).

Clean-up activities will be provided by dedicated oil spill equipment from both the nearest base and the other WREP and oil spill response contractor (SEACOR in Georgia) stockpiles. WREP has procured the necessary equipment and trained sufficient manpower resources to be able to contain and recover a tier 2 incidents

This level of response requires the IMT to mobilise additional operational in-country manpower/resources and the oil spill response contractor (Georgia). These will be sourced from the nearest oil spill equipment base and additionally from the other bases. The WREP OSR equipment stockpiles are located at:

- PS 11
- PS 13
- PS 15
- PRS 1
- PRS 2
- Supsa Terminal.

In addition, rest-of-country-based oil spill response equipment and resources could be mobilised (NRC Environmental Services).

Tier 3 (Crisis Events)

Tier 3 incidents are very large, possibly ongoing spills, which will require additional resources from outside Georgia and Azerbaijan. Such spills are very rare and would only occur through full-diameter pipe rupture or a major tanker incident such as collision with another vessel.

The clean up operation will utilise all BP Georgia operations and contractors' manpower and resources, and augmented by additional resources from BMES in Baku and/or OSRL from Southampton, UK. OSRL are the recognised tier 3 response, but BMES in Baku do have an equipment base from where resources can be drawn.

Over-react

The BP Crisis Management Framework document highlights the means of effectively over react to any emergency situation to ensure that it will be controlled as quickly and as efficiently as possible. The resources required could be escalated further or reduced at any time by the OC and operations section chief, as the situation becomes more clearly defined.

Oil spill response plan (OSRP)

The operational OSRP will be utilised together with associated emergency response plans, and containment manuals for the duration of the WREP-SR Project. In addition, results of the risk assessment (described in this section) will be used to inform a Project-specific oil spill response procedure for OSR resource deployment priorities (42.01).

The operational OSRP will be reviewed and updated as required to cover the re-routed sections of pipeline and new block valves and utilised together with associated emergency response plans and containment manuals for the duration of the WREP-SR Project (E-OP003). In accordance with Schedule 2, Part A, Clause 4 of the PCOA the revised OSRP will be submitted to GOGC (as representative of the Georgian Government) and will include:

- Sensitivity mapping of the entire pipeline route
- An environmental risk assessment
- Plans for the provision of relevant equipment and materials
- Details of the organisation required to handle oil spill response
- Plans for the treatment and disposal of contaminated materials

No significant changes to the response actions are expected to be required.

12.5 Residual Impacts

In the unlikely event of a spill, BP will ensure that the spill is contained and cleaned up as quickly as possible. They will pay compensation for any loss of crops or livelihood and make the necessary provisions in the event water supplies are affected.

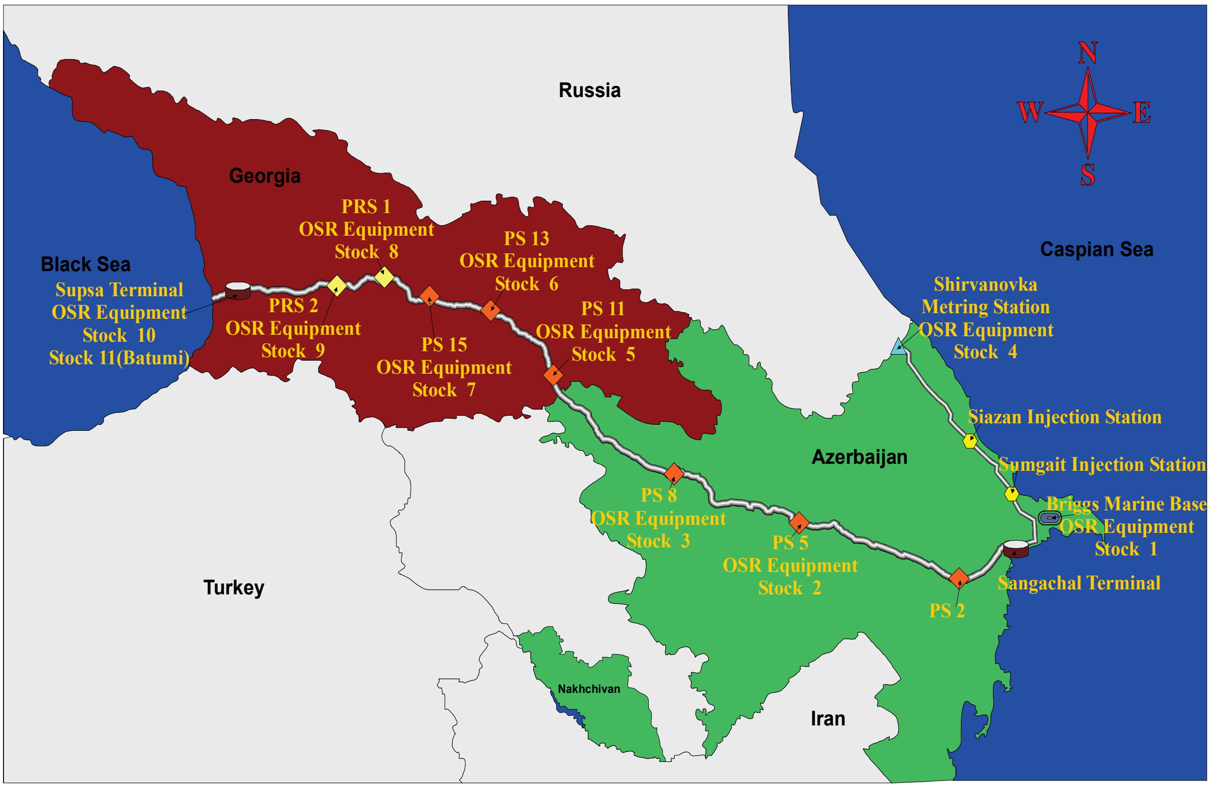


Figure 12-4: Oil Spill Response Materials and Equipment Stockpiles