BP Azerbaijan

OVERVIEW
of Environmental Monitoring Studies

1995-2017

BP Azerbaijan Overview of Environmental Monitoring Studies over the period - 1995-2017

This document presents an overview of the integrated Environmental Monitoring Studies conducted by BP Azerbaijan at ACG and SD areas in 1995-2017. This overview was published by BP, as the operator, on behalf of Azeri, Chirag and Gunashli the Azerbaijan International Operating Company (AIOC), Baku-Tbilisi-Ceyhan (BTC) and Shah Deniz/SCP (South Caucasus Pipeline) partners. The aim of the overview is to provide stakeholders and the public with an easily-accessible synopsis of the environmental monitoring work which has been undertaken and data with non-technical descriptions of the offshore contract areas Azeri-Chirag-Gunashli (ACG) and Shah Deniz (SD), around its onshore terminal (Sangachal) and along Azerbaijan oil and gas pipelines.

Acknowledgements:
BP as the operator and on behalf of ACG, BTC and SD/SCP partners would like to acknowledge with thanks the following organizations and group of experts for their contribution to the offshore, nearshore and onshore monitoring studies:

- ACG and SD Environmental Sub-Committee and the Monitoring Technical and Advisory Group
- BP AGT Region Communication and External Affairs
- BP AGT Region Regulatory Compliance and Environment Organisation
- BP AGT Region Survey & Geospatial Data Management Team
- James McNee, International Environmental Monitoring Consultant

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The overview document could also be found on the web-site: **www.bp.com/azerbaijan**

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Foreword from BP AGT regional president

For more than 27 years that we have been in Azerbaijan, BP has been committed to conducting a safe and environmentally sound business that benefits all our stakeholders and the wider society.

We safely and reliably operate giant oil and gas fields in Azerbaijan, which have contributed to the development of the Caspian Sea as a modern hydrocarbon province. The work we do in the Caspian, both in the Shah Deniz and the Azeri-Chirag-Gunashli (ACG) fields represents one of the highest levels of activity we have anywhere in the world. In addition, the Sangachal terminal and the vast network of pipelines spanning three countries are part of the infrastructure that has turned the Caspian into an important regional energy hub.

In our business we aspire to no accidents, no harm to people and no damage to the environment. Monitoring the environment in our contract areas to understand the impact of our operations, and taking the necessary actions to prevent or mitigate this impact is a major component of our strategy. It is one of the key regulatory compliance requirements reflected in the relevant governmental agreements and essential in maintaining our license to operate.

Throughout the history of our operations in Azerbaijan, BP has been using best practice approach to the environment using its internationally certified ISO 14001 Environmental Management System. Prior to execution of any new project and before development commences, a baseline environmental monitoring is conducted to provide information on ambient environment at the project location. Monitoring surveys are continued during the project and operational phases, through award-winning Environmental Monitoring Program (EMP) model established in the AGT region. Results of operational and ambient environment monitoring studies related to discharges and emissions in the contract areas are analyzed and used to continuously improve our operations.

Working in consultation with various stakeholders, including the Ministry of Environment and Natural Resources, the Academy of Sciences, SOCAR, and several NGOs, we have so far conducted more than 250 environmental monitoring surveys, both terrestrial and marine, between 1995 and 2017. These studies have provided sufficient data to achieve a good understanding of the environmental status and trends within the areas surrounding BP’s onshore and offshore operational sites.

This presented report is a result of all the environmental monitoring activity of BP in Azerbaijan over the past two decades. It is a comprehensive summary of what we have learned about the environment in the areas and communities where we operate. By publishing this overview, we aim to share this data with public. We hope and believe it can serve as a good database for anyone who wants to study the environment of Azerbaijan and the Caspian Sea.

Gary Jones

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Introduction

from BP AGT regional director, Regulatory Compliance and Environment

The aim of this overview is to provide stakeholders and the public with a basic summary of the monitoring work which has been undertaken by BP in Azerbaijan to characterise and understand changes to the marine, coastal and terrestrial environments in BP Azerbaijan contract areas between 1995 and 2017.

BP Azerbaijan, Georgia and Turkey (AGT) region has conducted environmental monitoring around its operational facilities since the commencement of exploration and production in the environmentally sensitive area of the South Caspian Sea in 1995. Production Sharing Agreements (PSAs) were signed in 1994 for the development of the Azeri-Chirag-Gunashli (ACG) field, and in 1996 for the development of the Shah Deniz (SD) field, one element common to both the PSAs is a requirement to carry out environmental monitoring.

BP and its co-venturers in the ACG and SD projects have made a significant investment in environmental monitoring and have commissioned a substantial volume of environmental monitoring work over the past 25 years. Monitoring began with the commencement of the Early Oil Project and has continued in support of the ACG Phase-1, Phase-2 and Phase-3, West Chirag, and SD Stage-1 and Stage-2 developments offshore, and the Sangachal Terminal Expansion project in the coastal environment. Environmental studies include baseline surveys, monitoring surveys, pre and post-drilling surveys, and long-term “background” trend studies.

Between 1995 and 2003, the primary purpose of monitoring was to describe the baseline environmental conditions at future operational locations. The only operational offshore location prior to 2005 was the Chirag production platform, which was constructed by the State Oil Company of the Republic of Azerbaijan (SOCAR) and was brought into full production by BP and its partners. The primary aim of the baseline monitoring was to provide information to support the development and publication of Environmental Impact Assessment (EIAs) for new developments.

In 2003, BP recognised that a more coordinated approach would be required when the new developments became operational from 2005 onwards, and the Integrated Environmental Monitoring Programme (IEMP) was designed to meet this need. The design of offshore and onshore monitoring studies was reviewed, and methods were improved and standardised to ensure that impacts and trends could be clearly identified. At the same time, a long-term monitoring schedule was established, to ensure that the necessary resources and expertise would be available.

Following BP’s change to a functional organisational structure, the Integrated Environmental Monitoring Programme was renamed the Environmental Monitoring Programme (EMP), this renaming was necessitated by the expanded scope of the environmental function which now covers all aspects of ambient and operational environmental monitoring within Azerbaijan, Georgia and Turkey.

In 2009, the AGT region EMP model was awarded the BP group exploration and production segment Health Safety Environmental Award for continuous improvement. Up to now AGT region’s environmental monitoring has been based on the ISO 14001 environmental management systems process approach and serves to implement BP Upstream Operating Management System (OMS) group essentials 3.6.1 and 3.6.2. The process flow diagram in Figure 1.1 below shows the AGT region environmental monitoring process.

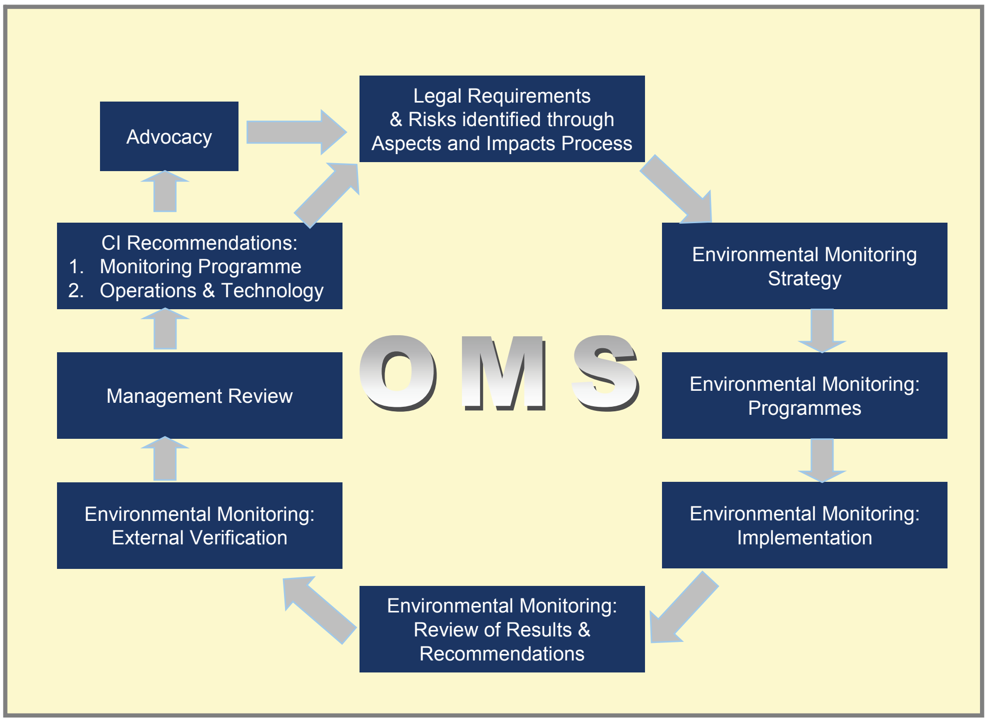

Figure 1.1 AGT region environmental monitoring process flow diagram

The period from 2004 to 2018 saw a substantial expansion in BP's activities in Azerbaijan with the addition of 7 (seven) new offshore installations. The inception of the EMP - with regular review and improvements to the monitoring studies - has delivered substantial data, resulting in a greater understanding of the interactions between our operations and the environment.

In Azerbaijan, from 2004 to the end of 2017, the EMP had completed a total of 209 ambient monitoring studies. Of the 16 surveys conducted in 2017, seven (7) were offshore marine surveys (Chirag-1, WA, DWG, SDA environmental surveys) including three BP Global Projects Organisation (GPO) related baseline surveys, and nine (9) were onshore monitoring surveys covering Sangachal Terminal (3 surveys), AZ Export Pipelines (3 surveys) and the Serenja Hazardous Waste Management Facility (three surveys).

Earlier monitoring activities, from 1995-2003, consisted of 38 studies, these were mostly baseline studies which were conducted to provide a description and assessment for the preparation of Environmental & Social Impact Assessments (ESIAs). All of these ESIAs have been made available to the public and have been the subject of public consultation.

Environmental monitoring programmes were undertaken with great support and contribution from the ACG and SD PSA Environmental Subcommittee, and the Monitoring Technical Advisory Group (formerly Research Monitoring Group) which include representatives from ACG and SD partners, Ministry of Ecology and Natural Resources of the Republic of Azerbaijan (MENR), SOCAR, Oil and Gas Research and Design Institute, and the Azerbaijan National Academy of Sciences.

Overall, the monitoring studies conducted by BP between 1995 and 2017 have provided sufficient data to achieve a good understanding of the environmental status and trends within the areas surrounding BP's onshore and offshore operational sites.

Faig Askerov

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Background

Before describing the monitoring activities and results, it is useful to briefly consider the purposes of monitoring, and the types of monitoring which are regularly carried out.

2.1. Reasons for monitoring

Monitoring is a requirement of the PSAs and is therefore a legal obligation. Since 1995, all monitoring studies specified in relevant ESIAs have been discussed with, and approved by, two national bodies before being carried out.

1. The Government environmental regulator: initially this was the State Committee on Ecology and Natural Resource Use, later replaced by the present MENR; and
2. The Research and Monitoring Group: established in compliance with PSA requirements to assist in the design and management of monitoring programmes, and consisting of representatives of government and SOCAR. The Research and Monitoring Group was the precursor to the current Monitoring Technical Advisory Group.

The PSA requirement for monitoring was based on a desire by all parties to ensure that the environmental impacts of developments were properly managed and minimised. Monitoring also ensures that any impacts which are unanticipated, or which are greater than expected, can be detected and remedied.

By delivering reliable scientific evidence on the status of the environment, monitoring provides assurance to all stakeholders that the environment is being effectively protected and that all laws are being complied with. Additionally, monitoring is a practical part of BP's environmental management system, ensuring that the correct protective/mitigating actions are taken in a timely manner.

2.2. Types of monitoring

BP's activities take place in two main ecological zones:

a) The marine environment within Sangachal Bay and the offshore contract areas.

b) The terrestrial environment around the Sangachal Terminal, the Serenja Hazardous Waste Management Facility, and the export pipeline routes.

There are three major aspects to the BP AGT region ambient environmental monitoring programme; offshore monitoring; nearshore monitoring; and onshore monitoring.

2.2.1. Marine offshore monitoring

Offshore ambient environmental monitoring is conducted at sites where potential impacts to the marine environment exist from the presence of production platforms, drilling rigs and subsea pipelines. The presence of impacts are identified and their magnitude assessed by conducting:

- **Baseline studies**: these are conducted before development is initiated to provide a general understanding of the environment and the ecology within the area, and also to identify any unusual or sensitive ecological features which might affect the design or final location of a development.
- **Regional studies**: these cover the areas outside those thought to be directly impacted by BP operations. These areas are considered to be "control" areas against which any environmental changes within the BP operational areas can be compared. These areas provide information on the general ecological health of the system and help to identify natural environmental and ecological trends and processes.
- **Ambient environmental monitoring at operational sites**: these provide an assessment of the impact of BP operations. Data from these studies are usually compared to data from the baseline and regional studies.
- **Exploration well pre and post-drilling surveys**: these are carried out before and after the drilling of single exploration wells to assess the impact of drilling discharges.

2.2.2. Marine nearshore monitoring

Nearshore ambient environmental monitoring is conducted within Sangachal Bay to monitor potential environmental changes arising from operations at Sangachal Terminal and/or the installation/presence of subsea pipelines. The presence of impacts are identified and their magnitude assessed by conducting:

- **Baseline studies**: these are conducted before development within Sangachal Bay is initiated to provide a general understanding of the environment and the ecology within the area, and also to identify any unusual or sensitive ecological features which might affect the design or final location of a development.
- **Ambient environmental monitoring:** these provide an assessment of the impact of BP operations within Sangachal Bay, such as the installation and presence of subsea pipelines, Sangachal Terminal operations, marine logistics and transportation.
- **Monitoring "control" areas**: monitoring of selected indicator species is carried out at remote control areas where environmental conditions are clean (positive control area) or contaminated (negative control area). The data is used to assess the condition of these selected indicator species within areas potentially affected by BP activities.

The field and laboratory methodology for marine and nearshore monitoring is described in detail in Section 3.

2.2.3. Onshore monitoring

Onshore ambient environmental monitoring is conducted to monitor potential impacts from operations at Sangachal Terminal, Supsa Terminal, waste management facilities and BP AGT region pipelines. The presence of impacts are identified and their magnitude assessed by conducting:

- **Baseline studies**: these provide a general understanding of the environment and the ecology at a particular location before development commences.
- **Ambient environmental monitoring at operational sites**: these provide an assessment of the impact of BP activities at operational sites, such as Sangachal Terminal, export pipelines pump stations, waste management facilities, etc.
- **Monitoring "control" areas**: monitoring of control sites effectively isolate the environment from one or more stressor, thereby allowing more rigorous and focused assessment of the effects of BP's activity on the environment.

The field methodology for onshore environmental monitoring is described in Section 6.

In addition to the regular monitoring around Sangachal Terminal, annual surveys of migrating and overwintering birds were conducted along the entire coastline from Apsheron to Astara. These surveys were not directly related to operational activities but were conducted to ensure that BP has information on the location of all nationally and internationally significant bird feeding and roosting areas.

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Offshore Ambient Environmental Monitoring

BP has been conducting environmental monitoring at offshore operational sites since 1995. Table 3.1 gives a breakdown of the monitoring survey schedule at each offshore location between 1995 and 2017.

Table 3.1 Offshore environmental survey schedule 1995 - 2017

Survey Location / Year	1995	1998	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
ACG Regional	x						X		x		x		x		x		x			
Central Azeri		x		x			X		x		x		x		x		x		x	
East Azeri					x				x		x		x		x		x		x	
West Azeri		x			x			x		x		x		x		x		x		x
Deep Water Gunashli				x						x		x		x		x		x		x
Chirag		x	x				X		x		x		x		x		x	x	x	x
West Chirag						x						x					x		x	
ACG - Sangachal Pipeline route			x						x		x		x		x		x			
SD Regional		x	x	x				x		x		x		x		x		x		
Shah Deniz Alpha				x				x		x		x		x		x		x		x
SDX-4								x			x									
SDX-5										x			x							
SDX-6											x									
SDII-WF												x							x	
Shah Deniz Bravo														x						
SDII East North Manifold														x						
SDII East South Manifold														x						
SDII West Manifold														x						
SDII West South Manifold														x						
Shafag Asiman																				x
ACE Platform																				x
SDX-8																				x

X Survey Carried Out

3.1. Offshore monitoring methodology

3.1.1.Benthic sampling

Sediment samples are collected using a double 0.1 m² Van Veen grab sampler to collect samples of 10 to 15 centimetres sediment depth from the surface of the seabed. Samples are collected for physical, chemical and macrobenthic analysis.

- Physical analysis
  - Particle-size distribution
  - total organic matter content
  - carbonate content
- Chemical analysis – hydrocarbons
  - Total petroleum hydrocarbons,
  - Unresolved complex mixture (UCM)
  - 2-6 ring PAH
  - Low molecular weight PAHs - naphthalenes, phenanthrenes, and dibenzothiophenes (NPD)
  - USEPA 16 PAH
  - If present, the quantity of HC based drilling fluid compounds.
- Chemical analysis - sediment metals
  - As, Ba(HNO_3), total Ba (by fusion), Cd, Cr, Cu, Fe, Hg, Mn, Pb, Zn
- Macrobenthic analysis
  - Taxonomy
  - Abundance
  - Biomass

3.1.2. Water sampling

Water samples for physicochemical analyses are collected using a Niskin water sampler. Temperature/depth profiles are measured using a CTD profiler.

Water samples are analysed for

- BOD & COD
- Total suspended solids (TSS)

3.1.3. Plankton sampling

Plankton samples are collected using a double bongo net system - 2 coarse-mesh nets (200µm) for zooplankton and 2 fine-mesh nets (53µm) for phytoplankton and zooplankton.

Each plankton sample is analysed for zooplankton and phytoplankton

- Taxonomy
- Abundance
- Biomass

On some surveys phytoplankton samples are also collected using Niskin water samplers. This is carried out to provide a qualitative cross-reference of the data acquired from the 53µm Bongo nets.

3.2. Azeri-Chirag-Gunashli (ACG) Contract Area

The Azeri Chirag Gunashli (ACG) Contract Area covers approximately 432km^2 and lies approximately 120km east of Baku (Figure 3.2.1). The Contract Area, which is operated by BP on behalf of the Azerbaijan International Operating Company (AIOC), has been developed in phases and to date has included:

- Early Oil Project (EOP) – Chirag-1 Platform
- ACG Phase 1- Central Azeri Platform
- ACG Phase 2 – East and West Azeri Platforms
- ACG Phase 3 – DWG platforms
- ACG FFD – West Chirag Platform

The position of operational platforms within the ACG contract Area is shown in Figure 3.2.2.

Operations at the ACG field began in November 1997 with the start-up of production from the Chirag-1 platform.

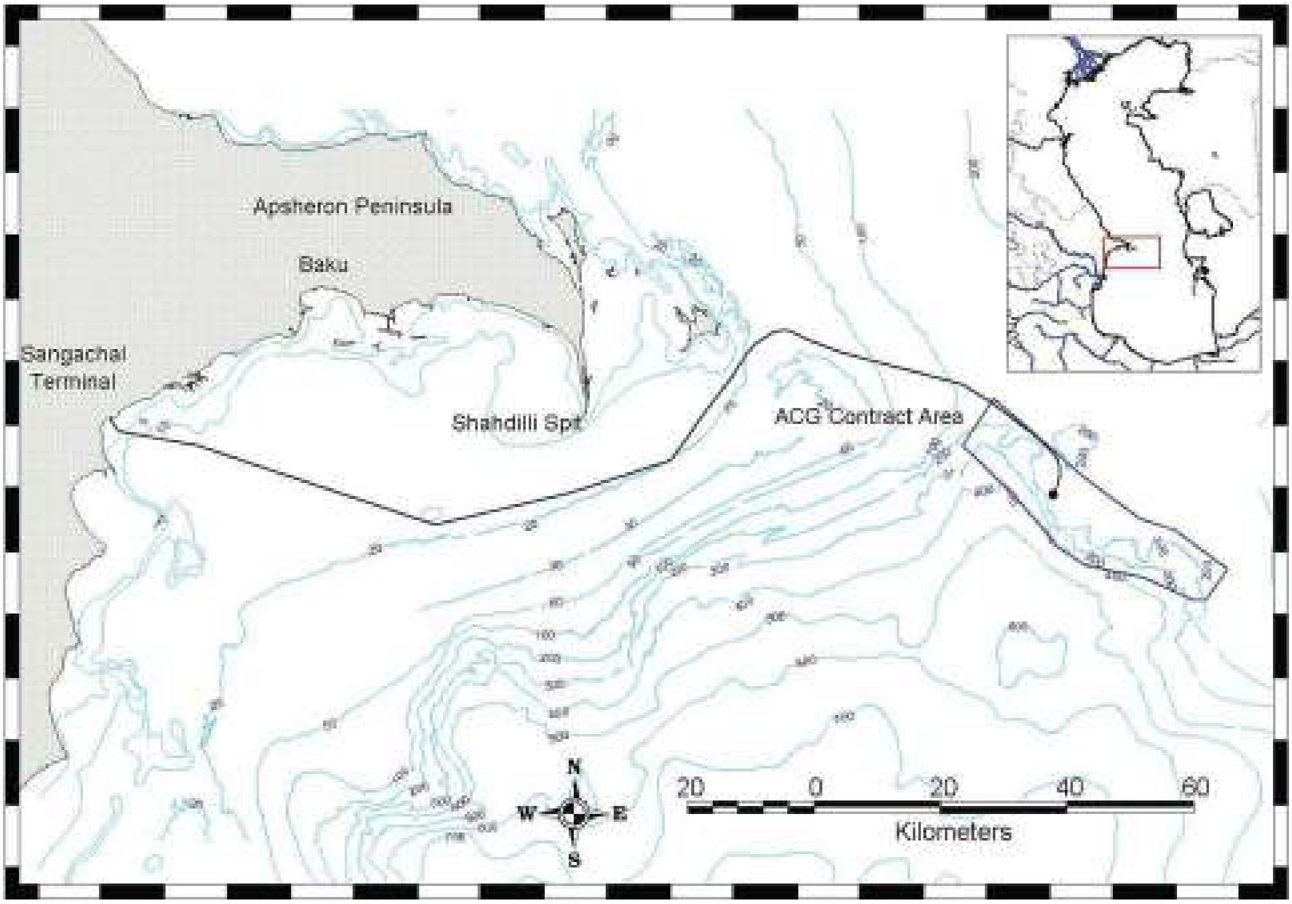


Figure 3.2.1 Location of the ACG Contract Area

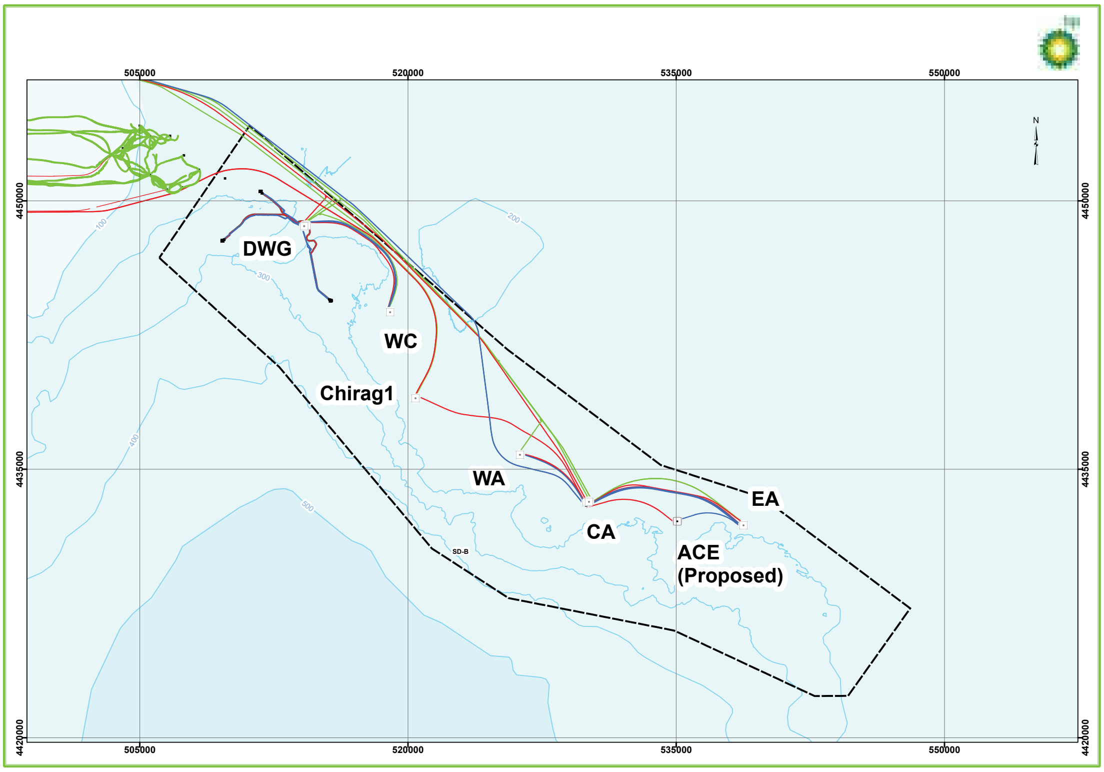


Figure 3.2.2 Platform positions within the ACG Contract Area

In 1995 a comprehensive environmental baseline study was carried out. The purpose of the study was to

- Assess the state of the environment in the area likely to be affected by AIOC's exploration and production operations
- Provide the basis for subsequent environmental impact assessment (EIA) and contingency planning
- Establish the reference (i.e. "baseline") for interpretation of data gathered during environmental monitoring of AIOC's exploration and production operations.

As part of the study an offshore survey was carried out covering the ACG contract area, the ACG – Sangachal pipeline route, and the coastal area adjacent to Sangachal Bay. As the study was designed to characterise a very large area, by necessity, the distribution of sampling points was sparse. However, the sampling and analysis scope was comprehensive and included

- Marine geology
  - Seabed geomorphology
  - Sediments
- Water column and atmosphere
  - Hydrography
  - Water chemistry
  - Air quality
- Biology
  - Macrobenthos
  - Phytoplankton
  - Zooplankton
  - Icthyoplankton
  - Microbiology
  - Fish tissue analysis

In addition, the study included coastal bird and seal surveys and provided an assessment of the coastal sensitivity to oil spills.

3.2.1. ACG Regional Survey

Regional baseline surveys were initially carried out within the ACG Contract Area in 1995 and 1996. In 2004 the survey design was updated to achieve coverage across the entire contract area and provide background data that can be used when identifying and assessing impacts at operational sites. The ACG regional surveys have been conducted biennially from 2004, the most recent survey was carried out in 2014.

The up to date survey design consists of 12 sample stations, six of which were included in the 1995 and 1996 surveys. Figure 3.2.3 gives the location of the ACG regional survey sample stations.

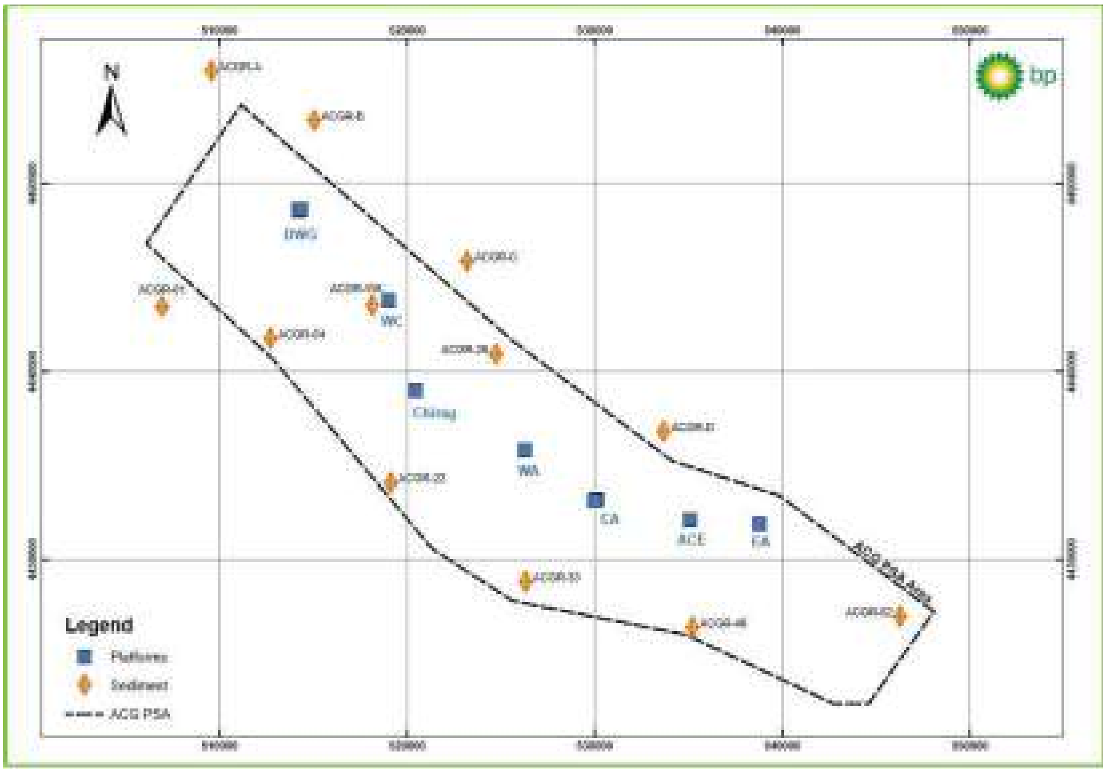


Figure 3.2.3 Location of ACG Regional benthic survey stations

The sediment characteristics recorded in 2014 were comparable to those recorded in previous surveys, with most samples being predominantly composed of silt and clay particles (Figure 3.2.4). The greatest between-survey differences have been recorded at stations within the northwestern part of the survey area (1, B, W6 & C). The variation observed at these locations is representative of sampling a patchy seabed environment, rather than real changes to the sediment structure.

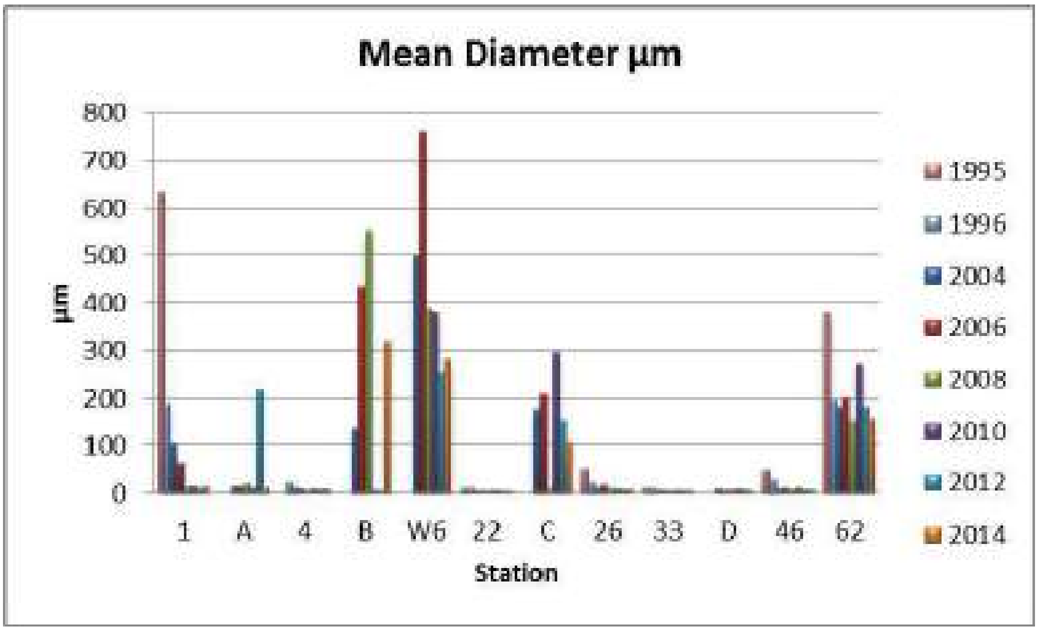


Figure 3.2.4 Station average mean particle size, ACG Regional surveys 1995 to 2014

Hydrocarbon concentrations are low at the majority of stations and have varied little over the monitoring period (Figure 3.2.5). Stations closest to the operational platforms, B, 4, W6, 26, D, 46, and 62 show no evidence of widespread impacts. An increase in hydrocarbon concentration was recorded at station 26 in 2014, but the results indicate this was due to an increase in natural compounds rather than an input from production related activities.

As was the case in previous surveys, samples from stations 22 and 33 were distinctive with higher concentrations of THC and PAH. These stations lie in deep water adjacent to and below large mud volcanoes. The very fine, high-organic content sediments sampled at these positions are likely to have originated from these natural geological features, which intermittently emit very fine clay mud, which contains varying concentrations of hydrocarbons.

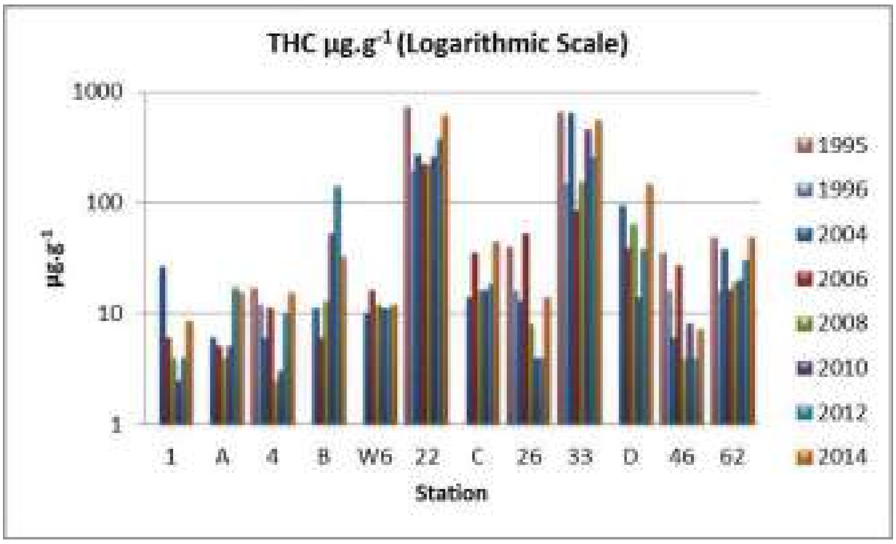


Figure 3.2.5 Station average THC concentrations (µg.g-1), ACG Regional surveys 1995 to 2014

The concentrations of metals in 2014 were consistent with the levels recorded on previous surveys. Metals concentrations are influenced by the natural physical characteristics of the sediment, with higher concentrations often associated with silt and clay. The highest levels of temporal variability have been recorded at stations B, C and W6 where sediments are composed of heterogeneous coarse grained particles and variable proportions of silt and clay.

Concentrations of barium have been consistently higher at contiguous stations W6 and C throughout the monitoring period (Figure 3.2.6). An association has been identified at these positions between Ba content and the larger particle size fractions. This is illustrated by the corresponding lower concentration of Ba and low mean particle size at station C in 2008. Ba fusion was added to the ACG Regional survey analytical scope in 2006; no data is available for pre-2006 surveys.

There is a reasonable degree of consistency in the physical and chemical data over time, indicating that at the majority of stations, ACG operations have had no observable regional impact.

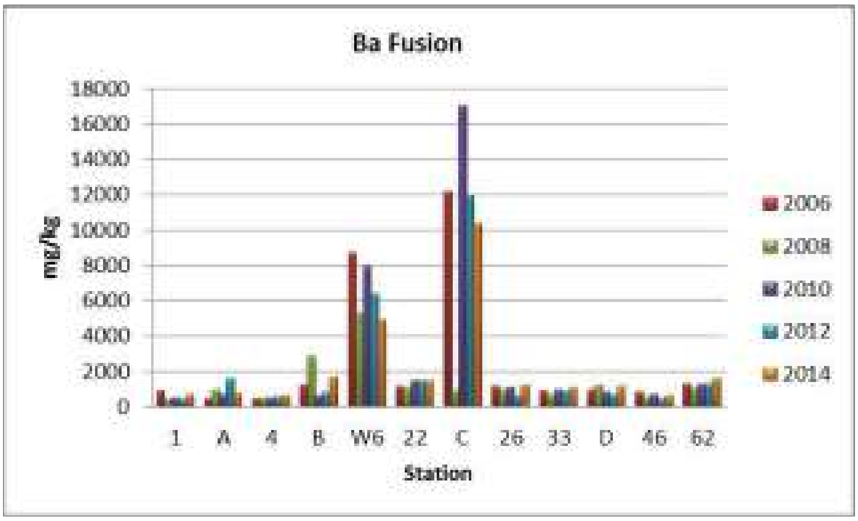


Figure 3.2.6 Station average Ba fusion concentrations (mg.kg-1), ACG Regional surveys 2006 to 2014

Regionally, the most abundant taxa in the macrobenthic community are amphipods, cumacea and oligochaetes. The composition of the communities recorded are mainly influenced by natural environmental factors such as sediment structure and water depth.

As observed in previous surveys, the highest benthic abundances in 2014 were recorded at stations A, B W6, C and 62: all located in water depths of <200m, while lower abundances and community diversity were found at stations in water depths of >350 m (4, 22, 33 and 46) (Figure 3.2.7).

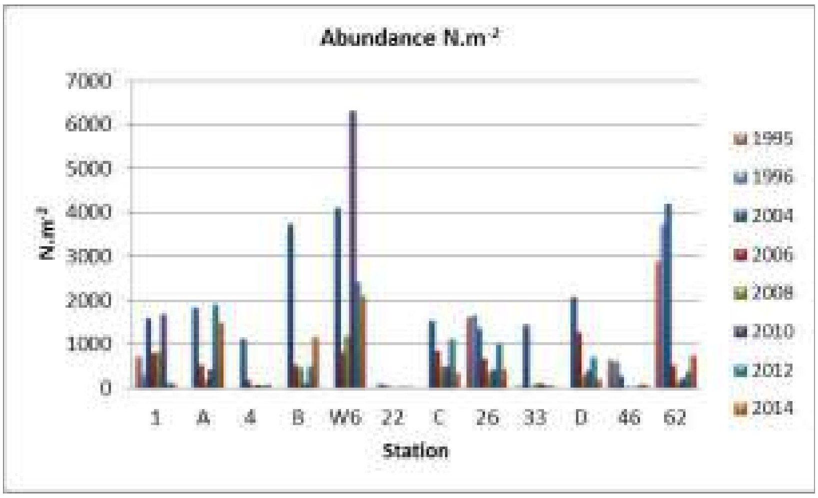


Figure 3.2.7 Macrofaunal abundance ($N.m^{-1}$), ACG Regional surveys 1995 to 2014

There is no evidence of spatial or temporal trends that could be related to operational activities at the ACG platforms, indicating that the ACG regional survey stations continue to provide background data across the ACG Contract Area.

Figure 3.2.8 gives an overview of the spatial and temporal physical, chemical and biological characteristics across the ACG survey area.

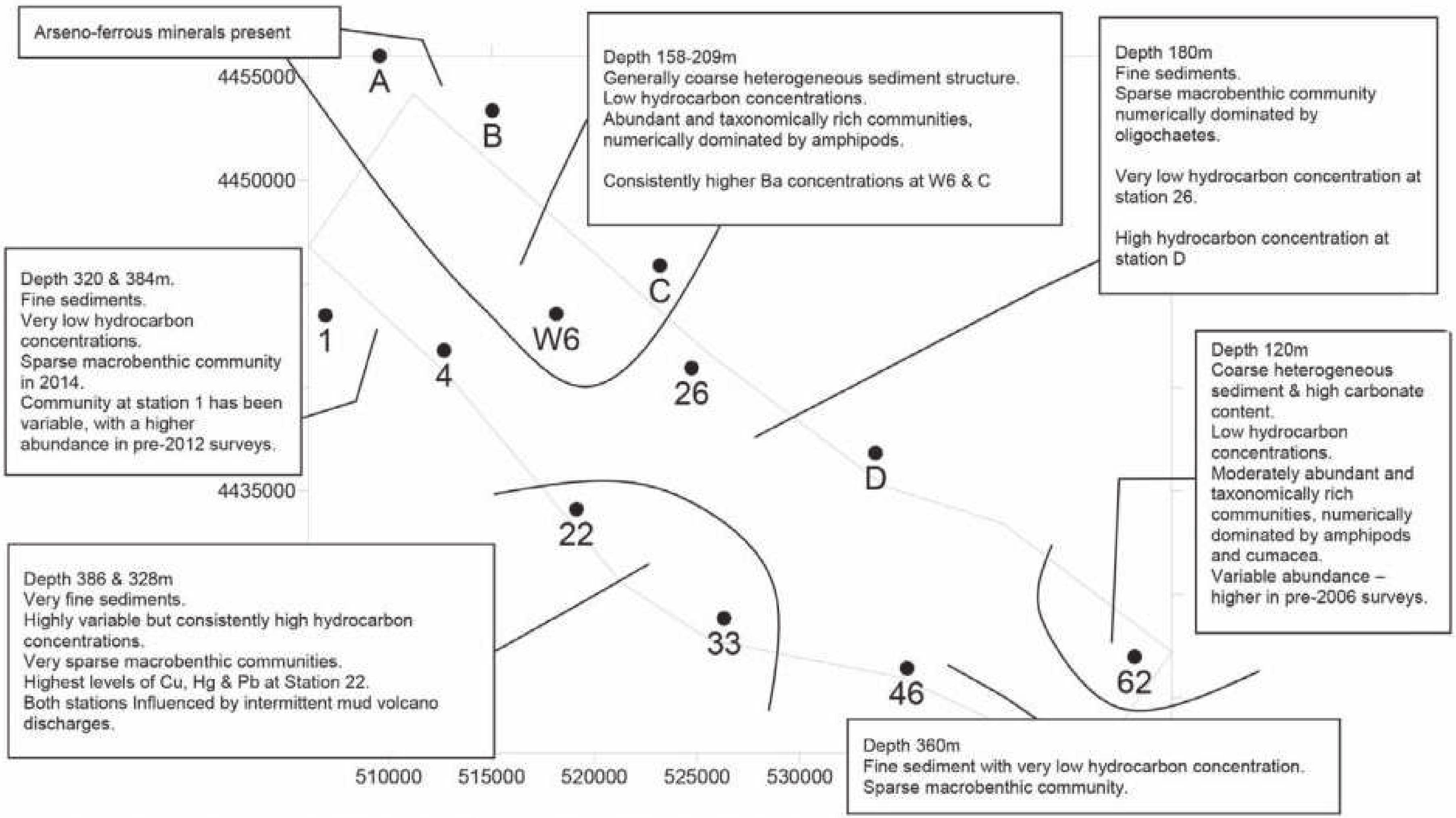


Figure 3.2.8 Key physical, chemical & biological characteristics of the ACG Regional survey area

3.2.2. Central Azeri Platform

Baseline surveys were initially carried out at Central Azeri (CA) in 1998 and 2001. In 2004, the survey design was updated from a basic cross design to a triangular grid design, and a biennial monitoring survey schedule was implemented. Figure 3.2.9 gives the Central Azeri sample station array used in the monitoring surveys from 2004 to 2016.

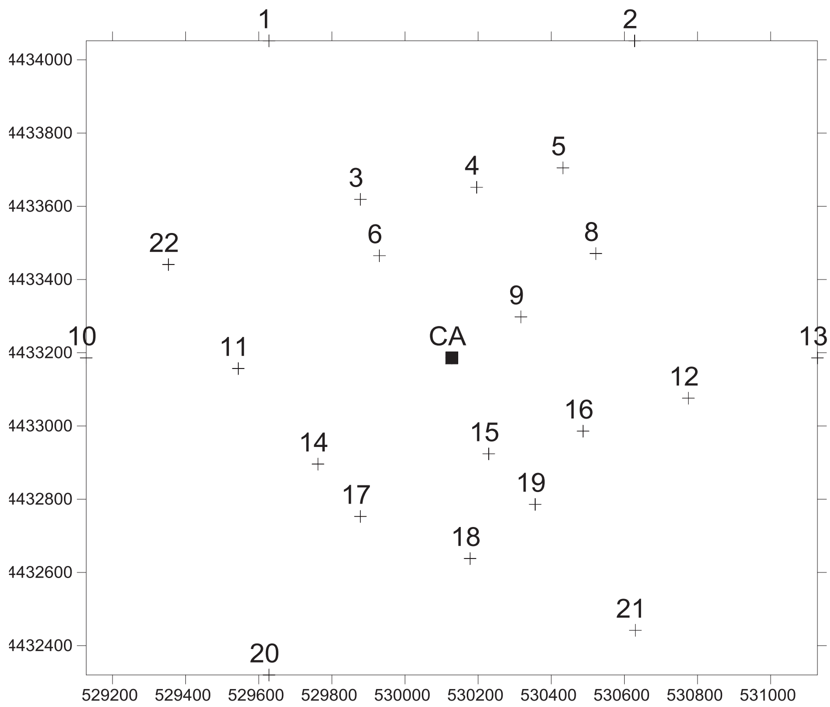


Figure 3.2.9 Central Azeri survey 2004 to 2016 sampling stations

Sediments within the Central Azeri survey area are heterogeneous and are generally characterised as being dominated by coarser grained fractions over the finer silt/clay fractions, with very low proportions of the mid-range sand fractions. In 2016 the physical composition of sediments at the majority of sample stations were very similar to previous surveys. Although some variation has been observed at individual stations over the monitoring period, the spatial distributions and overall survey wide characteristics have remained stable

Table 3.2.1 Sediment physical properties: Central Azeri surveys 1998 to 2016

	Survey Area Mean Value								
	1998	2001	2004	2006	2008	2010	2012	2014	2016
Mean diameter µm	595	625	341	396	382	457	352	332	372
Carbonate content %	67	69	58	53	61	58	55	59	63
Organic content %	2.2	1.7	2.4	2.8	2.1	2.7	2.6	2.4	1.7
Silt/Clay content %	17	16	29	28	26	27	29	27	26

Hydrocarbon concentrations were generally low throughout the survey area in 2016. The lowest THC concentrations were present in the NE and SE corners of the survey area, while the highest concentrations were present at stations in the northwest quadrant of the survey area and station 9 directly to the northeast of the platform (Figure 3.2.10). The proportions of UCM and NPD were indicative of weathered material being present throughout, with no evidence of recent inputs of THC or PAH being identified at any station.

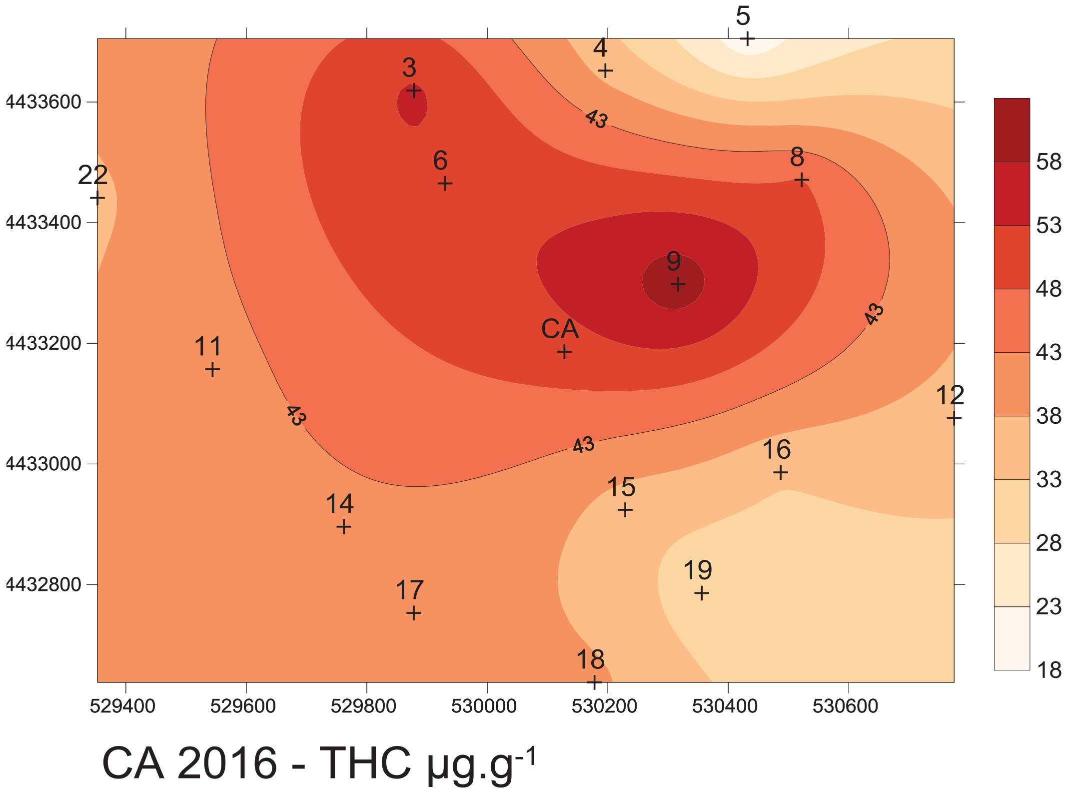


Figure 3.2.10 Spatial variation of THC concentrations (µg.g^{-1}), Central Azeri survey 2016

The higher THC concentration at station 9 in 2016 was partly due to the combined presence of low concentrations of hydrocarbon-based drilling fluids SBM & LTOBM. Signatures of these materials were detected at 8 and 4 stations respectively in 2016; the concentrations present were low or very low and are not expected to have a negative impact on the benthic communities present.

Synthetic based drilling mud (SBM) was first detected in sediments around CA in 2004 after an accidental spill which occurred in 2002. No other inputs have taken place and the SBM present has degraded and reduced in concentration on all subsequent surveys at CA.

The 1998 to 2016 survey area hydrocarbon average values are provided in Table 3.2.2. Overall the 2016 results are comparable to those recorded on previous surveys, as were the spatial distributions of all hydrocarbon parameters. Other than the presence of small concentrations of hydrocarbon-based drilling fluids, there is no evidence to suggest that operations at CA are influencing the hydrocarbon content of sediments within the survey area.

Table 3.2.2 Sediment hydrocarbon concentrations: Central Azeri surveys 1998 to 2016

	Survey Area Mean Value								
	1998	2001	2004	2006	2008	2010	2012	2014	2016
THC $\mu g.g^{-1}$	42	43	34	39	17	24	32	36	40
LTOBM $\mu g.g^{-1}$	ND	ND	ND	ND	ND	ND	ND	ND	5
SBM $\mu g.g^{-1}$	ND	ND	27	11	8	7	2	2	3
Total 2-6 ring PAH $ng.g^{-1}$	281	342	163	294	196	165	163	139	139

ND Not detected

The variability in the concentration of most metals over the survey area in 2016 was low. The concentrations present were similar or within the ranges observed on previous surveys and were unrelated to operational activates at CA (Table 3.2.3).

Table 3.2.3 Sediment metal concentrations: Central Azeri surveys 1998 to 2016

	Survey Area Mean Value $mg.kg^{-1}$								
	1998	2001	2004	2006	2008	2010	2012	2014	2016
As	NM	6.0	11.4	11.2	9.9	13.2	10.6	10.4	9.7
Ba HNO_3	2183	6956	6424	9200	6339	6780	6185	5734	6613
Ba fusion	NM	NM	9829	10651	8584	10035	10721	10598	10797
Cd	0.23	0.54	0.17	0.43	0.36	0.92	0.191	0.194	0.167
Cr	34.9	27.1	34.4	40.6	48.0	45.7	41.6	35.1	41.3
Cu	24.7	18.0	19.1	21.3	22.9	22.5	22.5	21.1	16.9
Fe	19104	14471	19229	25698	27026	24944	23543	21680	20505
Hg	0.050	0.030	0.130	0.036	0.031	0.057	0.028	0.032	0.010
Mn	NM	NM	NM	384	411	413	413	380	374
Pb	30.0	18.8	16.0	16.9	19.3	14.6	13.5	13.0	10.8
Zn	59.7	39.6	50.8	49.6	61.9	56.3	60.3	53.3	49.6

NM Not Measured

Water based drilling muds (containing large quantities of barium sulphate which is used as a weighting agent to ensure well stability during drilling) have been discharged to the seabed around the platform between 2002 and 2016. These discharges have led to increased barium concentrations in sediments close to the platform (within 500m).

Although the area of elevated Ba concentrations remains present, the range, mean, and variability of total Ba concentrations at stations within 500m are slightly lower in 2016 than those reported in 2010 to 2014 (Figure 3.2.11).

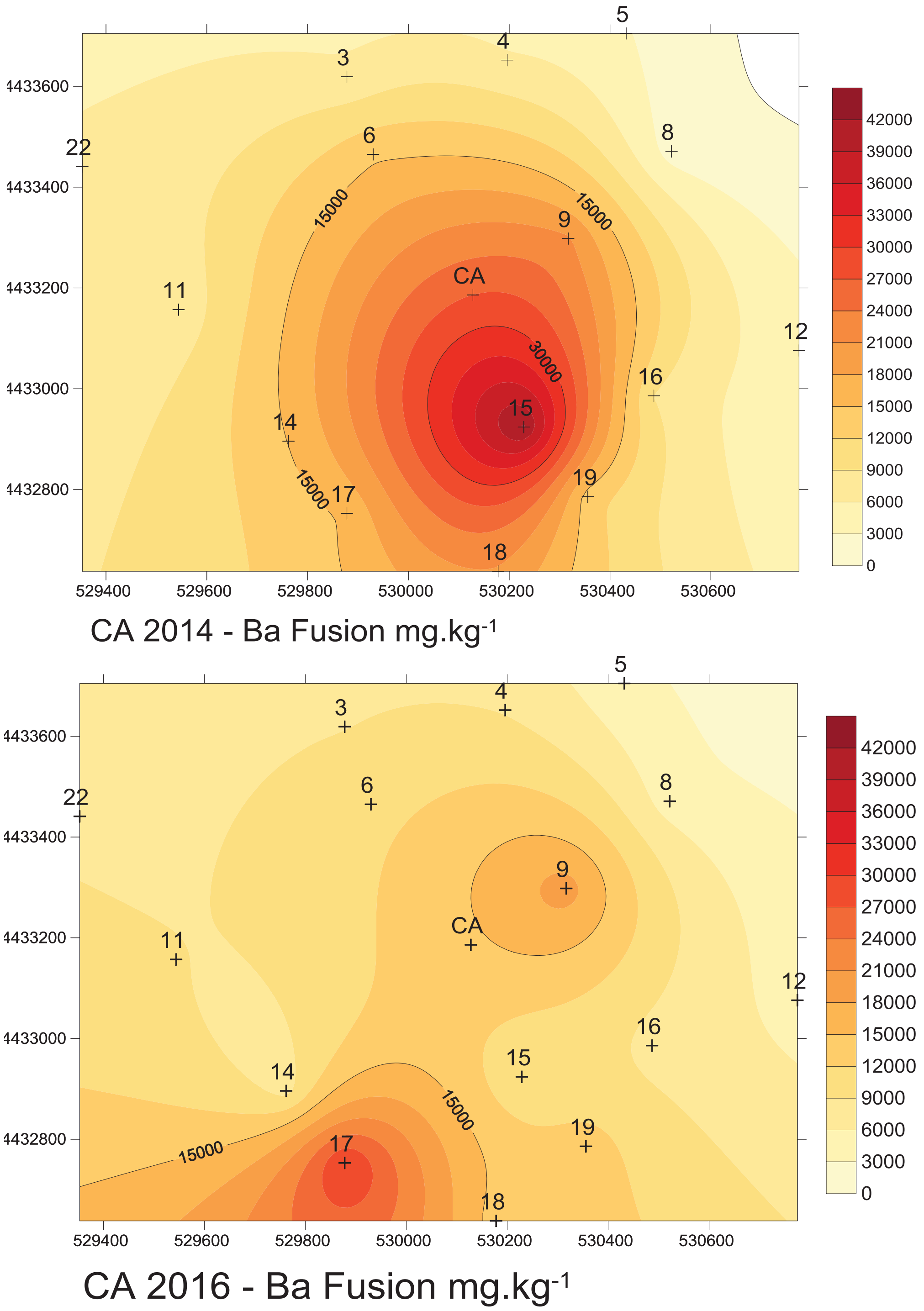


Figure 3.2.11 Spatial variation of Ba fusion concentrations (mg.kg-1), Central Azeri survey 2014 & 2016

Macrofaunal abundance and species richness were generally high throughout the CA survey area in 2016. As observed on previous years, the macrofaunal community was numerically dominated by amphipod crustaceans and the community structure was related to sediment physical properties; more abundant and species rich communities were present in areas where sediments have a higher proportion of coarse grained particle size fractions.

The community at stations within the historical Ba footprint area had a slightly lower taxonomic richness and higher annelid abundance than the surrounding stations in 2016. Although the communities were numerically dominated by amphipods, species rich and with a high overall abundance, the slightly different community structure may be due to localised disturbance from the discharge of WBM drilled cuttings.

When compared to previous survey data (Table 3.2.4), the 2016 community was found to be very similar to the communities present in 2012 and 2014. Changes in the overall community structure have been identified over the 1998 to 2016 monitoring period. However, these reflect faunal changes over a much wider area, and are not considered to be associated with operations at Central Azeri.

The only notable impacts from operational activities at Central Azeri are an area of elevated Ba concentrations from the discharge of WBM drill cuttings and low concentrations of hydrocarbon based drilling fluid from accidental spills.

Table 3.2.4 Taxa in survey area and station average abundance (N.m^{-2}) for major taxonomic groups, Central Azeri surveys 1998 to 2016

		1998	2001	2004	2006	2008	2010	2012	2014	2016
Class Polychaeta	Taxa	2	3	6	6	7	7	6	4	3
	n.m^{-2}	504	557	292	98	278	665	354	192	506
Class Oligochaeta	Taxa	1	2	3	3	3	3	3	3	3
	n.m^{-2}	626	597	516	219	236	1131	202	253	361
Order Cumacea	Taxa	3	7	7	6	6	8	7	6	6
	n.m^{-2}	10	39	87	72	46	104	124	97	53
Order Amphipoda	Taxa	21	23	21	14	29	37	28	28	29
	n.m^{-2}	1227	1285	1837	525	718	2038	1770	3479	4803
Order Isopoda	Taxa	1	2	2	2	2	2	1	1	1
	n.m^{-2}	11	2	31	11	3	9	3	3	4
Class Insecta	n.m^{-2}	50	166	84	18	4	4	6	23	13
Class Gastropoda	Taxa	17	7	17	5	7	14	15	13	15
	n.m^{-2}	41	12	125	7	5	23	83	61	68
Class Bivalvia	Taxa	2	4	4	2	2	6	3	3	4
	n.m^{-2}	55	64	954	351	17	209	117	114	94

3.2.3. East Azeri Platform

A baseline survey was carried out at East Azeri (EA) in 2002. This was followed by a biennial monitoring schedule which commenced in 2006.

The 2002 baseline survey comprised 15 stations arranged in a triangular grid design centred on the platform position.

An additional 6 stations were added to the design in 2006, extending the survey area to 1000m from the platform. The position of stations 2, 3, 4, 8 & 9 were moved from the 2002 location to allow safe clearance of seabed assets. Figure 3.2.12 gives the East Azeri sample station array used in the 2002 to 2016 monitoring surveys.

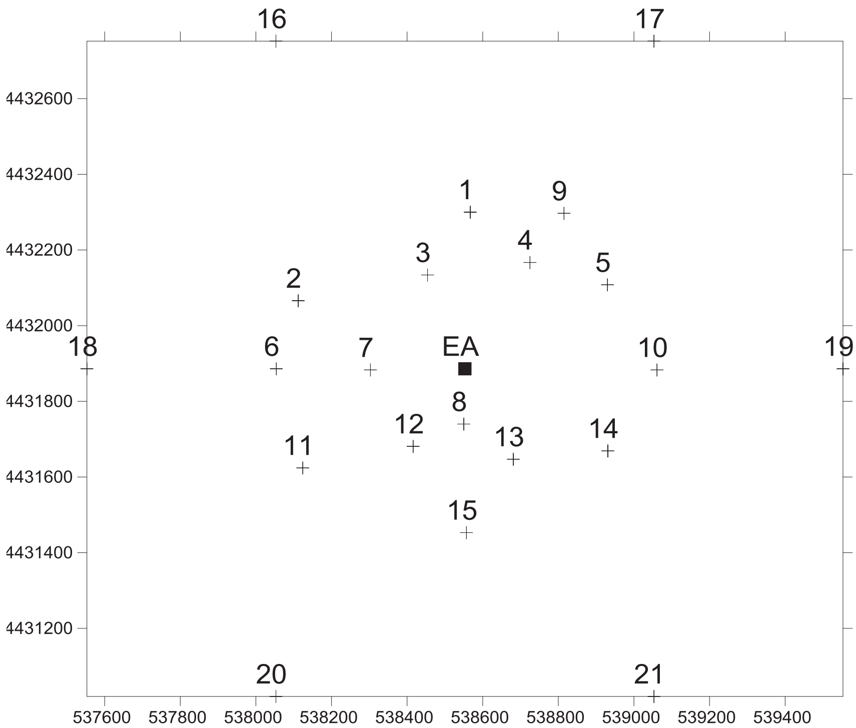


Figure 3.2.12 East Azeri Survey 2002 to 2016 sampling stations

Sediments within the East Azeri survey area are heterogeneous with a wide range of particle sizes present in most samples. In 2016 finer sediments with lower carbonate content were present at stations in the centre of the survey area to the southwest of the platform, and on the eastern and north-eastern flank of the survey area. This general spatial distribution has remained fairly constant over recent surveys.

Some variation has been observed in the survey wide physical characteristics over the 2002 – 2016 monitoring period (Table 3.2.5). The differences between years, particularly in mean diameter, are likely the result of sampling a physically heterogeneous environment, rather than the result of changes in the physical characteristics over large parts of the survey area. Overall the results from the most recent surveys have been consistent and similar to those recorded on the baseline survey.

Table 3.2.5 Sediment Physical properties: East Azeri surveys 2002 to 2016

	Survey Area Mean Value						
	2002	2006	2008	2010	2012	2014	2016
Mean diameter µm	112	293	116	204	149	121	125
Carbonate content %	47	49	48	46	46	50	53
Organic content %	3.2	3.3	3.3	3.2	3.0	2.5	2.8
Silt/Clay content %	62	62	63	58	63	62	52

Hydrocarbon concentrations were generally low throughout the survey area in 2016. Aromatic and aliphatic compounds were strongly correlated and the general composition was indicative of heavily weathered material being present throughout the survey area.

The spatial distribution of hydrocarbon concentrations in 2016 was similar to those observed on previous surveys at EA. The concentration of TPH was generally higher at stations within the northern third and eastern half of the survey area and reduced in a NE-SW gradient (Figure 3.2.13).

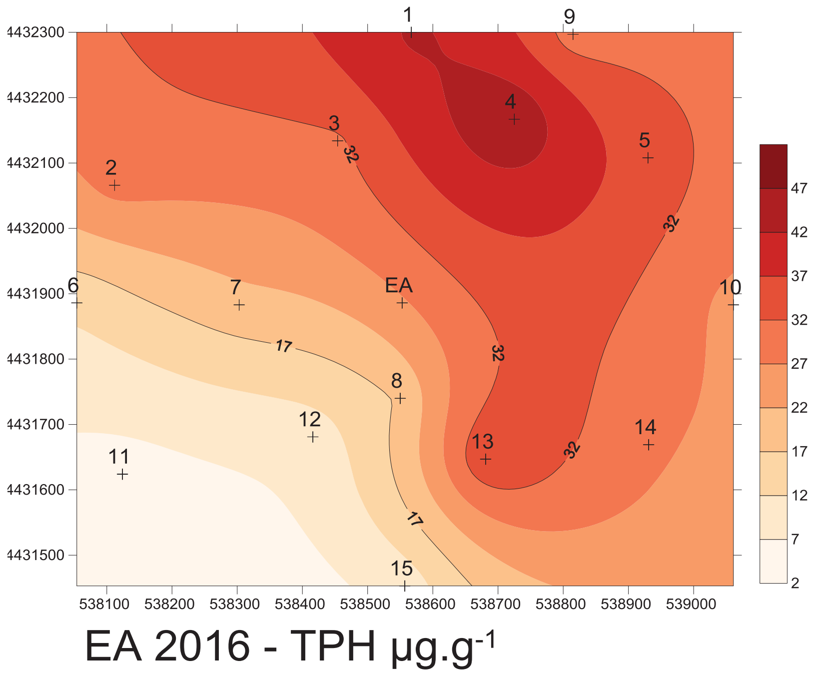


Figure 3.2.13 Spatial variation of TPH concentrations (µg.g^{-1}), East Azeri survey 2016

Low concentrations of HC drilling fluid compounds have been detected in a small number of samples on each survey from 2006 to 2016. The HC drilling fluid present originated from a small pre-2006 spill during drilling and concentrations have decreased substantially over the survey period; from an average level of 21 µg.g^{-1} in 2006 to 5 µg.g^{-1} in 2016 (Table 3.2.6).

There has been very little variation in the THC and PAH concentrations over the monitoring period (Table 3.2.6). Concentrations are generally low and are consistent with background levels recorded within the ACG Contract Area. Other than the low concentrations of hydrocarbon-based drilling fluids present on each survey, there is no evidence to suggest that operations at EA are influencing the hydrocarbon composition of sediments within the survey area.

Table 3.2.6 Sediment hydrocarbon concentrations: East Azeri surveys 2002 to 2016

	Survey Area Mean Value						
	2002	**2006**	**2008**	**2010**	**2012**	**2014**	**2016**
THC µg.g^{-1}	14	30	13	18	15	29	29
HC Drill Fluid µg.g^{-1}	ND	21	9	6	5	2	5
Total 2-6 Ring PAH ng.g^{-1}	50	129	77	71	78	82	79

ND Not Detected

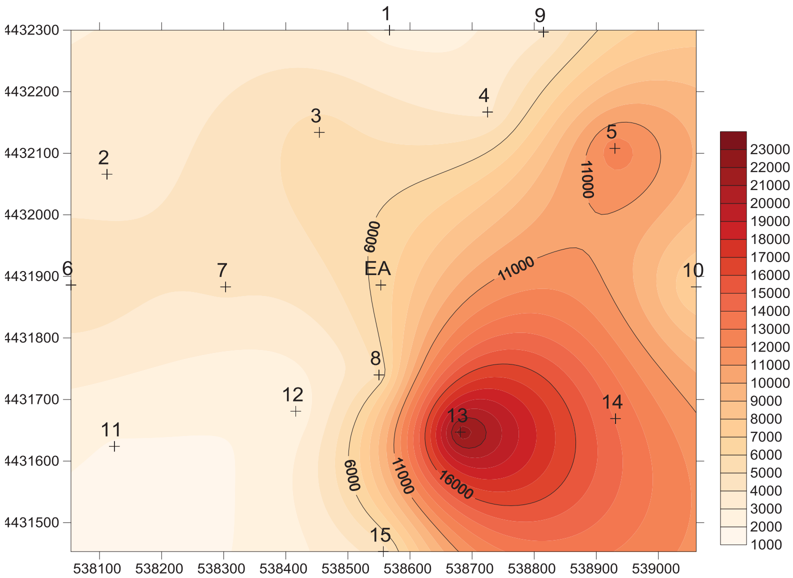
The variability in the concentration of most metals over the survey area in 2016 was low. The concentrations present were similar or within the ranges observed on previous surveys and were unrelated to operational activates at East Azeri (Table 3.2.7).

Table 3.2.7 Sediment metal concentrations: East Azeri surveys 2002 to 2016

	Survey Area Mean Value mg.kg^{-1}						
	2002	2006	2008	2010	2012	2014	2016
As	4.4	10.3	7.9	12.3	9.2	9.4	7.1
Ba HNO_3	1153	4985	3156	3235	3579	3375	3352
Ba Fusion	NM	6256	3717	4372	5014	5447	4993
Cd	0.17	0.31	0.29	0.58	0.19	0.18	0.16
Cr	47.7	42.5	49.6	39.9	46.9	45.7	36.5
Cu	26.2	32.1	30.1	24.7	26.8	28.1	18.8
Fe	20713	21020	23468	18534	22912	23491	17090
Hg	NM	0.024	0.030	0.029	0.025	0.025	0.008
Mn	406	478	468	377	470	475	359
Pb	23.0	11.8	10.8	11.2	12.7	11.9	10.8
Zn	45.6	45.4	55.1	48.1	58.0	60.6	41.7

NM Not Measured

Water based drilling muds (containing large quantities of barium sulphate) have been discharged to the seabed around the platform between 2006 and 2016. These discharges have resulted in a high variability in the concentration of Ba over the survey area and elevated barium concentrations at stations close to the platform (within 500m). The footprint and magnitude of elevated Ba concentrations has remained relatively stable since 2008, with the highest concentrations present at stations directly to the SE and NE of the platform. Figure 3.2.14 gives the distribution of Ba (fusion) concentrations in 2014 and 2016 and indicates that the levels have reduced between the 2014 and 2016 surveys.



EA 2014 - Ba Fusion mg.kg^{-1}

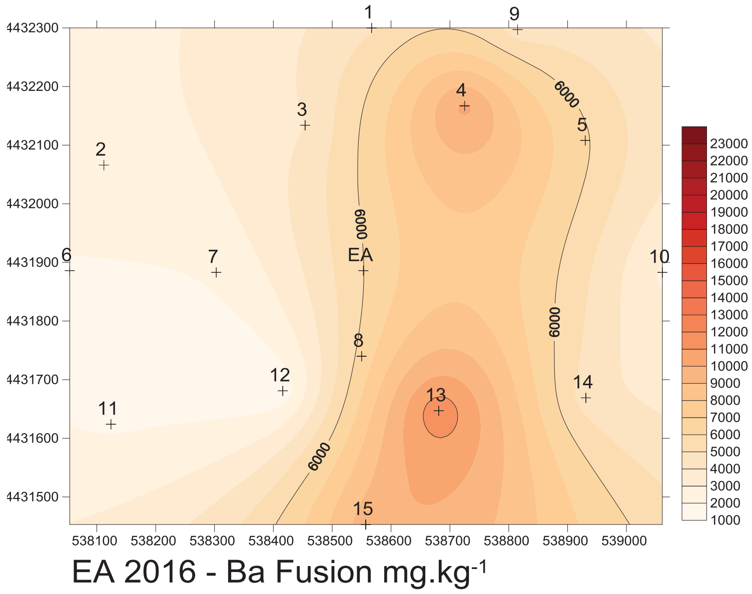


Figure 3.2.14 Spatial variation of Ba fusion concentrations (mg.kg^{-1}), East Azeri survey 2014 & 2016

The 2016 macrofaunal community at East Azeri was numerically dominated by amphipod crustaceans which accounted for 77% of the total abundance. The macrobenthic community varied in abundance and taxonomic richness over the survey area. As observed on previous surveys, the community structure was related to sediment physical properties, with more abundant and species rich communities present in areas where sediments have a higher proportion of coarse grained particle size fractions.

When compared to previous East Azeri survey data, the 2016 community was found to be very similar in composition and distribution to the communities present in 2012 and 2014. On average, the abundance of amphipods, cumacea and annelids have increased from the numbers present in 2012 and 2014 (Table 3.2.8).

Changes in the overall community structure have been identified over the 2002 to 2016 monitoring period. However, these reflect faunal changes over a much wider area, and are not considered to be associated with operations at East Azeri.

There was no evidence to suggest that operations at East Azeri have negatively affected the benthic macrofauna within the survey area. The only impacts identified from production/drilling operations are an area of elevated Ba concentrations from the discharge of WBM drill cuttings, and low concentrations of hydrocarbon based drilling fluid from accidental spills.

Table 3.2.8 Taxa in survey area and station average abundance (N.m^{-2}) for major taxonomic groups, East Azeri surveys 2002 to 2016

		2002	2006	2008	2010	2012	2014	2016
Class Polychaeta	Taxa	3	2	7	7	4	4	3
	n.m^{-2}	527	135	30	185	68	27	105
Class Oligochaeta	Taxa	3	3	3	3	3	3	3
	n.m^{-2}	315	314	161	485	129	105	131
Order Cumacea	Taxa	5	5	4	5	4	5	4
	n.m^{-2}	76	123	12	76	68	120	153
Order Amphipoda	Taxa	28	14	20	20	24	23	26
	n.m^{-2}	767	335	209	589	390	727	1307
Order Isopoda	Taxa	1	2	1	1	1	1	1
	n.m^{-2}	2	26	2	6	4	3	4
Class Insecta	n.m^{-2}	340	19	2	0	1	3	2
Class Gastropoda	Taxa	9	7	6	11	11	9	7
	n.m^{-2}	51	9	2	6	10	7	6
Class Bivalvia	Taxa	3	2	3	4	1	2	1
	n.m^{-2}	45	34	1	4	0	0	0

3.2.4. West Azeri Platform

Two baseline surveys were conducted at West Azeri (WA) in 1998 and 2002, followed by a biennial monitoring programme which commenced in 2005.

In 2002, the station array was updated from the basic cross design used in the 1998 baseline survey, to a triangular grid design comprising 15 sample stations. The 2002 design was used as the basis for all subsequent monitoring surveys. An additional 6 stations (16-21) were added to the 2002 design in 2005 - extending the survey area to 1000m from the platform, and a further 2 stations (22 & 23) were added to the array in 2007; the 2007 design was used in all subsequent monitoring surveys.

Figure 3.2.15 gives the West Azeri sample station array used in the 2007 to 2017 monitoring surveys. Due to the presence of seabed assets, the position of a number of stations have been altered over the 2002 to 2017 monitoring period.

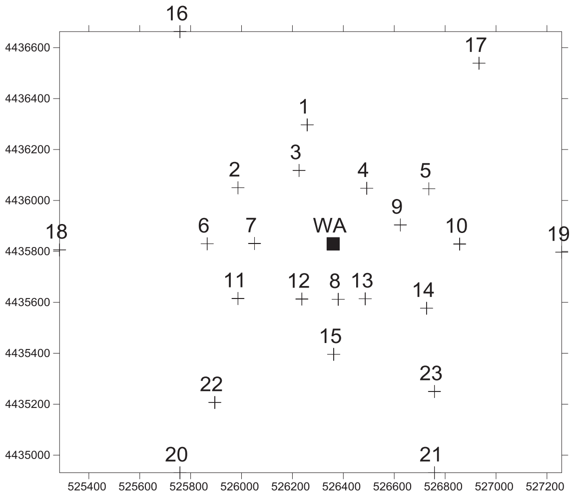


Figure 3.2.15 West Azeri survey sampling stations

Sediments within the West Azeri survey area are heterogeneous with a wide range of particle sizes present in most samples. Due to the heterogeneous nature of sediments, differences in the physical characteristics have been identified at individual stations over the monitoring period. While changes in the spatial distributions have been observed over time, the 2017 spatial patterns were broadly similar to those observed in 2013 and 2015. On average, from 2007 to 2017, sediments in the survey area have generally become finer and silt/clay content has slightly increased (Table 3.2.9).

Table 3.2.9 Sediment physical properties: West Azeri surveys 1998 to 2017

	Survey Area Mean Value								
	1998	2002	2005	2007	2009	2011	2013	2015	2017
Mean diameter µm	668	565	647	503	541	442	374	280	363
Carbonate %	70	62	58	62	58	67	61	56	62
Organics %	NR	2.9	3.0	2.4	3.5	3.5	2.3	2.4	2.1
Silt/Clay %	18	27	27	28	33	29	33	39	34

With the exception of station 3, located approximately 300m northwest of the platform, the hydrocarbon concentrations recorded throughout the survey area in 2017 were comparable to regional background levels. The high hydrocarbon concentration recorded at station 3 in 2017, and in previous surveys, was due to the presence of an historic, highly weathered input, and was unrelated to discharges from operations at the WA platform. The hydrocarbon contamination at station 3 likely originates from the drilling of the Azeri-2 well, which occurred prior to the commencement of AIOC's operations in the West Azeri field.

Variable quantities of hydrocarbon (HC) based drilling fluids have been detected within the survey area in all surveys from 2005 onwards. No operational discharges of HC based drilling fluid have taken place at West Azeri, the concentrations detected over the survey period are consistent with the small spills of drilling mud which have been reported, and are not indicative of operational discharges of hydrocarbon based drilling fluid. HC drilling fluid concentrations in sediments around West Azeri have decreased over the monitoring period from the peak values recorded in 2005 (Table 3.2.10).

Table 3.2.10 Sediment hydrocarbon concentrations: West Azeri surveys 1998 to 2017

	Survey Area Mean Value								
	1998	**2002**	**2005**	**2007**	**2009**	**2011**	**2013**	**2015**	**2017**
THC ($\mu g.g^{-1}$)	53	28	41	44	34	26	34	57	68
2-6 PAHs ($ng.g^{-1}$)	262	116	175	158	186	119	137	137	244
HC Drilling Fluid (**$\mu g.g^{-1}$**)	ND	0	13	6	6	3	2	1	3
ND Not detected									

The average concentration of most metals within the survey area have remained relatively consistent over the 2002 to 2017 monitoring period (Table 3.2.11). The higher mean concentrations of arsenic in post-2005 surveys were due to the presence of naturally occurring arseno-ferrous minerals at isolated stations in each survey, and were unrelated to operational activities at WA.

Elevated concentrations of a number of metals have been recorded at station 3 in all surveys at WA - including the 2002 baseline survey. This feature is related to the presence of drilling waste from pre-AIOC operations within the West Azeri field.

Water based mud (WBM) drilled cuttings have been discharged to the seabed around WA between 2005 and 2017. These discharges have resulted in an area of elevated sediment barium concentrations within 500m of the WA platform location. Although some variability has been observed at individual stations, the footprint of elevated Ba concentrations has remained relatively stable between 2005 and 2017, with the highest concentrations consistently recorded at stations 8 and 13. The distribution of sediment Ba concentration in 2015 and 2017 are provided in Figure 3.2.16. From 2009 there has been a general reduction in the Ba concentration levels recorded within the contamination footprint; the levels recorded in 2015 and 2017 were similar to the post-drill minimum recorded in 2007.

Table 3.2.11 Sediment metal concentrations: West Azeri surveys 1998 to 2017

	Survey Area Mean Value $mg.kg^{-1}$								
	1998	**2002**	**2005**	**2007**	**2009**	**2011**	**2013**	**2015**	**2017**
As	NM	6.4	15.8	14.3	17.5	16.8	15.5	17.2	15.5
Ba HNO_3	1500	1485	6128	14741	7116	7247	6231	5392	6051
Ba Fusion	NM	NM	29377	20084	27636	24804	21626	18347	23800
Cd	0.29	0.24	0.2	0.41	0.52	0.3	0.23	0.24	0.2
Cr	37	34	47	36	47	42	44	43	39
Cu	31	22	22	26	27	24	26	24	19
Hg	0.05	0.02	0.057	0.045	0.051	0.024	0.025	0.031	0.042
Fe	21000	19523	24117	23226	26452	25702	26708	27728	20663
Mn	NM	307	NM	395	457	441	476	485	423
Pb	35	26	26	19	26	21	19	19	12
Zn	78	37	59	57	76	68	68	72	50

NM Not measured

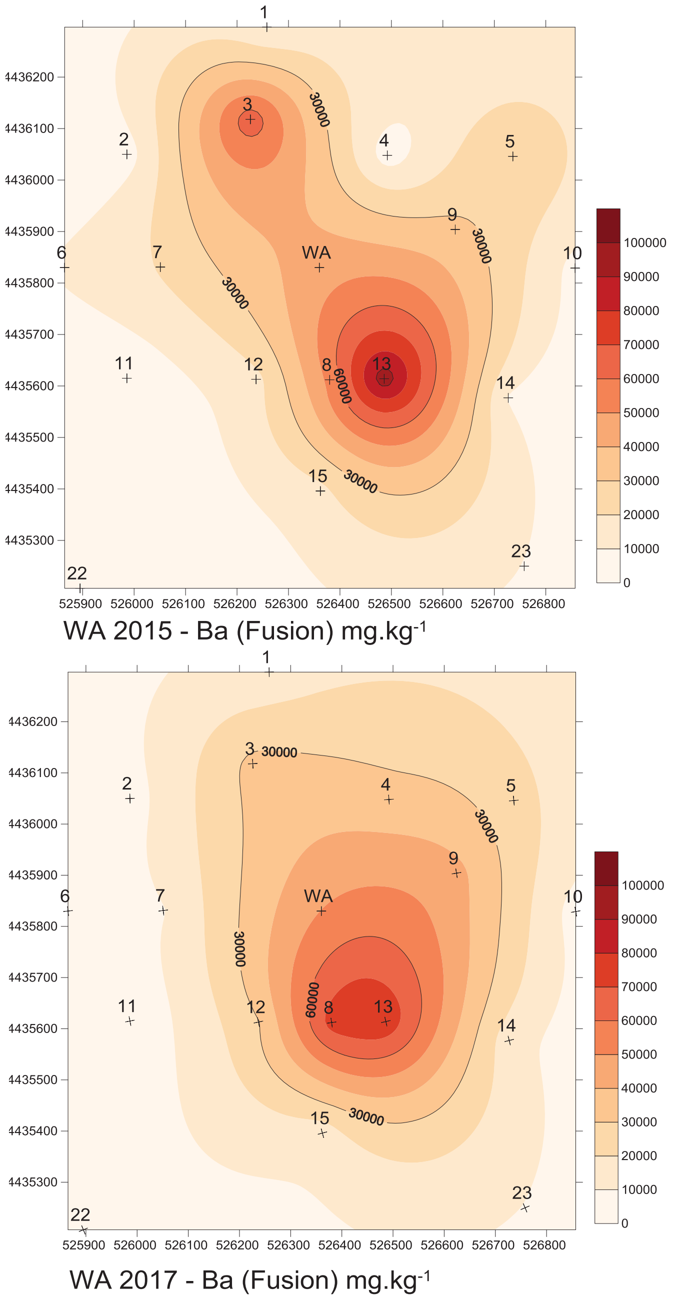


Figure 3.2.16 Spatial variation of Ba fusion concentrations (mg.kg^{-1}), West Azeri survey 2015 & 2017

The macrobenthic community recorded in 2017 was broadly similar to the communities present on recent surveys at West Azeri, with overall diversity and abundance being dominated by amphipods (Table 3.2.12). The changes in overall community structure recorded during the survey period (2002-2017) reflect faunal changes observed over a much wider area, and are not considered to be associated with operations at West Azeri.

The communities at stations within the discharge affected area were abundant and species rich and numerically dominated by amphipods - the abundance of which had increased on all consecutive surveys from 2011. No negative community changes were observed between 2015 and 2017 at stations 8 and 13 - the two stations most affected by drilling discharges.

Distinctly different benthic communities have been consistently recorded at stations 1 and 3 in all surveys conducted since 2005. The lower abundance and taxonomic richness, and distinct chemical characteristics at these locations, are likely related to pre-AIOC drilling operations.

The only impacts identified from production/drilling operations at West Azeri are an area of elevated Ba concentrations from the discharge of WBM drill cuttings, and low concentrations of hydrocarbon based drilling fluid from small accidental spills.

Table 3.2.12 Taxa in survey area and station average abundance (N.m^{-2}) for major taxonomic groups, West Azeri surveys 2002 to 2017

		2002	2005	2007	2009	2011	2013	2015	2017
Class Polychaeta	Taxa	4	6	6	6	6	4	5	5
	n.m^{-2}	372	1012	1616	756	746	380	737	1123
Class Oligochaeta	Taxa	3	3	3	3	3	3	3	3
	n.m^{-2}	491	574	273	486	135	147	154	183
Order Cumacea	Taxa	2	5	7	7	8	7	7	6
	n.m^{-2}	2	198	180	59	106	80	45	57
Order Amphipoda	Taxa	16	26	30	25	33	31	30	31
	n.m^{-2}	1079	2729	1325	1337	1624	2669	3711	3836
Order Isopoda	Taxa	1	2	2	2	2	1	1	2
	n.m^{-2}	2	15	23	17	9	1	2	1
Class Insecta	n.m^{-2}	831	79	27	14	8	12	13	16
Class Bivalvia	Taxa	3	4	4	4	4	3	4	4
	n.m^{-2}	190	839	365	326	338	303	134	72
Class Gastropoda	Taxa	6	6	20	12	15	12	9	10
	n.m^{-2}	82	2	112	46	76	72	32	36

3.2.5. Deepwater Gunashli Platform

A baseline environmental survey was conducted around the Deepwater Gunashli (DWG) platform location in 2001, the baseline survey was followed by a biennial monitoring programme which commenced in 2007. In 2007 the station array was updated from the basic cross design used in the 2001 baseline survey, to one based on a triangular grid design comprising 26 sample stations.

Figure 3.2.17 gives the DWG sample station array used in the 2007 to 2017 monitoring surveys. Due to the presence of seabed assets, the position of a number of stations have been altered slightly over the 2007 to 2017 monitoring period.

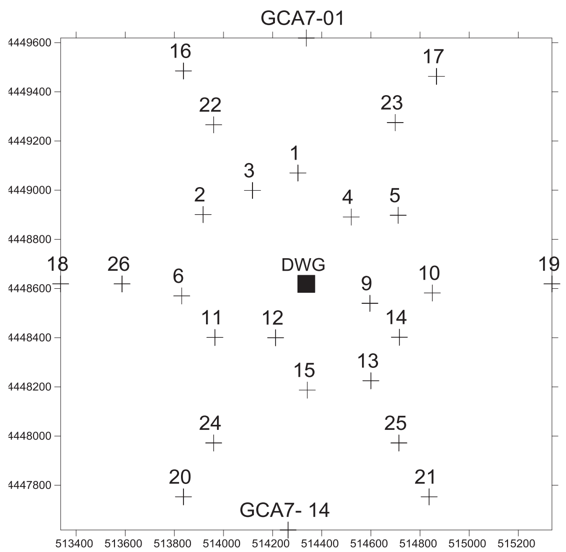


Figure 3.2.17 DWG Survey sampling stations

Sediments throughout the DWG survey area are heterogeneous and variable on both a small and large spatial scale. The mean diameter (µm) mean result in 2017 was the lowest recorded over the monitoring period (Table 3.2.13). This follows a trend observed from 2007, where the mean particle size has reduced from 371 to 85µm. The mean proportion of silt/clay in 2017 and 2015 were very similar and were slightly higher than the mean values observed in previous surveys.

Mean diameter and gravel content were lower at most stations in 2017 compared to 2015, whereas silt/clay content had remained relatively unchanged. Considering the patchy nature of sediments, and the overall differences between years, the distribution patterns of physical characteristics have remained relatively stable, with coarser sediments with a lower silt-clay content present at stations within the centre of the survey area.

Table 3.2.13 Sediment physical properties: DWG surveys 2001 to 2017

	Survey Area Mean Value						
	2001	2007	2009	2011	2013	2015	2017
Mean diameter µm	270	371	283	178	175	154	85
Silt/Clay content %	37	42	56	51	51	58	60
Carbonate content %	38	31	29	23	34	32	33
Organic content %	3.9	4	4.3	4.5	3.9	4.2	4.5

Sediment hydrocarbon concentrations vary across the DWG survey area. The spatial pattern has been relatively consistent throughout the 2001 to 2017 monitoring period; higher concentrations are present at stations within the southwestern and north-eastern quadrants of the survey area. Although concentrations were relatively high at some stations, the hydrocarbon compounds present within sediments in all DWG surveys were heavily weathered and were not related to operations at DWG.

Small quantities of hydrocarbon based drilling fluid were detected at two stations in 2013, three stations in 2015, and a single station in 2017; these materials originated from small spills of SBM and LTOBM which occurred in 2013 and 2015.

Table 3.2.14 Sediment hydrocarbon concentrations: DWG surveys 2001 to 2017

	Survey Area Mean Value						
	2001	2007	2009	2011	2013	2015	2017
THC ($\mu g.g^{-1}$)	35	41	28	29	41	51	57
Total 2-6 Ring PAH ($ng.g^{-1}$)	324	481	379	304	426	289	526

For the majority of metals the variation across the survey area has been low on all surveys and the survey wide average concentration has remained relatively consistent over the 2001 to 2017 monitoring period (Table 3.2.15). The lower concentrations of Cd, Cu, Pb and Zn in the 2017 survey were due to analytical variation from a change in the laboratory service provider.

The metal composition in sediments at the DWG location differs to other ACG platform locations; associations between metals present at other locations are absent within DWG sediments, and the concentration of manganese and arsenic are generally higher at DWG than in other areas (Table 3.2.15). Additionally, high concentrations of Ba are present in areas located at distance from the platform. These features have been recorded on all surveys at DWG, including the 2001 baseline survey, and are not related to drilling/production activities at DWG.

Water based mud (WBM) – containing high levels of barium sulphate - and WBM drilled cuttings have been discharged to the seabed at DWG between 2005 and 2009; from 2009 there have been no operational drilling discharges at DWG. Although no consistent footprint of elevated Ba concentrations has been identified at DWG, previous surveys have identified transient, elevated concentrations of Ba at stations adjacent to the platform, which may indicate the presence of WBM/ WBM drilled cuttings.

Table 3.2.15 Sediment metal concentrations: DWG surveys 2001 to 2017

	Survey Area Mean Value mg.kg^{-1}						
	2001	2007	2009	2011	2013	2015	2017
As	NM	45.3	30.2	43.0	43.4	32.4	24.9
Ba HNO_3	4067	3641	2187	1636	2131	1324	1126
Ba total (fusion)	NM	4942	2753	2243	3941	2790	3489
Cd	0.25	0.31	0.26	0.16	0.17	0.15	0.09
Cr	43.7	59.1	61.6	60.3	61.2	54.5	57.0
Cu	20.4	23.6	26.6	23.6	25.4	25.4	17.4
Fe	48008	53008	39970	44247	42304	40175	33567
Hg	0.02	0.04	0.02	0.04	0.04	0.04	0.04
Mn	1917	4155	1229	1346	1913	1744	1844
Pb	48.4	47.5	38.7	38.0	37.5	31.1	12.0
Zn	73.2	75.5	64.8	79.1	76	75.3	43.9

NM Not Measured

The macrobenthic community in 2017 was numerically dominated by amphipods and polychaetes (Table 3.2.16). When compared to previous DWG survey data, the macrobenthic community in 2017 had a lower abundance of amphipods, while polychaete abundance was higher. The reduction in amphipod abundance was observed across the entire survey area between 2015 and 2017, and was not restricted to individual stations or localised areas. Polychaete distributions in 2015 and 2017 were almost identical, the only difference was the higher abundance recorded in 2017.

As previously observed at DWG, the community variation in 2017 was associated with the physical characteristics of the sediments and depth. It is possible that the lower amphipod abundance in 2017 may be associated with the general reduction in coarser grained sediments across the survey area. However, it is also likely that the change between years is the result of natural faunal variation.

Changes have been identified in the community composition and structure over the 2001 to 2017 monitoring period. These changes represent widespread regional variations and are not related to operational activities at DWG. There was no evidence to suggest that operations at DWG have negatively affected the benthic macrofauna within the survey area.

Table 3.2.16 Taxa in Survey Area and Station Average Abundance (N.m^{-2}) for Major Taxonomic Groups, DWG Surveys 2001 to 2017

		2001	2007	2009	2011	2013	2015	2017
Class Polychaeta	Taxa	5	5	7	6	3	3	3
	n.m^{-2}	235	29	72	118	21	92	383
Class Oligochaeta	Taxa	5	4	3	4	3	3	3
	n.m^{-2}	547	92	170	105	91	86	91
Order Cumacea	Taxa	6	3	3	5	3	4	3
	n.m^{-2}	31	2	2	28	59	10	29
Order Amphipoda	Taxa	21	35	37	35	29	30	30
	n.m^{-2}	1295	1211	1343	2644	2872	1560	971
Order Isopoda	Taxa	1	1	1	1	1	1	1
	n.m^{-2}	7	1	4	11	2	2	4
Class Insecta	n.m^{-2}	9	7	1	2	<1	0	1
Class Gastropoda	Taxa	7	16	12	14	15	10	2
	n.m^{-2}	26	29	31	42	45	39	5
Class Bivalvia	Taxa	1	4	5	3	3	2	3
	n.m^{-2}	<1	28	4	6	5	1	1

3.2.6. Chirag Platform

This first survey at Chirag was carried out in 1998. This was not a baseline survey, as production had commenced at the platform with several wells being drilled before the 1998 survey. However, the area around the Chirag platform was included in the 1995 AIOC environmental baseline study. The 1998 survey was followed by a survey in 2000. The 1998 and 2000 survey station arrays differed to the array used on later surveys at Chirag.

From 2004 a biennial monitoring programme was implemented. The survey design consisted of 30 sampling stations, arranged in circles at 250, 500, 750, 1000, and 1200 metres from the platform. In 2006 an additional three stations were added to the 2004 design on a bearing of 045° (grid), the direction of greatest impact identified by the 2004 survey. This design was used on all subsequent biennial surveys at Chirag (Figure 3.2.18 A).

In addition to the biennial monitoring surveys, reduced scope surveys focussing on the area within 500m from the platform and designed to detect the spread of drilling discharges were introduced in 2015 and 2017 (Figure 3.2.18 B).

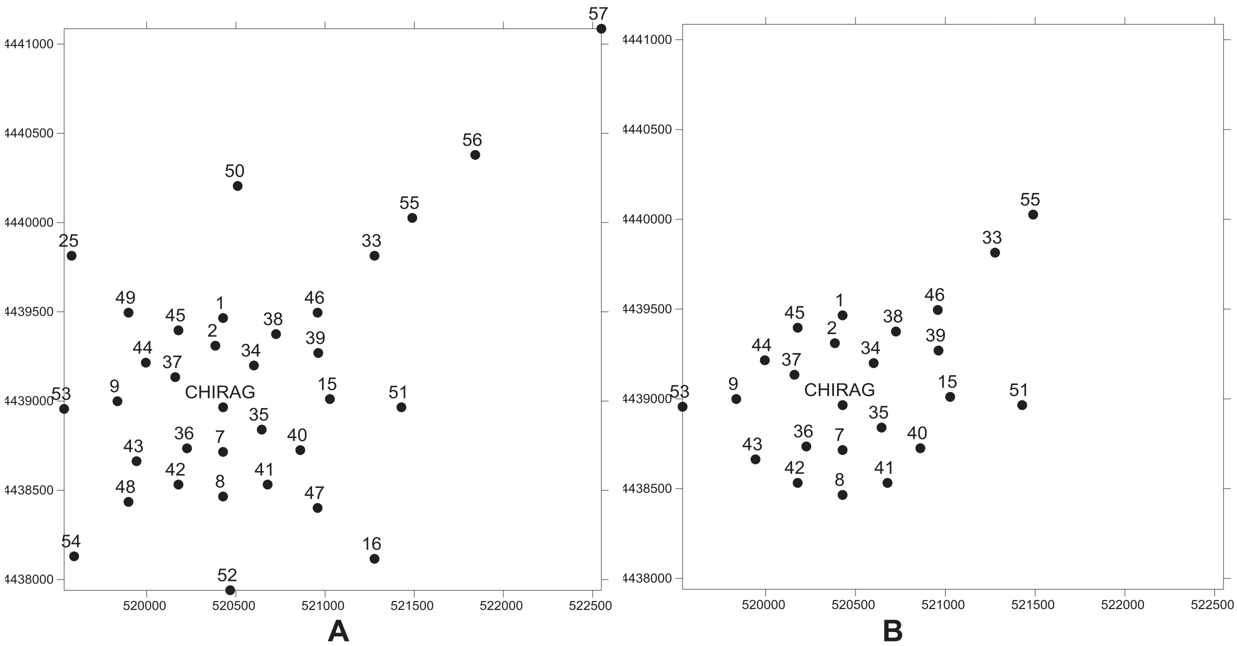


Figure 3.2.18 Chirag surveys 2004 - 2017 sampling stations

On average there was very little change in mean diameter or silt clay content within the 2017 survey area over the 2004-2017 monitoring period. The mean diameter results in surveys carried out between 2012 and 2017 exhibited the greatest similarity and were generally lower than the values observed on 2004-2012 surveys (Table 3.2.17). Although localised differences have been observed at individual stations over recent surveys, the general distribution patterns of key physical parameters have remained consistent.

Table 3.2.17 Sediment physical properties: Chirag surveys 1998 to 2017

	Survey Area Mean Value										
	1998	2000	2004	2006	2008	2010	2012	2014	2015	2016	2017
Mean diameter µm	403	363	695	685	609	704	457	503	366	403	433
Silt/Clay %	34	40	28	27	33	32	33	30	31	35	36

The spatial distributions of hydrocarbon parameters in 2017 were similar to those observed on recent surveys at Chirag. Higher THC concentrations are generally present at stations to the north of the platform extending 600m west and 700m northeast (Figure 3.2.19). The composition of the hydrocarbon compounds present in all samples were indicative of weathered material being present throughout, with no samples containing freshly deposited material.

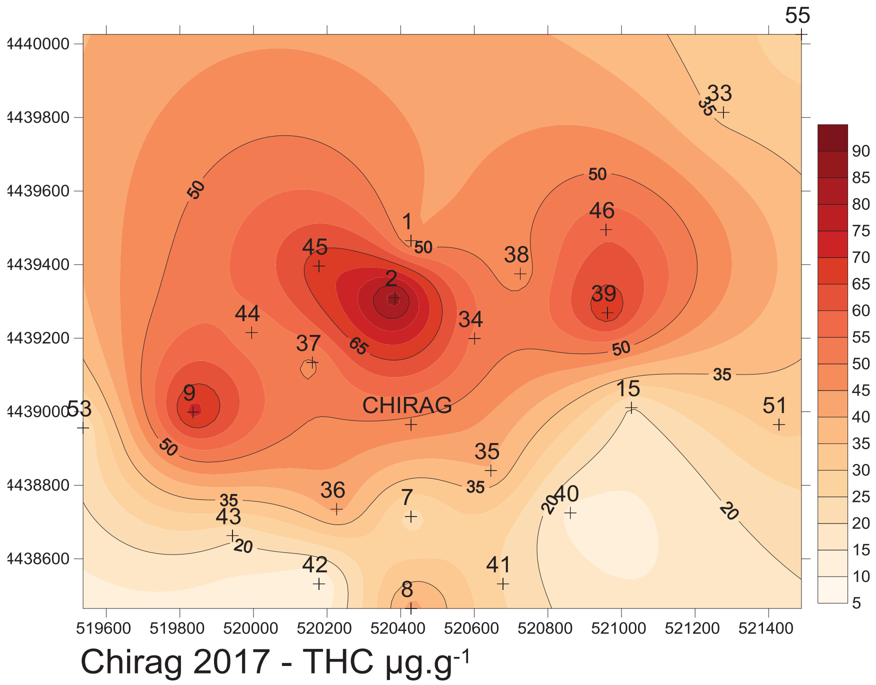


Figure 3.2.19 Spatial variation of THC concentration (µg.g-1), Chirag survey 2017

LAO drilled cuttings have been discharged to the seabed at Chirag between 1998–2009 and 2013-2017. The presence of LAO has been detected in samples on all surveys from 2004 onwards. The highest concentrations were recorded in surveys carried out in 2004 and 2006, concentrations then reduced on each consecutive survey until 2015 and 2016 when higher concentrations were recorded (Table 3.2.18).

The LAO contamination footprint area has remained relatively stable over the three most recent surveys: centred on station 34 and extending to the northeast and west. The concentration at station 34 was substantially lower in 2017 from the level recorded in 2016 and to a lesser extent 2015. Despite the continued discharge of LAO drilled cuttings at Chirag, the spatial extent of the LAO contamination footprint in 2017 and the recorded concentrations have reduced from those recorded in previous surveys (Figure 3.2.20).

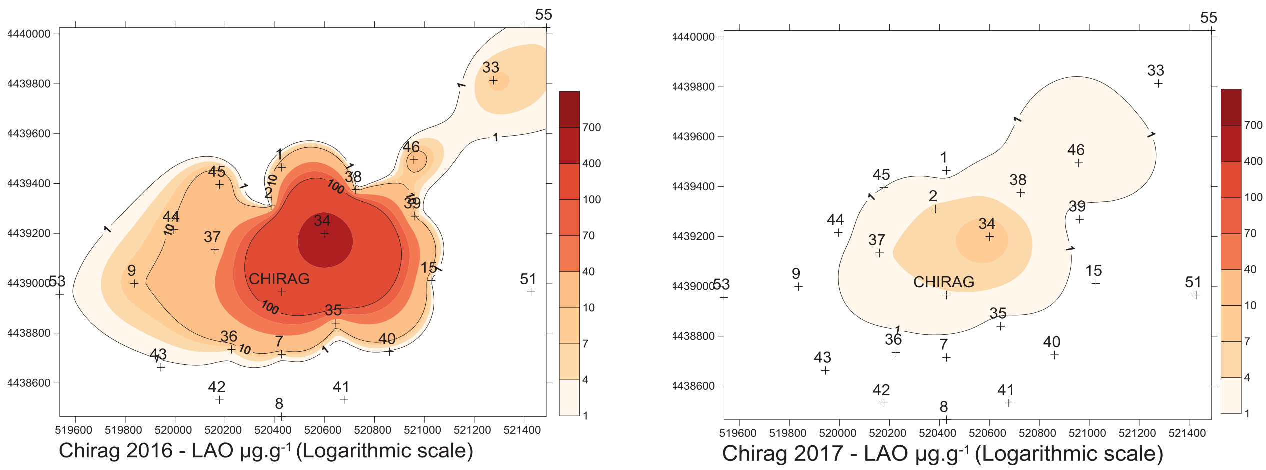
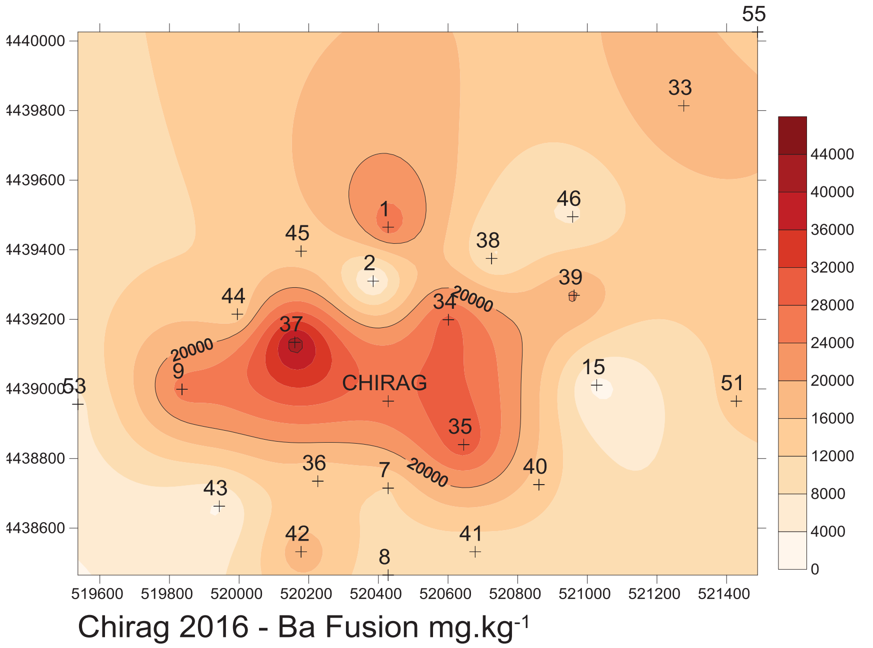


Figure 3.2.20 Spatial variation of LAO concentration (µg.g-1), Chirag surveys 2016 & 2017

Table 3.2.18 Sediment hydrocarbon concentrations: Chirag surveys 1998 to 2017

	Survey Area Mean Value										
	1998	2000	2004	2006	2008	2010	2012	2014	2015	2016	2017
THC, $\mu g.g^{-1}$	596	553	154	163	43	38	79	50	90	66	41
TPH, $\mu g.g^{-1}$	596	553	92	69	33	34	76	50	79	34	40
Total 2-6 ring PAH, $ng.g^{-1}$	1756	666	645	403	184	217	483	227	220	208	154
LAO, $ug.g^{-1}$	NM	NM	111	121	26	11	11	2	38	65	1
LAO Stations detected	NM	NM	17	28	11	15	12	5	9	8	6

The concentrations of most metals have remained consistent over the monitoring period (Table 3.2.19). Average barium concentrations and the spatial extent and magnitude of the footprint of elevated Ba concentrations have remained relatively stable over recent surveys. The highest concentrations were recorded at stations to the northwest and northeast of the platform (Figure 3.2.21).



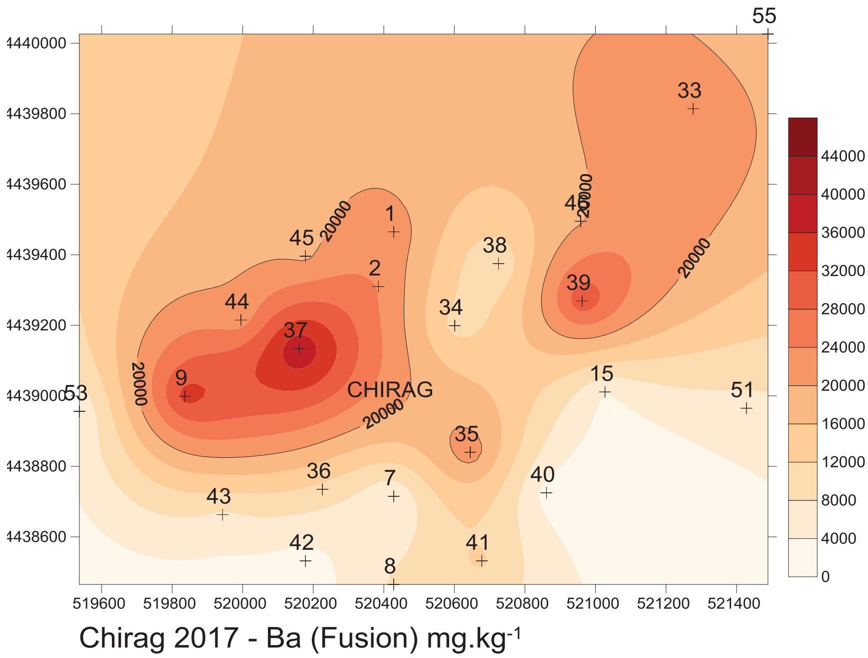


Figure 3.2.21 Spatial variation of Ba fusion concentrations (mg.kg^{-1}), Chirag surveys 2016 & 2017

Table 3.2.19 Sediment metal concentrations: Chirag surveys 1998 to 2017

	Survey Area Mean Value $mg.kg^{-1}$										
	1998	2000	2004	2006	2008	2010	2012	2014	2015	2016	2017
As	NM	NM	31	30	22	27	29	25	NM	29	NM
Ba HNO_3	1359	7160	7853	13358	9587	15093	6322	6493	NM	5998	NM
Ba Total (fusion)	NM	NM	26389	19066	13015	19724	13938	16040	16469	14525	15522
Cd	0	NM	0.21	0.43	0.48	0.46	0.241	0.207	NM	0.210	NM
Cr	37	44	44	46	44	47	40	44	NM	40	NM
Cu	26	22	21	26	22	23	25	25	NM	24	NM
Fe	23160	31064	25958	33070	28258	29820	29535	28429	NM	30758	NM
Hg	0.04	0.03	0.07	0.03	0.03	0.04	0.029	0.034	NM	0.038	NM
Mn	NM	NM	NM	506	455	508	617	486	NM	489	NM
Pb	29	23	22	21	17	25	17	18	NM	17	NM
Zn	81	75	56	65	57	76	70	69	NM	72	NM

The macrobenthic community in 2017 was very similar in composition to the communities present on recent surveys, and continues to increase in abundance throughout the survey area - particularly in amphipods and polychaetes (Table 3.2.20).

Increases in abundance have been observed at stations previously identified as being impacted by discharges at Chirag. However, station 34, the station closest to the discharge point and historically the most affected by discharges, remains biologically distinct. It is likely that the chemical composition of sediments around station 34 combined the on-going discharges are inhibiting the recovery at station 34 which has been observed at other previously impacted stations.

Table 3.2.20 Taxa in survey area and station average abundance ($N.m^{-2}$) for major taxonomic groups, Chirag surveys 1998 to 2017

		1998	2000	2004	2006	2008	2010	2012	2014	2015	2016	2017
Oligochaeta	Taxa	5	6	3	3	3	3	3	3	3	3	3
	$n.m^{-2}$	701	745	514	281	85	115	101	103	84	197	177
Polychaeta	Taxa	2	4	5	5	6	6	5	5	4	3	2
	$n.m^{-2}$	229	412	221	123	81	441	319	228	438	579	634
Amphipoda	Taxa	23	13	10	12	13	27	23	25	23	28	26
	$n.m^{-2}$	485	841	414	272	79	457	672	2049	1179	2264	2743
Isopoda	Taxa	1	1	2	2	1	1	1	1	1	1	1
	$n.m^{-2}$	46	15	8	14	1	4	4	4	3	6	3
Cumacea	Taxa	4	3	5	5	3	5	7	6	5	6	5
	$n.m^{-2}$	104	103	74	76	7	30	111	84	59	73	205
Insecta	$n.m^{-2}$	7	46	148	20	1	1	1	1	0	1	0
Gastropoda	Taxa	7	7	7	1	4	3	8	6	1	8	5
	$n.m^{-2}$	22	7	129	0	4	1	6	2	0	3	4
Bivalve	Taxa	3	3	4	5	2	3	4	5	3	5	3
	$n.m^{-2}$	306	14	1021	220	18	78	145	69	6	39	19

3.2.7. West Chirag Platform

A baseline survey was carried out at West Chirag in 2003. The 2003 survey comprised 15 stations arranged in a triangular grid and was centred 500m SW of the West Chirag platform location. When the planned platform position was revised, an additional baseline survey was carried out in 2009, comprising 12 stations centred on the updated platform position. A post platform installation survey was carried out in 2014. The 2014 survey design added 11 stations to the 2009 sample station array. An overlay of the 2003, 2009 and 2014 sample station positions are provided in Figure 3.2.22.

From 2016 a biennial monitoring schedule was implemented at West Chirag. The 2016 monitoring survey sampled the 2014 survey station positions (Figure 3.2.23).

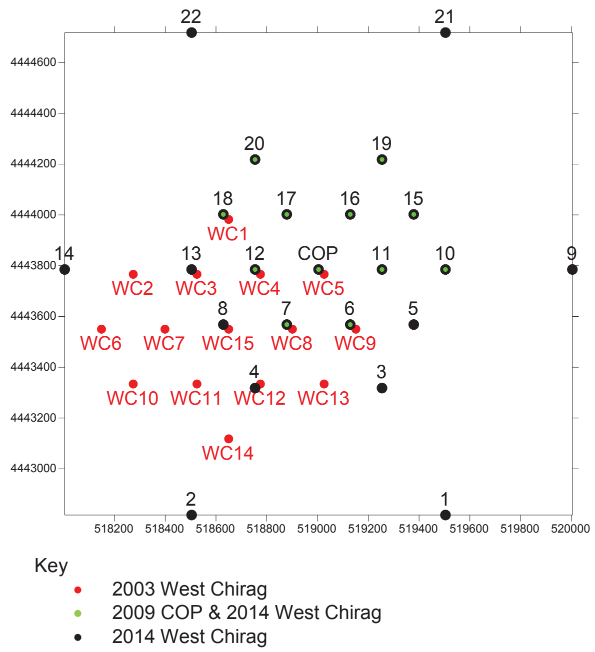


Figure 3.2.22 West Chirag (2003 & 2014) & COP (2009) sample stations

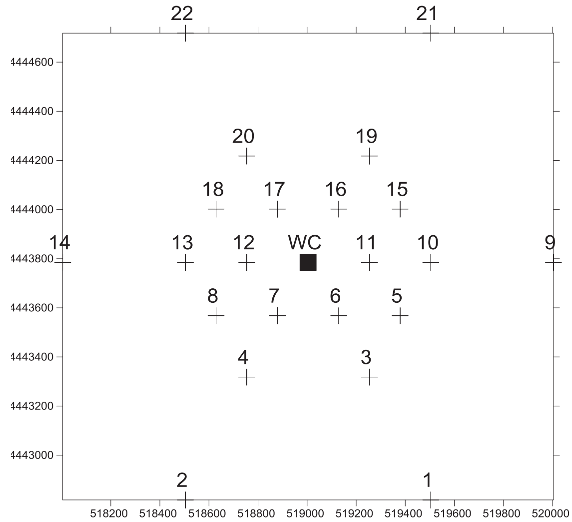
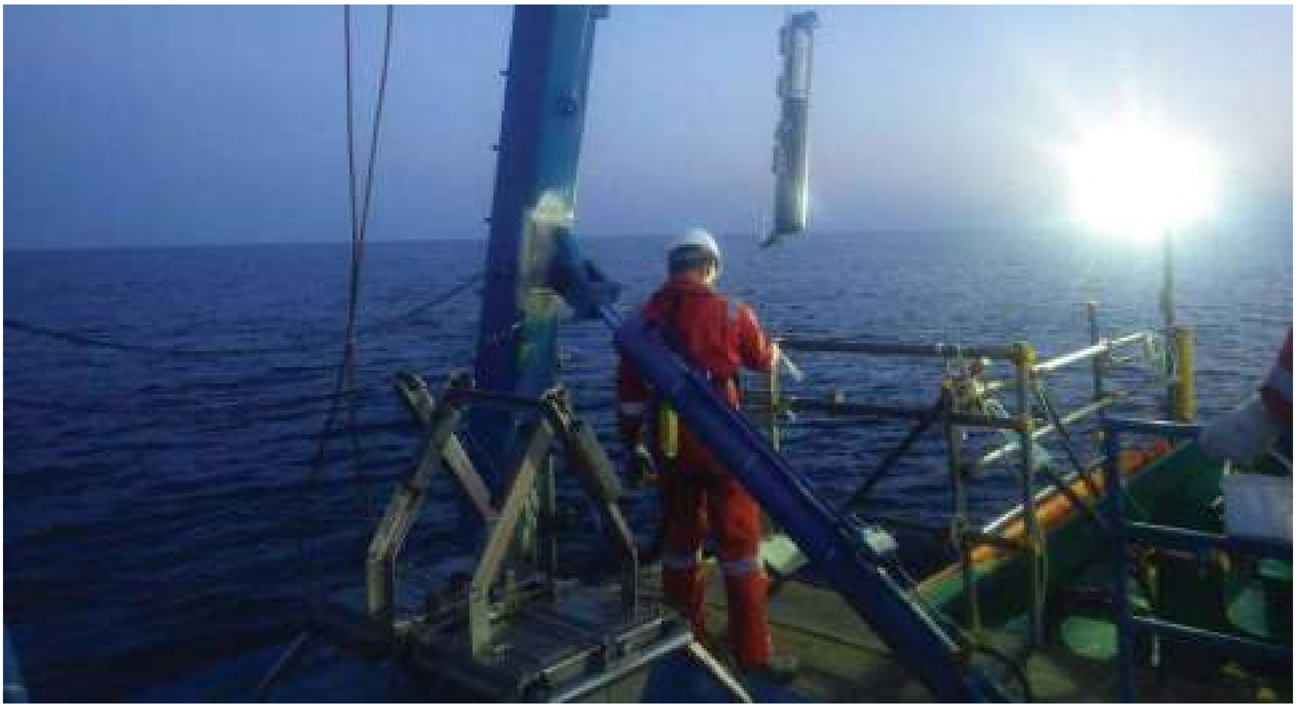


Figure 3.2.23 West Chirag sample stations 2014 & 2016



Sediments within the West Chirag survey area are heterogeneous with a wide range of particle sizes present in samples from across the survey area. In general sediments within the survey area were coarser in 2016 than observed on previous surveys (Table 3.2.21). Although some variation was observed in the physical characteristics at a small number of stations between 2014 and 2016, the overall spatial distribution has remained relatively consistent over the monitoring period.

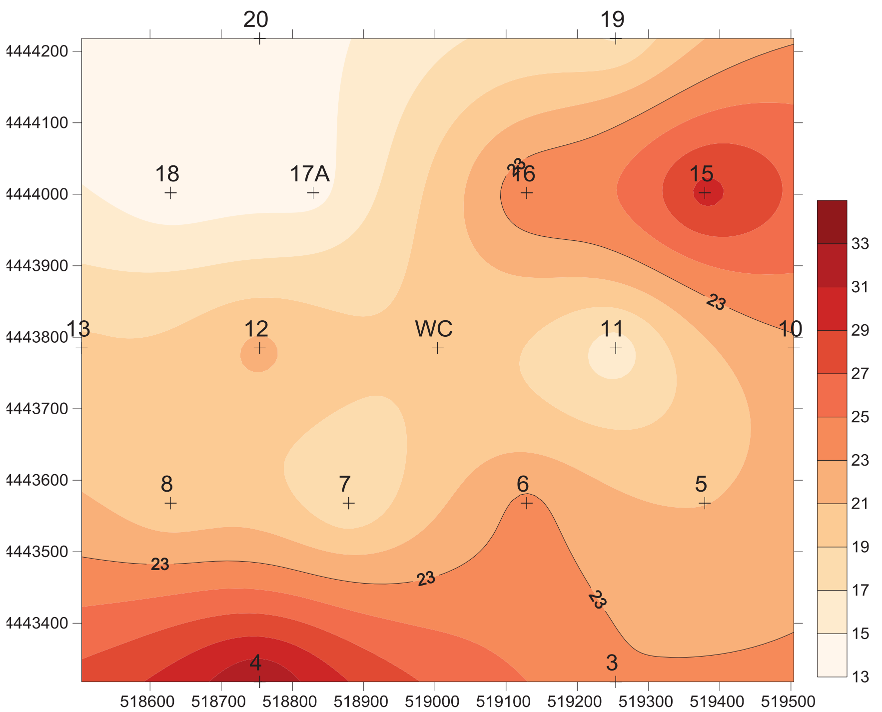
Table 3.2.21 Sediment physical properties: West Chirag surveys 2003 to 2016

	Survey Area Mean Value			
	2003	2009	2014	2016
Mean diameter µm	319	398	382	575
Carbonate %	51	47	49	60
Organic %	2.8	3.5	2.7	2.0
Silt/Clay %	40	48	40	27

Hydrocarbon concentrations were low throughout the survey area in 2016. As observed on previous surveys at West Chirag, the spatial distributions of aromatic and aliphatic compounds were independent of each other and the general composition was indicative of heavily weathered material being present throughout the survey area (Figure 3.2.24).

THC concentrations were similar to those recorded on previous surveys, while 2-6 ring PAH concentrations were lower (Table 3.2.22). The concentration and composition of all compounds were consistent with the background levels recorded within the ACG Contract Area.

Hydrocarbon based drilling fluid compounds were detected at low concentrations in a number of samples in 2014 and 2016. The distribution and concentrations recorded in 2016 were unchanged from those observed in 2014 when the material was first detected. The source of the contamination was a small spill of OBM which occurred in 2014.



West Chirag 2016 - TPH µg.g^{-1}

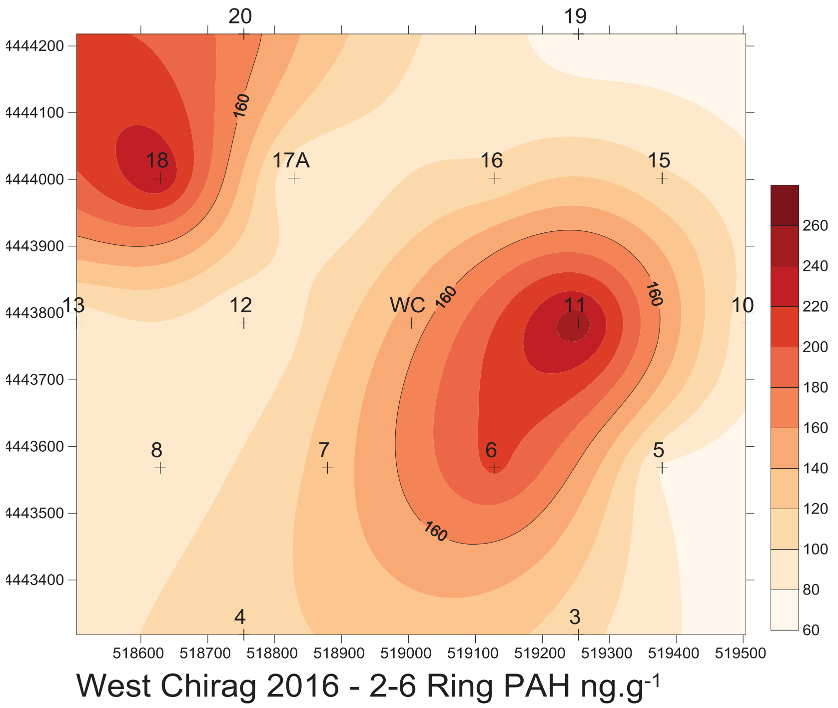


Figure 3.2.24 Spatial variation of TPH & 2-6 ring PAH concentrations, West Chirag survey 2016

For the majority of metals, the variation across the survey area has been low on all surveys and the survey wide average concentration has remained relatively consistent over the 2003 to 2016 monitoring period (Table 3.2.23).

Barium in the form of barites in WBM was discharged to the seabed during MODU drilling operations between 2010 and 2013, these discharges have resulted in higher average Ba (fusion) concentrations within the WC survey area in 2014 and 2016 (Table 3.2.23). Since the installation of the West Chirag platform there have been no drilling discharges; all WBM & LTOBM drilled cuttings have been reinjected back into the well.

In 2016, the spatial distribution of elevated Ba concentrations has remained consistent to that observed in 2014, but has increased in size (Figure 3.2.25). As no additional discharges have taken place between the 2014 and 2016 surveys, the larger footprint observed in 2016 is likely due to the spread of previously discharged material by natural physical processes.

Table 3.2.22 Sediment hydrocarbon concentrations: West Chirag surveys 2003 to 2016

	Survey Area Mean Value			
	2003	2009	2014	2016
THC (µg.g^{-1})	22	12	24	23
HC drilling fluid (µg.g^{-1})	ND	ND	2	2
2-6 PAHs (µg.g^{-1})	250	209	174	125

ND Not Detected

Table 3.2.23 Sediment metal concentrations: West Chirag surveys 2003 to 2016

	Survey Area Mean Value mg.kg^{-1}			
	2003	2009	2014	2016
As	9	16	18	19
Ba HNO_3	4908	5362	4954	6832
Ba fusion	NM	6731	9997	12844
Cd	0.18	0.31	0.16	0.16
Cr	39	53	48	50
Cu	23	24	22	19
Fe	19910	27429	29906	26157
Hg	0.110	0.036	0.033	0.010
Mn	453	553	609	662
Pb	15	18	15	12
Zn	53	56	63	61

NM Not Measured

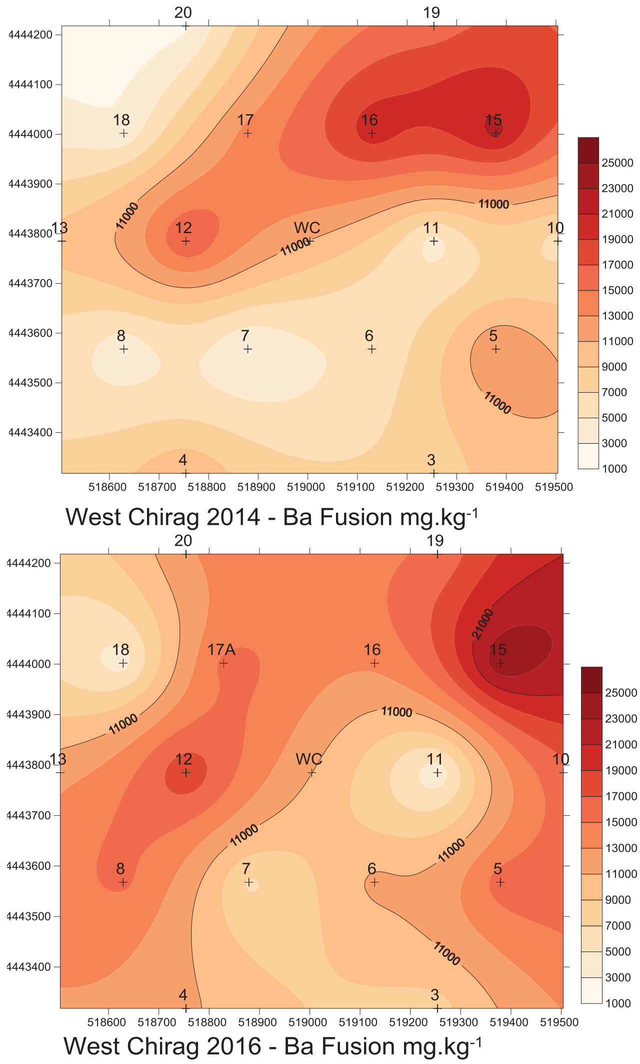


Figure 3.2.25 Spatial variation of Ba fusion concentrations (mg.kg^{-1}), West Chirag surveys 2014 & 2016

The 2016 West Chirag macrobenthic community was abundant and taxonomically rich and similar in composition to the community present in 2014 (Table 3.2.24). As observed on previous years, the community structure within the survey area was generally related to sediment physical properties, with more abundant, diverse and species rich communities present in areas where sediments have a higher proportion of coarse grained particle size fractions and lower proportions of silt and clay content.

A general reduction in the abundance of amphipods was observed throughout the survey area between 2014 and 2016, while an increase was observed in the abundance of polychaetes. As these changes were observed throughout the entire survey area, it is expected that they represent natural faunal variation and are unrelated to operational activities at West Chirag.

There was no evidence to suggest that operations at West Chirag have negatively affected the benthic macrofauna within the survey area. The only impacts identified from production/drilling operations are an area of elevated Ba concentrations from the discharge of WBM drill cuttings which took place prior to the installation of the platform, and low concentrations of hydrocarbon based drilling fluid from an accidental spill which occurred in 2014.

Table 3.2.24 Taxa in survey area and station average abundance ($N.m^{-2}$) for major taxonomic groups, West Chirag surveys 2003 to 2016

		2003	2009	2014	2016
Class Polychaeta	Taxa	4	5	1	4
	$n.m^{-2}$	348	1043	108	243
Class Oligochaeta	Taxa	3	3	3	3
	$n.m^{-2}$	559	249	178	235
Order Cumacea	Taxa	3	6	6	5
	$n.m^{-2}$	9	47	74	47
Order Amphipoda	Taxa	20	36	34	34
	$n.m^{-2}$	419	2123	2387	1982
Order Isopoda	Taxa	2	2	1	1
	$n.m^{-2}$	5	4	3	2
Class Insecta	$n.m^{-2}$	123	13	2	0
Class Bivalvia	Taxa	5	3	5	5
	$n.m^{-2}$	10	17	16	7
Class Gastropoda	Taxa	18	23	16	7
	$n.m^{-2}$	45	300	65	57

3.2.8. ACG– Sangachal Subsea Export Pipeline Route

Environmental surveys along the ACG-Sangachal export pipeline were carried out in 2000 and biennially between 2006 and 2014. The survey design comprises 15 seabed stations along the ~85 km pipeline route between the Chirag platform and the Sangachal Terminal (Figure 3.2.26)

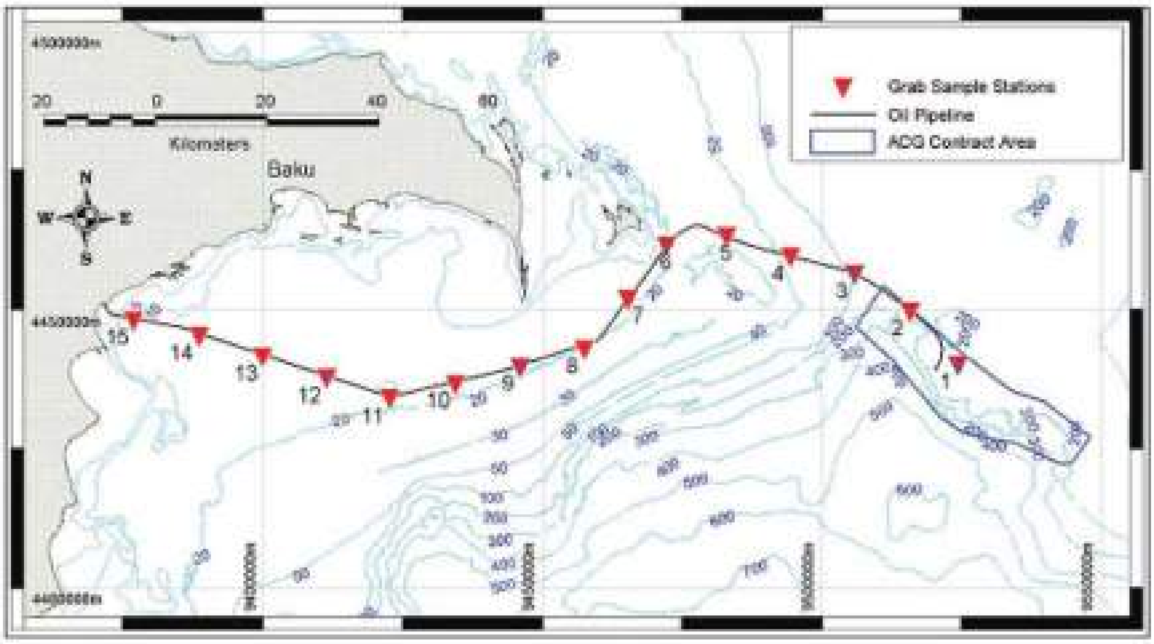


Figure 3.2.26 Location of ACG Pipeline survey area and seabed sample stations

The physical and chemical characteristics of sediments along the pipeline route have exhibited a clear pattern on all surveys. A general distinction can be made between the stations from the eastern and western parts of the survey area, the demarcation point being stations 6 and 7, south of Zhiloy Island.

The eastern part of the pipeline route (stations 1 to 6) was characterised by very low levels of all hydrocarbon fractions, with total hydrocarbon concentrations at station 6 close to the lower detection limit of the analysis on all surveys. At stations 7 to 15, concentrations of all hydrocarbon fractions were higher. Total hydrocarbons generally increased from stations 7 to 15, approaching Sangachal Bay. The distribution along the pipeline route and the heavily weathered nature of the hydrocarbon compounds present is indicative of historical contamination from coastal sources.

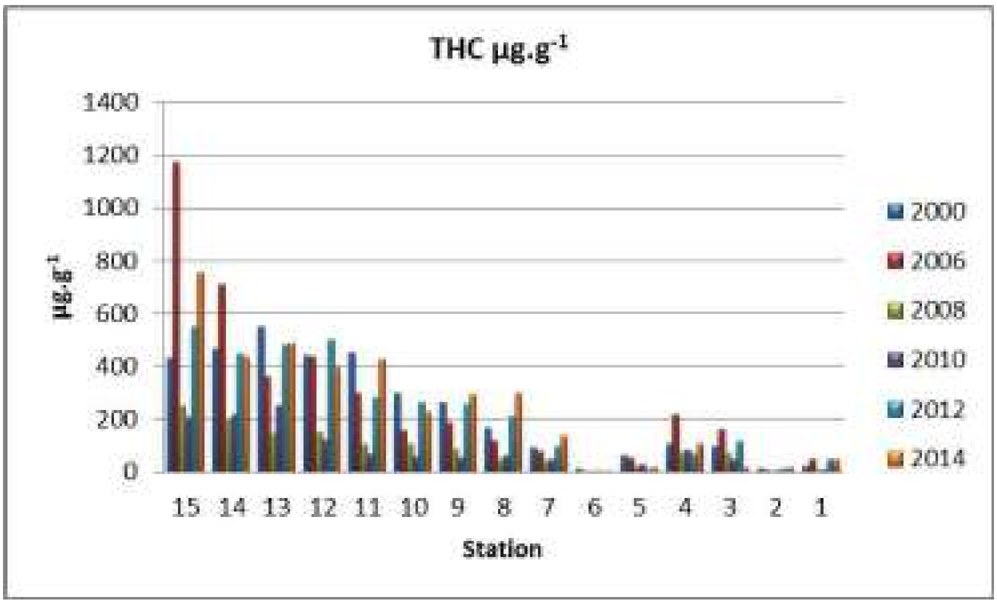
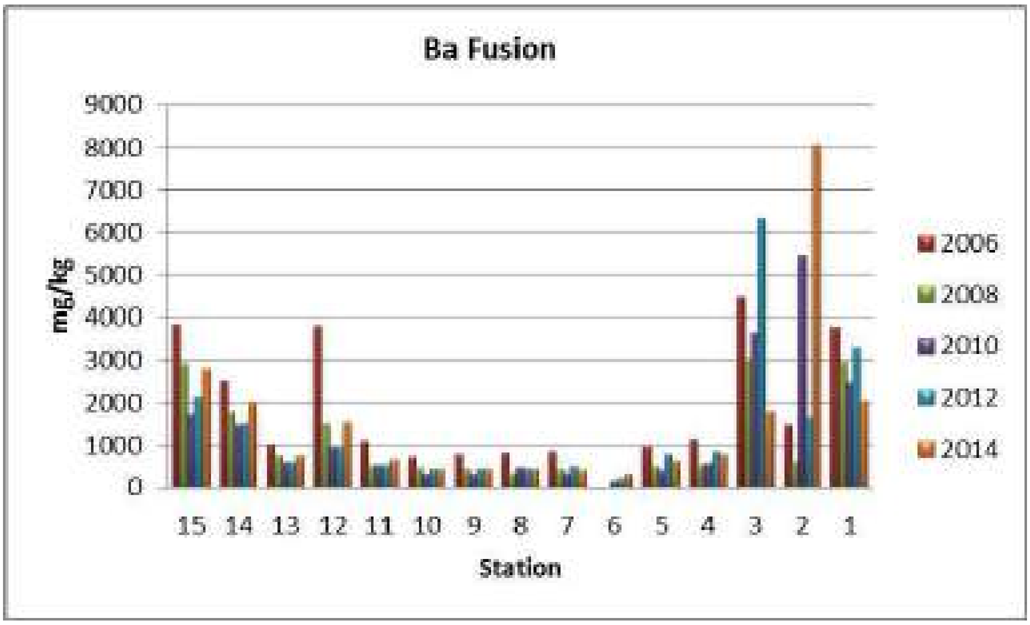


Figure 3.2.27 Sediment THC concentrations (μg.g^{-1}), ACG-Sangachal pipeline route surveys 2000 to 2014.

The concentrations and distributions of most metals have not changed significantly over the period of surveys. In general the distributions were related to the levels of sediment silt/clay content along the pipeline route. Notable exceptions were the distributions of Ba and Hg (Figure 3.2.28).

Barium concentrations, which are taken as being indicative of drilling waste on the seabed, were elevated at either end of the pipeline route, i.e. at stations within the ACG contract area, and at the shallowest stations in Sangachal Bay.

Mercury concentrations are lowest at stations located on the eastern end of the pipeline route; within the ACG contract area. From station 6 moving west, concentrations increase and are highest at stations 12 and 13. As with hydrocarbon contamination, the distributions of Ba and Hg are indicative of historical industrial contamination, unrelated to BP activities.



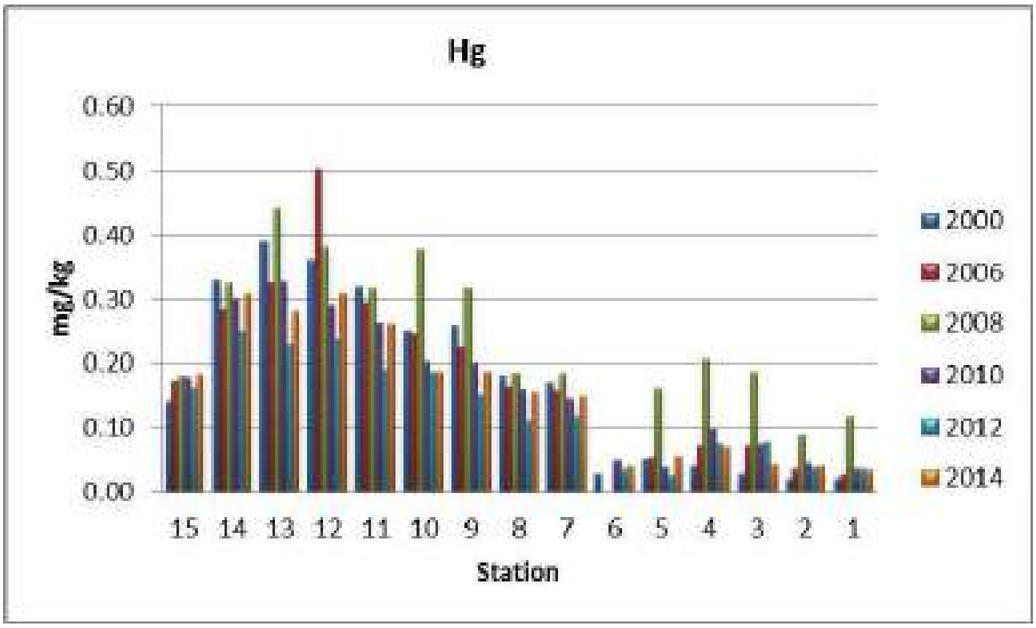


Figure 3.2.28 Sediment Ba & Hg concentrations ($mg.kg^{-1}$), ACG-Sangachal pipeline route surveys 2000 to 2014.

Although there has been a significant turnover of species; which reflects changes observed over the wider region, the structure of the macrobenthic communities of the pipeline route have remained stable over the fourteen year monitoring period.

All surveys have identified a clear demarcation between the more abundant and taxonomically rich communities in the offshore, eastern part of the survey area, and the sparser communities dominated by bivalves and polychaete worms, present in the more coastally-influenced, shallower western part. Figure 3.2.29 gives the total taxa and abundance results from the 2014 survey, which illustrates the general pattern observed on all surveys along the pipeline route.

From the results received over the 2000 to 2014 monitoring period, there has been no evidence to suggest that BP operations have influenced the physical, chemical or macrobenthic community characteristics along the pipeline route.

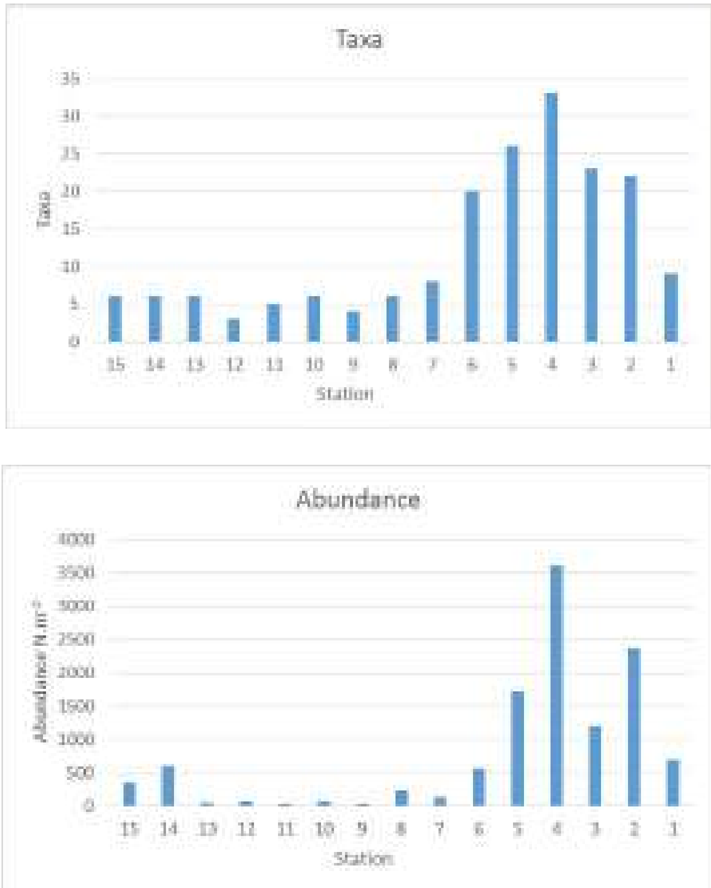


Figure 3.2.29 Abundance (N.m^{-2}) & taxonomic richness, ACG-Sangachal pipeline route survey 2014.

3.3. Shah Deniz (SD) Contract Area

The SD contract area in the Azerbaijan sector of the Caspian Sea is approximately 15 km south of the nearest land, Shahdilli spit (Figure 3.3.1). Water depth ranges from 20 to over 700 metres, the seabed slopes generally downward from northwest to southeast.

Several exploration wells have been drilled in the SD contract area including the Stage 1 Alpha platform (SDA) which was installed in 2006.

The SD Bravo platform was started-up in July 2018.

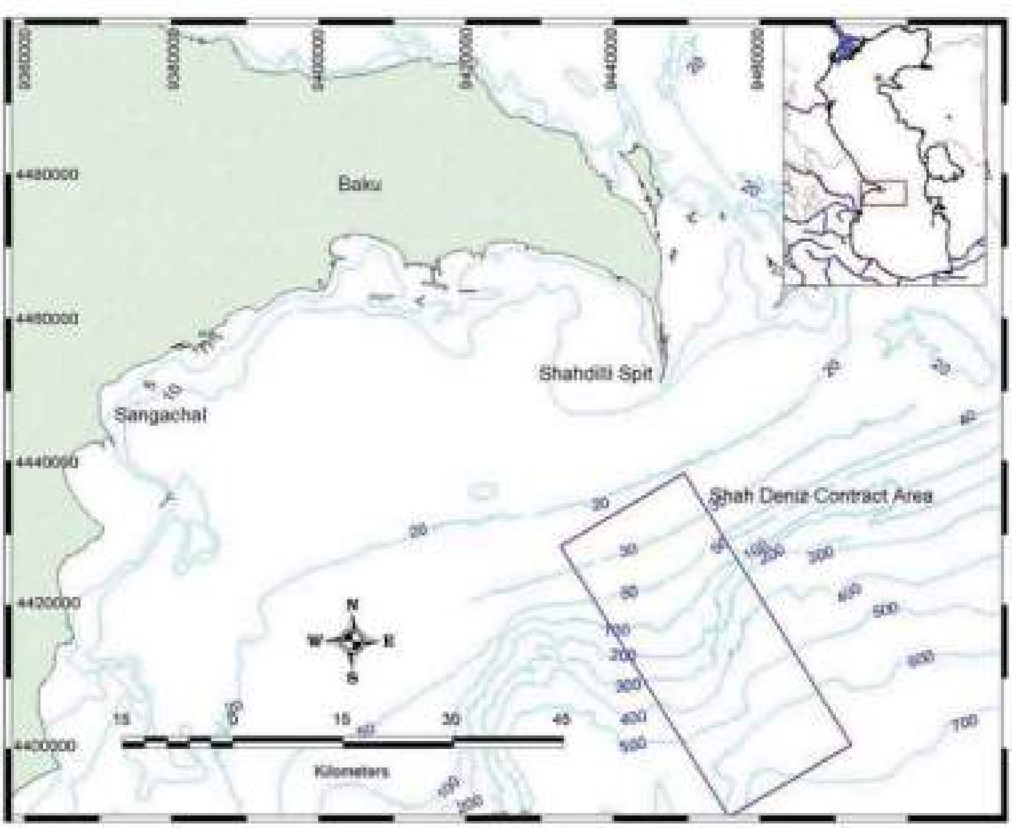


Figure 3.3.1 Location of the Shah Deniz Contract Area

3.3.1. Shah Deniz Regional survey

Regional environmental surveys have been conducted in 1998, 2000, 2001, then biennially from 2005 to 2015. The survey design comprises 13 sample stations spread across the SD contract area (Figure 3.3.2)

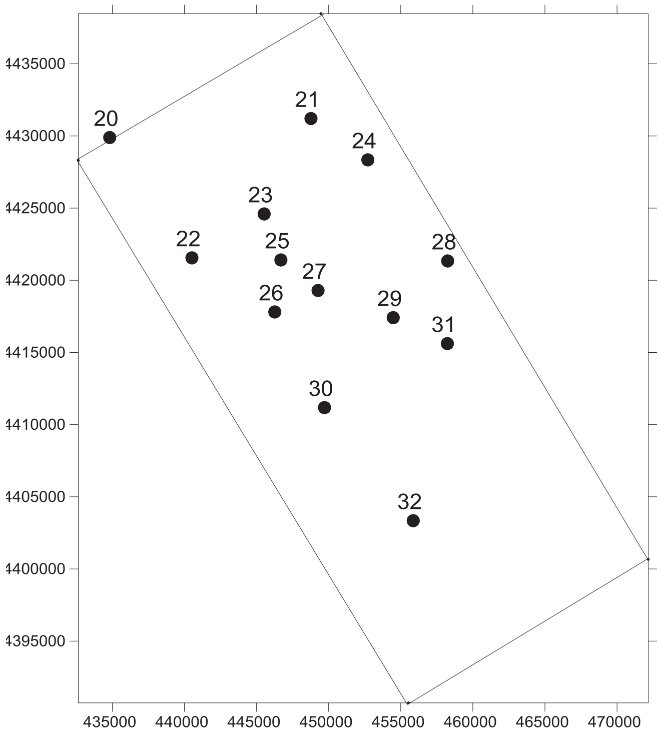


Figure 3.3.2 Sediment sample station positions, Shah Deniz Regional surveys 1998 to 2015

Sediments in the Shah Deniz Contract Area were of two types. At the majority of stations, the sediments consisted entirely or almost entirely of silt and clay particles. While at three stations in the central part of the contract area (26, 27, and 29) sediments are coarser with a wide range of particle size classes present (Figure 3.3.3).

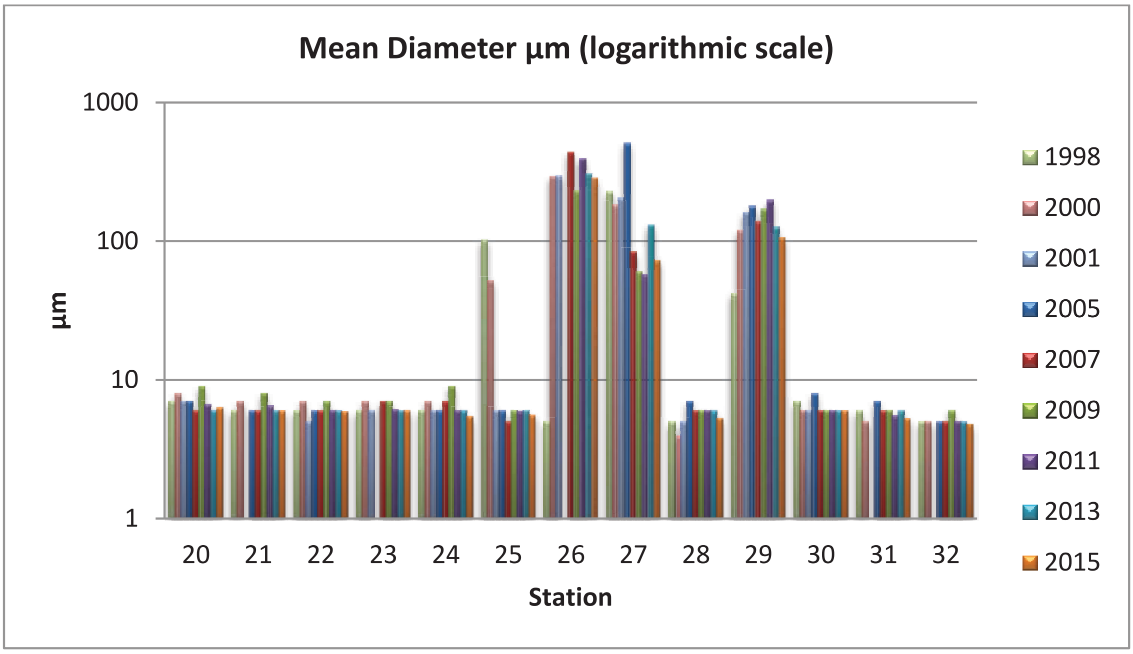


Figure 3.3.3 Station average mean diameter, SD Regional surveys 1998-2015

Over the survey area, the lowest hydrocarbon concentrations have been consistently recorded at stations 26, 27, 29, and 30.

On average total hydrocarbon concentrations were highest during the period 1998 to 2001; after 2001 a large decrease was recorded in all measured hydrocarbon compounds over the whole survey area. The lowest hydrocarbon concentrations were recorded in 2005 or 2007; since that period, most concentrations measured have increased by a small amount, but the variations were not consistent at all stations (Figure 3.3.4). There was no evidence that operations in the contract area have affected the hydrocarbon levels at any of the regional stations.

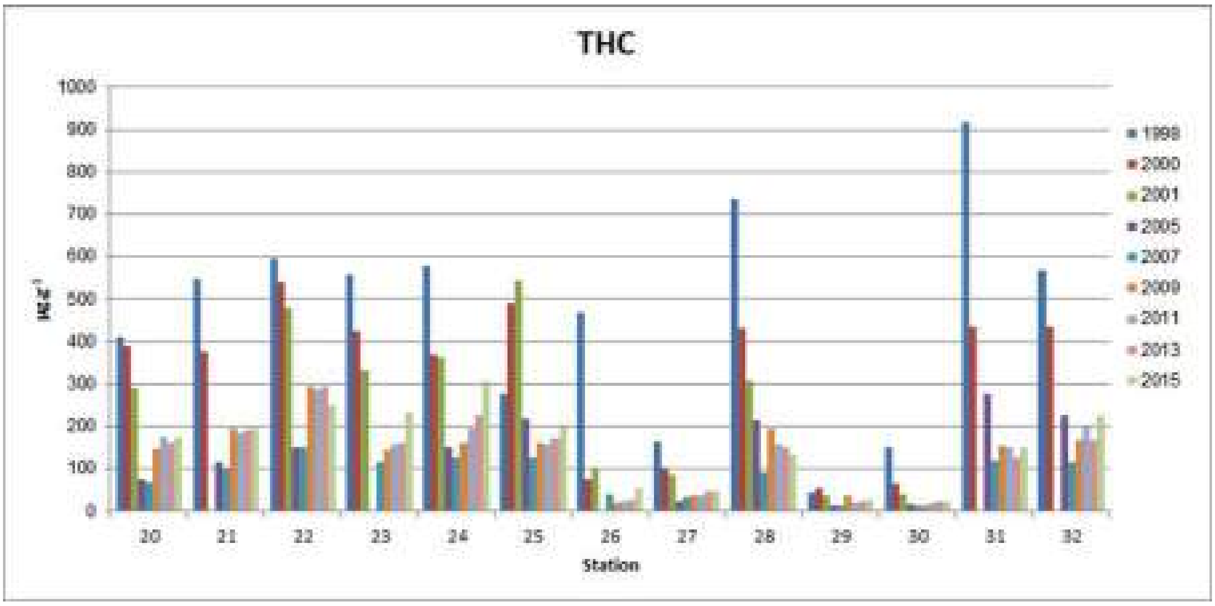


Figure 3.3.4 Station average total hydrocarbon concentrations, SD Regional surveys 1998-2015

The pattern of metal concentrations over the contract area appears to be mainly influenced by the natural sediment variability and results have changed very little over the period of surveys. The lowest levels of most elements were found at station 29, with low levels also at stations 26 and 27, and for some elements station 30. The results of successive surveys show a consistent distribution and concentration of most metals, with no evidence of continuing trends of increasing or decreasing concentrations.

There have been large variations in the macrobenthic community statistics over the period of the monitoring programme (1998-2015), but the spatial distribution of the different macrobenthic communities identified has remained consistent; being influenced by distance from shore, water depth and the physical structure of sediments. The most diverse and abundant communities are found at stations 26, 27, and 29 located with the central part of the survey area where sediments are coarse grained and heterogeneous; amphipods were an important feature of the macrobenthos at these positions.

The communities present at shallow water stations (20-25) in the northern part of the contract area have been variable over time with moderate abundance and low taxonomic richness, while the deepest stations (28, 31 and 32) have supported a sparse benthic community based on oligochaetes. The macrobenthic communities recorded on recent surveys were entirely consistent with historic observations and there is no evidence of an impact from operations in the area.

3.3.2. Shah Deniz Alpha Platform

A baseline survey was carried out at the Shah Deniz Alpha Platform (SDA) location in 2001, this was followed by a pre-installation survey in 2005 and a biennial monitoring programme from 2007.

The 2001 baseline survey comprised 14 stations arranged in a triangular grid pattern centred on the platform location. An additional 6 stations (15-20) were added to the array in 2005, extending the survey area to a distance of 1000m from the platform. Figure 3.3.5 gives the sample station positions for all surveys carried out at SDA from 2001*.

* In 2007 the position of stations 10 and 11 were moved to allow safe clearance of seabed assets. The revised positions were used in all future surveys.

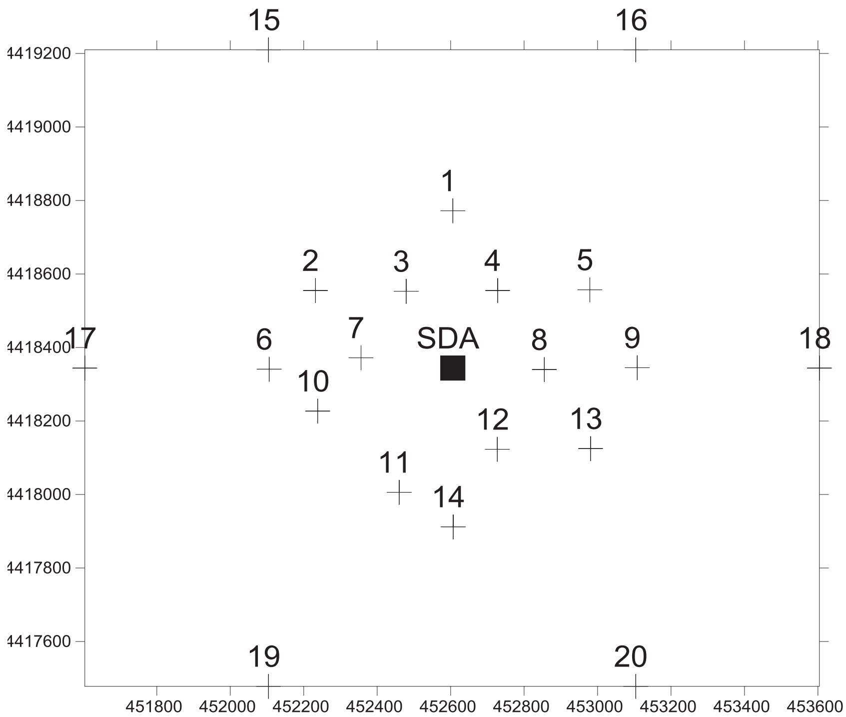


Figure 3.3.5 SDA sample stations 2001 - 2017

The SDA survey area straddles a transition between two different types of sediment, the characteristics of which have remained stable over the 2001 to 2017 monitoring period (Table 3.3.1). At the three northernmost stations (1, 15, and 16) the seabed was composed of well sorted, very fine silts, with high organic matter and a very high silt/clay content. The sediments at all other stations are coarse grained with low proportions of silt and clay (Figure 3.3.6). Stations 2 and 3 lie on the transition between the two sediments - the characteristics at these positions have fluctuated between the two main sediment types throughout the monitoring period.

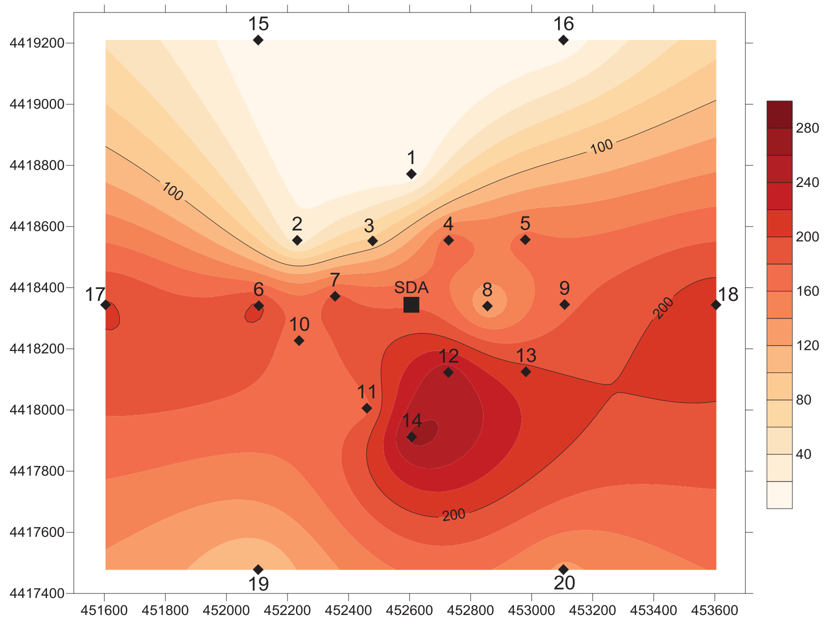


Figure 3.3.6 Contour plot of mean particle diameter (μm), SDA survey 2015

Table 3.3.1 Sediment physical properties: SDA surveys 2001 to 2017

	Survey Area Average Value							
	2001	2005	2007	2009	2011	2013	2015	2017
Mean diameter µm	184	180	181	230	158	149	144	141
Silt/Clay content %	21	29	29	28	25	28	28	28

The composition and concentration of hydrocarbons from across the SDA survey area, on all monitoring surveys, were typical of the regional background for the sediment types present; higher concentrations are naturally present in the fine silt clay sediments within the northern third of the survey area (Figure 3.3.7).

Compounds associated with the SBM component of the WBM system used at SDA were detected in samples from seven stations in 2015 and 2017, and from one station in 2013. Although a slightly different spatial distribution was observed in the 2015 and 2017 surveys, the stations where the compounds were detected were generally consistent on both surveys: predominantly located to the west, southwest and south of the platform.

The SBM concentrations present in 2013 and 2015 were typically low (>25 µg.g^{-1}), while higher concentrations were present in 2017. The highest average concentrations in 2017 were recorded at stations 7 (230µg.g^{-1}), 11 (42µg.g^{-1}) and 12 (28µg.g^{-1}). At all other stations the concentrations were very low, ranging from below the detection limit to 11µg.g^{-1} (Figure 3.3.8).

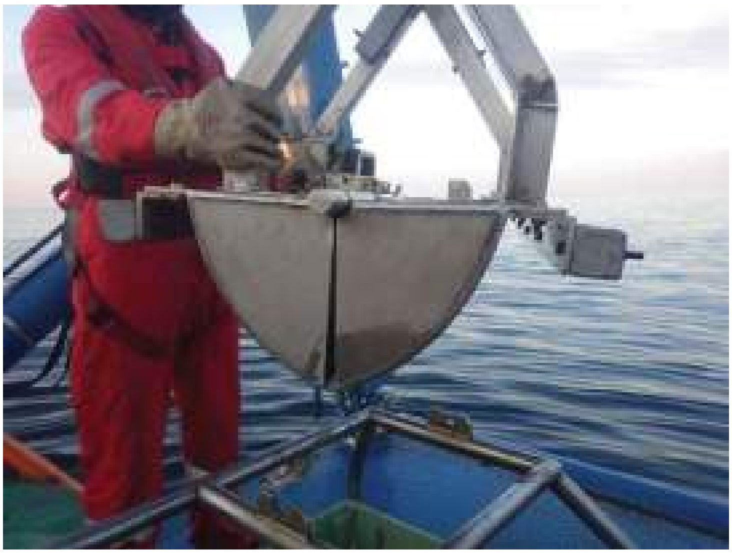
The 2017 mean THC concentration was the highest recorded over the 2001 to 2017 monitoring period (Table 3.3.2). The increase in the mean concentration between 2015 (75 µg.g^{-1}) and 2017 (139 µg.g^{-1}) was influenced by higher background concentrations recorded at stations 1 and 3, and to a lesser extent station 7 - where the higher concentration in 2017 was due to the presence of SBM. When the data from these stations were excluded, there was very little difference in the mean concentrations between 2015 ($\bar{x}$ = 25 µg.g^{-1}) and 2017 ($\bar{x}$ = 28 µg.g^{-1}).

Hydrocarbon concentrations are generally higher in surveys conducted between 2013 and 2017. It is possible that the higher THC concentrations in post-2011 surveys reflect a general increase in the concentration of sediment hydrocarbons across the survey area. However, as the small differences correspond to a change in the laboratory service provider, which took place in 2011, the higher concentrations may be the result of analytical variation.

With the exception of the high background concentrations at stations within the north of survey area, and the elevated concentration at station 7 (from the presence of drilling discharges), the THC concentrations in sediments around SDA are low.

Table 3.3.2 Sediment hydrocarbon concentrations: SDA surveys 2001 to 2017

	Survey Area Average Concentration							
	2001	2005	2007	2009	2011	2013	2015	2017
THC µg.g^{-1}	100	55	35	39	40	68	75	139
Total 2-6 ring PAH ng.g^{-1}	388	214	230	247	264	336	247	312



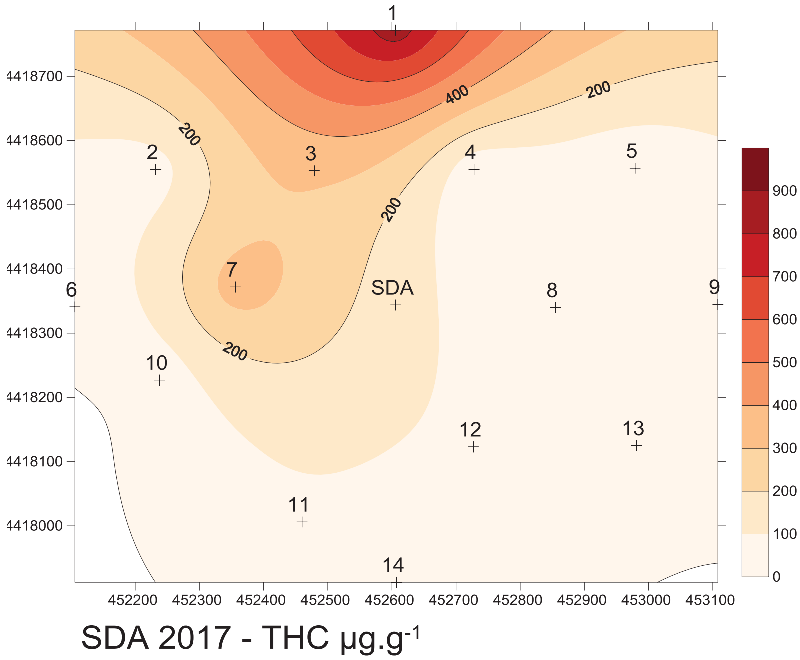


Figure 3.3.7 Spatial variation of THC concentrations, SDA survey 2017

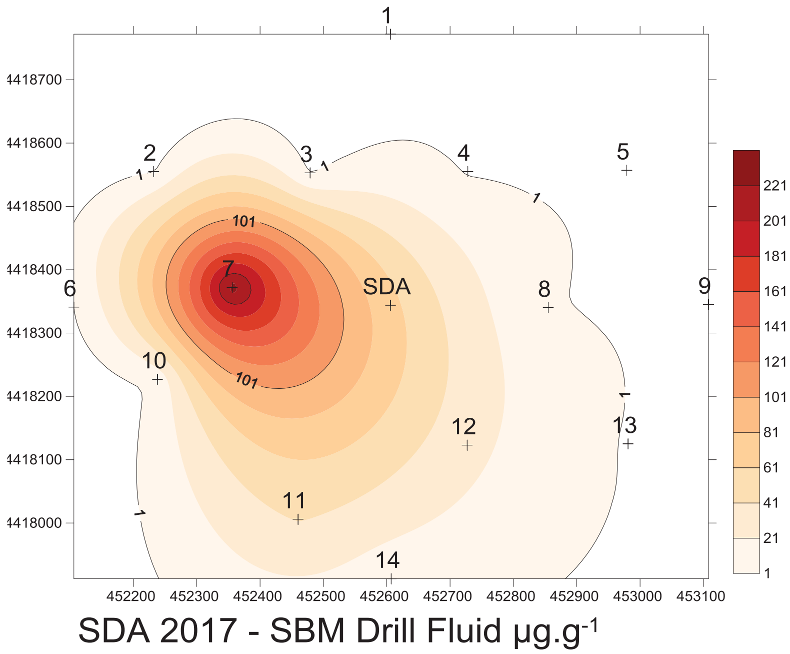


Figure 3.3.8 Spatial variation of SBM drill fluid concentrations, SDA survey 2017

The variation in sediment metal concentrations across the SDA survey area were generally related to the sediment silt and clay content and were typical of the regional background composition for the sediment types present.

As a result of the discharge of WBM drilled cuttings at SDA, elevated concentrations of Ba have been recorded at stations directly adjacent to the platform.

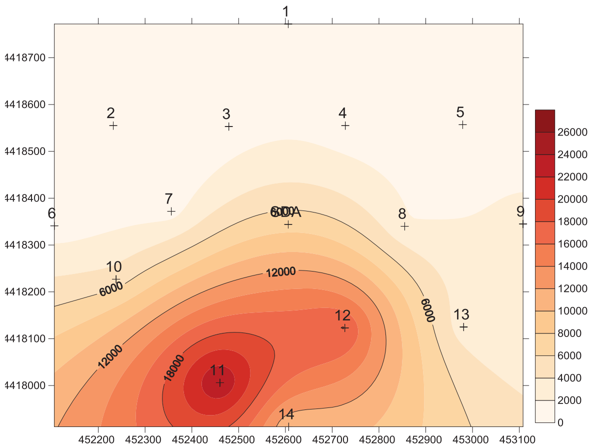
After an increase in the Ba concentration at stations 11, 12 and 14 between 2013 and 2015, the footprint of elevated Ba concentrations – indicating the presence of discharged WBM drilled cuttings – has remained relatively stable between 2015 and 2017, and includes stations 11, 12 and 14: south of the platform, and station 7: 250m west of SDA (Figure 3.3.9).

The mean concentration of barium (fusion) was highest in the two most recent surveys at SDA. These higher mean concentrations were due to the higher concentrations present at stations directly to the south and west of the platform; at all other stations the Ba concentrations were low and typical of the regional background concentration.

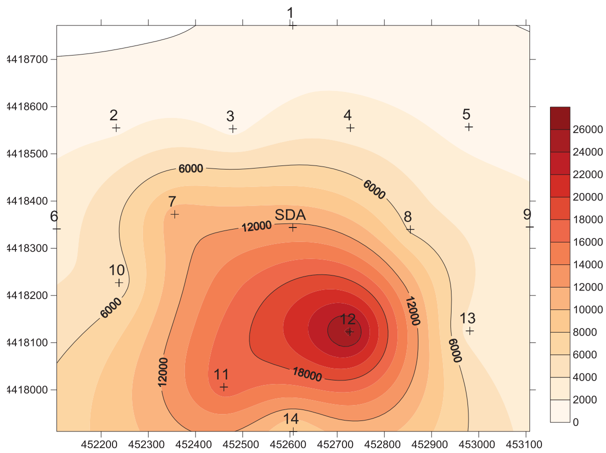
Table 3.3.3 Sediment metal concentrations: SDA surveys 2001 to 2017

	Survey Area Mean Concentration mg.kg^{-1}							
	2001	**2005**	**2007**	**2009**	**2011**	**2013**	**2015**	**2017**
As	9	8	10	13	12	11	12	10
Ba HNO_3	1343	532	892	703	1465	1578	2323	3647
Ba Fusion	NM	1260	1830	1145	1987	2183	3999	6469
Cd	NM	0.12	0.16	0.18	0.16	0.15	0.15	0.12
Cr	28	42	29	33	31	34	30	33
Cu	16	10	14	11	12	15	14	10
Fe	15330	18066	20329	19073	19901	20057	19519	17717
Hg	0.031	0.029	0.034	0.031	0.049	0.039	0.039	0.051
Mn	NM	NM	588	606	643	634	639	608
Pb	22	9	10	12	10	11	11	15
Zn	NM	35	35	40	44	44	45	38

NM Not Measured



SDA 2015 - Ba (Fusion) mg.kg^{-1}



SDA 2017 - Ba (Fusion) mg.kg^{-1}

Figure 3.3.9 Spatial variation of Ba fusion concentrations (mg.kg^{-1}), SDA surveys 2015 & 2017

The 2017 macrobenthic community in the SDA survey area was numerically dominated by amphipod crustaceans and polychaetes. The abundance of all other taxonomic groups was low (Table 3.3.4).

While the average abundance of most taxonomic groups in 2017 was comparable to the communities present in previous surveys, the average abundance of polychaetes increased substantially between 2015 and 2017, becoming the numerically co-dominant taxa with amphipods. Although the survey wide average abundance of amphipods was comparable to the averages recorded in previous surveys, large variations in abundance were observed at individual stations between 2015 and 2017.

The greatest reduction in amphipod abundance and increase in polychaete abundance between 2015 and 2017 was observed at stations directly to the west and south of the SDA platform. As this localised area corresponds to the drilling discharge contamination footprint, it is possible that the faunal variation observed within this area may have been influenced by drilling discharges from SDA.

Table 3.3.4 Taxa in survey area and station average abundance ($N.m^{-2}$) for major taxonomic groups, SDA surveys 2001 to 2017

		2001	2005	2007	2009	2011	2013	2015	2017
Class Polychaeta	Taxa	5	6	8	7	7	5	5	5
	$n.m^{-2}$	1270	1909	1262	953	504	249	605	4117
Class Oligochaeta	Taxa	3	4	3	3	3	3	3	3
	$n.m^{-2}$	325	265	137	177	173	134	117	118
Order Cumacea	Taxa	8	10	13	10	9	9	8	7
	$n.m^{-2}$	149	237	253	52	67	139	194	117
Order Amphipoda	Taxa	29	28	33	33	31	30	32	29
	$n.m^{-2}$	703	2074	1806	1757	1831	3113	4151	3962
Order Isopoda	Taxa	2	2	2	1	1	1	1	1
	$n.m^{-2}$	4	14	2	2	1	2	1	<1
Class Insecta	$n.m^{-2}$	33	45	32	25	2	1	4	1
Class Gastropoda	Taxa	4	18	27	18	12	12	12	5
	$n.m^{-2}$	37	108	209	22	11	8	15	5
Class Bivalvia	Taxa	5	5	5	4	3	5	4	3
	$n.m^{-2}$	384	1095	172	51	21	26	13	6

3.3.3. SDX-4 Well Site

A pre-drill baseline survey was carried out at the SDX-4 well site in 2005 and was followed by a post-drill survey in 2008. The location of the SDX-4 well site within the SD contract area is provided in Figure 3.3.10. The 2005 baseline survey comprised 7 stations arranged in a cross design centred on the well site, while the post-drill survey comprised 22 stations (Figure 3.3.11).

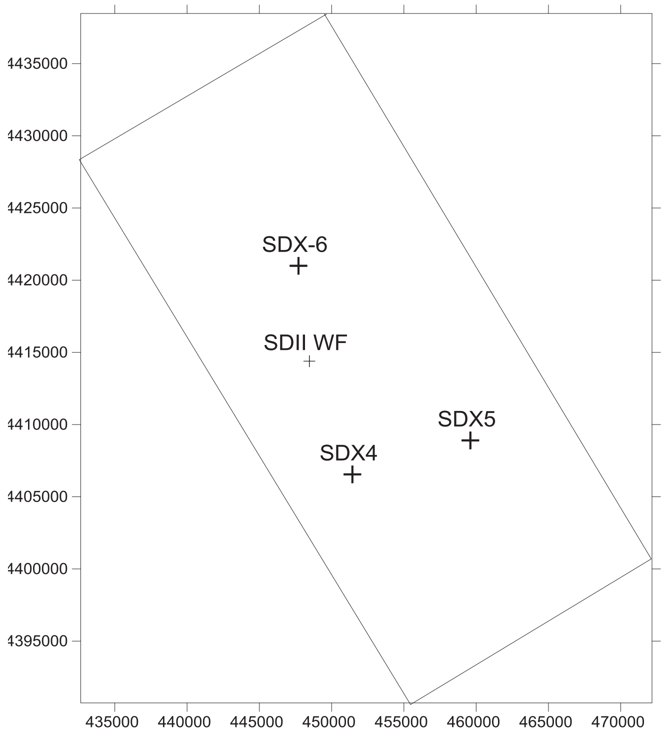


Figure 3.3.10 Position of SDX4, SDX5, SDX6 & SDII-WF Well Sites

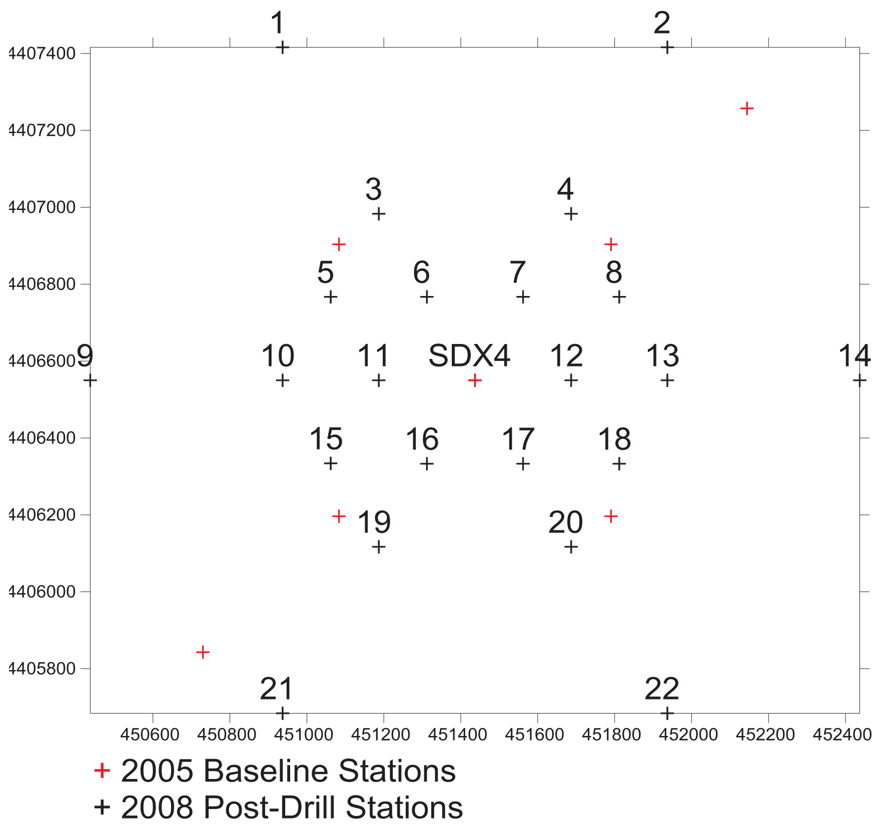


Figure 3.3.11 SDX-4 sample stations, 2005 & 2008 surveys

Sediments within the SDX-4 survey area, on both surveys, were a homogenous very fine silt/clay with almost no variation across the survey area.

Hydrocarbon and metal results from the 2008 post-drill survey were very similar to those recorded during the 2005 baseline survey, and were characteristic of the concentrations recorded from comparable locations and depths within the SD contract area.

Higher levels of Ba were recorded at two stations adjacent to the platform in 2008, possibly indicating the presence of small amounts WBM discharged during drilling (Figure 3.3.12).

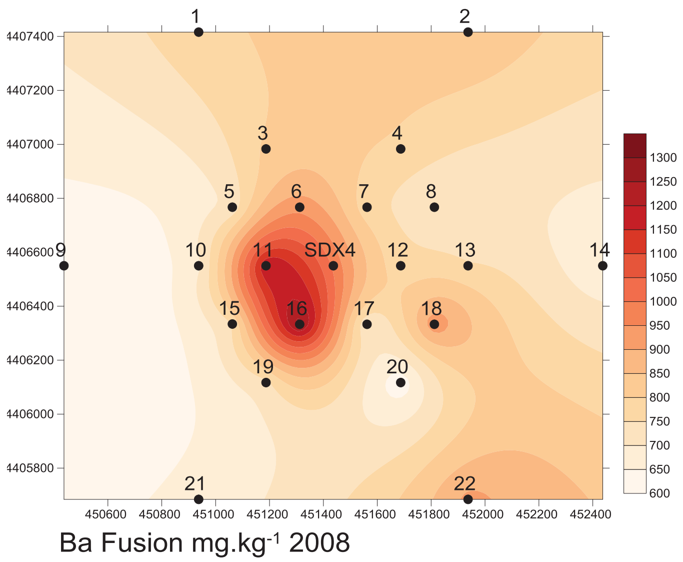


Figure 3.3.12 Ba fusion concentrations, SDX-4 post-drill survey 2008

The macrobenthic community was characterised by low abundance and species richness throughout and was dominated by annelids. Overall, the community present was similar to those present in the 2005 SDX4 baseline survey and the results from previous surveys from a similar depth and location. There was no evidence of impact to the macrobenthic community from the drilling operations at SDX-4.

3.3.4. SDX-5 Well Site

A baseline survey was carried out at the SDX-5 (Figure 3.3.10) well site in 2007 and was followed by a post drill survey in 2010. The survey design consisted of 13 sample stations, the layout of stations is given in Figure 3.3.13. Due to the presence of a Navy prohibited area, no samples could be taken west of stations 14, 9, 4 & 1.

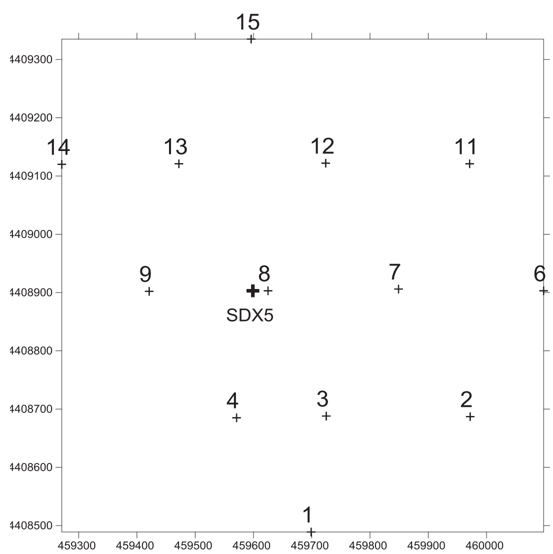


Figure 3.3.13 SDX-5 sample stations, 2007 & 2010 surveys

Sediments within the SDX-5 survey area, on both surveys, were a homogenous very fine silt/clay with almost no variation across the survey area. Slightly coarser sediments were present at station 8 (adjacent to the well site) in 2010, suggesting the presence of discharged drill cuttings.

The presence of hydrocarbon compounds indicative of SBM were detected in samples from stations 4 and 8. SBM drilled cuttings were not intentionally discharged during drilling at SDX-5. It is possible that the SBM present at stations 4 and 8 was the result of a discharge of WBM cuttings which were contaminated with SBM drilling fluids.

Very high concentrations of Ba (fusion) were recorded at station 8 in 2010, indicating the presence of discharged water based drilling mud. Other than slightly higher concentrations at stations 3 and 11, the Ba levels at all other stations were unchanged from those recorded in 2007.

As a result of the depth of the survey area (>500m), the macrobenthic community on both surveys was characterised by extremely low abundance and species richness throughout.

With the exception of the SBM and high concentrations of Ba at station 8, the metal composition and hydrocarbon content in sediments in 2010 were similar to those recorded in the 2007 baseline survey, indicating that contamination from drilling discharges at SDX-5 was isolated to station 8 - directly adjacent to the well site.

3.3.5. SDX-6 Well Site

A baseline survey was conducted at the SDX-6 well site in 2008 (Figure 3.3.10). A post-drill survey will be carried out on completion of the drilling/construction activities.

3.3.6. SDII-WF Well Site

A pre-drill baseline survey was carried out at the SDII-WF well site in 2009 and was followed by a post-drill survey in 2016. The location of the SDII-WF well site within the SD contract area is provided in Figure 3.3.10, above. The position of the SDII-WF sample stations is provide in Figure 3.3.14, below.

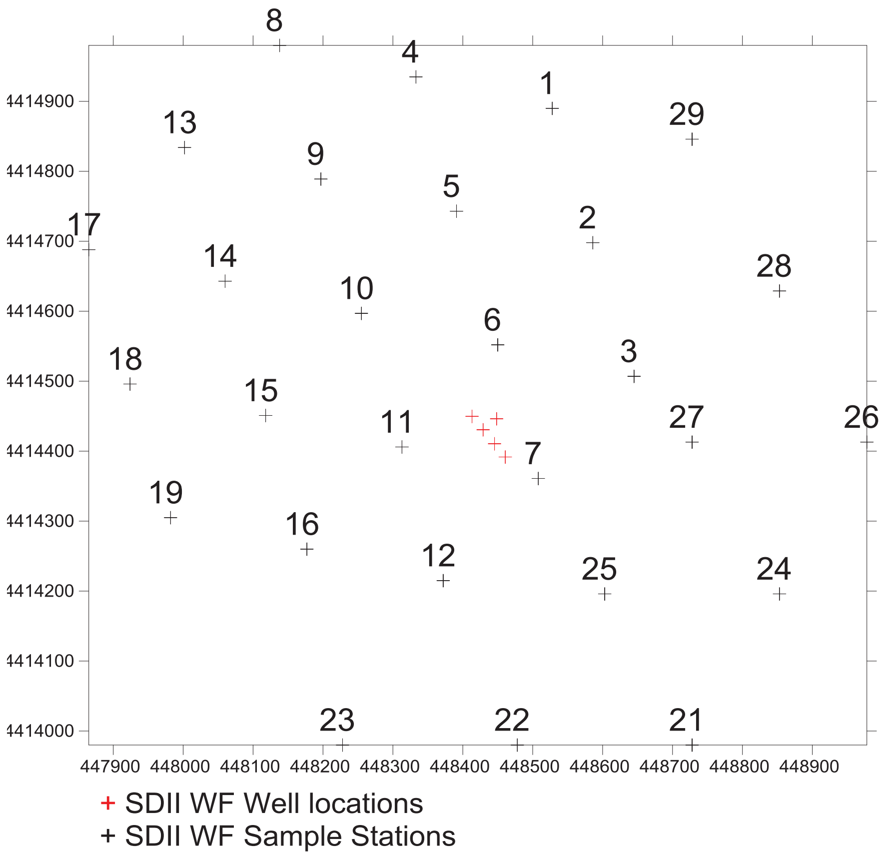


Figure 3.3.14 SDII-WF sample stations, 2009 & 2016.

The geographical variation in the physical characteristics and survey area mean values in 2016 were similar to those observed in 2009 (Table 3.3.5).

Total hydrocarbon concentrations at a number of stations were heavily influenced by high concentrations of compounds associated with hydrocarbon-based drilling fluids. The highest concentrations were centred on station 7 located directly to the southeast of the well cluster and extended predominantly to the east, southwest and south of the well site. These compounds were either absent or present in very low concentrations in the north-western half of the survey area (Figure 3.3.15).

The spatial distributions of PAH and TPH in 2016 were very similar to those observed in 2009. An increase in the concentration of TPH and PAH was recorded throughout the survey area in 2016 (Table 3.3.5); the increase in the concentration of both measures were generally highest at stations within the south-eastern half of the survey area. The relationship between the distribution of HC drilling fluid compounds and the increase in TPH or PAH was weak, suggesting that, in general, the large increases in TPH and PAH recorded in 2016 were not entirely related to drilling discharges.

Table 3.3.5 SDII-WF physical characteristics & hydrocarbon concentrations: survey area mean values, 2009 & 2016

	2009	2016
Mean diameter µm	26	22
Silt/Clay %	66	61
TPH µg.g^{-1}	34	154
2-6 Ring PAH ng.g^{-1}	232	179

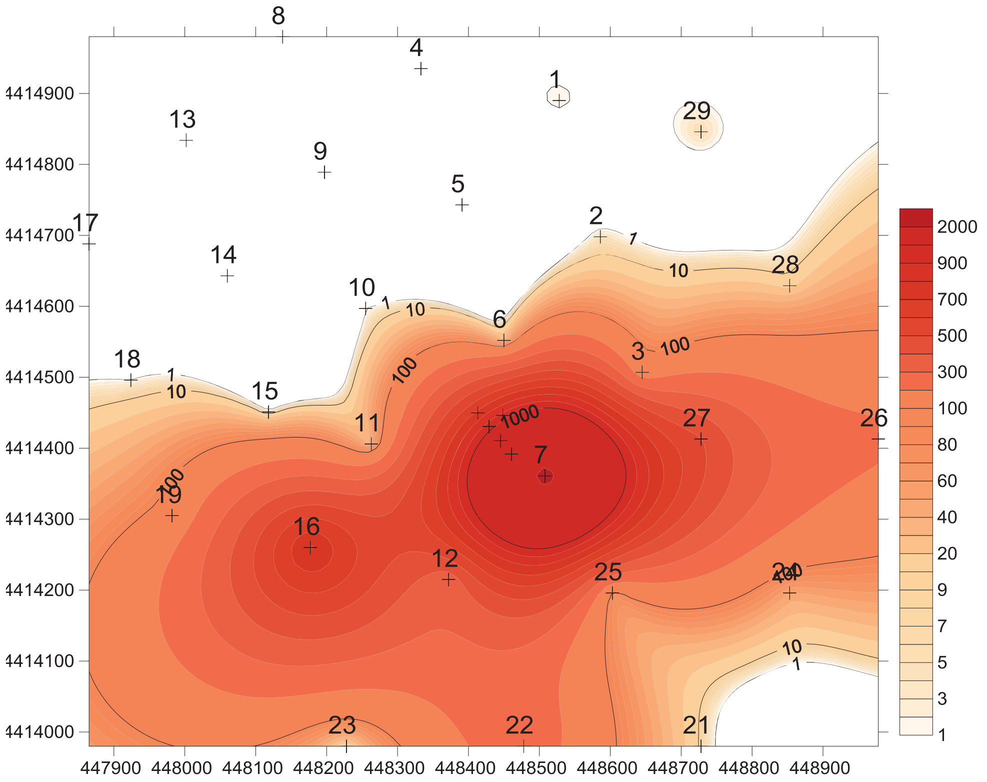


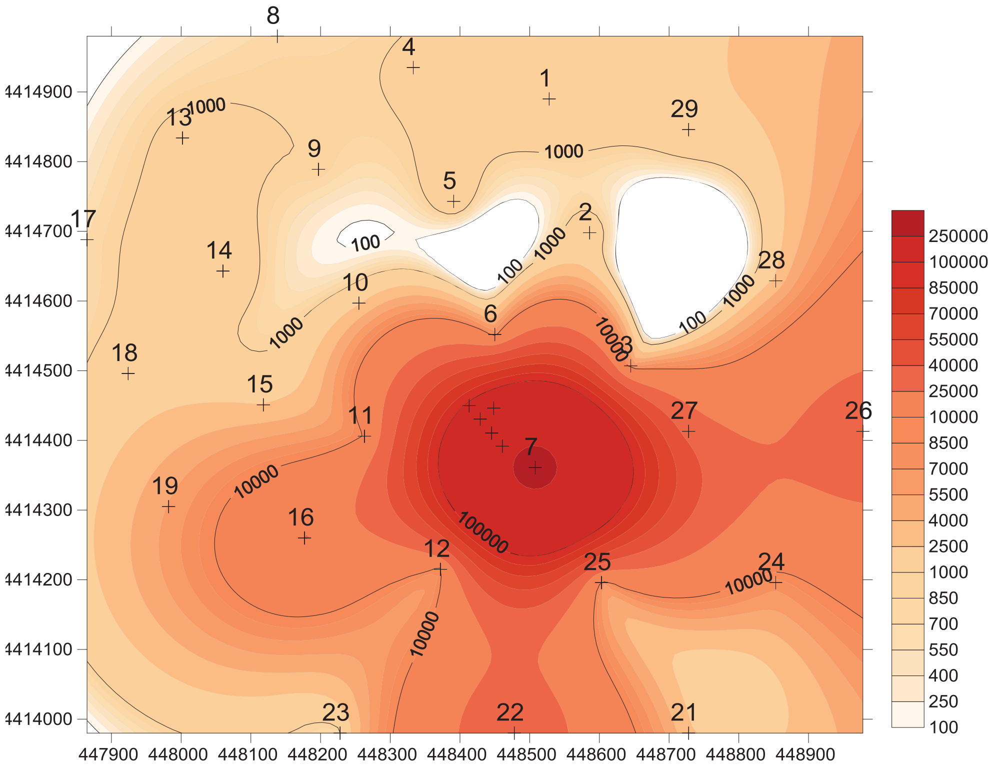
Figure 3.3.15 Station average hydrocarbon-based drilling fluid concentrations, SDII-WF post drill Survey, 2016

The distribution of most metals was associated with natural variations in sediment silt & clay content and the survey wide concentrations were relatively similar on both surveys (Table 3.3.6). The discharge of WBM has resulted in a highly elevated concentration of Ba at station 7 directly to the SE of the well cluster. The footprint of elevated Ba concentrations (>10,000mg.kg^{-1}) extends 550m east, 300m west and 450m south from the centre of the well cluster (Figure 3.3.16).

Table 3.3.6 SDII-WF sediment metals: survey area mean concentration (mg.kg^{-1}), 2009 & 2016

	2009	2016
As	18	11
Ba HNO3	325	3101
Ba Fusion	489	18272
Cd	0.13	0.11
Cr	60	45
Cu	21	19

	2009	2016
Fe	26371	22806
Hg	0.05	0.01
Mn	525	520
Pb	16	13
Zn	63	55



SDII-WF 2016 - Ba Fusion mg.kg^{-1}
Logarithmic Scale

Figure 3.3.16 Spatial variation of Ba (fusion) concentrations (mg.kg^{-1}), SDII-WF post-drill survey, 2016

Overall the 2016 macrobenthic community had fewer taxa and a lower average abundance than the community present in 2009. Community changes with regard to polychaete community structure and gastropod presence were consistent with regional fluctuations and were not associated with drilling activities (Table 3.3.7).

The similarity between the 2009 and 2016 macrobenthic communities was found to be lowest at stations within the combined Ba and HC drilling fluid contamination footprint, with the greatest change being observed at station 7. The community change within this area was characterised by a reduction in oligochaete abundance greater in magnitude than that observed in other parts of the survey area, and an absence of polychaete species.

Table 3.3.7 Taxa in survey area & station average abundance (N.m^{-2}) for major taxonomic groups, SDII-WF 2009 baseline survey & 2016 post-drill survey

		2009	2016
Polychaeta	Taxa	4	3
	n.m^{-2}	55	30
Oligochaeta	Taxa	4	3
	n.m^{-2}	607	253
Cumacea	Taxa	8	7
	n.m^{-2}	62	178
Amphipoda	Taxa	20	14
	n.m^{-2}	128	120

		2009	2016
Isopoda	n.m^{-2}	0	1
Insecta	n.m^{-2}	24	3
Bivalvia	n.m^{-2}	0	<1
Gastropoda	Taxa	13	0
	n.m^{-2}	4	0
Total	Taxa	51	30
	n.m^{-2}	879	585

The greatest impact from drilling discharges was observed at station 7: 100m SE of the well cluster. The highest concentrations of Ba and HC drilling fluid compounds were recorded at this position along with the greatest community change.

The combined Ba and HC drilling fluid contamination footprint covered an area 550m east and 450m west and south from the centre of the well cluster. As the macrobenthic communities within this area exhibited the least similarity to the 2009 baseline community, it is likely that drilling discharges have influenced the different community structure present within this wider area.

3.3.7. Shah Deniz Phase II Baseline Surveys

As part of the Shah Deniz Phase II development, baseline surveys were carried out in 2011 at the planned position of the

- Shah Deniz Bravo Platform (SDB)
- SDII East North Manifold (SDEN)
- SDII East South Manifold (SDES)
- SDII West Manifold (SDW)
- SDII West South Manifold (SDWS)

The planned location of each installation and centre point of each baseline survey is shown in Figure 3.3.17.

The objective of each survey was to provide data on the current status of the benthic environment, providing information on the physical characteristics, sediment chemistry (hydrocarbon and metal content) and macrobenthic fauna (species abundance & biomass) at each location. Post-installation surveys will be carried out at each location when drilling/construction activities have been completed.

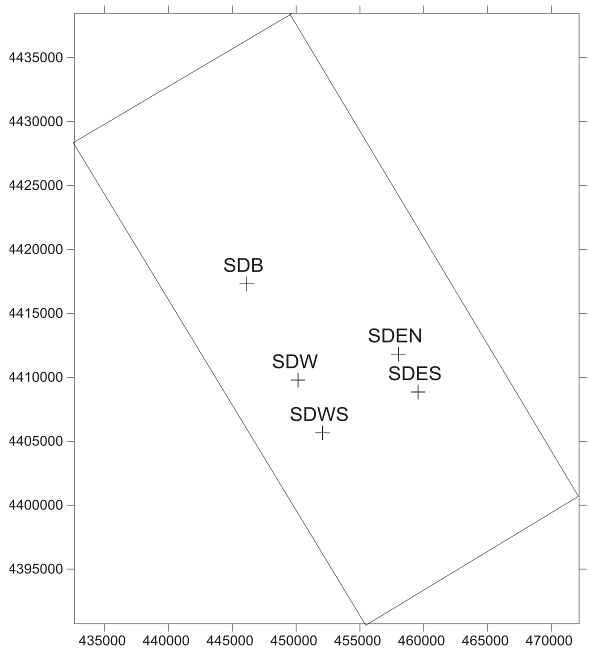


Figure 3.3.17 Planned position of SDII installations

3.4. 2017 Baseline Surveys

Baseline surveys were carried out at the following locations in 2017

- Shafag Asiman Field – Proposed platform location
- ACG Contract Area – ACE - Azeri Central East proposed platform location
- SD Contract Area – SDX-8 well site proposed SD3 platform location

Post-drill/installation surveys will be carried out at each location on completion of the drilling and construction activities.

3.5. Environmental summary of offshore fields

Table 3.5.1 Summary of the environmental status of offshore platform locations

Platform	Survey Period	Current Status	
		Sediment	**Macrobenthos**
Central Azeri	1998-2016	Elevated barium concentrations recorded at stations located within 500m of the platform due to WBM discharge. No significant hydrocarbon contamination.	Spatial variations associated with natural differences in sediment structure. No evidence of any influence from activities at the platform.
East Azeri	2002-2016	Elevated barium concentrations recorded at stations located within 300m of the platform due to WBM discharge. No significant hydrocarbon contamination.	Spatial variations associated with natural differences in sediment structure. No evidence of any influence from activities at the platform.
West Azeri	2002-2017	High levels of weathered, hydrocarbon-based, drilling fluid and heavy metals (from Pre-AIOC activity) recorded 300m northwest of the platform. Elevated barium concentrations recorded at stations located within 300m of the platform due to WBM discharge. No evidence of significant hydrocarbon contamination from recent operations.	Most of the spatial variability is associated with natural differences in sediment structure. Distinctly different benthic communities consistently recorded northwest of the platform. The sparse communities present at these locations are likely related to pre-AIOC drilling operations and there is no evidence of any influence from recent BP operations.
DWG	2001-2017	Elevated barium concentrations recorded at stations located within 500m of the platform due to WBM drilling discharge. No significant hydrocarbon contamination.	Spatial variations associated with natural differences in sediment structure. No evidence of any influence from activities at the platform.
Chirag	1998-2017	Evidence of deposition of synthetic OBM cuttings (increased levels of hydrocarbons, barium and metals) recorded in sediments collected within 500-600 m of the platform.	Lower abundance of amphipods recorded at stations within the area historically affected by drilling discharges. Despite the general recovery observed over recent surveys within the area historically affected by drilling discharges, the community at the station adjacent to the discharge point remains distinct. The lack of recovery at this position is likely due to ongoing drilling discharges. Other spatial variations observed are associated with natural differences in the sediment structure.
West Chirag	2009-2016	Elevated barium concentrations recorded at stations located within 400m to the north, west and northeast of the platform due to WBM discharge. No significant hydrocarbon contamination.	Spatial variations associated with natural differences in sediment structure. No evidence of any influence from activities at the platform
SDA	2001-2017	Elevated barium concentrations and SBM drilling fluid compounds recorded at stations located within 300m to the south and west of the platform due to WBM drilling discharge.	Spatial variations are associated with natural differences in the sediment physical composition. Possible macrofaunal variation - reduced amphipod abundance and increased polychaete abundance - at stations within the drilling discharge affected area.

3.6. Regional Water & Plankton Surveys

Water quality and plankton sampling have been carried out within the ACG and SD contract areas and along the ACG-Sangachal Pipeline route between 2000 and 2015 (Table 3.6.1).

Table 3.6.1 Water & plankton survey schedule 2000-2015

Year		2000	2001	2004	2005	2006	2008	2009	2010	2011	2012	2013	2014	2015
ACG Contract Area	Water Quality			+	+	+	+		+		+		+	
	Plankton			+	+	+	+		+		+		+	
ACG Pipeline	Water Quality	+				+	+		+		+		+	
	Plankton	+			+	+	+		+		+		+	
Shah Deniz Contract Area	Water Quality	+	+		+			+		+		+		+
	Plankton	+	+		+			+		+		+		+

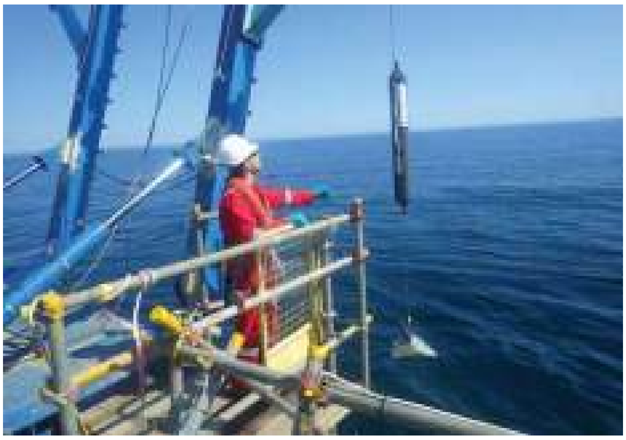
3.6.1. ACG & ACG-Sangachal pipeline route water & plankton surveys

Figure 3.6.1 below gives the position of the ACG Regional water sampling stations and pipeline route plankton sampling stations. Figure 3.6.2 gives the position of the ACG survey area plankton sampling stations.

The water column was stratified on all surveys, with a major temperature decline of more than 10 °C between 15 and 40 metres water depth. This pronounced thermocline isolates the surface layer from the deeper sub-thermocline layer.

Turbidity and salinity of water samples showed spatial variation indicative of an influence of proximity to land. Stations closer to shore had lower salinity and higher turbidity/suspend solids (TSS) than stations further offshore. Concentrations of metals were generally low, and the variation was patchy. Iron concentrations, however, displayed a fairly clear influence of proximity to land, with highest concentrations found at the stations with high TSS levels. Hydrocarbon content, BOD and COD were generally below the detection limit in all samples over the monitoring period.

Nutrient levels were generally higher in samples collected from below the thermocline, indicating that the removal of nutrients by phytoplankton metabolism was more prevalent in surface waters above the thermocline.



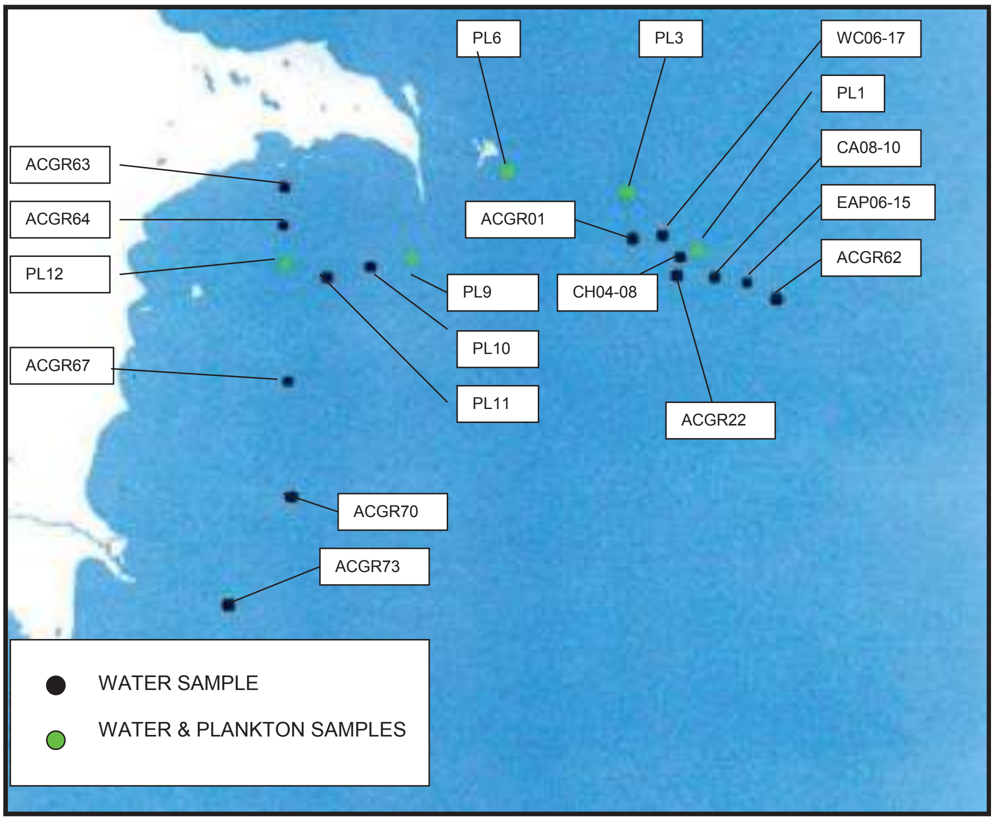


Figure 3.6.1 Locations of all ACG Contract Area & pipeline route water & plankton sampling stations

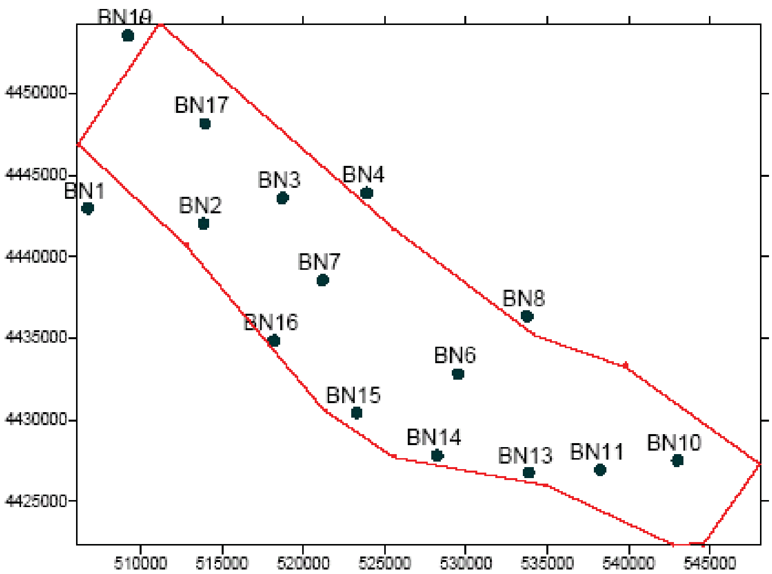


Figure 3.6.2 Location of ACG regional plankton sample stations

Plankton samples were collected at 15 stations in the ACG contract area and 5 stations along the ACG-Sangachal Pipeline route. Samples were collected by surface trawls of ~100m, using a double bongo net system with mesh sizes of 53 and 200µm.

Table 3.6.2 below gives the number of phytoplankton taxa recorded for each main taxonomic group on all surveys from 2004. The data has been separated between the samples collected within the ACG contract area and samples collected along the pipeline route.

The number of taxa recorded in 2014 is the highest recorded in the ACG contract area, which is mainly due to a large number of bacillariophyta (diatom) species. It should also be noted that the five chlorophyta species recorded in 2014 is the highest observed in the survey area.

There has been little change in recent surveys in the total number of taxa and distribution between taxonomic groups at stations along the pipeline route. As observed within the ACG survey area, there has been an increase in the number of chlorophyta species in 2014. However, the number of cyanophyta species has reduced at pipeline stations, with the single species in 2014 the lowest number recorded. The large numbers of bacillariophyta species observed at offshore ACG stations are not present at coastal pipeline stations.

Table 3.6.2 Taxonomic richness of major phytoplankton groups, ACG regional and pipeline route surveys, 2000-2014

	ACG Contract Area						
Phytoplankton Group	**2004**	**2005**	**2006**	**2008**	**2010**	**2012**	**2014**
Cyanophyta	5	6	7	7	9	3	6
Bacillariophyta	16	12	18	10	11	12	23
Dinophyta	9	6	11	13	12	8	13
Chlorophyta	1	0	0	1	1	1	5
Euglenophyta	0	0	0	1	0	0	0
Total :	31	24	36	32	33	24	47

	ACG-Sangachal Pipeline Route						
Phytoplankton Group	**2000**	**2005**	**2006**	**2008**	**2010**	**2012**	**2014**
Cyanophyta	7	2	4	5	7	4	1
Bacillariophyta	10	4	14	17	7	13	14
Dinophyta	5	5	9	8	10	9	8
Chlorophyta	1	0	0	0	1	1	3
Total :	23	11	27	30	25	27	26

Table 3.6.3 below gives the zooplankton species recorded in 53 µm and 200 µm net samples from 2006 to 2014.

Cladocera were the most species rich group in ACG 200 µm net collected samples on all surveys. Overall there has been very little change in the number of species recorded in each group between 2006 and 2014. When the pipeline and ACG data are compared, a generally higher number of Cladoceran species are present in ACG samples than pipeline samples, and although being consistently present in pipeline samples, Rotatoria are absent from ACG samples. This indicates a difference in the composition of coastal and offshore zooplankton communities.

In numerical terms, and as a proportion of zooplankton biomass, the zooplankton community was dominated at all stations by the copepod *Acartia tonsa*. The other ecologically significant observation was the presence in all samples of the invasive ctenophore *Mnemiopsis leidyi*. Its density in 2014 ranged from 34 to 67 individuals per cubic metre of seawater, a similar but less spatially variable density to the 16 to 94 individuals per m^3 recorded in 2012. This organism appears to have become established as a permanent component of the zooplankton in the middle Caspian Sea, but has not been found at the high densities known to have caused environmental problems in other seas.

Table 3.6.3 Taxonomic richness of zooplankton groups, ACG regional and pipeline route surveys, 2006-2014

	ACG 200µm Net					ACG 53µm Net				
	2006	2008	2010	2012	2014	2006	2008	2010	2012	2014
Cladocera	4	4	4	4	4	3	4	4	2	1
Copepoda	1	2	2	2	2	1	2	2	2	2
Ostracoda		1	1	1	1	1	1	1	1	1
Rotatoria	1									
Mysidea Nauplii	1									
Cumacaea larvae						1				
Polychaete larvae	1				1	1	1		1	
Cirripedia Nauplii		1	1	1	1	1	1	1	1	1
Mollusc larvae		1	1	1	1		1	1	1	1
Scyphozoa		1								
Ctenophora	1	1	1	1	1					

	Pipeline 200µm Net					Pipeline 53µm Net				
	2006	2008	2010	2012	2014	2006	2008	2010	2012	2014
Cladocera	2	2	2	3	3	2	2	3	1	2
Copepoda	1	1	1	2	2	1	1	1	2	2
Ostracoda				1			1	1		1
Rotatoria		3	3	2	1		3	3	2	1
Mysidea Nauplii	1									
Cumacea larvae		1								
Polychaete larvae		1		1		1	1		1	
Cirripedia Nauplii		1	1	1	1	1	1	1	1	1
Mollusc larva							1	1		1
Scyphozoa										
Ctenophora	1	1	1	1	1					

3.6.2. Shah Deniz plankton surveys

Figure 3.6.3 gives the location of plankton sampling stations within the SD contract area.

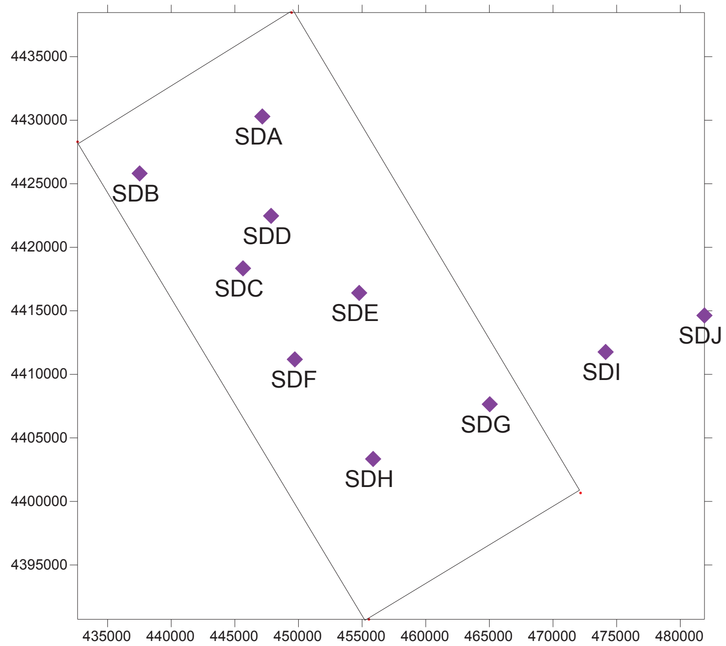


Figure 3.6.3 Location of SD regional plankton sample stations

The number of taxa, distribution of taxa between major phytoplankton groups, and identity of the commonest species in 2015 was different to the communities described in recent surveys (Table 3.6.4). Diatoms (Bacillariophyta) and dinoflagellates (Dinophyta) have consistently been important constituents of the phytoplankton community and have remained as such. In 2015, more dinoflagellate species and many more diatom species were recorded. Conversely, there were fewer species of blue-green algae (Cyanobacteria).

Table 3.6.4 Species diversity of major phytoplankton taxonomic groups, Shah Deniz regional surveys 2000-2015

	2000	2001	2005	2009	2011	2013	2015
Cyanophyta	2	4	5	8	6	6	3
Bacillariophyta	3	8	7	13	12	9	21
Dinophyta	5	9	5	12	14	14	16
Chlorophyta	0	0	1	1	1	1	2
Total	10	21	18	34	33	30	42

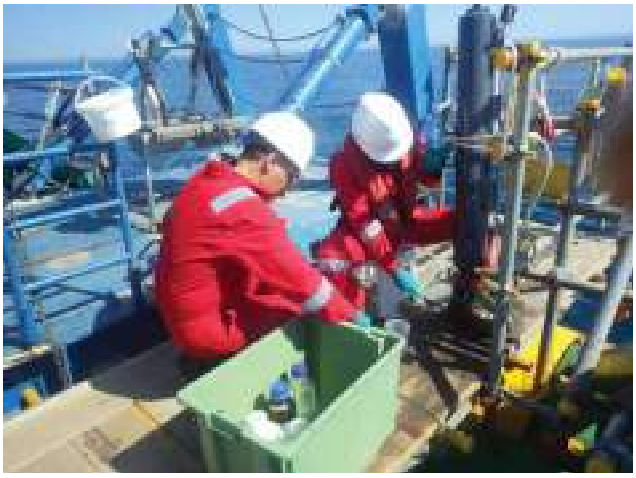
The number of taxa found in each zooplankton survey in the SD contract area is shown in Table 3.6.5. The 2015 survey shows a continuing recovery from the sparse community recorded in 2005 and 2009. The zooplankton community in 2015 was similar to the community present in 2011, though less variable over the survey area. As in all the previous Shah Deniz contract area regional surveys, *Acartia tonsa* was the dominant taxon, adult specimens constituting, on average, 39% of the individuals and 80% of the biomass.

Table 3.6.5 Zooplankton taxonomic richness, Shah Deniz regional surveys 2000-2015

Year	2000	2001	2005		2009		2011		2013		2015	
			53µm	200µm	53µm	200µm	53µm	200µm	53µm	200µm	53µm	200µm
Taxa	20	18	2	6	6	8	9	13	9	13	11	15

4

Nearshore Environmental Ambient Monitoring



4.1. Sangachal Bay Surveys

4.1.1. Sangachal Bay environmental survey

Environmental surveys are carried out at Sangachal Bay (Figure 4.1.1) to monitor potential environmental changes arising from operations at Sangachal Terminal and/or the installation/presence of pipelines within the Bay.

Surveys were initially conducted in 2000 and 2003, comprising 24 sediment sampling stations located within the northern coastal sector of the bay (North of 4449000N). In 2006 the survey design was updated to a triangular grid design comprising 57 sediment stations - covering a larger area within the Bay, and 5 water and plankton sampling stations (Figure 4.1.2)*. From 2006, surveys have been carried out at Sangachal Bay in 2008, 2010, 2013 and 2015.

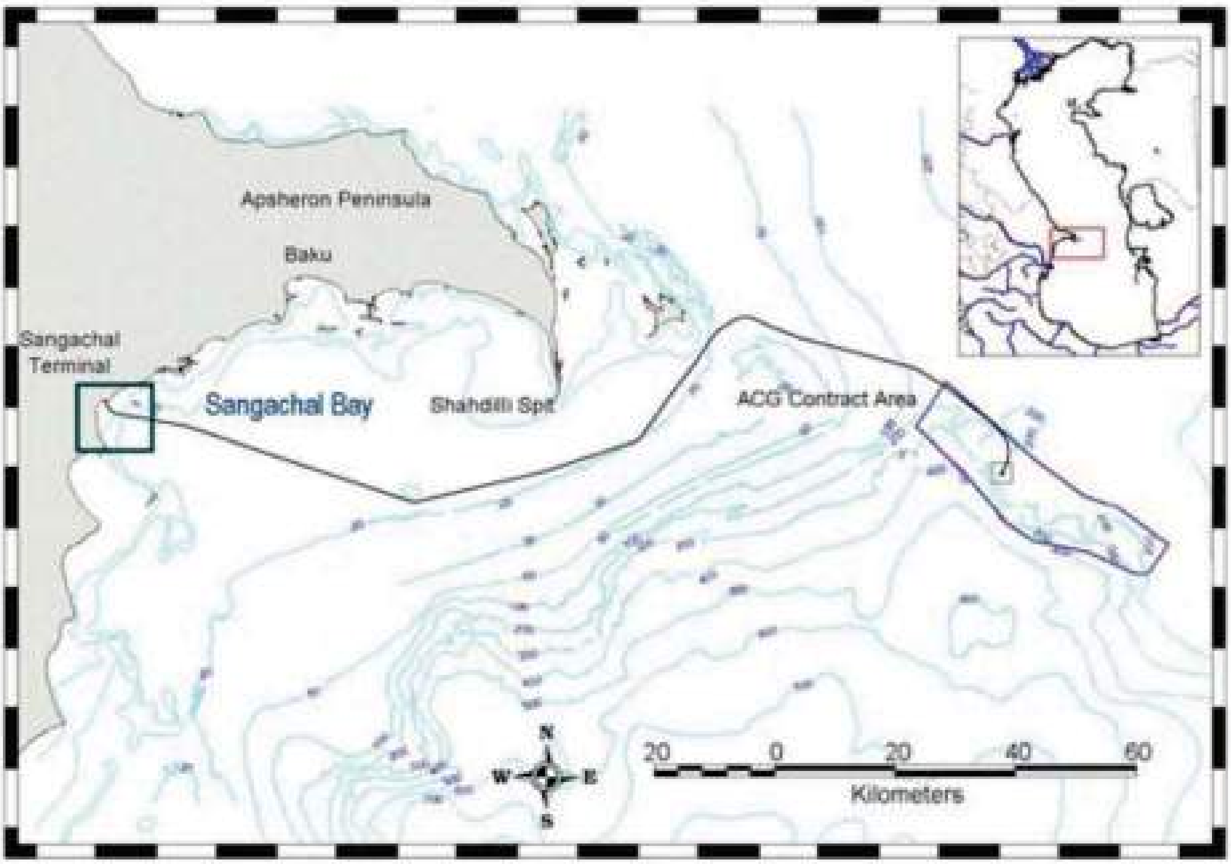


Figure 4.1.1 Sangachal Bay location

* Over the 2006 -2015 monitoring period the position of a number of sediment sampling stations have been moved slightly from their original 2006 position.

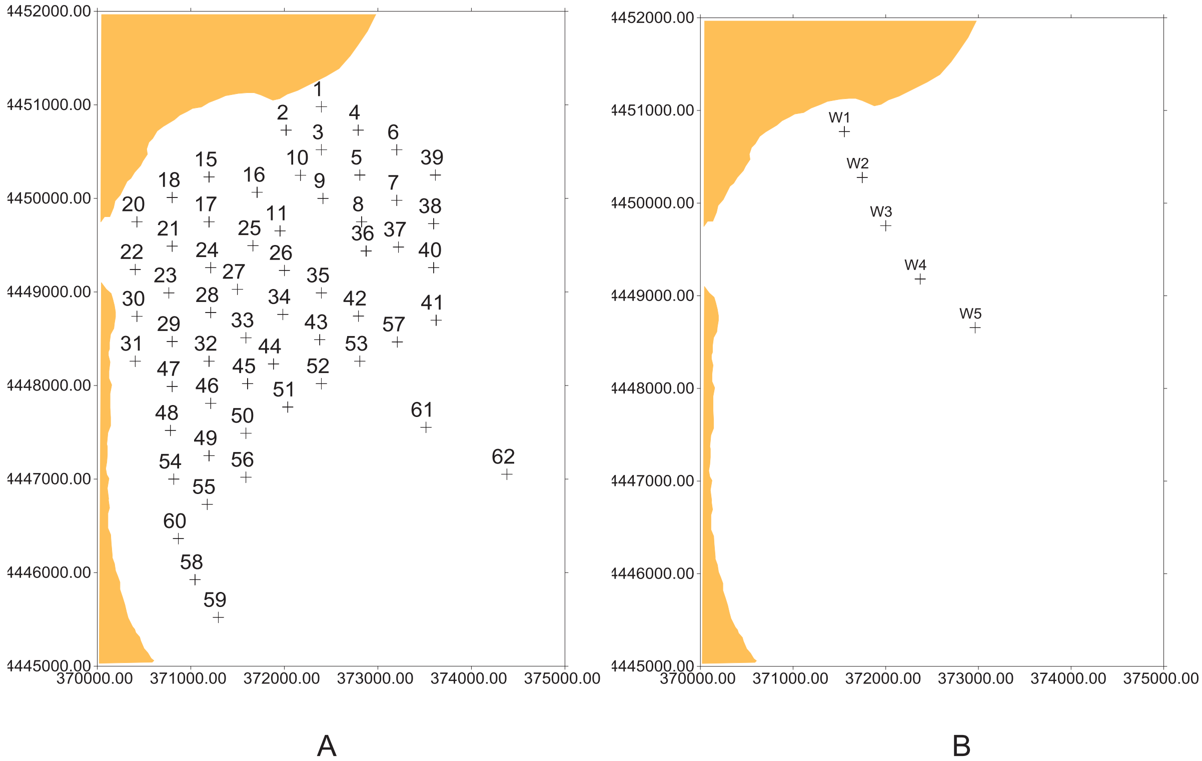


Figure 4.1.2 2006 Sangachal Bay sediment (A) and water (B) sampling stations

The physical characteristics of sediments within the bay cover a wide range; from homogenous very fine silt clays to heterogeneous coarser grained sediments. From 2006 the survey wide physical characteristics and distributions within the Bay have remained relatively stable (Table 4.1.1).

Table 4.1.1 Sediment physical properties: Sangachal Bay surveys 2000 to 2015

	Survey Area Average Value				
	2006	2008	2010	2013	2015
Mean Diameter µm	310	361	402	263	288
Silt/Clay %	44	44	45	48	44

There is a high level of variability in the hydrocarbon characteristics of the sediments across the survey area but distribution patterns have remained broadly similar over time. The highest concentrations have consistently been recorded at stations on the eastern boundary of the survey area, particularly at stations 61 and 62 extending to the southeast of the Bay, marking the transition to the more heavily contaminated sediments in the deeper waters outside of Sangachal Bay (Figure 4.1.3). The higher hydrocarbon concentrations outside the Bay originate from historical industrial sources and are not related to BP operations.

Although the distribution pattern did not alter, increases in hydrocarbon concentrations were recorded at eastern stations in 2013 and 2015, resulting in a higher survey area average concentration (Table 4.1.2). The compounds present were heavily weathered and characteristic of those present in sediments outside of the bay. It is likely that the increases in concentration were the result of inputs of contaminated sediments from outside of the Bay, by natural physical processes.

The concentration and spatial distribution of sediment metals have remained stable over the monitoring period (Table 4.1.3). The majority of metal exhibit the same spatial pattern as sediment silt/clay content, while barium, mercury and lead had a similar distribution to hydrocarbon compounds, indicating the influence of more heavily, historically contaminated sediment from outside the bay.

There has been no evidence that BP operations have influenced the hydrocarbon and metal composition of sediments within Sangachal Bay over the 2000-2015 monitoring period.

Table 4.1.2 THC and PAH concentrations, Sangachal Bay surveys 2006 – 2015

	Survey Area Average Concentration				
	2006	2008	2010	2013	2015
THC µg.g^{-1}	55	34	34	64	80
Total 2-6 Ring PAH ng.g^{-1}	159	108	121	168	101

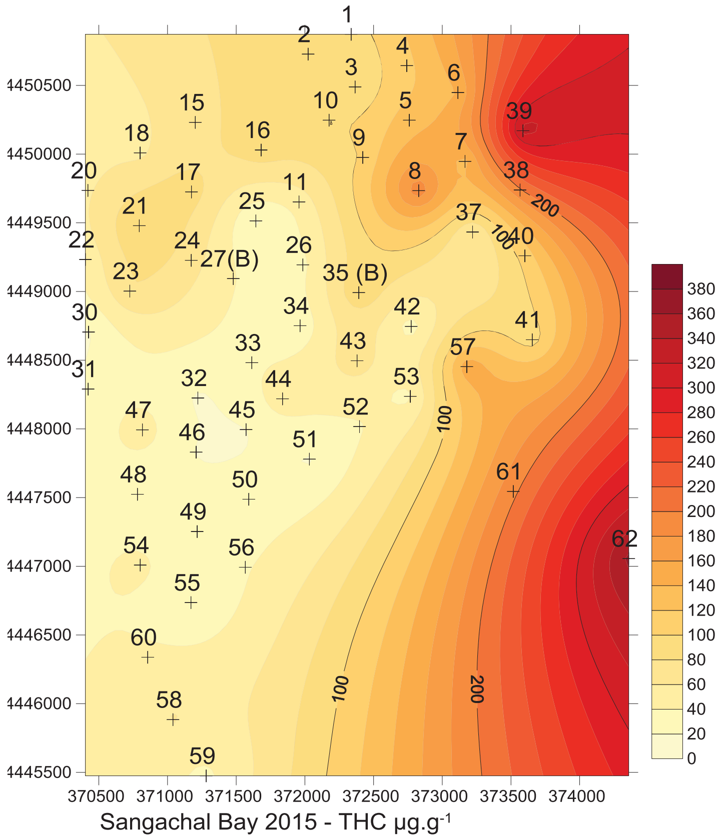


Figure 4.1.3 THC concentrations, Sangachal Bay survey 2015

Table 4.1.3 Sediment metal concentrations, Sangachal Bay surveys 2006-2015

	Survey Area Average Concentration mg.kg^{-1}				
	2006	2008	2010	2013	2015
As	23	18	20	17	18
Ba HNO_3	366	318	288	354	331
Ba total (fusion)	NM	368	455	451	453
Cd	0.20	0.27	0.38	0.28	0.28
Cr	43	48	36	42	37
Cu	31	30	25	27	25
Fe	28885	27468	22542	26155	24585
Hg	0.038	0.039	0.037	0.039	0.039
Mn	738	663	564	664	642
Pb	15	16	15	15	16
Zn	64	63	50	59	58

NM Not Measured

The macrobenthic communities were, as previously observed, highly variable in species composition, biomass, and abundance across the survey area. The macrobenthic community in 2015 was largely similar to that observed in 2013, with communities in both surveys dominated by polychaetes, oligochaetes and bivalves (Table 4.1.4).

The different communities were broadly grouped geographically and the patterns in the faunal distribution was related to the physical characteristics of the sediment. There was no relationship between faunal communities and the distribution of hydrocarbons or metals and so no indication that contamination has had an impact on the macrobenthic community in any part of the survey area.

The community composition has varied over the survey area, particularly between the pre and post 2010 surveys, with the later having a higher abundance of polychaetes. Overall the macrobenthic communities in Sangachal Bay appear to be dynamic, but relatively stable on average over the period of surveys.

Table 4.1.4 Total taxa and station average abundance (N.m^{-2}) for major taxonomic groups, Sangachal Bay surveys 2006 to 2015

		2006	2008	2010	2013	2015
Polychaeta	Taxa	3	5	4	5	5
	N.m^{-2}	144	105	437	2772	1500
Oligochaeta	Taxa	2	4	4	4	4
	N.m^{-2}	44	151	1140	677	436
Cumacea	Taxa	1	1	0	0	2
	N.m^{-2}	0	0	0	1	1
Amphipoda	Taxa	3	12	3	8	14
	N.m^{-2}	2	9	2	4	76
Decapoda	N.m^{-2}	0	0	6	1	3
Insecta	N.m^{-2}	7	0	1	0	41
Gastropoda	Taxa	2	3	0	4	4
	N.m^{-2}	1	4	0	129	148
Bivalvia	Taxa	3	3	3	3	3
	N.m^{-2}	965	808	544	698	1541

The analysis of the water samples collected in 2015 showed no significant variation between stations and the results were similar to those recorded in previous surveys in the bay, showing no evidence of contamination of the water column.

The phytoplankton community of Sangachal Bay in 2015 was richer in species, due to an increase in the number of diatom taxa observed (Table 4.1.5). The overall structure of the phytoplankton community has remained stable with diatoms the dominant group both numerically and in terms of biomass in all surveys.

Table 4.1.5 Species diversity of major phytoplankton taxonomic groups, Sangachal Bay surveys 2006-2015

Division	2006	2008	2013	2015
Cyanophyta	8	10	12	5
Bacillariophyta	16	22	19	35
Dinophyta	6	7	10	9
Chlorophyta	0	1	1	6
Total	30	40	42	55

As observed on previous surveys, the zooplankton composition in Sangachal Bay was low in species (Table 4.1.6). The community was numerically dominated by non-native species, particularly the copepod *Acartia tonsa* and to a lesser extent the ctenophore *Mnemiopsis leidyi*. Cladocerans, which had not been recorded since the 2006 survey, were present in the 2015 samples.

Table 4.1.6 Species diversity of major zooplankton taxonomic groups, Sangachal Bay surveys 2006-2015

Group	2006	2008	2013	2015
Cladocera	3	0	0	2
Copepoda	2	3	2	2
Ostracoda	1	1	1	1
Cirripedia	1	1	1	1
Bivalvia	1	1	1	1
Annelida	1	0	1	1
Ctenophora	1	2	2	1
Rotatoria	0	0	0	1
TOTAL	**10**	**8**	**8**	**10**

4.1.2. SDII Sangachal Bay survey

In 2011 additional surveys were implemented within Sangachal Bay to monitor the potential impacts from the installation of the Shah Deniz Phase 2 export pipeline. The first and second surveys in 2011 and 2014 were conducted prior to the pipeline installation to provide baseline data. The 2016 survey was the first survey designed to detect impacts from the trenching works and the installation and operation of the pipelines.

The SDII Sangachal Bay survey area straddles the northeast sector of the existing Sangachal Bay environmental monitoring survey area (Figure 4.1.2). The 2016 survey was based on the 2011 and 2014 survey designs and consisted of 45 sediment sampling stations and 5 water and plankton sampling stations. Figure 4.1.4 gives the 2016 SDII Survey sample station layout and indicates the years in which samples were collected at each of the 2016 sediment sample stations.

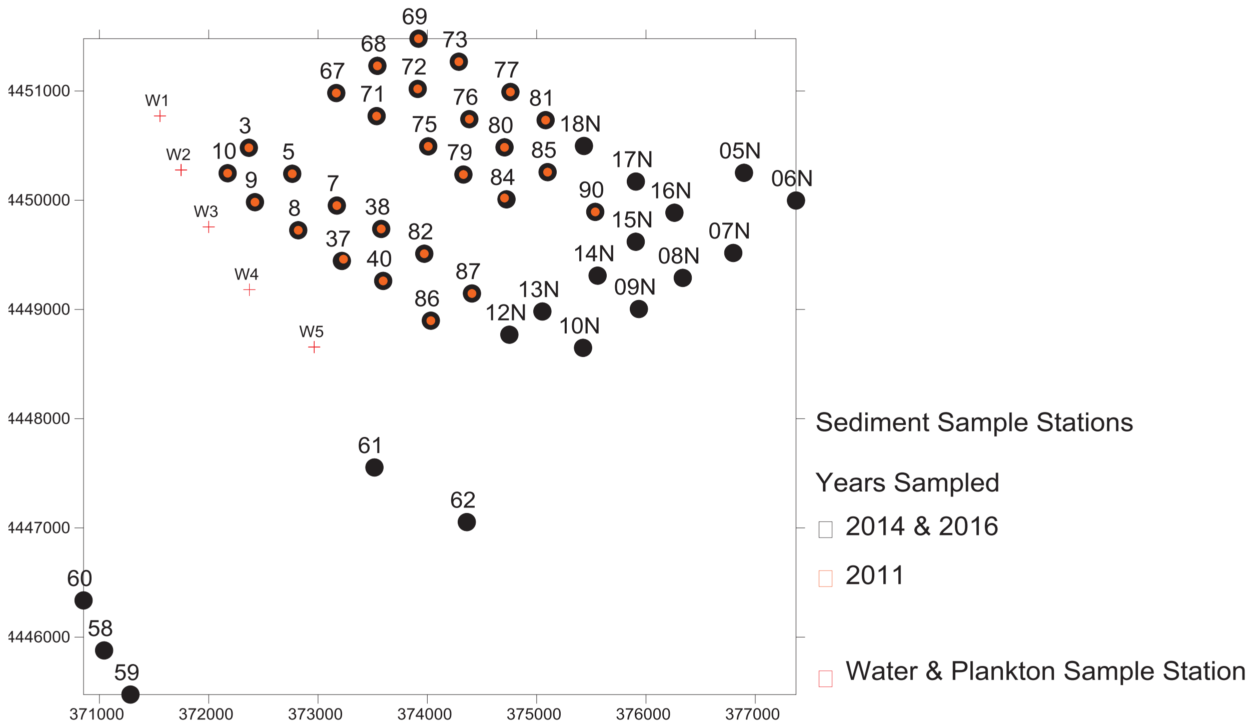


Figure 4.1.4 2016 SDII Sangachal Bay sampling stations & years sampled

The range and average values for all parameters have remained stable between 2011 and 2016 (Table 4.1.7). Although some changes have been identified at individual stations, the overall spatial distributions of each parameter have remained relatively similar between the 2014 and 2016 pre and post-installation surveys. Overall there is no evidence to suggest that the SDII pipeline installation works have modified the physical nature of sediments within Sangachal Bay.

Table 4.1.7 Sediment physical properties: SDII Sangachal Bay surveys 2011 to 2016

	Survey Area Average Value		
	2011	**2014**	**2016**
Mean diameter µm	320	264	227
Silt & Clay content %	23	31	32

The highest concentrations of THC and PAH were present in samples from stations on the south-eastern edge of the sample area which marks the transition to the more heavily contaminated sediments in the deeper waters outside of Sangachal Bay. There was a general gradient present from the low concentrations present at nearshore stations in the northwest of the survey area, to the highest concentrations on the south-eastern edge of the survey area (Figure 4.1.5).

The range and average values for all hydrocarbon parameters have remained stable between 2014 and 2016. Although some changes have been identified at individual stations, the overall spatial distributions of each parameter have remained relatively similar between the 2014 and 2016 pre and post-installation surveys. Overall there is no evidence to suggest that the SDII pipeline installation works have influenced the hydrocarbon characteristics of sediments within Sangachal Bay.

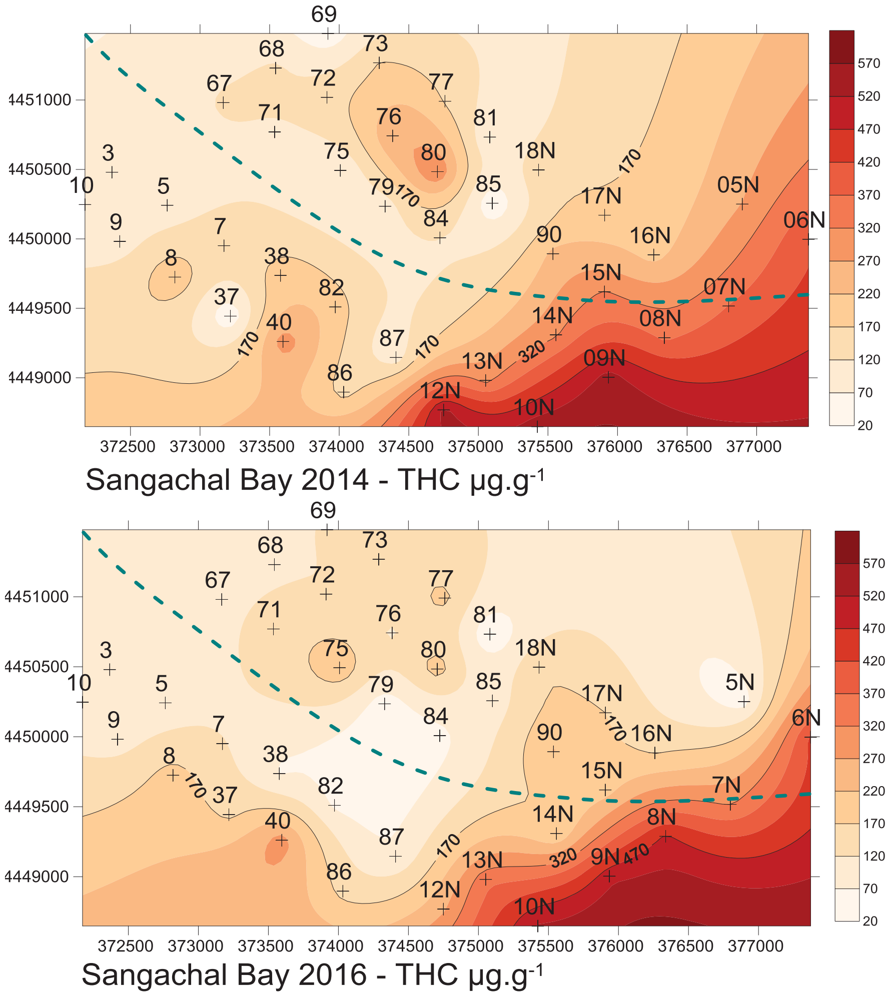


Figure 4.1.5 Spatial variation of THC (µg.g-1) concentrations, Sangachal Bay surveys 2014 & 2016

Table 4.1.8 THC and PAH concentrations, SDII Sangachal Bay surveys 2011-2016

	Survey Area Average Value		
	2011	**2014**	**2016**
THC µg.g-1	58	207	179
Total 2-6 ring PAH ng.g-1	125	230	220

As observed on previous surveys within Sangachal Bay, a strong positive inter-correlation was present between Cu, Cr, Fe, Mn, Pb and Zn. The distribution of these metals were similar to sediment silt & clay content, with higher concentrations present at stations where silt & clay content was greatest. For most metals the concentrations were greatest at stations on the south-eastern edge of the survey area, with the lowest concentrations present at stations in the centre of the northern half of the survey area.

The 2016 spatial distributions and average concentrations were generally comparable to those observed in 2014. Variability between years for the Cu group of associated elements generally corresponded to changes in sediment silt/clay content. Overall there is no evidence to suggest that the SDII pipeline installation works have influenced the metal characteristics of sediments within Sangachal Bay.

Specific activity of six radionuclide isotopes was determined in a single sediment sample from four stations. Results were similar to those recorded in 2014 and were lower than the levels recorded at offshore locations.

As observed on previous surveys within Sangachal Bay the 2016 macrofaunal community was numerically dominated by polychaetes and bivalves which accounted for >90% of the total abundance.

Examination of the previous survey data identified a slight change in the community between 2011 and 2014, and a strong similarity between the communities present in 2014 and 2016. The dissimilarity between the community present in 2011 and those present in 2014 and 2016 was mainly due to the absence of gastropod species of the genus *Caspiohydrobia* in 2011 and the low abundance of the polychaete *Manayunkia* - which was the dominant polychaete taxa in 2014 and 2016.

The only notable differences between the 2014 and 2016 communities were a lower average abundance of annelid taxa and a higher average abundance of bivalves in 2016 (Table 4.1.9). Examination of the individual station data indicates that the reduction in the species abundance between 2014 and 2016 was observed throughout the survey area, including stations located >3km from the pipeline route. Overall there were no changes identified that could be associated with the installation of the SDII export pipelines.

Water samples taken from within the Bay were representative of uncontaminated inshore waters and the plankton community was similar in abundance and taxonomic richness to the communities present on previous surveys carried out within Sangachal Bay. Overall there is no evidence to suggest that the SDII pipeline installation works have influenced the physical or chemical characteristics of sediments or negatively affected the macrobenthic communities within Sangachal Bay.

Table 4.1.9 Total taxa and average abundance ($N.m^{-2}$) in survey area for major taxonomic groups, Sangachal Bay surveys 2011 to 2016

		2011	2014	2016
Polychaeta	$N.m^{-2}$	940	3279	2167
	Taxa	5	5	5
Oligochaete	$N.m^{-2}$	277	585	258
	Taxa	2	2	2
Amphipod	$N.m^{-2}$	7	44	42
	Taxa	6	13	12
Insect	$N.m^{-2}$	0	8	37
Bivalve	$N.m^{-2}$	715	1053	2279
	Taxa	3	3	3
Gastropod	$N.m^{-2}$	<1	220	125
	Taxa	1	5	4

5

Specific Environmental Studies

In addition to the routine monitoring surveys carried out at offshore and inshore operational sites, BP conducts a number of non-routine studies which are designed to monitor impacts from specific activities.

Studies are implemented to

- Address governmental/regulatory requirements
- To meet specific requirements outlined in project ESIA's
- Address requirements from MTAG & ESC
- Meet internal BP commitments

5.1. Biomonitoring

5.1.1. In-situ biomonitoring in Sangachal Bay: baseline studies using the bivalve mollusc *Mytilaster lineatus,* 2000

A three-month study was carried out in 2000 to assess the water quality within Sangachal Bay. Bivalve molluscs, *Mytilaster lineatus* were deployed in cages in the vicinity of the Sangachal terminal outfall, and were also exposed to samples of the same effluent in the laboratory.

The primary purpose of the study was to assess the potential impact of discharges in terms of sublethal physiological stress, and (for the field component of the study) to relate physiological response to changes in tissue concentration of heavy metal and hydrocarbon contaminants. The study also aimed to provide a technical evaluation of the methodology for field deployment and the methodology for feeding rate measurement.

In addition to the specific field study, laboratory measurements were conducted for verification of the health and sensitivity status of the test species *Mytilaster*.

The physiological health of the experimental bivalves was assessed by measurement of feeding (filtration) rate; feeding rate is (in many aquatic species) a sensitive indicator of general sublethal contaminant-induced stress.

One batch of bivalves was deployed at Sangachal on 30th July 2000. Half of these animals were returned to the laboratory after 6 weeks, and a fresh batch of bivalves were placed in the cages on this occasion. The remaining half of the original batch were left in the cages, and were returned, together with the second batch of animals, after a further five weeks of exposure.

Measurements of growth, feeding rate, and tissue contaminant concentrations, indicated that there was no adverse effect of surface water quality during the deployment period. All bivalves grew well, feeding rates increased in all exposure groups, and contaminant concentrations declined from pre-deployment levels in all exposure groups. The results were considered to represent 'baseline' conditions under a low-discharge scenario.

5.1.2. In-situ biomonitoring in Sangachal Bay using the bivalve mollusc *Mytilaster lineatus*, May-September 2004

Biomonitoring of water quality in Sangachal Bay using caged mussels *(Mytilaster lineatus)* was carried out between May – September 2004. The aim of the study was to assess potential impacts from trenching activity.

Three batches of mussels were exposed for successive periods of approximately 4-7 weeks each, and a long-term group was deployed for 16-17 weeks. Moorings were located at five stations in Sangachal Bay (two to the east of the pipeline trenching activities, three to the west, at different distances from the shore); one reference station was located in Zagulba at the north coast of the Absheron Peninsula (also the collection site for mussels).

Overall survival during deployments was 95-99%. Almost all test animals increased in size during deployment period, and there were no particular differences between stations in Sangachal Bay. The growth rate within Sangachal Bay was higher than the rate observed in mussels deployed at the Zagulba reference site.

Filtration ability of mussels was generally higher in post-deployment groups compared to pre-deployment animals and there were no recorded increases in the concentration of hydrocarbon or metals within the tissues of animals deployed within Sangachal Bay.

Variations observed in the measured responses are considered to be within range of natural variation. There was no evidence to suggest that trenching operations had negatively affected water quality within Sangachal Bay.

5.1.3. In-situ biomonitoring at the Chirag 1 platform using the bivalve mollusc Mytilaster lineatus, June-September 2003

A thirteen-week study was carried out in 2003 to assess exposure impacts related to cooling water discharges from the Chirag platform. A copper-chlorine anti-foul system is used within the cooling water system which results in elevated copper concentrations in the discharged cooling water.

Bivalve mussels *Mytilaster lineatus* (Gmelin) were deployed in cages at four stations surrounding the platform. At three of the stations, three consecutive batches of animals were deployed for a short-term period of 4 weeks, while at the fourth station a single long-term batch was deployed for the full thirteen week period.

After each period of deployment, the cages with *Mytilaster* were returned to the laboratory for analysis of

- metals Fe, Zn, Cu, Cd & Hg in tissue
- total hydrocarbons (THC) in tissue
- evaluation of physical parameters; weight & shell length
- sub-lethal stress indicator; filtration rate
- micronuclei frequency; a method used to indicate exposure to genotoxic compounds

The same set of measurements were conducted on animals acclimated in the laboratory but not deployed in the field.

Almost all test animals showed an increase in size during the deployment periods. With the exception of the third short-term batch, the survival rate was high for all batches of bivalves, with all animals recording an increase in filtration rate from pre-deployment levels.

Metal concentrations were found to have increased in animals at two stations during the first short-term batch deployment. This increase was observed for all metals, excluding mercury. There was no increase in the levels in animals at the third short-term station during this period.

The concentration of metals in the tissue of animals deployed during the second and third short-term deployment and the thirteen-week long-term deployment, were either lower than or similar to the pre-deployment concentrations.

Hydrocarbon concentrations were generally higher in all animals after the deployment period. The UCM proportion of the THC was similar in pre and post deployed animals. From the analysis carried out, it was not possible to determine the source of the hydrocarbons.

Increased levels of micronuclei frequency were observed in gill tissue of bivalves after all deployment periods compared to the levels in pre-deployed mussels; similar levels were observed between the stations. The increased levels in deployed animals may indicate the presence of mutagenic agents, but may also be a response in the animals to stresses induced by the collection, transportation and deployment processes, temperature changes, or maturity stages of the animals. Overall the micronuclei frequency results were inconclusive.

There was no conclusive evidence that the discharge of cooling water had negatively impacted the test animals.

5.2. Fish Monitoring

5.2.1. Fish Monitoring, Sangachal Bay

In 2000-2001 four surveys were performed at Sangachal Bay to provide information on the status of resident fish populations. Species abundance, temporal distribution and community composition as well as two different collection techniques were evaluated. Measurements of selected physiological parameters; micronucleus frequency, level of blood albumen protein, and heavy metal concentrations were performed to provide baseline data to assess environmental impacts arising from the BP operations within Sangachal Bay.

Monitoring studies were carried out in 2002/2003, 2004, 2005, 2008 and 2009. The objective of fish monitoring in Sangachal Bay is to monitor the presence, contamination levels and health status of fish populations, with sandsmelt (*Atherina mochon caspia)* and gobies (*Neogobius fluviatilis pallasi)* serving as indicator species. The analytical parameters in the study were chosen to detect possible exposure to metals and polycyclic aromatic hydrocarbons (PAH), as well as recording any indications of genotoxic/histopathological effects in the fish collected.

Three sites within Sangachal Bay were sampled on all surveys. In addition to the three monitoring sites, fish were collected at 2 (clean) references sites and one positive control (presumed contaminated) site; this was reduced to 1 reference site and no positive control site for the 2008 & 2009 surveys. Fish were collected using a hand-held trawl net at all sites, and transported alive to the Laboratory for subsequent processing. Water quality measurements were carried out at the fish collection sites on each sampling occasion.

The micronuclei response and PAH metabolite levels were consistently higher in fish collected from the positive (contaminated) control site. Metal and PAH exposure levels for sandsmelt and gobies collected from Sangachal Bay observed low variation over the monitoring period and were generally similar to those recorded for fish collected at the (clean) reference site.

Metal concentrations in fish muscle were comparable between both species with the exception of mercury and zinc, levels of which were higher in sandsmelt; a pattern observed over the monitoring period. There were no trends observed between the study stations in the concentration of metals in either species. The levels recorded on all surveys were relatively similar and are regarded as background levels of metals in fish.

A range of different histopathological disturbances were observed in liver and in gills from the two study species. Some disturbances were observed in fish collected from Sangachal Bay and also from the (clean) reference site. However, the nature of the disturbances in fish from these stations can be regarded as reversible and their frequency did not indicate that the individuals were significantly affected. More severe disturbances - and at a higher frequency - were noted for both species collected from the positive control site. These findings indicate that fish from the positive control site were more affected by contamination than those collected at the reference site and from within Sangachal Bay.

In general, fish collected from within Sangachal Bay demonstrated levels of the monitoring parameters in line with levels recorded for the clean reference site, indicating that the conditions for resident fish in Sangachal Bay, over the monitoring period, were similar to those at the reference site with regard to the investigated parameters.

5.2.2. SD2 pipeline trenching, Sangachal Bay fish monitoring

Three fish monitoring surveys were carried out within Sangachal Bay between 2014 and 2016 to assess impacts from trenching activities related to the installation of the SD2 export pipeline.

Surveys were carried out pre, during and on completion of the trenching work. Samples were collected from six sites within Sangachal Bay and from one (clean) reference site and one (contaminated) positive control site. The reference and control sites were consistent with those used in previous Sangachal Bay fish monitoring surveys.

With the exception of PAH metabolites, the parameters were consistent with those measured on previous Sangachal Bay fish monitoring surveys:

- Water quality at sampling stations
- Population density of two resident fish species (silverside *Atherina boyeri caspia* and gobies *Neogobius sp.*)
- Length, weight (hence condition factor), sex, maturity and liver and gonadosomatic indices for general health status assessment
- Metals in biological tissue for assessment of levels of metal exposure in the environment
- Micronucleus assay for assessments of potential

mutagenic effects

- Histopathological analyses for assessment of morphological changes or anomalies in liver and gills.

The results from the study did not identify any impacts to fish collected from within Sangachal Bay. The pattern of results were similar to those recorded on previous fish monitoring studies; in general, fish collected from within Sangachal Bay demonstrated levels of the monitoring parameters in line with levels recorded in fish collected from the clean reference site.

5.3. Seagrass Monitoring

5.3.1. Sangachal Bay, seagrass mapping surveys

Seagrass mapping surveys were carried out within Sangachal Bay in 2001, 2003, 2006 and 2008 to monitor impacts from the installation of pipelines and operations at Sangachal Terminal.

The surveys utilised a combination of drop-down video sampling, video transects and Acoustic Ground Discrimination System (AGDS) for mapping the physical properties of the seabed. The AGDS data was interpreted through information supplied by the video records and grab samples. The video transects were designed so that the borders/extents of any seagrass beds could be determined in order to monitor any future change.

Footage from the video transects indicate that the seagrass beds within Sangachal Bay appear to be very densely populated and where seagrass does occur it almost always occupies 100% coverage. There is therefore very little variation in seagrass density within the seagrass beds.

Seagrass presence/absence results, obtained from video samples, shows consistency between the most recent surveys carried out in 2006 and 2008. The increased presence of seagrass reported in the 2006 survey was reflected in the 2008 data.

There was no evidence that operations had affected the presence or density of seagrass habitats within Sangachal Bay.

5.3.2. SDII Sangachal Bay, seagrass mapping surveys

Seagrass surveys were carried out within Sangachal Bay to assess the impacts from the installation of the SDII export pipeline. A survey was conducted in 2014 prior to the pipeline installation to provide baseline data. A follow up survey was carried out in 2016 to detect impacts from the trenching works and the installation of the pipelines. The surveys utilised a combination of drop-down video sampling and video transects.

Both surveys identified that seagrass habitats were restricted to areas of the bay which are shallower than approximately 5m in depth and occupy sediment types which are sandy with some gravel component and limited silt or clay content. As depth increases and the incident light level decreases there is a cessation in the presence of seagrass and some occurrence of algal film.

The coverage and distribution of seagrass in 2016 was very similar to that found in 2014. However, the quality of the seagrass was noted to have changed in the 2016 video footage, with the vast majority of seagrass being colonised by epiphytic growth. The 2016 video footage also showed an increased presence of finer sediments within the seagrass.

Algal film presence and distribution decreased considerably; very little was present in the 2016 survey, but was a notable feature in video data from 2014. Macroalgae presence has increased slightly and appears to coincide with locations where mussel beds have colonised areas between the seagrass.

If the observed changes are related to trenching and pipeline installation works, it is expected that any effects to the seagrass habitats will be temporary.

5.4. Caspian Seal Monitoring

To establish the potential impacts of BP's activities, Caspian seal specialists have been preparing studies compiling the latest information on seal presence, behaviour, migration and status within Azerbaijani waters and across the Caspian Sea since 2010 as part of the ESIAs completed for projects within the ACG, SD and SWAP Contract Areas. In 2016 the previous studies were updated with the latest available data to focus specifically on seal status and presence within the SWAP Contract Area where seismic survey activities were planned. The study identified periods of expected low and peak seal presence during the planned seismic survey period.

During the seismic survey activities to mitigate the potential disturbance to seals from seismic survey operations, a visual survey for seals within 500m of the source was carried out prior to the commencement of the soft-start* procedure. This was implemented for all seismic source vessels operating in water depths greater than 2 metres. The pre soft-start observation process is summarised in Figure 5.4.1 below.

To ensure the Caspian Seals autumn season migration was not impacted by seismic operations a protocol was put in place involving a team of seal experts conducting observations from a dedicated vessel. The purpose of the observations was to ensure the seals were outside of the temporary buffer zone around the seismic vessels when seismic activities commenced as well as to record the seals present within the wider area and on the islands. The observations started on 1 October 2016 and lasted until 15 December 2016. Observations were conducted around the islands of the Absheron archipelago within 2-8km from the seismic operation area using high resolution cameras and binoculars. Seal experts recorded 154 seals around the islands of the Absheron archipelago. No seals were detected within the temporary buffer zone established around the seismic vessels when activities were in progress or inside the buffer zone of the Absheron National Park during the monitoring period.

Seal observations were also recorded during the offshore EMP surveys undertaken in 2017 at the SDA, Chirag, DWG and WA platforms, as well as at the proposed ACE platform location. A total of 33 seals were observed between 26 May 2017 and 27 June 2017. The greatest number of seals (15) were observed at the DWG platform, with 12 seals observed across three separate sightings on 31 May 2017 and 3 seals observed as a group on 3 June 2017. The fewest seals (1) were observed at the SDA platform. In general seals were observed during calm sea conditions predominantly during May.

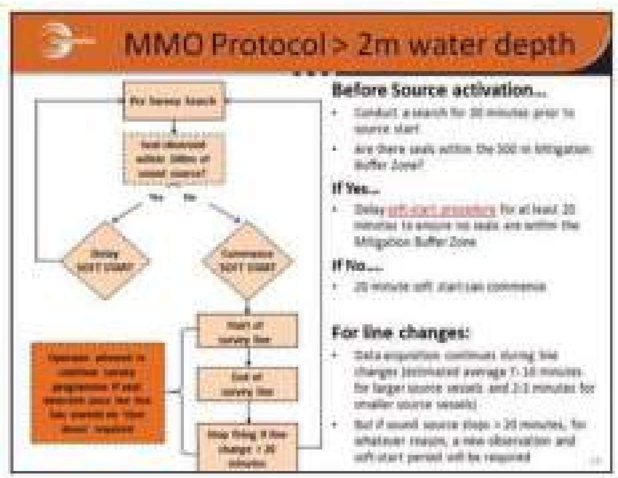


Figure 5.4.1 MMO (Marine Mammal Observation) Soft-Start Protocol

* The soft-start is a gradual increase in the power output of the seismic source. A soft-start is carried out to allow animals to leave the survey area prior to the air guns being operated at full power.

5.5. Caspian microbiology survey

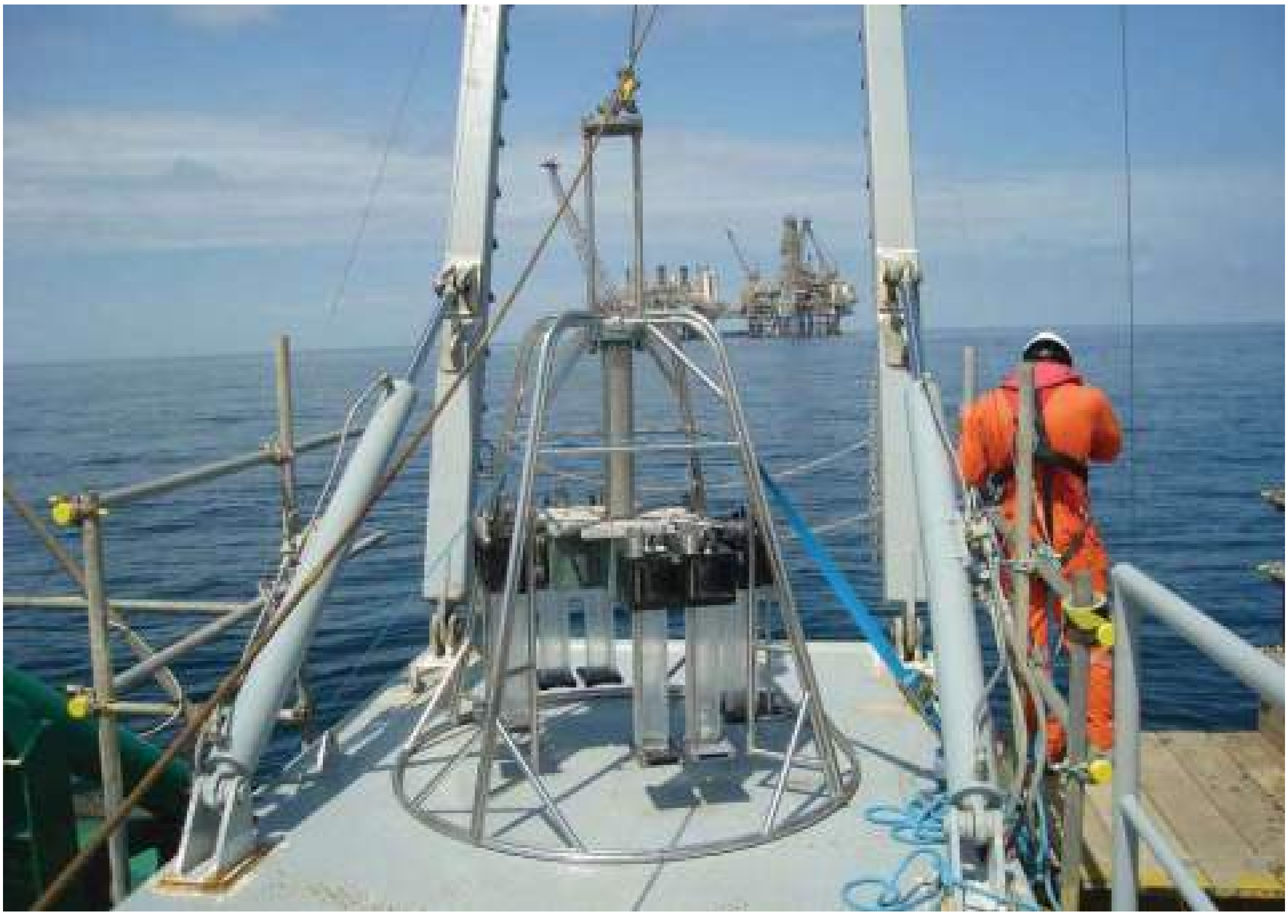
In 2013 a survey was carried within the ACG and SD contract areas to characterise the microbial community within the water column and surface sediments, and to determine the oil degradation potential of the microbial communities present. The Caspian Sea survey was part of an international multi-region programme to determine the oil degradation potential in areas where BP conduct offshore operations. The results of the studies will be used in the development of oil spill response plans.

In all sample sites there were major distinctions in composition and abundance between the surface and deep-water bacterial communities. *Gammaproteobacteria* were dominant at all sites and depths, suggesting the presence of oil-degraders. In sediment samples, similar taxonomic groups were present across all stations: *Deltaproteobacteria*, specifically sulphate-reducing bacteria (SRB) were more abundant at anaerobic or microaerophilic stations, which is a natural condition for the Caspian Sea. It is known that SRB can degrade a wide range of oil constituents including alkanes, benzene, and PAHs.

Lab based studies carried out to assess the degradation of hydrocarbons by the microbial communities present; in aerobic and anaerobic conditions, determined that the half-life for total hydrocarbon was approximately 11 days anaerobically and 15 days aerobically - in the deep water environment, low oxygen concentrations appear to have allowed the microbial community to adapt to higher biodegradation rates then even under aerobic conditions.

From the results of the study, it was determined that if a spill or leak were to occur in the Caspian Sea it is expected that the same groups of bacteria observed in the laboratory experiments would respond to oil biodegradation.

It was concluded that the addition of nutrients for bio stimulation would not have much effect on biodegradation rates given the already low 11-15 day half-lives; however, dispersant application, would definitely help disperse the oil to form small oil droplets (given the currents in the Caspian Sea) and make it more inherently biodegradable. Since nutrient additions are likely to cause stimulus of other problems like hazardous algal blooms and eutrophication in general, once a spill is controlled and as much of the oil as can be contained or removed, natural attenuation should be the goal.



5.6. Monitoring produced water discharges using passive membrane samplers

From 2009, onshore separated Produced Water (PW) has been sent to the Long Term Produced Water (LTPW) plant at Sangachal Terminal for mechanical and chemical treatment after which it is returned offshore to the Central Azeri (CA) Compression and Water Injection Platform (CA-CWP) via a dedicated PW pipeline for re-injection into the reservoir.

In order to assess the potential impact of produced water discharges to the offshore environment - as part of the ACG PWDP ESIA Addendum - a monitoring programme was implemented utilising passive membrane samplers with the aim of identifying and quantifying organic and inorganic pollutants associated with produced water discharges.

In 2013-2014 a trial study was carried out to assess the suitability of the methodology and sampling equipment, and in 2015 a monitoring programme was implemented at the Central Azeri platform; a single array of membrane samplers was deployed to a depth of 10 metres for a period of 1 month on each sampling round. The sampler array was located on the southwest corner of the CA platform, downwind of the prevailing wind direction.

Table 5.6.1 gives the passive membrane sampler deployment schedule at CA.

Table 5.6.1 Passive membrane sampler monitoring schedule

Sampling round	Deployment	Retrieval
2015 RN1	01/08/2015	30/08/2015
2015 RN2	03/10/2015	03/11/2015
2016 RN1	15/03/2016	15/04/2016
2016 RN2	26/06/2016	02/08/2016
2016 RN3	18/10/2016	18/11/2016
2016 RN4	16/12/2016	16/01/2017
2017 RN1	01/03/2017	29/03/2017
2017 RN2	28/06/2017	28/07/2017

Monthly average concentrations of the following parameters were determined for each sampling round.

- C9-C36 alkanes
- EPA list 16 PAH's
- NPD PAH's
- C1-Phenols
- Octylphenols and Nonylphenols
- BTEX
- PAH's
- Heavy metals

The results were compared against the results from the analysis of produced water samples and samples collected from an offshore control site.

In 2016 a leakage of commingled injection water was discovered at the CA and DWG platforms. Due to the implementation of the monitoring programme at CA, the potential impact of the leak could be assessed. The highest volumes of PW discharged from the leak at CA took place during rounds 1 and 2 in 2016.

The concentrations of phenols, BTEX and a large number of individual PAH compounds were below the detection limit on all sampling rounds.

Concentrations of C9-C36 alkanes ranging from 0.62 – 5.41 µg/l were detected during the monitoring period. The highest concentrations of 4.34 and 5.41 µg/l were detected in rounds 2 and 3 in 2016, while the concentration in 2016 RN1 was below the MDL. All recorded concentrations of C9-C36 alkanes were below the national standard of 50µg/l.

Where detected, the concentrations of C9-C36 alkanes, PAHs, nonylphenols and metals were all within the applicable national and EU environmental standard.

A nonlinear positive correlation was observed between the volume of produced water discharged and the detection and recorded concentrations of C9-C36 alkanes, PAHs and nonylphenols. In sampling rounds when the volume of discharged produced water was lowest, the concentrations of these parameters were lower than on rounds when higher volumes had been discharged. This indicates that the PW discharged at CA is dispersing and is not accumulating in the vicinity of the platform.

As the volume of PW discharged at CA is significantly higher than the volumes discharged at all other platforms, it was concluded that the concentrations of the measured parameters at other platforms, as a result of PW discharges, would be present at a lower concentration than those observed at CA, and would also be within the applicable environmental standards.

5.7. Conclusions from offshore and inshore monitoring

The results from the recent surveys carried out at offshore locations indicate that there has been no increase in the levels of contamination at operational sites, and where contamination was previously recorded – often a legacy of contamination from several years ago - there was evidence of a slow recovery.

The only observed impact at platform locations was a defined footprint of elevated Ba levels from the discharge of water-based drilling mud or WBM drilled cuttings. At most locations the extent and magnitude of the Ba footprint has either remained stable or has reduced in size.

Hydrocarbon content within sediments at operational sites is typical of the background composition with no evidence of hydrocarbon contamination from production activities. Compounds signifying the presence of hydrocarbon-based drilling fluids have been observed at low concentrations in sediments around a number of platforms. With the exception of the Chirag platform, these materials are not discharged as part of the drilling programmes and their presence is either due to small spills of drilling fluid or are related to the SBM component of the WBM used at some fields.

The discharge of LAO drilled cuttings at Chirag has resulted in a larger LAO contamination footprint. The spatial extent and magnitude of LAO contamination at Chirag reduced significantly on consecutive surveys from 2006, but increased in 2015. From 2015 the area affected has remained stable but the concentration levels present within were found to have reduced in the most recent survey carried out in 2017.

A continual and sustained recovery has been observed in the Chirag macrobenthic community at stations previously identified as being impacted by drilling discharges. The communities present now generally exhibit the same characteristics as those observed at stations located at distance from the platform, outside the previously affected area. The only exception was one station located adjacent to the discharge point were the community continues to remain distinct.

With the exception of the localised impact at Chirag, and a possible localised community variation at SDA, the macrobenthic communities present at platform survey sites were characteristic of the wider area and there was no indication of impacts from production activities. Community variation is generally associated to sediment structure, with more abundant and diverse communities present in areas where sediments were heterogeneous with higher proportions of coarse grained particle size fractions.

There was evidence of macrobenthic community change at most offshore survey areas over the monitoring period, across both the ACG and the Shah Deniz contract areas. These changes reflect natural variation and are unrelated to operational activities. Observed community changes include a general increase in the abundance of amphipods, particularly of the genus *Gammarus* and *Corophium*, and a change in the polychaete community structure, with *Hypania invalida* and *Hypaniola kowalewskii* reducing in abundance and occurrence and *Manayunkia Caspica* becoming the numerically dominant polychaete species.

An extensive inshore monitoring programme has been carried out in the area within and surrounding Sangachal Bay. A wide range of surveys have been conducted including; bio-monitoring using caged mussels; monitoring impacts to fish; seagrass habitat surveys; benthic environmental surveys; and water column and plankton surveys. Over the monitoring period these surveys have confirmed that the inshore environment at Sangachal Bay is similar to other coastal reference sites and the activities related to the installation of export pipelines within the bay have not resulted in significant impacts to the seabed environment, water column or the species present.

6

Onshore Ambient Environmental Monitoring

Onshore Ambient Environmental Monitoring is carried out at Sangachal Terminal, Serenja Hazardous Waste Management Facility and at facilities along the Azerbaijan Export Pipelines; Baku-Tbilisi-Ceyhan Pipeline (BTC), Western Route Export Pipelines (WREP) and South Caucasus Pipeline (SCP).

Table 6.1 below gives schedule of monitoring surveys carried out at each facility and pipeline route.

Table 6.1 Onshore environmental monitoring surveys at BP facilities; schedule of completion

Monitoring Survey Type	Sangachal Terminal	Serenja HWMF	Azerbaijan Export Pipelines	
			BTC/SCP	WREP
Ambient air quality	2003-2017	2004-2017	2005-2017	2006, 2010, 2013, 2017
Ground and surface water quality	BL 2001 2006-2017	1998 BL, 2001-2017	2004-2017	N/A
Soil stability and vegetation cover	2006-2016	2016-2017	N/A	N/A
Faunal survey (excluding birds)	2011-2016	N/A	N/A	N/A
Birds survey	2001/02 BL, 2008-2016	N/A	N/A	N/A
Wetlands	2002-2016	N/A	N/A	N/A
Bio restoration	N/A	N/A	2007-2017	N/A

BL - Baseline

N/A - Not Applicable

6.1. Onshore environmental surveys methodology

6.1.1. Terrestrial ecosystems

6.1.1.1. Vegetation cover & soil stability

This monitoring programme measures 4 key indicators of soil condition (and ecosystem functioning) namely: *1.bare soil cover, 2. vegetation cover, 3.soil stability; and 4. crust (macrobiotic) cover*. At each monitoring point three 100m transects were extended uphill.

- Perennial plant cover and bare soil cover were measured directly off the outer edge of the 100m (start at 0 m and end at 100m) transect tape.
    - Plant and bare soil patch size was calculated along with percentage cover and patch size of life-forms (grass, shrub or forb)
    - A site descriptive bare patch index (BPi) and vegetation patch index (VPi) was calculated for each site.
- Soil stability (SS) samples were collected from the surface and sub-surface (3-4cm depth) at three random locations on each transect.
    - SS analysis was assessed (from not stable –1 to stable - 6) using a modified Slake Test.
    - Surface and sub-surface SS was calculated for protected (i.e. with an overlying perennial plant canopy) and unprotected soils and as an average value.
- Microbiotic crust cover is presented in the form of the ratio of crust to cover (CCr).
    - 0.5m x 0.5m quadrat subdivided into 0.01m^2 segments was used to measure CCr.
    - Ten quadrats were sampled along each 100m transect line.
    - CCr was calculated for each canopy type at each monitoring site; bare soil, shrub-covered area, grass/forb-covered areas

The 4 indicators - BPi, VPi, SS and CCr were categorised as detailed in Table 6.1.1.1.1 below.

Table 6.1.1.1.1 Ecosystem Condition Values (ECV) generated from indicator ranges

Indicator / ECV	1 – very good	2 - good	3 - threatened	4 - deteriorated
BPi	0 - 50	51 - 100	101 - 150	>150
VPi	>50	25 - 49	10 - 24	<10
SS	4.1 - 6	3.1 - 4	2.1 – 3	1 - 2
CCr	>0.25	0.10 - 0.24	0.01 - 0.09	<0.009

Each plot has 4 ECVs, which were added to achieve a combined secondary score, known as the Ecosystem Condition Category (ECC). The ECC have a range of 4 threshold limits, each with a designated category, as shown in Table 6.1.1.1.2. The lower the overall ECV score, the ‘better’ the ecosystem condition.

Table 6.1.1.1.2 Ecosystem Condition Categories (ECC) generated from ECVs

Ecosystem condition value (overall ranges)	Ecosystem condition category
< 8	Very Good
9 - 10	Good
11 - 12	Threatened
13 - 16	Deteriorated

6.1.1.2. Bird monitoring

The Bird Survey is based on a fixed-duration point count method consisting of survey locations within 2.5km of the centre of Sangachal Terminal, and two points at the edge of the coastline along Sangachal Bay that were used to survey over-wintering water fowl within Sangachal Bay. The sample points are located 250m apart, and given the 100m radius of the survey, this leaves a minimum 50m “buffer” between adjacent survey sites to minimize the potential for duplicate observations.

The bird count period is 10 minutes at each monitoring point. The survey includes identifying the species of each bird, the number of individuals, their status (juvenile/adult) and gender (male/female) if possible, and their location which is then recorded on the datasheet.

Surveys are carried out during early mornings, beginning 30 minutes after dawn and proceeding for a period of not more than five hours thereafter. The two coastal sites are monitored differently than the terrestrial sites. Observations are restricted to a 1km distance into Sangachal Bay and did not include terrestrial areas. Care is also taken to avoid overlap between D1 and D2 in order to not count the same birds more than once.

6.1.1.3. Mammals & herpetofauna monitoring

The investigations are based on the visual observations made along dedicated walking routes. Surveyors collect and register as much data as possible (species identification, number and status [age, sex etc.] of individuals, habitat conditions etc.). The key aim is to identify the species via direct and indirect observations.

From the location of the station the surveyors walked a transect line as shown in Figure 6.1.1.3.1. The direction of the initial line was selected by the surveyors in the field. The field of search along each line was 10 m either side of the line resulting in a surveyed belt of 20m for each line and therefore an area of survey of 1000 square meters per line making 3000 square meters per survey station.

Along each of the line walks the surveyors collected data on direct evidence of mammals, reptiles and amphibians; essentially these were actual sightings of individuals. In addition, indirect evidence was recorded. Such signs included faeces, footprints, burrows or other living areas. The location of direct and indirect observations along the walk route was recorded.

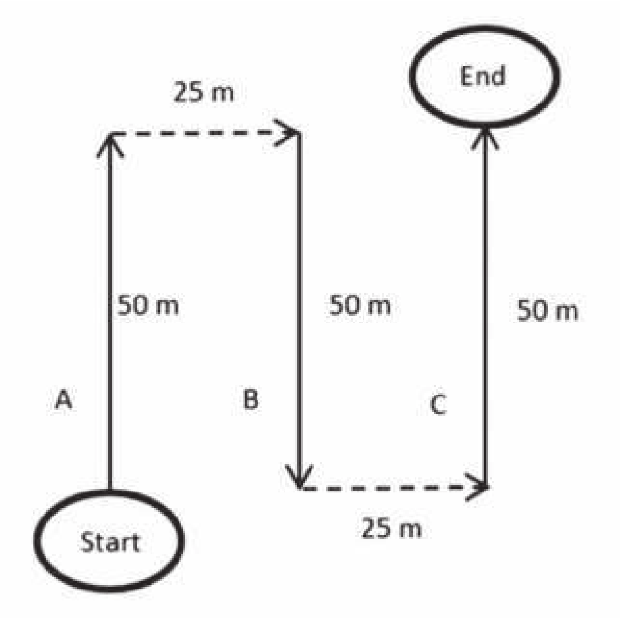


Figure 6.1.1.3.1 Mammals & herpetofauna survey walking route

Small mammal traps were deployed in the evening with suitable baits and rechecked for captures early the following morning. Trapped animals were identified to species level. All trapped animals were released unharmed in the trapping location.

6.1.2. Ambient air quality analysis

6.1.2.1. Long term monitoring

- NOx, NO and NO_2 and SO_2 were sampled using passive diffusion samplers fitted with triethanolamine impregnated filters. Samplers were placed in the field for 30 days.
- VOC's and Benzene was sampled using thermal desorption tubes. The specified time of exposure is two weeks per sampler, so two samplers were deployed sequentially at each sampling site to obtain a four-week exposure period. The averages of the two-week sampling are produced to provide the four-week averaged results.

6.1.2.2. Short term (real-time) monitoring

Real-time monitoring is included in the ST AAQ monitoring programme. The Real-time monitoring station is programmed to provide continuous hourly results for the atmospheric concentrations of the measured parameters and meteorological data.

- Nitrogen oxides were measured using Chemiluminescence Nitrogen Oxides Analyser.
- Sulphur dioxide (SO_2) was measured using a UV Fluorescence analyser.
- PM10 was measured using a BAM 1020 Particulate Monitor.

6.1.3. Ground & surface water analysis

- Monthly groundwater level measurements around ST and Serenja HWMF were measured in boreholes and also in piezometers located around the ST produced water storage ponds and the Serenja bio-remediation cells. The piezometers are used to monitor the integrity of the ST produced water storage ponds and the Serenja bio-remediation cells.
- Water samples were collected using bailers provided with low flow discharge valves to limit sample aeration. Samples were stored in appropriate containers and returned to the laboratory for testing – the suite of parameters varied for the monitoring sites and are listed in the individual chapters.
- ST Ground and surface water samples are analysed for the following parameters:
  - Conductivity
  - pH
  - Inorganics; fluoride, chloride, sulfate
  - Metals; As, Ba, Cd, Cr, Cu, Pb, Li, Mn, Fe, Hg, Ni, Tl, V, Zn
  - Benzene, Toluene, Ethylbenzene, Xylene, (BTEX)
  - TPH, Polycyclic Aromatic Hydrocarbons (PAHs)
  - Total phenols

6.1.4. Wetland ecosystems

6.1.4.1. Fauna

Conducted via visual observations, the focus of the survey was vertebrate fauna only (excluding birds – as these are covered in the ST bird monitoring survey). A high level approach was taken which involved collation of data through direct observation of the species concerned, and the collection of indirect evidence of presence (burrows, nests, footprints, etc.).

At each survey site the vertebrate fauna present, and the numbers of each species present, were observed and recorded for the area encompassing a 10m radius from the centre of the survey station. A standard ten minutes survey period was used. Any additional faunal species which were observed during the other elements of the survey work were recorded.

6.1.4.2. Flora

The survey covers the higher plant species only. A high-level approach was taken which involved collation of data through direct observation.

While walking to the survey stations within the wetland areas, the species of wetland flora encountered were recorded. At each survey station, the flora present was observed and recorded for the area encompassing a 10m radius from the centre of the survey station. Estimates of the cover contributed by each species were also recorded.

6.1.4.3. Water quality

Where standing or flowing water was present at a wetland survey station, in-situ measurements were recorded and samples were collected into appropriate containers for the analysis of the following parameters:

- pH
- Water temperature
- Ambient temperature
- Electrical conductivity
- Salinity
- Turbidity
- Dissolved oxygen
- Total petroleum hydrocarbons (TPH) and polycyclic aromatic hydrocarbons (PAHs)
- Polychlorinated biphenyls (PCBs)
- Phenols
- Heavy metals (As, Ba, Cd, Cr, Cu, Fe, Hg, Pb, and Zn)
- Nutrients (ammonia, nitrite, nitrate, total nitrogen and total phosphorous).

6.1.4.4. Soil chemistry

Soil or sediment samples were collected from the upper 10 cm of the ground surface at each survey station and transported to the laboratory for analysis of the following parameters:

- PCBs
- Phenols
- Heavy metals (As, Ba, Cd, Cr, Cu, Fe, Hg, Pb, and Zn)
- Sulphates
- Chlorides
- Carbonates.

6.2. Sangachal Terminal (ST) monitoring survey results

6.2.1. Ambient air quality survey

Monitoring of ambient air quality around ST is mandated in the ACG Phase 1, 2 and 3 ESIA's (2001, 2002 & 2004), Shah Deniz Stage 1 ESIA (2002), lender requirements (World Bank), and Azerbaijan national legislative requirements.

Ambient air quality monitoring surveys have been conducted in the vicinity of the ST for more than 15 years. The first ambient air quality assessments were carried out in 1997 (air quality baseline prior to Early Oil Project - EOP), using diffusive samplers, and then again in 2000 during EOP operations.

A regular long-term ambient air quality monitoring programme was initiated in 2003, to assess wind-dispersion patterns for the main pollutants emitted by the stacks and other sources at Sangachal Terminal, and to assess their impacts on the local area. Passive samplers were situated at 12 stations within and around the Sangachal Terminal. The parameters measured were; NOx, SO_2, VOC's, PM10, BTEX, HC: C5-C10.

In 2007 the survey design was modified to include better coverage of natural (undeveloped, unpopulated) areas to the north, west, and east of the terminal, and additional monitoring locations between the ST and the Sangachal and Umid settlements. Of the 13 stations in the updated monitoring design, seven (AAQ6, 7, 8, 9, 10, 11, and 12) were existing locations used during the 2003 to 2006 monitoring surveys (Figure 6.2.1.1). The parameters measured in the 2007 monitoring survey were

- Long-term: NOx, SO_2 & VOC's.
- Short-term: NOx, SO_2, and PM10.

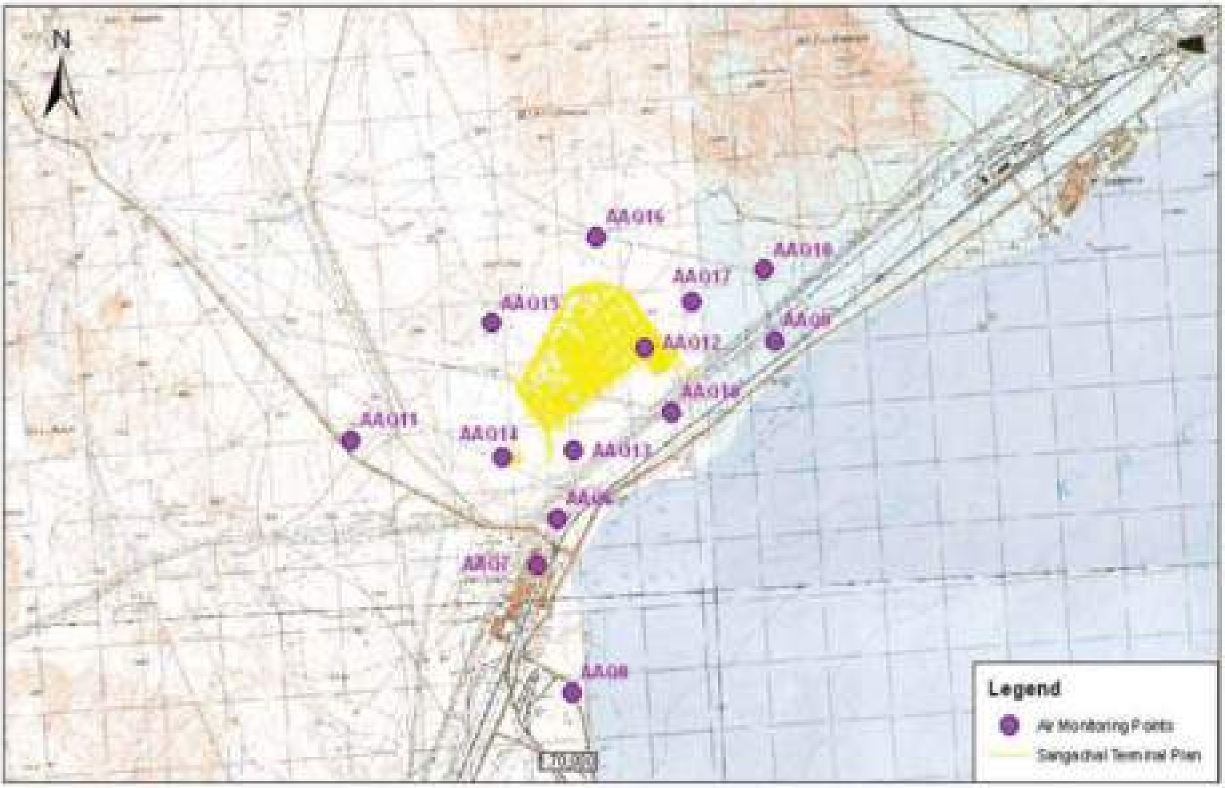


Figure 6.2.1.1 2007 ambient air quality sample points

Further updates to the monitoring programme were carried out in 2008 and 2009. In 2008 four additional long-term monitoring stations (AAQ19-AAQ22) were added to the previous 13 stations that were deployed in 2007. In addition to the seventeen long-term stations, a real-time monitoring station (RTMS) was established at AAQ23 (Figure 6.2.1.2) in order to assess short-term temporal variations in the ambient air quality in real time.

The 2008 programme consisted of three rounds of long-term measurements, each of one month duration. The parameters measured were

- Long-term: NOx, SO_2, VOC's, benzene & CO.
- Real-time: NO, NO_2, NOx, SO_2, and PM10

Due to technical difficulties the real-time station was only operational for part of the year, measuring only NOx and SO_2.

In 2009, the sampling frequency was increased to four rounds of long-term measurements, each of one month duration, carried out once in each quarter. Passive diffusion samplers were deployed at the existing seventeen long-term monitoring stations, measuring:

- Long-term: NO, NO_2, SO_2, VOC's & benzene

The RTMS - AAQ23 is located approximately 2.8 km downwind of the ST and 1 km upwind and NNE of the Sangachal settlement. It is programmed to provide continuous hourly results for the atmospheric concentrations of the following parameters, and meteorological data

- PM10
- SO_2
- NOx, NO & NO_2
- Air temperature
- Wind speed & direction

From 2009 the long-term and real-time sample station layout and parameter list have remained consistent. The results of the monitoring programme are assessed against the national and European Union (EU) air quality standards, these are provided in Table 6.2.1.1 below.

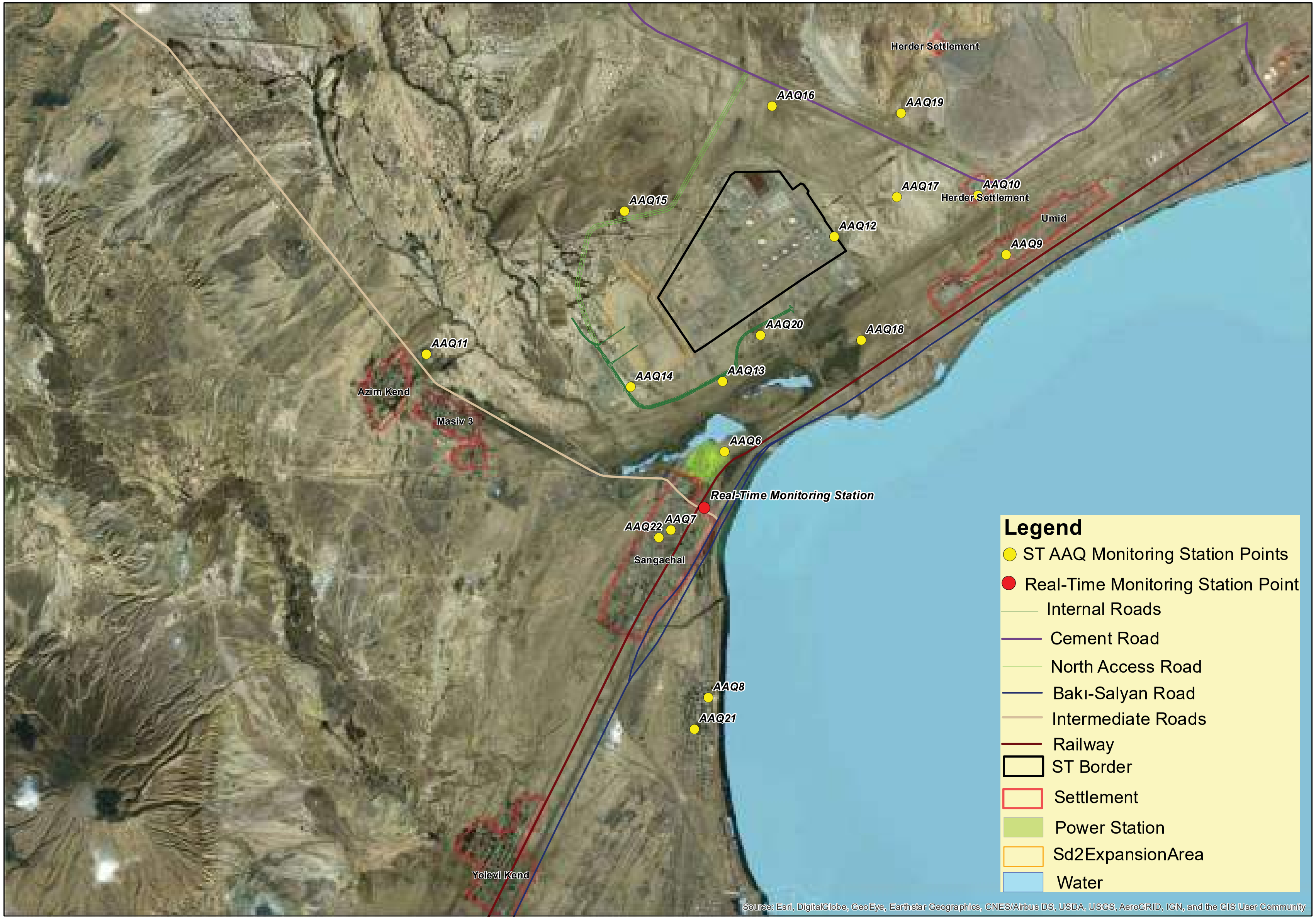


Figure 6.2.1.2 Location of ambient air quality monitoring stations around the Sangachal Terminal - 2017

Table 6.2.1.1 Applicable ambient air quality standards

Parameter	µg m^{-3}	Standard description	Reference	Force
PM10	50	EU average daily –not to be exceeded more than 35 times per calendar year	2008/50/EC, p31	2010
PM10	40	EU annual average	2008/50/EC, p31	2010
SO_2	50	Azerbaijan average daily	N3086-84, USSR, Health Ministry	1984
SO_2	350	EU one-hour average – not to be exceeded >24 times in a calendar year; margin of tolerance 150ug m-3	2008/50/EC, p30	
SO_2	125	EU average daily – not exceeded > 3 times in a calendar year	2008/50/EC, p30	2010
NO	60	Azerbaijan average daily	N3086-84, USSR, Health Ministry	1984
NO_2	40	Azerbaijan average daily	N3086-84, USSR, Health Ministry	1984
NO_2	40	EU average annual – no margin of tolerance after 2010	2008/50/EC, p30	2010
NO_2	200	EU daily average, not to be exceeded more than 18 times per year.	2008/50/EC, p30	2010
Benzene	100	Azerbaijan average daily	N3086-84, USSR, Health Ministry	1984
Benzene	5	EU average annual - December 2000 decreasing by 1 µg m-3 every 12 months afterwards	2008/50/EC, p30	2010
Total VOC	NA			NA
Total VOC	NA			NA

ST operations and construction activities may affect the surroundings by the release of airborne pollutants. There are a number of potential sources of pollutants both directly from, and indirectly associated with, the activities at the terminal. The relevant sources, pollutant types and patterns of release are presented in Table 6.2.1.2 below.

Table 6.2.1.2 Atmospheric pollutants generated at the Sangachal Terminal

Source	Associated pollution	Pattern of release
Construction activities		
Construction activities	Particulates NO_x, CO	Irregular, daytime
Welding	Particulates NO_x, Ozone	
Painting	VOCs	
Transportation	Particulates NO_x, SO_2, CO	Regular, daytime
Terminal operation		
Flares	NO_x, CO, CH4	Regular, 24 hours
Heaters	NO_x, CO, CH4	
Generators	NO_x, CO, SO_2 (if diesel used), CH4	
Spills	VOCs	Irregular, 24 hours
Storage Tanks	VOCs	Irregular

Being downwind of the terminal and upwind of the settlement, the RTMS location was originally considered as suitable. However, during the 2016 survey period, the station was also generally downwind of a power station which was built in 2008, and became operational shortly after this. This power station is located approximately 600 meters north of the RTMS.

The power station is believed to make a significant contribution to the measurement results at the RTMS - generally masking the results from the ST, as the atmospheric emissions from these two sources will be combined during the prevailing wind direction.

The power station is stated to use natural gas as its main fuel, with the main emissions likely being nitrogen oxides (NOx), primarily in the form of nitrogen monoxide (NO) with a generally smaller quantity of nitrogen dioxide (NO_2). However, it is also capable of using heavy fuel oil for combustion, which will give rise to potentially increased emissions of particulates and of sulphur dioxide (SO_2).

Results from the RTMS have a tendency to show high levels of PM10 in exceedance of the air quality standard. Levels are higher in the spring and summer months when local conditions are dry and dusty. Figure 6.2.1.3 below gives the polar plot for hourly PM10 concentrations recorded during the 1st, 2nd, 3rd and 4th quarter of 2017.

The results show that the samplers are picking up particulates from all directions, but predominantly from the south, west and east; the directions of the local road and rail network. The high levels of airborne particulates within the survey area are likely from the pick-up and transportation of the fine dry dusty soils present in the region. There is no evidence to link the PM10 levels to operations at the terminal.

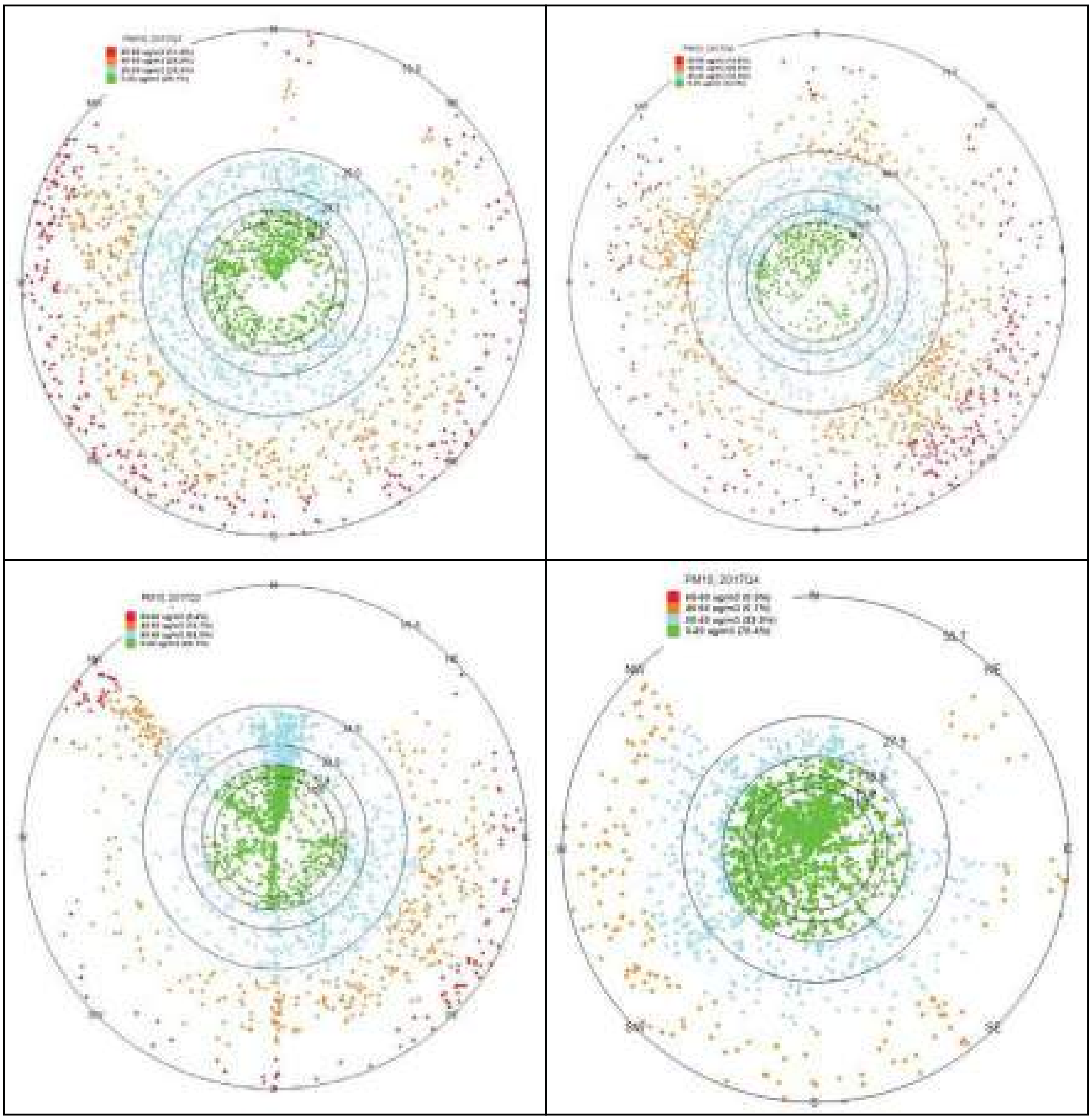


Figure 6.2.1.3 Polar plot diagram for PM10 concentrations quarters 1, 2, 3 and 4, 2017

Monthly real-time measurements of nitrogen oxides have exceeded the air quality standard in previous years. It is suspected that the source of the higher results is the adjacent third-party operated power station (600m from the RTMS) which uses natural gas as its main fuel source - resulting in emissions of nitrogen oxides.

Figure 6.2.1.4 to Figure 6.2.1.8 give the long-term monitoring annual average results of each measured parameter over the 2008 to 2017 monitoring period. Ambient air quality standards are given in Table 6.2.1.1 and are also noted in the title of each figure. The upper bar chart in each figure gives the results from northerly stations, while the lower bar chart gives the results from southern, downwind sample points.

The terminal sources of NOx are designed to direct emissions into the atmosphere, where – as shown through dispersion modelling – they rapidly disperse. It was identified in the SDII ESIA that local sources, including vehicle traffic, would have a greater influence on NOx levels than operations at ST.

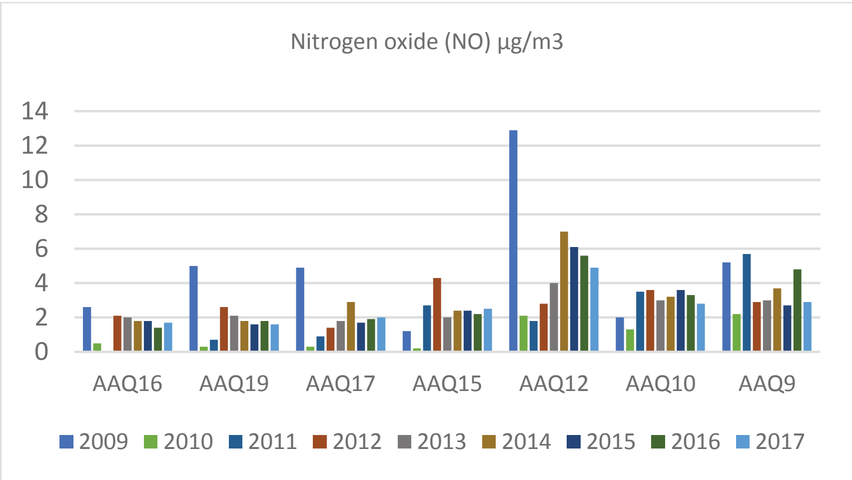
The pattern of NO results over the nine-year period has varied at individual stations (Figure 6.2.1.4). With the exception of the results from 2009, the lowest concentrations were consistently recorded at stations AAQ16, AAQ19, AAQ15, AAQ17 and AAQ1; all of which are located on the northern and north-western side of the terminal.

The highest concentrations have generally been recorded at station AAQ23 and AAQ12. As AAQ12 is located directly adjacent to the terminal boundary, the higher concentrations present may be influenced by activities at ST; it should be noted that a continual downward trend has been recorded at AAQ12 from 2014 onwards.

It is unlikely that the maximum levels recorded at station AAQ23 are related to ST activities, as lower levels have been recorded at intermediate sample points AAQ13 and AAQ6. The likely source of the higher levels at AAQ23 is the third-party operated power station.

Although the concentrations are essentially low and well within the national air quality standard concentration of 60 µg.m^{-3}, a relatively continuous upward trend was present in the data at a number of sample points, notably AAQ18, AAQ13 and AAQ14, all of which are located to the south of the ST. The upward trend was reversed in 2017, with lower concentrations being recorded at all three stations. As these sample points are located adjacent to the terminal road network, it is possible that the variation at these positions may have been influenced by vehicle traffic.

Nitrogen oxide (NO) was not measured in surveys conducted prior to 2009. Overall the average concentrations of NO between 2009 and 2017 have been low and within the national air quality standard concentration.



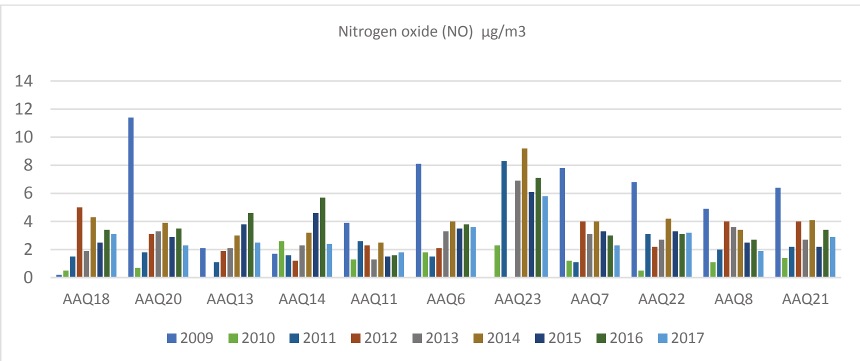
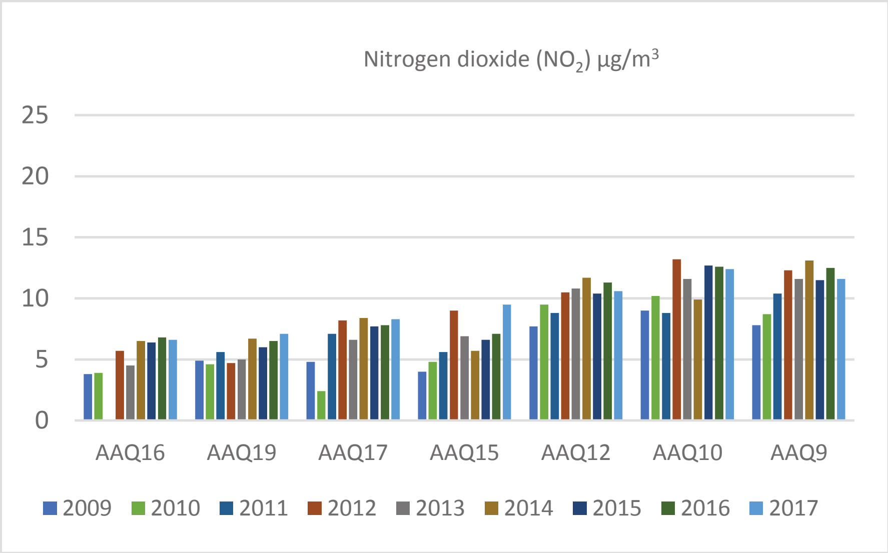


Figure 6.2.1.4 Nitrogen oxide (NO) results measured in 2009 - 2017 (µg.m^{-3}) National standard - daily average 60 µg.m^{-3}

The pattern of NO_2 results over the 9 years period is similar to NO (Figure 6.2.1.5), with the highest concentrations being observed at station AAQ23 and the lowest concentrations consistently present at northern stations AAQ16, AAQ19, AAQ15 and AAQ11. The upward trend observed in NO concentrations at stations directly to the south of the terminal is also present in the NO_2 data.

NO_2 was not measured in surveys conducted prior to 2009. All station average NO_2 values recorded between 2009 and 2017 were well below the EU annual average and national daily average of 40µg.m^{-3}.



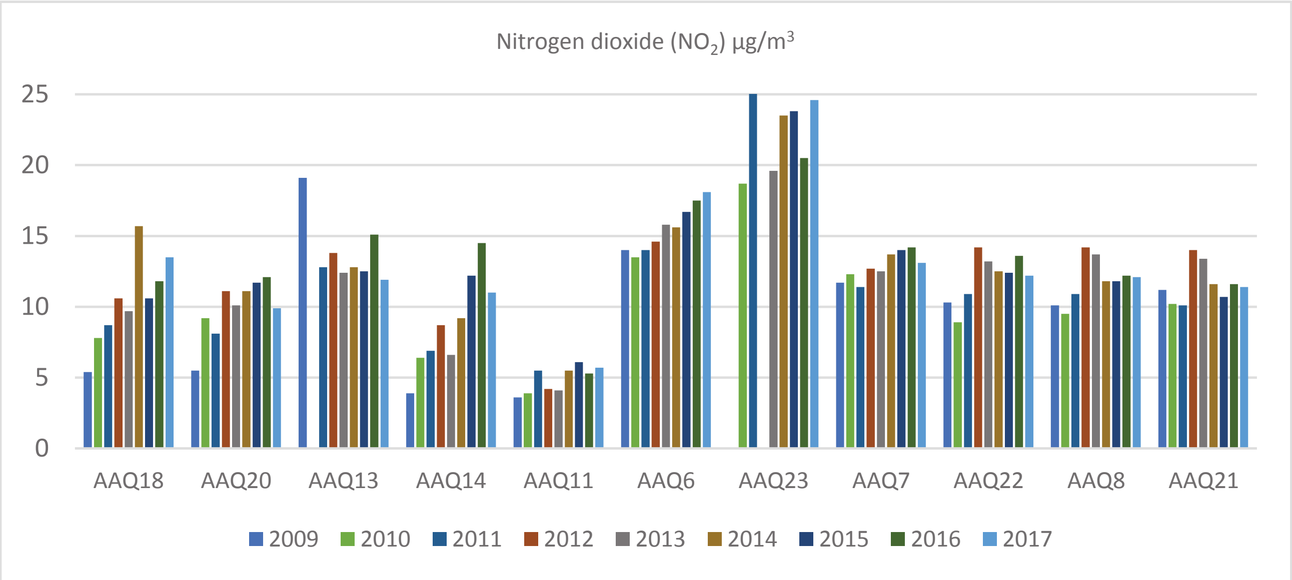


Figure 6.2.1.5 Nitrogen dioxide (NO_2) results measured in 2009 - 2017 (µg.m^{-3}) National standard (daily) & EU annual average 40 µg.m^{-3}

Sulphur dioxide (SO_2) annual average results were below the detection limit of 2 µg.m^{-3} in 2014, 2015, 2016 and 2017 (Figure 6.2.1.6). The recordable levels in previous surveys were generally low or very low at all stations, and well below the EU and national reference daily averages of 125 and 50µg.m^{-3}.

Between 2005 and 2008, SO_2 concentrations were recorded at a number of stations. Over the entire monitoring period the average concentration exceeded the Azerbaijan air quality standard on three occasions.

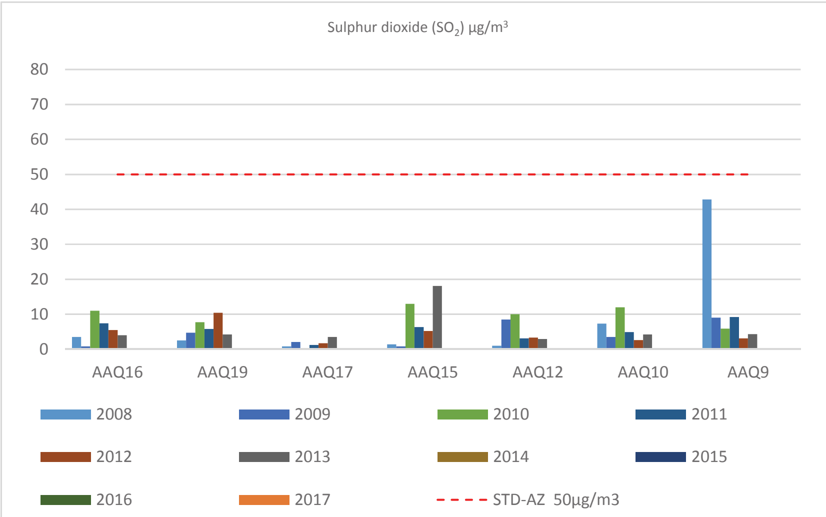
In 2008, concentrations of 50.2µg.m^{-3} and 70.8µg.m^{-3} were recorded at station AAQ13 and AAQ21. It is possible that the higher concentration at sample point AAQ13 - located adjacent to the southern boundary of the ST - was influenced by activities at the facility.

The high concentration at sample point AAQ21 - located >4km from the ST – is likely associated with local activities and unrelated to terminal operations, as lower concentrations were observed at intermediate sample points.

Although within the Azerbaijan air quality standard, a relatively high concentration of 42.8µg.m^{-3} was recorded at station AAQ9 in 2008. Station AAQ9 is located within the Umid settlement, east of ST. It is unlikely that the terminal operations were responsible for this higher concentration, as lower levels were reported from sample points between AAQ9 and the ST.

A concentration of 102.6µg.m^{-3} was observed at sample point AAQ18 in 2007. As AAQ18 lies to the south of ST, it is possible that this isolated higher concentration may have been influenced by activities at the terminal. However, it should be noted that lower levels were reported from sample points located closer to the ST.

There was no pattern in the data to indicate that the SO_2 concentrations were related to emissions from the ST.



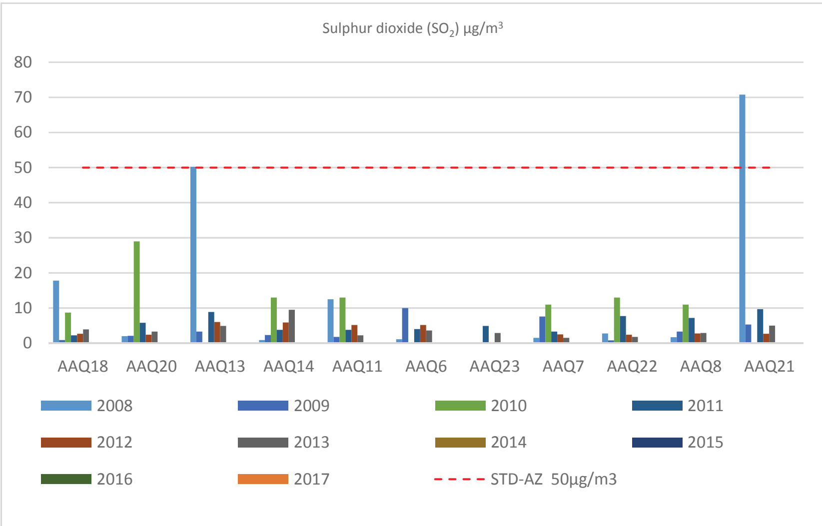


Figure 6.2.1.6 Sulphur dioxide (SO_2) results recorded in 2008 – 2017 (µg.m^{-3})
National standard - daily average 50 µg.m^{-3} and EU daily average 125 µg.m^{-3}

There was very low variation in the average concentration of benzene across the sample sites on all surveys between 2013 and 2017 (Figure 6.2.1.7). Concentrations were low at all stations and well within the EU annual average of 5µg.m^{-3}.

The highest average values were recorded in surveys carried out in 2009 and 2010. As the concentrations in both years were higher at all sample points, including sample points up-wind from the terminal, it is unlikely that terminal operations were responsible for the universally higher concentrations recorded in these years.

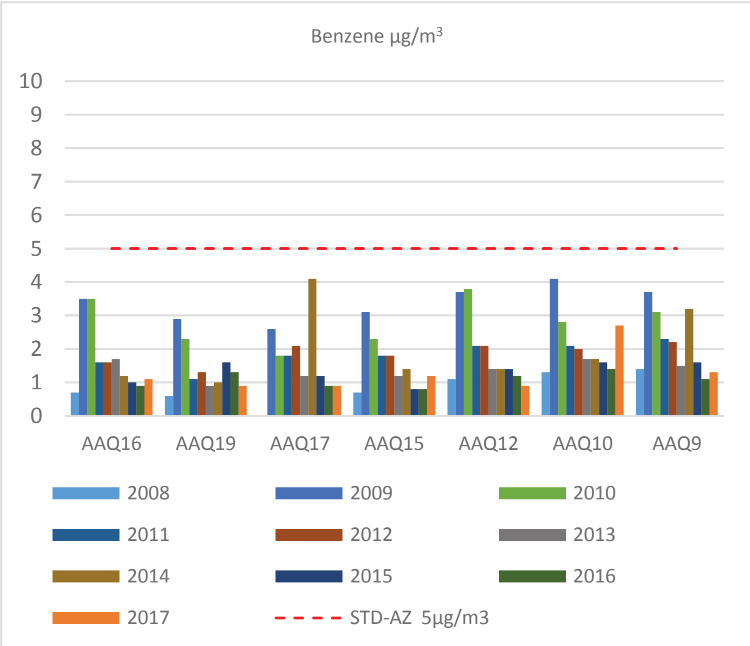
The EU annual average of 5µg.m^{-3} was exceeded in 2009 in samples from stations AAQ20 and AAQ6, and again at station AAQ6 in 2010.

Station AAQ20 is located adjacent to the southern perimeter of the terminal. While generally higher concentrations were recorded throughout the survey area in 2009, the concentration at AAQ20 was significantly higher than those recorded at other stations, which may indicate a transient influence from terminal activities at this position.

The high concentrations at station AAQ6 in 2009 and 2010 are unlikely to be related to operations at ST, as lower levels were observed at intermediate station AAQ13. The higher concentrations at AAQ6 are expected to be associated with local activities.

Benzene levels were recorded at a number of stations between 2005 and 2008. Over the three year period the EU standard was exceeded on one occasion; a concentration of 17.9 µg.m^{-3} was recorded at station AAQ7 in 2007. This isolated high concentration was likely related to local activities adjacent to the sample point and was not considered to be associated with terminal operations.

Other than a possible transient influence at station AAQ20 in 2009 resulting in an exceedance of the EU air quality standard, there was no evidence to indicate that benzene levels in the surrounding area have been influenced by activities at the terminal. Recorded levels on recent surveys are low and have varied little between stations and between years.



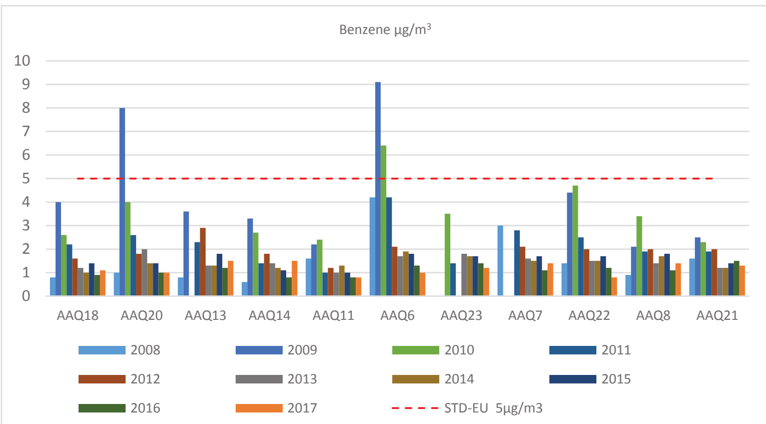


Figure 6.2.1.7 Benzene results recorded in 2008 - 2017 (µg.m^{-3})
National standard - daily average 100 µg.m^{-3} and EU annual Average 5 µg.m^{-3}

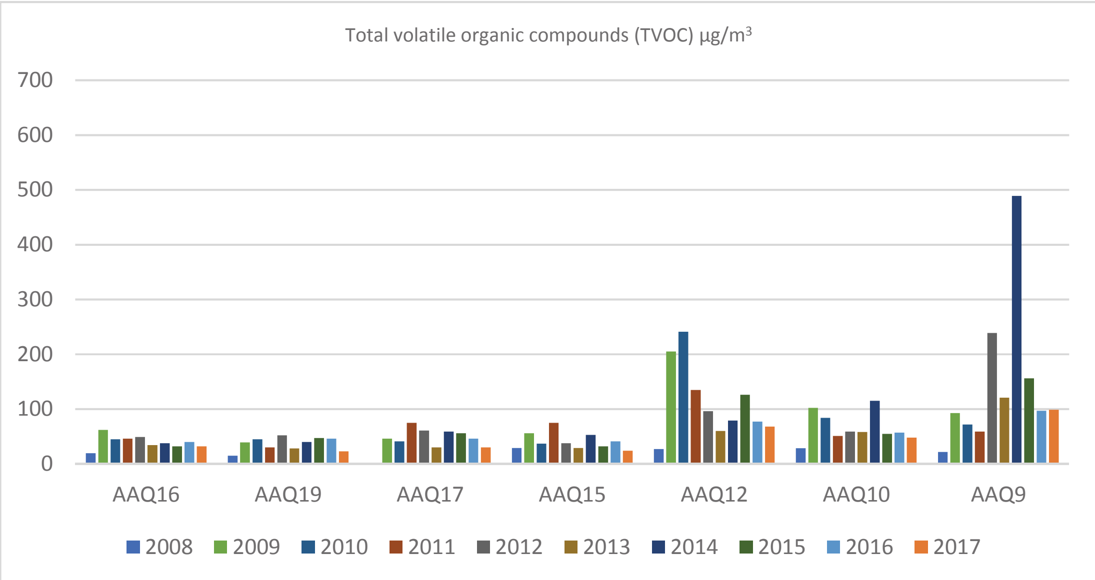
No environmental standard exists for total volatile organic compounds (TVOC). On recent surveys the highest levels were observed at station AAQ9 (Figure 6.2.1.8). Station AAQ9 is located to the east of the terminal, within the Umid village, and does not lie downwind of the prevailing wind direction from the terminal. As lower concentrations are consistently recorded at station AAQ12 which is located between the ST and station AAQ9, it is expected that the higher concentrations at AAQ9 are associated with local activities and are unrelated to operations at the terminal.

High TVOC concentrations were recorded in 2009 and 2010 at sample points AAQ20 and AAQ6, and in 2009 at sample point AAQ7.

While the proximity of sample point AAQ20 to ST suggests that the higher level in 2009 may be related to activities at the terminal, it is not expected that terminal operations have resulted in the higher concentrations at AAQ6 and AAQ7, as lower levels were observed at intermediate station AAQ13. The higher levels at AAQ6 and AAQ7 are likely related to local activities.

Across the monitoring period, the highest average TVOC concentrations have been recorded at sample sites AAQ6, AAQ7, AAQ9, AAQ12 and AAQ20. While the highest concentrations at AAQ6, AAQ7 and AAQ9 are expected to be related to local activities, the generally higher concentrations at AAQ12 and AAQ20 may be related to terminal activities.

A possible source of VOC from the terminal are the produced water ponds, which are located in the northeast of the terminal. It is possible that evaporation of volatile compounds from the produced water ponds may contribute to the relatively higher VOC concentrations recorded at AAQ12 and AAQ20.



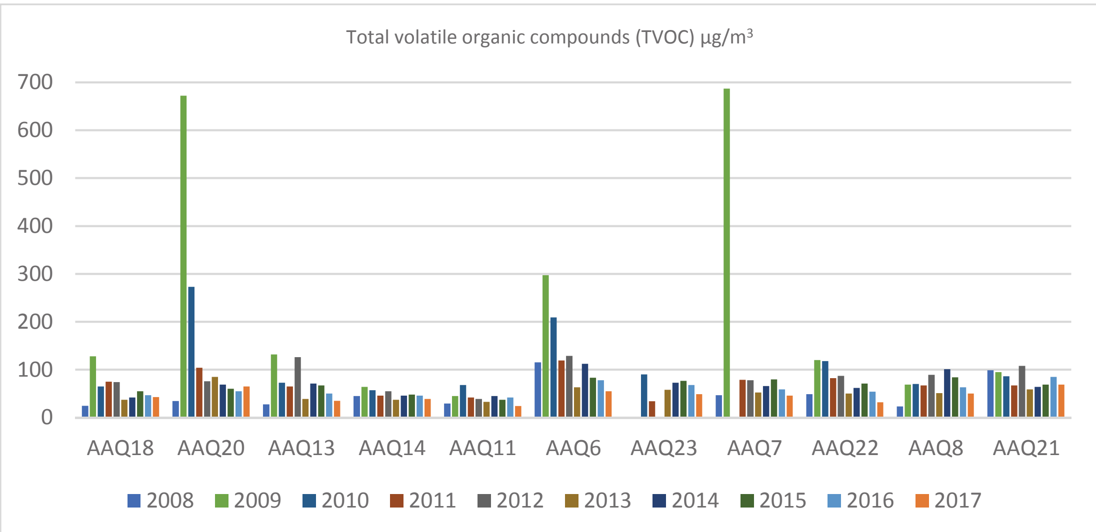


Figure 6.2.1.8 TVOC results recorded in 2008 - 2017 (µg.m^{-3})

Exceedances in the real-time monitoring data for PM10 were unrelated to terminal activities and were likely due to the pickup and transportation of the dry dusty soils present within the Sangachal area. While SDII expansion project activities involving ground works were carried out between 2012-2013 and 2015 and 2017, mitigation to manage dust generation was in place and there was no evidence to suggest that these works contributed to increased PM10 levels.

With the exception of 4 isolated occurrences between 2007 and 2010 for benzene and 3 between 2007 and 2008 for SO_2, the results from the long term monitoring programme have been within the National and EU air quality standards.

With the exception of a possible influence at station AAQ20 in 2009 resulting in an exceedance of the EU air quality standard for benzene, a possible association between relatively higher NOx and TVOC at AAQ12 and TVOC at AAQ20, there was no evidence to indicate that NOx, benzene, TVOC or SO_2 levels in the surrounding area have been influenced by emissions from or activities at the terminal.

6.2.2. Ground and surface water quality monitoring

As part of the EMP, monitoring of ground and surface water is conducted in areas within and surrounding ST to identify the presence of impacts on the ground and surface water quality from operations at the terminal.

A baseline study was carried out in 2001, this was followed by an annual monitoring programme which commenced in 2006. The monitoring programme involves the collection and analysis of water samples from predrilled boreholes and predetermined surface water sampling points. The data is measured against a Generic Assessment Criteria (GAC) of relevant water quality standards* and the risk is assessed based on the relationship between contaminants, pathways and receptors. National standards for ground water quality are not available.

Of the six boreholes drilled during the 2001 baseline study, groundwater was only encountered in one well. The salinity analysis results indicated that the groundwater contained greater than 10% total dissolved solids (TDS) and was therefore saline. Trace concentrations of copper, iron, lead and zinc were reported and total petroleum hydrocarbons (TPH) were detected at a concentration of 68.6 $\mu g.l^{-1}$.

From 2006, the survey design has continually developed; some boreholes have been removed from the scope while many more have been added. The survey design is based around the direction of the regional ground water flow, which is anticipated to flow from high ground in the north towards the Caspian Sea to the southeast. A total of 41 boreholes are sampled for monitoring groundwater quality and seven locations for surface water quality in the current monitoring scope (Figure 6.2.2.1).

The groundwater level is monitored on a monthly basis. The water level is measured in the boreholes located within and around the terminal, and also by piezometers which are located around the produced water storage ponds. The piezometers are used to monitor the integrity of the produced water storage ponds.

* The results are assessed against the UK regulatory standards
- UK drinking water standard
- UK coastal & freshwater environmental quality standard

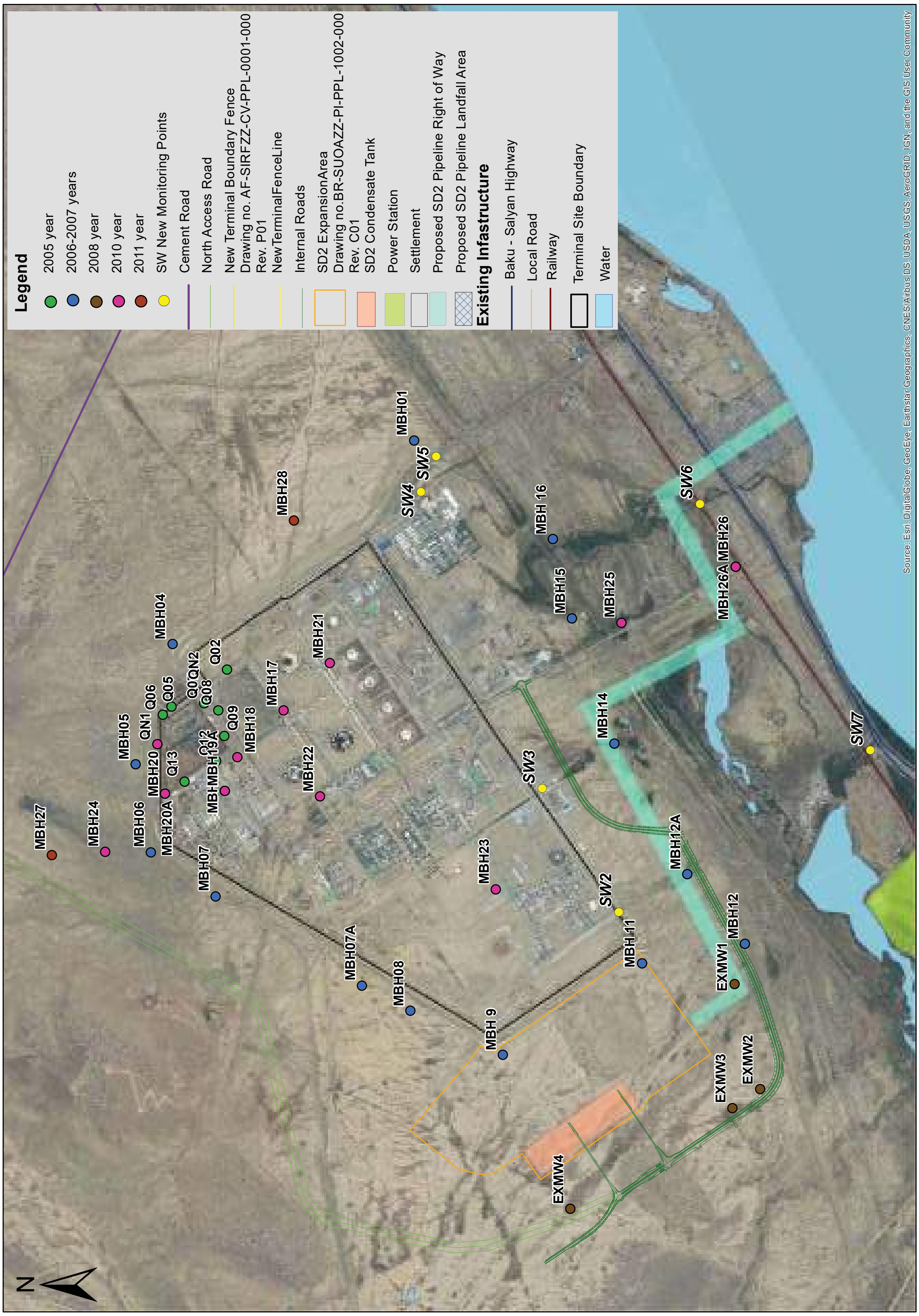


Figure 6.2.2.1 Ground & surface water quality monitoring locations in and around the Sangachal Terminal

Figure 6.2.2.2 gives the groundwater level measurements over the period June 2011 – December 2017. Over this period, ground water levels in the majority of sample boreholes have been relatively stable and generally exhibited a consistent relationship with each other, confirming a consistent groundwater flow direction, which is predominantly to the south – in line with the general topography. In general, the groundwater level in deeper wells has exhibited considerably more variability than the level in shallower wells.

The only observable trends in the groundwater levels were; a general decline in groundwater from 2011 within well pairs MBH19/MBH19A and MBH20/20A (located west and north of the produced water ponds respectively); a generally increasing trend in groundwater level from 2015 at MBH17 and MBH22, and from 2011 at QN2 (all located south of the produced water ponds); and a generally decreasing trend in groundwater level from 2014 at MBH15 located south of the terminal.

Figure 6.2.2.2 Groundwater levels – m above Pulkovo 1942 datum (July 2011 – January 2017)

The electrical conductivity data indicate that groundwater was of high salinity. The lowest salinities (electrical conductivity consistently below 50,000 μS/cm) were found on the eastern part of the site. The highest salinities (inferred by electrical conductivity >100,000 μS/cm) were consistently observed in the vicinity of the produced water ponds and may be indicative of a leakage of saline produced water from these ponds.

A number of parameters are reported at levels in excess of the reference standards. Although the distribution of some indicate or suggest an influence from terminal activities, a number were consistently high throughout the survey area and were attributable to regional background concentrations; such as copper, lithium and zinc.

A number of possible contamination sources exist within the terminal; the most notable being the produced water storage ponds. Higher concentrations of a number of parameters have been recorded over a number of surveys in samples from the boreholes adjacent to these ponds.

The chloride concentration has exceeded the UK drinking water standard (DWS) of 250mg.l^{-1} in all ground water samples over the entire monitoring period. The highest chloride concentrations are consistently detected in the vicinity of the produced water ponds and may be a result of a leakage of saline produced water. However, levels have remained relatively stable across the site since 2010 (Figure 6.2.2.3).

Chloride concentrations in the produced water ponds in 2008 ranged from 9,592-24,851 mg.l[-1], which is towards the lower range of the concentrations detected in groundwater samples. This may reflect a change in produced water salinity since 2008 or chloride may also be derived from leaching of the underlying saline soils.

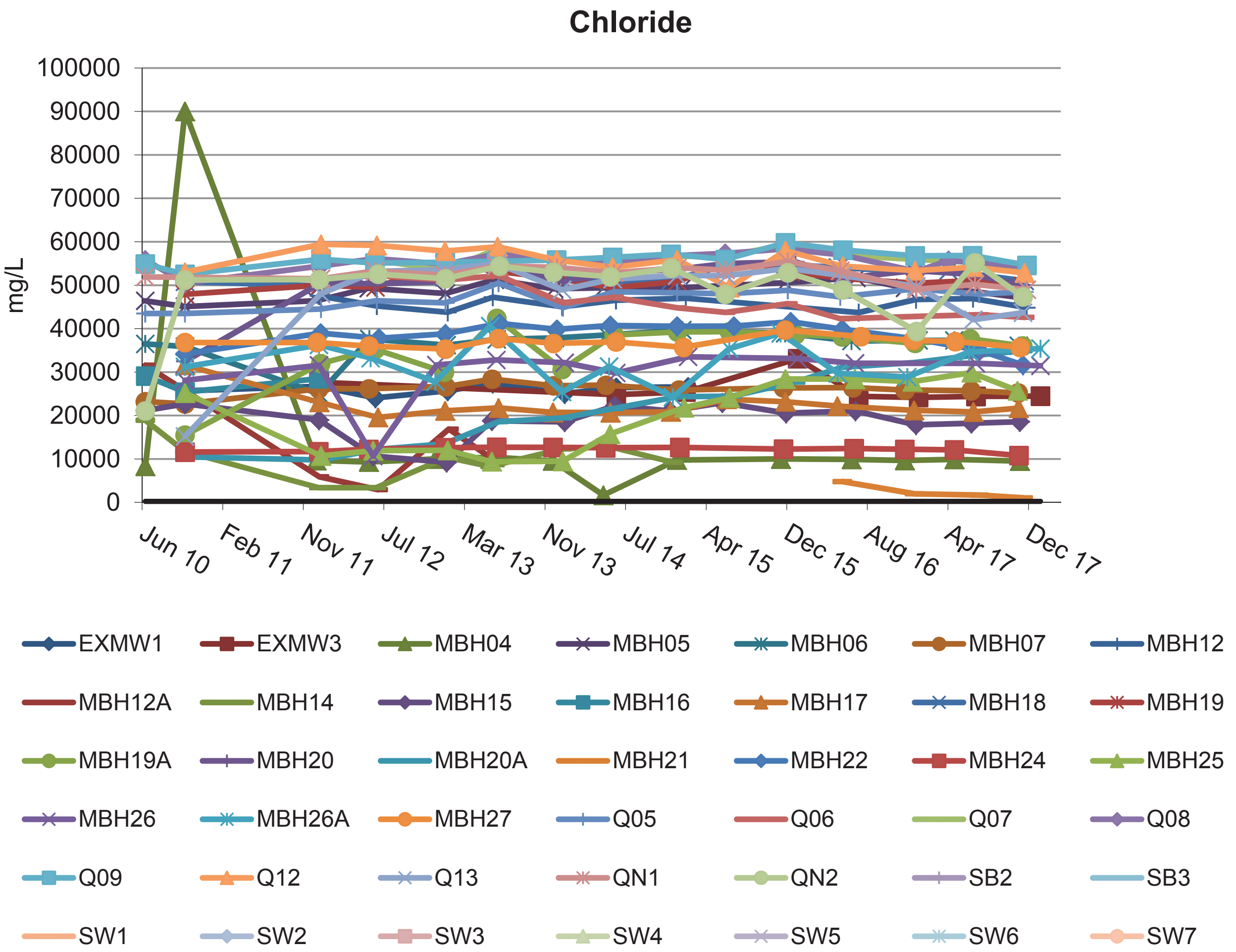


Figure 6.2.2.3 Chloride concentrations in ground water samples

Sulphate concentrations are generally stable, with the exception of location MBH17 which has shown a generally increasing trend since 2010 (Figure 6.2.2.4). MBH17 is located southeast of the produced water ponds. The sulphate concentrations detected in groundwater at this location are higher than those detected in the immediate vicinity of the ponds. This could indicate another localised source of sulphate or it may be linked to the ponds through a leak that bypasses the closer monitoring well network.

A modest upward trend was also present from 2013 at MBH07. MBH07 is located outside the terminal boundary to the northwest and up-gradient from the produced water ponds.

Sulphate concentrations in the produced water ponds in 2008 ranged from 920-1,670 mg.l[-1], which is towards the lower range of the concentrations detected in groundwater. This may reflect a change in produced water quality since 2008, or sulphate may also be derived from leaching of the underlying saline soils from leaking produced water.

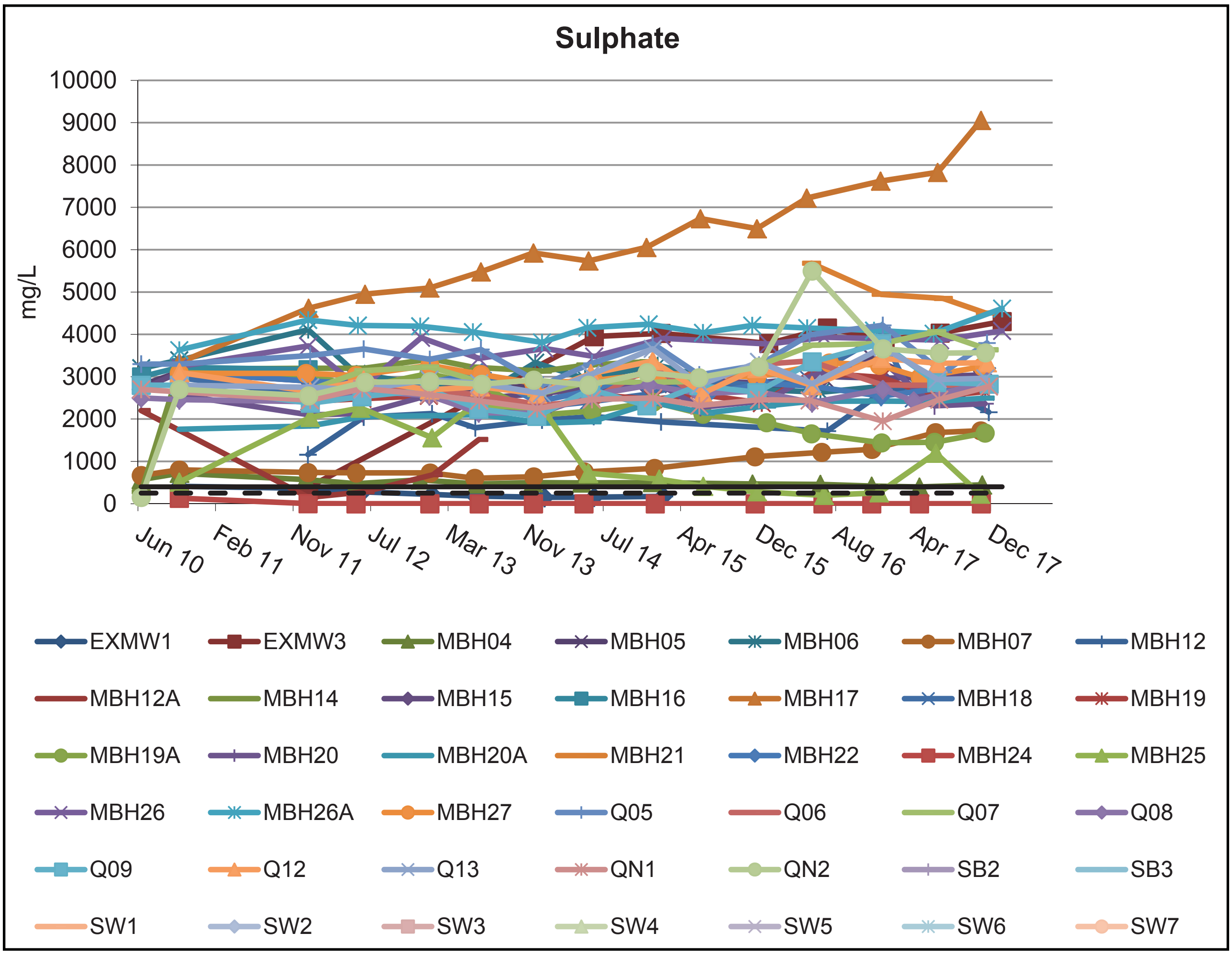


Figure 6.2.2.4 Sulphate concentrations in ground water samples

Cadmium concentrations have exceeded the conservative UK Freshwater Environmental Quality Standard (EQS)of 0.08µg.l^{-1} at almost all locations. The highest concentrations; exceeding the UK DWS concentration of 5 µg.l^{-1}, are generally observed in the vicinity of the produced water ponds (Figure 6.2.2.5). The highest concentration on previous years (pre-2013) was observed at MBH05 located off-site to the north of the terminal.

Cadmium was detected in the produced water ponds at concentrations ranging from 0.4-1.9 µg.l^{-1} in 2008, which represents the lower end of the range of concentrations detected in the groundwater below the site. This may reflect a change in produced water quality since 2008, or a contribution from leaching of the underlying saline soils from leaking produced water.

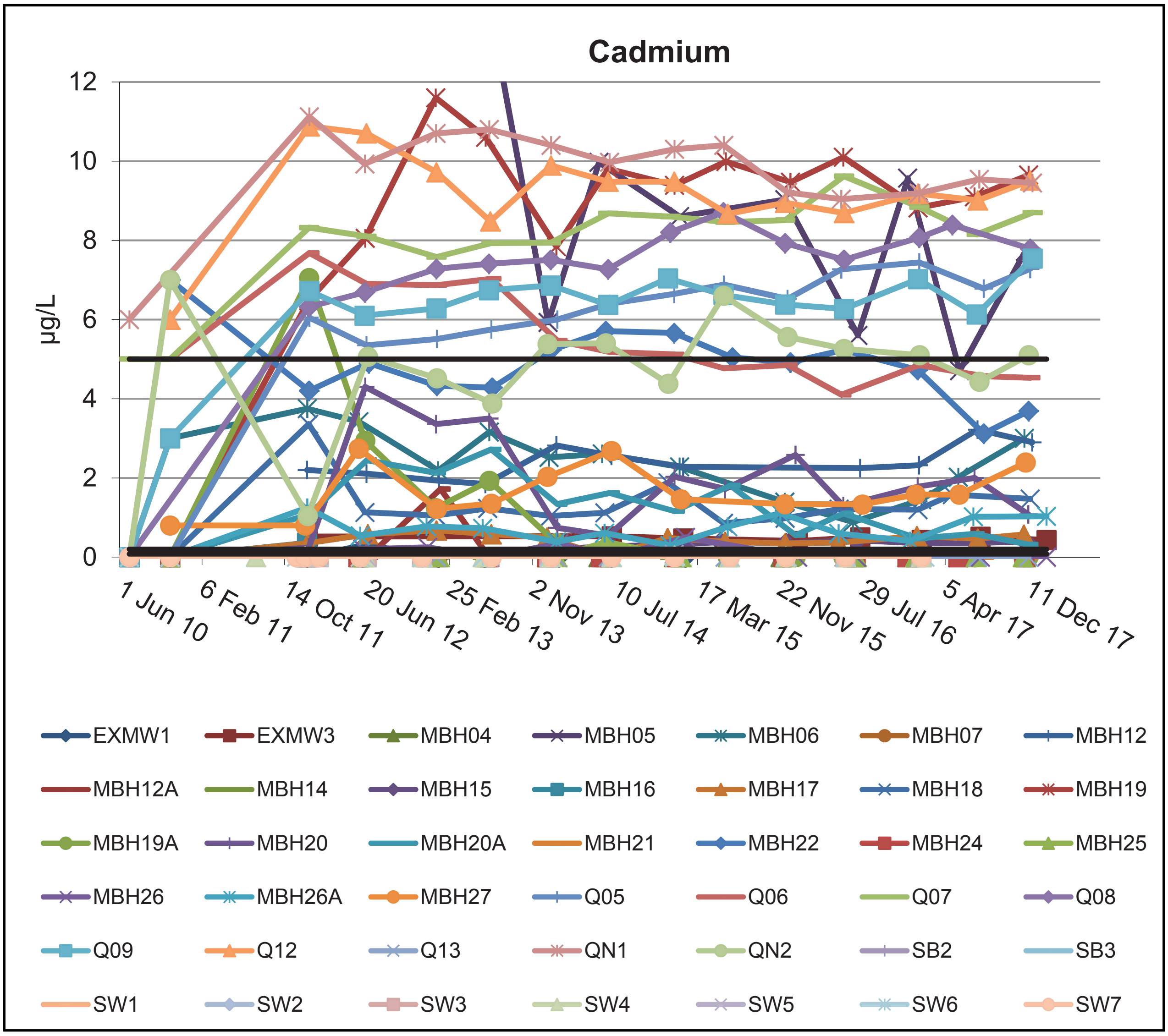


Figure 6.2.2.5 Cadmium concentrations in ground & surface water samples

Barium concentrations were detected below the UK DWS GAC of 1,300 $\mu g.l^{-1}$ at all locations except MBH24 (21,414 & 20,251251 $\mu g.l^{-1}$) and MBH25 (2,115 $\mu g.l^{-1}$, 2nd round) during the monitoring events in 2017 (Figure 6.2.2.6).

The barium concentration reported at MBH24 has consistently remained significantly higher than any other sampling locations and may be related to the dissolution of barite ($BaSO_4$) from historical drilling mud contamination associated with an abandoned oil exploration well located to the northeast of this borehole location.

Barium concentrations above the GAC have not been detected between 2010 and 2017 at MBH06 located down-gradient of MBH24, which may reflect a limited mobility.

The source of the recent increase in barium concentrations at MBH25 located to the south east of the terminal is unknown, however barium concentrations have reduced since July 2016.

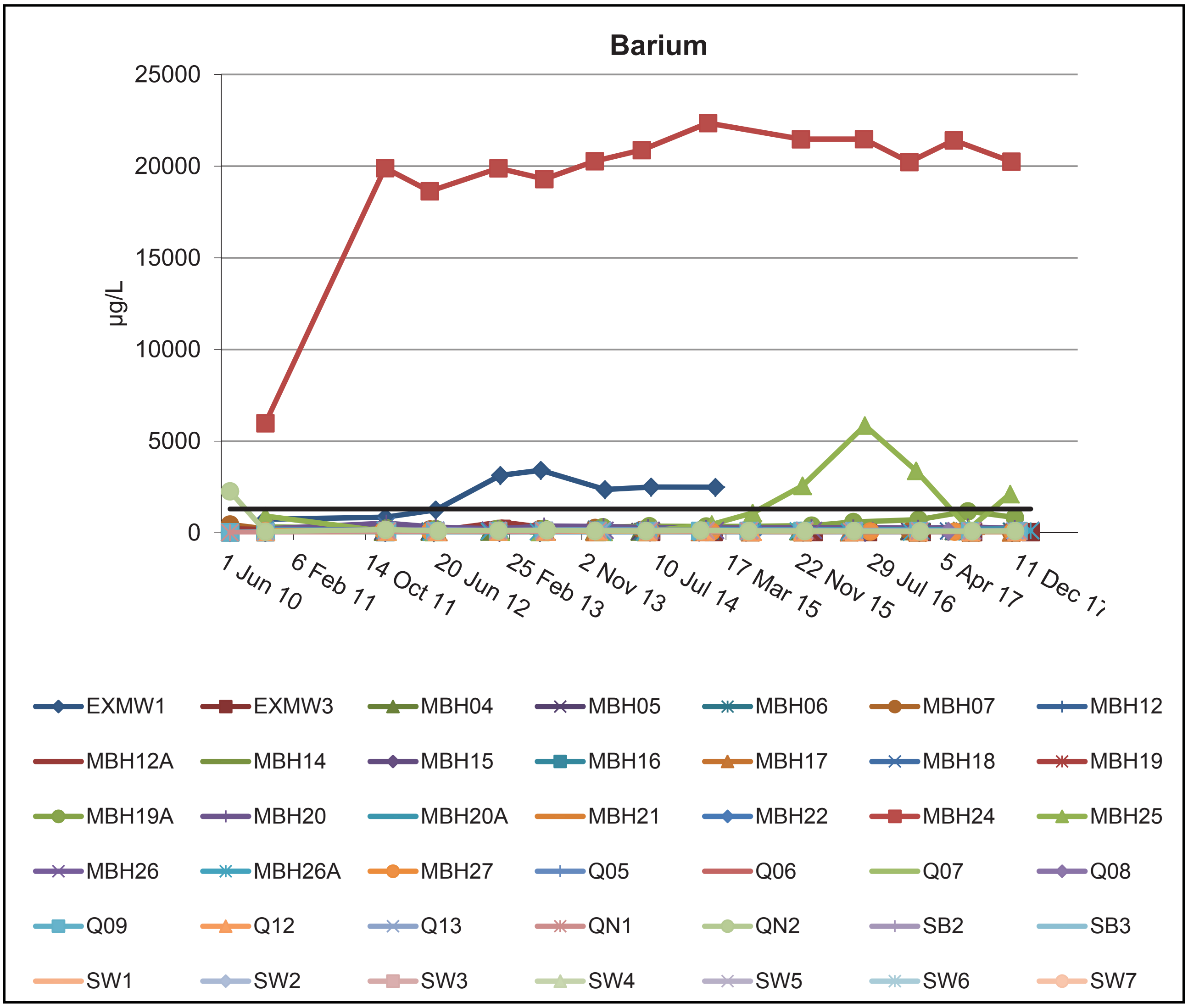


Figure 6.2.2.6 Barium concentrations in ground water samples

Copper was detected in the produced water ponds at concentrations ranging from 12-44 µg.l[-1] in 2008, which is similar to the range of concentrations detected in the majority of groundwater samples.

The UK Freshwater EQS GAC of 1 µg.l[-1] was exceeded at most locations in 2017 (Figure 6.2.2.7). It is noted that this GAC is for bioavailable copper and hence, its comparison with total copper concentrations is highly conservative.

Concentrations above the Freshwater EQS GAC were recorded across the site, not just in the vicinity of the produced water ponds. This may suggest locally high copper concentrations, rather than exceedances being attributed to site activities.

The UK DWS for copper is 2000 µg.l[-1]. All copper concentrations recorded in 2017 and previous years were significantly below the UK DWS.

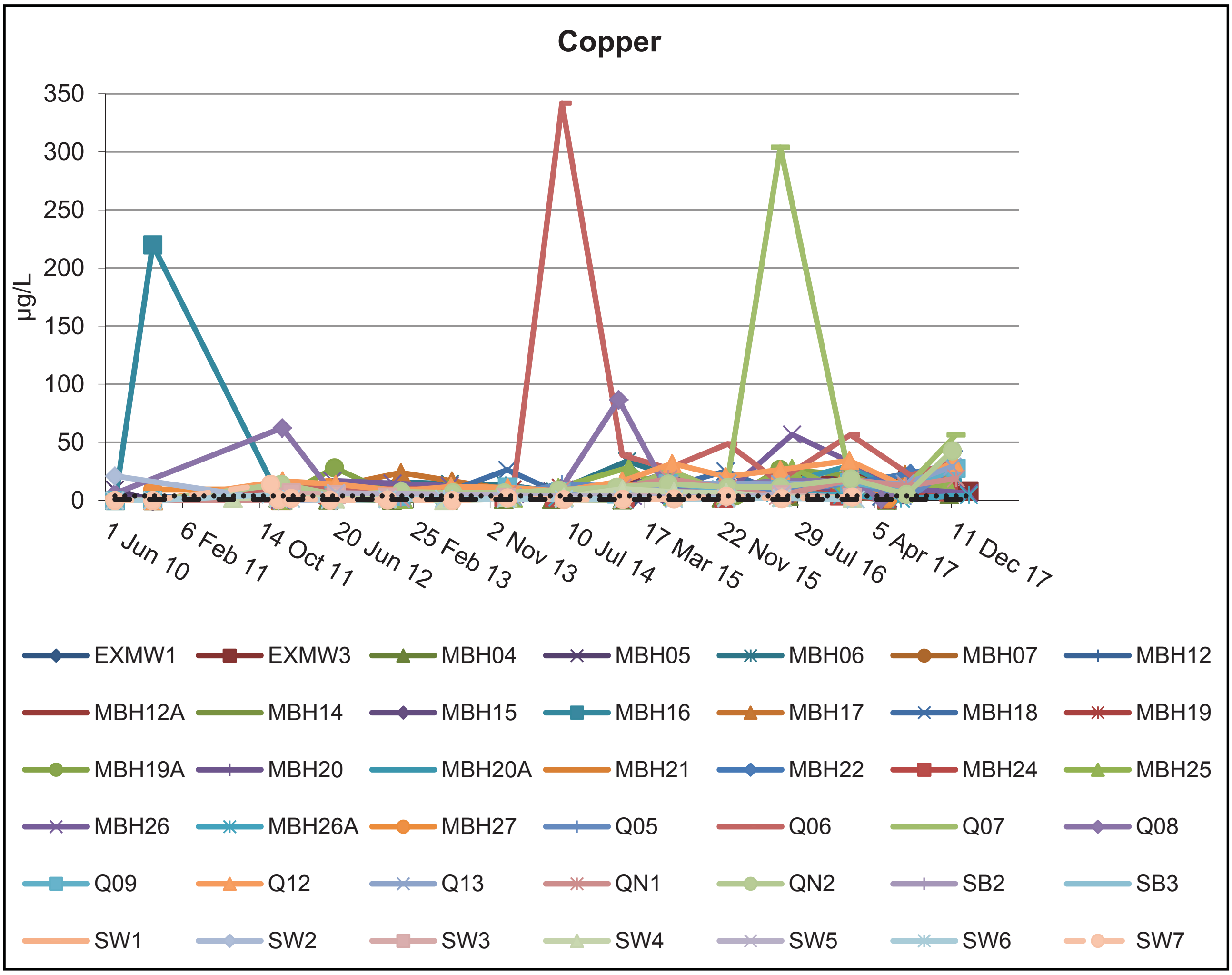


Figure 6.2.2.7 Copper concentration in ground & surface water samples

During the 2017 monitoring events, the iron concentration at most locations was less than the UK DWS GAC of 200µg.l^{-1} (Figure 6.2.2.8). The UK Freshwater and Coastal EQS GAC of 1,000µg.l^{-1} was exceeded by over an order of magnitude at MBH20A, MBH25 and Q13. MBH20A and Q13 are located adjacent to the produced water ponds and MBH25 is located down-gradient of the site.

Iron was detected in the produced water ponds at concentrations ranging from 1,900-10,950 µg.l^{-1} in 2008, indicating that the produced water could be a source of the iron detected in groundwater in this area.

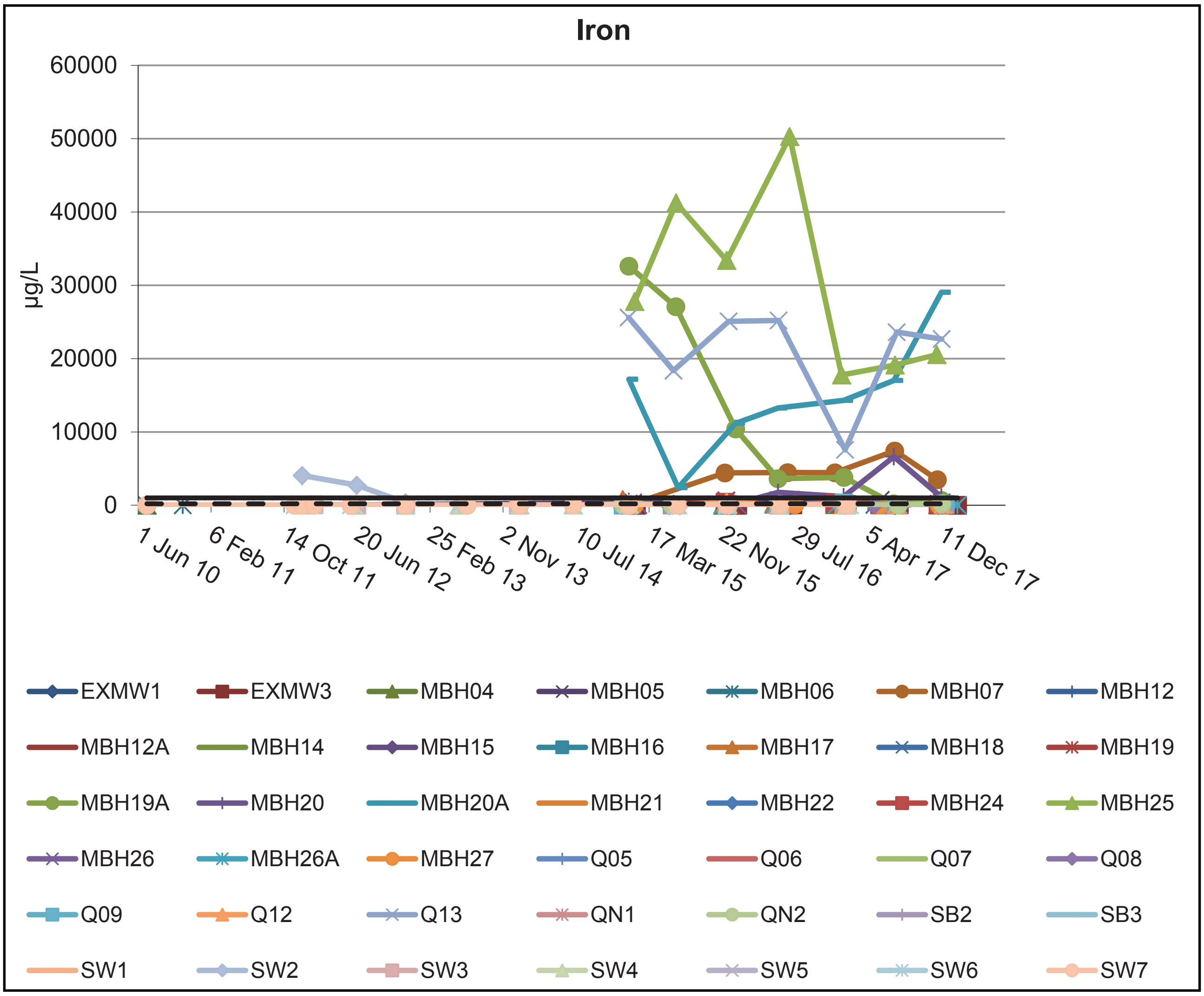


Figure 6.2.2.8 Iron concentration in ground & surface water samples

During the 2017 monitoring events, the lead concentration at all locations was less than the UK DWS GAC of 10 $\mu g.l^{-1}$ with the exception of MBH20A (16.4 $\mu g.l^{-1}$) in the second round (Figure 6.2.2.9). MBH20A is located in the vicinity of the produced water ponds.

Lead was detected in the produced water ponds at concentrations ranging from 5-36 $\mu g.l^{-1}$ in 2008. Over the monitoring period the highest lead concentrations have generally been recorded in samples from boreholes adjacent to the produced water ponds; Q8 & Q6 in 2014; Q9 in 2012/2013; MBH20A in 2011/2013; and Q7 and MBH20A in 2016. This suggests that the produced water ponds are a potential source of these elevated lead concentrations. As the higher concentrations are generally isolated and sporadic, it appears that the contamination is localised and that the mobility of lead is limited.

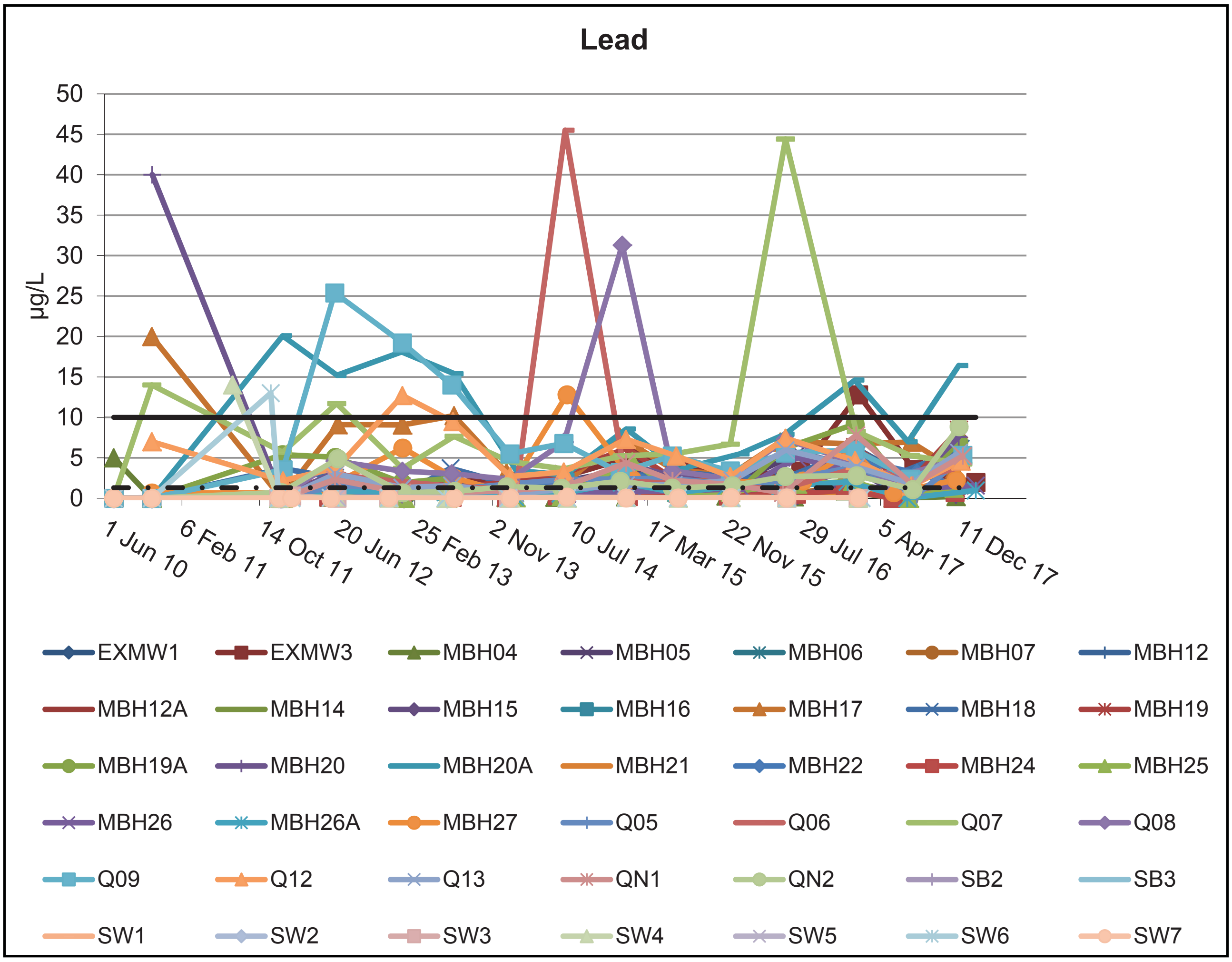


Figure 6.2.2.9 Lead concentration in ground & surface water samples

In 2017, the maximum recorded nickel concentration of 528 µg.l^{-1} was detected at MBH17, located in the centre of the site, down-gradient of the produced water ponds. This concentration is considerably above the UK DWS GAC of 20 µg.l^{-1} and the UK Freshwater and Coastal EQS of 4 µg.l^{-1} (bioavailable) and 8.6 µg.l^{-1} respectively. The two highest nickel concentrations over the past three years of monitoring have been consistently detected at MBH17 and MBH20A, both located in the vicinity of the produced water ponds. Concentrations at both locations have been relatively stable over this period.

Nickel was detected in the produced water ponds at concentrations ranging from 135-298 µg.l^{-1} in 2008, which is similar to, albeit slightly lower than, the maximum concentrations detected on-site. Therefore, the produced water ponds may be a potential source for this metal.

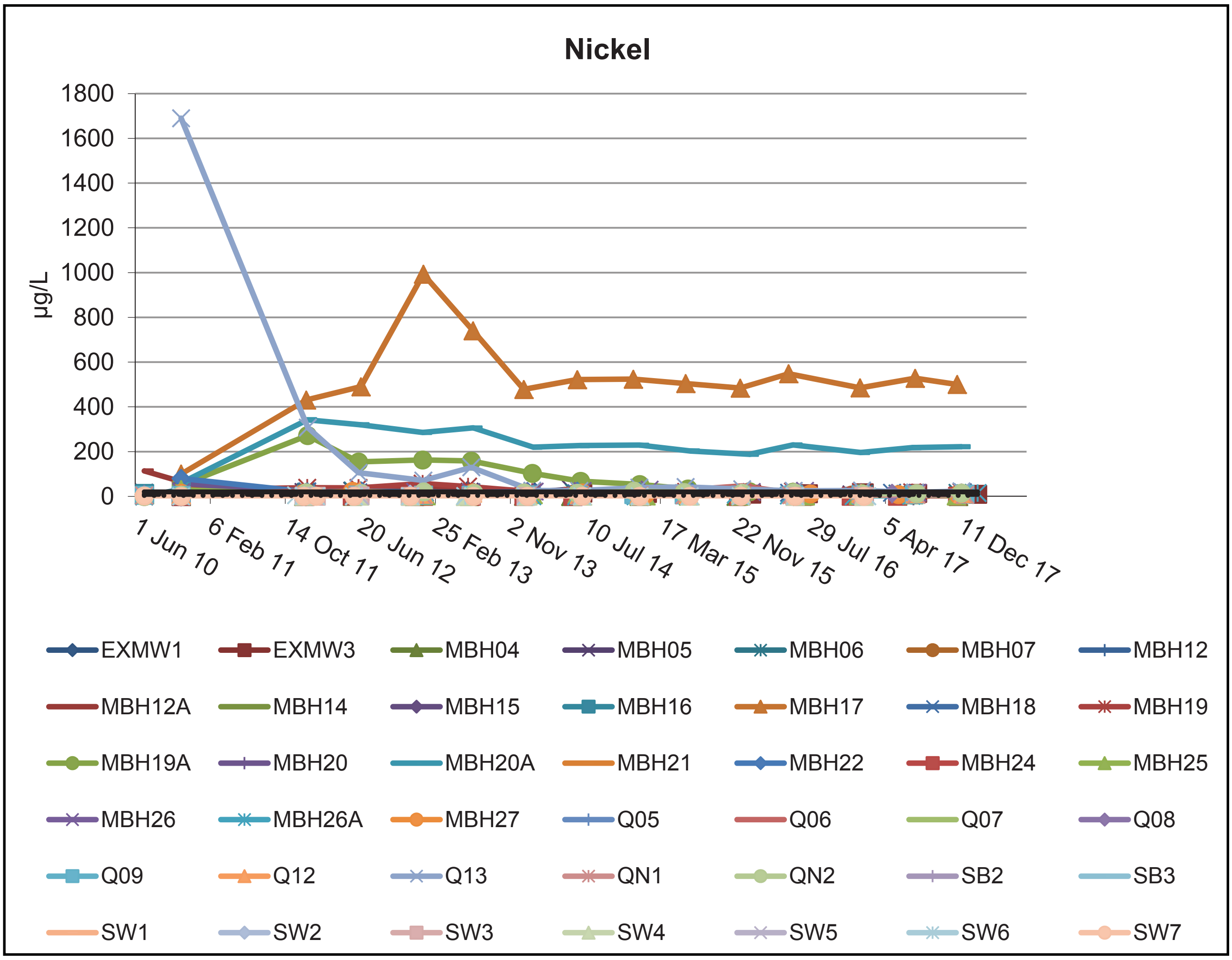


Figure 6.2.2.10 Nickel concentration in ground & surface water samples

BTEX were detected at low concentrations in a large number of samples during the 2017 monitoring rounds. Similar to the results from 2013 to 2016, the highest BTEX concentrations were detected at MBH20A (Figure 6.2.2.11 & Figure 6.2.2.12) adjacent to the produced water ponds, suggesting a link to site activities.

In addition to the highest concentrations at MBH20A, benzene was detected above the UK DWS GAC at MBH19A in both rounds (5.9 and 4.0 $\mu g.l^{-1}$), and above the UK DWS and Freshwater EQS GAC in MBH17 (15.6 $\mu g.l^{-1}$) during the second round.

BTEX were detected in the produced water ponds at concentrations ranging from <7-34,400 $\mu g.l^{-1}$ in 2008, with benzene ranging in concentration from <7-23,000 $\mu g.l^{-1}$, confirming the ponds as a potential source of these compounds.

Elevated BTEX concentrations have not generally been detected in groundwater down-gradient of the produced water ponds, which is consistent with the findings of the 2011 Risk Assessment of the impact of potential hydrocarbon contamination from this area of the site.

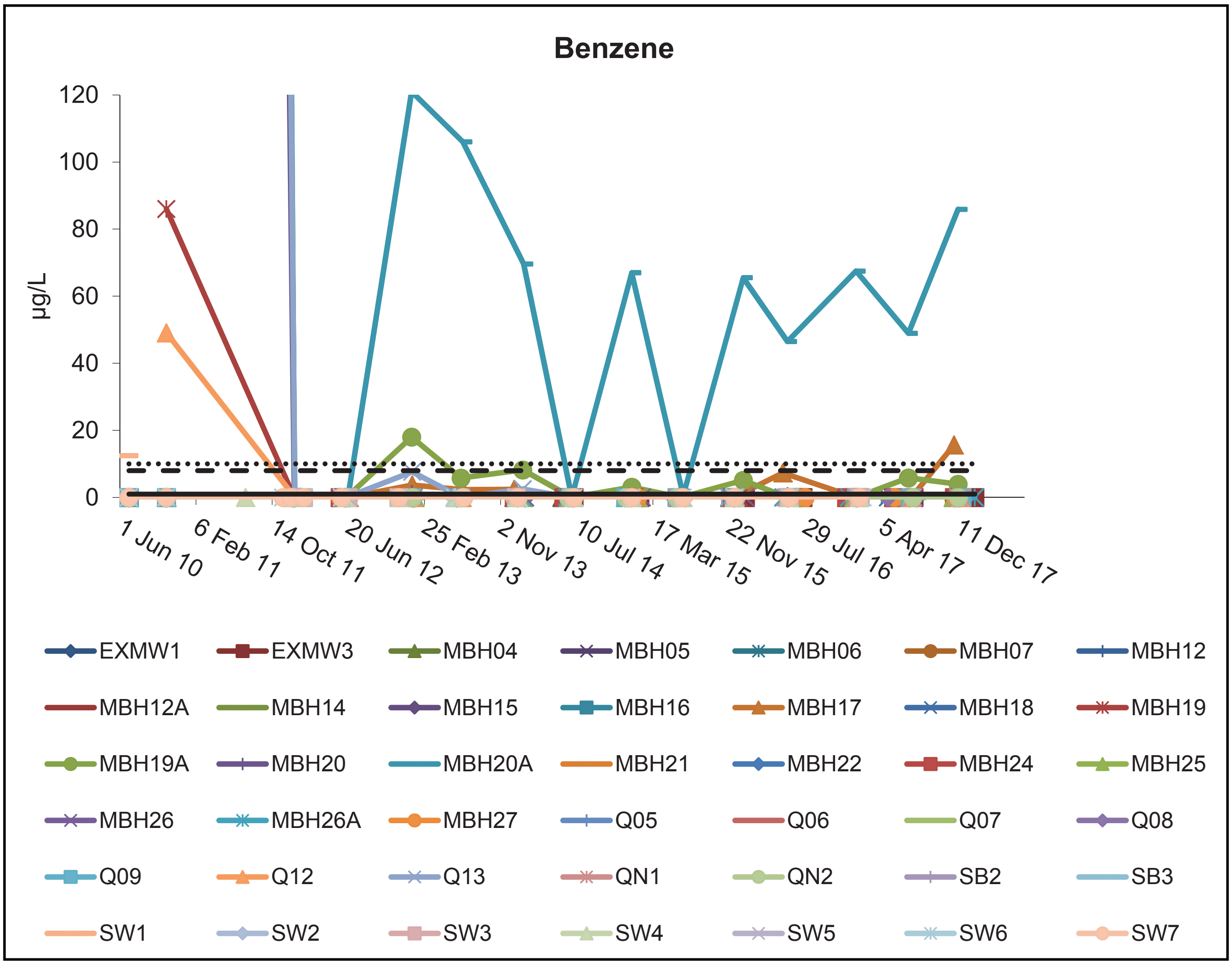


Figure 6.2.2.11 Benzene concentrations in ground & surface water samples

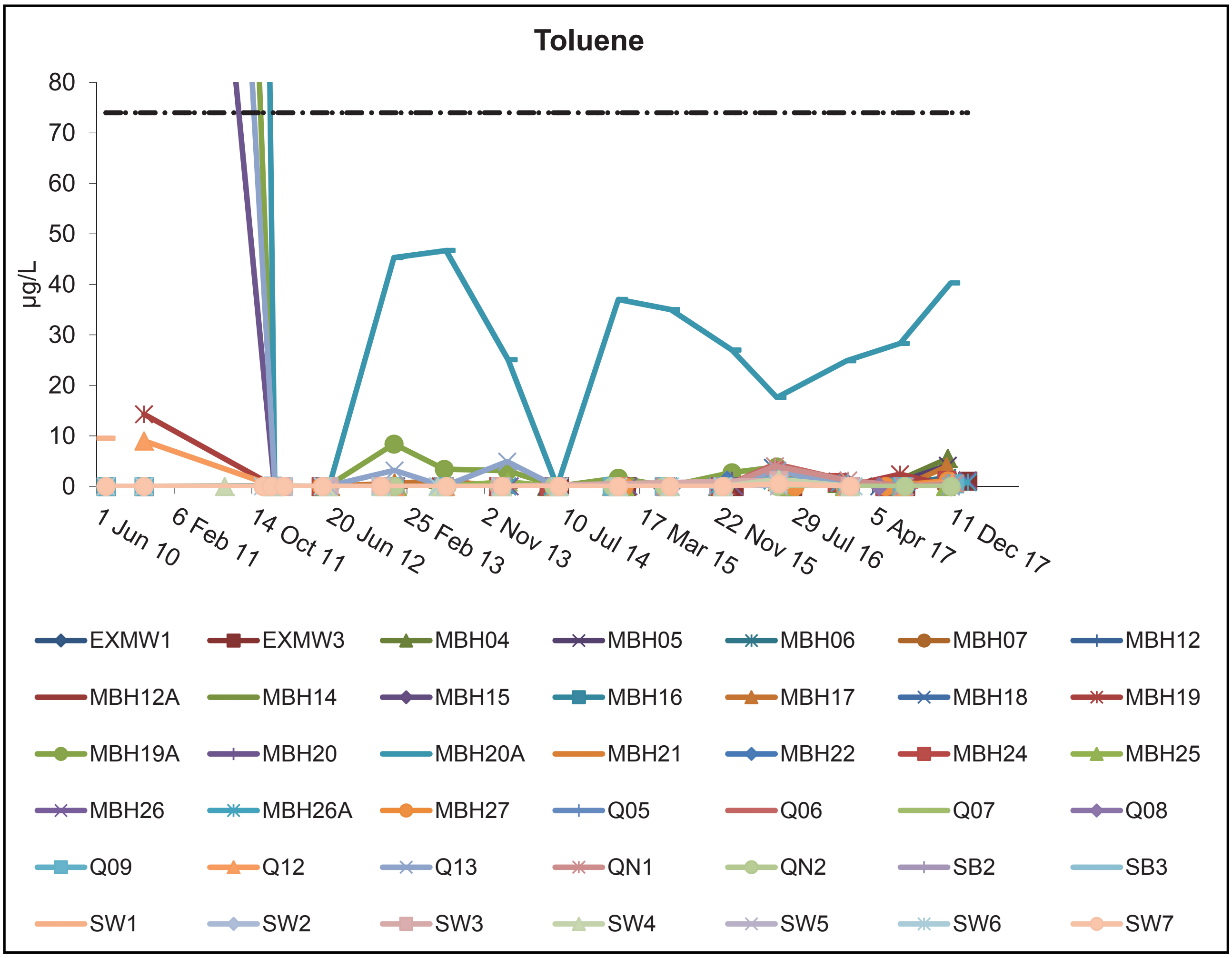


Figure 6.2.2.12 Toluene concentration in ground & surface water samples

Total phenol concentrations were compared against the UK freshwater and coastal EQS GAC for phenol of 7.7 $\mu g.l^{-1}$. In 2017, some exceedances were recorded. However, as in previous years, the majority of exceedances were recorded in samples collected in the vicinity of the produced water ponds (MBH17, MBH19A & MBH20A) and not from the well located in proximity of the wadi stream (EXMW3) or the wetlands area to the south. Where detected above the EQS GAC, phenol concentrations are observed to fluctuate in line with historical data.

The USEPA Regional Screening Level (RSL) for tap water for average total phenols is 5,800 $\mu g.l^{-1}$. In 2017, the maximum total phenol concentration was 710 $\mu g.l^{-1}$, which is significantly below the USEPA tap water standard and a decrease from the 2015 monitoring results.

As for BTEX, the maximum phenol concentration was recorded at MBH20A (adjacent to and north of the produced water ponds). Phenols were detected in the produced water ponds at concentrations ranging from 400-3,600 $\mu g.l^{-1}$ in 2008, confirming the ponds as a potential source of these compounds.

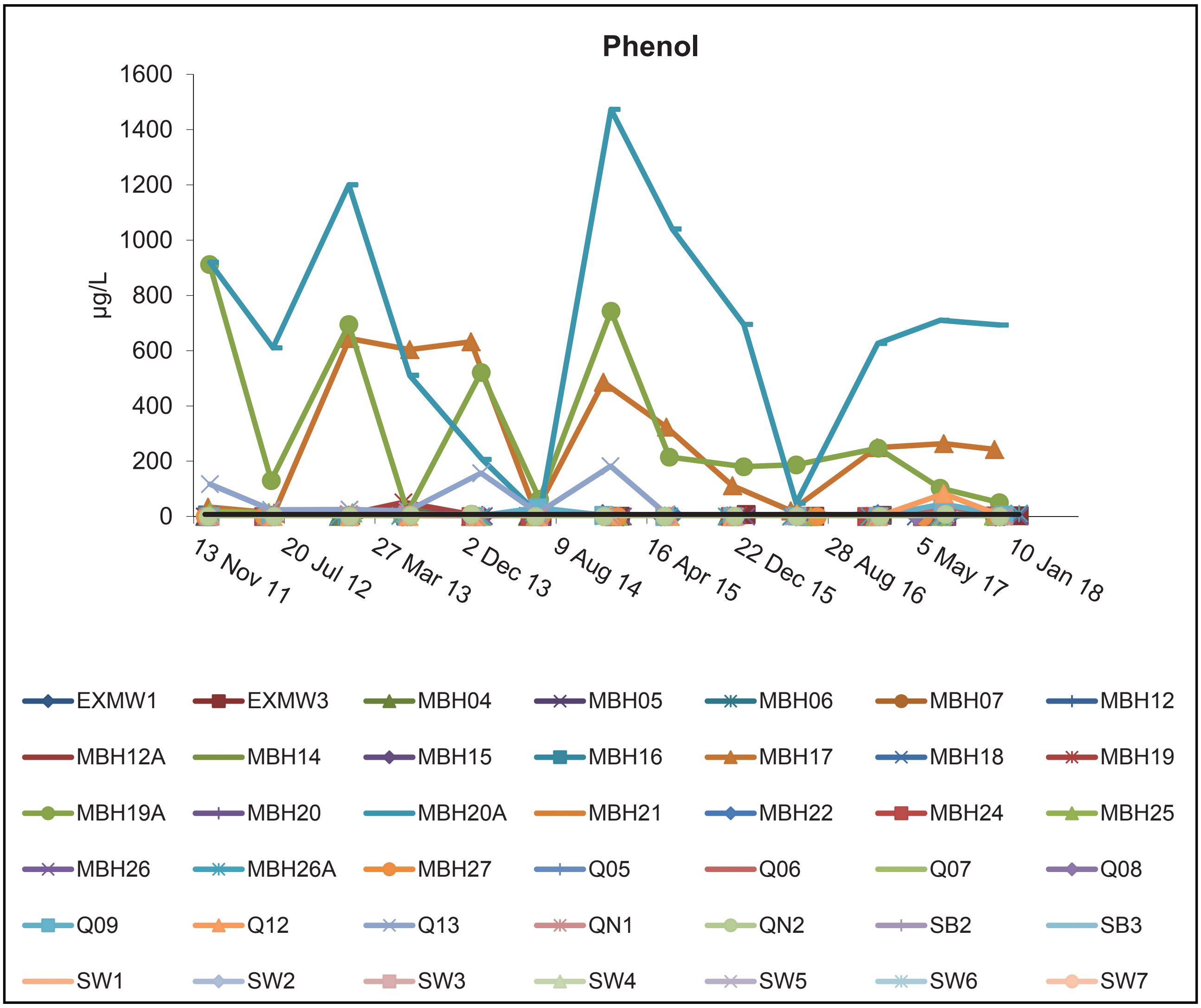


Figure 6.2.2.13 Phenol concentration in ground water samples

As observed on previous years, the majority of samples in the 2017 monitoring rounds did not exceed the laboratory method detection limit (MDL) of 0.01 µg.l-1 for USEPA 16 PAH.

The maximum recorded USEPA 16 PAH concentrations in 2017 in the first and second rounds were 1.97 & 0.93µg93 µg.l-1, recorded within MBH17. MBH17 is located downgradient of the produced water ponds. The concentration of 1.97 µg.l-1 is the highest USEPA16 PAH concentration recorded within this location to date, and is the highest concentration recorded on site since 2012. Based on the magnitude of the total PAH concentrations and the typically limited mobility of PAHs in groundwater, the significance of these concentrations is considered to be low.

The latest monitoring data continues to show fluctuations in Total Petroleum Hydrocarbon (TPH) concentrations across the site (Figure 6.2.2.14).

In 2017, the maximum TPH (EC10-EC40) concentration of 423 µg.l-1 was detected at MBH20A during the second round of monitoring. Concentrations of TPH were generally lower during the first round of monitoring, with a maximum concentration of 202 µg.l-1 detected at MBH17. TPH concentration fluctuations in wells downgradient of the produced water ponds were observed in 2017, and were similar to trends observed during previous monitoring rounds.

There are no UK DWS or EQS for TPH. The WHO suggests that using 90 µg.l-1 as a GAC for TPH provides a conservative level of protection for drinking water. Over the 2017 monitoring period only the samples from MBH17, MBH19A and MBH20A – located in the vicinity of the PW ponds - exceeded this criterion, indicating that the produced water ponds could be a possible source.

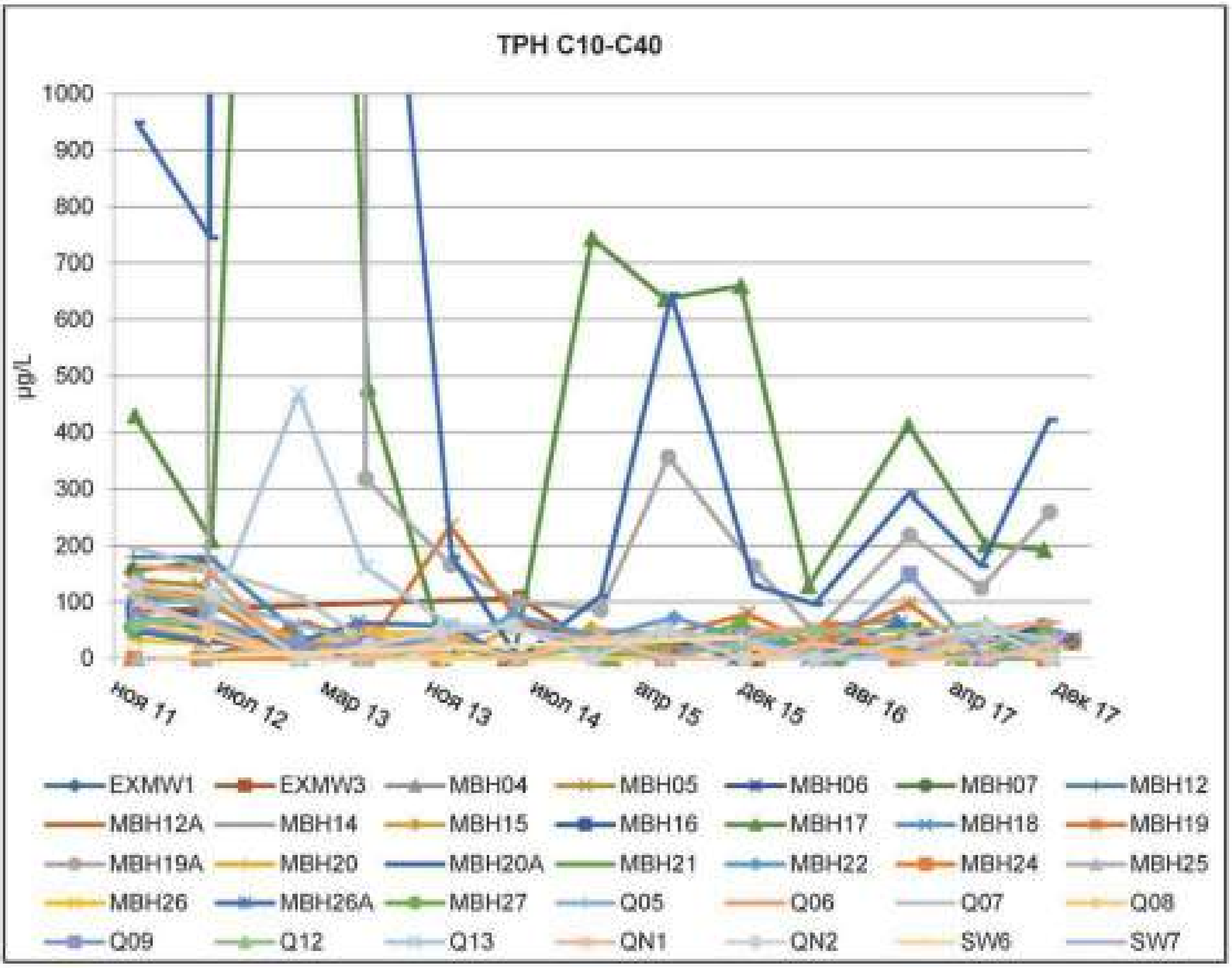


Figure 6.2.2.14 Hydrocarbon concentration in ground & surface water samples

Chloride, cadmium, iron and nickel concentrations in groundwater show a pattern of higher concentrations at sites adjacent to the produced water ponds. The distribution of other parameters such as sulphate, lead, TPH, PAH, BTEX and phenol exhibit a similar association; but with sporadic and/or isolated higher concentrations at sites adjacent to the ponds - indicating that the ponds may be a potential source for these contaminants.

The seven surface water sampling locations are situated either along the southern terminal boundary or to the south of ST, close to the Caspian Sea, down hydraulic and topographic gradient of the terminal. Sampling points are located near to the discharge points of large open drain channels which collect rain water from smaller drains within ST.

In 2017, surface water sampling was undertaken at SW3, SW4, SW5, SW6 and SW7. Other surface water locations were found dry during each sampling event and therefore samples were not collected.

Metal concentrations in surface water samples were generally reported to be below the relevant assessment standard. The exceptions in 2017 were:

- Copper, at SW3, SW4, SW5 and SW7 which was reported above the UK freshwater EQS GAC of 1.0 μg.l^{-1}. However, this GAC refers to bioavailable copper, so the reported concentrations may not be exceedances. The concentrations recorded are significantly lower than the UK DWS of 2,000 μg.l^{-1}.
- Manganese at SW7 (265 μg.l^{-1}), which exceeded the manganese UK DWS GAC of 50 μg.l^{-1}. The UK DWS GAC is based on aesthetic issues rather than toxicity and all concentrations are below the WHO health-based value of 400 μg.l^{-1}; and
- Chromium at SW3 (2.23 & 0.969 μg.l^{-1}) and SW5 (1.17 & 0.841 μg.l^{-1}), which exceeded the Chromium VI Coastal EQS of 0.6 μg.l^{-1}; however, all four results were below the Freshwater EQS of 3.4 μg.l^{-1}.

BTEX concentrations were not detected above the GAC at any of the surface water sampling locations. Toluene was detected at low concentrations within SW7 during the first round and at four locations during the second round (SW3, SW4, SW6 and SW7) - the maximum concentration was 1.7 μg.l^{-1} in SW4.

In 2017 the TPH concentration in surface water samples was at or only marginally above the detection limit in all samples, the exception being the first round sample from station SW7 located to the south of the terminal, adjacent to the highway, where a maximum concentration of 151 μg.l^{-1} was reported – this was the only reported exceedance against the WHO suggested GAC of 90 μg.l^{-1}. The location of the maximum TPH concentration in surface water has varied over the monitoring period. It is considered unlikely that the source of the higher TPH concentrations are from groundwater migration.

Biochemical oxygen demand (BOD) exceeded the UK Freshwater EQS GAC of 4 mg.l^{-1} in the first round of monitoring within SW4 and SW7. No exceedances were reported during the second round.

A risk evaluation is carried out using a Conceptual Site Model (CSM) which shows the possible relationship between contaminants, pathways and receptors. In order to demonstrate that a risk to a receptor may exist, it must be shown that each of the three components of a potential pollutant linkage (PPL) are present:

- A contaminant source – defined as a substance which is in, on or under the land and which has the potential to cause harm or to cause pollution of controlled waters;
- A receptor – generically defined as either controlled waters, humans, ecological systems or property (including domestic animals and buildings); and
- A pathway between the source and the receptor – one or more routes or means by, or through which, a receptor can be exposed to, or affected by, a contaminant.

Potential exposure and migration pathways associated with groundwater and surface water at Sangachal terminal that have the potential to link the sources and receptors (i.e. potential pollutant linkages - PPLs) are presented in Table 6.2.2.1. PPLs that can be assessed (in whole or in part) through the collection of groundwater and surface water quality data are indicated in bold.

Table 6.2.2.1 Potential exposure and migration pathways

Human Health	Controlled Waters	Property
Vapour inhalation (indoor and outdoor) **Migration of vapours along backfill around service pipes and through permeable strata** **Surface water ingestion** **Surface water/ oil dermal contact** Soil and dust ingestion Dust inhalation Dermal contact with soil and dust	**Leaching from soil due to infiltrating precipitation / surface water** **Leaks from the produced water ponds** **Vertical migration through the unsaturated zone to the saturated zone** **Lateral migration through the shallow aquifer** Downstream migration of dissolved phase contamination in surface water **Infiltration of impacted surface water** **Surface run-off** **Dissolution of non-aqueous phase oils into surface water** **Bulk transport of non-aqueous phase oils on flowing surface water**	**Permeation of water supply pipes** **Consumption of surface water (livestock)**

The reported concentrations of BTEX and phenols were not above the human health commercial GAC, and no viable pathways were identified for metals and inorganics in groundwater - based on groundwater salinity levels restricting its use.

PAHs and TPH could not be screened against a human health commercial GAC, as individual PAHs were not analysed and TPH was not split into fractions. However, the total PAH concentrations are not expected to pose a vapour intrusion risk and TPH concentrations exceeding the WHO recommended GAC for drinking water were restricted to groundwater sample points adjacent to the PW ponds. The maximum TPH concentration at surface water sampling point SW7 marginally exceeded the WHO value and was deemed to not pose a significant risk to human health.

Based on the depth to groundwater, which ranged between 1.24m (MBH25 in November 2017) and 17.55m (EXMW3 in December 2017), and the concentrations of chemicals detected in groundwater and surface water, there is not considered to be a viable pathway for groundwater permeation of water supply pipes or risk to livestock.

The following parameters have been detected in groundwater during monitoring completed in 2017 at concentrations exceeding the GAC for the protection of aquatic ecosystems: fluoride, chloride, sulphate, aluminium, arsenic, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, zinc, benzene and phenol. The majority of these parameters exceeded the GAC throughout the entire survey area, indicating high regional background levels unrelated to terminal operations. Where the exceedance/highest concentrations were observed at sample wells adjacent to the PW ponds and likely the result of PW leaks, there was no evidence that the contamination had spread down gradient or outside the ST boundary.

The following parameters have been detected in surface water during monitoring completed in 2017 at concentrations exceeding the GAC for the protection of aquatic ecosystems: copper, manganese and chromium. The copper GAC relates to bioavailable concentrations rather than total concentrations and hence, the recorded concentrations may not represent exceedances.

The higher concentrations of a number of parameters at groundwater sample points adjacent to the produced water ponds suggests that the groundwater in these areas is being influenced by leaks of produced water. As the higher concentrations are not observed at stations outside and down-gradient of the terminal, it appears that the contamination is limited to the area directly adjacent to the ponds, within the ST boundary.

No risks to human health or property were identified. Although a number of parameters were recorded at concentration levels exceeding the GAC for aquatic ecosystems, there was no evidence to indicate a pollution migration pathway from the terminal.

The long-term monitoring of ground and surface water quality within and around the ST indicates that contamination from produced water ponds is contained within the boundaries of the terminal. Taken as a whole this supports the risk assessment carried out by BP which showed that the extremely slow water movement rates and the absence of receptors in the area is likely to result in any small leakages posing no significant risk.

6.2.3. Soil stability and vegetation cover monitoring

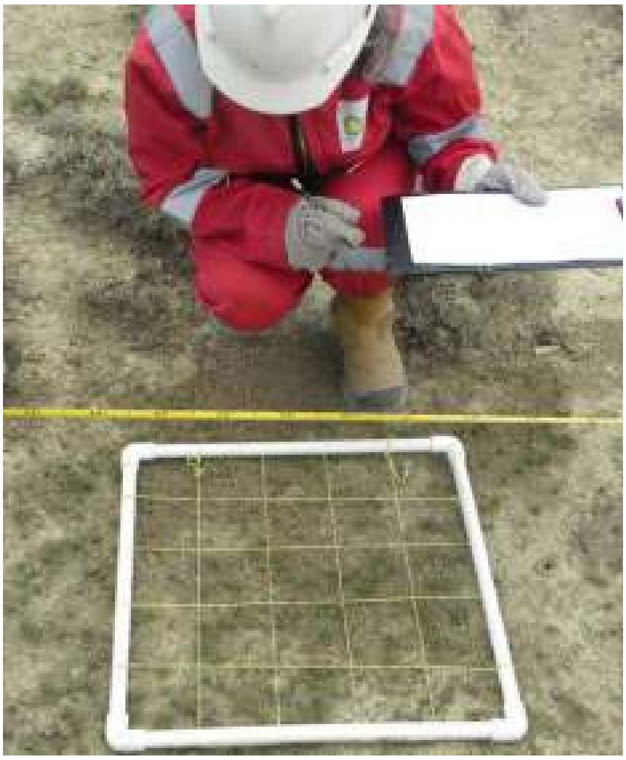
Biannual (spring & autumn) soil and vegetation (S&V) surveys have been carried out around the ST from 2006.

The objective of the soil and vegetation survey is to provide information on the status of the terrestrial environment around ST. The data is used to identify temporal trends, highlighting areas that may have undergone significant deterioration and identifying if deterioration is associated with anthropogenic stresses that can be ascribed to ST activities.

From 2009, the S&V monitoring focussed on the collection of ecosystem stability indicators. The indicators, listed below, were selected to provide an early indication of ecosystem change when compared with annual and time series data.

- Indicator 1: Bare soil cover - bare soil areas are more prone to erosion.
- Indicator 2: Vegetation cover.
- Indicator 3: Soil stability.
- Indicator 4: Microbiotic crust cover - crust organisms contribute to increased soil stability where they occur.

At each monitoring point measurements of each indicator were taken along a 100m transect. A map showing the position of the 2016 monitoring points* is provided in Figure 6.2.3.1. Photographic records are included to provide a visual record during each monitoring survey. An example of a photo point image taken during the 2016 spring survey showing a survey transect is provided in Figure 6.2.3.2.



* The number of monitoring points has changed from 20 original points in 2006 to 38 points in 2015. Points have been added and removed over the monitoring period.

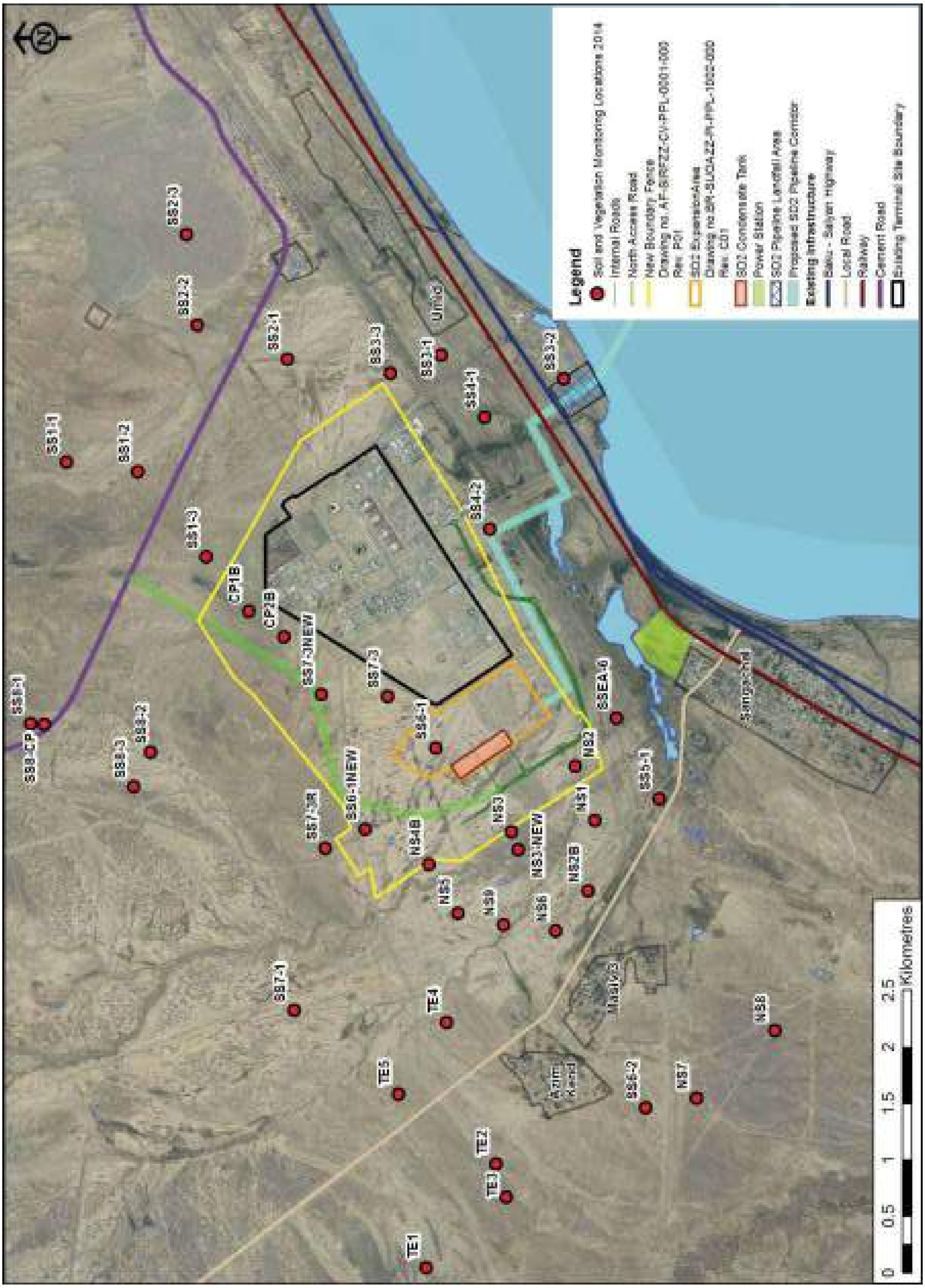


Figure 6.2.3.1 2016 soil and vegetation monitoring locations around the Sangachal Terminal

Figure 6.2.3.2 Example photo point image - spring 2016 (NS-9)

Table 6.2.3.1 gives the percentage cover comparison between bare soil and vegetation for 2009-2016 and the average change (Δ) over the years.

The cover of bare ground has fluctuated over the monitoring period but has remained broadly consistent at a typical baseline level of around 60 to 65% cover. Increases and decreases of bare ground away from typical cover values are likely to relate directly to rainfall levels in the season immediately preceding monitoring.

Shrub cover has increased over the monitoring period, with a substantive increase after 2013, but has stabilised at approximately 12-14% cover in 2014-16. Grass cover appears to have gone through a cycle of decline and recovery over the monitoring period. In 2016, the cover of grass present was comparable to that present at the start of monitoring in 2009.

The increase in grass cover, and to a lesser extent shrub cover, in autumn 2016 relative to autumns 2014 and 2015 is considered a function of a significant late rainfall in 2016 which would have promoted a flush in vegetation growth late in the season.

Forbs have declined significantly and abruptly after 2013 and have showed no sign of recovery. This is likely to reflect the increase in shrub cover over the same period. Given there has been no real change in the availability of bare ground over this period, it is assumed that forbs have declined because the habitat patches most suitable for them have been lost to encroachment from shrubs. The reasons for this are not known, but could be related to; ecological succession; changes in land management or grazing pressure; or may reflect short-term climatic regimes.

Table 6.2.3.1 Percentage cover of bare soil and vegetation (2009-2016)

	Spring average % cover				Autumn average % cover			
Year	Bare	Shrub	Grass	Forb	Bare	Shrub	Grass	Forb
2009	61.1	0.1	24.8	14	64.5	0.4	20.2	14.9
2010	61.7	0.1	24	14.2	64.5	0.5	18.7	16.3
2011	83.1	0.3	0.3	16.2	85.9	0.6	0.1	13.4
2012	85.1	1.6	1.2	12.5	87.3	1.5	0.3	11
2013	66.1	1.9	16.4	15.5	68.7	2.6	13.1	15.5
2014	73.3	12.7	12.4	1.6	73.7	13.7	10.4	2.1
2015	64.3	12.7	22.9	0.1	69.8	13.6	16	0.6
2016	63.4	12.1	24.4	0.1	56.0	14.7	28.3	1.0
Average Δ 2009-2016	-8.3	9.3	11.2	-12.2	-18.1	11.5	17.9	-11.2

In 2016 the average size of bare soil patches dominated during both the spring and autumn survey when compared to the patch sizes of vegetation types. The grass and shrub patches were approximately 43% and 14% respectively (based on spring data) of the size of the bare soil patches (or collectively about half of the size). This is an important indicator as areas of bare soil have a higher risk of erosion from wind and water flow.

Table 6.2.3.2 presents the patch size data for bare soil, shrub, grass and forb for the years 2009-2016. The average changes (Δ) between 2009 and 2016 imply changes in the cover of bare ground, shrubs, grasses and forbs, but with the exception of forbs, there is no clear trend over time in the source data.

The source data shows fluctuations between years, most likely in response to inter-annual variations in rainfall pattern but perhaps also influenced by inter-annual variances in land management. Overall, the results are relatively consistent over the 8 year period of monitoring. Forbs have clearly undergone a marked reduction in cover over the monitoring period, and this is consistent with the percentage cover data presented in Table 6.2.3.1.

Table 6.2.3.2 Bare soil and vegetation patch sizes for spring and autumn (2009-2016)

	Spring mean size (cm)				Autumn mean size (cm)			
Year	Bare	Shrub	Grass	Forb	Bare	Shrub	Grass	Forb
2009	176.1	27.4	102.9	19.8	182.3	28.9	100.5	37.6
2010	173.1	25.2	95.6	14.4	152.9	28.1	83	40
2011	234.3	42.7	72.7	33.2	282.1	37.6	69.6	43.6
2012	254.6	34.7	20.7	19.2	263.3	29.7	17.5	19.2
2013	173.7	36.1	88.9	23.8	176.2	32.8	79.6	29.1
2014	138.8	24.1	56.4	20.6	165.6	30.5	70.5	27
2015	200.8	28.1	83.4	0.9	223.5	32	68.1	2.3
2016	225.7	31.3	96.6	0.8	200.1	35.6	106.9	5.2
Average Δ 2009-2016	32.7	0.1	22.3	-18.0	-6.4	4.2	37.1	-23.2
Note: Some plot locations have changed over time; therefore a comparison of annual mean has been made and then an average change calculated.								

The soil stability* data were summarised on the basis of the presence or absence of a plant canopy; with soil supporting vegetation considered to be "protected", and soil with no plant canopy considered to be "unprotected". In the 2016 data both the surface and sub-surface protected soils exhibited a greater stability than the unprotected soils, indicating that both soil structure and vegetative cover are important in maintaining soil stability and reducing erosion.

Table 6.2.3.3 below presents mean soil stability values for protected and unprotected soils at the soil surface and subsurface for spring and autumn from 2009 – 2016. The data shows that over the monitoring period protected soils have a higher stability than unprotected soils (irrespective of being from the surface or sub-surface); and that surface soils are more stable than sub-surface soils (irrespective of canopy cover).

The average change over the years shows that, overall, the soil bonding has increased for protected soils. In comparison, unprotected soils show no substantive change in stability over the monitoring period, although there is a slight indication of a potential reduction in the stability of unprotected surface soils (Table 6.2.3.3).

The increased stability in protected surface soils may reflect increases in shrub cover, as shrubs will protect soils through both canopy cover and roots binding soil. Whereas the slight reduction in the stability of unprotected surface soils may indicate that, in the absence of protective vegetation coverage, wind and water erosion are affecting soil stability.

* A higher soil stability value indicates that the soil is more stable, and therefore more resistant to erosion by wind and water.

Table 6.2.3.3 Soil stability for protected and unprotected soils at surface and sub-surface (2009 – 2016)

	Spring							Autumn						
	Surface		Sub-surface*		Total site** (Soil)			Surface		Sub-surface*		**Total site (soil)		
Year	Protected	Unprotected	Protected	Unprotected	Surface	Sub-surface	Mean	Protected	Unprotected	Protected	Unprotected	Surface	Sub-surface	Mean
2009	4.21	1.36	3.15	1.01	3.26	2.44	2.85	4.25	1.35	3.02	1.01	3.28	2.35	2.82
2010	4.54	1.46	3.21	1.03	3.00	2.12	2.56	4.64	1.33	3.4	1.00	3.54	2.6	3.07
2011	4.04	1.33	2.78	1.00	2.69	1.89	2.29	3.67	1.23	2.44	1.00	2.45	1.72	2.09
2012	4.17	1.24	2.92	1.00	2.7	1.96	2.33	4.38	1.44	3.12	1.03	2.91	2.08	2.49
2013	4.93	1.37	3.19	1.00	3.15	2.1	2.62	4.35	1.4	3.13	1.07	2.87	2.1	2.49
2014	4.30	1.29	3.05	1.00	2.8	2.02	2.41	4.56	1.27	3.33	1.00	2.91	2.16	2.54
2015	4.98	1.35	3.81	1.00	3.77	2.87	3.32	5.08	1.32	3.66	1.00	3.83	2.77	3.3
2016	4.97	1.14	3.66	1.00	3.70	2.77	3.23	5.06	1.20	3.67	1.00	3.77	2.78	3.27
Δ 2009-16	0.76	-0.22	0.51	-0.01	0.44	0.33	0.38	0.81	-0.15	0.65	-0.01	0.49	0.43	0.45
Δ 2010-1**6**	0.43	-0.32	0.45	-0.03	0.70	0.65	0.67	0.42	-0.13	0.27	0.00	0.23	0.18	0.20
Δ 2011-**16**	0.93	-0.19	0.88	0.00	1.01	0.88	0.94	1.39	-0.03	1.23	0.00	1.32	1.06	1.18
Δ 2012-1**6**	0.80	-0.10	0.74	0.00	1.00	0.81	0.90	0.68	-0.24	0.55	-0.03	0.86	0.70	0.78
Δ 2013-1**6**	0.04	-0.23	0.47	0.00	0.55	0.67	0.61	0.71	-0.20	0.54	-0.07	0.90	0.68	0.78
Δ 2014-1**6**	0.67	-0.15	0.61	0.00	0.90	0.75	0.82	0.50	-0.07	0.34	0.00	0.86	0.62	0.73
Δ 201**5-16**	-0.01	-0.21	-0.15	0.00	-0.07	-0.10	-0.09	-0.02	-0.12	0.01	0.00	-0.06	0.01	-0.03
Average of Δ	0.52	-0.20	0.50	-0.01	0.64	0.57	0.61	0.64	-0.13	0.51	-0.02	0.66	0.52	0.59

* Sub-surface: 3-4cm below the surface.
**Total site refers to surface and sub-surface soils

Table 6.2.3.4 presents the microbiotic crust cover ratio against bare soil, shrubs, grass/forbs, as well as the mean under these 3 conditions for the years 2009 – 2016.

Minor inter-annual fluctuations (increases and decreases) in crust cover are apparent across the survey period, typically in the order of 1 to 2%, and indicate that the change values calculated are unlikely to be meaningful.

Inter-annual variation in crust cover is greatest in spring in bare ground patches where there is no protection from vegetation. The cover of crust in bare ground patches seems to achieve a relatively consistent 2% in autumn regardless of the starting point in spring. There is certainly no evidence of a change trend in crust cover over time. The minor variation observed could reflect observer differences, variation in rainfall distribution, or other indeterminable factors.

Table 6.2.3.4 Crust cover ratio for bare soil and vegetation in spring and autumn (2009-2016)

	Spring				Autumn			
Year	Bare	Shrub	Grass/ Forb	Mean	Bare	Shrub	Grass/ Forb	Mean
2009	0.05	0.05	0.07	0.06	0.02	0.03	0.04	0.03
2010	0.07	0.08	0.19	0.11	0.07	0.08	0.17	0.11
2011	0.03	0.03	0.04	0.03	0.03	0.03	0.01	0.02
2012	0.03	0.03	0.03	0.03	0.01	0.01	0.03	0.02
2013	0.04	0.05	0.05	0.05	0.02	0.03	0.05	0.03
2014	0.02	0.03	0.04	0.03	0.02	0.02	0.04	0.03
2015	0.04	0.04	0.05	0.04	0.02	0.03	0.05	0.03
2016	0.01	0.03	0.04	0.02	0.02	0.04	0.09	0.05
% Δ 2009-2016	-0.04	-0.02	-0.03	-0.03	0.00	0.01	0.05	0.02
% Δ 2010-2016	-0.06	-0.05	-0.16	-0.09	-0.06	-0.04	-0.08	-0.06
% Δ 2011-2016	-0.03	0.00	0.00	-0.01	-0.01	0.02	0.08	0.03
% Δ 2012-2016	-0.02	0.00	0.00	-0.01	0.00	0.03	0.06	0.03
%Δ 2013-2016	-0.03	-0.02	-0.02	-0.02	0.00	0.01	0.04	0.02
% Δ 2014-2016	-0.01	-0.01	0.00	-0.01	-0.01	0.02	0.06	0.02
% Δ 2015-2016	-0.03	-0.01	-0.01	-0.02	-0.01	0.01	0.04	0.01
Average of Δ	-0.03	-0.02	-0.03	-0.03	-0.01	0.01	0.04	0.01

The aim in measuring the 4 indicators has been to establish a composite index from which an early indication of ecosystem change can be determined. To determine the status at each sample point, each of the 4 indicators are considered together and the status is categorised into ‘very good’, ‘good’, ‘threatened’, or ‘deteriorated’ (see explanation in methods section 6.1.1.1). Table 6.2.3.5 gives the number of stations in each category for spring and autumn 2016, and indicates that the majority of sites were categorised as being good or deteriorated in spring and deteriorated in autumn.

Table 6.2.3.5 Number of stations in each Ecosystem Condition Category (ECC) 2016

	Spring	Autumn
Very Good	3	0
Good	13	11
Threatened	9	12
Deteriorated	13	15

The annual average ecosystem condition value for each indicator, and the average condition category across the survey area, are provided for 2009-2016 in Table 6.2.3.6. Despite 2013 being classified as a 'good' year for ecosystem condition, the classification was 'threatened' for 2009, 2010, 2012, 2014, 2015 and 2016; and 'deteriorated' for 2011.

Table 6.2.3.6 Survey average Ecosystem Condition Values (ECV) & Ecosystem Condition Category (ECC) 2009 – 2016

Year	Annual Mean (Spring & Autumn)					
	ECV means				Total ECV	ECC
	BP_i	VP_i	SS	CC		
2009	2.64	2.65	2.21	3.41	10.91	Threatened
2010	2.47	2.83	2.50	2.79	10.59	Threatened
2011	3.51	3.69	3.39	3.46	14.05	Deteriorated
2012	3.69	3.85	3.10	1.44	12.08	Threatened
2013	2.58	2.92	2.95	1.68	10.12	Good
2014	2.61	3.52	3.05	1.55	10.73	Threatened
2015	2.62	3.46	2.30	3.31	11.69	Threatened
2016	2.55	2.83	3.17	3.27	11.81	Threatened

The notable points on an indicator level are as follows:

- Bare patches are generally stable in size;
- The vegetation patch index has fluctuated, but with 2016 broadly comparable to 2013, 2010 and 2009, and representing an improvement over 2014 and 2015;
- Soil stability has fluctuated, but in 2016 the mean soil stability ECV was at the highest (worse) level recorded over the most recent 4 year period, and was similar to the poorer values observed in 2011 and 2012;
- Crust cover increased between 2011 and 2012 then decreased markedly (worsened) between 2014 and 2015, but was consistent between the years in each of these two bands;
- Overall, the combination of these 4 indicators has meant that the ecosystem condition slipped to deteriorated from threatened in 2011, then improved on consecutive surveys, achieving a condition of good in 2013, then slipped out of the category in 2014 to a threatened status and has remained in this category ever since. The reasons for these overall changes are unknown, and are indeterminable given the available data.

Rainfall was limited during the spring of 2013 and 2014 which may have had an impact on the results noted for those years. However, based on the currently available data, the reasons for the improvement between 2011 and 2013 could not be definitively determined.

When the time series data was examined at each sample plot, the individual ECV and ECC scores for each plot show fluctuation over time, as well as variation between the plots in any given year. In general, there were no clear trends identified and the reason for the variation was undetermined. Any change implied by the data for some plots may just be chance alone, or otherwise within the typical range of inter-annual variation to be expected when dealing with semi-natural ecosystems.

Surveys carried out between 2006 and 2008 assigned ecosystem condition categories using an integrated ranking system which differs to the direct ranking ECV system used in the 2009-2016 surveys. However, ECC's were determined for each sample plot, the results are provided in Figure 6.2.3.3 below. Due to the variation in the number of plots sampled on each survey, the data has been presented showing the percentage of plots within each ecosystem condition category.

There was a slight increase in the percentage of plots being classified as very good or good in the spring data between 2006 and 2008, which was followed by another increase in 2009. The results remained stable between 2009 and 2010, prior to the large increase in threatened and deteriorated plots in 2011. After the improvements observed in 2012 and 2013 the spring condition was variable. However, the percentage data indicates that the spring time condition was slightly poorer in the surveys conducted in 2015 and 2016, with a higher proportion of plots being categorised as threatened or deteriorated than in the two preceding surveys.

There was less variability between years in the overall ecosystem condition during autumn surveys. Prior to the decline in condition in 2011, there was very little variability in the overall condition between 2006 and 2010, with approximately 45% of autumn survey plots being classified as very good or good. From 2013 there was a general increasing trend in the proportion of plots being classified as deteriorated, which was combined with a reducing trend in the proportion being classified as very good.

Figure 6.2.3.3 Percentage of plots in each Ecosystem Condition Category 2006-2016

The monitoring surveys carried out in 2008 largely reinforced the patterns of ecosystem condition identified during the earlier seasonal surveys of 2006 and 2007. However, there were changes in site condition; plant cover appeared to be increasing, soil stabilities remained the same and there appeared to be a decrease in microbiotic crust cover.

Comparisons made between the 2009 survey data and the 2006 to 2008 data suggested that there was a general improvement in the vegetation patch indicator in spring 2009 compared to the spring data from 2006-2008. While no notable difference was identified in the bare patch indicator, there was a slight reduction in the spring survey soil stability indicator between 2008 and 2009. The improvement in the vegetation patch indicator will likely account for the increase in the proportion of spring survey plots classified as very good and good between 2008 and 2009.

There was very little difference observed between the 2009 and 2006-2008 autumn survey data for bare patch and vegetation patch indicators, and soil stability. The autumn microbiotic crust cover ratio was variable over the 2006-2009 monitoring period. The ratios observed in 2009 were similar to those measured in 2007 and higher than those from 2008. Overall there was very little difference observed in the 2006-2009 autumn data which is reflected in the similar proportions exhibited in Figure 6.2.3.3.

In addition to the measurement of ecosystem stability indicators, the 2016 survey included a soil survey. The sample stations and the parameters tested followed the design of the previous soil survey that was carried out in 2010.

Soil moisture was generally higher in 2016 samples, which was due to unseasonably wet conditions during sampling.

The pH range was lower in 2016 samples (5.9 – 8.7) compared to 2010 (7.4 - 8.2). The variable and lower (acidic in many samples) pH values reported in 2016 were not considered to be typical of the expected conditions. No explanation could be provided for the difference in pH between surveys. The change over the entire surveys area was too widespread to be associated with a pollution incident and over too short a period to be associated with natural processes or acid rain infiltration. The change between survey data may be the results of analytical variability or inaccuracies. It has therefore been recommended to conduct annual soil tests on future surveys.

No difference was observed in the concentration of absorbed bases; calcium, magnesium, sodium and potassium, or in total nitrogen, total phosphorous and organic matter (humus) content between the 2016 and 2010 data.

The water-soluble bicarbonate content values were higher in 2016 samples. The higher values were primarily due to the results from a number of samples spread throughout a range of previously characterised soil types and at varying distances and directions from the Terminal. Given the distribution of the sample points, there was no evident connection to operations at the Terminal.

The hydrocarbons and metals results were assessed against human health generic assessment criteria (GAC), taken from

- UK Suitable 4 Use Levels (S4ULs)*; and
- UK Category 4 Screening Levels (C4SLs)**

The reported concentrations of hydrocarbons and heavy metals did not exceed any of the UK risk-based criteria used for the assessment.

* LQM/CIEH, 2015. The LQM/CIEH S4ULs for Human Health Risk Assessment

** Defra, British Geological Survey and CL:AIRE, 20th December 2013. SP1010 – Development of Category 4 Screening Levels for Assessment of Land Affected by Contamination

The 2016 TPH concentrations were consistently lower in comparison to the 2010 concentrations. The maximum value (137mg/kg) in 2016 was recorded at SS4-1, which was the same monitoring location that the 2010 maximum value (634mg/kg) was recorded. The lower concentrations in 2016 indicate that there is no evidence of hydrocarbon impact to soils during the period 2010 to 2016 in the area surrounding the terminal.

In general, the 2016 heavy metals minimum, maximum and median concentrations were very similar to the 2010 data set. Higher concentrations of some elements were observed at a small number of isolated stations in 2016 compared to the results from 2010. However, there was no evidence to link the differences with operations at the ST.

Table 6.2.3.7 Infrastructure and other potential factors affecting soil and vegetation

Location	Plot cluster	Key soil physical / chemical properties	Structure / other	3rd party	BP	Potential impact on S&V
~2.5km north-east (north of) outside link road to cement factory	SS1-1, SS1-2, SS2-3, SS2-2	saline gypseous grey-brown / volcanic mud	Two-lane asphalt highway running NW - SE	Y	N	No
~3km north, cement factory road dissects cluster	SS8-1, SS8-3-CPI, SS8-3, SS8-2	typical grey-brown	Two-lane asphalt highway NW - SE	Y	N	Tracks and trails
north, within or near extended footprint, or within north circular road	SS7-3N, CP2B, CP1B, SS1-3	saline gypseous grey-brown / volcanic mud	Two-lane asphalt highway running NE - SW	N	Y	ST extended footprint
west, within extended footprint or east of SE -NW road	NS5, NS4B, NS9, NS6, NS2B	saline thickened grey-brown / chal-meadow depression species	Two-lane asphalt highway running SE - NW	Y	N	Tracks and trails cross the wadi
south, south-east, and south west running between ST and coast	SS4-1, SS3-1, SSEA-6	Solonchak-saline thickened grey-brown / originally wetland	Baku 4-lane asphalt highway running NE-SW, pipelines, feeder roads	Y	Y	Heavy fragmentation and compaction
~4km east	TE1 to TE5 cluster	not surveyed, but expected to be typical grey-brown	Two-lane asphalt highway running SE - NW	Y	N	Tracks and trails, north of Azim Kend village
Qizildas cement factory 3km to north	n/a	n/a	lime / cement factory	Y	N	No
Non-specific -open access areas	non-specific	non-specific	All public grassland areas	Y	N	Winter-spring grazing, before migration to summer pastures. Suspected neutralising impact, but not quantified.
SD2 Pipeline landfall area	SS3-2	Solonchak-saline thickened grey-brown	Engineered area for pipelines transitioning between land and sea environments	N	Y	Potential localised physical damage by construction and pollution if construction not well managed
SD2 Pipeline corridor	SS3-2, SS4-2	Solonchak-saline thickened grey-brown	Trenches for pipes	N	Y	Disturbance of soils in pipeline route and potential for pollution if pipelines not well maintained
New Terminal boundary fence	SS3-3, SS4-2, NS3, NS3-NEW, NS4B, SS7-3R, SS6-1NEW, SS1-3	Various, including: - Solonchak-saline thickened grey-brown; - saline gypseous grey-brown / volcanic mud; - saline thickened grey-brown soils (wadi); and - typical grey-brown soils	Fence	N	Y	Minor localised physical damage to soils during construction but little long-term disruption once construction is complete

Table 6.2.3.7 indicates a number of potential factors in the vicinity of ST that may impact on soil and vegetation; the key points are

- Road infrastructure – in recent years, a number of new roads have been constructed in the vicinity of ST, which may suggest that vehicle traffic would be limited to these roads (as opposed to driving off-road) thereby having an overall positive effect on the soil and vegetation. However, ST security services patrol the wider Sangachal area and may drive off-road where required.
- ST expansion – impacts include permanent land loss and an influx of workers who require settlement and services (waste water and sewage removal). There has also been an impact to the south of ST due to the SD2 construction activities (road, pipelines) resulting in soil displacement, soil compaction (affecting flow and infiltration), and wetland habitat fragmentation.
- Shachkaiya wadi – lies south-west of ST, is bounded by roads and is therefore geographically constrained. As a result, the water flow may become channelled in periods of high rainfall. It is also likely that the wadi is subject to human and livestock influences from the adjacent roads. The Wadi will incur greater livestock grazing when seasonal water allows the meadow species to grow in the depression.
- Other industrial developments – Including an electricity plant near Sangachal town; and a cement plant to the north; which are likely to have limited impact on the soil and vegetation around ST.
- Livestock grazing – the impact of grazing is unquantified. Anecdotally, the grazing is considered to be widespread. However, it appears to be seasonal and there is not a discernible trend on the ecosystem condition and not one that can be attributed to grazing. Manure from grazing most likely increases the availability of micro-nutrients such as zinc to plants, thus moderate grazing may be beneficial to the vegetation. The surface soil stability figures are high which would not indicate any particular impact from hooves or trampling.

Based on the indicators and their composite ECV index, no discernible trend was identified in the ecosystem condition over the monitoring period. However, in terms of ecosystem change, the 2009-2016 period is considered too short to determine a trend, even one where the ecosystem integrity remains largely the same.

In general - based on the % of plots in each condition category - the overall ecosystem condition was generally similar or improving between 2006 and 2010. The overall condition reduced between 2010 and 2011, then increased between 2011 and 2013. From 2013 the condition reduced in 2014 then slightly reduced again in 2015 and 2016.

From 2009-2016, shrub cover has increased from virtually zero to approximately 13%. Grass and bare patch cover has remained stable and forb cover has largely been lost. The reasons for the decline in forbs are unknown, however, may be linked to trends of increased scrub cover and soil stability. In general, the most reliable indicator over time is considered to be the percentage of bare soil cover which appears to have stabilised more or less back to the levels recorded during 2009-2010.

Protected soils have a higher stability than unprotected soils (irrespective of their surface or sub-surface origin). However, irrespective of canopy cover, surface soils are more stable than sub-surface soils; which strongly indicates that soil bonding is greater at the surface and is not due to vegetation; but rather due to soil structural differences at the surface compared with below. This surface stability is likely to be attributed to the presence of gypsum (known to be visible on the surface), which is a strong binding agent; and the presence of a microbiotic crust.

Crust cover has not changed significantly over the survey period, and would not be expected to, unless there was a significant change in conditions. In spring, against bare soil, crust cover was 5% in 2009 and 1% in 2016. Based on the variation in cover recorded over the eight-year period, the latter value may just be due to chance and at present there is no evidence to indicate a long-term change in cover. Autumn crust cover against bare ground is very consistent over the eight-year period and typically in the order of 2%. This suggests that whatever the crust cover in spring, it will generally balance out to a comparable level by autumn. Again, this provides reassurance that there has been no significant change to the environmental conditions supporting crust cover.

There was no evidence of any impacts from terminal activities to the soil chemistry across the survey area. In general, the soil chemistry results in 2016 were similar to those previously observed in 2010.

The reported concentrations of hydrocarbons and heavy metals did not exceed any of the UK risk-based criteria used for the assessment. Concentrations were generally comparable to those recorded in 2010 and there was no evidence linking the concentrations of hydrocarbons or metals present within soils to ST activities.

The pH level of soils in 2016 was significantly lower than in 2010; the reason for the difference is unknown. It is suspected that the difference may due to analytical variability rather than being representative of a real change in the pH across the survey area.

A number of possible factors were identified in the vicinity of ST that may impact on soil and vegetation. The only factors relating to operations at the terminal were:

- disturbance and compaction from ST security patrol vehicles required to drive off-road
- soil displacement and soil compaction from construction activities relating to terminal expansion.

6.2.4. Mammal and herpetofauna monitoring

As part of the EMP, annual surveys of mammals and herpetofauna (reptiles and amphibians) have been undertaken in the area surrounding ST since 2011.

The objective of the monitoring surveys is to characterise the terrestrial vertebrate faunal species (mammals, reptiles and amphibians) occurring in the vicinity of ST, and to understand if terminal operations are having deleterious effects on the species composition, distribution and the number of individuals present.

Surveys are carried out twice yearly; in spring and autumn. Following feedback from various stakeholders, the survey design has naturally evolved over the years to improve the accuracy of the monitoring results.

In 2011, the method in which the data were collected changed from walked transects to the use of sampling stations located around the entire terminal *, this method has remained consistent for all surveys carried out between 2011 and 2016**. The position of the 2016 monitoring stations are shown in Figure 6.2.4.1.

Species diversity was estimated through a combination of direct visual observations of the species, or indirectly through the observation of signs of presence. The survey was augmented with a programme of live-trapping of small mammals at designated monitoring stations.

In total, 15 species of fauna were recorded on the 2016 surveys; two species of amphibian, four species of reptile and nine species of mammal. The faunal composition remained broadly consistent across both 2016 survey periods, with mammals comprising approximately 60% of the encounters recorded.

Of the 15 species recorded, 11 (73%) were detected through direct observation. The number of species directly observed in June (7) was slightly lower than that observed in October (9). When direct and indirect observations were combined, twelve species were observed in June while all fifteen were observed in October.

In contrast to mammals, herpetofauna were detected more frequently through direct observation. Both species of recorded amphibian (*Pelophylax ridibundus* and *Bufotes variabilis*) and one species of reptile (*Ophisops elegans*) were detected solely through direct observation (Table 6.2.4.1).

A single *M. libycus* was trapped in June within sampling station M130. No animals were captured during October; however, unidentified small mammal scats were recorded in two traps (M133 and NM104A).

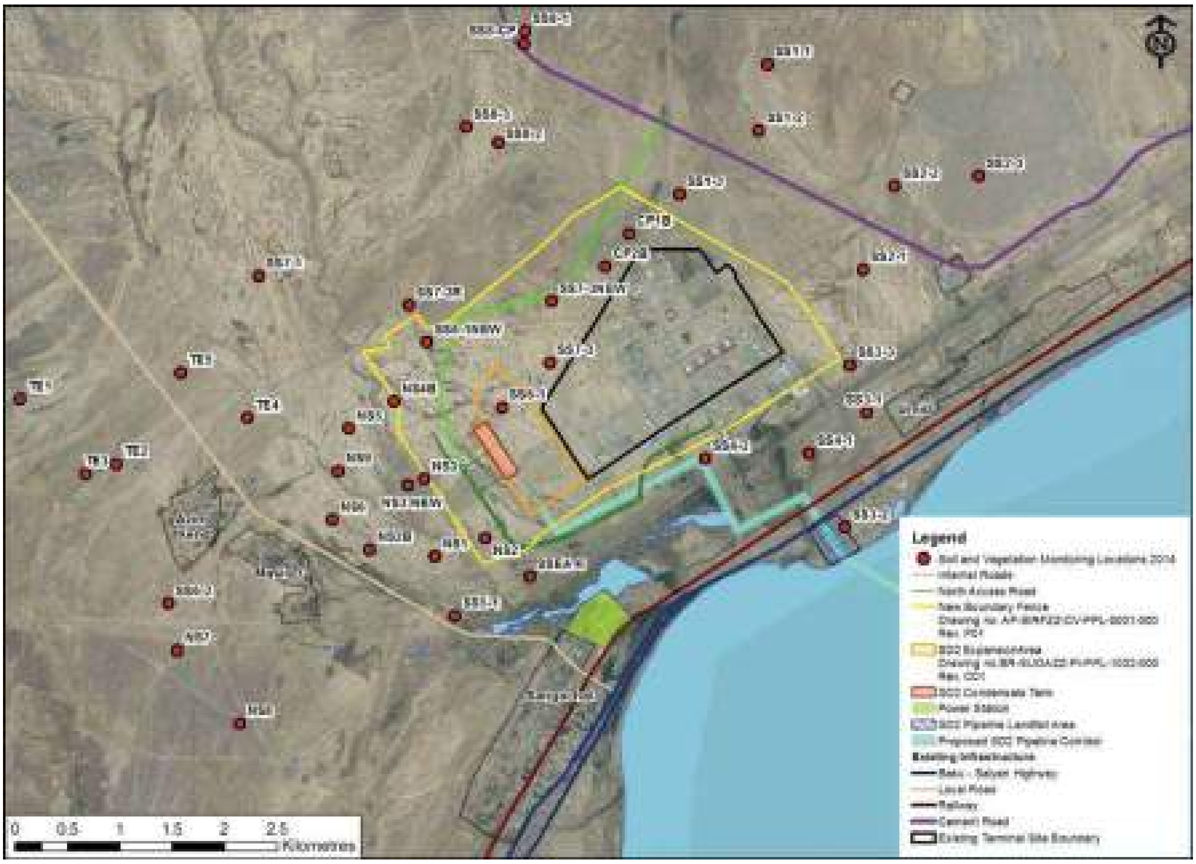


Figure 6.2.4.1 2016 mammals and herpetofauna monitoring locations

* A survey was carried out in 2009 which covered a smaller, site specific area.
** Monitoring stations have been added and removed over the 2011 – 2016 monitoring period. The required changes were due to a number of activities, including the ST expansion.

Table 6.2.4.1 Direct & indirect observation species data, 2016 survey

Species		Jun-16		Oct-16	
Scientific	English	Direct	Indirect	Direct	Indirect
Amphibians					
Pelophylax ridibundus	Marsh frog	✓	x	✓	x
Bufotes variabilis	Variable green toad	x	x	✓	x
Reptiles					
Emys orbicularis	European pond turtle	✓	x	✓	✓
Eremias arguta	Steppe runner	✓	x	✓	✓
Natrix tessellata	Dice snake	✓	x	x	✓
Ophisops elegans	Snake eyed-lizard	✓	x	✓	x
Mammals					
Allactaga elater	Five-toed jerboa	x	x	x	✓
Erinaceus concolor	White-breasted hedgehog	x	✓	x	✓
Hemiechinus auritus	Long-eared hedgehog	x	✓	x	✓
Lepus europaeus	Brown hare	x	✓	✓	✓
Meriones libycus	Libyan jird	x	✓	x	✓
Mus musculus	House mouse	x	✓	✓	✓
Canis aureus	Golden jackal	x	x	✓	✓
Canis lupus	Grey wolf	✓	✓	x	✓
Vulpes vulpes	Red fox	✓	✓	✓	✓

One species of special conservation interest was identified in 2016, namely *Emys orbicularis* (European pond turtle). This species is listed as 'Near Threatened' within the IUCN Red List; however, the species is not listed in the ARDB. It was recorded in 2016 at seven monitoring stations distributed throughout the survey area principally in the south near the coast and north near the cement road. As a semi-aquatic species, pond turtle is closely associated with open water and therefore its presence to the north of the terminal is indicative of further waterbodies.

Amphibians occupied 17% of the sampling stations, which is likely to reflect the availability of open pools of fresh water. Reptiles had a fairly restricted distribution, occupying 31% of monitoring stations in June and 21% in October. The most widespread reptile species were *O. elegans* and *E. arguta*, which were present at eleven and seven monitoring stations respectively. In contrast, *N. tessellata* was restricted to a single monitoring station. No obvious pattern of distribution was discernible.

Mammals were recorded at 99% of the monitoring stations. The most widely distributed species of mammal was the brown hare, which occurred at 92% of the monitoring stations. There were no obvious distribution patterns and mammals occurred both within and outside of the terminal site boundary.

The total number of species recorded in 2016 was four fewer than that of 2015; despite this, more species of both amphibian and mammal were recorded in 2016 (Table 6.2.4.2). The disparity between years arises largely from the reduction in reptiles (snakes in particular) recorded in 2016. Five species of snake were recorded in 2015. In contrast, *Natrix tessellata* was the only species of snake recorded in 2016. Although the number of mammal species remained broadly consistent across years, the species composition has varied.

Table 6.2.4.2 Number of species present on each survey, 2011 – 2016

	2011	2012	2013	2014	2015	2016
Amphibian	2	2	2	1	1	2
Reptile	7	7	10	8	10	4
Mammal	3	8	10	9	8	9
Total	12	17	22	18	19	15

The distribution of animals, measured by monitoring station occupancy, was slightly higher in 2016 than previously reported. Seventy of the 71 monitoring stations (99%) contained evidence of herpetofauna, mammals or both.

Figures 6.2.4.2 and 6.2.4.3 illustrate a comparison of the June (springtime) and October (autumn) distribution of 5 species that have been recorded every year since 2011. The 5 species include 1 mammal, 1 amphibian and 3 species of reptiles. The common names of the five species are

- *Eremias arguta* – steppe runner (lizard)
- *Eremias velox* - rapid racerunner (lizard)
- *Lepus europaeus* – brown hare
- *Ophisops elegans* – snake-eyed lizard
- *Pelophylax ridibundus* - Eurasian marsh frog

The 2016 distribution of the five selected species is largely comparable with previous years, being higher in some instances and lower in others. The obvious exception to this is *Eremias velox*. This species is typically recorded in low numbers but in 2016, no individuals were recorded at all. In contrast, marsh frog, which was not recorded in October 2015, was recorded from the highest number of sites to date in October 2016. This counters the recent trend of decreasing sample station occupancy that was reported for this species between 2013 and 2015.

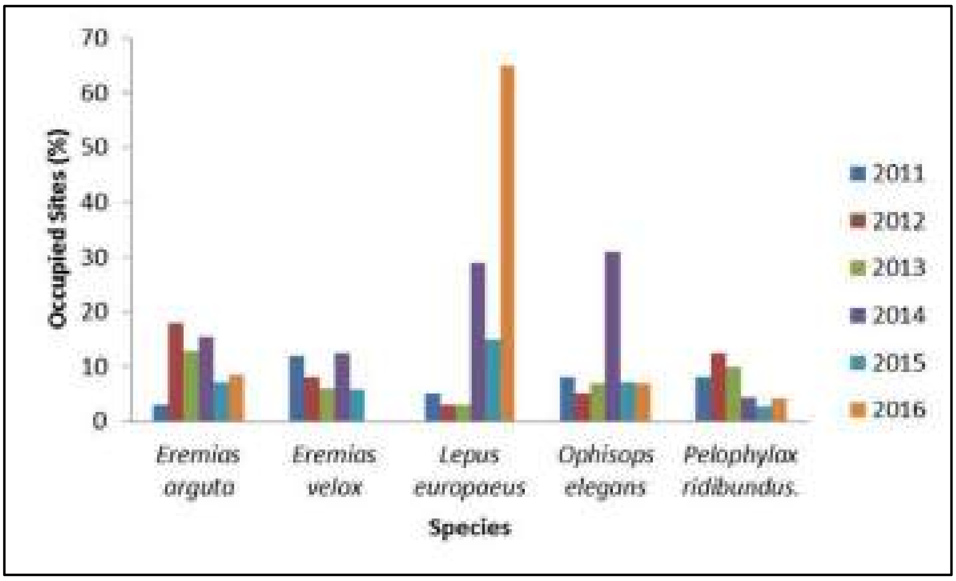


Figure 6.2.4.2 Distribution of 5 consistently present species during spring (June) of 2011-2016

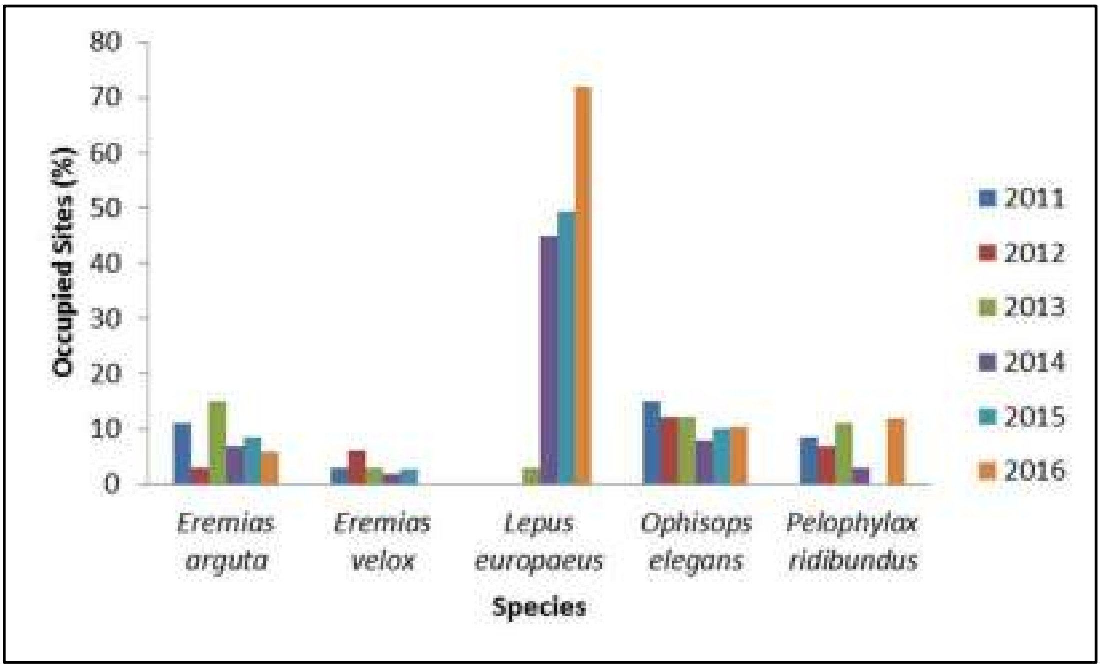


Figure 6.2.4.3 Distribution of 5 consistently present species during autumn (October) of 2011-2016

To establish whether operations at ST are affecting the distribution of herpetofauna and mammals, the occupied monitoring stations were broadly divided into two categories: 1) those within 500m of the terminal's boundary fence (near), and 2) those that lie beyond 500m of the fence (distant).

Of critical importance to amphibians is access to clean, open water. The only occupied waterbodies are situated just beyond 500m south of the terminal; however, these wetlands are influenced by the Terminal through the input of treated water. Although not confirmed, the input of treated water could be actively extending the period that open water is present in ephemeral pools, providing amphibians with sufficient time to metamorphose. No other waterbodies are currently affected by the Terminal; as such, there is no evidence to suggest that Terminal operations are adversely affecting the distribution of amphibians.

No significant differences were detected in 2016 data between the number of reptile occupied stations within (20%) and outside (26%) the 500m ST buffer. This minor difference is likely to be the result of detectability. A high level of variability in the distribution of reptiles has been recorded both within and between years, but no overall trends have been identified.

Eighty percent of monitoring stations located within 500m of the terminal were occupied by mammals in June 2016; however, in October this was 100%. This was slightly higher than the average rate of occupancy (98%) recorded beyond the 500m buffer.

The 2016 survey has shown that mammals and, to a lesser extent, reptiles are distributed more or less evenly across the monitoring stations. Of the 15 monitoring stations located within 500m of the Terminal, 87% and 100% were occupied in June and October respectively. Identical values (i.e. 87% in June and 100% in October) were achieved for the remaining 62 sites located beyond the 500m buffer.

Similar results were observed on previous surveys. In 2015 the proportion of monitoring stations located within the Terminal boundary that were occupied by mammals was 80%; nearly double the occupancy recorded beyond the boundary fence (43%), whereas no significant differences were identified between the monitoring stations occupied within or beyond the boundary fence in the proportion of stations occupied by reptiles.

With the exception of the general reduction in marsh frog presence between 2012 and 2015 which was reversed in 2016, no overall trends have been identified in species presence and/or distribution.

Overall, there is no evidence from the monitoring survey data that ST operations are having a negative impact on the distribution of mammals or herpetofauna.

6.2.5. Bird monitoring

Bird monitoring surveys have been conducted in the vicinity of ST since 2001, the scope and design of the early studies varied, but were not specifically designed to detect impacts from ST. From 2008 specific monitoring surveys have been carried out to determine if the terminal, and its associated activities, have affected the bird species present within the adjacent habitats.

A total of 418 monitoring points around ST, spaced 250 metres (m) apart, have been used as bird sampling points

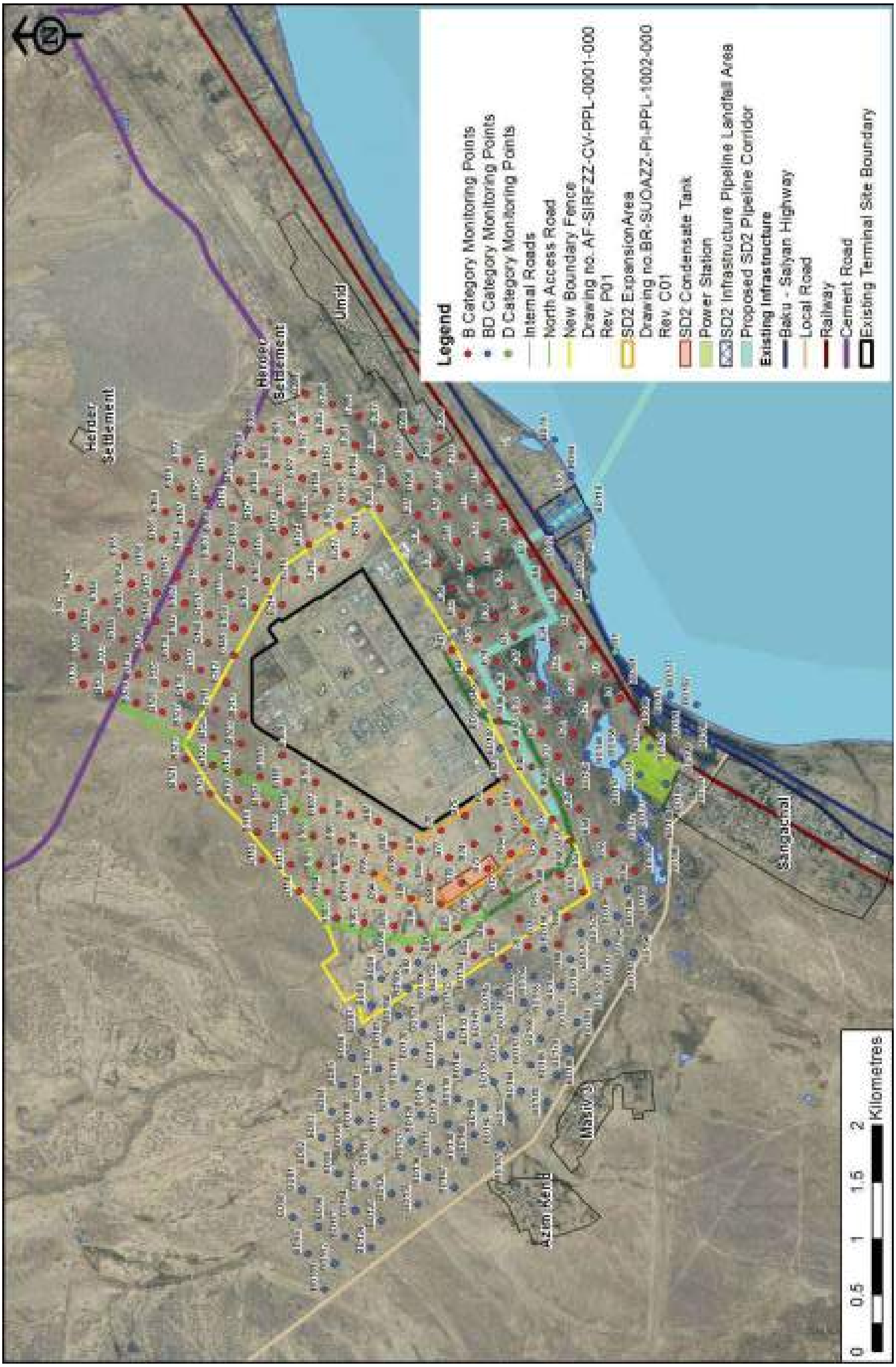


Figure 6.2.5.1 Bird monitoring locations around the Sangachal Terminal

for the ornithological monitoring work since 2011* (Figure 6.2.5.1).

When conducting the surveys, observers recorded all birds seen and heard during a 10-minute sampling period; and for a 30-minute period for the D1-D2 monitoring points located at Sangachal Bay. The survey uses a 100m-radius ‘point count’ method to identify the species, numbers of individuals, and status of individual birds at each survey point.

Surveys were undertaken in 3 time periods: winter (cycle 1), spring / summer (cycle 2) and autumn (cycle 3). These periods include the key seasons for birds: wintering bird season; spring migration season / breeding season (including breeding summer migrant species); and autumn migration season.

An important aim of long-term ecological monitoring is to provide early warning of changes that could negatively affect species or ecosystems. Rather than employing the full dataset for this purpose, a selection of bird species are used as indicators of wider environmental conditions. A total of 17 ornithological bio-indicator species have been selected for use in the assessment of the bird survey data.

- Little Grebe - *Tachybaptus ruficollis*
- Great Crested Grebe - *Podiceps cristatus*
- Common Pochard - *Aythya ferina*
- Ferruginous Duck - Aythya nyroca
- Tufted Duck - *Aythya fuligula*
- Dalmatian Pelican - *Pelecanus crispus*
- Great Cormorant - *Phalacrocorax carbo*
- Pygmy Cormorant - *Microcarbo pygmaeus*
- Purple Heron - *Ardea purpurea*
- Pallid Harrier - *Circus macrourus*
- Marsh Harrier - *Circus aeruginosus*
- Coot - *Fulica atra*
- Black-bellied Sandgrouse - *Pterocles orientalis*
- Black-winged Stilt - *Himantopus himantopus*
- Pied Wheatear - *Oenanthe pleschanka*
- Reed Warbler - *Acrocephalus scirpaceus*
- House Sparrow - *Passer domesticus*

A total of 82 species were recorded during the 2016 survey period, these included; 53 migratory species, 23 resident species, 4 wintering species and 2 transit species.

A total of 3 of the resident species recorded in 2016 are considered to be ornithological bio-indicator species, these were; marsh harrier, house sparrow and black-bellied sandgrouse. Of the 53 migratory species recorded in 2016, six were ornithological bio-indicator species, these were; common pochard, tufted duck, great cormorant, pygmy cormorant, purple heron and pied wheatear.

The following 3 IUCN Red listed species were recorded during the 2016 surveys (Near-threatened to Endangered category):

- Meadow Pipit (*Anthus pratensis*) – Near-threatened;
- Common Pochard (*Aythya ferina*) – Vulnerable, and;
- Egyptian Vulture (*Neophron percnopterus*) – Endangered.

* 2008 survey - 6 cycles with 220 point counts; 2009 & 2010 surveys - 3 cycles with 220 point counts; 2011-2016 surveys - 3 cycles with 418 point counts.

A total of 3 species are listed within the ARDB, namely:

- Purple Heron (*Ardea purpurea*);
- Egyptian Vulture (*Neophron percnopterus*); and
- Black-bellied Sandgrouse (*Pterocles orientalis*).

Table 6.2.5.1 presents a summary of the bird survey results between 2010 and 2016. With the exception of the higher abundance in 2014, there has been little difference in the number of registrations and individuals recorded over the 2011 to 2016 monitoring period. The lower number of both measures recorded in 2010 is due to the lower number of point counts included in the 3 surveys conducted during that year; 220 compared to 418 in later years.

Figure 6.2.5.2 plots the trend in the number of resident and migratory bird species recorded on surveys carried out between 2008 and 2016. The population trend of resident species is the key focus of the survey, as fluctuations in migratory species will be affected by factors unrelated to local conditions.

The number of resident bird species recorded on each survey ranges between 21 and 30. With the exception of the higher number of 30 in 2011, there has been very little change recorded in resident bird species over the monitoring period. There was no real difference between the results from the 6 cycle survey carried out in 2008 and the 3 cycle surveys in 2009 – 2016, or between surveys with 220 point counts in 2009 and 2010 and the higher point count surveys in 2011 – 2016. This suggests that the numbers of resident species present within the area surrounding ST is stable.

Migratory bird species numbers were highest in 2008 when the six cycle survey was conducted. There was some variation in the numbers observed between 2008 and 2016. However, no obvious trend was present in the data.

Table 6.2.5.1 Summary of bird survey results from 2010 – 2016

	2010	2011	2012	2013	2014	2015*	2016**
Resident species	23	30	22	23	24	23	22
Migratory species	63	58	78	56	59	59	47
Total species	86	88	100	79	91	94	84
Total registrations	1700	2380	2814	2553	2715	2515	2005
Total individuals	5832	9905	9572	8377	11058	8678	8969
Total species at Sangachal Bay (D1/D2)	13	12	8	9	14	12	13
2010 3 cycles 220 point counts							
2011 - 2016 3 cycles 418 point counts							
* 42 point counts were not surveyed in 2015							
** 46 point counts were not surveyed in 2016							

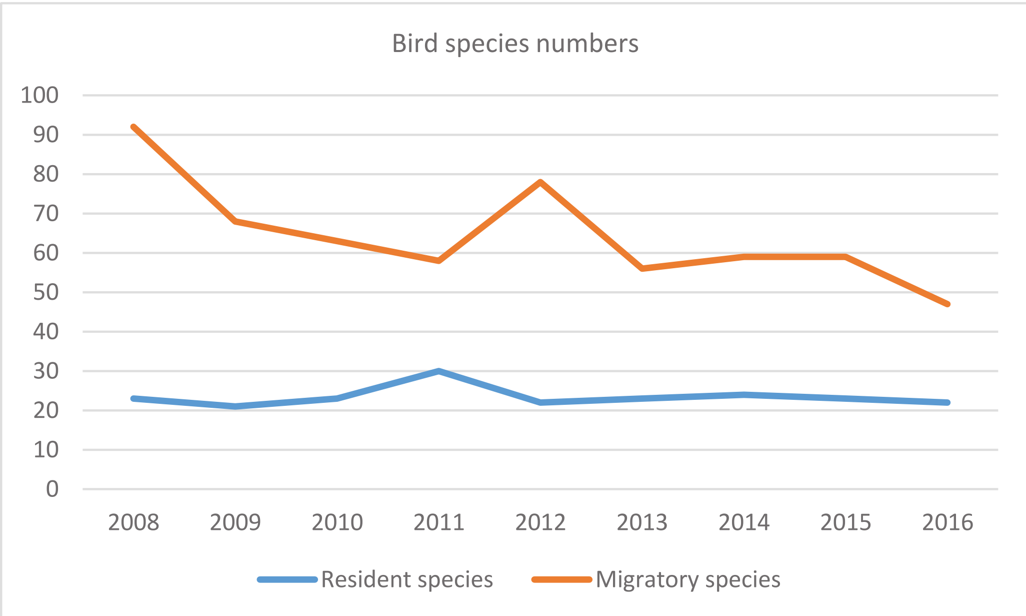


Figure 6.2.5.2 Resident & migratory bird species totals over the period of 2008-2016

Table 6.2.5.2 gives the number of registrations for indicator species for the period 2011-2016. Key trends have been identified as follows.

In terms of waterfowl populations, which are considered good bio-indicators of wetland habitats within the survey area, there is little evidence to suggest noticeable trends in the respective populations. However, black-winged stilt has not been recorded in 2014, 2015 and 2016; and the large flocks (100) of ferruginous duck (an ARDB species) were not recorded in 2011, 2015 or 2016. It is difficult to draw conclusions from the paucity of records for Dalmatian pelican (an IUCN Threatened species), as it is unknown whether this registration referred to overflying birds on migration or birds commuting to/from breeding areas in the locality.

Populations of black-bellied sandgrouse and marsh harrier (both resident species) appear to be fairly stable.

The fairly consistent numbers of reed warbler (which breeds exclusively in reed-bed habitat) and pied wheatear (breeds in desert habitat) suggest little changes in the quality of these birds' preferred habitat types over consecutive years since 2011.

The average number of house sparrow registrations is fairly consistent between the 2011 to 2016 monitoring period. The comparatively high number of registrations for this human commensal species over consecutive years is not surprising as this species in commonly associated with human habitation and development.

Table 6.2.5.2 Bird indicator species over the period of 2011-2016

Species		No. of registrations (average per registration)					
Common name	**Latin name**	**2011**	**2012**	**2013**	**2014**	**2015****	**2016*****
Reed Warbler	*Acrocephalus scirpaceus*	4 (2.5)	1 (2)	5 (2.2)	4 (2)	8 (2.63)	8 (1.38)
*Purple Heron	*Ardea purpurea*	1 (1)		1 (1)		2 (1)	6 (2.17)
*Common Pochard	*Aythya ferina*	1 (8)	1 (13)	1 (5)	1 (90)	5 (12)	6 (49)
*Tufted Duck	*Aythya fuligula*		2 (25.50)		2 (6.50)	2 (36)	7 (20.57)
*Ferruginous Duck	*Aythya nyroca*		1 (100)	1 (100)	1 (100)		
Marsh Harrier	*Circus aeruginosus*	60 (1.1)	82 (1.35)	62 (1.4)	64 (1.11)	41 (1.32)	44 (1.34)
Pallid Harrier	*Circus macrourus*	3 (1)	2 (1)	1 (1)	3 (1)	1 (1)	
*Eurasian Coot	*Fulica atra*	1 (12)	7 (18.43)	1 (8)	3 (8.33)	4 (10)	6 (14.50)
*Black-winged Stilt	*Himantopus himantopus*	3 (4)	4 (6)	2 (1.5)			
Pied Wheatear	*Oenanthe pleschanca*	19 (1.63)	27 (1.78)	13 (1.31)	14 (1.79)	21 (1.71)	12 (1.42)
*Dalmatian Pelican	*Pelecanus crispus*		1 (7)				
*Great Cormorant	*Phalacrocorax carbo*	9 (2.33)	8 (2.5)	9 (2.44)	16 (2.56)	19 (2.89)	16 (2.25)
*Pygmy Cormorant	*Phalacrocorax pygmaeus*	1 (1)	8 (6.13)	5 (3.4)	13 (2.54)	12 (2.83)	9 (2.22)
*Great Crested Grebe	*Podiceps cristatus*			1 (1)		4 (3.25)	5 (3.20)
*Little Grebe	*Podiceps ruficollis*		2 (2.5)	3 (4.33)	1 (1)	4 (3.5)	
Black-bellied Sandgrouse	*Pterocles orientalis*	4 (3.25)	10 (1.5)	9 (2)	3 (2)	4 (1.5)	3 (5.33)
House Sparrow	*Passer domesticus*	142(6.18)	132(6.8)	138(7.09)	141(7.88)	134(6.97)	134 (6.25)

**Waterfowl species*
*** 42 point counts were not surveyed in full in 2015*
**** 46 point counts were not surveyed in 2016*

To assess spatial patterns within the ST area, point count data is assessed within segments centred on the terminal, each of which are divided into inner, intermediate and outer zones in relation to distance from this facility.

Figure 6.2.5.3 gives the average number of species per point count within each segment in 2016. The lowest diversity in 2016 was recorded in the WSW sector, while the highest diversity was observed in the ESE and SSE sectors which include the coastal zone. This spatial pattern has been exhibited on all recent surveys.

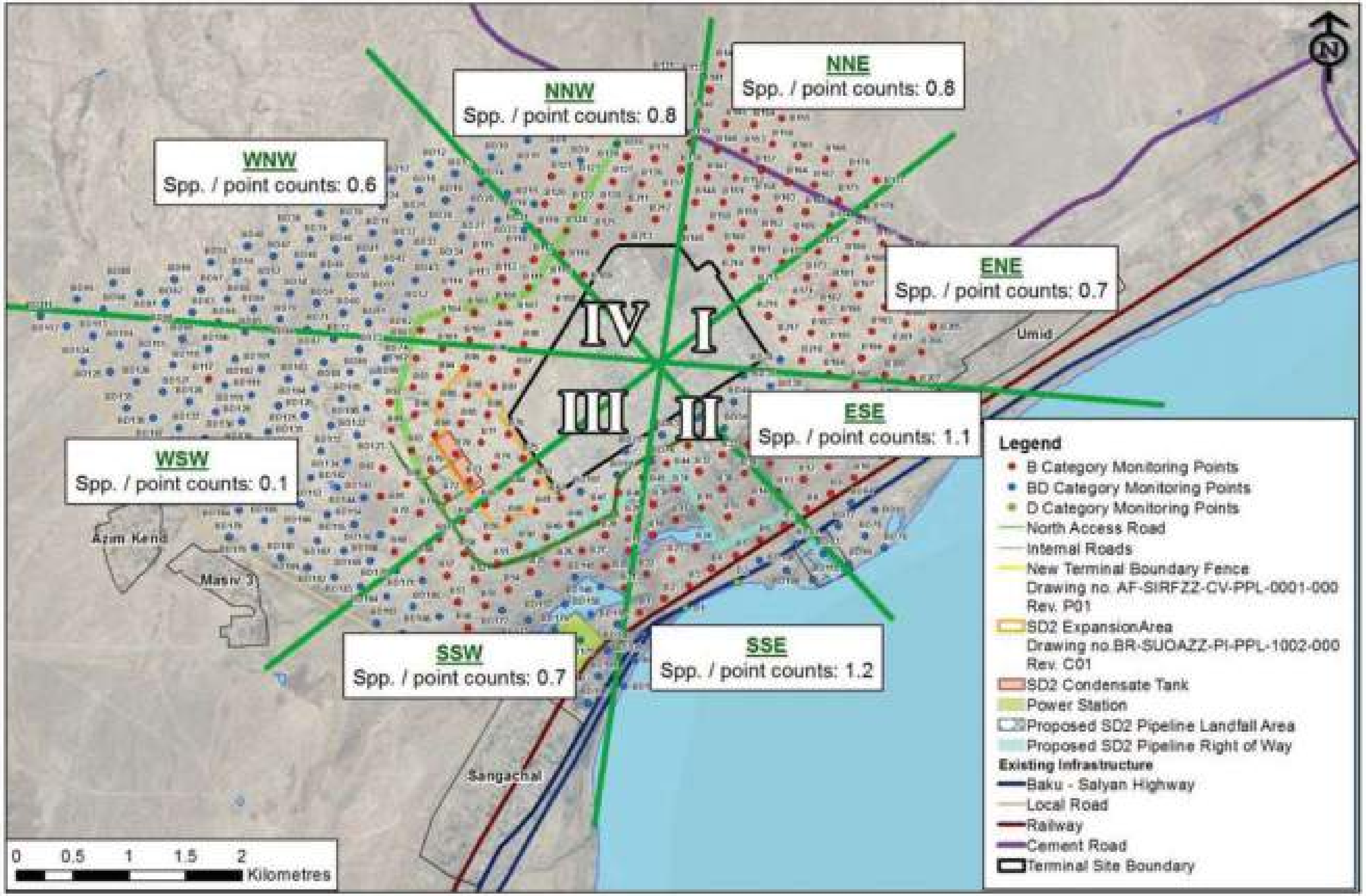
A gradual decrease in ornithological diversity was observed between 2011-2016 in the SSW (inner) and WSW (inner and intermediate) segments. Construction activity was reported to be taking place within these segments during the 2016 and previous surveys and a large proportion of the ST infrastructure is located within these segments; factors which may be related to the observed decline within these areas. The species diversity in the NNE (outer) segment gradually increased (slightly) during the 2011-2015 period; however, the cause of this increase was unknown.

From the bird monitoring surveys conducted in the area surrounding ST, the following conclusions can be drawn in terms of the terminal activities and bird populations occurring within the survey area.

The populations of indicator species, including waterfowl species which have been selected as bio-indicators in terms of the environmental conditions for the wetland habitat, appear to be fairly stable over consecutive years. However, the fluctuating numbers and occurrence of ferruginous duck (an ARDB listed resident species) is a cause for concern; as such, it has been recommended that this species be a focus for future monitoring.

The decrease in species diversity over consecutive years (2011-2016) within SSW and WSW survey area segments is a notable trend, and these decreases may relate to high levels of construction activity in this part of the survey area, in combination with terminal operations.

Studies have shown that the number of resident bird species observed within the survey area has remained stable, and in general, there was no evidence to indicate that the terminal activities were negatively impacting bird populations within the wider survey area. There was however some evidence to suggest that the presence of the terminal and human activities is leading to an increase in human commensal species in and around the facilities themselves.



Note: W – west, E-east, N-north, S-south, e.g. WSW stands for West – South – West

Figure 6.2.5.3 Average number of species per point count (species/point count) within each segment in 2016.

6.2.6. Wetlands survey

The first Sangachal wetland survey was undertaken during summer and autumn of 2002. The purpose of the 2002 survey was to establish a baseline condition against which future changes to the wetland areas could be monitored. Subsequent wetland surveys were undertaken during the spring and autumn of 2004 and 2005 to monitor changes in vegetation and biomass.

From 2012 a biennial monitoring programme was implemented of wetlands ecology, soil and surface water conditions. The sample stations selected were consistent with the twelve stations sampled on the 2002 baseline survey. Three additional stations were added to the scope in 2014.

The wetlands survey comprises 15 locations distributed throughout the wetlands area to the east, south, and southeast of the ST. The position of each sample location is shown in Figure 6.2.6.1.

To understand whether there is a correlation between the survey results and distance from the terminal, for the purpose of reporting, the survey locations are grouped into ‘zones of influence’ based on the distance from the terminal. Each ‘zone of influence’ has been assigned a colour code (red, amber or green) as illustrated in Table 6.2.6.1.

At each survey site, ecological data is collected through high level faunal (for vertebrate fauna) and flora surveys. This data is supplemented by other data derived from ornithological surveys undertaken in the vicinity of the wetland survey locations.

Where standing or flowing water is present at a wetland survey station in-situ measurements are recorded and samples are collected for the analysis of the parameters listed in chapter 6.1.4.3.

Soil or sediment samples are collected from the upper 10 centimetres (cm) of the ground surface at each survey station for analysis of the parameters listed in chapter 6.1.4.4.

Figure 6.2.6.1 2016 wetland survey locations in relation to 2015 wetland extent and the Sangachal Terminal

Table 6.2.6.1 Zones of influence

Colour code	Monitoring locations	Description
Red	ST01, ST02 , ST03 , ST04, ST13, ST14 , ST15	Stations which are closest to the Sangachal Terminal with the highest potential to be impacted by Terminal activities.
Amber	ST05, ST06, ST07, ST08	Stations which are within the Sangachal Terminal area, but are less likely to be impacted by Terminal activities.
Green	ST09, ST10, ST11, ST12, ST12 Alt	Stations which are furthest from the Sangachal Terminal and least likely to be impacted by Terminal activities.

Sixty two species were recorded within the wetland areas during the 2016 faunal, bird and wetland surveys (Table 6.2.6.2); comprising fifty three bird species, five mammal species, one amphibian and three reptile species.

Species numbers were relatively similar on surveys conducted in 2012, 2014 and 2016. The only notable difference was a reducing trend in reptile species from 7 in 2012, to 3 in 2016.

Specific faunal and bird surveys were not conducted in 2002, so the data are not directly comparable with the results from 2012-2016. The number of mammals reported in 2002 (17) included species which there was the potential to encounter, resulting in the substantially higher figure compared to later surveys when only observed species were reported.

Table 6.2.6.2 Fauna species recorded on wetland surveys 2002-2016*

	2002	2012	2014	2016
Birds	31	56	55	53
Mammals	17	6	7	5
Reptile	6	7	6	3
Amphibian	4	2	1	1
Total	58	71	69	62

There was no association between the proximity to the terminal and the number of species observed on the wetland, bird and faunal surveys. In general there was no difference in the number of species observed at near, intermediate or distant sample points.

Table 6.2.6.3 Flora species recorded on wetland surveys 2002-2016

	2002	2012	2014	2016
Flora species	36	25	51	62

The number of flora species observed in the 2016 survey was broadly consistent with the results of the 2014 survey; however, more plant species were recorded in 2016 than in 2014. The floral diversity recorded in 2016 remains substantively higher than that recorded in 2012, when only 25 plant species were recorded (Table 6.2.6.3).

In terms of species diversity, all of the stations in 2016 registered at least eight plant species, and all but one of the 15 stations registered 12 or more plant species.

A comparable mean number of plant species were recorded between the red, amber and green stations in 2002, 2015 and 2016. The results suggest that no obvious association is present between proximity to the Terminal and the number of plant species recorded. Any variance between stations is most likely the result of natural variation as a result of differences in soil moisture, soil properties and other factors unknown.

* 2012-2016 data is based on the registered species observed on fauna and bird surveys from those stations which overlap with the wetland area – this data is not included in individual wetland reports.

Due to the sample sites being dry, no water samples could be collected at the following sites

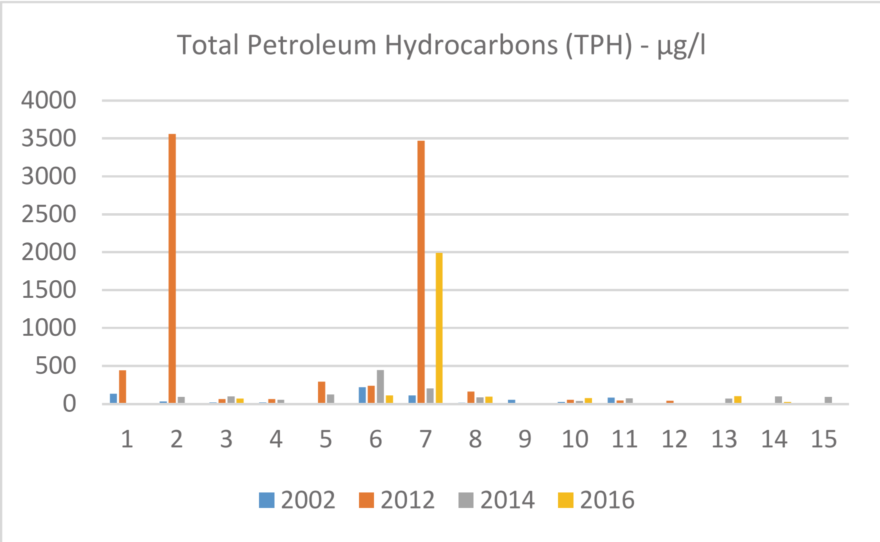
- 2012: ST9
- 2014: ST01, ST09 and ST12alt
- 2016: ST01, ST02, ST09 and ST12alt

Polycyclic aromatic hydrocarbons (PAH), phenolic compounds, polychlorinated biphenyls (PCB) concentrations were below the limit of detection (LOD) in all samples.

TPH levels were high in a number of samples in 2016. The highest level was recorded at ST07 (an amber location), with a concentration of 1,990 µg/l. Concentrations were also relatively high at ST06 (111 µg/l), ST08 (95.1 µg/l) and ST13 (103 µg/l). Although TPH concentrations have varied at individual stations over the monitoring period, concentrations have been consistently high at amber stations 6 and 7 (Figure 6.2.6.2).

Due to their location relative to the Terminal, is unlikely that the higher TPH at ST06, ST07 and ST08 is associated with terminal activities. Likely sources of influenced include the adjacent infrastructure including the railway, highway and Umid settlement. However, the high concentrations at station ST7 suggest contamination from a historical oil spill.

Elevated TPH concentrations in surface water at ST13 could be associated with vehicle usage on the road. However, ST13 was not sampled in 2012 and therefore only two data-points are available, which is insufficient to identify potential data trends.



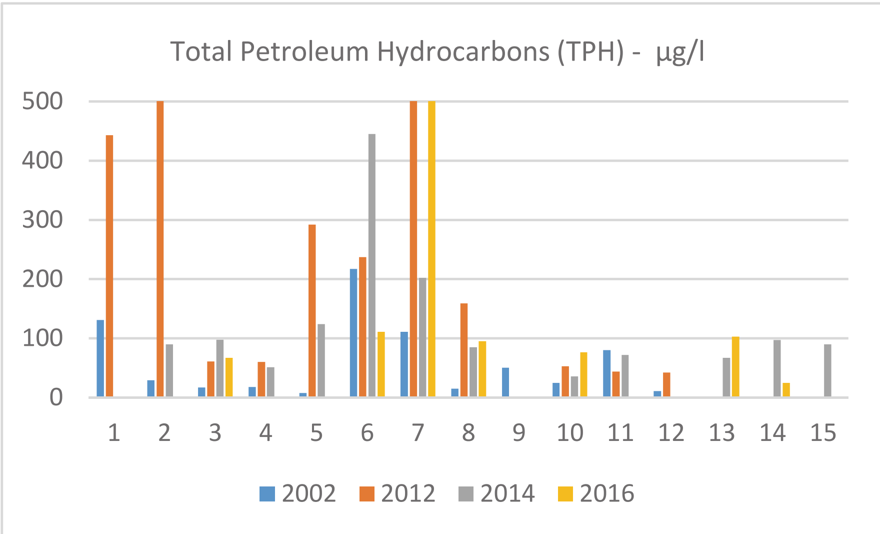
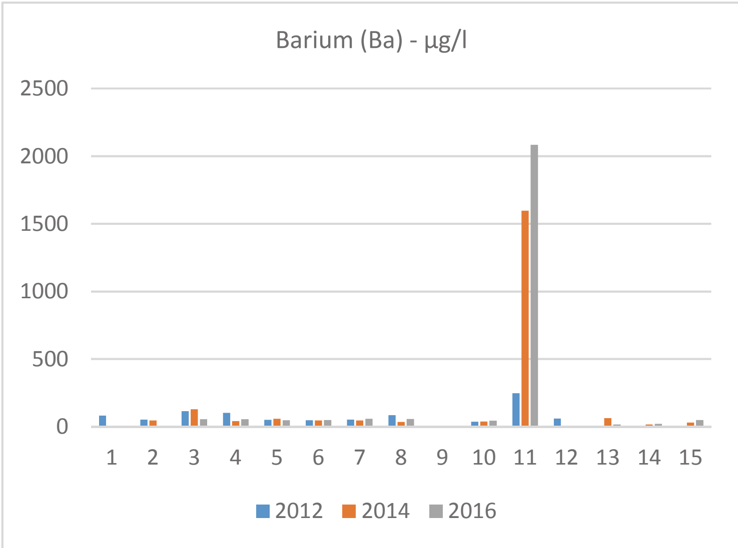


Figure 6.2.6.2 THC in water samples, wetland surveys 2002-2016

The water chemistry at station 11 has been distinctive over the monitoring period, with high concentrations of ammonium and metals Ba, Cu, Zn and Pb (Figure 6.2.6.3). Station 11 is a green category station, lying over 2 kilometres from the Terminal. It is unlikely that the distinctive water chemistry at this position is related to ST activities.



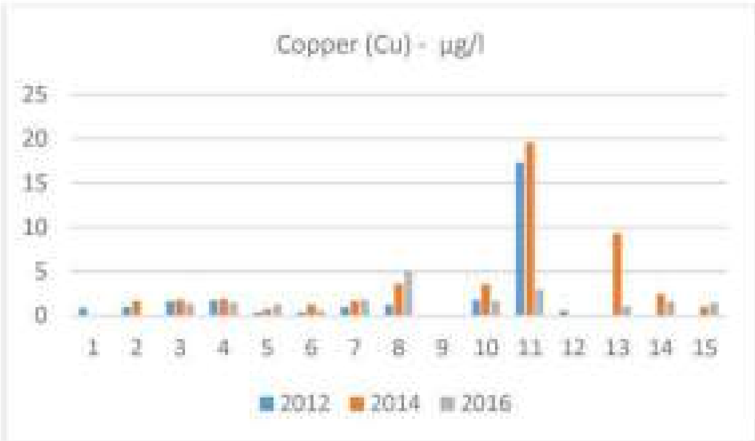


Figure 6.2.6.3 Ba & Cu concentrations in water samples, wetland surveys 2012-2016 (2002 concentrations <LOD)

Soil chemistry results in 2016 were either lower or similar to the previous results for all analytes. The exception was THC which was higher at station 11 in 2016. As noted above, the water chemistry at station 11 is distinctive, which indicates that this position is affected by a contamination source. This is not considered to be related to terminal activities given that ST11 is the furthest location from this facility and there is no evidence of significant TPH concentration increases at any other sampling point.

Given that the soil chemistry at all sampling locations remained largely the same as previous surveys, there is not considered to be any evidence of impact on soil quality within the wetlands areas that could be caused by operations at ST.

Overall there is no indication from the surveys carried out that operations at ST are impacting on the adjacent wetland habitats. Flora and fauna presence, particularly in 2014 and 2016, is relatively equal in areas close to and at distance from the Terminal. Although Water chemistry results fluctuate between stations, there was no evidence to indicate that the variation was being influenced by ST operations.

It has been identified that the wetlands coverage has decreased in extent between 2007 and 2014 as follows

- 2007 - 2,088,503 m^2
- 2009 - 1,252,019 m^2
- 2014 - 946,503 m^2

Satellite imagery of the area taken during 2015 indicates a very similar wetland extent to that of 2014, suggesting no major change in the wetland area between those years. Equivalent data was not available for 2016; however, the fact that the number of dry sample stations has increased from 3 in 2014 to 4 in 2016 suggests that there may have been a decrease in the extent of the wetlands area between 2014 and 2016.

In 2017 a dewatering project was conducted by a third party to prevent corrosion of underlying third party pipelines. This activity has reduced the sources feeding the wetland and is expected to result in a sharp reduction (or elimination) of reed bed coverage in the area of wetland to the immediate south of the terminal.

6.3. Serenja Hazardous Waste Management Facility (HWMF)

6.3.1. Ambient air quality monitoring

An ambient air quality monitoring programme is in place at the Serenja HWMF to identify any possible impacts to the local air quality from operations at the site. Monitoring is conducted in the area directly surrounding the facility and within the adjacent settlements Shongar, Gizildash and Korgez.

Ambient air quality monitoring was initially conducted at Serenja HWMF in March 2004 and in May 2005. Monitoring also took place in 2006. However, the design only covered the area within the facility and included 3 (three) monitoring stations; 1 station at the perimeter fence NW, 1 station at the perimeter fence SE and 1 station within the compound area.

In 2009 the ambient air quality monitoring programme for this facility was redesigned to provide coverage at the potential impact source (Serenja HWMF) and also the areas potentially affected (the local settlements).

Two sample stations were positioned adjacent to the HWMF; AAQS1 is located adjacent to and upwind of the facility and AAQS2 is located downwind of the facility (prevailing wind direction N). Three stations; AAQS3, AAQS4 and AAQS5 are located within the surrounding settlements of Shongar, Gizildash and Korgez (Figure 6.3.1.1). From 2009, long-term AAQ monitoring has been conducted twice a year using passive samplers located at the five sample stations – the programme does not include real-time monitoring.

Operations carried out at Serenja HWMF are related to the treatment of drill cutting wastes produced at offshore production sites. The potential sources of impact to the air quality in the Serenja area from operations at Serenja HWMF are

- Emissions from raw drill cuttings when transporting, loading and storage in Serenja HWMF
- Emissions from Bioremediation area
- Emissions from the operation of Indirect Thermal Desorption Units (ITDUs)
- Emissions from the operation of Thermo-mechanical Cuttings Cleaner (TCC)
- Emissions from Treated Drill Cuttings (TDC) storage cells

The six parameters that are measured in the long-term ambient air quality monitoring programme and their potential sources are listed in Table 6.3.1.1.

Table 6.3.1.1 Serenja HWMF ambient air quality monitoring parameters & potential sources

Potential Source / Monitoring Parameter	Benzene	TVOC	PM10	SO_2	NO	NO_2
Storage of raw drill cutting	Yes	Yes	No	No	No	No
Bioremediation area	Yes	Yes	Yes	No	No	No
ITDUs operation	Yes	Yes	Yes	Yes	Yes	Yes
TCC operation	Yes	Yes	Yes	Yes	Yes	Yes
TDC storage cells	Yes	Yes	Yes	No	No	No

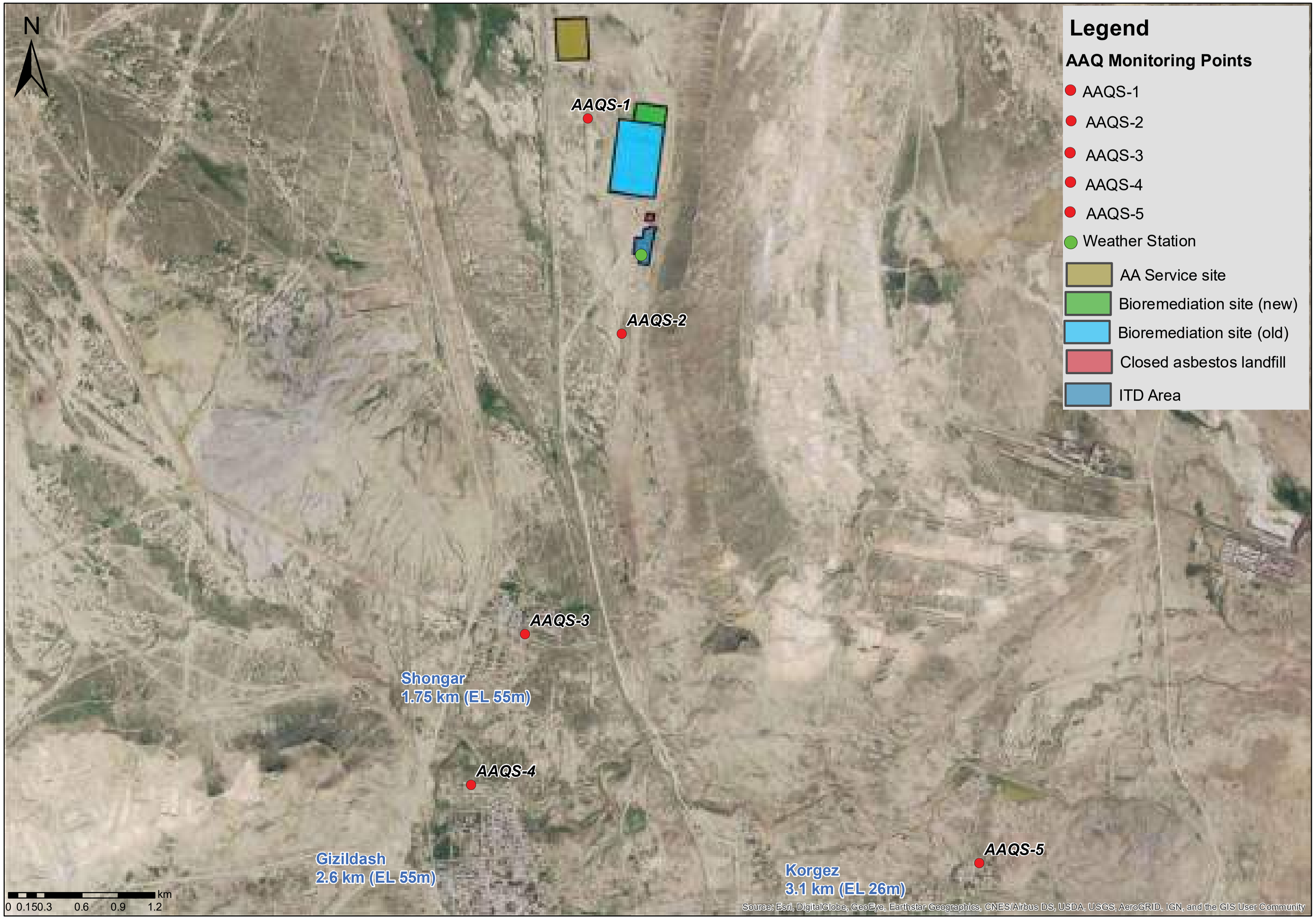


Figure 6.3.1.1 Serenja HWMF ambient air quality monitoring stations

Samples for benzene, TVOC, SO_2, NO/NO_2 are collected over a one month period, twice a year, while particulate PM10 concentrations are monitored using 24-hour sampling twice a year.

Figure 6.3.1.2 to Figure 6.3.1.7 give the annual averages for each parameter for 2009 to 2017. Ambient air quality standards are noted in Table 6.2.1.1 and are provided in each figure.

The concentrations of benzene measured around the Serenja HWMF and within the local populated areas (AAQS3, AAQS4 and AAQS5), in 2017 and previous years, were all within EU and national ambient air quality standards (5µg.m^{-3} and 100 µg.m^{-3} respectively) (Figure 6.3.1.2).

Background benzene concentrations suggest no significant influence from the operations at the Serenja HWMF site, with the background levels generally consistent across all locations monitored and likely to be associated with routine vehicle emissions on the local road network..

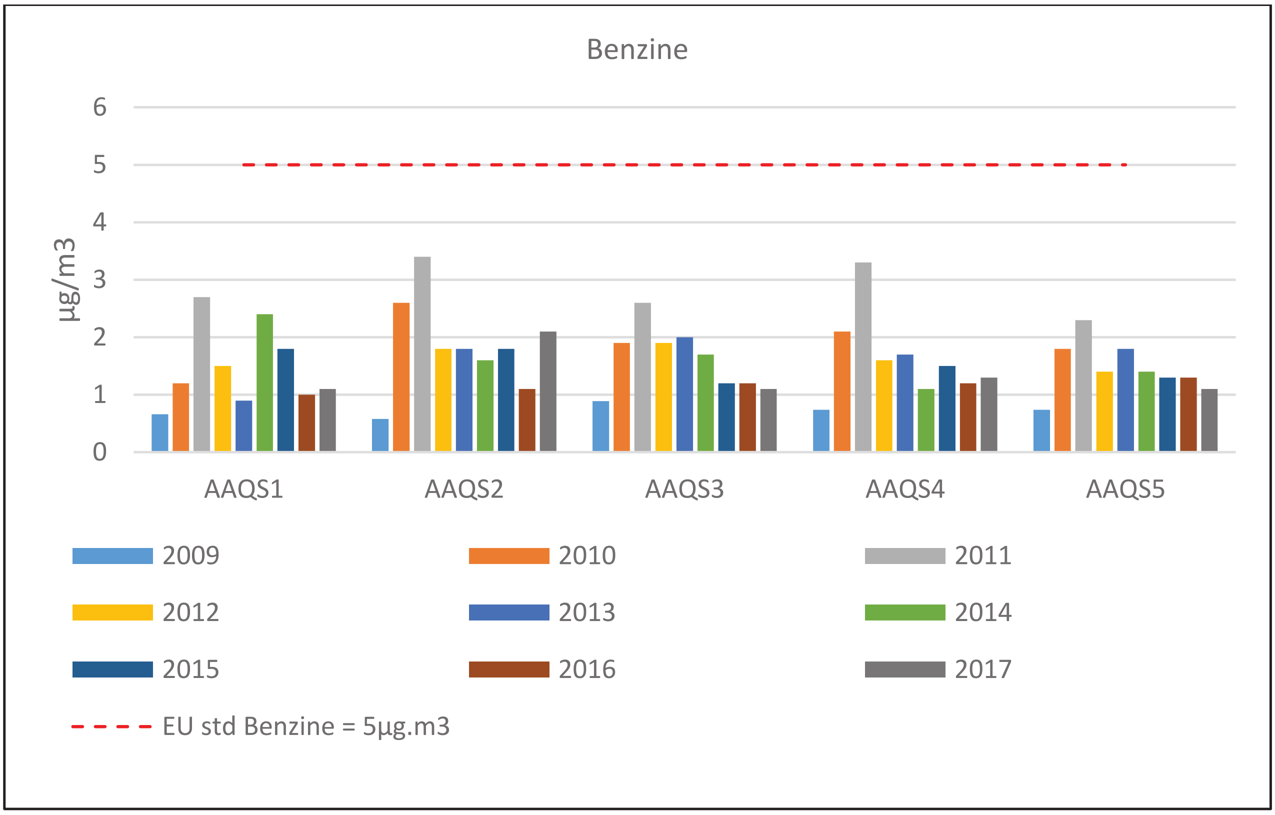


Figure 6.3.1.2 Benzene concentrations recorded in 2009 to 2017 (µg.m^{-3})

TVOC concentrations varied between years and between stations (Figure 6.3.1.3). When compared to the levels recorded adjacent to the HWMF (AAQS2), higher concentrations were generally present within the settlements (AAQS3, AAQS4 and to a lesser extent AAQS5) - a possible source being local industrial activities within and around the surrounding settlements. The only exception was 2010 when high levels were recorded at station AAQS2.

The only notable trend in the data is a general increase from 2009 to 2016 at station AAQS5.

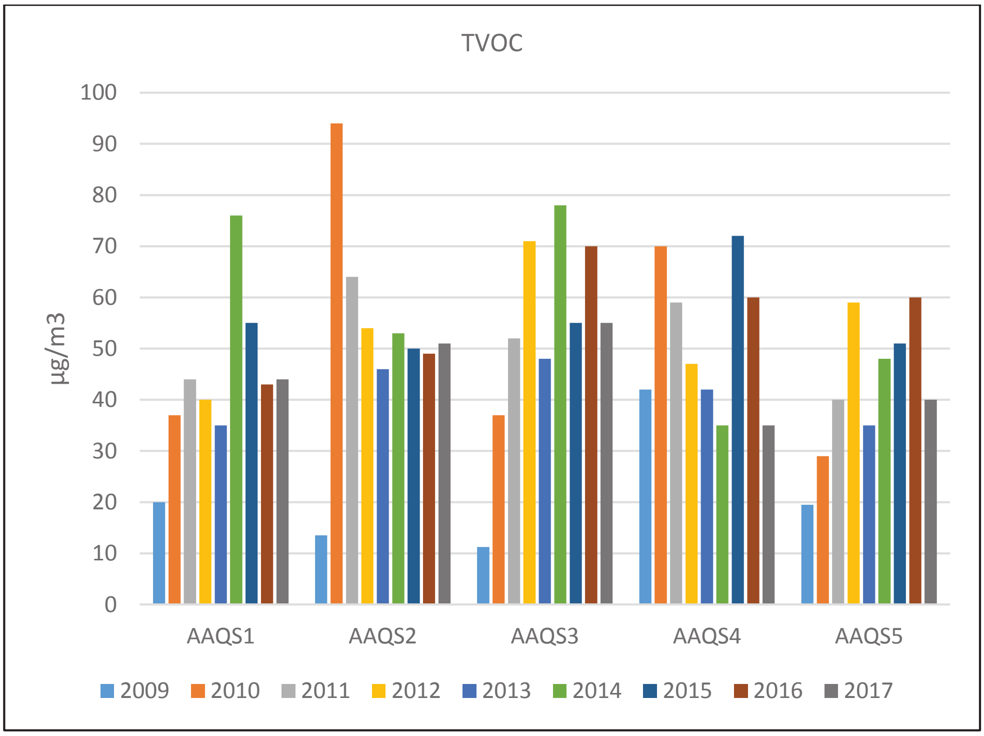


Figure 6.3.1.3 TVOC concentrations recorded in 2009 to 2017 (µg.m^{-3})

In general, sulphur dioxide levels were very low at all locations on all surveys, either below or close to the method detection limit of 2µg.m^{-3} (Figure 6.3.1.4). The higher concentrations recorded in 2011 were within the national and EU air quality standards.

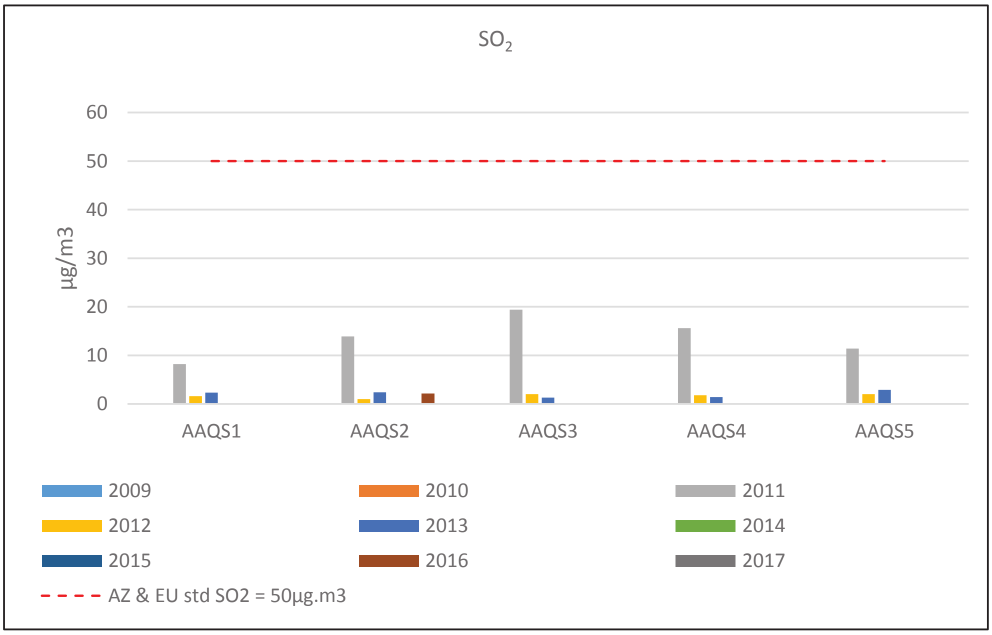


Figure 6.3.1.4 SO_2 concentrations recorded in 2009 to 2017 (µg.m^{-3})

As observed on all previous years, NO measured in 2017 around the Serenja HWMF site, and from within the local populated areas, are all considerably lower than the national ambient air quality standard of 60 µg.m^{-3} (Figure 6.3.1.5).

With the exception of a possible pattern in 2010, there is no consistent evidence from the results that operations at Serenja HWMF are contributing to the atmospheric concentrations of NO within the local settlements (AAQS3, AAQS4 and AAQS5).

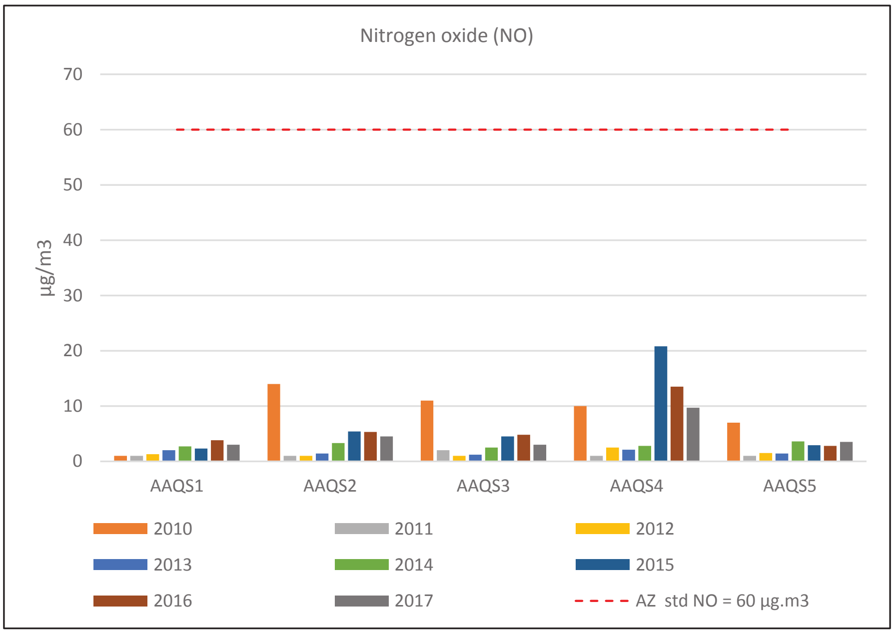


Figure 6.3.1.5 NO concentrations recorded in 2010 to 2017 (µg.m^{-3})

The results for NO_2 concentrations for 2017, and for previous years, are all within the national and EU annual-average air quality standards (40µg.m^{-3}), all being around a third of the annual limit for NO_2 (Figure 6.3.1.6).

There was no evidence in the data that the NO_2 levels within the settlements had been influenced by operations at Serenja HWMF. Concentrations recorded at AAQS2 were generally similar to, or lower than the levels reported within the settlements.

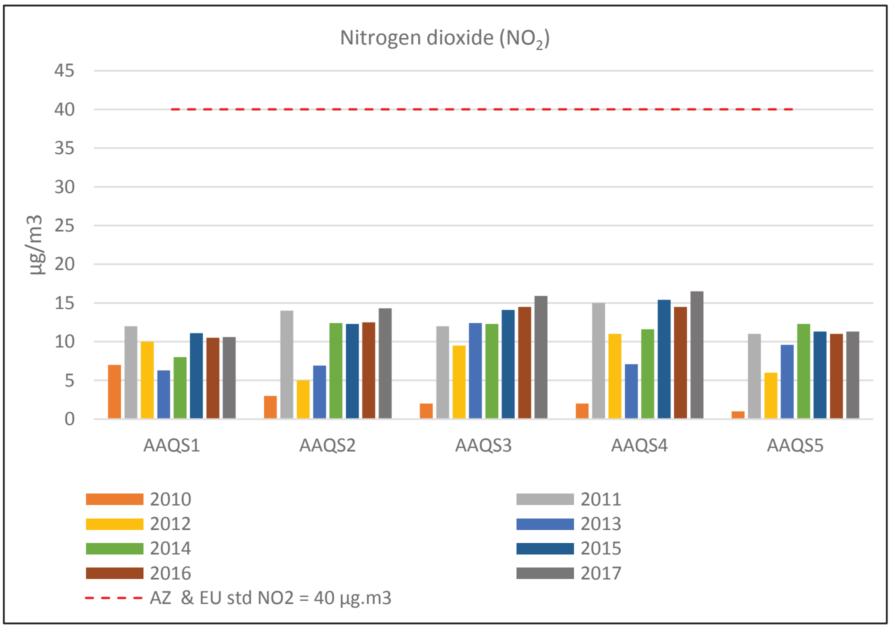


Figure 6.3.1.6 NO_2 results recorded in 2010 to 2017 (µg.m^{-3})

The averaged PM10 results from the two days of data obtained in 2017 exceeded the EU limit values at 2 sites: AAQS1 and AAQS4. This differs to the results from 2016 and 2015 when the average results from all sites exceeded the EU limit.

The results do not indicate a pattern of association between PM10 levels and operations at Serenja HWMF. The average PM10 results in 2009, 2014 and 2017 were within the standard at station AAQS2 adjacent to the HWMF, but exceeded the standard at some of the other stations.

High levels were recorded in 2014 and 2016 at station AAQS1 to the north (upwind) of Serenja HWTF.

Airborne particulates within the survey area are from the pick-up and transportation of the fine dry dusty soils present in the region.

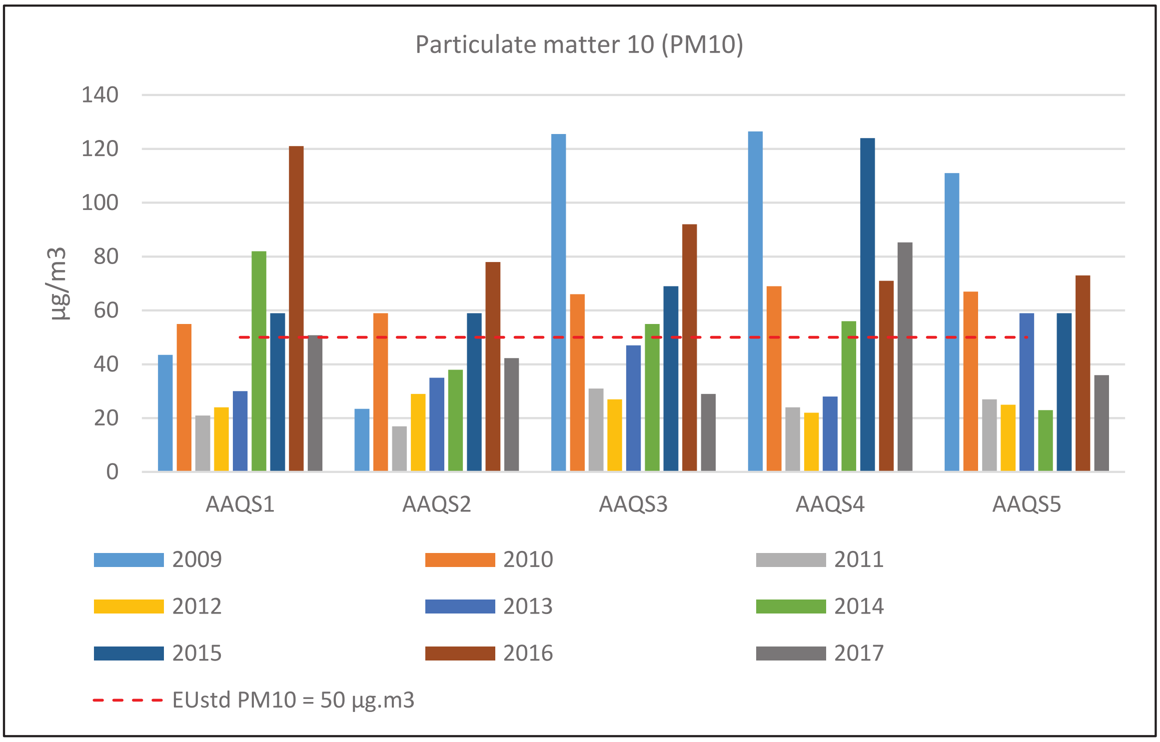


Figure 6.3.1.7 PM10 concentrations recorded in 2009 to 2017 (µg.m^{-3})

With the exception of PM10 results, the concentrations of all parameters at all stations - including station AAQS2 adjacent to Serenja HWMF – are within air quality standards. There was no evidence to link the concentrations of the measured parameters at offsite locations to operations at Serenja HWMF.

Other than a general increase in TVOC's at station AAQS5 from 2009 to 2016, no overall trends were observed in the data over the monitoring period.

6.3.2. Serenja HWMF ground water monitoring

The objective of the Serenja groundwater monitoring programme is to provide assurance that waste management activities at the Serenja HWMF are not affecting local groundwater resources.

The monitoring programme involves the collection and analysis of water samples from predrilled boreholes. The data is measured against the GAC of relevant water quality standards* and the risk is assessed based on the relationship between contaminants, pathways and receptors.

Water samples collected from the boreholes are analysed for

- Electrical conductivity
- Dissolved oxygen
- TPH & PAH
- Phenol
- BTEX
- Metals – Arsenic (As), Barium (Ba), Cadmium (Cd), Chromium (Cr), Copper (Cu), Iron (Fe), Lead (Pb), Mercury (Hg), Nickel (Ni), Zinc (Zn)
- Phosphorus, Nitrate, Nitrite, Phosphate, Nitrogen (total), Ammonium

* UK Freshwater and Coastal Environmental Quality Standards (EQS, 2015); UK Drinking Water Standard (DWS); World Health Organisation (WHO) Guidelines for Drinking Water Quality & US Environmental Protection Agency (USEPA) Regional Screening Levels (RSLs) .

- COD & BOD

A number of potential contamination sources are present within the Serenja HWMF, these include

- Ground pits for reception of drill cuttings (base oil, heavy metals, TPH, PAH)
- Indirect Thermal Desorption Units (ITD) area (heavy metals, TPH, PAH, phenols)
- Former asbestos landfill (asbestos)
- Former bioremediation site, now clean cuttings area (base oil, heavy metals, TPH, PAH and historical application of fertilisers)
- New bioremediation site (base oil, heavy metals, TPH, PAH); 1,300kg of fertiliser containing nitrogen (N), phosphorus (P) and potassium (K) were used in 2015
- Diesel storage and temporary waste storage areas.

In 1998, a site investigation was carried out to provide environmental data confirming the site suitability and specific engineering data necessary to design a landfill for the disposal of asbestos waste. Baseline soil and groundwater quality was assessed through the drilling of three boreholes and the excavation of five trial pits. One groundwater sample was analysed for hydrocarbons and metals and three groundwater samples were analysed for nutrients. A further survey was carried out in 2001 with 8 boreholes being sampled.

From 2008 an annual monitoring programme was initiated, consisting of 11 boreholes SBH1-3 & SBH5-12. In 2010 boreholes BH1 & BH7 were added to the scope and from 2015 NSB1 to NSB4 were included, taking the total number of borehole samples in the current scope to 17 (Figure 6.3.2.1).

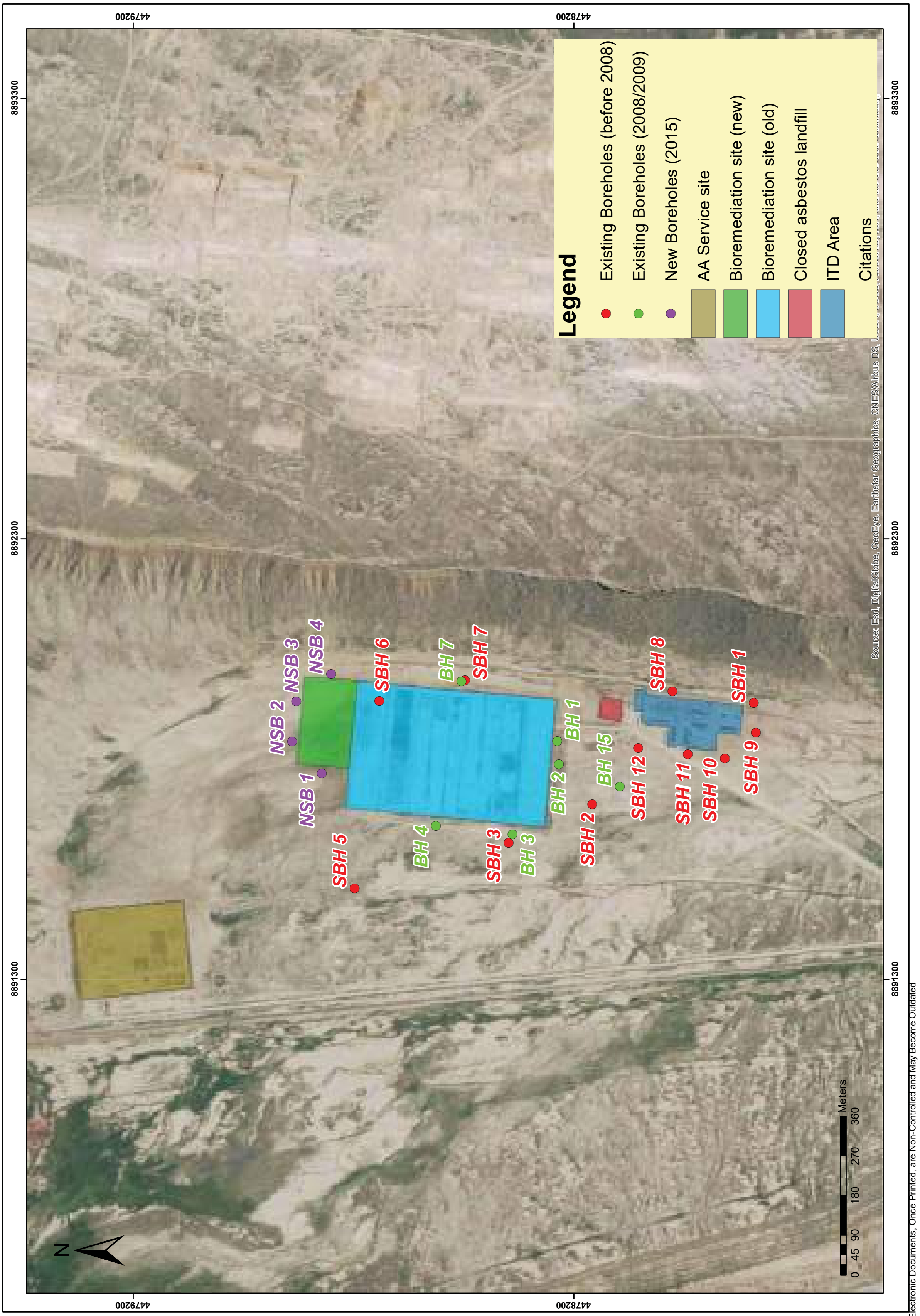


Figure 6.3.2.1 Ground water monitoring wells – boreholes around the Serenja HWMF

The groundwater level around Serenja HWMF is monitored on a monthly basis. The water level is measured in the boreholes located within and around the HWMF, and also by piezometers which are located around the bioremediation cells. The piezometers are used to monitor the integrity of the bioremediation cells.

Groundwater in the area flows from the northwest to the southeast. Figure 6.3.2.2 gives the groundwater level measurements over the period December 2008 to December 2017. The relationship between groundwater levels across the monitoring well network has remained generally consistent between 2008 and 2017, indicating a consistent groundwater flow direction.

The groundwater level reduced by approximately 0.5m in the second half of 2011. This was followed by an upward trend until 2014. Apart from a brief reduction in May 2015, the level remained relatively stable between June 2014 and August 2016. From August 2016 there has been a general upward trend at all sampling sites.

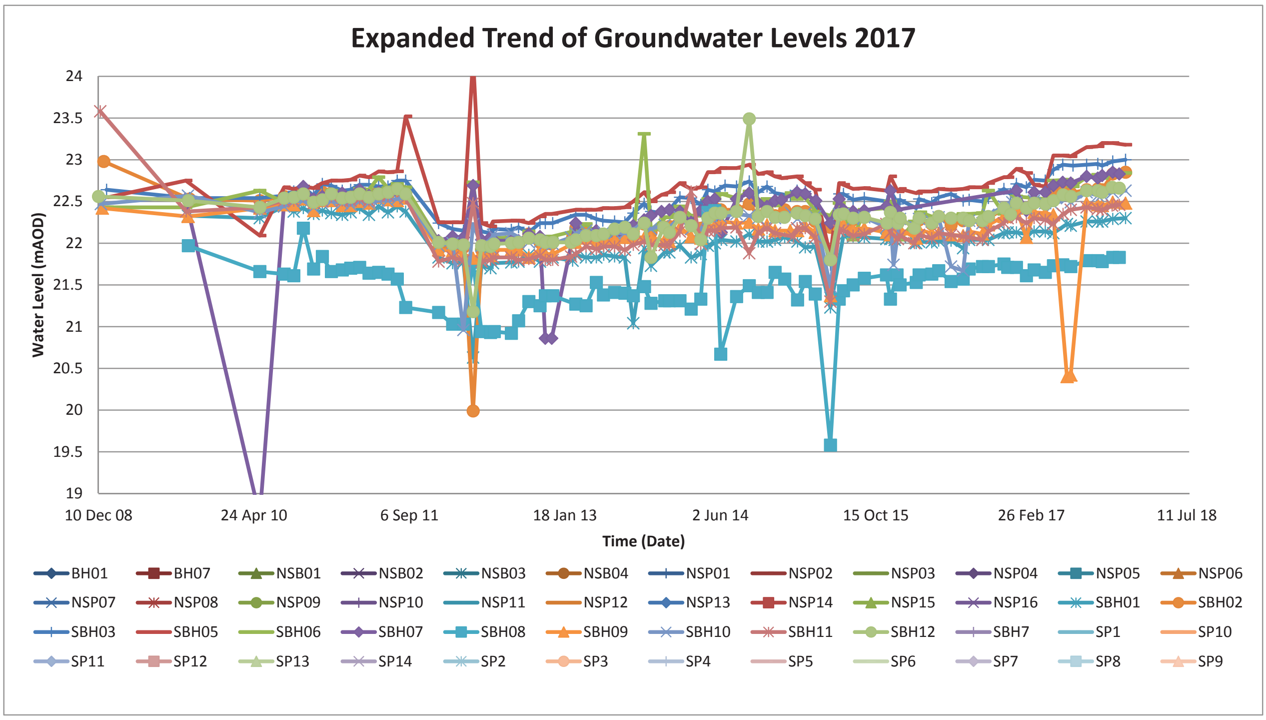


Figure 6.3.2.2 Serenja HWMF groundwater levels recorded in 2008 – 2017

Salinity levels have remained relatively stable at all locations over the monitoring period. The salinity contours suggest increasing salinity down-gradient of the site with the highest levels generally present at boreholes SBH1 and SBH08 (Figure 6.3.2.3). Based on electrical conductivity (and therefore salinity), it is unlikely that the groundwater within the superficial deposits would provide a viable resource for potable, irrigation or stock watering use.

The highest ammonium concentrations in 2017, and previous years, were reported at sample points located to the east or south/southeast (down-gradient) of the bioremediation site, which may reflect the use of ammonia-based fertilisers during the bioremediation process. However, no upward trend has been identified in the data (Figure 6.3.2.4).

The maximum ammonium concentration in 2017 (30.79mg.l^{-1}) was recorded during the second round at NSB04 located east of the new bioremediation site. Concentrations encountered within NSB04 during 2017 were similar to those recorded during 2016, but slightly lower than the historical maximum concentrations recorded on site (ammonium concentrations in SBH08 were 56mg.l^{-1} and 46mg.l^{-1} in 2009 and 2012 respectively).

While the ammonium distribution exhibits a possible link, the concentrations of nitrite and phosphorus in groundwater does not appear to be associated with site activities.

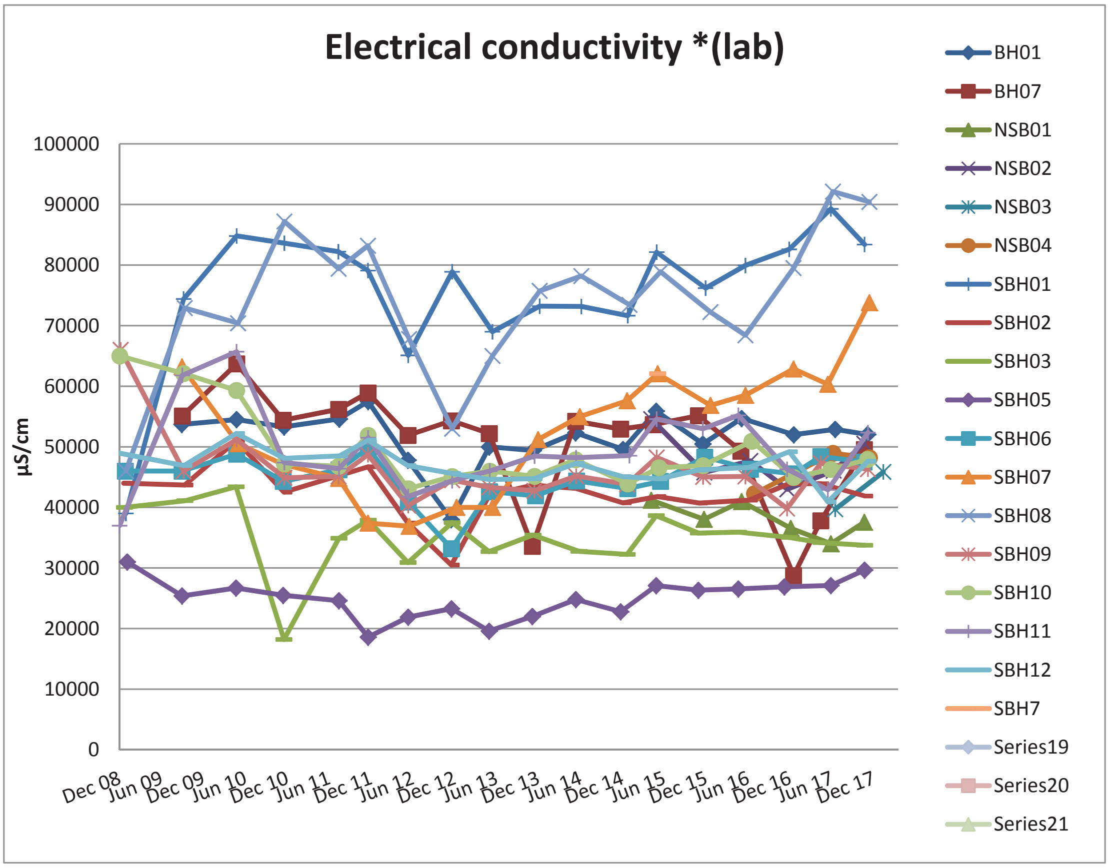


Figure 6.3.2.3 Groundwater electrical conductivity

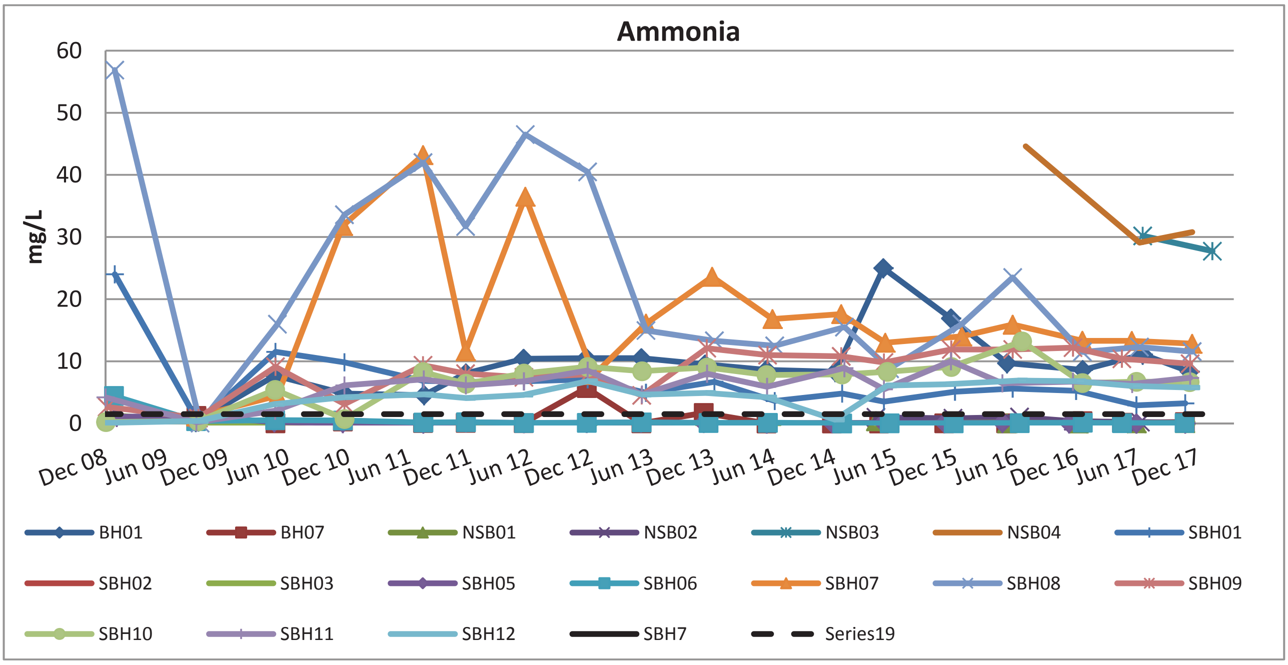


Figure 6.3.2.4 Ammonium concentration in groundwater

Cadmium in 2017 monitoring was detected above the conservative UK Freshwater EQS GAC of 0.08 µg.l-1 and the UK Coastal EQS GAC of 0.2 µg.l-1 in two locations in the first round (BH01 and SBH09) and five locations during the second round (BH01, BH07, SBH09, SBH08 and NSB03) (Figure 6.3.2.5). All results were below the UK drinking water standard of 5µg.l-1.

The maximum concentration of cadmium in 2017 was detected at SBH09 (during the second monitoring round), located south and therefore down-gradient of the new bioremediation site and ITD Area. This is consistent with previous monitoring rounds.

The current cadmium concentrations are within the range of baseline concentrations and, combined with the relatively low cadmium concentrations anticipated from leachate testing of drill cuttings, indicate that cadmium is not currently considered to pose a significant pollutant linkage.

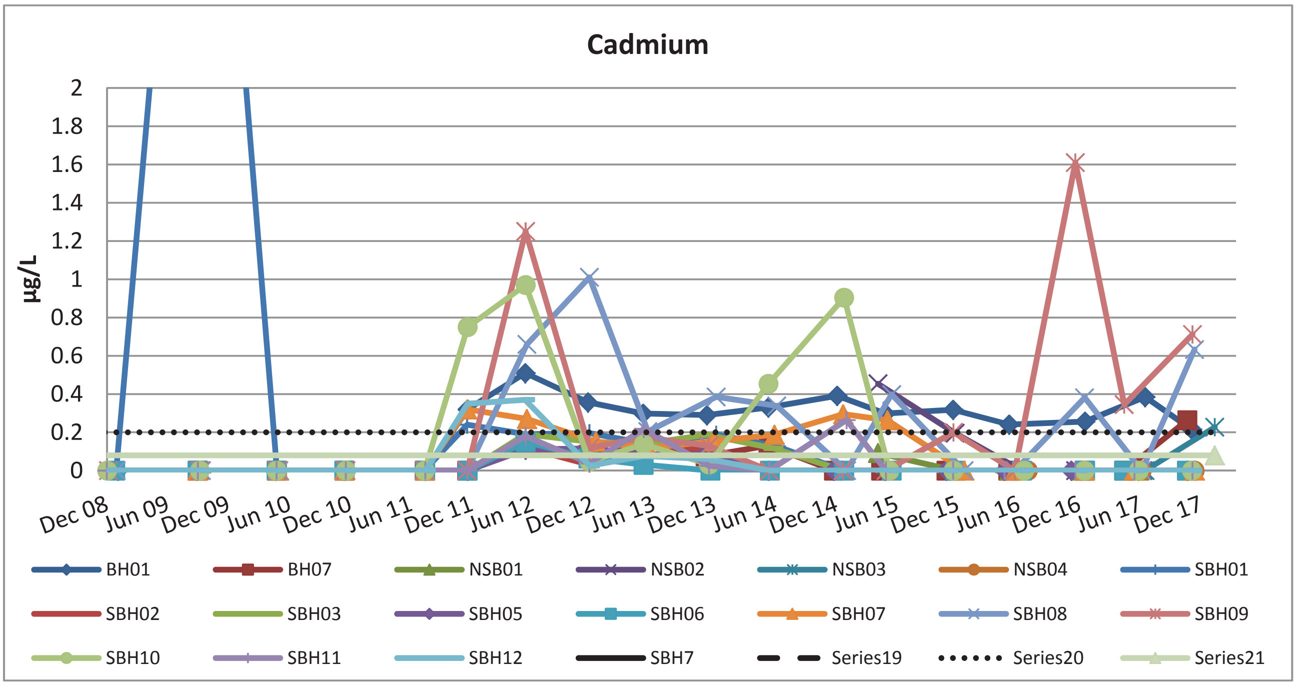


Figure 6.3.2.5 Cadmium concentration in groundwater

Copper concentrations have varied over the monitoring period, with sporadic high concentrations being recorded at some sites. Copper concentrations were high on the baseline survey and the levels present in ground water may be attributable to a combination of background concentrations and operational activities (such as leaching from drill cuttings).

Copper was detected above the UK Freshwater EQS GAC of 1 µg.l-1 at all locations during both monitoring rounds (Figure 6.3.2.6). Increases in concentrations were recorded during the second round at SBH01, SBH07, SBH08, BH01 and NSB04, with the maximum concentration to date being reported at SBH01 (41.9 µg.l-1) located to the east of the old bioremediation site. All copper concentrations have been below the UK DWS value of 2,000 µg.l-1.

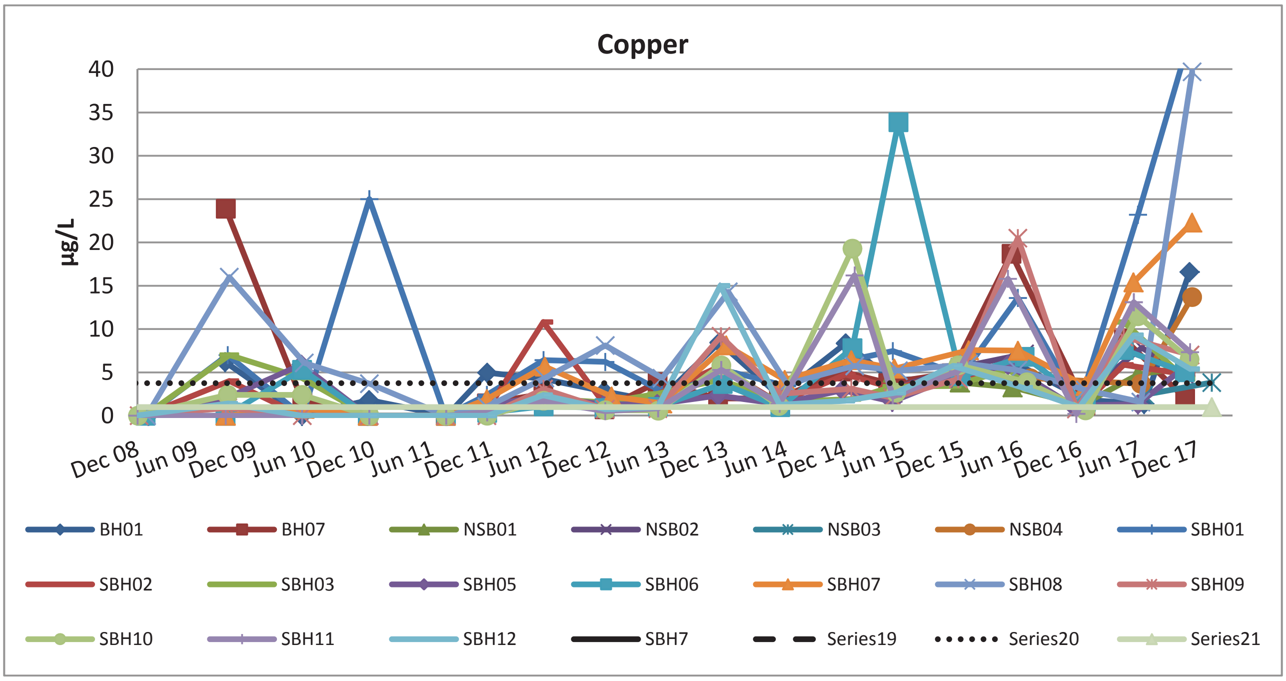


Figure 6.3.2.6 Copper (Cu) concentration in groundwater

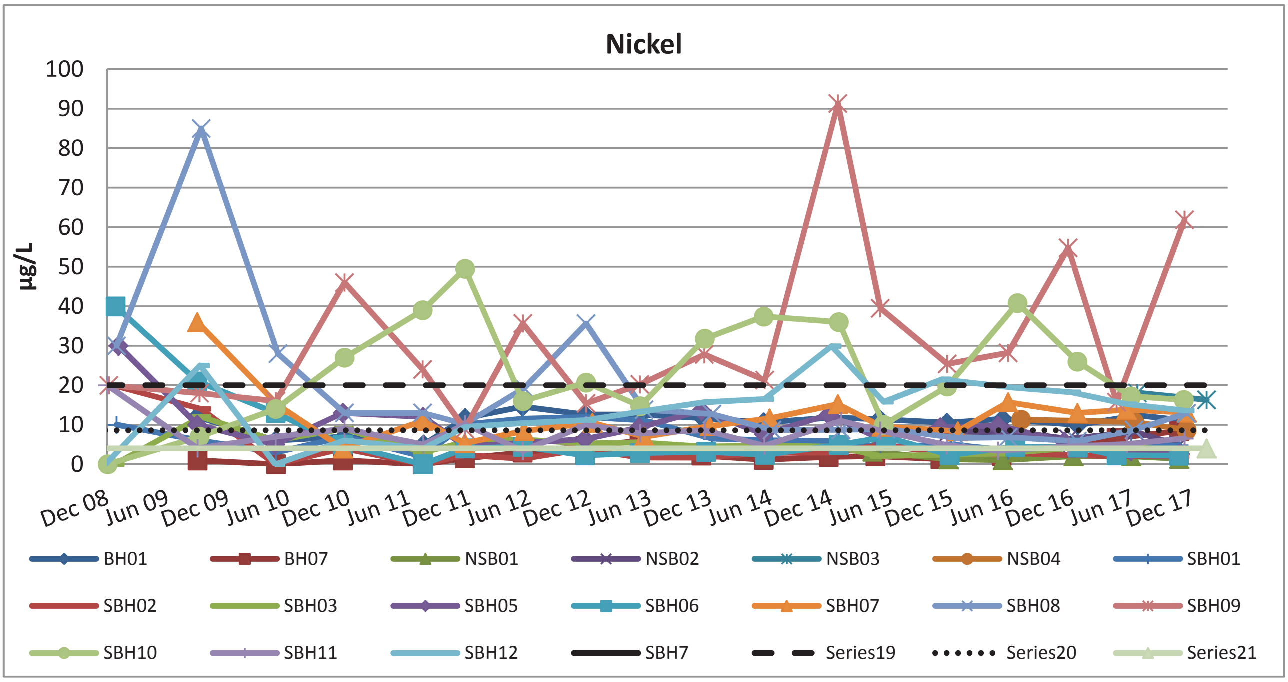


Figure 6.3.2.7 Nickel concentration in groundwater

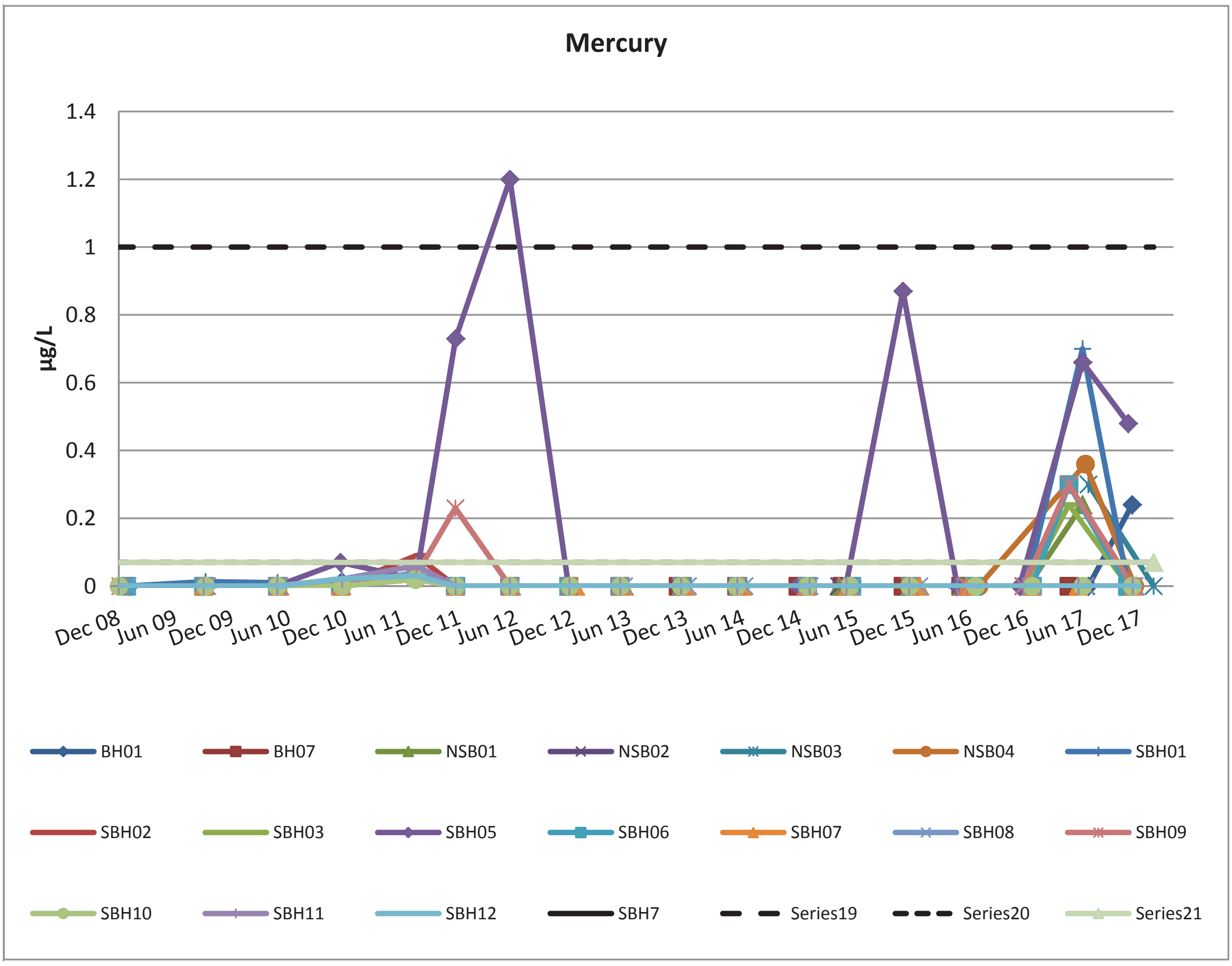


Figure 6.3.2.8 Mercury concentration in groundwater

In 2017, nickel was detected above the UK Freshwater EQS GAC of 4 µg.l^{-1} at thirteen of the seventeen locations in the first round and at twelve of seventeen locations in the second round (Figure 6.3.2.7). The maximum concentration was detected at SBH09, south of the ITD area, where the highest result was also recorded in 2015 and 2016. Concentrations show a decreasing trend in almost all wells with the exception of SBH09, which showed an increase in nickel concentration between the first and second round from 15.7 µg.l^{-1} to 61.9 µg.l^{-1}. This increase continues the trend of large fluctuations in nickel concentration at SBH09, but remains below the recent historical high of 91.3 µg.l^{-1} recorded in January 2015.

Leachate testing of drill cuttings indicated that nickel was one of the most leachable metals indicating a potential on-site source. Baseline concentrations for nickel at the site were reported ranging between 31.8 µg.l^{-1} to 56.5 µg.l^{-1} in 2001. Only the results from SBH09 in 2015, 2016 and 2017, and from SBH08 in 2009, have exceeded the baseline maximum.

In 2017, mercury was detected above the laboratory method detection limit in nine locations during the first round and at two locations during the second round (Figure 6.3.2.8). All concentrations are within one order of magnitude of the method detection limit (MDL) and the UK EQS GACs. Mercury was not recorded above the MDL in any location during 2016, however concentrations up to 0.87 µg/l were recorded in 2015.

Mercury was not detected (<0.1 µg.l^{-1}) during baseline groundwater monitoring in 1998 and 2001. Mercury was also not detected during leachate testing of drill cuttings, so is not currently considered to pose a significant pollutant linkage.

As the higher concentrations in 2017 samples were recorded from stations both up-gradient and down-gradient from the facility, no direct association can be made with operations at the site. Further monitoring of mercury during 2018 will provide further information on any possible increase in concentrations over time, or a link to on-site operations.

Lead concentrations in 2017 exceeded the UK Freshwater EQS GAC of 1.2 µg.l^{-1} in the majority of locations during the first round (14 of 17), but this reduced to 5 of 17 during the second round (Figure 6.3.2.9). Fluctuations in lead concentrations have been observed regularly over previous monitoring rounds.

The maximum lead concentration recorded during 2017 was 10.5 µg.l^{-1} at SBH08 (located east of the ITD area) which marginally exceeded the UK drinking water standard

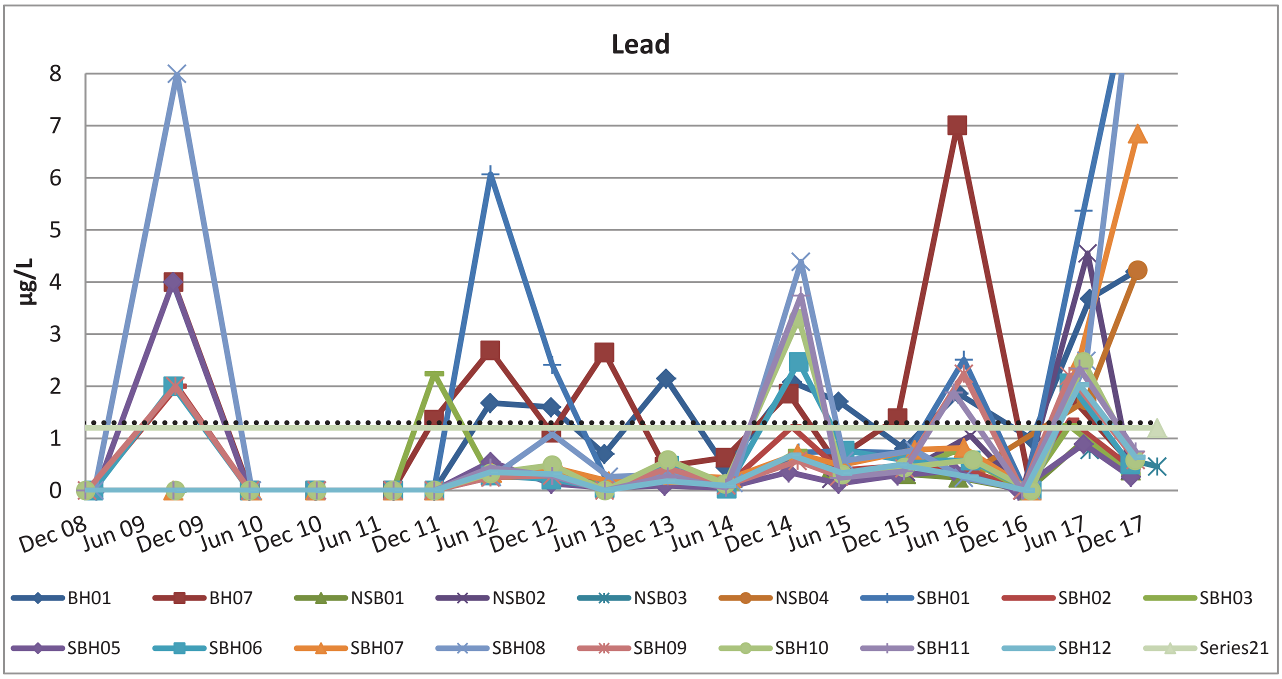


Figure 6.3.2.9 Lead concentration in groundwater

of 10µg.l^{-1}. Future monitoring will determine whether concentrations at SBH08 and SBH01, where the second highest concentration was recorded, return to previous levels at these locations.

The baseline concentration of lead at the site was reported to be <30 µg.l^{-1} in 1998 and up to 319 µg.l^{-1} in 2001, which reflects a significant regional contribution for this metal.

As observed on previous years, benzene, ethylbenzene and xylenes were not detected in any samples during both rounds of monitoring in 2017. tolueneToluene was reported above the MDL on one occasion during the first round at BH07, and at nine locations on the second round; BH07, SBH01, SBH02, SBH03, SBH05, SBH06, NSB01, NSB02 and NSB03. The concentrations reported were all well below the UK Freshwater and Coastal EQS GAC of 74 µg.l^{-1} and the WHO DWG of 700 µg.l^{-1} for this compound.

The 2017 first and second round maximum TPH concentrations of 53 µg.l^{-1} and 228 µg.l^{-1} were detected at BH01 south of the old bioremediation site. Fluctuations in concentration observed between the two monitoring rounds in 2017 are consistent with the general fluctuations in TPH observed since monitoring began in 2011 (Figure 6.3.2.10).

Baseline concentrations of TPH at the site ranged between <10 to 31.1 µg.l^{-1}. Where detected, the baseline TPH may be attributable to the presence of the former oil wells located up-gradient of the site. TPH concentrations have generally oscillated within a similar order of magnitude since 2011. The November 2017 concentration at BH1 is however the highest recorded in this location and the second highest recorded across the site since monitoring commenced in 2011.

PAH concentrations were below the MDL of 0.01µg.l^{-1} in all samples in 2017 with the exception of BH01 during the first and second rounds (0.01 and 0.02µg.l^{-1}), and at NSB03 during the second round (0.0102µg.l^{-1}), the concentrations of each individual PAH were below their respective GACs.

The UK Freshwater and Coastal EQS GAC for phenol for the protection of surface water quality is 7.7 µg.l^{-1}. The GAC was not exceeded at any location during the 2017 and 2016 monitoring events, which is a reduction from the 2015 monitoring where one exceedance was reported.

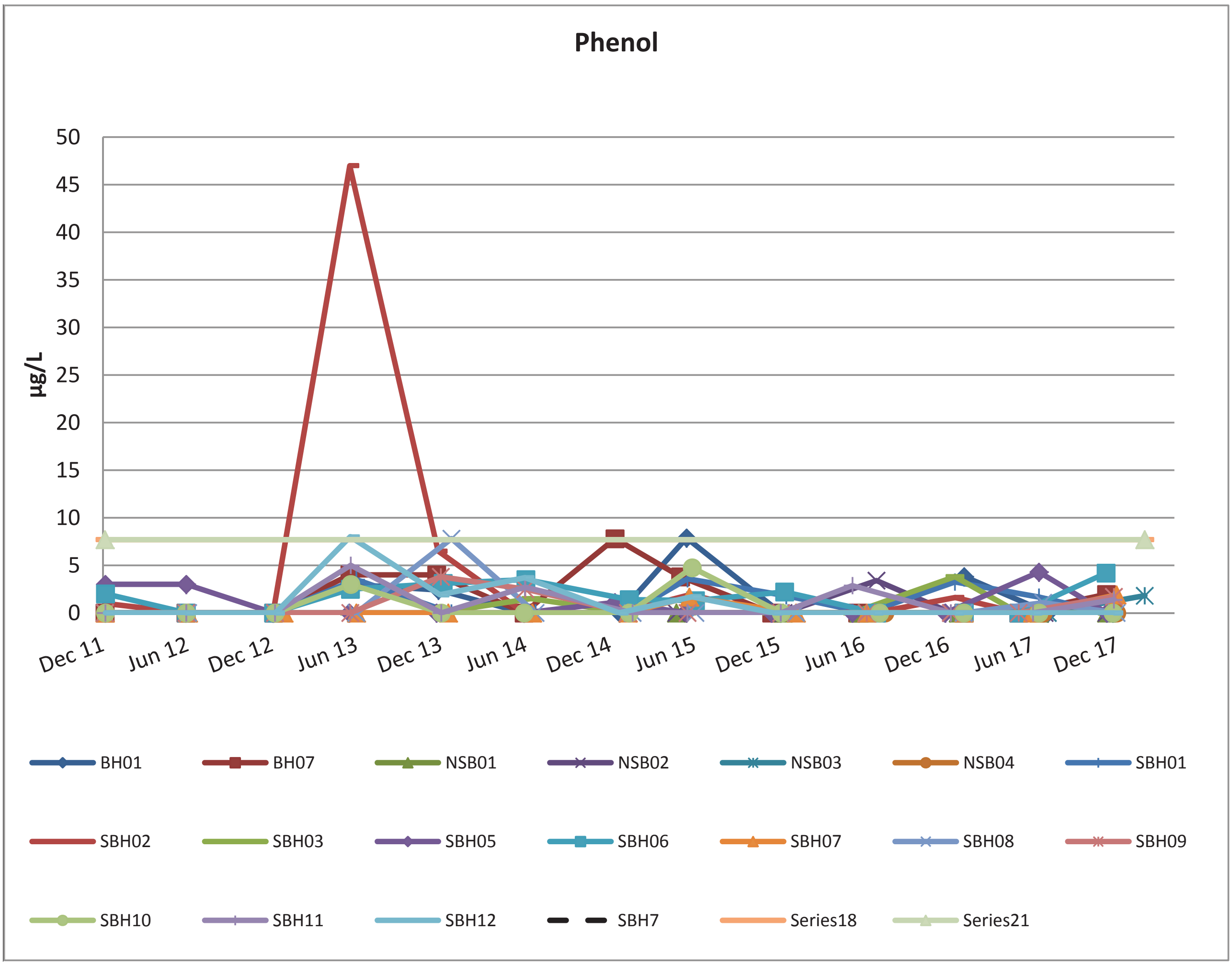


Figure 6.3.2.11 Phenol concentrations in groundwater

In general there has been very little variability in phenol concentrations over the monitoring period (Figure 6.3.2.11).

The highest phenol concentration of 47 µg.l^{-1} was detected in May 2013 at SBH2, located south of the Bioremediation site. This was an isolated observation, with the concentration reducing to 6.5µg.l^{-1} in December 2013 and remaining within the GAC on all following surveys.

A risk evaluation is carried out using a Conceptual Site Model (CSM) which shows the possible relationship between contaminants, pathways and receptors. In order to demonstrate that a risk to a receptor may exist, it must be shown that each of the three components of a potential pollutant linkage (PPL) are present:

- A contaminant source – defined as a substance which is in, on or under the land and which has the potential to cause harm or to cause pollution of controlled waters;
- A receptor – generically defined as either controlled waters, humans, ecological systems or property (including domestic animals and buildings); and
- A pathway between the source and the receptor – one or more routes or means by, or through which, a receptor can be exposed to, or affected by, a contaminant.

Potential exposure and migration pathways associated with groundwater at Serenja HWMF that have the potential to link the sources and receptors (i.e. Potential Pollutant Linkages - PPLs) are presented in Table 6.3.2.1. PPLs that can be assessed (in whole or in part) through the collection of groundwater quality data are indicated in bold.

Table 6.3.2.1 Potential exposure and migration pathways

Human Health	Controlled Waters	Property
Soil and dust ingestion. Dust inhalation. Dermal contact with soil and dust. **Vapour inhalation (indoor and outdoor).** **Migration of vapours along backfill around service pipes and through permeable strata.**	**Leaching from soil due to infiltrating precipitation / surface water.** **Vertical migration through the unsaturated zone to the saturated zone.** **Lateral migration in groundwater.** Downstream migration of dissolved phase contamination in surface water.	**Permeation of water supply pipes.**

No compounds have been detected in groundwater during monitoring completed in 2017 at concentrations exceeding human health commercial GAC, based on a vapour intrusion pathway.

On the basis of salinity across the site, it is unlikely that the groundwater within the superficial deposits would provide a viable resource for potable, irrigation or stock watering use. Hence, it is unlikely that there is a pollutant linkage present with respect to groundwater use; and therefore, it is considered that groundwater is unlikely to impact on human health. Metals have not been screened against human health commercial GAC as there is no exposure pathway considered to be present.

No volatile hydrocarbons (BTEX) have been identified in groundwater, with the exception of traces of toluene within various locations. As such, no risk from vapour intrusion / vapour migration along service trenches from a groundwater source has been identified.

In terms of the potential impact on surface water quality and aquatic ecosystems, the following compounds have been detected in groundwater during monitoring completed in 2017 at concentrations exceeding GAC for the protection of aquatic ecosystems and with a distribution and/or on-site leachable source that indicates a potential contribution from site activities:

- Ammonium
- Metals; Cd, Cu, Ni, Hg, Pb
- BOD (marginal exceedance and inconsistent between monitoring rounds).

Whilst the drill cuttings provide a potential leachable source of both copper and nickel (which both exceed GAC for the protection of aquatic ecosystems), when the distributions and/or baseline concentrations of copper, nickel and cadmium are taken into account, it is considered that the concentrations present in ground water are generally representative of the regional groundwater quality. It is worth noting however, that the highest Ninickel and cadmium concentrations in 2017 were recorded in samples collected from SBH09, directly to the south of the ITD area, which may indicate a link with on-site operations.

As the higher mercury concentrations recorded in 2017 samples were recorded from stations both up-gradient and down-gradient from the facility, no direct association can be made with operations at the site. Monitoring of mercury in the following surveys will provide information on any possible increase in concentrations over time and possible links to on-site operations.

While GAC exceedances in the concentration of lead have been inconstant over the monitoring period, the highest concentrations recorded in 2017 were in samples collected from sites to the east and south of the facility. Further monitoring will be required to establish a link with on-site operations.

BOD exceedances of the GAC are relatively low and inconsistent between monitoring rounds.

Ammonium was detected above the UK Coastal EQS GAC in boreholes located to the east or south/southeast (down-gradient) of the bioremediation site and may reflect the use of ammonia-based fertilisers during the bioremediation process. The current maximum recorded concentration was at well NSB04, located east of the new bioremediation site. However, the concentration recorded is lower than the historical maximum recorded on site. Ongoing monitoring will allow for an assessment of the significance of the 2017 results from NSB04.

The closest watercourse, passing between the site and the escarpment to the east, is ephemeral and is reported to carry water a few times a year for a few days after very heavy rain. The compounds present in groundwater at the site are unlikely to interact with this ephemeral watercourse and affect surface water quality.

Based on the depth to groundwater and the concentrations of compounds detected in groundwater, there is not considered to be a viable pathway for groundwater permeation of water supply pipes.

Based on the results of current monitoring, historical baseline data and leachate testing; arsenic, chromium, iron and zinc are not currently considered to pose a significant pollutant linkage to operations at Serenja HWMF.

BTEX, PAH and phenol concentrations are low, and generally below the method detection limit. TPH levels have fluctuated over the monitoring period, but are generally consistent with background levels and are not considered to be associated with the HWMF operations.

With the exception of ammonium and possibly copper, nickel and cadmium there is no evidence to link the operations at Serenja HWMF with the concentrations of the tested parameters within the surrounding groundwater.

No exposure pathways were identified in relation to human health or property and it is unlikely that the groundwater at the site will interact with the nearest watercourse and affect surface water quality.

6.3.3. Serenja HWMF soil & vegetation monitoring

Biannual (spring & autumn) soil and vegetation (S&V) surveys around the Serenja HWMF commenced in autumn 2016.

The objective of this monitoring is to provide an assessment of ecosystem stability and soil chemistry through the interpretation of vegetation and soil monitoring data at the HWMF and in particular to identify any changes or trends. The overall aim of the monitoring is to provide assurance to BP that waste management activities at the HWMF are not affecting local ecological resources.

The S&V monitoring focusses on the collection of ecosystem stability indicators. The indicators, listed below, were selected to provide an early indication of ecosystem change when compared with annual and time series data.

- Indicator 1: Bare soil cover - bare soil areas are more prone to erosion.
- Indicator 2: Vegetation cover.
- Indicator 3: Soil stability.
- Indicator 4: Microbiotic crust cover - crust organisms contribute to increased soil stability where they occur.

At each monitoring point measurements of each indicator were taken along 3 x 100m transects. A map showing the position of the eleven monitoring points is provided in Figure 6.3.3.1. Photographic records are included to provide a visual record during each monitoring survey. An example of a photo point image taken during the 2017 spring survey showing a survey transect is provided in Figure 6.3.3.2.

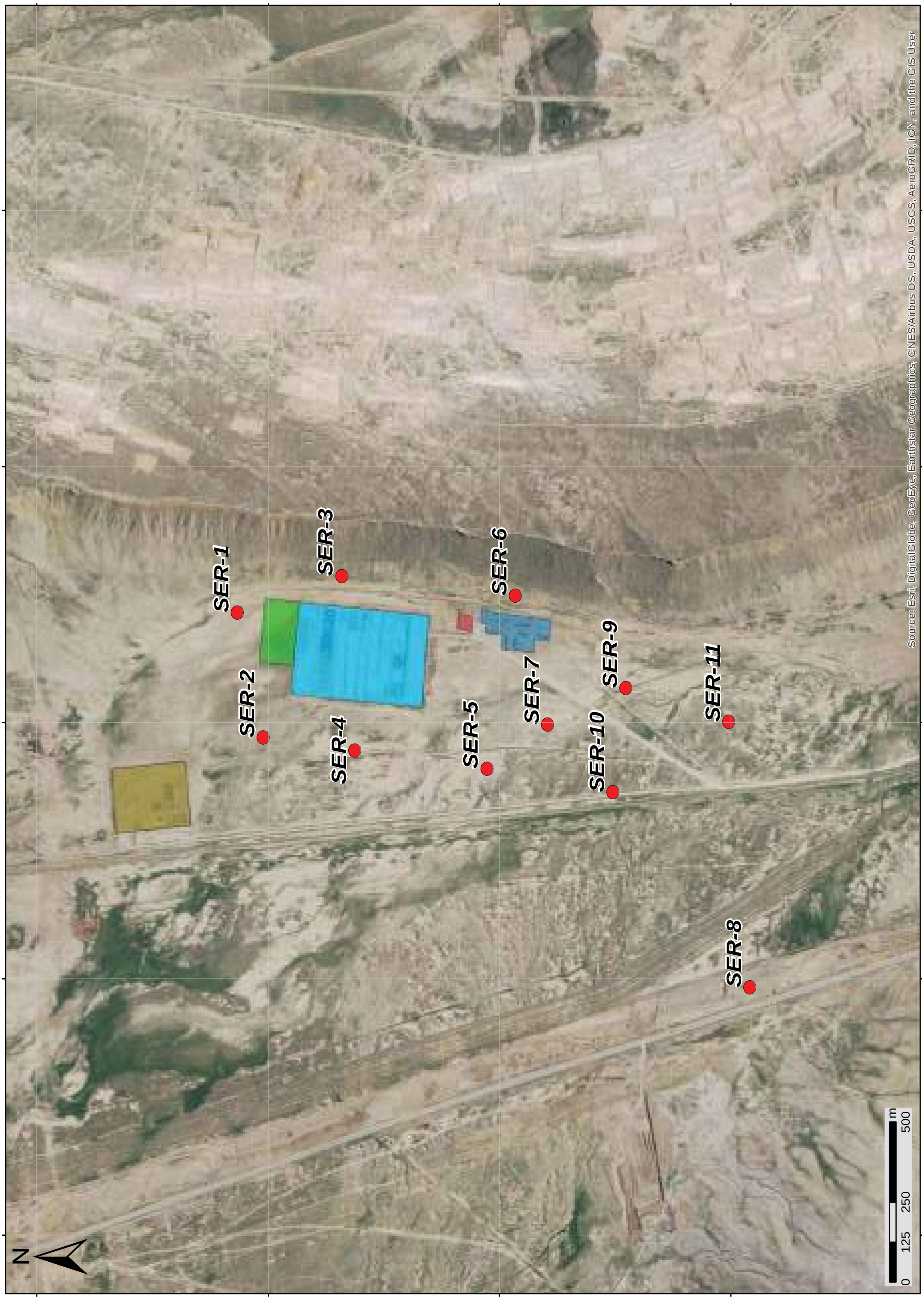


Figure 6.3.3.1 Soil and vegetation monitoring locations around the Serenja HWMF

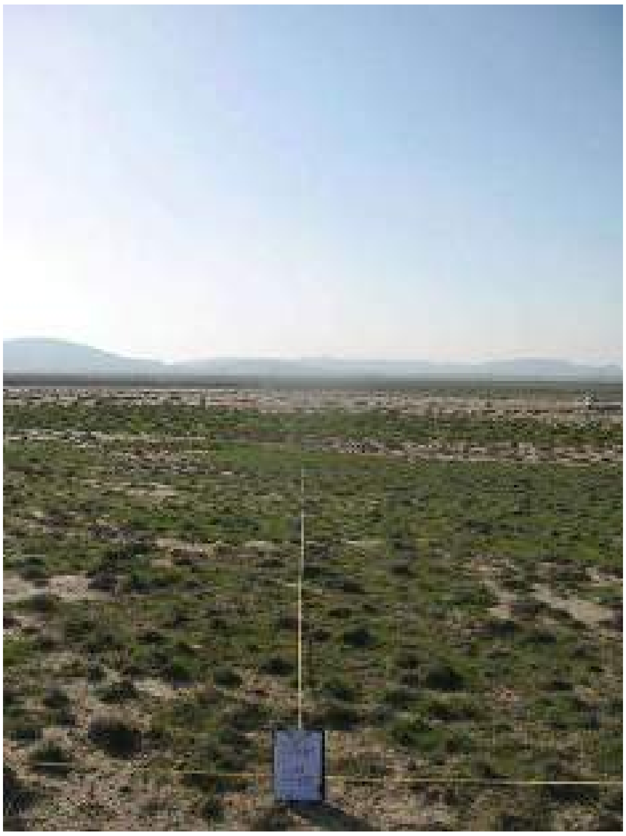


Figure 6.3.3.2 Example photo point image - spring 2017 (SER1)

Table 6.3.3.1 gives the percentage cover comparison between bare soil and vegetation for 2016 and 2017 and the average change (Δ) between the autumn surveys over the two years.

Between spring and autumn 2017, the average bare soil cover was 63% and 68% respectively. Grass cover varied from 22% to 18%. Shrub cover was 14% and 12% respectively, and forb cover was 1.5% during spring and 1.7% in autumn.

The results indicate an increase in bare ground in the 2017 autumn survey (68%) compared to the 2016 survey (56%), and a corresponding decrease in both shrub and grass cover. Only forb cover, which was low in both surveys, remained the same.

Increases and decreases of bare ground away from typical cover values are likely to relate directly to rainfall levels in the season immediately preceding monitoring. The corresponding decrease in shrub and grass cover in autumn 2017 relative to autumn 2016 is potentially a function of the low rainfall in the spring of 2017 which would have reduced vegetation growth late in the season.

At this stage it is not possible to infer any long term trends given that this is the first two years of vegetation monitoring at this site. It is possible that the observed changes reflect prevailing climatic regimes over the short-term and it may not be a permanent change.

Table 6.3.3.1 Percentage cover of bare soil and vegetation (2016-2017)

	Spring average % cover				Autumn average % cover			
Year	Bare	Shrub	Grass	Forb	Bare	Shrub	Grass	Forb
2016	No data				56	24	18	1.7
2017	63	22	14	1.5	68	18	12	1.7
Average Δ 2016-2017	Insufficient data				12.4	-6.2	-6.2	0.0

Table 6.3.3.2 provides the patch size data for bare soil, shrub, grass and forb for autumn 2016 and spring and autumn 2017.

The average size of bare soil patches dominated during both the 2017 spring and autumn surveys, and also the 2016 autumn survey, when compared to the patch sizes of vegetation types. The vegetation patches (based on 2017 autumn data), were collectively approximately half the size of the bare soil patches.

The average changes in patch size (Δ) between autumn 2016 and 2017 show an increase in the cover of bare ground, and a reduction in the cover of grasses, while more modest differences were recorded for shrubs and forbs.

Table 6.3.3.2 Bare soil and vegetation patch sizes for spring and autumn (2016-2017)

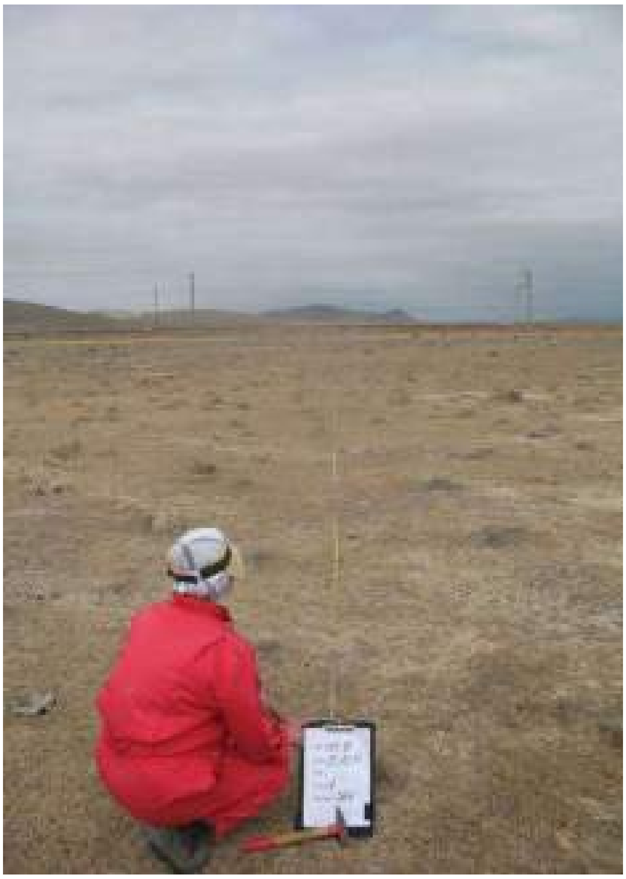
	Spring mean size (cm)				Autumn mean size (cm)			
	Bare	**Shrub**	**Grass**	**Forb**	**Bare**	**Shrub**	**Grass**	**Forb**
2016	No data				251.2	63.5	77.0	25.3
2017	276.2	55.9	69.2	28.2	287.8	60.7	51.8	26.2
Average Δ 2010-2017	Insufficient data				36.6	-2.8	-25.2	0.9

The soil stability* data were summarised on the basis of the presence or absence of a plant canopy, with soil supporting vegetation considered to be "protected", and soil with no plant canopy considered to be "unprotected".

Table 6.3.3.3 below presents mean soil stability values for protected and unprotected soils at the soil surface and subsurface for autumn 2016 and spring and autumn 2017. In the 2016 and 2017 data both the surface and sub-surface protected soils exhibited a greater stability than the unprotected soils, indicating that both soil structure and vegetative cover are important in maintaining soil stability and reducing erosion.

On all three surveys surface soils were more stable than sub-surface soils, irrespective of canopy cover.

There was little change in soil stability values over the two survey years 2016 and 2017. However, as the proportion of unprotected, bare soils was higher in the 2017 surveys, the soil stability of the surface and sub-surface soil, in general, will likely have decreased on the site.



* A higher soil stability value indicates that the soil is more stable, and therefore more resistant to erosion by wind and water.

Table 6.3.3.3 Soil stability for protected and unprotected soils at surface and sub-surface (2016-2017)

	Spring							Autumn						
	Surface		**Sub-surface		Total site* (Soil)			Surface		**Sub-surface		Total site* (soil)		
Year	Protected	Unprotected	Protected	Unprotected	Surface	Sub-surface	Mean	Protected	Unprotected	Protected	Unprotected	Surface	Sub-surface	Mean
2016	No data		No data		No data			5.1	1.2	3.8	1.0	3.8	2.9	3.3
2017	4.98	1.06	3.64	1.06	3.68	2.78	3.23	4.56	1.06	3.21	1.00	3.39	2.47	2.93
Δ 2016-17	n/a	n/a	n/a	n/a	n/a	n/a	n/a	-0.52	-0.15	-0.59	-0.03	-0.38	-0.39	-0.39

*Total site refers to surface and sub-surface soils
**Sub-surface: 3-4cm below the surface.

Table 6.3.3.4 presents the microbiotic crust cover ratio against bare soil, shrubs, grass/forbs, as well as the mean under these 3 conditions for autumn 2016 and spring and autumn 2017.

Microbiotic crust cover was highest in areas with grass/forb cover, while the lowest crust cover was recorded on areas of bare ground.

The autumn results recorded in 2016 and 2017 were very similar. While crust cover in spring and autumn on bare ground and shrub covered ground were similar, a higher crust cover was recorded in grass/forb covered ground in the autumn data.

Table 6.3.3.4 Crust cover ratio for bare soil and vegetation in spring and autumn (2016-2017)

Year	Spring				Autumn			
	Bare	Shrub	Grass/ Forb	Mean	Bare	Shrub	Grass/ Forb	Mean
2016	No data				0.017	0.030	0.049	0.032
2017	0.023	0.028	0.031	0.027	0.021	0.028	0.049	0.033
Δ 2016-17	n/a	n/a	n/a	n/a	0.004	-0.002	0.000	0.001

The aim in measuring the 4 indicators has been to establish a composite index from which an early indication of ecosystem change can be determined. To determine the status at each sample point, each of the 4 indicators are considered together and the status is categorised into 'very good', 'good', 'threatened', or 'deteriorated' (see explanation in methods section 6.1.1.1). Table 6.3.3.5 gives the sample sites in each category for spring and autumn 2017, and indicates that the majority of sites were categorised as being good or deteriorated in spring and threatened or deteriorated in autumn.

Table 6.3.3.5 Sample sites in each Ecosystem Condition Category (ECC) 2017

	Spring	Autumn
Very Good		SER-10
Good	SER-3, SER-6, SER-7, SER-10	SER-3, SER-7
Threatened	SER-1, SER-2	SER-1, SER-5, SER-6
Deteriorated	SER-4, SER-5, SER-8, SER-9, SER-11	SER-2, SER-4, SER-8, SER-9, SER-11

The average ecosystem condition value for each indicator, and the average condition category across the survey area, are provided for autumn 2016 and spring and autumn 2017 in Table 6.3.3.6. The classification of the site was 'threatened' for all three surveys.

The slightly higher total ECV value in autumn 2017 compared to autumn 2016, indicates that the overall condition was slightly poorer in autumn 2017 data. As only two years of data is available, it is not possible to indicate if this deteriorating condition is a trend or simply natural inter-annual variability in these indices, further years monitoring data are required.

Table 6.3.3.6 Survey average Ecosystem Condition Values (ECV) & Ecosystem Condition Category (ECC) 2016-2017

Year	ECV means				ECV value	ECC
	Bpi	Vpi	SS	CCr	Total	
Spring						
2017	2.64	3.27	2.45	3.36	11.73	Threatened
2016	No data					
Autumn						
2017	3.00	3.36	2.55	3.36	12.27	Threatened
2016	2.36	3.18	2.36	3.45	11.36	Threatened
Mean						
2017	2.82	3.32	2.50	3.36	12.00	Threatened
2016	Insufficient data					
Note - ECV total values are taken to the nearest full integer in order to create an ECC rating.						

In addition to the measurement of ecosystem stability indicators, the 2017 survey included a soil survey. Samples were collected from the eleven monitoring locations from two depths: surface 0-5cm, and sub-surface 10-20cm.

The following chemical analysis was undertaken for the soil samples:

- Bulk density;
- Soil water content;
- pH;
- Organic matter (humus) content;
- Total nitrogen and gross phosphorus content;
- Composition of water-soluble salts (HCO_3^-, CO_3^{2-}, Cl^-, SO_4^{2-}, Ca^{2+}, Mg^{2+}, Na^+, K^+);
- Composition of absorbed bases leached by ammonium acetate (Ca^{2+}, Mg^{2+}, Na^+, K^+);
- Total hydrocarbons (petroleum products) content; and
- Heavy metals (As, Cd, Co, Cu, Sb, Mo, Hg, Ni, Pb, V, Zn, Sn) content.

Overall the samples from the site were characterised by limited humus and moisture content characteristic of semi-desert soils, which may explain the low vegetation cover within the study area.

All but two stations had characteristic chloride-sulphate (sodic) saline soils, with the exception of SER10 and SER11 which had a higher HCO_3 content. No traces of accumulations of mineral oils or heavy metals were recorded - concentrations were within the regional ranges in the Absheron Peninsulapeninsula.

Sodic (saline) soils tend to occur within arid to semi-arid regions and are innately unstable, exhibiting poor physical and chemical properties, which impede water infiltration, water availability, and ultimately plant growth.

As only two years of monitoring data are available it is not possible, at this stage, to infer any long term trends in vegetation cover and soil stability. Overall the results were characteristic of the surrounding area, and there was no contamination identified from operations at the site.

6.4. Azerbaijan Export Pipelines

BP is carrying out environmental monitoring to ensure that environmental impacts arising from the operations of the Baku-Tbilisi-Ceyhan Pipeline (BTC), Western Route Export Pipelines (WREP) and South Caucasus Pipeline (SCP) are clearly identified, and that they are managed and mitigated as effectively as possible.

6.4.1. Ambient air quality monitoring

Ambient air quality monitoring is carried out at pump stations located on the BTC and WREP pipeline routes. Sampling frequency and the parameters tested are provided in Table 6.4.1.1.

Table 6.4.1.1 BTC & WREP AAQ monitoring schedule & parameters

BTC AAQ monitoring		
Year	**Parameters**	**Frequency**
2005	NOx, SOx, Benzene, PM10	Annual
2006	NOx, SOx, Benzene, PM10	Annual
2007	NOx, SOx, Benzene	Bi-Annual
2008	NOx, SOx, Benzene	5 times per year
2009	NOx, SOx, Benzene	6 times per year
2010	NOx, SOx, Benzene	Annual
2011	NOx, SOx	Annual
2012 - 2017	NOx	Annual

WREP AAQ monitoring		
Year	**Parameters**	**Frequency**
2000	NOx, SOx, Benzene, PM10	Annual
2006	NOx, SOx, Benzene, PM10	Annual
2010	NOx, SOx, Benzene, PM10	Annual
2013	NOx, SOx	Annual
2017	NOx	Annual

Sampling on the BTC pipeline is currently carried out at five locations around the PSA2 station and camp (Pump Station Azerbaijan 2).

Figure 6.4.1.1 gives the NO_2 results at the BTC PSA2 AAQ monitoring stations for 2005-2017. The results at all sample sites on all years are well within the annual air quality standard of 40µg.m^{-3}. The highest concentrations were recorded in samples collected in 2006. From 2009 to 2013 there is a general reducing trend in the NO_2 concentration at all stations. From 2013 the concentration has been stable at ~5µg.m^{-3} at all sample points.

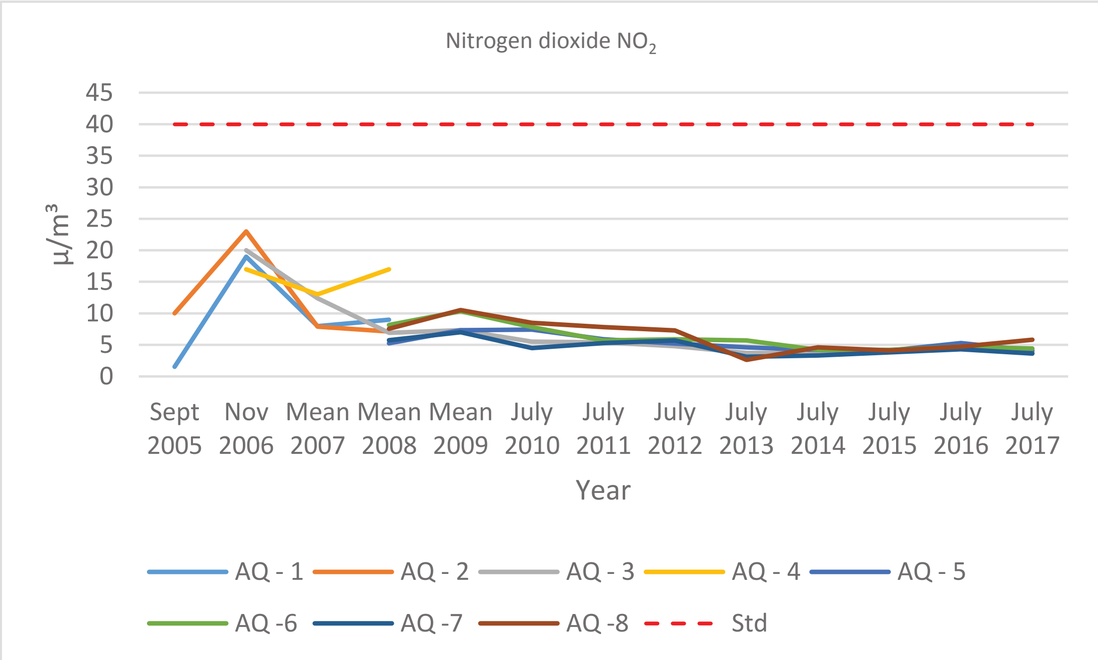


Figure 6.4.1.1 NO_2 concentrations at BTC PSA2 2005-2017

As a result of low concentrations being consistently recorded, and exceedances known to be unrelated to operations at PSA2, parameters; PM10, SO_2 and benzene have been removed from the scope during the monitoring period.

Benzene concentrations were below the annual air quality standard of 5µg.m^{-3} on all sampling rounds between 2005 and 2010 (Figure 6.4.1.2).

Particulate matter results were highest in the samples collected in 2006 (Figure 6.4.1.3). The high PM10 results above the standard concentration of 30 µg.m^{-3}, are from the pick-up and transportation of the fine dry dusty soils present in the area, and are not related to operations at the pump station.

Sulphur dioxide levels were above the annual air quality standard of 20µg.m^{-3} in one sample in 2007 and two samples in 2008 and 2010 (Figure 6.4.1.4).

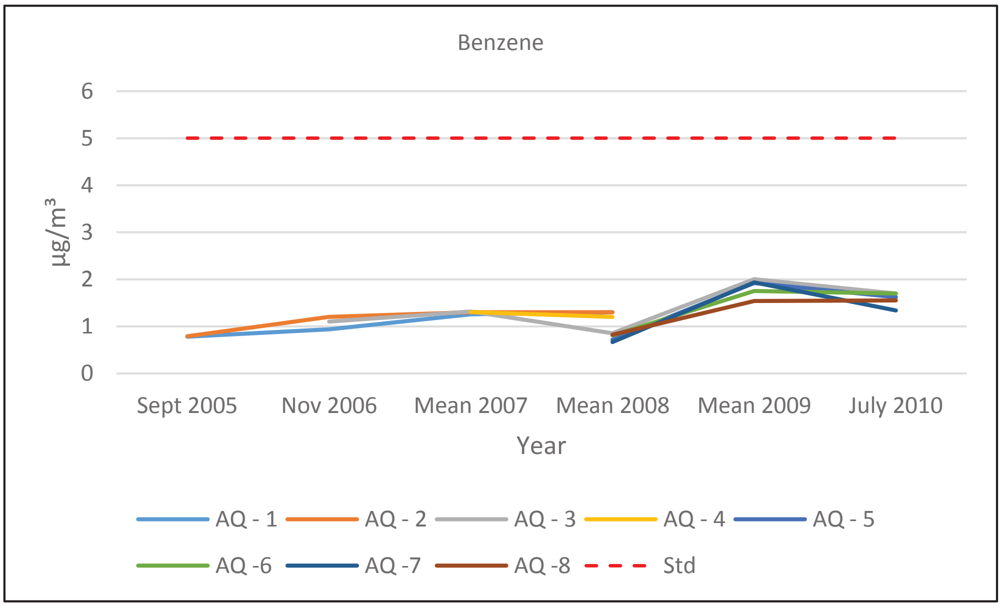


Figure 6.4.1.2 Benzene concentrations at BTC PSA2 2005-2010

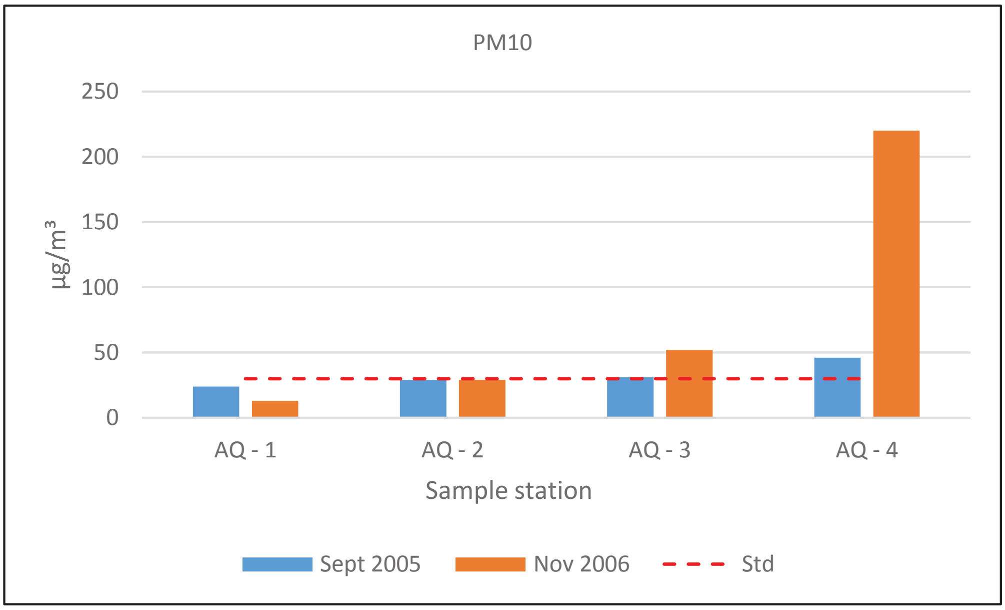


Figure 6.4.1.3 PM10 concentrations at BTC PSA2 2005 & 2006

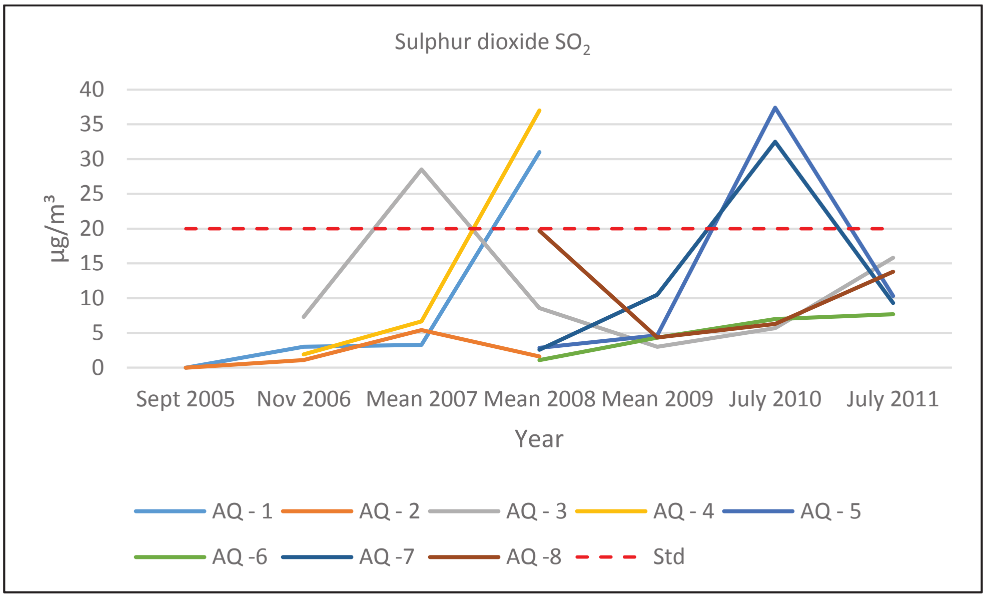


Figure 6.4.1.4 SO_2 concentrations at BTC PSA2 2005-2011

There is no legal requirement to carry out AAQM at WREP pump stations. However, BP conduct monitoring to ensure that operations at WREP pump stations are not impacting the surrounding air quality.

Sampling on the WREP is carried out at five locations around Pump Station 5 and Pump Station 8. Results are assessed using the BTC ESIA criteria. Over the monitoring period the only result to exceed the criteria was PM10 results at pump station 5 in 2010.

Overall, the monitoring results indicate that the WREP and BTC pump stations are not affecting the local air quality.

6.4.2. Ground & surface water quality monitoring

Ground water quality is monitored in samples collected from 10 wells located at the Karayazi Aquifer (Kar M1 – M10) in the Agstafa region, and from two monitoring wells near BTC PSA2 (Pump Station Azerbaijan 2).

Surface water samples are collected from two sampling points (one up stream and 1 downstream) on the canal at the PSA2 & IPA1 (Intermediate Pigging Station Azerbaijan 1) locations. Sampling frequency and the parameters tested are provided in Table 6.4.2.1 and Table 6.4.2.2

Table 6.4.2.1 BTC ground water monitoring schedule & parameters

BTC Ground Water Quality		
Year	**Parameters**	**Frequency**
2004	pH, DO, Conductivity, TPH	Bi-annual
2006	pH, DO, Conductivity / TPH / PAH /BTEX	Annual
2007	pH, DO, Conductivity/ TPH /PAH /BTEX	Bi-annual
2008 -2010	pH/DO/Conductivity/ TPH/PAH/BTEX/ TSS	Bi-annual
2011 -2015	pH/DO/Conductivity/TPH/PAH/BTEX	Bi-annual
2016	pH/Redox/Conductivity/TPH	Bi-annual
2017	pH/Redox/Conductivity/TPH	three times per year

Table 6.4.2.2 BTC surface water monitoring schedule & parameters

Year	**Parameters**	**Frequency**
2004	TCB/pH/COD/BOD/TSS/TN/TP/Heavy Metals/ O&G/ Cyanide	Annual
2005	TCB/pH/ COD/BOD/TSS/Cl/TN/TP/Heavy Metals/O&G/Cyanide	3 times per year
2006	TCB/pH/ COD/BOD/TN/TP/NH4/TPH/PAH/BTEX	Annual
2007-2010	TCB/pH/COD/BOD/TN/TP/NH4/TSS/TPH/PAH/BTEX	Bi-annual
2011 & 2012	pH/DO/Conductivity/TPH/PAH/BTEX	Bi-annual
2012	pH/DO/Conductivity/TPH/PAH/BTEX	Bi-annual
2013	TCB/pH/COD/BOD/Cl/TSS/TN/TP/Heavy Metals/ O&G/ Cyanide/Sulphides/ Fluorides/Phenols	four times per year
2014 & 2015	TCB/pH/COD/BOD/Cl/TSS/TN/TP/Heavy Metals/ O&G/ Cyanide/Sulphides / Fluorides/Phenols	Monthly
	DO/Conductivity/TPH/PAH/BTEX	Bi-annual
2016 & 2017	TCB/pH/COD/BOD/Cl/TSS/TN/TP/Heavy Metals/ O&G/ Cyanide/Sulphides/ Fluorides/Phenols	Monthly

BTEX - Benzene, Toluene, Ethylbenzene, xylenes
O&G - Oil & grease
TCB - Total coliform bacteria
TN - Total nitrogen
TSS - Total suspended solids
TP - Total phosphorus
TPH - Total petroleum hydrocarbons
PAH - Polycyclic aromatic hydrocarbons

The concentration of PAH and BTEX in ground water samples have been below the method detection limits at all sampling points on all sampling rounds. The only exception was a PAH concentration of 0.115µg/l at Kar M1 in October 2006.

Total hydrocarbon concentrations were recorded above the method detection limit in ground water samples on a small number of occasions (Figure 6.4.2.1). The detectable concentrations recorded in 2013 coincided with third party railway and road reconstruction activities, which were suspected to be the source of the detectable concentrations.

The reason for the detectable concentrations in samples from 5 wells in October 2006 is unknown, however, it is not expected to be associated with the operations at PSA2 and IPS1. The concentration at all sample points were below the MDL on the following sampling round.

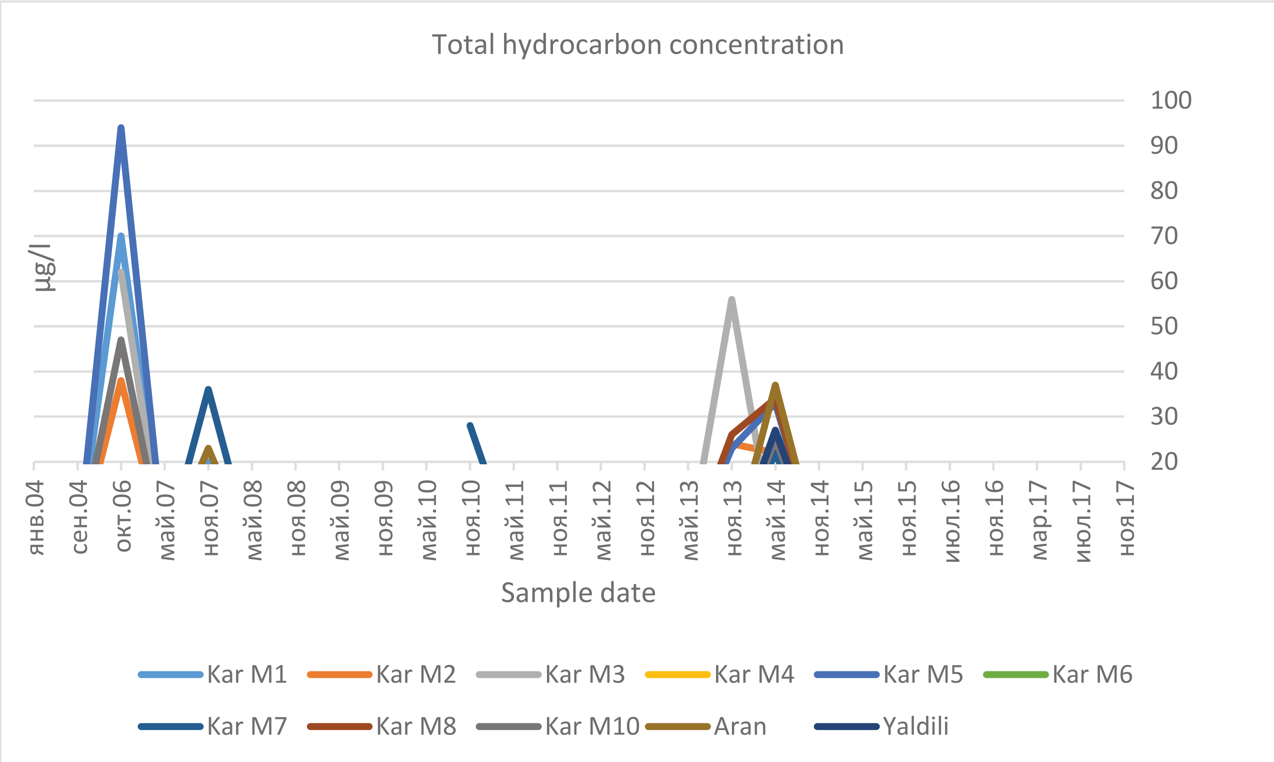


Figure 6.4.2.1 Total hydrocarbon concentrations in groundwater samples 2004 - 2017

From the results collected over the monitoring period, there has been no indication that surface and ground water quality has been affected by operations at PSA2 and IPS1 on the BTC pipeline. Results have been consistent with the pre-project baseline conditions and are compliant with the relevant standards.

6.4.3. Bio restoration (vegetation cover) survey

The aim of bio-restoration monitoring is to assess the extent to which vegetation on the pipeline Right Of Way (ROW) corresponds with vegetation in undisturbed adjacent areas – the effectiveness of bio-restoration to restore the original vegetation cover and composition to the state prior to the construction of the pipelines.

It is measured using two parameters; vegetation cover and species diversity. It is expected that recovery of vegetation cover is achieved more quickly than species-diversity recovery, as the ruderal plants that initially colonise the ROW are eventually followed by species characteristic of the surrounding areas vegetation.

Data has been collected from 55 transects along the Azerbaijan section of the BTC pipeline ROW from 2007 to 2017. Over the monitoring period, the majority of ROW transects (85%) have achieved vegetation cover targets based on the adjacent off-ROW cover in 2007; as per a commitment made in the project ESIA.

Vegetation cover data collected in 2017 indicated that 86% of the ROW transects sampled that year had achieved vegetation cover equal to or greater than the cover within the adjacent, undisturbed areas.

At the majority of transects, the vegetation cover on the ROW has shown an increasing growth trend over eleven years of monitoring. Six transects were reported as having particularly low rates of recovery in 2015. However, five of these six transects were reported to have increased vegetation cover in 2016.

The most recent results from bio-restoration monitoring carried out in 2017 show a continuation of the trend of increasing vegetation cover along the majority of the pipeline route ROW. The transects which were previously noted as potentially decreasing, have largely improved and have started to show an increasing trend in vegetation re-growth, some of which having reached off-ROW cover levels.

There are noticeable differences in establishment of vegetation cover between different habitats. The establishment of vegetation cover has been particularly slow in habitats where high temperatures, high soil salinity and high wind speeds prevail. It is likely that these factors have affected seedlings establishment and survival. Human activities, such as livestock grazing, also negatively affect the restoration of vegetation habitats.

Figures 6.4.3.1, 6.4.3.2 and 6.4.3.3 below, present the vegetation cover trend graphs for three different habitat types encountered along the pipeline route; ephemeral desert, *Salsoletum nodulosae* clayey desert and chal meadow. All three habitat types have observed an increase in the % vegetation cover on the ROW during the monitoring period.

The drop in % cover in 2009 off-RoW in ephemeral desert habitat was likely due to disturbance from vehicles. Vegetation cover on-RoW has shown a steady increase every year, with the exception of a decrease in 2014.

Salsoletum nodulosae clayey desert habitat is a moderately species-rich habitat characterised by a naturally high vegetation cover dominated by scattered low bushes. The vegetation recovery on-RoW is steadily increasing. The arid and compacted soils, and disturbance by livestock and vehicles are probably the main reasons for the low vegetation cover compared with off-RoW.

Chal Meadow is a species-poor habitat of damp meadow soils. The natural vegetation is characterised by a patchy grass with scattered plants. This is one of the few habitats to show a significant increase in species-commonality; in 2011 the RoW on two transects was virtually indistinguishable from the undisturbed vegetation in terms of species composition (although natural percentage cover has not yet been achieved).

Figure 6.4.3.1 Ephemeral desert habitat: vegetation cover trend graph

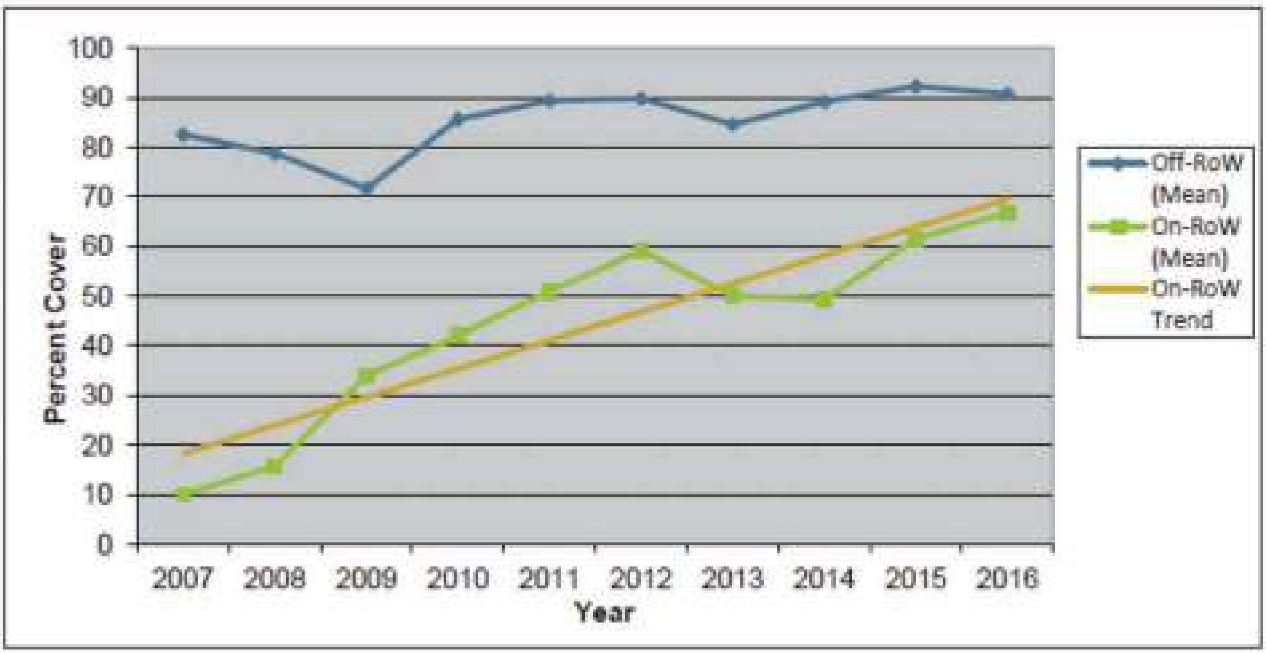


Figure 6.4.3.2 *Salsoletum nodulosae* **clayey desert habitat: vegetation cover trend graph**

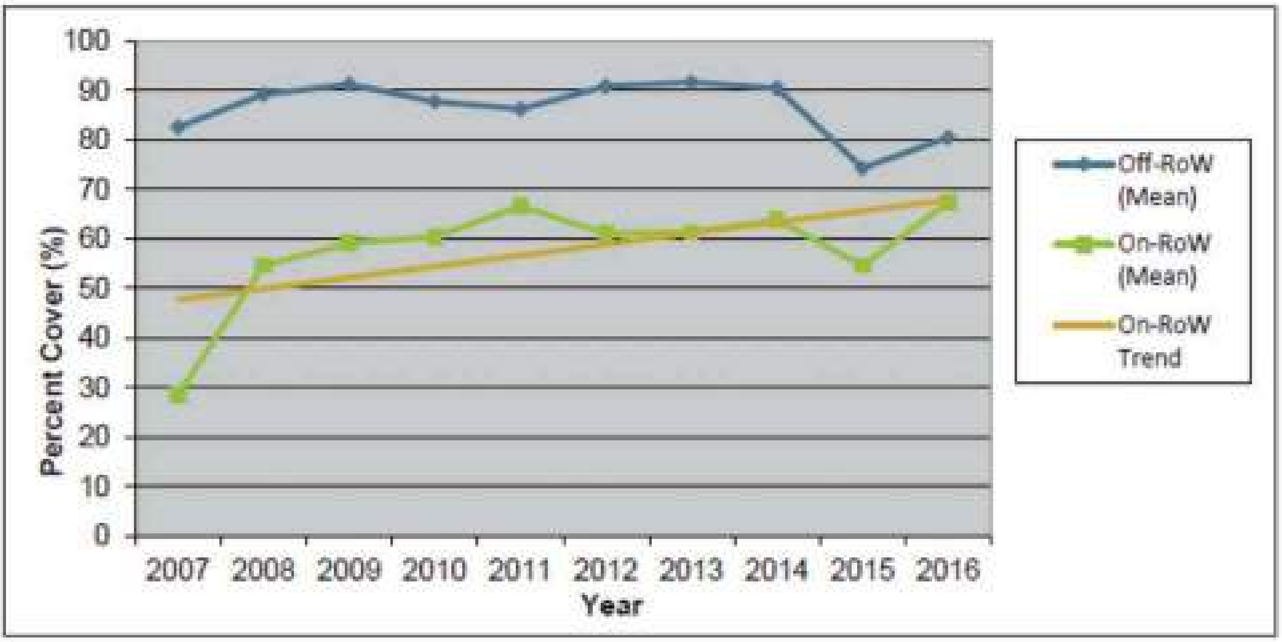


Figure 6.4.3.3 Chal Meadow habitat: vegetation cover trend graph

6.5. Onshore monitoring summary

Table 6.5.1 summarises the findings from monitoring surveys at each onshore operational site and highlights any observed trends and links to operational activities.

Table 6.5.1 Summary of monitoring surveys and identified trends at onshore locations

Sangachal Terminal	Status and identified trends
Ambient air quality	There was no evidence to indicate that operations at the terminal were having a negative effect on the surrounding air quality. While some exceedances of the relevant air quality standards have been recorded at stations adjacent to the terminal, these have been transient and localised. Although the recorded concentrations were low and within the national and EU standards, generally higher concentrations of nitrogen oxides were recorded at AAQ12, and relatively higher concentrations of TVOC were recorded at AAQ12 and AAQ20, located on the terminal boundary, which may be associated with on-site activities.
Ground and surface water quality	The higher concentrations of a number of parameters at sample points adjacent to the produced water ponds suggests that the ground water quality in these areas is being influenced by leaks of produced water. As the higher concentrations are not observed at stations outside and down-gradient of the Terminal, it appears that the contamination is limited to the area directly adjacent to the ponds, within the Terminal boundary.
Soil stability and vegetation cover	The ecosystem condition over the survey area has largely remained unchanged throughout the monitoring period. Shrub cover has increased, while grass and bare patch cover has remained stable and forb cover has largely been lost. The observed changes in shrub and forb cover are unrelated to operational activities at the terminal.
Faunal survey (excluding birds)	There is no evidence from the monitoring survey data that Sangachal Terminal operations are having a negative impact on the distribution of mammals or herpetofauna within the area surrounding the Terminal. With the exception of a general reduction in marsh frog presence between 2012 and 2015, which reversed in 2016, no overall trends have been identified in species presence and/or distribution.
Birds survey	Studies have shown that while the number of resident bird species has remained stable, the number of migratory species recorded in the area has fluctuated between surveys. Other than a localised decrease in diversity between 2011 and 2016 within the south-western sector of the survey area, which may be linked to construction activities at the Terminal, there was no evidence to indicate that the Terminal activities were negatively impacting bird populations within the wider survey area.
Wetlands	There is no indication from the surveys carried out that operations at Sangachal Terminal are impacting on the adjacent wetland habitats. Flora and fauna presence is relatively equal in areas close to and at distance from the Terminal. Although water chemistry results fluctuate between stations, there was no evidence to indicate that the variation was being influenced by Sangachal Terminal operations.

Serenja HWMF	Status and identified trends
Ambient air quality	With the exception of PM10 results; which were unrelated to operations at Serenja HWMF, the concentrations of all parameters at all stations have been within air quality standards. There was no evidence to link the concentrations of the measured parameters at off-site locations to operations at Serenja HWMF.
Ground and surface water quality	With the exception of isolated concentrations of ammonium and possibly copper cadmium and nickel, there is no evidence to link the operations at Serenja HWMF with the concentrations of the tested parameters within the surrounding groundwater. Concentrations of the measured parameters have either been within the previously reported background levels or have shown no association with the operations at Serenja.
Soil stability and vegetation cover	The ecosystem condition within the survey area was characteristic of the surrounding area. Bare patch was dominant over shrub, forb and grass cover. Soils were characterised by limited humus and moisture content typical of semi-desert soils, which may explain the low vegetation cover within the study area. No traces of accumulation of mineral oils or heavy metals were recorded; concentrations were within the regional background ranges in the Absheron Peninsula.

Aze Export PLs	Status and identified trends
Ambient air quality	Monitoring results indicate that pipeline pump stations are not affecting the local air quality. As a result of very low concentrations being consistently recorded, a number of parameters have been removed from the sampling scope.
Ground and surface water quality	There is no indication that surface and ground water quality has been affected by pipeline operations. Results have been consistent with the pre-project baseline conditions and compliant with the relevant standards.
Bio-restoration	There has been a continual trend of increasing plant growth and coverage within the ROW. Over the monitoring period, the majority of ROW transects (85%) have achieved ESIA vegetation cover targets.

6.6. Conclusions from onshore monitoring programme

A comprehensive monitoring programme has been implemented at Sangachal Terminal, monitoring impacts to air quality, ground and surface water quality, impacts to adjacent wetland habitats and the local populations of birds, and terrestrial fauna.

There was no evidence to indicate that operations at the terminal were having a negative effect on the surrounding air quality. While some exceedances of the relevant air quality standards have been recorded at stations directly adjacent to the terminal, these have been transient and localised.

Ground water monitoring over a number of years has detected the presence of a leak from the produced water evaporation ponds located within the terminal boundary. The leak has resulted in elevated concentrations of chloride, cadmium and iron and possible sporadic and/or isolated higher concentrations of other elements at sampling points adjacent to the produced water ponds. As the higher concentrations are not observed at stations outside and down-gradient of the terminal, it appears that the contamination is limited to the area directly adjacent to the ponds, within the terminal boundary, and poses no significant risk to the ground water quality within the wider area.

Surveys carried out to assess vegetation cover and soil stability in the area surrounding the terminal have identified an increase in shrub cover, a reduction in forb cover and no real change in grass and bare patch cover. Protected soils were found to have a higher stability than unprotected soils and surface soils exhibited a greater stability than sub-surface soils. Overall, the general condition was found to have remained relatively stable over the monitoring period.

Monitoring of mammals and herpetofauna around and within the terminal perimeter have identified no observable impacts to species presence or abundance from ST operations. The most recent survey identified the presence of one species of special conservation interest: *Emys orbicularis* (European pond turtle). Assessment of the monitoring data has not identified any differences between the number of species found within the 500m terminal buffer and those present beyond, giving an indication that animals were not avoiding the area within or directly surrounding the terminal. The only notable trend in species presence and abundance was a general reduction in marsh frog presence between 2012 and 2015; however, this trend was reversed in 2016.

Bird monitoring in the area surrounding the terminal has found that the number of resident bird species has remained stable over the monitoring period. No trends were identified in the presence or abundance of indicator species. However, fluctuations were recorded in numbers and occurrence of ferruginous duck (an Azerbaijan Red Book listed resident species). The only notable impact to bird populations from terminal activities was a localised reduction in diversity which may be related to construction activity. In general there was no evidence to indicate that the terminal activities were negatively impacting bird populations within the wider survey area.

Monitoring of wetland habitats surrounding the terminal have revealed no indication of impacts from operations. There was no notable difference between the observed flora and fauna species in areas close to and at distance from the terminal. While some water samples indicated the presence of contamination, this was unrelated to Sangachal Terminal operations.

Air and ground water monitoring carried out at the Serenja HWMF has not revealed any significant impacts from operations at the site. There was no exceedances of air quality standards at the site over the monitoring period. While a small number of parameters were recorded at higher concentrations in groundwater at isolated stations directly adjacent to the site, there was no definitive linkage between the concentrations of the tested parameters within the surrounding groundwater and operations at the site.

Surveys carried out to assess vegetation cover and soil stability around the Serenja HWMF have identified the site to be characteristic of the surrounding area. Bare patch was dominant over areas with vegetation cover. Soils were characterised by limited humus and moisture content typical of semi-desert soils, which may explain the low vegetation cover within the study area. Mineral oils and heavy metals concentrations were within the regional background ranges and there was no evidence of impacts from operations at the site.

Monitoring of air quality and the quality of surface and groundwater at locations along the export pipeline routes have revealed no detrimental impacts from operations. Air quality results have been within National and EU air quality standards; the last exceedance was reported in 2007. Water quality results have been consistent with the pre-project baseline conditions and were compliant with the relevant standards.

Bio restoration monitoring, carried out to assess the restoration of vegetation cover along the export pipeline routes right of way has recorded a continual trend of increasing plant growth and coverage. Over the monitoring period, the vast majority of ROW transects have achieved ESIA vegetation cover targets.

7

Summary

BP has been carrying out a comprehensive Environmental Monitoring Programme at offshore, inshore and onshore locations since 1995. The programme is designed to identify the presence of operational related impacts to the surrounding environment. The design and scope of the surveys have been continually developed to improve the quality of data and the overall effectiveness of the programme.

The results from recent surveys carried out at offshore locations indicate that there has been no increase in the levels of contamination at operational sites. Hydrocarbon content within sediments is typical of the background composition with no evidence of hydrocarbon contamination from production activities. Impacts at offshore locations are generally restricted to relatively stable footprints of elevated concentrations Ba, indicating the presence of contamination from the discharge of WBM and WBM drilled cuttings.

The macrobenthic communities present at platform survey sites were characteristic of the wider area. With the exception of a possible localised variation in community structure at stations directly adjacent to the Shah Deniz Alpha platform in 2017 there was no indication of impacts from production activities. Widespread regional changes in the macrobenthic community structure have been observed over the monitoring period. These changes reflect the natural variability of the benthic communities of the middle Caspian and are unrelated to production activities.

The Chirag platform is the only site where LAO drilled cuttings are discharged to the seabed. The spatial extent and magnitude of LAO contamination at Chirag reduced significantly on consecutive surveys from 2006, but increased in 2015. From 2015 the area effected has remained stable but the concentration levels present were found to have reduced in the most recent survey carried out in 2017.

A continual and sustained recovery has been observed in the Chirag macrobenthic community at stations previously identified as being impacted by drilling discharges. The communities present at these stations now generally exhibit the same characteristics as those observed at stations located at distance from the platform, outside the historically affected area. The only exception was one station located adjacent to the discharge point were the community continues to remain distinct.

An extensive inshore monitoring programme has been carried out in the area within and surrounding Sangachal Bay. A wide range of surveys have been conducted including; bio-monitoring using caged mussels; monitoring of impacts to fish; seagrass habitat surveys; benthic environmental surveys; water column and plankton surveys; and seal monitoring in the area surrounding the Absheron Peninsula.

The Sangachal Bay surveys have confirmed that the inshore environment at this location is similar to other coastal reference sites and the activities related to the installation of export pipelines within the bay have not resulted in significant impacts to the seabed environment, water column or the species present.

A comprehensive monitoring programme has been implemented at the Sangachal Terminal, monitoring impacts to air quality, ground and surface water quality, impacts to adjacent wetland habitats and the local populations of birds and terrestrial fauna.

There was no evidence to indicate that operations at Sangachal Terminal were having a negative effect on the surrounding air quality. While some exceedances of the relevant air quality standards have been recorded at stations directly adjacent to the terminal, these have been transient and localised.

Ground water monitoring has detected the presence of a leak from the produced water ponds within the terminal. The leak has resulted in elevated concentrations of a number of parameters at sample points adjacent to the ponds. The contamination, which has been present for a number of years, is restricted to the area within the terminal boundary and poses no significant risk to the ground water quality within the wider area.

No impacts have been detected to adjacent wetland habitats or to the populations of mammals or herpetofauna. Other than a localised reduction in diversity which may be related to construction activity, there was no indication that operations at the terminal were negatively impacting bird populations within the wider area.

No impacts have been detected to the air and water quality at the Serenja HWMF or along the export pipeline routes.

Overall the Environmental Monitoring Programme continues to provide comprehensive coverage across BP's operational sites and ensures that any impacts are quickly identified, allowing mitigating actions to be put in place. The widespread implementation of the programme and its continued development is driven by BP's goal of achieving no damage to the environment.

List of Acronyms

AAQ	Ambient Air Quality
ACG	Azeri Chirag Gunashli
AGT	Azerbaijan Georgia Turkey
AIOC	Azerbaijan International Operating Company
AQS	Air Quality Standard
ARDB	Azerbaijan Red Data Book
BOD	Biochemical Oxygen Demand
BPi	Bare Patch Index
BTC	Baku Tbilisi Ceyhan pipeline
BTEX	Benzene, Toluene, Ethylbenzene & Xylene
CA	Central Azeri Platform
CCr	Crust to Cover Ratio
COD	Chemical Oxygen Demand
CSM	Conceptual Site Model
DO	Dissolved Oxygen
DUQ	Drilling, Utilities and Quarters
DWG	Deep Water Gunashli Platform
DWS	Drinking Water Standard
EA	East Azeri Platform
ECC	Ecosystem Condition Category
ECV	Ecosystem Condition Value
EMP	Environmental Monitoring Program
EOP	Early Oil Project
EQS	Environmental Quality Standard
ESC	Environmental Sub-Committee
ESIA	Environmental & Socio-economic Impact Assessment
EU	European Union
GAC	Generic Assessment Criteria
GHG	Greenhouse gases
GPO	BP Global Projects Organisation
HWMF	Hazardous Waste Management Facility
ITDU	Indirect Thermal Desorption Units
IUCN	The International Union for Conservation of Nature
LAO	Linear Alfa Olefin Drilling Mud
LTOBM	Low Toxicity Oil Based Drilling Mud
MDL	Method Detection Limit
MENR	Ministry of Environment and Natural Resources
MODU	Mobile Offshore Drilling Unit
MTAG	Monitoring Technical and Advisory Group
NPD	Low-molecular weight, volatile PAHs; a low percentage value indicates weathered material
NREP	Northern Route Export Pipeline

OBM	Oil Based Drilling Mud
OMS	Operating Management System
PAH	Polynuclear Aromatic hydrocarbons
PCBs	Polychlorinated biphenyls
PCWU	Pressure Compression Water injection Unit
PM10	Particulate matter 10µm in diameter
PPL	Potential Pollutant Linkage
PSA	Production Share Agreement
PW	Produced Water
PWDP	Produced Water Disposal Project
ROW	Right Of Way
RSL	Regional Screening Level
RTMS	Real Time Monitoring Station
SBM	Synthetic Hydrocarbon Based Drilling Mud
SCP	South Caucasus gas Pipeline
SD	Shah Deniz
SDA	Shah Deniz Alfa
SDR	Shah Deniz Regional
SD2	Shah Deniz Phase 2 Expansion
SWAP	Shallow Water Apsheron Peninsula
SOCAR	State Oil Company of Azerbaijan Republic
SS	Soil Stability
ST	Sangachal Terminal
TCC	Thermo-mechanical Cuttings Cleaner
TDC	Treated Drill Cuttings
THC	Total Hydrocarbons
TPH	Total Petroleum hydrocarbons
TSS	Total Suspended Solids
UCM	Unresolved Complex Mixture; a high percentage indicates weathered hydrocarbon material
USEPA	United States Environmental Protection Agency
VOC	Volatile Organic Compounds
VPi	Vegetation Patch Index
WA	West Azeri Platform
WBM	Water Based Drilling Mud
WHO	World Health Organisation
WREP	Western Route Export Pipeline

Glossary of terms

Amphipod - A small crustacean of the order Amphipoda having a laterally compressed body with no carapace.

Annelid - Any of various worms or wormlike animals of the phylum *Annelida*, characterised by an elongated, cylindrical and segmented body.

Anthropogenic - Originating from human activity.

Associated Gas - Natural gas found as part of or in conjunction with other constituents of crude oil. This may be dissolved in the crude oil or found as a cap of free gas above the oil.

Background Level - The concentration of a substance or energy intensity level (such as noise or light) that is characteristic of the surrounding environment.

Barite - A very heavy substance used as a main component of drilling mud to increase its density (mud weight). Main constituent of barite is the chemical element barium.

Barrels - The traditional unit of measure of oil volume, equivalent to 159 litres (0.159 m3) or approximately 35 imperial gallons (42US gallons).

Benthos - The collection of organisms attached to or resting on the bottom (benthic) sediments and those which bore or burrow into the sediments.

Biodegradable - Susceptible to breakdown into simpler compounds by microorganisms in the soil, water and atmosphere. Biodegradation often converts toxic organic compounds into non- or less toxic substances.

Biological Oxygen Demand (BOD) - The amount of oxygen required by aerobic microorganisms to decompose the organic matter in a sample of water, such as that polluted by sewage. It is used as a measure of the degree of water pollution.

Biomass -The total mass of living matter within a given quantity.

Bivalve - A marine or freshwater mollusc having a laterally compressed body and a shell consisting of two hinged valves.

Borehole - A hole in the ground made by drilling; the uncased drill hole from the surface to the bottom of the well.

Cement - A powdery substance that acts as a binder that hardens (sets) after mixing with water. Cement is often used to bind aggregate materials (such as sand and gravel) together, to form concrete.

Chal-Meadow - Vegetation community that is linked to the temporary retention of surface water following rainfall, this type of vegetation usually occurs in depressions and along drainage lines.

Chemical Oxygen Demand (COD) - The amount of oxygen consumed within a solution. It is used to indirectly measure the amount of organic compounds in water.

Coliform - Of or relating to the bacteria that commonly inhabit the intestines/colons of humans and other vertebrates.

Communities - A social group whose members reside in a specific locality, share government and often have a common cultural and historical heritage / an ecological unit composed of the various populations of micro-organisms, plants, animals that inhabit a particular area.

Conductivity - A measure of the ability of a substance to transmit heat, electrical charge or sound through a medium without noticeable motion of the medium itself.

Contract Area - Area of the sea that has been sub-divided and licensed/leased to a company or group of companies for exploration and production of hydrocarbons.

Copepod - Any member of a large family of the phylum *Arthropoda*, including many crustaceans, living in freshwater and marine water. Some copepods are parasitic and others are free living.

Crude Oil - An unrefined mixture of naturally-occurring hydrocarbons with varying densities and properties.

Ctenophore - Any of various marine animals of the phylum Ctenophora, having transparent, gelatinous bodies bearing eight rows of comb-like cilia used for swimming. Also known as comb jelly.

Cumulative Impact - Environmental and/or socio-economic aspects that may not on their own constitute a significant impact but when combined with impacts from past, present or reasonably foreseeable future activities, result in a larger /more significance impact(s).

Cuttings - See drill cuttings.

Daphnia - Small planktonic invertebrate, Cladoceran, varying in length from 0.2 to 5 mm.

Dispersant - Specially designed oil spill products that are composed of detergent-like surfactants in low toxicity solvents. Dispersants do not remove oil from the water but break the oil slick into smaller droplets, which then disperse into the water where they are further broken down by natural processes.

Domestic waste - Solid waste, composed of garbage and rubbish, which normally originates from a residence/living quarters.

Drilling Mud - A special clay mixed with water or oil and chemical additives, pumped downhole through the drill pipe (string) and drill bit. The mud cools the rapidly rotating bit, lubricates the drill pipe as it turns in the well bore, carries rock cuttings to the surface and serves as a plaster to prevent the wall of the borehole from collapsing. Also known as drilling fluid.

Early Oil Project - The first large-scale oil project in the Caspian Sea. It commenced in 1994 and involved a consortium of companies who invested to extract oil from the Azeri, Chirag and Guneshli wells.

Ecosystem - The interrelationships between all living organisms in a given area, and their relationships to non-living materials.

Effluent - Waste products emitted as a liquid by an operation or process.

Endemic - Present within a localised area or peculiar to organisms in such an area.

Environmental and Socio-economic Impact Assessment (ESIA) - Systematic review of the environmental or socio-economic effects a proposed project may have on its surrounding environment.

Environmental Aspect - An element of an organisation's activities, products or services that can interact with the environment.

Environmental Impact - Any change to the environment, whether adverse or beneficial, wholly or partially resulting from an organisation's activities, products or services.

Environmental Impact Management Process -A full life-cycle process that seeks to identify and understand a project's environmental impacts, to avoid, minimise, mitigate and remediate the impacts.

Environmental Management System - A system established to plan, manage and document an organisation's activities and processes and resultant environmental impacts.

Environmental Receptors - Any of various organisms that are directly or indirectly affected by environmental impact.

Ephemeral - Something living or lasting for a brief time, such as the flow of a river during certain months of the year.

Exploration Well - A well drilled in search of an undiscovered reservoir or to greatly extend the limits of a known reservoir.

Flora/fauna - Plants/wildlife that occur within a defined geographical area.

Footprint - The spatial impact/impression on the land from a facility, building or disturbed area.

Gastropod - Any of the various molluscs of the class Gastropoda such as the snail.

Groundwater - Water that collects or flows beneath the Earth's surface, filling the porous spaces in soil, sediment, and rocks. Groundwater originates from rain and from melting snow and ice and is the source of water for aquifers, springs, and wells.

Habitat - An area where particular animal or plant species and assemblages are found, defined by environmental parameters.

Hazard - The potential to cause harm, including ill health or injury; damage to property, plant, products or the environment; production losses or increased liabilities.

Heavy Metals - A subset of elements that exhibit metallic properties with high atomic weights, and which include the transition metals and a number of metalloids, lanthanoids, and actinides. Examples include mercury, chromuim, cadmuim, arsenic and lead.

Hydrocarbon - Organic chemical compounds of hydrogen and carbon atoms. There are a vast number of these compounds and they form the basis of all petroleum products. They may exist as gases, liquids or solids, examples being methane, hexane and paraffin.

Indicator species – A species that can be used to infer conditions in a particular habitat.

Infiltration - The flow of water from the land surface into the subsurface.

Invertebrates - Any animal lacking a backbone, including all species not classified as vertebrates.

ISO 14001 - An evolving series of generic environmental management system standards developed by the International Standards Organisation that provides business management with a structure for managing environmental impacts.

Isopod - A type of Peracarid crustacean.

Landfill - Disposal of waste materials by burial.

Larvae - An immature free-living form of animal that develops into a different form through metamorphosis.

Macrobenthos or Macrofauna - Organisms that live on/in sediment at the bottom of a water column. Relatively larger than other benthos with a size range of approximately 20 cm to 0.5 mm.

Mammal - A class of air-breathing warm-blooded vertebrates, Mammalia, having mammary glands in the female.

Manifold - Assembly of pipes, valves and fittings which allows fluids from more than one source to be collected together and directed to various alternative routes.

Migration - Movement of people to a new area or country in order to find work or better living conditions / any regular animal journeys along well-defined routes, particularly those involving a return to breeding grounds.

MODU - A semi-submersible mobile drilling rig.

Oligochaete - Any of various annelid worms of the class Oligochaeta, including the earthworms and a few small freshwater forms.

Operator - The company responsible for conducting operations on a concession on behalf of itself and any other concession-holders.

Particulates - Tiny particles of solid or liquid suspended in a gas or liquid.

pH - A scale of alkalinity or acidity, running from 0 to 14 with 7 representing neutrality, 0 maximum acidity and 14 maximum alkalinity.

Phytoplankton - Microscopic photosynthetic organisms which float or drift in the surface waters of seas and lakes, e.g. diatoms, dinoflagellates.

Pigging - The process of cleaning or measuring internally the pipeline whereby a "pig" is sent though the line to clean/measure the inside of the pipeline.

Pipeline Landfall - Location where an offshore pipeline reaches the coast.

Plankton - Tiny plants (phytoplankton) and animals (zooplankton) that drift in the surface waters of seas and lakes. They are of high ecological importance as they provide a source of food to larger marine organisms such as fish.

Platform - A large structure offshore which has facilities to drill, extract, process and temporarily store hydrocarbons.

Plug -To seal a well or part of a well.

Pollution - The introduction by man, directly or indirectly, of substances or energy to the environment resulting in deleterious effects such as harm to living resources; hazards to human health; hindrance of marine activities including fishing and impairment of the quality for use of seawater and reduction of amenities.

Polychaete - Any of various annelid worms of the class Polychaeta, including mostly marine worms such as the lugworm, and characterised by fleshy paired appendages tipped with bristles on each body segment.

Polycyclic Aromatic Hydrocarbons (PAH) - Hydrocarbons whose carbon atoms form a ring or rings.

Polymer - Two or more molecules of the same kind, combined to form a compound with different physical properties.

Precipitation - The product of atmospheric water vapour condensation that falls to the Earth's surface under gravity. The main types of precipitation are: drizzle, rain, sleet, snow and hail.

Predrill - Drilling activities taking place to accelerate early production once offshore facilities are in place.

Produced Water - Water that naturally accompanies produced oil/condensate. Also known as produced formation water.

Production - Extraction of hydrocarbon from the reservoir.

Production Sharing Agreement (PSA) - Type of contract signed between a government and a resource extraction company (or group of companies).

Receptor - The aspect of the environment (air, water, ecosystem, human, fauna, etc.) that is affected by/interacts with an environmental or socio-economic impact.

Recycling/Recovery - The conversion of wastes into usable materials and/or extraction of energy or materials from wastes.

Red List / Red Data Book - A list comprised of rare or endangered species of plants and animals / the book containing rare/endangered species.

Reservoir - A porous, fractured or cavitied rock formation with a geological seal forming a trap for producible hydrocarbons.

Rig - A collective term to describe the equipment needed for drilling a well.

Riser - A pipe through which fluids flow upwards.

Risk - The product of the chance that a specified undesired event will occur and the severity of the consequences of the event.

Sail-away - The process of transporting equipment from onshore to its offshore location by vessel.

Salinity - Total amount of salt dissolved in an aqueous solution usually expressed as parts per thousand.

Screening - The process by which it is decided if an ESIA is required to be carried out for a project.

Sediment - Solid fragments of inorganic or organic material that come from the weathering and erosion of **rock** and are carried and deposited by wind, water, or ice.

Seismic - The characteristics (e.g. frequency and intensity) of earthquake activity in a given region.

Seismic survey - A method of investigating underground properties and rock patterns using induced shock wave reflections. Used for oil and gas exploration.

Semi-submersible Rig - A type of floating offshore drilling rig which has pontoons or buoyancy chambers located on short legs below the drilling platform.

Sensitivity - The recovery rate of flora or fauna from significant disturbance or degradation.

Shrub - A woody plant of relatively low height, having several stems from the base.

Stakeholder - A person, group and/or organisation with an interest in a project.

Strata - Distinct, usually parallel beds of rock.

Taxon - Plural -Taxa. A taxonomic category or group, used to classify organisms.

Thermal desorption - A non-oxidising process using heat to desorb oil from oily wastes.

Thermocline - Temperature differential in the water column.

Toxicity - Inherent potential or capacity of a substance to cause adverse effects on living organisms.

Toxicity Test - Procedure that measures the toxicity produced by exposure to a series of concentrations of a test substance. In an aquatic toxicity test, the effect is usually measured as either the proportion of organisms affected or the degree of effect shown by the organism.

Turbidity - The cloudiness or haziness of a fluid caused by individual particles. It is used as a test of water quality.

Venting - The release of uncombusted gases to the atmosphere.

Water Based Muds (WBM) - Drilling fluid based on suspension of solids in water.

Water Injection - The injection of water into a reservoir or well.

Weathering (of oil) - the changes that occur to oil as it spends time in the environment.

Wetland - An area of land whose soil is saturated with moisture either permanently or seasonally.

Zooplankton - Plankton that consists of animals such as corals and jellyfish, and the immature stages of larger animals, usually small and often microscopic.

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List of Tables & Figures

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8.2. Figures