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# **Interim Pre-Drill Environmental Monitoring Report**

**Balcombe Site, Sussex**

**Prepared for:  
Cuadrilla Resources Limited**

Interim Pre-Drill Environmental Monitoring Report  
Balcombe Site, Sussex

## Document Control Page



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### Introduction

Ground-Gas Solutions (GGS) have been appointed by Cuadrilla Resources Limited to complete independent environmental monitoring at their Balcombe Exploration Site. Included within our remit was to test air quality, groundwater and surface waters and as part of Cuadrilla's environmental due diligence and in accordance with permitting requirements.

This interim report represents a summary of the environmental data obtained to date and represents pre-drill results for the site. With all industrial processes, there is a potential for pollution of the environment should site activities not be well managed and maintained. These results will be considered against future operational programmes and help to set ambient levels at the site.

### Air Quality

Operations at the site have the potential to contribute to local air pollution. As such GGS have completed pre-drill monitoring of two locations at the site. Samples were taken from both upwind (BALUW) and downwind (BALDW) at the site for a range of common air pollutants and others which may be associated with the planned activities including methane and other hydrocarbons.

Sulphur Dioxide (SO<sub>2</sub>), Nitrogen Dioxide (NO<sub>2</sub>) and Hydrogen Sulphide (H<sub>2</sub>S) have been sampled using passive tubes exposed for an approximate 25 day period between 23<sup>rd</sup> May 2013 and 17<sup>th</sup> June 2013. The results are presented in Table 1 below.

Determinands	Lab L.O.D.	BALDW		BALUW		Air Quality Screening Criteria $\mu\text{g}/\text{m}^3$
		$\mu\text{g}$	Total $\mu\text{g}$	$\mu\text{g}/\text{m}^3$	Total $\mu\text{g}$	
SO <sub>2</sub>	0.03	<L.O.D.	<L.O.D.	*	*	266 (15min mean) 350 (1hr mean) 125 (24hr mean)
NO <sub>2</sub>	0.017	0.38	8.55	0.56	12.68	350 (1hr mean) 125 (annual mean)
H <sub>2</sub> S	0.04	<0.04	<0.102	<0.04	<0.103	140 (long term Annual EAL) 150 (Short term hourly) EAL

\*BALUW has no upwind data due to the tube being tampered with whilst in-situ on site.

**Table 1:** Air Quality Onsite, Balcombe Site, Sussex. Passive Tubes

All results are shown to be below current UK Air Quality Objectives or Environmental Assessment Levels.

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Methane ( $\text{CH}_4$ ) concentrations were also monitored in the ambient air at the site on the 23<sup>rd</sup> May 2013 using a methane tuned laser diode instrument and the range of results are presented in Table 2 below:

Determinand	Unit	Date	Start Time	End Time	CH4 Range
$\text{CH}_4$	ppmv	23/05/2013	08:37	16:20	1.5-2.5

**Table 2:** Ambient  $\text{CH}_4$  Monitoring

Ambient methane concentrations in the UK are not well documented. The nearest observation station is Mace Head, County Galway, Ireland which reported an annual average concentration of 1.9ppmv. The results are therefore in line with ambient concentrations.

To provide screening of non-methane volatile organic compounds (VOCs), short term pumped air samples were taken using sorbent tubes on the 23<sup>rd</sup> May 2013.

BTEX quantified analysis was undertaken and are presented in Table 3.

Determinands	Laboratory L.O.D.	BALDW		BALUW		Air Quality Screening Criteria
		ng	Total ng	$\mu\text{g}/\text{m}^3$	Total ng	$\mu\text{g}/\text{m}^3$
Benzene	<5.00	5.54	0.58	5.72	0.60	5 (annual mean)
Toluene	<5.00	5.10	0.54	<5.00	<0.53	1,910 (long term Annual EAL) 8,000 (Short term hourly) EAL
Ethyl Benzene	<5.00	<5.00	<0.53	<5.00	<0.53	4,410 (long term Annual EAL) 55,200 (Short term hourly) EAL
m/p-Xylene	<5.00	7.35	0.77	<5.00	<0.53	4,410 (long term Annual EAL) 66,200 (Short term hourly) EAL
o-Xylene	<5.00	6.30	0.66	<5.00	<0.53	

**Table 3:** BTEX Quantitative Analysis of pumped Sorbent Tubes

In addition, a screen of VOCs using GC/MS tentatively identified 15 compounds which are presented in Table 4 below:

Determinands	BALDW		BALUW	
	Total ng	$\mu\text{g}/\text{m}^3$	Total ng	$\mu\text{g}/\text{m}^3$
Benzene	13.11	1.38	11.76	1.24
Butane	8.88	0.93	<5.00	<0.53
Tridecane	6.82	0.72	<5.00	<0.53
Isobutane	6.75	0.71	-	-

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Determinands	BALDW		BALUW	
	Total ng	µg/m <sup>3</sup>	Total ng	µg/m <sup>3</sup>
Dodecane	6.46	0.68	<5.00	<0.53
Geptane	<5.00	<0.53	-	-
Undecane	<5.00	<0.53	<5.00	<0.53
Toluene	<5.00	<0.53	<5.00	<0.53
Tetradecane	<5.00	<0.53	<5.00	<0.53
Butane, 2-Methyl	<5.00	<0.53	<5.00	<0.53
Acetone	<5.00	<0.53	-	-
Pentane, 2,3,4-trimethyl	<5.00	<0.53	-	-
Decane	<5.00	<0.53	<5.00	<0.53
m/p-Xylene	<5.00	<0.53	-	-
Pentadecane	<5.00	<0.53	-	-
1-Hexanol, 2-ethyl-	-	-	<5.00	<0.53

L.o.D 5ng (indicative) - not identified in sample

**Table 4:** VOC Semi- Quantitative Analysis of pumped Sorbent Tubes

Table 4 shows the results of the tentatively identified VOCs and provides an estimation of concentration only (Semi-Quantitative Analysis) providing an indicative value for consideration. With the exception of benzene, other compounds are considered representative of ambient conditions. The quantified benzene result with Table 3 should be used. In either case, the result is well below the current air quality objective of 5 µg/m<sup>3</sup> annual mean.

## Groundwater Results

All groundwater samples have been taken from a recently constructed groundwater well (BALMW01) located on the site. This well has been drilled into the Ashdown Beds and has a response zone at its base. The well is artesian and sampling has conducted following purging of 3 well volumes and stabilisation of physical water characteristics. A comprehensive range of determinands has been sampled and analysed including physical properties, heavy metals, non-metals and hydrocarbons are presented in Tables 5 and 6, with dissolved gases presented in Table 7.

Determinand	Units	BALMW01 Sample Date		
		08/07/2013	11/07/2013	17/07/2013
Dissolved Oxygen	ppm	0.00	0.00	0.00
pH		8.01	7.96	7.99
Temperature	°C	16.01	15.95	14.87
Electrical Conductivity	µS/cm	607	1154	1135
Total Dissolved Solids	ppm	303	577	568
Salinity	PSU	0.30	0.58	0.57
Oxidation Reduction Potential	mV	-184.9	-200.7	-190.3

**Table 5:** In-Situ Groundwater Monitoring Data (pre-sample).

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Table 5 displays the stabilised results of physical parameters of groundwater immediately prior to samples being taken for laboratory analysis.

Table 6 below shows the laboratory results for a comprehensive suite of testing completed on 3 monitoring rounds.

Determinand	Lab L.O.D.	Units	BALMW01 Sample Date			EQS Inland Surface Waters*
			08/07/2013	11/07/2013	17/07/2013	
Arsenic <sup>#</sup>	<2.5	µg/l	13.3	<2.5	8.6	50
Barium <sup>#</sup>	<3	µg/l	1256	637	666	-
Boron <sup>#</sup>	<12	µg/l	827	847	828	2000
Cadmium <sup>#</sup>	<0.5	µg/l	5.3	<0.5	<0.5	0.08-0.25 <sup>#</sup>
Calcium <sup>#</sup>	<0.2	mg/l	12.6	8.1	7.3	-
Total Chromium <sup>#</sup>	<1.5	µg/l	115.7	2.7	<1.5	5-50 <sup>#</sup>
Copper <sup>#</sup>	<7	µg/l	10	<7	<7	1-28 <sup>#</sup>
Total Iron <sup>#</sup>	<20	µg/l	10600	631	115	1000
Lead <sup>#</sup>	<5	µg/l	99	<5	<5	7.2
Magnesium <sup>#</sup>	<0.1	mg/l	17.0	1.1	0.9	-
Mercury <sup>#</sup>	<1	µg/l	<1	<1	<1	0.05
Nickel <sup>#</sup>	<2	µg/l	30	<2	<2	20
Potassium <sup>#</sup>	<0.1	mg/l	46.3	2.3	2.2	-
Selenium <sup>#</sup>	<3	µg/l	<3	<3	<3	-
Sodium <sup>#</sup>	<0.1	mg/l	357.7	310.7	331.5	170
Strontium <sup>#</sup>	<5	µg/l	11	149	141	-
Zinc <sup>#</sup>	<3	µg/l	145	12	8	8-125 <sup>#</sup>
Total aromatics (C5-35)	<10	µg/l	<10	<10	<10	-
Total aliphatics (C5-35)	<10	µg/l	<10	<10	<10	-
MTBE	<5	µg/l	<5	<5	<5	-
Benzene	<5	µg/l	<5	<5	<5	10
Toluene	<5	µg/l	<5	<5	<5	50
Ethylbenzene	<5	µg/l	<5	<5	<5	-
m/p-Xylene	<5	µg/l	<5	<5	<5	30
o-Xylene	<5	µg/l	<5	<5	<5	30
Bromide	<0.05	mg/l	<0.05	<0.05	<0.05	-
Sulphate	<0.05	mg/l	2.81	1.13	0.08	400
Chloride	<0.3	mg/l	29.5	28.0	23.8	-
Nitrate as NO <sub>3</sub>	<0.2	mg/l	1.0	0.3	<0.2	-
Nitrite as NO <sub>2</sub>	<0.02	mg/l	<0.02	<0.02	<0.02	-
Ammoniacal Nitrogen as N	<0.03	mg/l	<0.03	0.05	<0.03	0.015

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Determinand	Lab L.O.D.	Units	BALMW01 Sample Date			EQS Inland Surface Waters*
			08/07/2013	11/07/2013	17/07/2013	
Total Alkalinity as CaCO <sub>3</sub>	<1	mg/l	698	572	578	-
Total Cations		none	18.77	14.07	14.91	-
Total Anions		none	14.84	12.24	12.22	-
% Cation Excess		none	11.7	6.9	9.9	-
BOD (Settled)	<1	mg/l	165	169	170	-
COD (Settled)	<7	mg/l	564	526	462	-
Electrical Conductivity @25C	<2	µS/cm	1181	1230	1197	-
pH	<0.01	pH	7.78	7.87	8.02	-
Salinity	<0.1	%	<0.1	<0.1	<0.1	-
Total Dissolved Solids	<10	mg/l	1630	1502	1075	-

**Table 6:** Groundwater Laboratory Analysis

Presented where available are the current environmental quality standards (EQS) for consideration. Please note that these should not be directly applied to groundwater as pass or fail values but provide an indicator of water quality. Whilst the majority are below these standards, several are in excess or near to these values indicating potentially poor water quality for some determinands, particularly metals and sodium.

Determinand	Units	BALMW01 Sample Date		
		08/07/2013	11/07/2013	17/07/2013
Methane CH <sub>4</sub>	mg/l	12.4	6.84	7.42
Carbon Dioxide CO <sub>2</sub>	mg/l	2.3	1.92	1.48
Ethane C <sub>2</sub> H <sub>6</sub>	mg/l	0.29	0.97	1.10
δ <sup>13</sup> CH <sub>4</sub>	ppm	-53.3	-45.1	-45.2
δ <sup>13</sup> CO <sub>2</sub>	ppm	-25.2	-21.1	-29.8

**Table 7:** Groundwater Dissolved Gas Analysis

The dissolved gas results indicate the presence of methane, carbon dioxide and ethane. Although there are no current UK standards for methane or ethane, the results are considered relatively elevated and confirmed present in the shallow aquifer.

## Surface Water Results

GGS completed one sampling round of 5 surface water sampling points on the 23<sup>rd</sup> May 2013. A comprehensive range of determinands has been sampled and analysed including physical properties, heavy metals, non-metals and hydrocarbons are presented in Tables 8 and 9 below.

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Table 8 displays the stabilised results of physical parameters of surface waters immediately prior to samples being taken for laboratory analysis.

Determinand	Units	Sample Location				
		BALSW01	BALSW02	BALSW03	BALSW04	BALSW05
Dissolved Oxygen	ppm	13.06	13.46	13.4	12.00	11.62
pH		9.17	9.45	9.38	10.10	9.19
Temperature	°C	10.04	10.22	10.24	10.18	10.38
Electrical Conductivity	µS/cm	458	362	498	388	381
Total Dissolved Solids	ppm	229	181	249	194	190
Salinity	PSU	0.22	0.17	0.24	0.19	0.18
Oxidation Reduction Potential	mV	-102.2	-111.0	-111.1	-127.9	-114.1

**Table 8:** In-Situ Surface Water Monitoring Data (pre-sample).

Table 9 below shows the laboratory results for a comprehensive suite of testing completed for surface waters on the 23<sup>rd</sup> May 2013.

Determinand	Lab L.O.D.	Units	Sample Location					EQS Inland Surface Waters*
			BALSW01	BALSW02	BALSW03	BALSW04	BALSW05	
Arsenic <sup>#</sup>	<2.5	µg/l	<2.5	3.6	<2.5	3.3	<2.5	50
Barium <sup>#</sup>	<3	µg/l	24	17	26	17	17	-
Boron <sup>#</sup>	<12	µg/l	16	37	22	20	38	2000
Cadmium <sup>#</sup>	<0.5	µg/l	<0.5	<0.5	<0.5	<0.5	<0.5	0.08-0.25 <sup>#</sup>
Calcium <sup>#</sup>	<0.2	mg/l	56.1	37.1	66.9	40.8	35.3	-
Total Chromium <sup>#</sup>	<1.5	µg/l	<1.5	2.3	<1.5	<1.5	<1.5	5-50 <sup>#</sup>
Copper <sup>#</sup>	<7	µg/l	<7	<7	<7	<7	<7	1-28 <sup>#</sup>
Total Iron <sup>#</sup>	<20	µg/l	<20	105	<20	34	112	1000
Lead <sup>#</sup>	<5	µg/l	<5	<5	<5	<5	<5	7.2
Magnesium <sup>#</sup>	<0.1	mg/l	7.7	6.2	8.3	6.6	5.9	-
Mercury <sup>#</sup>	<1	µg/l	<1	<1	<1	<1	<1	0.05
Nickel <sup>#</sup>	<2	µg/l	<2	<2	<2	<2	2	20
Potassium <sup>#</sup>	<0.1	mg/l	2.9	2.5	3.0	2.9	2.4	-
Selenium <sup>#</sup>	<3	µg/l	<3	<3	<3	<3	<3	-
Sodium <sup>#</sup>	<0.1	mg/l	19.1	20.0	20.3	16.9	19.9	170
Strontium <sup>#</sup>	<5	µg/l	171	149	253	132	146	-
Zinc <sup>#</sup>	<3	µg/l	<3	<3	<3	<3	<3	8-125 <sup>#</sup>
Total aromatics (C5-35)	<10	µg/l	<10	<10	<10	<10	<10	-
Total aliphatics (C5-35)	<10	µg/l	<10	<10	<10	<10	<10	-
MTBE	<5	µg/l	<5	<5	<5	<5	<5	-

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Determinand	Lab L.O.D.	Units	Sample Location					EQS Inland Surface Waters*
			BALSW01	BALSW02	BALSW03	BALSW04	BALSW05	
Benzene	<5	µg/l	<5	<5	<5	<5	<5	10
Toluene	<5	µg/l	<5	<5	<5	<5	<5	50
Ethylbenzene	<5	µg/l	<5	<5	<5	<5	<5	-
m/p-Xylene	<5	µg/l	<5	<5	<5	<5	<5	30
o-Xylene	<5	µg/l	<5	<5	<5	<5	<5	30
Bromide	<0.05	mg/l	0.13	0.05	0.12	0.09	0.07	-
Sulphate	<0.05	mg/l	26.99	25.60	45.33	34.22	25.71	400
Chloride	<0.3	mg/l	33.2	28.6	33.3	29.6	28.6	-
Nitrate as NO <sub>3</sub>	<0.2	mg/l	17.9	8.4	11.2	8.0	8.5	-
Nitrite as NO <sub>2</sub>	<0.02	mg/l	<0.02	<0.02	<0.02	<0.02	<0.02	-
Ammoniacal Nitrogen as N	<0.03	mg/l	<0.03	0.03	<0.03	<0.03	0.05	0.015
Total Alkalinity as CaCO <sub>3</sub>	<1	mg/l	122	88	129	82	NDP	
Total Cations		none	4.34	3.3	4.98	3.39	NDP	-
Total Anions		none	3.94	3.09	4.46	3.19	NDP	-
% Cation Excess		none	4.8	3.2	5.6	3.1	NDP	-
BOD (Settled)	<1	mg/l	<1	<1	<1	<1	1	-
COD (Settled)	<7	mg/l	20	16	19	11	16	-
Electrical Conductivity @25C	<2	µS/cm	445	339	475	355	334	-
pH	<0.01	pH	7.87	7.73	7.93	7.64	7.36	-
Salinity	<0.1	%	<0.1	<0.1	<0.1	<0.1	<0.1	-
Total Dissolved Solids	<10	mg/l	276	226	295	219	191	-

**Table 9:** Surface Water Laboratory Analysis

Presented where available are the current EQS Standards for consideration. The EQS values are an indicator of surface water quality. The results show relatively good water quality in respect of EQS values with a minor exceedance of Ammoniacal Nitrogen.

## Summary

The results published in the tables above provide pre-drill indications of environmental quality of air, groundwater and surface waters at the Balcombe exploration site. The air and surface water samples generally show ambient conditions indicative of good environmental quality. Groundwater results have displayed some elevated heavy metals and sodium and has been confirmed to contain elevated dissolved methane and ethane gas.