

# Groundwater monitoring results at Origin Kyalla and Velkerri well sites in the Beetaloo sub-basin in accordance with the Code of Practice: December 2018 – December 2019

## Introduction

This report is a continuation of a series of quarterly public reports compiled by the Department of Environment and Natural Resources (DENR). The Code of Practice: Onshore Petroleum Activities in the Northern Territory (the Code) (2019) requires 6 months of baseline monitoring of groundwater at a well site prior to undertaking hydraulic fracturing activities. This report presents results of on-going groundwater monitoring undertaken by Origin at its well sites in the Beetaloo sub-basin in compliance with the Code. The report includes updated ongoing groundwater monitoring data for the Kyalla petroleum well site on EP117 and new baseline groundwater monitoring data for the Velkerri well site on EP76 (Figure 1).

## Groundwater Monitoring Program

Companies are required to submit groundwater monitoring data quarterly, in compliance with the the Code. DENR has committed to publishing the monitoring results from interest holders to increase the transparency of monitoring and reporting of groundwater potential impacts by the onshore gas industry in the Northern Territory.

The Origin groundwater monitoring program consists of:

- Control Monitoring Bore (CMB), which is located “upstream” and within 100 m of each planned or existing petroleum well pad, screened across the Gum Ridge aquifer and a separate CMB screened across the Anthony Lagoon aquifer in compliance with the Code; and
- Impact Monitoring Bore (IMB), which is located 20 m “downstream” of the location of the petroleum well(s). These will be drilled following construction of the petroleum well but prior to hydraulic fracturing.

These bores enable an ongoing comparison of the groundwater upstream and downstream of the petroleum well, to allow for an immediate identification of any variation in the groundwater that can be directly related to the petroleum activity.

## Groundwater quality

At both the Kyalla and Velkerri petroleum well sites the regional Cambrian Limestone Aquifer (CLA) system consists of both the Gum Ridge aquifer and the shallower Anthony Lagoon aquifer. These karstic aquifers are used as a source of groundwater by pastoralists and regional communities. A groundwater extraction licence (GRF10285) has been granted to Origin for extraction of up to a total of 175 ML per year from the Gum Ridge aquifer across its exploration permit areas in the Beetaloo sub-basin. At the Kyalla well site, the drilling of the approved Kyalla exploration petroleum well commenced in September 2019. Hydraulic fracturing of the Kyalla well had not yet occurred during the reporting period (February 2019 to December 2019). At the Velkerri well site the drilling of the approved Velkerri exploration petroleum well had not yet commenced.

Groundwater monitoring results at Origin Kyalla and Velkerri well sites in the Beetaloo sub-basin in accordance with the Code of Practice: December 2018 – December 2019

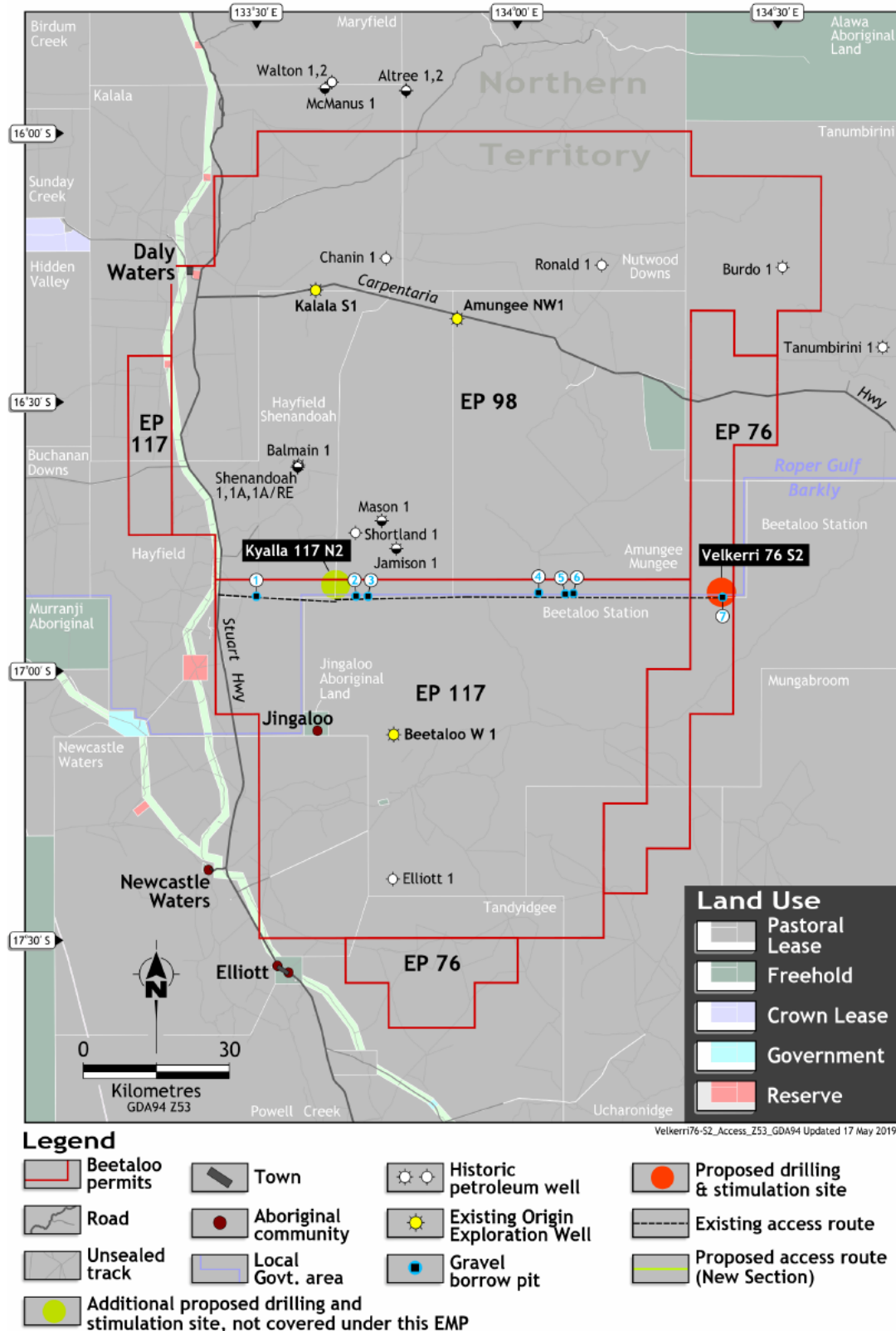


Figure 1: Origin Exploration Permit (EP) areas and associated well sites in the Beetaloo sub-basin (courtesy: Origin)

## Summary and Interpretation of Results

The updated raw groundwater monitoring results reported quarterly by Origin for the Beetaloo sub-basin are available at Appendix 1.

Table 1 lists a summary of key “indicator” analyte averages and standard deviations for the sampling events at both Kyalla and Velkerri well sites. Six sampling events for the Gum Ridge aquifer and twelve sampling events for the Anthony Lagoon aquifer were undertaken at Kyalla during the sampling period from February to December 2019. Two sampling events for the Gum Ridge aquifer and three sampling events for the Anthony Lagoon aquifer were undertaken at the newly established Velkerri well site during the sampling period from November to December 2019. No groundwater level loggers were installed at the Velkerri site during this monitoring period.

The greatest difference in groundwater quality was between the Kyalla and Velkerri well sites for a range of water quality parameters, the most notable being salinity related variables such as total dissolved solids, electrical conductivity and chloride concentration. Velkerri well site, situated approximately 70 km east of Kyalla well site, was markedly “fresher” than Kyalla in both the Anthony Lagoon aquifer and the Gum Ridge aquifer. Water quality was very similar between the Anthony Lagoon aquifer and the Gum Ridge aquifer at Kyalla. At Velkerri, the deeper Gum Ridge aquifer was slightly more saline than the overlying Anthony Lagoon aquifer.

Figure 2 provides graphical presentation of the baseline quartile ranges for key “indicator” analytes in the Gum Ridge and Anthony Lagoon aquifers at the Kyalla well site. Figure 3 presents similar data at the Velkerri well site.

Each analyte has been scaled appropriately as shown in the horizontal axis. For example, electrical conductivity is divided by a factor of 10 so in the Gum Ridge aquifer the quartile range is approximately 1140 to 1340  $\mu\text{S}/\text{cm}$  at Kyalla. Similarly gross alpha is multiplied by a factor of 100 so in the Gum Ridge aquifer the quartile range is approximately 0.83 to 1.96 Bq/L. Average values for all analytes in both aquifers were below drinking water guidance values except for gross alpha radionuclides. Radionuclides (both alpha and beta) also had the largest variation in the range of values among the key analytes, as can be seen in Figure 1. While groundwater may on occasion exceed gross alpha drinking water standard in the Gum Ridge aquifer (Table 1) at both Kyalla and Velkerri, this is not uncommon in groundwater systems where concentrations of dissolved natural constituents can build up during prolonged periods of water/rock contact. For example, similar results have been reported around Katherine (1996):

<https://www.territorystories.nt.gov.au/jspui/bitstream/10070/228526/1/WRD96073.pdf>

The groundwater will continue to be monitored in accordance with the Code and the Preliminary Guideline: Groundwater Monitoring Bores for Exploration Petroleum Wells in the Beetaloo sub-basin (2018).

## Conclusion

In accordance with the Code and Ministerial condition of approval of the EMP, results of ongoing groundwater monitoring must be provided by Origin every quarter for three years from the approval date of the EMP (13 September 2019 and 23 December 2019 for Kyalla and Velkerri EMP respectively). This data will be reported and published on the DENR website as they become available.

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Table 1: Average and standard deviation results for key 'indicator' analytes for Origin control monitoring bores, at in the Gum Ridge aquifer and Anthony Lagoon aquifer at the Kyalla and Velkerri well sites.

Key analyte	Drinking Water Guidance	KYALLA Anthony Lagoon aquifer n = 12	KYALLA Gum Ridge aquifer n = 12	VELKERRI Anthony Lagoon aquifer n = 3	VELKERRI Gum Ridge aquifer n = 2
Standing Water Level AHD (m)	-	156.0 ± 0.1	155.9 ± 0.02	N.A.	N.A.
Total Dissolved Solids (mg/L)	600	711 ± 37	711 ± 60	356 ± 14	454 ± 23
Total Alkalinity (mg/L)		260 ± 20	294 ± 19	342 ± 8	349 ± 4
Electrical Conductivity (µS/cm)	< 2,500	1226 ± 78	1231 ± 86	674 ± 8	865 ± 45
Chloride (mg/L)	~ 250	171 ± 9	160 ± 5	8 ± 0.6	42 ± 1
Barium (mg/L)	0.7	0.08 ± .02	0.066 ± .006	0.063 ± 0.003	0.057 ± .001
Boron (mg/L)	4.0	0.21 ± 0.02	0.21 ± 0.008	0.22 ± 0.01	0.08 ± 0.001
Strontium (mg/L)	N.A.	0.66 ± 0.04	0.81 ± 0.06	0.80 ± 0.06	0.31 ± 0.03
Methane mg/L	N.A.	0.03 ± 0.01	<0.01	0.013 ± 0.0005	0.03 ± 0.01
Gross alpha (Bq/L)	0.5	0.34 ± 0.06	1.36 ± 0.27	1.08 ± 0.45	1.4 ± 0.2
Gross beta (Bq/L)	1.0	0.23 ± 0.1	0.48 ± 0.2	0.50 ± 0.21	0.52 ± 0.09

Groundwater monitoring results at Origin Kyalla and Velkerri well sites in the Beetaloo sub-basin in accordance with the Code of Practice: December 2018 – December 2019

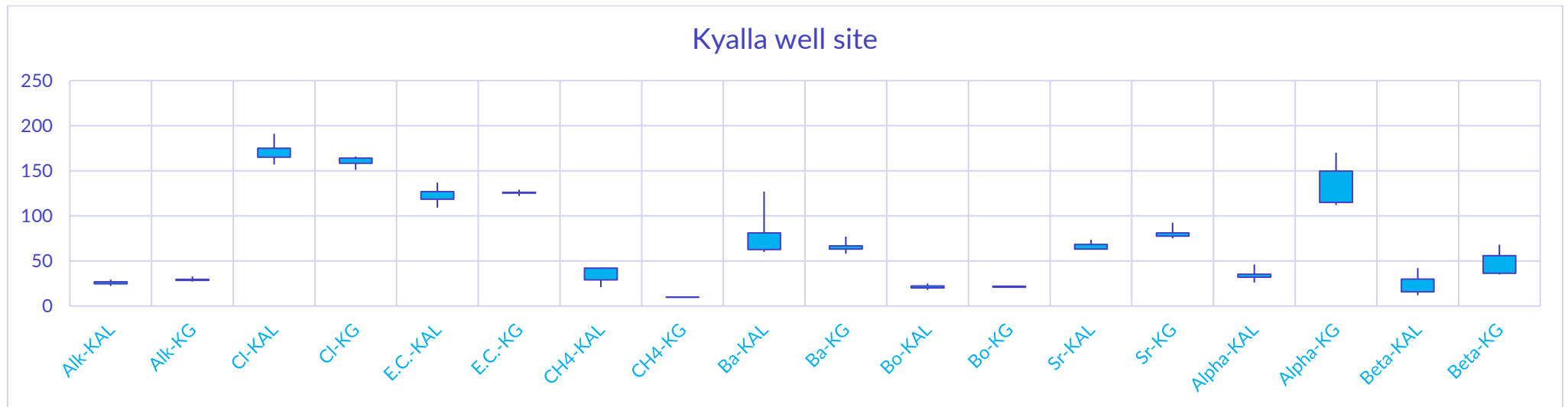


Figure 2: Natural background quartile ranges for key “indicator” analytes in the Gum Ridge aquifer (KG) and Anthony Lagoon aquifer (KAL) at the Kyalla well site based on sampling events from Dec’18 to Dec ’19. Analytes have been scaled for graphical presentation.

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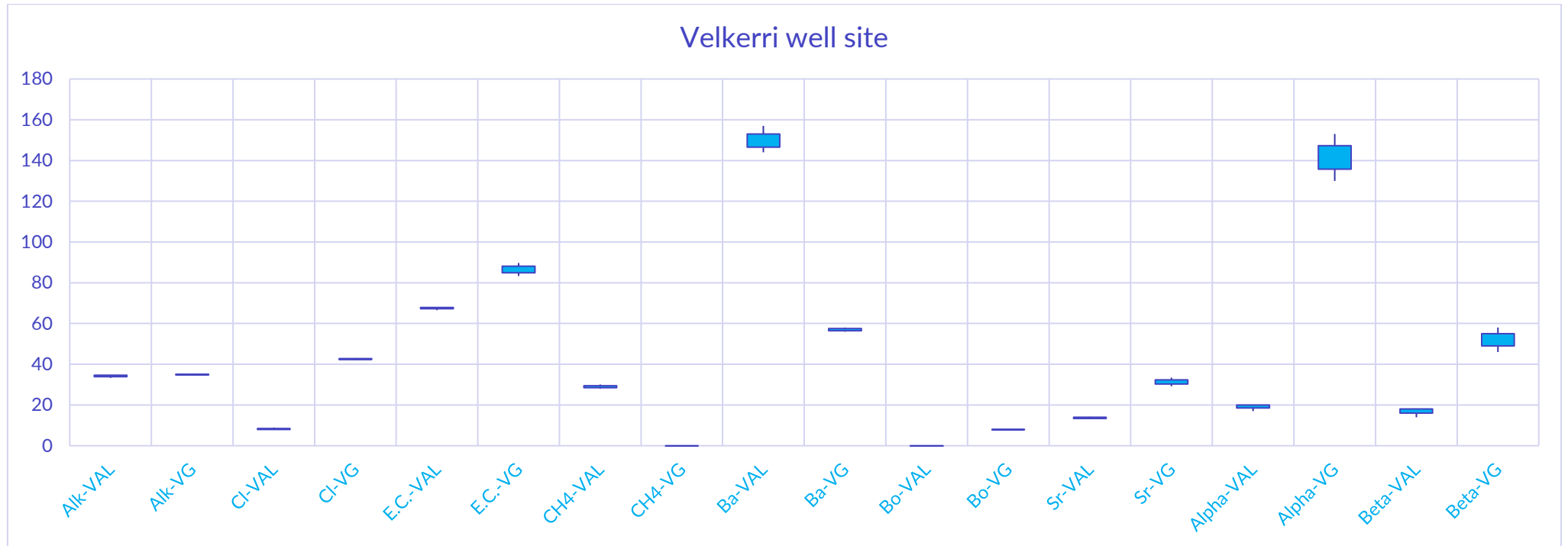


Figure 3: Natural background quartile ranges for key “indicator” analytes in the Gum Ridge aquifer (VG) and Anthony Lagoon aquifer (VAL) at the Velkerri well site based on sampling events from Nov’19 to Dec ’19. Analytes have been scaled for graphical presentation.







origin



Format Exceedances

Metals

	Barium	Barium (Filtered)	Boron	Boron (Filtered)	Cadmium	Cadmium (Filtered)	Chromium (III-VI)	Chromium (III-VI) (Filtered)	Copper	Copper (Filtered)	Iron	Iron (Filtered)	Lead	Lead (Filtered)	Lithium	Lithium (Filtered)	Manganese	Manganese (Filtered)	Mercury	Mercury (Filtered)	Nickel	Nickel (Filtered)	Selenium	Selenium (Filtered)	Silver	Silver (Filtered)	Strontium	Strontium (Filtered)	Zinc	Zinc (Filtered)	Acenaphthene	Acenaphthylene	Anthracene	Benz(a)anthracene	Benz(a)pyrene	Benzofluorene TEQ (zero)
EQI	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	
ADWG 2015 Aesthetic	0.001	0.001	0.05	0.05	0.0001	0.0001	0.001	0.001	1	1	0.05	0.05	0.001	0.001	0.001	0.001	0.001	0.001	0.0001	0.0001	0.001	0.001	0.01	0.01	0.001	0.001	0.001	0.001	0.005	0.005	1	1	1	1	0.5	0.5
ADWG 2015 Health	2	2	4	4	0.002	0.002	1	1	2	2			0.01	0.01			0.5	0.5	0.001	0.001	0.02	0.02	0.01	0.01	0.1	0.1									0.01	
ANZECC Water Quality Guidelines for Livestock 2000			5	5	0.01	0.01	1	1	0.5	0.5			0.1	0.1					0.002	0.002	1	1	0.02	0.02				20	20							

Location_Code	Alternative_Name	Sampled_Date_Time	Barium	Barium (Filtered)	Boron	Boron (Filtered)	Cadmium	Cadmium (Filtered)	Chromium (III-VI)	Chromium (III-VI) (Filtered)	Copper	Copper (Filtered)	Iron	Iron (Filtered)	Lead	Lead (Filtered)	Lithium	Lithium (Filtered)	Manganese	Manganese (Filtered)	Mercury	Mercury (Filtered)	Nickel	Nickel (Filtered)	Selenium	Selenium (Filtered)	Silver	Silver (Filtered)	Strontium	Strontium (Filtered)	Zinc	Zinc (Filtered)	Acenaphthene	Acenaphthylene	Anthracene	Benz(a)anthracene	Benz(a)pyrene	Benzofluorene TEQ (zero)	
RN040896	KYA117-N2 CMB-AL	1/02/2019	0.06	0.051	0.25	0.22	<0.0001	<0.0001	<0.001	<0.001	0.001	<0.001	0.68	0.4	0.004	0.003	0.056	0.052	0.023	0.017	<0.0001	<0.0001	0.002	<0.001	<0.01	<0.01	<0.001	<0.001	0.694	0.611	0.018	0.008	<1	<1	<1	<1	<0.5	<0.5	
RN040896	KYA117-N2 CMB-AL	23/02/2019	0.122 - 0.127	0.104 - 0.105	0.2 - 0.21	0.19 - 0.2	<0.0001	<0.0001	0.002	<0.001	<0.001	<0.001	2.56 - 2.8	<0.05	<0.001	<0.001	0.066 - 0.068	0.056 - 0.058	0.119 - 0.124	0.076 - 0.078	<0.0001	<0.0001	0.001 - 0.003	<0.001	<0.01	<0.01	<0.001	<0.001	0.673 - 0.686	0.564 - 0.59	0.011 - 0.012	<0.005	<1	<1	<1	<1	<0.5	<0.5	
RN040896	KYA117-N2 CMB-AL	23/02/2019	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
RN040896	KYA117-N2 CMB-AL	20/03/2019	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
RN040896	KYA117-N2 CMB-AL	20/03/2019	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
RN040896	KYA117-N2 CMB-AL	20/03/2019	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
RN040896	KYA117-N2 CMB-AL	20/03/2019	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
RN040896	KYA117-N2 CMB-AL	20/03/2019	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
RN040896	KYA117-N2 CMB-AL	20/03/2019	0.08	0.087	0.22	0.23	<0.0001	<0.0001	<0.001	<0.001	0.012	<0.001	0.53	0.6	0.006	<0.001	0.052	0.055	0.047	0.05	<0.0001	<0.0001	0.016	0.002	<0.01	<0.01	<0.001	<0.001	0.736	0.718	0.026	0.007	<1	<1	<1	<1	<0.5	<0.5	
RN040896	KYA117-N2 CMB-AL	3/05/2019	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
RN040896	KYA117-N2 CMB-AL	3/05/2019	0.085 - 0.089	0.081 - 0.082	0.2	0.2	<0.0001	<0.0001	<0.001	<0.001	<0.001	<0.001	0.6 - 0.65	0.52 - 0.57	<0.001	<0.001	0.05 - 0.051	0.048 - 0.05	0.045 - 0.047	0.04 - 0.042	<0.0001	<0.0001	<0.001	<0.001	<0.01	<0.01	<0.001	<0.001	0.624 - 0.631	0.594 - 0.611	<0.005	<0.005	<1	<1	<1	<1	<0.5	<0.5	
RN040896	KYA117-N2 CMB-AL	3/06/2019	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
RN040896	KYA117-N2 CMB-AL	3/06/2019	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
RN040896	KYA117-N2 CMB-AL	3/06/2019	0.084	0.077	0.21	0.21	<0.0001	<0.0001	<0.001	<0.001	0.011	<0.001	1.66	1.55	0.002	<0.001	0.051	0.051	0.067	0.063	<0.0001	<0.0001	0.018	0.002	<0.01	<0.01	<0.001	<0.001	0.707	0.629	0.098	0.015	<1	<1	<1	<1	<0.5	<0.5	
RN040896	KYA117-N2 CMB-AL	3/06/2019	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
RN040896	KYA117-N2 CMB-AL	4/07/2019	0.079	0.075	0.23	0.22	<0.0001	<0.0001	<0.001	<0.001	<0.001	<0.001	0.69	0.55	<0.001	<0.001	0.051	0.053	0.043	0.041	<0.0001	<0.0001	0.001	<0.001	<0.01	<0.01	<0.001	<0.001	0.679	0.657	0.012	<0.005	<1	<1	<1	<1	<0.5	<0.5	
RN040896	KYA117-N2 CMB-AL	4/07/2019	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
RN040896	KYA117-N2 CMB-AL	17/08/2019	0.067	0.064	0.18	0.21	<0.0001	<0.0001	<0.001	<0.001	<0.001	<0.001	1.09	0.89	<0.001	<0.001	0.059	0.063	0.052	0.046	<0.0001	<0.0001	0.003	<0.001	<0.01	<0.01	<0.001	<0.001	0.65	0.65	0.016	<0.005	<1	<1	<1	<1	<0.5	<0.5	
RN040896	KYA117-N2 CMB-AL	17/08/2019	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
RN040896	KYA117-N2 CMB-AL	14/09/2019	0.063	0.06	0.2	0.21	<0.0001	<0.0001	<0.001	<0.001	<0.001	<0.001	0.69	0.78	<0.001	<0.001	0.056	0.063	0.041	0.043	<0.0001	<0.0001	0.001	<0.001	<0.01	<0.01	<0.001	<0.001	0.627	0.618	0.01	0.009	<1	<1	<1	<1	<0.5	<0.5	
RN040896	KYA117-N2 CMB-AL	14/09/2019	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
RN040896	KYA117-N2 CMB-AL	16/10/2019	0.062	0.059	0.22	0.21	<0.0001	<0.0001	<0.001	<0.001	0.001	<0.001	0.58	0.45	<0.001	<0.001	0.052	0.044	0.034	0.03	<0.0001	<0.0001	<0.001	<0.001	<0.01	<0.01	<0.001	<0.001	0.63	0.603	0.094	0.074	<1	<1	<1	<1	<0.5	<0.5	
RN040896	KYA117-N2 CMB-AL	16/10/2019	0.064	0.06	0.23	0.2	<0.0001	<0.0001	<0.001	<0.001	0.001	<0.001	0.54	0.4	<0.001	<0.001	0.053	0.045	0.033	0.029	<0.0001	<0.0001	<0.001	<0.001	<0.01	<0.01	<0.001	<0.001	0.651	0.61	0.08	0.073	<1	<1	<1	<1	<0.5	<0.5	
RN040896	KYA117-N2 CMB-AL	16/10/2019	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
RN040896	KYA117-N2 CMB-AL	26/11/2019	0.065	0.064	0.21	0.2	0.0001	<0.0001	<0.001	<0.001	<0.001	<0.001	1.25	0.88	<0.001	<0.001	0.045	0.043	0.038	0.037	<0.0001	<0.0001	<0.001	<0.001	<0.01	<0.01	<0.001	<0.001	0.642	0.655	0.155	0.135	<1	<1	<1	<1	<0.5	<0.5	
RN040896	KYA117-N2 CMB-AL	17/12/2019	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
RN040896	KYA117-N2 CMB-AL	17/12/2019	0.061	0.053	0.21	0.22	<0.0001	<0.0001	<0.001	<0.001	<0.001	<0.001	0.25	0.17	<0.001	<0.001	0.045	0.042	0.014	0.01	<0.0001	<0.0001	<0.001	<0.001	<0.01	<0.01	<0.001	<0.001	0.634	0.59	0.025	0.017	<1	<1	<1	<1	<0.5	<0.5	
RN041132	KYA117-N2 CMB-G	17/08/2019	0.067	0.062	0.2	0.25	<0.0001	<0.0001	<0.001	<0.001	0.007	0.002	2.54	0.89	0.006	<0.001	0.044	0.049</																					



