Presented to: bp Southern Africa (Pty) Ltd

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SAPIA_Climate Change Impacts on Remediation.

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End State Vision & Objectives

End State Vision

- To prevent impact to existing down gradient receptors, particularly residential borehole BH1

Remediation Objectives

- To comply with the Remediation Order
- To remove mobile, extractable LNAPL in the shallow aquifer to the prescribed ITRC transmissivity value (0.009 to 0.07 m2/d)
- To assess natural attenuation through bi annual groundwater monitoring; and
- To conduct bi annual monitoring, as per the Remediation Order, in order to demonstrate that the plume is stable or receding in order to achieve no further action

Stakeholders

- Residential borehole owners BH1, BH2 and BH3
- Bp owner / site manager
- Regulators (DFFE & DWS)

Site Setting

- Hydrogeology
  - The site is underlain by an intergranular and fractured rock aquifer
  - The aquifer is classified as a minor aquifer of moderate vulnerability and medium susceptibility to surface contamination
  - Borehole logs indicate that the regional intergranular fractured aquifer coincides with the moderately weathered fractured shale identified at depths of approximately 12 m bgl. GW 9m bgl
  - Hydrocarbon impacts are observed above the perched groundwater conditions in the shallow aquifer

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LNAPL Skimming System Performance (2018-2022)

- The LNAPL skimming remediation system was installed in November 2018
- The system comprises of seven Xitech™ skimmer pumps which are programmed to activate within specific time frames
- Recovered LNAPL and groundwater is collected into an oil / water storage tank where the groundwater is manually pumped through two GAC filters in lead / lag configuration into a 1,000L flow bin

Site Setting

- Groundwater Levels (Feb 2023 – Feb 2024)
  - All gauged groundwater monitoring wells have shown some seasonal variation over the 12 month period. to February 2024 with close to historic highs in January 2024, most likely as a result of the extended La Nina climatic event.
  - While there was some decreasing trends towards the end of the winter months, groundwater levels appeared to increase again in January 2024.
- Groundwater Levels (Jan 2016 – Feb 2023)
  - There has been a significant increase in water levels, particularly from November 2020 onwards, since the initial gauging at the site in January 2016.
  - Whilst some water levels have decreased, they have not decreased back to those historic levels observed prior to November 2020

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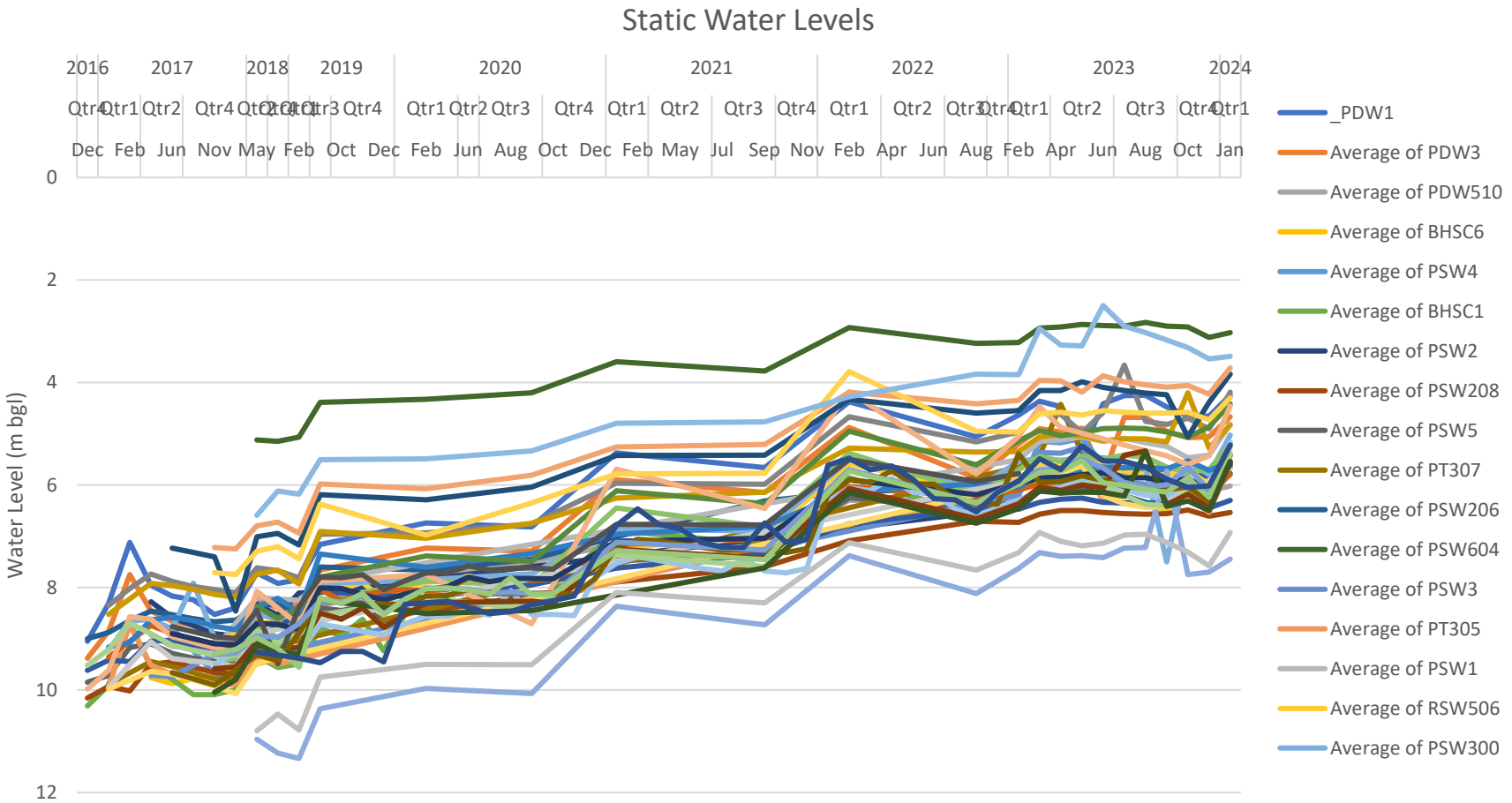
Site Setting

- Groundwater Level Trends – (December 2016 - January 2024)



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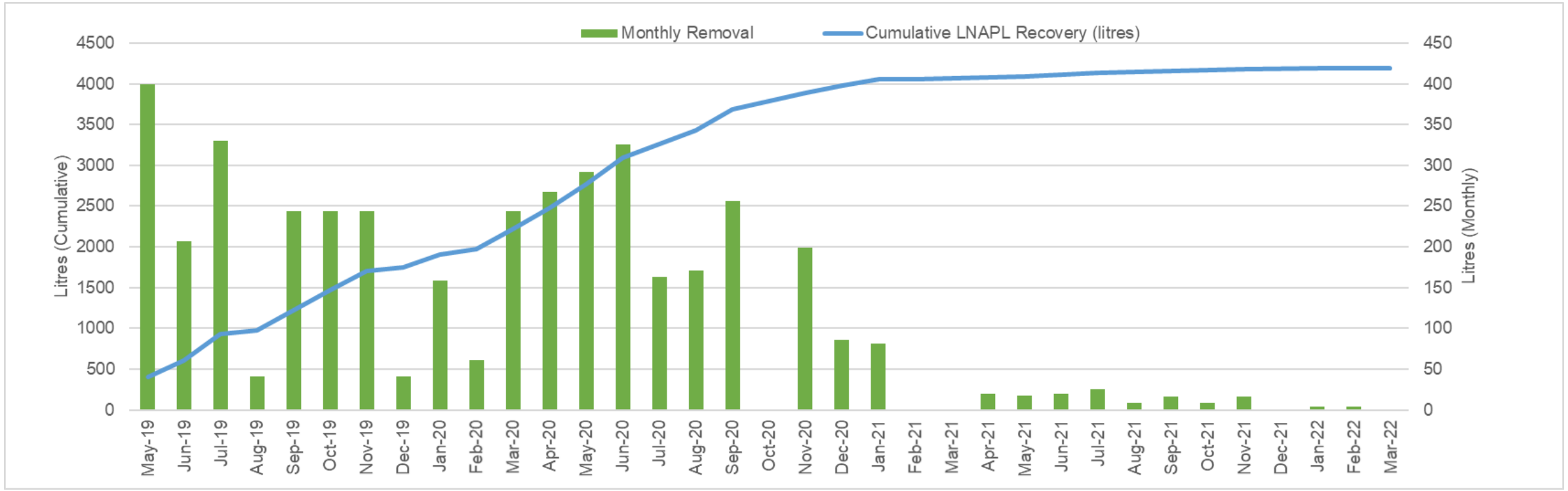
LNAPL Recovery – Cumulative vs Monthly

Graph showing reduced LNAPL recovery since Nov/Dec 2020



Temporary System Shutdown

- The skimming system was placed into temporary shutdown on 4 November 2022 due to reduced LNAPL recovery rates (see graphs on previous slides)
- A total volume of approximately 4,193 L LNAPL had been extracted up until 4 November 2022
- A contingency plan was developed should conditions change (increase in LNAPL thickness)
- Monthly monitoring was conducted from December 2022 and is currently ongoing

LNAPL Monitoring Contingency Plan

Risk Management Category	Selected Risk Mitigation Strategy	Remedial Technology Endpoint (When do we stop?)		Contingency Measures (When may we need to take action?)	
		Key Performance Criteria	Trigger Condition	Trigger Condition	Mitigation Actions
Product mobility risk management	PSH recovery through passive skimming	• Stable to decreasing trends in measured LNAPL thicknesses, relative to Corrected Water Level • Cumulative recovery volumes • Recovery rates • LNAPL transmissivity • LNAPL plume extent	• Where apparent LNAPL thickness is >150mm, Tn < 0.01m²/day • System cumulative recovery curves and decline curve analyses indicate that asymptotic recovery conditions have been achieved • No new occurrence of LNAPL is observed in monitoring wells within the monitoring network, relative to Corrected Water Level	• Significant increase in apparent LNAPL thicknesses in wells that causes an increase in Tn • Appearance of LNAPL in wells that were previously not impacted by LNAPL, relative to Corrected Water Level • Appearance of LNAPL in wells where dissolved phase concentrations were not indicative of LNAPL smear zone conditions (LNAPL smear zone indicative conditions: Benzene > 1,000ug/L - 2,000ug/L, GRO > 10,000ug/L)	• Conduct LNAPL transmissivity tests in wells with sufficient LNAPL (i.e. >150mm) to assess transmissivity and potential migration risk • Determine appropriate LNAPL recovery action, where Tn > 0.01 m²/day, until endpoint conditions are reconfirmed.
Groundwater ingestion & use risk management	Monitoring of groundwater quality from private wells BH1, BH2 and BH3 to be protective of end use (irrigation)	• Tier 1 analytical compounds (BTEX, GRO, EPH, MTBE)	• COPCs below detection limits and/or below adopted health based screening criteria	• COPCs exceed adopted health based screening criteria	• Engage private well owners to temporarily cease use of the wells; • Use of alternative water supplies (e.g. municipal water) • Consider wellhead treatment or other corrective action as part of response action

	Monitored natural attenuation of dissolved plume	• Reduction in Tier 1 analytical compounds (BTEX, GRO, EPH)
		• Tier 2 analytical compounds (DO, SO4, NO3, Fe, Mn) indicate that natural attenuation processes are occurring
			• Dissolved plume is confirmed to be stable and poses no new or additional risks to surrounding receptors
			• Plume stability confirmed by stable plume centre of mass and stable mass flux trends in down gradient monitoring wells
			• Engage Regulator(s)
				• Dissolved plume observed to be expanding and/or detections noted in clean margin wells
				• Plume stability assessments indicate:
				  ○ Increase plume mass, and/or
				  ○ Down-gradient migration of plume centre of mass, and/or
				  ○ Increases in mass flux trends in down gradient monitoring wells
					• Increase monitoring frequency of private wells to assess whether impacts are noted (and if so apply the mitigation approach in the above row)
					• Determine appropriate remedial/monitoring options to address plume expansion
					• Integrity assessment of USTS infrastructure
					• Engage Regulator(s)

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Conclusions & Recommendations

Monitoring data over the period November 2022 – February 2024 was assessed and evaluated against remedial technology endpoint

LNAPL Plume

- No new occurrence of LNAPL observed in monitoring wells within network indicating LNAPL plume extent is not increasing
- No significant increases in LNAPL thickness in monitoring wells with exception of PSW1 where trigger condition was realised. No LNAPL rebound observed post bail down test indicting low Tn
- Stable to decreasing trends in LNAPL thickness in majority of LNAPL wells

Dissolved Phase Plume

- Dissolved phase COPC concentrations generally stable
- No COPC concentrations detected in any of the four deep wells
- MTBE concentrations stable in BH1, non-detect in BH2, BH3

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Conclusions & Recommendations

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Conclusions & Recommendations

- Internal Evaluation - Inherent risks associated with skim system decommissioning
- Regulatory alignment.