**BEFORE THE INDEPENDENT COMMISSIONER**

**AT DUNEDIN**

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| **UNDER** | Resource Management Act 1991 (**RMA**) |
| **IN THE MATTER** | of an application for discharge permits by Mobil Oil New Zealand Limited (**Application**) |

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**STATEMENT OF EVIDENCE OF ANDREW HART**

**ON BEHALF OF**

**MOBIL OIL NEW ZEALAND LIMITED**

**16 JANUARY 2023**

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**Qualifications and Experience**

1. My full name is Andrew Thomas Hart.

2. I currently hold the position of Technical Principal – Contaminated Land at WSP New Zealand Limited (**WSP**). Prior to this I held the position of Associate and Senior Environmental Scientist at Golder Associates (NZ) Limited (**Golder**). In April 2021, Golder was acquired by WSP. In my current role at WSP, I provide technical direction on contaminated land assessment and remediation projects for a wide range of clients including in the oil and gas, manufacturing and urban development sectors.

3. I have 17 years' experience as an environmental consultant with particular expertise in the assessment and management of contaminants in the environment including the assessment of potential risks to human health and the effects of discharges of contaminants of soil and groundwater. I have the following qualifications and relevant experience:

   a) I hold a Bachelor of Science (BSc) degree in Geography (2001) and a Master of Science with Honours degree in Geography (2004) from the University of Otago.

   b) I have led and continue to lead the assessment and management of a portfolio of petroleum hydrocarbon impacted site for more than 10 years both in New Zealand and Australia.

   c) I led the assessment and consenting process to address legacy soil and groundwater impacts at a former bulk fuel terminal in Hamilton.

   d) I led the contaminated land assessment for design of the new arena Te Kaha in Christchurch which included providing specialist contaminated land advice during the consenting process for the project.

   e) I was the contaminated land specialist during the consenting stage of the City Rail Link in Auckland which included providing expert evidence to support the consent hearings.

   f) I have provided technical review and advice, including supporting cases in front of the District and High Courts in relation to the adequacy of contaminated land assessments involving the storage and handing of waste chemicals, effects associated with shooting ranges and asbestos identified during a residential subdivision.

g) I have prepared guidance documents for the Ministry for the Environment including in relation to the application of bioavailability in contaminated land site-specific health risk assessment.

4. I have read the Code of Conduct for Expert Witnesses as contained in the Environment Court Practice Note 2023, and I agree to comply with it as if this hearing was before the Environment Court. My qualifications as an expert are set out above. I confirm that the issues addressed in this brief of evidence are within my area of expertise. I have not omitted to consider material facts known to me that might alter or detract from the opinions expressed.

**Scope of Evidence**

5. In my evidence, I will:

a) Describe my involvement in the Application, and provide an overview of the key elements of the Application that relate to my area of expertise.

b) Summarise the reports provided in support of the Applications, including additional assessments or analysis that I have undertaken since the Application was filed.

c) Respond to matters raised in submissions relevant to my area of expertise.

d) Respond to matters in the Section 42A Report (**Officer's Report**) that relate to my area of expertise.

e) Comment on the proposed conditions of consent, including any changes to those conditions that I recommend.

6. My evidence is supported by the following documents which were prepared to support the Application and additional assessment work following lodgement of the Application:

a) Golder 2022. Resource Consent Application and Assessment of Effects on the Environment – Discharge of Contaminants. Former Mobil Dunedin Terminal – 199 Fryatt Street, Dunedin. Prepared by Golder Associates (NZ) Limited for Mobil Oil New Zealand Ltd, February 2022.

b) Golder 2019a. Former Mobil Dunedin Terminal – 199 Fryatt Street, Dunedin. Closure Report. Prepared by Golder Associates (NZ) Limited for Mobil Oil New Zealand Ltd, November 2019.

c) Golder 2019b. Former Mobil Dunedin Terminal – 199 Fryatt Street, Dunedin. Environmental Site Assessment. Prepared by Golder Associates (NZ) Limited for Mobil Oil New Zealand Ltd, November 2019.

d) Golder 2020a. Former Mobil Dunedin Terminal – 199 Fryatt Street: Environmental Management Plan. Prepared by Golder Associates (NZ) Limited for Mobil Oil New Zealand Ltd, March 2020.

e) Golder 2020b. Former Mobil Dunedin Terminal – 199 Fryatt Street: Environmental Management Plan – Fryatt Street Adjacent to Former Terminal. Prepared by Golder Associates (NZ) Limited for Mobil Oil New Zealand Ltd, March 2020.

f) WSP 2022a. Response to Request for Further Information – RM22.099 – Mobil Oil New Zealand Limited. Prepared by WSP New Zealand Limited for Mobil Oil New Zealand Ltd, 1 August 2022.

g) WSP 2022b. Phase 1 Review of Per-and Polyfluoroalkyl Substances (PFAS), Former Mobil Dunedin Terminal –199 Fryatt Street, Dunedin. Prepared by WSP New Zealand Limited for Mobil Oil New Zealand Ltd, July 2022.

h) WSP 2022c. Response to Request for Further Information – RM22.099 – Mobil Oil New Zealand Limited. Prepared by WSP New Zealand Limited for Mobil Oil New Zealand Ltd, 25 October 2022.

i) WSP 2023. Former Mobil Dunedin Terminal – Sampling of Halsey Street Stormwater Network. Prepared by WSP New Zealand Limited for Mobil Oil New Zealand Ltd, 12 January 2023.

7. In addition to the above documents, my evidence is also supported by documents prepared as part of previous environmental site assessment (**ESA**) works undertaken at the site. A list of these documents is attached as Appendix A to this evidence.

**Background and Role**

8. Mobil Oil New Zealand Limited (**Mobil**) has applied to Otago Regional Council (**ORC**) for resource consents to authorise the discharge of residual petroleum hydrocarbon impacts onto or into land from the former Mobil Dunedin Terminal located at 199 Fryatt Street, Dunedin (**Former Mobil Terminal**).

9. Specifically, Mobil has applied to ORC for the following resource consents:

    a) A discharge permit for the discharge of hazardous waste onto or into land in circumstances that may result in that hazardous waste entering water, pursuant to Rule 5.6.1(3) (discretionary activity) of the Regional Plan: Waste for Otago (**Waste Plan**).

    b) A discharge permit for the discharge of any hazardous substance to water or onto or into land in circumstances which may result in that substance entering water, pursuant to Rule 12.B.4.2 (discretionary activity) of the Regional Plan: Water for Otago (**Water Plan**).

10. WSP (and its predecessor Golder) has been engaged by Mobil since 2014 to undertake ESA works to assess the nature and extent of chemical impacts to soil and groundwater associated with historical fuel storage at the site (the **Project**).

11. My role on the Project has been to provide technical support to investigation programmes undertaken by Golder, and recently by WSP, and to prepare the technical reports on behalf of Mobil in support of the Application.

12. I am familiar with the physical environment of the Former Mobil Terminal and surrounding land and have visited the site during the investigation programme.

**Summary of Environmental Site Assessment Works**

13. Mobil ceased operations at the Former Mobil Terminal in 1995 and decommissioned the facility between 1995 and 2007.

14. Mobil has progressively undertaken ESA works at the Former Mobil Terminal, both on site and off site, between 1992 and 2017. The ESA works have been undertaken in an iterative manner. A summary of the timing and scope of the ESA works is provided in Appendix B.

15. The ESA works undertaken to date form the basis for development of a robust conceptual site model (**CSM**) and provide an understanding of the extent of residual impacts to soil, groundwater and soil vapour and the associated risks to human health and the environment. The time-series of the ESA data also provides for an understanding of the stability and attenuation of residual Light Non-Aqueous Phase Liquid[1] (**LNAPL**) and dissolved phase hydrocarbons in groundwater.

16. A Phase 1 ESA was completed for the Former Mobil Terminal in 2007 (Pattle Delamore Partners Limited (**PDP**) 2007). The Phase 1 ESA:

    a) Documents the site history;

    b) Identifies the type and location of activities with the potential to result in contamination; and

    c) Presents the inventory of products stored.

17. As such, the Phase 1 ESA establishes the preliminary CSM including the primary contaminants of interest at the site. Given the iterative nature of ESA works, it is common industry practice to leverage and build on existing information rather than generate replicate data. Key potential sources of contamination were identified to comprise the following:

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1 A light non-aqueous phase liquid (e.g., petroleum oil, gasoline, diesel fuel) that has a density less than water and is immiscible with water (ITRC 2018).

a) Bulk storage ASTs –13 ASTs principally storing leaded and unleaded petrol, diesel, slops, turpentine, kerosene and white spirits (Stoddard Solvent). Lubricants were not stored onsite (PDP 2007).

b) Rail car loading/unloading rack along the south-east site boundary.

c) Drum storage in the north-west corner of the site and drum filling midway along the west area of the site.

d) Small tanker wagon fill station in the west area of the site.

e) Tank sludge.

18. As outlined in the Phase 1 ESA, the primary contaminants of interest were identified to be petroleum hydrocarbons and metals (primarily lead). Based on the identified sources of contamination, the ESA works included analysis of media including:

a) Soil – total petroleum hydrocarbons (**TPH**), benzene, toluene, ethylbenzene and xylenes (**BTEX**), polycyclic aromatic hydrocarbons (**PAH**) including naphthalene, and a suite of metals including arsenic, cadmium, chromium, copper, lead, nickel and zinc. Historical testing also included analysis for organic lead in areas where "weathered sludge from the weathering slab had been buried" (PDP 1994).

b) Groundwater – dissolved TPH, dissolved BTEX, dissolved PAH, dissolved metals and a suite of geochemical parameters including nitrate-nitrogen, sulphate, dissolved iron and dissolved manganese.

c) Soil vapour – volatile organic compounds, aromatic and aliphatic hydrocarbons, oxygen, carbon dioxide and methane.

d) LNAPL – fingerprinting using gas chromatogram along with in situ characterisation using laser induced fluorescence[2] (**LIF**).

19. The sampling and analysis undertaken during the ESA works carried out prior to and following the Phase 1 ESA is consistent with the historical land use

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[2] LIF is a field-portable system that detects NAPL in the subsurface, including most refined fuels through heavy crude petroleum. LIF employs laser light to excite fluorescent molecules in NAPL, including jet fuel/kerosene, petroleum fuels/oils, coal tars, and creosotes. Under the right conditions, the intensity of the fluorescence is proportional to the quantity of the NAPL present (ITRC 2019).

activities at the site and the identified contaminants of interest at the time of the ESA works.

**Key Findings of ESA Works**

20. The programme of ESA works culminated in the preparation of a Closure Report (the **Closure Report** (Golder 2019a)). The CSM presented in the Closure Report was based on the direct assessment of soil, groundwater, and soil vapour supported by in-situ assessment of LNAPL. The Closure Report incorporated the results of previous ESA work commissioned by Mobil (PDP 1992, 1994, 2007, 2011, 2012, 2013; Golder 2014, 2015) including a programme of supplementary ESA works undertaken between 2014 and 2017 to delineate the extent of residual petroleum hydrocarbon impacts on and off the site, principally focussing on the extent of LNAPL (Golder 2019b).

21. The following provides a summary of the key findings of the ESA works as presented in the Application documents.

**Environmental Setting**

22. The Former Mobil Terminal is located in an industrial area of Dunedin and surrounded by commercial/industrial land uses. Surrounding land uses include a Z Energy Limited bulk fuel storage terminal across Akaroa Street to the north-east, a Fulton Hogan Limited bitumen plant and HarbourCold cold store facility across Fryatt Street to the east/south-east, and a mix of commercial and industrial businesses to the south and west along Halsey Street and Jutland Street.

23. The nearest surface water body is Otago Harbour which is located approximately 60 m to the south-east across Fryatt Street. The Former Mobil Terminal is located adjacent to the upper harbour basin which comprises a highly modified environment as a result of reclamation, road works and dredging activities (URS-Opus 2011).

24. The sensitivity of groundwater was assessed as part of the ESA works. The assessment, as presented in Section 2.4.6 of the Closure Report (Golder 2019a), considered that although the site is located within 60 m of Otago Harbour, the shallow aquifer would be classified as not sensitive with respect to abstractive use and environmental discharges for the following reasons:

a) No registered groundwater abstractions for potable, irrigation or stockwater use purposes are located within 1.5 km of the site with registered wells mainly used for monitoring or geological investigation purposes.

b) Unregistered potable abstractions are considered unlikely given the proximity of Otago Harbour (low groundwater quality) and the presence of a reticulated supply in the vicinity of the site.

c) Previous ESA works have not documented the presence of LNAPL in monitoring wells installed immediately adjacent to Otago Harbour (Golder 2019b; PDP 2011, 2013).

d) Otago Harbour is a large water body and would facilitate significant dilution as outlined in Section 5.2.3 of MfE (2011).

25. The area of the Former Mobil Terminal and surrounding land comprises reclaimed land constructed during the early 1900s. The subsurface geology (presented in Section 2.4.4 of the Closure Report) is consistent with these reclamation activities and investigations have shown the Former Mobil Terminal to be underlain by the following geological sequence:

a) Fill comprising:

i. Gravel (sandy fine gravel) predominately from surface to 0.7 m below ground level (**m bgl**), however the fill extends to depths up to 2 to 3 m bgl beneath and between former Tank 1 and Tank 8, and the southern corner of the site.

ii. Sand (fine to medium coarse, often with shells and varying amounts of silt) with discontinuous layers of silt or gravels at varying thicknesses underlies the gravel fill unit. This sand unit extends to between 4.5 and 5 m bgl.

b) Marine sediments – Clayey silt and silty clay between 4.5 m and about 8.0 m bgl. These deposits are inferred to comprise the historical harbour sediments underlying the fill material. Competent material (possibly bedrock) was encountered below about 8 m bgl.

26. A shallow unconfined aquifer system is present within the fill material, with groundwater present at depths between approximately 0.45 m and 3.0 m bgl based on data collected between November 2015 and April 2017 (refer Table 3 of the Closure Report (Golder 2019a)). Measured groundwater elevations have ranged between 100.115 m relative level (**m RL**) (BHA)[3] and 101.875 m RL (BH26) in November 2015, 100.475 m RL (BH29) and 102.654 m RL (BH23) in June 2016, and 100.801 m RL (BH46) and 102.852 m RL (BH56) in April 2017. Groundwater levels are typically lower (up to 0.5 m) in monitoring wells located closer to Otago Harbour than those located in the centre or north-west of the site.

27. The shallow groundwater system in the area of Fryatt Street and in close proximity to the harbour shows evidence of tidal influence (up to 0.23 m), while little or no tidal influence was noted within the confines of the Former Mobil Terminal (maximum ~ 0.002 m). Tidal influence on the groundwater system is also evident in the groundwater electrical conductivity which has been measured to range from 400 µS/cm to 2,009 µS/cm (Golder 2019a).

**Soil Quality**

28. As documented in Section 6.0 of the Golder (2019b) ESA Report, petroleum hydrocarbon impacted soil was identified primarily in the south-west of the Former Mobil Terminal. The highest concentrations were identified in soils adjacent to the former drum rack, former 45,400 L kerosene AST, former drum fill and pumps in the south-west, in the footprint of former Tank 5, and to the south of the tank farm bund wall along the Fryatt Street boundary. These site features are shown on Figure 3 in the Closure Report (Golder 2019a).

29. Hydrocarbon impacts to soil are generally characterised by $C_7$-$C_9$ TPH, $C_{10}$-$C_{14}$ TPH and total xylenes with the highest concentrations present between 1.0 m and 4.0 m bgl including in soils below the groundwater table.

30. The Closure Report (Golder 2019a) presents an assessment of the nature and extent of on-site soil impacts associated with historical bulk fuel storage activities at the Former Mobil Terminal. The assessment involved the comparison of concentrations of petroleum hydrocarbons in on-site soils with

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3 The references in brackets in this sentence are references to monitoring wells.

Ministry for the Environment (MfE 2011) commercial /industrial Tier 1 acceptance criteria.

31. Petroleum hydrocarbon concentrations in soil exceeded MfE (2011) Tier 1 acceptance criteria for a commercial/industrial land use. Primarily these exceedances have been identified for $C_7$-$C_9$ TPH, $C_{10}$-$C_{14}$ TPH and (total) xylenes and for specific criteria for the protection of excavation workers based on the inhalation pathway.

32. Evaluation of the soil quality data identifies that the bulk of the excavation worker criteria exceedances are present in soils between 1.0 m and 4.0 m bgl including in soils located below the groundwater table. The exceedances are primarily located in the former tank farm area to south-west of former Tank 5 and toward the southern corner of the site.

33. A limited number of exceedances of the indoor inhalation pathway, primarily for total xylenes were also identified. Exceedances of the indoor inhalation pathway were primarily located in soil samples collected at and below the groundwater table. As volatilisation is controlled by solubility, soil samples collected below the groundwater table cannot be used to assess vapour inhalation risk. Direct assessment of soil vapour concentrations was undertaken as discussed in paragraph 47 below.

**LNAPL Extent and Stability**

34. LNAPL is present in several monitoring wells located across the southern half of the Former Mobil Terminal, specifically the southern part of the former tank compound, drum filling site and tanker wagon fill station. The LNAPL consists predominately of diesel with some petrol. Given the heterogeneous nature of the fill, it is likely that the LNAPL does not comprise one single continuous layer. Rather, residual LNAPL is present as a series of smaller discontinuous LNAPL pockets with varying LNAPL saturations.

35. Overall the lateral extent of LNAPL has, and is continuing to contract over time. Monitoring has documented a reduction in in-well LNAPL thickness at many locations over the past decade. LNAPL bail down testing at the site indicates low LNAPL transmissivity, low recoverability and low mobility. As such, the

LNAPL is not considered to be mobile and does not pose a risk of migration towards or discharge into Otago Harbour.

**Dissolved Phase Contaminants**

36. Dissolved TPH, BTEX and naphthalene (**BTEXn**) and PAHs are present in groundwater beneath the Former Mobil Terminal and off site to the south beneath Fryatt Street and to a lesser extent Halsey Street. The detected concentrations are below MfE (2011) Tier 1 acceptance criteria based on the indoor air inhalation pathway. Naphthalene, ethylbenzene and m&p-xylene above adopted ANZG[4] (2018) guideline values[5] for the protection of marine ecosystems have been identified in a limited number of off-site monitoring wells (BH51, BH49, BH56 and BH41) within Fryatt Street.

37. The highest concentrations were identified in wells in close proximity to the inferred LNAPL extent (MW41 and MW49). It is important to note that monitoring wells immediately adjacent to Otago Harbour (BH53 and BH54) were below the adopted ANZG (2018) guideline values.

38. An assessment of the stability of the dissolved phase contaminant plume was undertaken using trend analysis, estimates of the plume velocity, attenuation rates and predicted plume lengths. The stability of dissolved phase plume is summarised below.

    a) The concentration trend for ethylbenzene, $C_{10}$-$C_{14}$ TPH and naphthalene, which are considered to be the key indicators of the dissolved phase petroleum hydrocarbon contamination, indicate that overall concentrations have decreased over the past decade.

    b) The assessment the ethylbenzene and naphthalene attenuation rates indicate that the dissolved phase contamination does not extend further than 40 m downgradient of the leading edge of the LNAPL.

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4 It is noted that the assessment of groundwater quality presented in the 2019 ESA and Closure Reports was based on the ANZECC (2000) trigger values. The ANZG (2018) guidelines have superseded the ANZECC (2000) trigger values.

5 ANZG (2018) 95% guideline values for benzene and naphthalene and unknown reliability guideline values for toluene, ethylbenzene and xylenes.

39. Therefore, given the decreasing trends and the relatively short extent of impacts, the dissolved phase hydrocarbons are unlikely to migrate beyond the current extent and are unlikely to pose a future risk to Otago Harbour.

## Assessment of Risks to Human Health and the Environment

### Risks Associated with Direct Contact

40. As noted above, the ESA works identified soil petroleum hydrocarbon concentrations exceeding MfE (2011) Tier 1 All Pathways acceptance criteria. Exceedances were indicated in shallow soils less than 1 m bgl primarily for the protection of excavation workers (via vapour inhalation). No exceedances of the dermal, soil ingestion and outdoor inhalation pathways were identified. As such, the data indicates no unacceptable risk associated with direct contact with shallow soils above the groundwater table.

41. In the context of the CSM, typical maintenance workers such as gardeners or utility maintenance contractors are unlikely to contact hydrocarbon impacted soils. However, there is the potential for unexpected discovery and as such there is an obligation under the Health and Safety at Work Act 2015 to inform workers of the hazards associated with the possibility of encountering hydrocarbon impacts in these soils. These hazards can be addressed through adoption of a precautionary approach with implementation of an Environmental Management Plan (**EMP**).

### Risks to Excavation Workers

42. The majority of the petroleum hydrocarbons exceedances in soil were identified deeper than 1 m bgl, below the groundwater table, and for the protection of excavation workers (via vapour inhalation). The exposure route for the majority of exceedances relates to volatilisation and the inhalation of petroleum hydrocarbon vapours.

43. As outlined in MfE (2011) guidance, the excavation criteria have been modelled based on the protection of unprotected workers in a 10 m x 10 m x 4 m deep excavation using the New Zealand Workplace Exposure Standards (eight-hour time-weighted average) as the target air concentrations. These criteria are therefore considered to provide a conservative approach to assessing risk to human health.

44. Workers conducting deeper excavation below the water table need to prepare an appropriate work plan incorporating procedures to mitigate risks to health, safety and the environment and considering the data available of the locations to be excavated based on the ESA or through collection of additional data.

45. Given the majority of exceedances were detected in soils below 1.0 m, direct exposure to these concentrations via excavation work would likely trigger confined space entry requirements and specific occupational health and safety requirements under the Health and Safety at Work Act 2015 including the requirement to undertake appropriate air monitoring.

**Vapour Intrusion Risks**

46. The presence of LNAPL in the south-west of the site is a source of soil vapour which may represent a risk to indoor air of newly constructed buildings where the LNAPL occurs.

47. Soil vapour monitoring undertaken to date shows concentrations of the primary chemicals of interest (COIs), namely BTEX and naphthalene, in soil vapour on Former Mobil Terminal are below MfE (2011) target soil gas concentrations for the protection of indoor quality. The on-site soil vapour samples identified the presence of a range of petroleum hydrocarbon related compounds in addition to BTEX and naphthalene. The reported concentrations of these compounds, with the exception of 1,2,4-trimethylbenzene at soil vapour bore SV3 were below adopted vapour intrusion screening criteria.

48. It is considered that the risk to indoor air can be managed through appropriate consideration in building design such as ventilation or use of a vapour barrier, depending on the building use and location with respect to the groundwater impacts.

**Risks to the Environment**

49. Overall the lateral extent of LNAPL has contracted over time. This is supported by the apparent reduction in LNAPL thickness at many locations over the past decade, which indicates it is not mobile and does not pose a risk of migration towards or discharge into Otago Harbour. This is supported from testing of wells which indicate a low LNAPL transmissivity, low recoverability and low mobility.

50. Petroleum hydrocarbon compounds including ethylbenzene, m&p-xylene and naphthalene exceeded adopted ANZG (2018) guideline values for the protection of marine ecosystems in groundwater off site. These exceedances were identified in a limited number of wells (BH51, BH49, BH56 and BH41 (as shown on Figure 4 in the Closure Report (Golder 2019a)) within Fryatt Street. Concentrations of these compounds in monitoring wells adjacent to Otago Harbour are below the ANZG (2018) guideline values.

51. More importantly the contaminants are being effectively attenuated through biodegradation of the dissolved phase hydrocarbons. The assessment of the attenuation rates of key contaminants (as documented in the Closure Report) support the conclusion that the concentrations observed in the off-site groundwater are not likely to present a risk to the marine ecosystems in Otago Harbour.

52. This is also supported by the assessment of the dissolved phase contaminant trends which indicates that the concentrations are stable or decreasing and will not pose a future risk to Otago Harbour.

**Assessment of PFAS Contamination**

53. In addition to the contaminants listed above, and in response to a request for further information from ORC dated 13 May 2022, WSP (2022b) undertook a desk top review in relation to the potential for per-and polyfluoroalkyl substances (PFAS) to have been used, stored or tested on or adjacent to the site and the subsequent potential for PFAS contamination of soil and groundwater on- and off-site was undertaken.

54. Given the historical use of the site as a bulk fuel terminal, the primary potential source of PFAS contamination at the Former Mobil Terminal is associated with the storage and use of Class B foams. Class B foams are a recognised source of PFAS including perfluorooctanoate (PFOA), perfluorooctane sulfonate (PFOS) as well as fluorotelomer-based derivatives (e.g., fluorotelomer sulfonic acids (FTS) such as 8:2 FTS) (ITRC 2021). The key findings of the review are summarised as follows.

55. There is no evidence of Class B foam having been stored on site. Class B foams were available to the Former Mobil Terminal in the event of a fire from

the Petroleum Industry Emergency Action Committee (PIEAC) foam store located adjacent to the Z Energy terminal located to the north of the site across Akaroa Street.

56. Fire-fighting infrastructure at the Former Mobil Terminal comprised a water based hydrant line. The hydrant line was installed to provide a source of water within the bunded tank compound. The hydrant line was not fitted with foam nozzles and there is no evidence indicating it was designed with foam injection points.

57. Site staff indicated that fire-fighting training on the Former Mobil Terminal was limited to use of small extinguishers only. No records of training events using foam were identified.

58. In the event of a fire event, the primary response was provided by the NZ Fire Service. Information reviewed as part of the Phase 1 ESA noted that no hazardous substance incidents had been recorded at the site.

59. Given the Former Mobil Terminal operated as a bulk fuel terminal between the mid to late 1920s and 1995, the potential for Class B foams to have been used at the site cannot be discounted. However, available information suggests that application of Class B foams, if used, would likely have been limited.

60. The information reviewed indicates a low potential for soil and groundwater contamination to be present at levels likely to result in adverse environmental effects. Further it is noted that there are other land use activities surrounding the Former Mobil Terminal that are also likely sources of potential PFAS impacts.

61. Given the on-going use of the Former Mobil Terminal for commercial / industrial land use, and the low sensitivity of the receiving environment (as per the sensitivity assessment presented in Section 2.4.6 of the Closure Report), the management framework outlined in the EMPs[6] is considered appropriate for the management of potential PFAS impacts.

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6 Two EMPs have been prepared for the Former Mobil Terminal– relating to on-site and off-site activities as described below.

**Summary**

62. The CSM developed for the Former Mobil Terminal supports a position that risks to human health associated with residual petroleum hydrocarbon impacts are able to be managed on the basis of continued commercial/industrial use of the site. Further, natural attenuation processes are acting to degrade residual petroleum hydrocarbon impacts such that there is not considered to be unacceptable risks to the environment.

63. The CSM developed for the Former Mobil Terminal supports a position that further active remediation is not practicable or required given the risks posed to receptors. Rather the contaminant conditions documented through the ESA works, and based on the intended land use, are supportive of a passive attenuation approach based on Natural Source Zone Depletion[7] (**NZSD**) and implementation of regulatory and management controls consistent with industry accepted practice.

64. Based on the ESA works undertaken, Mobil commissioned the Closure Report. The Closure Report established that no further action was required and that risks to human health could be addressed through site management practices and existing regulatory controls.

65. Potential risks to current and potential future on-site and off-site human receptors should be addressed through an EMP. EMPs have been prepared for the Former Mobil Terminal (Golder 2020a) and the off-site area comprising Fryatt Street and Halsey Street (Golder 2020b). The EMPs were provided to Dunedin City Council (**DCC**) in March 2020 and subsequently to the landowner of the Former Mobil Terminal (Chalmers Properties Limited (**Chalmers**)).

**Response to Submissions**

66. One submission, made by DCC, was received in relation to the Application.

67. DCC's submission raised concerns regarding the presence of dissolved phase hydrocarbons within the off-site management area and potential or actual adverse effects of discharges to Otago Harbour via the stormwater network, the adequacy of the mitigation measures proposed to be implemented through

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7 Natural source zone depletion (NSZD) refers to naturally-occurring biodegradation processes that facilitate attenuation of LNAPL.

conditions of resource consent, and the financial implications imposed on DCC through implementation of the EMP.

68. DCC's Geographic Information System[8] (**GIS**) shows the stormwater network beneath Halsey Street comprises two stormwater lines. The stormwater lines comprise two concrete pipes 1,950 mm and 1,300 mm in diameter with invert levels of 99.89 m RL (2.36 m bgl) at Jutland Street and 99.83 m RL (2.94 m bgl) at Fryatt Street. The stormwater lines form part of the stormwater system that receives stormwater from the wider Dunedin City. The stormwater lines discharge to Otago Harbour via outfalls beneath the HarbourCold facility.

69. There are five monitoring wells located near these stormwater lines. Monitoring wells BH48 and BH59 are located within Halsey Street between the Terminal and the stormwater pipes. Monitoring wells BH51 and BH52 are located to the south-east of Fryatt Street and situated between the Terminal and the stormwater pipes. Monitoring well BH60 is located within Fryatt Street and on the opposite side of the stormwater pipes.

70. Groundwater elevations in these monitoring wells are higher (based on available monitoring data) than the reported inverts of the stormwater lines. Mean groundwater elevations based on monitoring between 2011 and 2017 (as presented in the Closure Report) are 101.27 m RL at BH48, 101.20 m RL in BH59 and 101.23 m RL in BH51. Groundwater elevations have ranged between 98.74 m RL (BH48) and 101.87 m RL (BH48) over this period.

71. Given the stormwater pipes are located below the groundwater table it is possible that groundwater could enter the stormwater system through cracks in the pipes and joints. Potential interactions between groundwater and the stormwater lines can be assessed based on groundwater elevations around the stormwater pipe. Where groundwater is leaking into the stormwater pipe, it would be anticipated that groundwater elevations around the stormwater pipe would be lower compared to wells further away from the stormwater pipes indicating that the stormwater line is acting as a ground water sink.

72. In preparing my evidence, I have reviewed groundwater elevations measured between 2011 and 2017 (as presented in Appendix A of the Closure Report) in monitoring wells on-site adjacent to the Halsey Street boundary of the Former

[8] https://www.dunedin.govt.nz/do-it-online/maps-and-photos/water-services-map-and-wws-work-in-progress

Mobil Terminal (BH38 and BH39) and within Halsey Street (BH48, BH59) and Fryatt Street (BH51 and BH60) adjacent to the Halsey Street stormwater lines.

73. Measured groundwater levels in the monitoring wells located adjacent to stormwater lines are similar to groundwater levels in monitoring wells located on the Former Mobil Terminal. Further, groundwater gradients[9] in monitoring wells reviewed are consistent with gradients measured across the wider area of the Former Mobil Terminal.

74. In my opinion, given the measured groundwater levels in monitoring wells adjacent to the stormwater lines, there is no evidence that the stormwater lines are acting as a groundwater sink and a preferential pathway for the migration petroleum hydrocarbon impacted groundwater from the Former Mobil Terminal.

75. In the event that the stormwater lines were influencing groundwater, it would be expected to observe consistently lower groundwater elevations in the monitoring wells adjacent to the stormwater lines (i.e., BH48, BH59, BH51 and BH60) compared to monitoring wells further away from the stormwater lines (i.e., BH38 and BH39). The monitoring data does not show this to be the case.

76. Additionally, the time series of groundwater quality data, as presented in Figure 2, Figure 3 and Figure 4 in the Closure Report (Golder 2019a) does not indicate that groundwater contamination is being drawn toward the stormwater lines as would be expected if the stormwater lines were acting as a groundwater sink and preferential pathway.

77. I note that Mr Simon Beardmore has drawn a similar conclusion as noted in paragraph 47 of his evidence attached to the Officer's Report.

78. As previously discussed, groundwater monitoring has identified the presence of dissolved hydrocarbons in monitoring wells located adjacent to the DCC stormwater network beneath Halsey Street. As documented in the Closure Report and WSP (2022c), dissolved phase groundwater hydrocarbon concentrations are delineated with respect to adopted ANZG (2018) marine

[9] The change in groundwater levels over the distance between two monitoring wells.

guideline values[10] prior to the point of contact with the stormwater lines and point of discharge to Otago Harbour.

79. Monitoring data collected by DCC (as presented in WSP (2022c)) from the Halsey Street stormwater lines identifies low concentrations of total PAH. The identified concentrations are at least two orders of magnitude below dissolved phase groundwater concentrations in monitoring wells adjacent to the stormwater pipes (i.e., BH48, BH59) and adopted ANZG (2018) marine guideline values (refer Table 1 in WSP 2022c).

80. Finally, assessment of the groundwater concentrations against the ANZG (2018) marine guideline values provides a conservative assessment in that it does not account for attenuation and dilution between the site and Otago Harbour. Specifically, the ANZG (2018) guidelines are based on assessing receiving water quality after reasonable mixing. Given that Otago Harbour is a large water body, dilution rates are likely to be high following the discharge of stormwater potentially impacted by the ingress of hydrocarbon impacted groundwater.

81. To further address DCC's concern regarding the potential ingress of petroleum hydrocarbon impacted groundwater into the stormwater network, Mobil commissioned WSP to undertake a round of stormwater sampling of the Halsey Street stormwater network (WSP 2023). Samples were collected on 21 December 2022. As agreed with DCC, samples were collected from manholes located upstream (intersection of Halsey Street and Jutland Street) and downstream (Halsey Street and Fryatt Street) of the Terminal.

82. Stormwater samples were collected during low tide and following a period of limited rainfall. Potential petroleum hydrocarbon impacted ground water intrusion into the storm water system were considered more likely to be identified during these conditions.

83. Petroleum hydrocarbon compounds including TPH and BTEXN were not identified above the laboratory limits of reporting (**LORs**) in the samples collected from the up- and down-stream locations. The laboratory LORs were below the adopted ANZG (2018) marine guideline values.

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10 ANZG (2018) 95% guideline values for benzene and naphthalene and unknown reliability guideline values for toluene, ethylbenzene and xylenes.

84. Given the Halsey Street stormwater network discharges to Otago Harbour via an outfall, samples were also analysed for indicators of salinity (conductivity) to assess the extent of tidal influences on stormwater adjacent to the Terminal. Based on the reported conductivity (240 to 250 µS/cm), water in the stormwater pipes would be considered brackish[11]. The presence of brackish water in the stormwater pipes indicates that the network adjacent to the Terminal is subject to ingress by seawater during flood tides. Tidal influence on the lower parts of the Halsey Street catchment has previously been identified (URS-Opus 2011).

85. The presence of saline water in the stormwater pipes indicates that the stormwater network adjacent to the Terminal is subject to regular flushing (including during periods of low flow in the stormwater network) which would result in significant dilution and mixing of any hydrocarbon impacted groundwater if it were present in the stormwater pipes. As such, I consider that even if low concentrations of petroleum hydrocarbons did enter the stormwater network via groundwater ingress, the tidal flushing would result in mixing and dilution of contaminants prior to discharge to Otago Harbour. The stormwater discharge would then be subject to further mixing and dilution following discharge to Otago Harbour.

86. Based on the additional information obtained through sampling of the Halsey Street stormwater network, I consider that the CSM developed for the site (Golder 2019b) remains valid, particularly in relation to there being no unacceptable risks to the receiving environment (Otago Harbour) associated with residual groundwater impacts from historic operations on the Former Mobil Terminal.

87. Given the CSM presented in the Closure Report is supported by the findings of the stormwater sampling undertaken in December 2022, there is no justification to support DCC's request to reline the Haley Street stormwater mains as outlined in its submission.

88. As noted in paragraph 65 of my evidence, both the EMP for the Former Mobil Terminal and the off-site EMP were provided to DCC in March 2020. It is my understanding that Mobil received confirmation[12] from DCC on 15 July 2020

[11] Land and Water Aotearoa (LAWA) notes that "high quality deionized water (nearly pure) has a conductivity of about 0.05 µS/cm, whereas seawater has a conductivity of approximate 50,000 µS/cm. The electrical conductivity of fresh groundwater is typically less than 150 µS/cm".

[12] Email from DCC (Mr D Dewhirst) to Mobil (Ms S Veluayitham) titled "RE: Site location - Former Mobil Terminal, Dunedin" dated 15 July 2020.

that the EMPs had been uploaded to DCC's file management system and referenced against the property, the management area had been uploaded to DCC's GIS system and that the off-site EMP provided to DCC's primary contractor (City Care).

89. In its submission, DCC indicates that the management controls outlined in the EMP will impose a "*significant impact on the way standard road and utility maintenance works can be delivered and, …, the relative cost and efficiency of their delivery*".

90. The EMP was not prepared to be prescriptive in terms of what controls are required for specific work activities and various depths. Rather it was prepared to outline generic controls to manage hazards associated with the presence of petroleum hydrocarbons in the subsurface.

91. I note that the controls in the off-site EMP are also consistent with the controls presented in the Long-Term Management and Monitoring Plan (**LTMMP**) prepared under ORC discharge permit RM12.312 for the adjacent Z Energy operated terminal at 203 Fryatt Street. The Z Energy LTMMP has been in place since granting of discharge permit RM12.312 in 2013.

92. The LTMMP includes an off-site management area that includes areas of Akaroa Street and Fryatt Street adjacent to the Z Energy terminal. I note that the Z Energy management area extends along Fryatt Street adjacent to the Former Mobil Terminal (as shown in Appendix A to the Recommended Conditions of Consent in the Officer's Report).

93. In terms of impacting standard road and utility maintenance works, the ESA works have not identified the presence of petroleum hydrocarbon impacts derived from the Former Mobil Terminal in shallow fill/soil that would be disturbed during shallow maintenance activities (e.g., footpath or road surface maintenance). As such it is considered that specific additional controls are unlikely to be required during road maintenance works in relation to petroleum hydrocarbons impacts resulting from the Former Mobil Terminal.

94. In the context of the CSM developed for the Former Mobil Terminal including the surrounding off-site area, typical maintenance workers such as roading contractors or shallow utility contractors (e.g., electricity, water) are unlikely to

contact petroleum hydrocarbon impacted soils. However, there is the potential for unexpected discovery (including contamination derived from sources other than the Former Mobil Terminal) and there is a need to inform workers of the hazards associated with the possibility of encountering hydrocarbon impacts in these soils. These hazards can be addressed through adoption of a precautionary approach with implementation of an EMP.

95. The requirement to undertake vapour monitoring during shallow (<1.0 m) works needs to be considered by the contractor as part of its risk assessment when preparing health and safety documentation for works. However, it is noted that petroleum hydrocarbon concentrations in soils above 1.0 m bgl did not exceed Tier 1 acceptance criteria for the protection of human health where exposure to volatile contaminants is the primary risk.

96. Given the majority of hydrocarbon impacts and exceedances of MfE (2011) Tier 1 acceptance criteria were detected in soils below 1.0 m (and typically between 1.5 m and 2.0 m), there is a potential exposure during excavation works intersecting soils at these depths. However, deep excavation work would likely trigger confined space entry requirements and specific occupational health and safety requirements under the Health and Safety at Work Act 2015 including the requirement to undertake appropriate air monitoring. In my opinion, such controls would be applicable for similar works outside of the area adjacent to the Former Mobil Terminal given the industrial history of the surrounding land and the potential for contamination to be present.

97. DCC's submission also refers to the 'relative cost' of undertaking maintenance activities in the road reserve. In reviewing DCC's submission, it is noted that DCC has not provided any information to understand the difference in 'relative cost' that may be incurred as a result of implementing the EMP.

98. My interpretation of 'relative cost' is that DCC is referring to the potential incremental cost of undertaking works in the management area given the presence of petroleum hydrocarbon impacted soil associated with the Former Mobil Terminal. A key element of this would be in relation to cost effectively disposing of surplus soil and fill material.

99. As noted above, the ESA works have not identified the presence of petroleum hydrocarbon impacted soil associated with the Former Mobil Terminal in the

off-site management area within the upper 1 m of the soil profile. As such I consider that surplus fill material and soil from this zone would not result in additional disposal costs as a result of impacts from the Former Mobil Terminal.

100. Further, I note that given the area is underlain by reclamation fill, has a long history of industrial land use activities, and the management area primarily comprises the road reserve, there is highly likely to be a level of soil contamination, not associated with historical activities at the Former Mobil Terminal, that would preclude the ability to dispose of surplus soil as cleanfill (without soil quality testing to confirm suitability).

101. In preparing this evidence, I have evaluated potential disposal facilities within Dunedin and surrounding regions. Based on this review, the Burnside Dunedin Landfill, a Class A facility consented by ORC (resource consent RM17.198), represents a local option for the disposal of surplus material. I have reviewed the existing soil quality data collected during the ESA works and compared these to the Burnside Dunedin Landfill waste acceptance criteria. On the basis of this review, it is considered that surplus soil from the proposed management area would be accepted at the landfill at the same rate as material that does not meet the definition of clean soil.

102. DCC, in its submission, has requested the inclusion of a number of consent conditions. The following provides specific comment to each of these points.

a) As outlined in paragraph 9 of its submission, DCC has requested that ORC include a consent condition requiring that the consent holder reline the two stormwater mains in Halsey Street. As noted in paragraph 87 of my evidence, the CSM presented in the Closure Report supported by the findings of the stormwater sampling undertaken in December 2022, there is no justification to support DCC's request to reline the Haley Street stormwater mains. The Officer's Report (refer page 29), supported by evidence from Mr Simon Beardmore, considers that this proposed condition is unreasonable.

b) In relation to paragraph 10(a)(i) of DCC's submission, the proposed extent of the off-site management area was based on the findings of the ESA works including the data from monitoring well BH48 which has been used to delineate the extent of impacts from the Former Mobil Terminal.

DCC has not provided technical information to support a revision to the off-site management area. As noted in the Officers Report (page 29), without further clarification it is not clear which additional areas of Halsey Street DCC would like to be included within the management area.

c) In relation to paragraph 10(a)(ii) of DCC's submission, I consider that this does not add any relevant information. I agree with the Officer's Report which notes (page 29) that "*Mobil will be the Consent Holder and are therefore responsible for ensuring that any conditions on the Discharge Permit are met*".

d) In relation to paragraph 10(a)(iii) of DCC's submission, I take no objection to the inclusion of the amended wording in the EMP as proposed.

e) In relation to paragraph 10(a)(iv) of DCC's submission, it is beyond my area of expertise to comment in relation to the inclusion of consent conditions that address financial responsibilities. However, I note that the Officers' Report in relation to this proposed condition states (page 30) "this lies outside the scope of this resource consent process because it does not relate to the management of a relevant environmental effect".

f) In relation to paragraph 10(b), Mobil has been engaging with DCC in relation to the off-site EMP following submission to DCC in March 2020 and more recently following receipt of the DCC submission on the Application. I don't agree that the consent should include a specific condition requiring that the EMP be updated in consultation with DCC. I do concur with the Officer's Report which considers that the EMPs are fit for purpose (a position support by the technical audit undertaken by Mr Simon Beardmore) and recommends a condition for providing the EMPs to the relevant parties. I also agree with the recommendation in the Officer's Report to modify the recommended condition to allow for future amendments to the EMPs.

**Response to Officers' Report**

103. I have read those aspects of the Officer's Report which are relevant to the assessment of contaminated land effects.

104. The Officer's Report considered that based on the CSM developed for the site, potential risks to human health could be adequately managed via controls proposed in the on-site and off-site EMPs. This position is supported by a technical audit of the Application by Mr Simon Beardmore of E3 Scientific. Mr Beardmore concluded that the controls outlined in the EMPs are comprehensive and appropriate for the site.

105. The Officer's Report also considered effects on water quality with respect to the discharge of petroleum hydrocarbons via groundwater to Otago Harbour. The Officer's Report, supported by a technical audit by Mr Simon Beardmore of the CSM, concluded that adverse effects on water quality were likely to be less than minor.

106. The Officers Report also addresses the submission from DCC in relation to the discharge of petroleum hydrocarbons to Otago Harbour via the DCC stormwater network. The Officers Report considered that, based on additional information provided in relation to potential impacts to stormwater quality (WSP 2022), and expert evidence from Mr Simon Beardmore, potential adverse effects on water quality would remain less than minor even if potential ingress of petroleum hydrocarbons was occurring to the stormwater network.

107. I agree with the findings of the Officer's Report in relation to the assessment of effects associated with the discharge of petroleum hydrocarbons from the Former Mobil Terminal.

108. I note that the Officers Report does not recommend including the DCC's proposed conditions in the set of recommended conditions. I agree with this position for the reasons outlined in paragraph 102 of my evidence.

**Proposed Conditions**

109. I have read the recommended conditions set out in the Officer's Report and I support the conditions as presented in the Report subject to the following comments.

110. Recommended condition 5 requires that the Consent Holder must maintain critical monitoring wells on the site for the purpose of future groundwater monitoring required by recommended condition 7. In my opinion, recommended condition 7 should be amended to reflect the need to maintain

critical monitoring wells located both on- and off-site. There is the potential for the site to be redeveloped in the future which may result in the loss of on-site monitoring wells and potentially require replacement. The location of replacement wells would need to be considered in light of any future development and the objectives for future ESA works.

111. My view is that retention of an off-site monitoring well network is more important with respect to supporting the risk assessment presented in the CSM. Further, retention of an off-site monitoring well network would provide for the ability to document that petroleum hydrocarbon impacts are continuing to degrade and not present an unacceptable risk to the receiving environment.

112. On this basis, I have proposed a network of wells (included in Appendix C) to retain and form the basis for future monitoring outlined in recommended condition 5.

113. With respect to recommended condition 6, I agree with the recommended condition to provide the EMPs to the identified parties within 30 working days if issue of the consent. However, I do note that EMPs documented in recommended condition 3 were provided to DCC in March 2020 and are considered to have been in place since this time. I note that a HAIL property search provided by DCC on 26 May 2022 (obtained as part of the PFAS review (WSP 2022b)) included a copy of the EMP for the Former Mobil Terminal.

114. Additionally, I note that the EMPs are intended to be a live document and be updated to reflect changes in the CSM, management approaches and regulatory requirements. As such, I suggest that recommended condition 6 also include reference to providing copies of future updated versions of the EMPs to the relevant parties.

**Conclusions**

115. Mobil has progressively undertaken ESA works at the Former Mobil Terminal, both on site and off site, between 1992 and 2017. The ESA works undertaken to date form the basis for development of a robust CSM and provide a detailed understanding of the extent of residual impacts to soil, groundwater and soil vapour and the associated risks to human health and the environment.

116. The time-series of the ESA data also provides an understanding of the stability and attenuation of residual LNAPL and dissolved phase hydrocarbons. Monitoring data shows that the hydrocarbon impacts to groundwater are reducing. Further the groundwater impacts have been delineated to below ANZG (2018) marine guideline values prior to the point of discharge to Otago Harbour.

117. In my opinion, and as agreed in the Officer’s Report, the residual petroleum hydrocarbon impacts do not represent an unacceptable risk to the receiving environment and human health, and residual impacts can be managed through implementation of the EMPs.

**Andrew Thomas Hart**

**16 January 2023**

## Appendix A - References


ANZECC 2000. Australian and New Zealand Guidelines for Fresh and Marine Water Quality. National Water Quality Management Strategy Paper No. 4, Vol. 1 (2nd revision). ANZECC, Canberra.

ANZG 2018. Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Australian and New Zealand Governments and Australian state and territory governments, Canberra ACT, Australia.

Golder 2014. Former Mobil Dunedin Terminal – Groundwater Monitoring Event. Report prepared by Golder Associates (NZ) Limited for Mobil Oil New Zealand Limited, August 2014.

Golder 2015. Former Mobil Dunedin Terminal – Groundwater Monitoring Event. Report prepared by Golder Associates (NZ) Limited for Mobil Oil New Zealand Limited, August 2015.

Golder 2019a. Former Mobil Dunedin Terminal – 199 Fryatt Street, Dunedin: Closure Report. Report prepared by Golder Associates (NZ) Limited for Mobil Oil New Zealand Limited, May 2019.

Golder 2019b. Former Mobil Dunedin Terminal – 199 Fryatt Street, Dunedin: Supplementary Environmental Site Assessment. Report prepared by Golder Associates (NZ) Limited for Mobil Oil New Zealand Limited, May 2019.

Golder 2020a. Former Mobil Dunedin Terminal – 199 Fryatt Street, Dunedin: Environmental Management Plan. Report prepared by Golder Associates (NZ) Limited for Mobil Oil New Zealand Limited, March 2020.

Golder 2020b. Former Mobil Dunedin Terminal – 199 Fryatt Street, Dunedin: Environmental Management Plan – Fryatt Street Adjacent to Former Terminal. Report prepared by Golder Associates (NZ) Limited for Mobil Oil New Zealand Limited, March 2020.

Golder 2022. Resource Consent Application and Assessment of Effects on the Environment – Discharge of Contaminants: Former Mobil Dunedin Terminal – 199 Fryatt Street, Dunedin. Report prepared by Golder Associates (NZ) Limited for Mobil Oil New Zealand Limited, February 2022.

ITRC 2018. LNAPL Site Management: LCSM Evolution, Decision Process, and Remedial Technologies. LNAPL-3. Washington, D.C.: Interstate Technology & Regulatory Council. LNAPL Update Team. https://lnapl-3.itrcweb.org.

ITRC 2019. Implementing Advanced Site Characterization Tools. ASCT-1. Washington, D.C.: Interstate Technology & Regulatory Council. https://asct-1.itrcweb.org/1-introduction/.

ITRC 2021. PFAS Technical and Regulatory Guidance Document and Fact Sheets PFAS-1. Washington, D.C.: Interstate Technology & Regulatory Council, PFAS Team. https://pfas-1.itrcweb.org/.

MfE 2011. Guidelines for Assessing and Managing Petroleum Hydrocarbon Contaminated Sites in New Zealand. Ministry for the Environment, Wellington.

PDP 1992. Interim Report on Environmental Site Investigation for Dunedin Plant Site, Dunedin. Prepared for Mobil Oil New Zealand Limited by Pattle Delamore Partners Limited, September 1992

PDP 1994. Environmental Site Investigation for Bulk Storage Site Dunedin. Prepared for Mobil Oil New Zealand Limited by Pattle Delamore Partners Limited, July 1994.

PDP 2007. Phase 1 Environmental Site Assessment for the Mobil Dunedin Terminal (410-350). Prepared for Mobil Oil New Zealand Limited by Pattle Delamore Partners Limited, December 2007.

PDP 2011. Preliminary Site Investigation Works at the Former Dunedin Terminal, Fryatt Street, Dunedin (410-350). Prepared for Mobil Oil New Zealand Limited by Pattle Delamore Partners Limited, September 2011.

PDP 2012. 2012 Groundwater Monitoring and Sampling Round & Extras – Former Dunedin Terminal, Fryatt Street, Dunedin (410-350). Prepared for Mobil Oil New Zealand Limited by Pattle Delamore Partners Limited, July 2012.

PDP 2013. Additional Site Investigations at Former Mobil Dunedin Terminal, Fryatt Street, Dunedin (410-350). Prepared for Mobil Oil New Zealand Limited by Pattle Delamore Partners Limited, October 2013.

URS-Opus 2011. Halsey Street Integrated Catchment Management Plan 2010-2060-Contract No. 3206 Dunedin 3 Waters Strategy. Report prepared by URS New Zealand Limited and Opus International Consultants Limited for Dunedin City Council, 18 October 2011.

WSP 2022a. Response to Request for Further Information – RM22.099 – Mobil Oil New Zealand Limited. Prepared by WSP New Zealand Limited for Mobil Oil New Zealand Ltd, 1 August 2022.

WSP 2022b. Phase 1 Review of Per-and Polyfluoroalkyl Substances (PFAS), Former Mobil Dunedin Terminal –199 Fryatt Street, Dunedin. Prepared by WSP New Zealand Limited for Mobil Oil New Zealand Ltd, July 2022.

WSP 2022c. Response to Request for Further Information – RM22.099 – Mobil Oil New Zealand Limited. Prepared by WSP New Zealand Limited for Mobil Oil New Zealand Ltd, 25 October 2022.

WSP 2023. Former Mobil Dunedin Terminal – Sampling of Halsey Street Stormwater Network. Prepared by WSP New Zealand Limited for Mobil Oil New Zealand Ltd, 12 January 2023.

**Appendix B – Timeline of ESA Works (extracted from Closure Report)**

| Investigation Timing (Report Reference) | Scope of ESA works |
|---|---|
| September 1992 and July 1994 (PDP 1992, 1994a, 1994b) | Installation of 18 groundwater monitoring wells (BH1 to BH18), the drilling of 22 shallow (to ~1.5 m bgl) soil bores and the collection of soil and groundwater samples. Soil samples were analysed for total petroleum hydrocarbons (TPH) and lead (organic and inorganic). Groundwater samples were analysed for TPH and inorganic lead. |
| March to June 1995 (PDP 1995) | LNAPL recovery pumping trial. Three water/LNAPL recovery wells (R1-R3) were installed to recover water and LNAPL. Between 13 $m^3$ and 21 $m^3$ per day (approximately 813 $m^3$ in total) of water was pumped from the recovery wells to Tank 10 with overflow discharging to Tank 1. The trial recovered approximately 80 L of LNAPL. |
| December 2007 (PDP 2007) | Phase 1 ESA comprising a desktop information review and site visit to understand the site's operational history. |
| September 2011 (PDP 2011) | Drilling of 96 soil bores (88 on site and eight off site) based on a 12 m x 12 m grid spacing.<br>Installation of 22 on-site groundwater monitoring wells (BH19 to BH40) and 10 off-site groundwater monitoring wells (BH41 to BH50) with associated soil and groundwater sampling.<br>Groundwater sampling of 24 on-site and four off-site (BH44, BH45, BH48 and BH50) groundwater monitoring wells. Samples were not collected from on-site wells BH20, BH1, BHA and BHB and off-site wells BH43, BH46, BH47 and BH49 due to the presence of measurable LNAPL.<br>Collection of LNAPL sample from BH43 for identification purposes.<br>LNAPL bail-down test on monitoring well BH43 to assess LNAPL recoverability. |
| July 2012 (PDP 2012) | Groundwater monitoring of 28 on-site (BH1, BH19-BH42, BHA, BHB and BHC) and eight off-site (BH43-BH50) monitoring wells. Analysis of samples for dissolved lead (field filtered), total petroleum hydrocarbons (TPH), individual BTEX (benzene, toluene, ethylbenzene and total xylenes) compounds and polycyclic aromatic hydrocarbons (PAHs). Samples from six monitoring wells (BH21, BH23, BH28, BH37, BH40 and BH50) analysed for geochemical parameters including nitrate-nitrogen, sulphate, dissolved iron and dissolved manganese).<br>LNAPL bail-down tests performed at BH29, BH31 and BH35.<br>Hydraulic testing (slug tests) performed at BH19, BH30 and BH37. |
| October 2013 (PDP 2013) | Installation of three additional off-site groundwater monitoring wells (BH51, BH52 and BH53) and a nested soil vapour bore (SV1_S and SV1_D) adjacent to an off-site property (HarbourCold).<br>Sampling of 11 off-site (BH43, BH44, BH45, BH46, BH47, BH48, BH49, BH50, BH51, BH52 and BH53) groundwater monitoring wells. Samples were not collected from BH46, and BH47 due to the presence of measurable LNAPL. |

| **Investigation Timing (Report Reference)** | **Scope of ESA works** |
|---|---|
| | Sampling of shallow off-site soil vapour bore (SV1_S).<br>LNAPL removed from the monitoring wells with measurable LNAPL thicknesses (BH1, BH24, BH25, BH29, BH31, BH33, BH35, BH46, BH47, BHA and BHB). An approximate total of 18L of LNAPL was removed from the monitoring wells. |
| December 2013 and August 2014 (Golder 2014) | Gauging of 39 monitoring wells BH1, BH19 to BH53 and BHA, BHB and BHC in December 2013 and June 2014.<br>Sampling of wells BH42, BH43, BH44, BH45, BH48, BH50, BH51, BH52 and BH53 in December 2013 with analysis for TPH, BTEX and PAHs.<br>Sampling of wells BH48, BH49, BH50, BH51, BH52 and BH53 in June 2014 with analysis for TPH, BTEX, PAHs and dissolved lead.<br>Sampling of shallow off-site soil vapour bore (SV1_S) in December 2013 and June 2014. |
| November 2014 (Golder 2019) | Installation of seven off-site monitoring wells along Fryatt Street (BH54 to BH58 and BH60) and Halsey Street (BH59).<br>Installation of pressure transducers in two transects of monitoring wells. One transect comprised monitoring wells BH45, BH21, BH22 and BH23 and the second comprised monitoring wells BH53, BH40, BH38 and BH37. |
| May 2015 (Golder 2015) | Gauging of 23 on-site (BH1, BH19 to BH40, BHA-BHC) and 20 off-site (BH41 to BH60) monitoring wells.<br>Sampling of 18 off-site (BH41 to BH60) monitoring wells for TPH, BTEX and PAHs. |
| November 2015 (Golder 2019) | Gauging of 23 on-site (BH1, BH19 to BH40, BHA-BHC) and 20 off-site (BH41 to BH60) monitoring wells<br>Sampling of 18 off-site (BH41 to BH49, BH51 to BH56, BH58, BH59) monitoring wells for TPH, BTEX and PAHs. |
| December 2015 (Golder 2019) | Direct push investigation using laser induced fluorescence (LIF) technology was undertaken to assist with evaluating the lateral and vertical extent of the LNAPL.<br>Cone penetrometer testing (CPT) at four locations. |
| March 2016 (Golder 2019) | Excavation of 13 test pits across the site to validate the findings of the LIF investigation.<br>Sampling of off-site shallow soil vapour bore (SV1_S). |
| June-July 2016 (Golder 2019) | Gauging of 25 on-site (BH19 to BH40, BHA to BHC) and 20 off-site (BH41 to BH60) monitoring wells.<br>Sampling of 14 off-site (BH41 to BH45, BH48, BH51 to BH55, BH58 to BH60) monitoring wells. Samples not collected at BH46, BH47 and BH57 due to measurable LNAPL. Monitoring well BH50 recorded as dry.<br>Installation and sampling of three on-site soil vapour bores (SV2, SV3, and SV4). The soil vapour bores were installed at 1.0 m bgl toward the southern corner of |

| Investigation Timing (Report Reference) | Scope of ESA works |
|---|---|
| | the site adjacent to Fryatt Street with soil vapour well SV4 installed centrally in the western half of the site between former AST4 and AST5.<br>LNAPL bail-down testing on monitoring well BH25. |
| April 2017 (Golder 2018) | Gauging of 24 on-site (BH1, BH19 to BH40, BHA to BHC) and 19 off-site (BH41 to BH60) on-site and 15 off-site groundwater monitoring wells.<br>Groundwater sampling of 15 off-site groundwater monitoring wells (BH41 to BH45, BH48, BH49, BH51 to BH54, BH56, BH58 to BH60).<br>Sampling of one off-site soil vapour bore (SV1_S) and three on-site soil vapour bores (SV2, SV3 and SV4). |

**Appendix C – Proposed Monitoring Wells to Retain**

| On-Site | Off-Site |
|---|---|
| BH36, BH31, BH28, BH25, BH24, BH21, BH38, BH35, BH32, BH30, BH29, BH39, BH33, BH40 | BH48, BH59, BH60, BH51, BH52, BH47, BH58, BH57, BH56, BH46, BH45, BH44 |