PROPOSED BECKENHAM BIKE PUMP TRACK

GEOG309

CONTAMINATION REPORT

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1. Executive Summary

- The Christchurch City Council propose creating a permanent bike pump track in an empty lot in Beckenham, Christchurch, as this land has been used unofficially as such for years.
- Carcinogenic blue-grey residue from the Christchurch Gas Works has previously been deposited on the site causing contamination concerns, which is why the Beckenham Neighborhood Association asked us to investigate this.
- Our aim was to determine if the soil in the Beckenham Bike Pump Track was contaminated. If so, to what extent, and what mitigation strategies could be implemented that align with the interests of the community?
- This included determining what heavy metals were present, at what concentration, where the hot spots are, and based on this conclude whether the land is safe or if there is a way to make the land safe for public recreational use.
- Background information about the site was gathered from historical articles/records, South Library Draft Plan Report, Retrolens, Canterbury Maps, Lister Land Use Register, S-map, the NESCS soil contamination guidelines for human health and I-Naturalist.
- Contamination testing methodology included X-ray Fluorescence and ICP-MS Lab analysis, visualized through ArcGIS Pro.
- Results concluded that Cu, Zn, Pb and As concentrations were all below the NESCS guidelines. The elements of Zn, Pb, and As were identified as below natural background concentrations, Cu and Zn were slightly above but not at a level that is concerning human health.
- Bitumen was present across the site 10-20cm below the surface but is unlikely to be of concern unless heated.
- In terms of remediation, we recommend asphalt capping of the track as a physical barrier between any contamination in the soil and the children using this land.
- We also recommend implementing phytoremediation to manage and limit the exposure pathways of these heavy metals and increase green space in the area, especially because the dirt and grass track will now be asphalt.
- Limitations of our research include the lack of depth sampling due to bitumen as it narrows the application of our research and ability to make any definitive conclusions about the presence of heavy metal contamination.
- Polycyclic Aromatic Hydrocarbons (PAHs), a common byproduct from historic gasworks sites, were unable to be tested for due to time/resource constraints, which may be of concern for human health if present.
- There are also knowledge gaps on which plant species are best to add to contaminated land for Phyto-management at this stage limiting the effectiveness of this remediation strategy.

2. Introduction

Our research was conducted in the South Christchurch suburb of Beckenham (Figure 1). The research site was an empty piece of land on Hunter Terrace by the Heathcote River and the South Christchurch Library.

Figure 1. *Location of the research site in Beckenham, South Christchurch.*

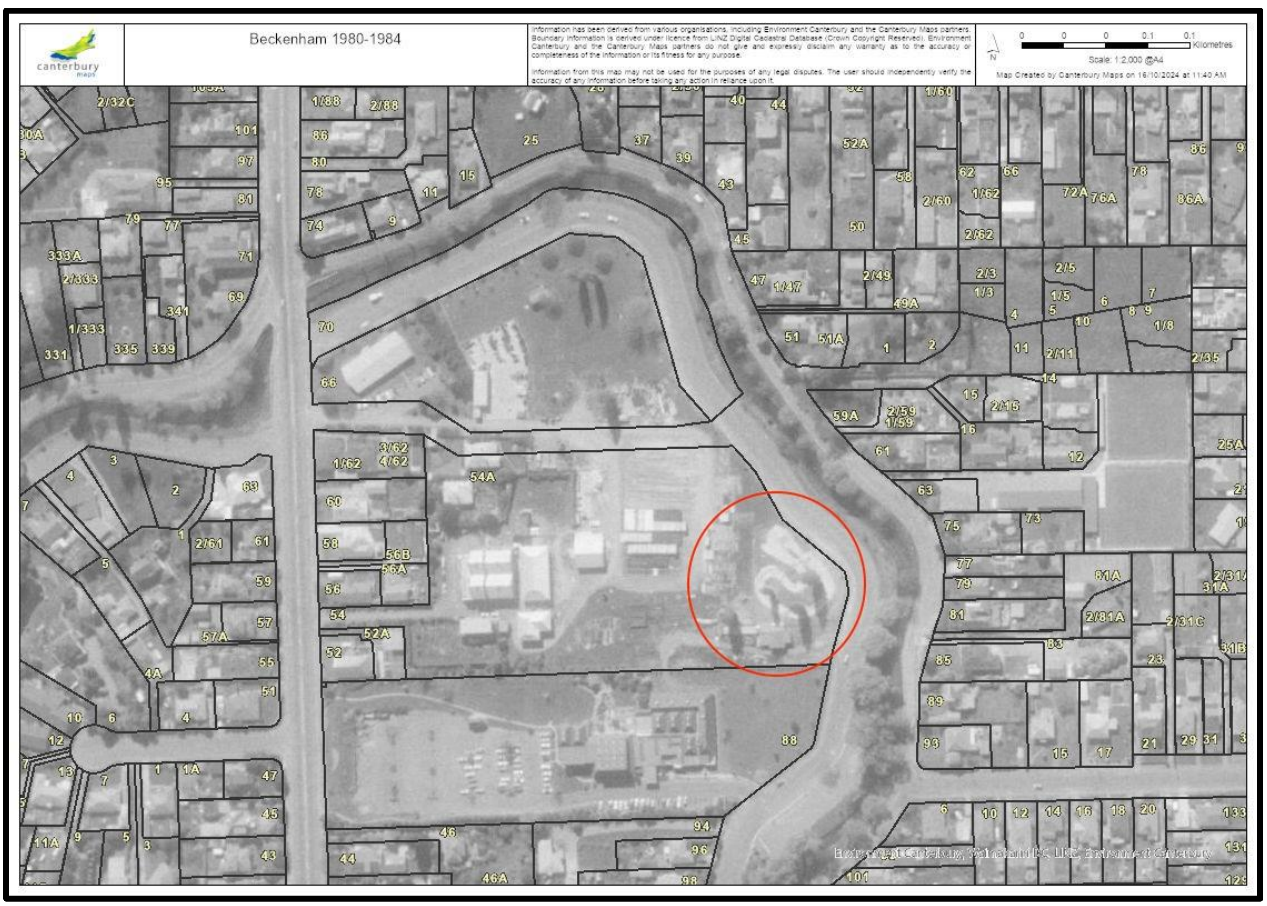

Figure 2. Historical Image of Beckenham, 1980-1984. (Canterbury Maps)

For years, children have used this site as an unofficial pump track, building jumps and riding bikes, as far back as 1980 (Figure 2). Recently, the Christchurch City Council, who owns this land, has allocated funds and has been working in collaboration with the Beckenham Neighborhood Association to develop the land into a permanent community facility.

Before construction, the Beckenham Neighborhood Association requested site testing over concerns about heavy metal contamination. Historically, a blue-grey residue from the Christchurch gasworks was spread on Hunter Terrace, where the pump track is located, to keep weeds down (Beckenham Neighbourhood Association, 1993). This is most likely bitumen, which contains carcinogenic compounds like PAHs as well as heavy metals (Legret et al., 2001). PAHs are a class of compounds produced by incomplete combustion of material like crude oil, which bitumen comes from, while heavy metals are a class of naturally occurring elements that commonly contaminate crude oil (Legret et al., 2001). The heavy metals typically found are copper (Cu), zinc (Zn), lead (Pb), and arsenic (As), which are concerning because they can leach into the surrounding soil, spreading contamination (Jayaneththi et al., 2024).

Our research is crucial because if we discovered high contamination, it means that individuals who have been using this land may have been exposed to harmful heavy metals, posing serious health risks. Additionally, the movement of soil during construction increases the likelihood of exposing contaminants like heavy metals, as the deeper soil is brought to the surface. Identifying if there are any areas with high contamination will guide the pump track's construction to ensure safety and minimize health risks during and after development.

The Beckenham Neighborhood Association provided the preliminary design plans for the pump track (Figure 3). The dark grey and green areas indicate where asphalt will be laid over the existing soil and tracks. Additionally, a section will remain uncovered, giving kids access to soil for creating their own jumps. This jump-building area will be filled with new, easy-to-dig soil for the community to use.

Figure 3. Preliminary pump track design

Upon initial consultation with the Beckenham Neighbourhood Association, we developed our research question: Is the soil in the Beckenham Bike Pump Track contaminated? If so, to what extent, and what mitigation strategies could be implemented that align with the interests of the community? This question addressed the key concerns of our community partners while remaining feasible within the project's timeframe.

3. Literature Review

To gain a comprehensive understanding of our project and methods involved with it, our group reviewed a wide range of background literature relevant to our research question. These included: effects of bike pump tracks on communities; potential contaminants of concern; sampling methods; exposure pathways; and remediation options and communicating these to the public.

Our research question directly relates to broader literature on contaminated land management, particularly in urban spaces. Studies on heavy metal contamination from industrial residues, such as those left from gasworks, have demonstrated the importance of assessing soil health to protect community well-being (Legret et al., 2001; Jayaneththi et al., 2024). By drawing on established research, we aligned our study with proven methods of soil testing and remediation, ensuring our work was scientifically grounded.

Our project also aligns with the interests of our community partners, the Beckenham Neighborhood Association, who raised concerns about potential contamination on the site due to the historical spreading of gasworks residue (Beckenham Neighborhood Association, 1993). Their goal is to create a safe recreational space for children and the wider community, making our research essential in providing the necessary data to inform the safe development of the pump track. By addressing both the scientific literature and the community's safety concerns, we bridged academic research with practical, local needs.

Due to the knowledge of historical contamination, we conducted a review of relevant literature on gasworks contamination. Papers by Ashrafzadeh et al. (2018) and Ajmone-Marsan & Biasioli (2010) deepened our understanding of health concerns related to exposure, while studies by the Ministry for the Environment (1997) and Byers et al. (1994) identified heavy metals and polycyclic aromatic hydrocarbons (PAHs) as the most associated contaminants from gasworks sites. These contaminants often originate from retort houses, coal dumps, gas purifiers, and coal-tar residue. Finally, Weigand et al. (2001) emphasized the importance of considering contaminant mobility, particularly in the leaching of heavy metals, highlighting the importance of sampling at depth to account for this.

A synthesis of Christchurch-based and urban environments contamination studies found the elements of Cu, Zn, As and Pb to be commonly present in soil (Ashrafzadeh et al. (2018); Jordan & Hogan (1975). We also wanted to make sure we were testing for those with significant health impacts as children use this land daily. A review of papers; Ramírez et al., 2021; Tong et al., 2000; Abdul et al., 2015; ATSDR, n.d. helped us understand the health effects of common heavy metals, which helped us confirm testing for As, Pb, Zn, and Cu in our X-ray Fluorescence (XRF) testing. However, our ICP-MS analysis was kept broader, testing for 30 elements so we can ensure the site poses no health risks.

Our sampling approaches were based on established methods for testing contaminated land, as outlined in various literature sources. Ramsey & Boom, 2012 and Ramsey, 2008 highlighted the use of in-situ methods such as portable X-ray fluorescence as an effective tool to use because it is cost-efficient, easy to do, and produces results in minutes. However, there can be uncertainty in accuracy of results. The other method for testing for contaminates is through ex-situ methods from soil samples using inductively coupled plasma mass spectrometry (ICP-MS) which Rouillon and Taylor (2016) discuss. Ex-situ methods can be more reliable due to the controlled environment. However, this paper also highlighted that ex-situ methods are typically more costly.

We conducted a thorough academic review of soil remediation techniques to determine the best methods for mitigating risks at this site. Papers by Dickinson et al. (2009), Lui et al. (2018), and the EPA (2013) highlighted two common approaches. The first is soil capping, which provides a physical barrier such as with concrete between the contaminants and the environment. This is a quick and effective solution, but will still leave the heavy metals beneath the cap. The other was phytoremediation or bioremediation, which works by adding plants to absorb, degrade, or stabilise contaminants in the soil. This has the potential to rid the soil of its contaminants but is a longer-term and slower solution. Since the new track will be capped with asphalt, this provides immediate protection, but understanding these additional methods allows us to implement further measures if needed.

When considering how to present our research to the Beckenham community, Reynolds & Seeger (2005) highlighted the importance of transparent and clear communication in alleviating fear and misinformation. However, our community partners later indicated that they would manage this aspect, so we did not address this further.

Researching the benefits that bike pump tracks offer to children and the broader community helped us better understand the scope of our project. Papers like O'Connor & Penney (2021), Poulton, Moffitt, & Silva (2015) and White et al. (2010) assess these benefits to well-being and health, such as socialisation, physical activity, and exposure to greenspace. We initially aimed to include a social aspect in our research and conduct surveys for community engagement, but after consulting community partners, we found the research had already been done. Therefore, we used the existing data and shifted our focus to the physical aspect of soil testing. The one area that was used was the research done on the benefits of greenspace, as this was useful when deciding on our recommendations for this piece of land (White et al. 2010).

4. Methodology

4.1 Preliminary Consultation

Within the early weeks after being assigned to our group, we met with community partners Dave Kelly and Mike Fisher to discuss their vision for our project. This helped us gain a deeper understanding of the task ahead of us and why this project was so important to the community.

In the early stages, we consulted Professor Brett Robinson, who advised us on cost-effective, skill-appropriate soil testing methods. His guidance, along with our literature review, shaped our approach. Brett also led a preliminary site investigation using an XRF gun to measure contamination and assess our potential project route. We found no major issues at randomly selected sites, and due to bitumen being near the surface, we opted for shallow, inexpensive, and time-efficient testing methods.

We also used historical articles/records of Beckenham, the South Library Draft Plan Report, Retrolens for imagery, Canterbury Maps for imagery and background concentrations, Listed

Land Use Register, S-map to understand the geology of the site, and I–Naturalist to understand the plant species growing there. All of these contributed to give us a broad historical site evaluation.

4.2 Analysis of Community Feedback

We initially planned to create a survey for the Beckenham community to gather input on their vision for the pump track and involve them in our project. However, our community partner Mike Fisher informed us that two previous GEOG309 groups had already conducted this research, so we utilised this existing research (Howat et al. 2013; King et al. 2021). In King et al.'s (2021) survey, 60% of respondents were dissatisfied with the current pump track, and 52% said they would use it more if upgraded. This highlights the importance of improving the track for increased community engagement. Howat et al.'s (2013) report included a quote from a participant: "We hope the bike track stays; the kids love it!" and King et al.'s (2021) report stated, "Most residents see the space as ugly, undermaintained, poorly formed, and uninviting." These insights helped inform our recommendations for the site once we had analysed the land.

4.3 Heavy Metal Testing Selection

Because of the bitumen found and site history, our literature review informed us the most common contaminants likely to be present would be PAHs and heavy metals. PAHs require expensive specialized tests that were not available to us, so we focused on testing for heavy metals, specifically for Cu, Zn, As, and Pb. It was crucial we tested for Pb and As specifically as Pb is a cumulative neurotoxin, especially potent to children, and As is extremely carcinogenic. These are also both common contaminants with Pb getting into soil from gas works pollution, metal smelting, leaded petrol, lead paints, and pesticides. As, on the other hand, is present through timber treatments and insecticides. We also learned it was important to test for Cu and Zn because although they are of relatively low toxicity to humans, they can be highly toxic to plants, and they are often found in very high levels. Zn can arise in soil through nearby galvanized structures and roofing. While Cu is a result of fungicide use or roofing.

4.4 Methods Selection

The methods used to determine whether the Beckenham bike pump track was contaminated were done by determining the concentration of heavy metals. The methods were advised by Professor

Brett Robinson and supported by the literature review and were chosen due to time and resource constraints.

Data was collected using portable x-ray fluorescence, taking soil samples and testing them in the lab along with spatial analysis. XRF is quick and accurate at testing for heavy metals, which is why we chose it. Figure 4 shows the 16 locations that samples were taken from. These 16 samples were chosen randomly throughout our site insuring to cover areas that will be capped and uncapped. Random sampling also ensures valid unbiased data (Botha, 2021).

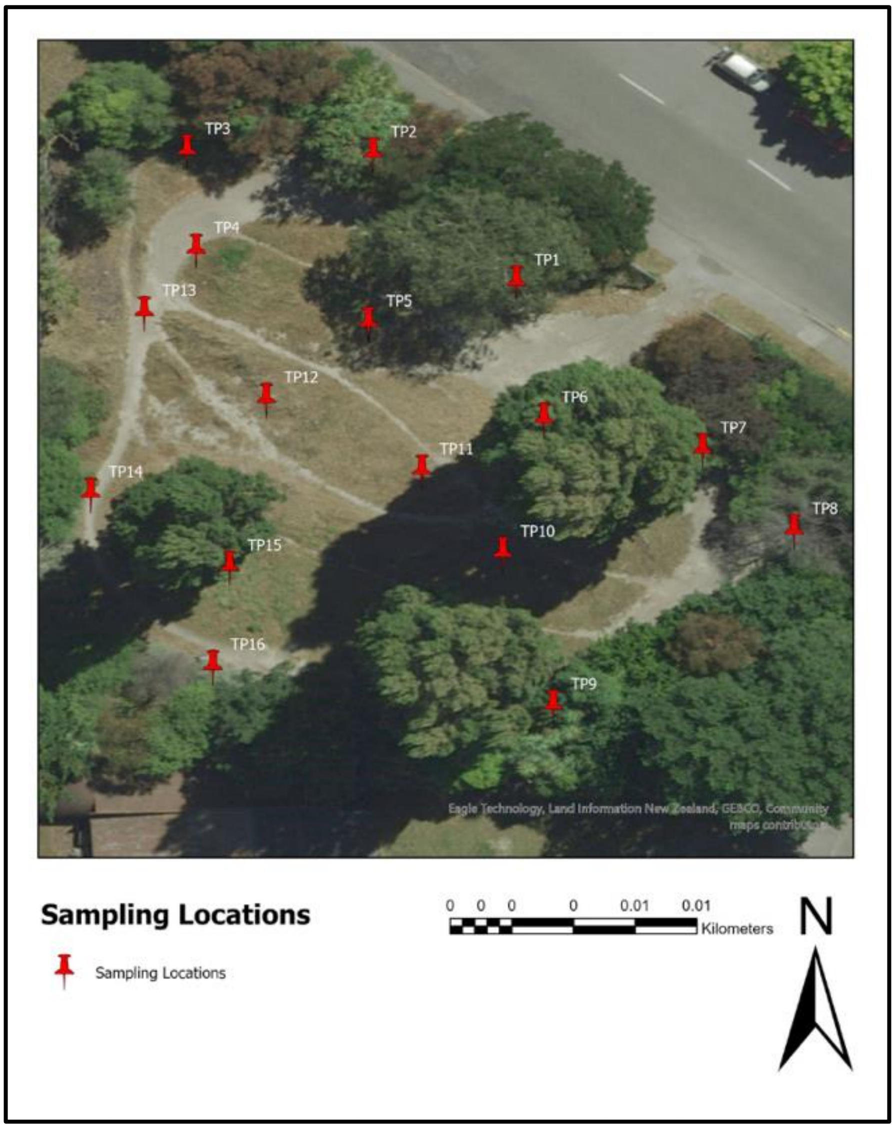

Figure 4. Locations of the 16 soil samples used for XRF analysis

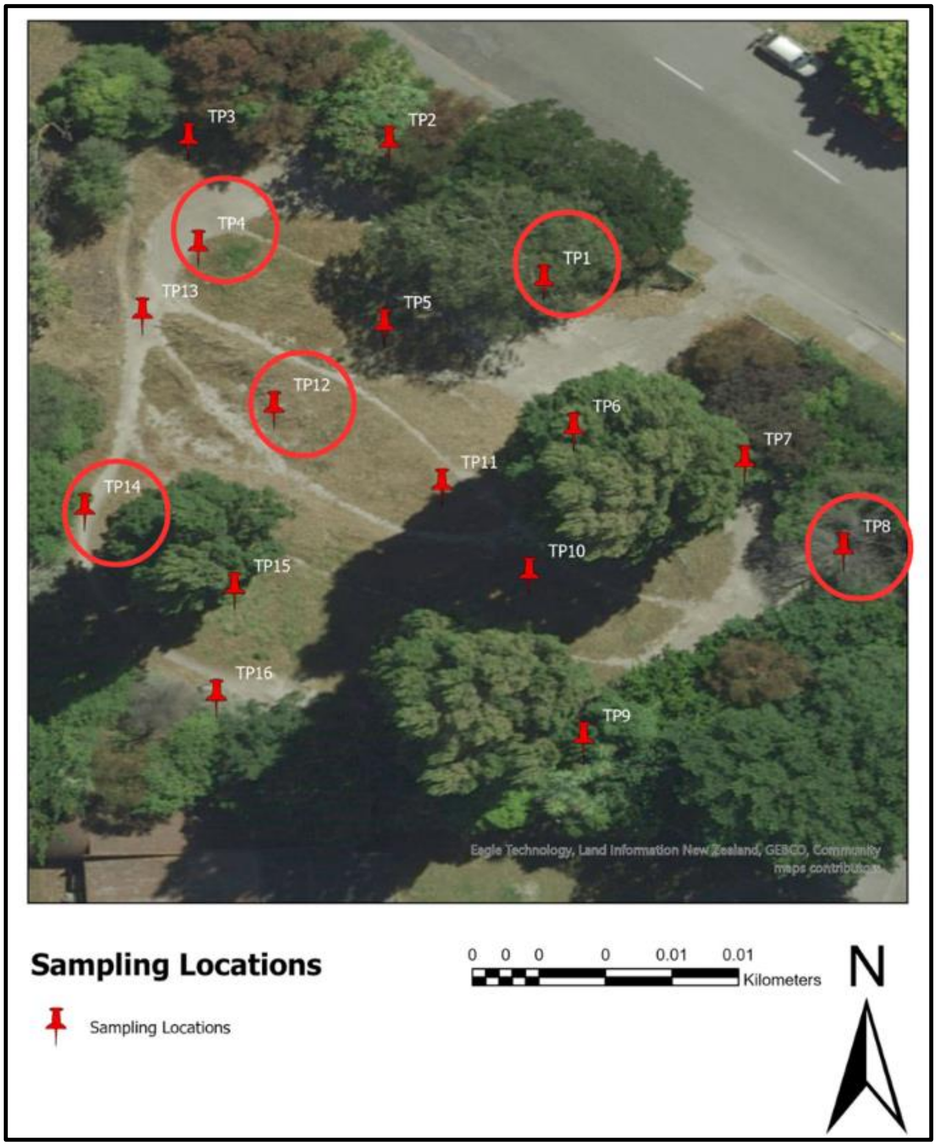

Figure 5. Locations of the 5 randomly selected soil samples used for ICP-MS analysis

X-ray fluorescence is an in-situ method determining the concentration of heavy metals of the materials being tested. As the X-ray hits the soil it fluoresces, and X-rays are sent back to the analyser identifying the elements present and their concentrations. This means you can take the XRF machine to the site and have efficient and accurate results for each plot.

Another method we used for heavy metal analysis was Inductively Coupled Plasma Mass Spectrometry (ICP-MS). This is completed in a Geochemistry laboratory and tests for a much larger range of elements, in our case 30. For this method we randomly selected five soil samples from our site map (Figure 5) and collected them in plastic bags using a hand trowel and spade.

The samples were then prepared for ICP-MS by drying in aluminum trays in an oven at 60°C for three days. After drying, the samples were sieved with a 2mm stainless steel sieve, making them ready for the digestion stage. At this point 0.25 g of each sample was weighed and added to separate flasks ensuring the exact weight of the soil sample was recorded, followed by the addition of 10 mL of 70% nitric acid to each. They were then placed on a hot plate set to 184^{o}C to help facilitate the digestion process. Once complete all the metals and metal oxides present will be dissolved in the nitric acid, but the carbon and other soil components will be left at the bottom of the flask. These samples were then cooled and placed in labeled tubes which now only contained the dissolved metals, which were subsequently diluted with distilled water to 40 mls. This process meant that samples were ready to be sent into the ICP-MS for ionization and detection to give us the heavy metal concentrations in the 5 soil samples.

4.5 Analysis of Results

After gathering and tabulating our XRF results we used both spatial analysis on ArcGIS software and compared our results to National contamination guidelines (NESCS) and natural background concentrations to analyse our samples and investigate the extent of contamination. To analyse the spatial extent and distribution of identified elements of copper, arsenic, zinc and lead, we created interpolation maps on ArcGIS Pro.

This was achieved by joining the geographic locations of samples to their subsequent XRF results and using the Inverse Distance Weighting (IDW) Interpolation spatial analyst tool. This tool estimates unknown values across the site by using a weighted average of known values. IDW analysis was selected as it has previously been identified to be the optimal interpolation model for assessing the spatial distribution patterns of toxic metal concentration (Saha et al, 2022). Displaying the results visually helped to determine if there were certain areas of the site with elevated levels and the overall estimation of contaminant concentrations in non-sampled areas.

5. Results

5.1 XRF Results

Table 1 demonstrates the raw XRF results collected from sampling the surface layer across 16 different test locations as seen in Figure 4. The elements presented were those chosen for analysis due to their common presence in urban soils and concerns for exposure effects on humans.

***Table 1*.**

Raw XRF Results

Location	Arsenic Conc.	Lead Conc.	Copper Conc.	Zinc Conc.
TP1	6	16	31	95
TP2	8	16	21	79
TP3	9	27	33	90
TP4	6	25	21	77
TP5	5	21	18	89
TP6	6	16	20	137
TP7	6	25	27	74
TP8	BD	51	28	135
TP9	BD	21	20	109
TP10	5	14	22	149
TP11	8	24	23	112
TP12	10	27	27	111
TP13	BD	27	33	102
TP14	BD	17	23	114
TP15	10	25	21	109
TP16	BD	28	30	341

*Note: BD = Below Detect.

The raw XRF results were compared to both natural background concentration values (Table 2) and the National Standards for Soil Contamination to Protect Human Health (Table 3). While some of the elements were above their natural background concentrations, they were still significantly below the National Environmental Standards for Assessing and Managing Contaminants in Soil to Protect Human Health (Table 3).

***Table 2*.**

Element Background Concentrations Recent Soil (Canterbury Maps, 2024).

Element	Background Concentration (mg/kg)
Copper	19.5
Zinc	166.8
Arsenic	16.3
Lead	128.8

***Table 3*.**

Soil contaminant standards for health ($SCSs_{(health)}$ for inorganic substances (Ministry for the Environment, 2012; Dutch Ministry of Housing, 2010).

Element	Residential 10% (mg/kg)	Recreation (mg/kg)
Copper	> 10,000	> 10,000
Zinc	720	720
Arsenic	20	80
Lead	210	880

*Note: All concentrations refer to dry weight (ie, mg/kg dry weight). The value for Zinc is the "Intervention Value" for Dutch Standards.

5.2 ICP-MS Results

Our ICP-MS analysis took 5 samples from the site, and this soil was tested for Li, B, Na, Mg, Al, K, P, Ca, Cr, Mn, Fe, Co, Ni, Cu, Zn, Ga, As, Se, Sr, Zr, Ag, Cd, In, Ba, Tl, Pb, Bi, Rh.
The analysis revealed that none of the samples contained any of the elements at levels concerning human health. Some elements, such as lead and copper, were found above background concentration but were still not of concern for human health. A table displaying the calculated values for each element is provided in the appendices.

5.3 Spatial Analysis

The visualisation of contaminant concentrations across the site, including estimations of values without sampled values, shows varying areas of contamination for each respective element. The interpolation maps produced (Figures 5-8) identify areas of lower concentration, blue shades, and higher concentrations, red shades. Upon inspection, there doesn't appear to be a consistent hotspot of contamination across the site. For example, Figure 7, showing the spatial variation in lead concentration shows higher levels of lead in the east of the site, while Figure 8, showing zinc concentrations has higher levels in the south-west. The higher concentration may be due to external factors, for example, the hotspot for zinc was likely due to galvanized iron sheets on a neighboring building. However, overall, the concentrations of analysed elements across the site are considered safe levels for human health.

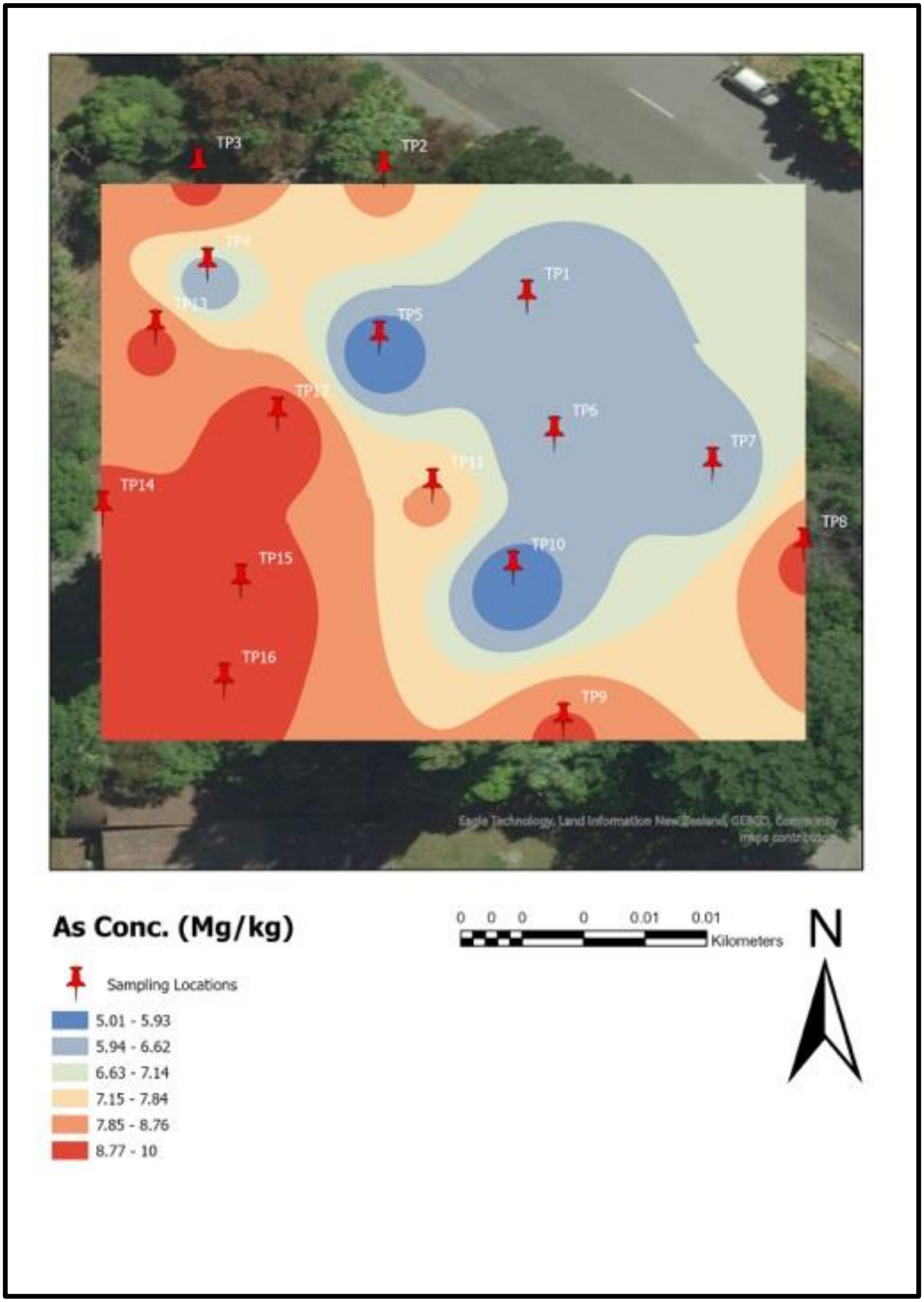

Figure 5. IDW Interpolation Map of Arsenic Concentrations

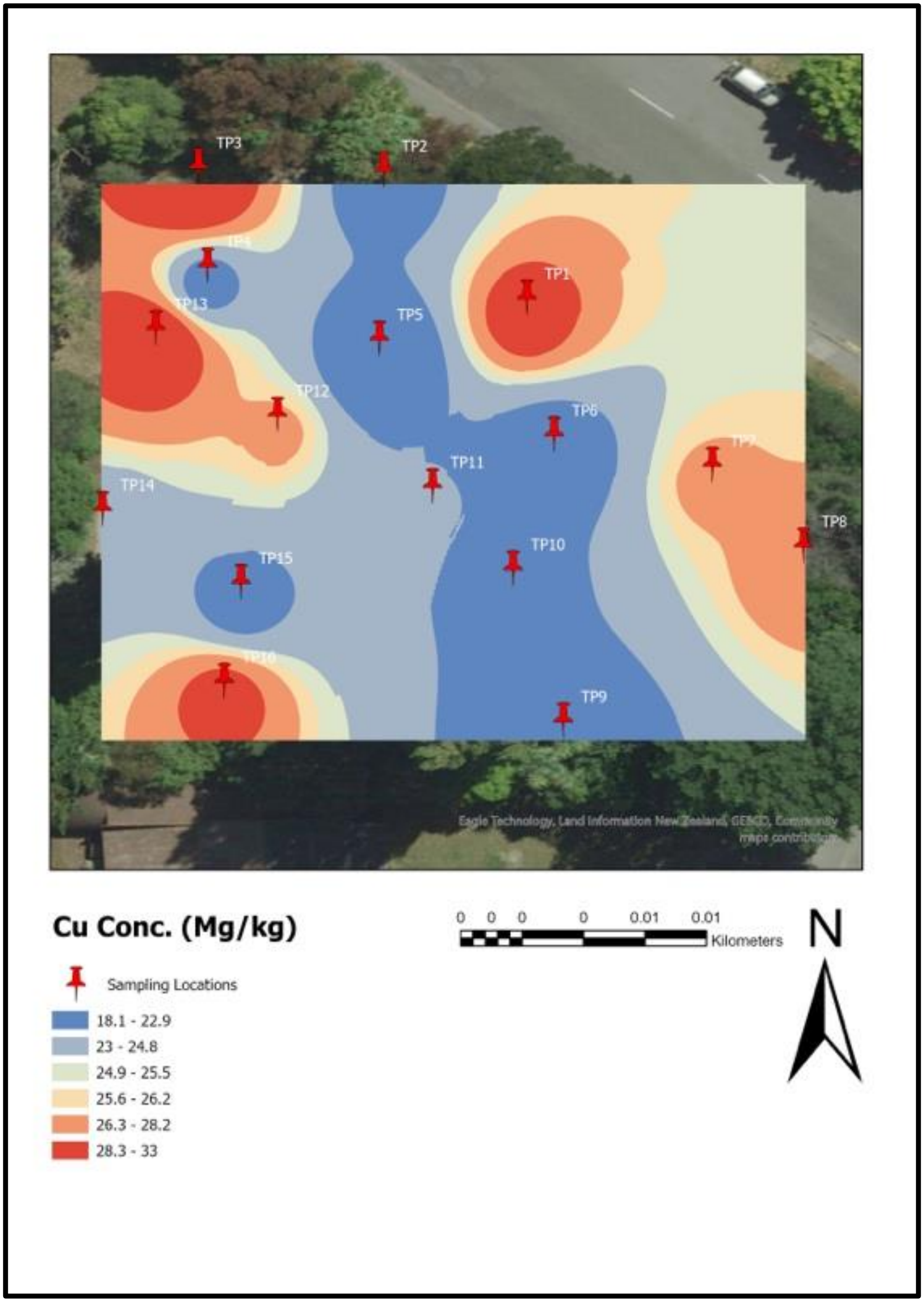

Figure 6. IDW Interpolation Map of Copper Concentrations

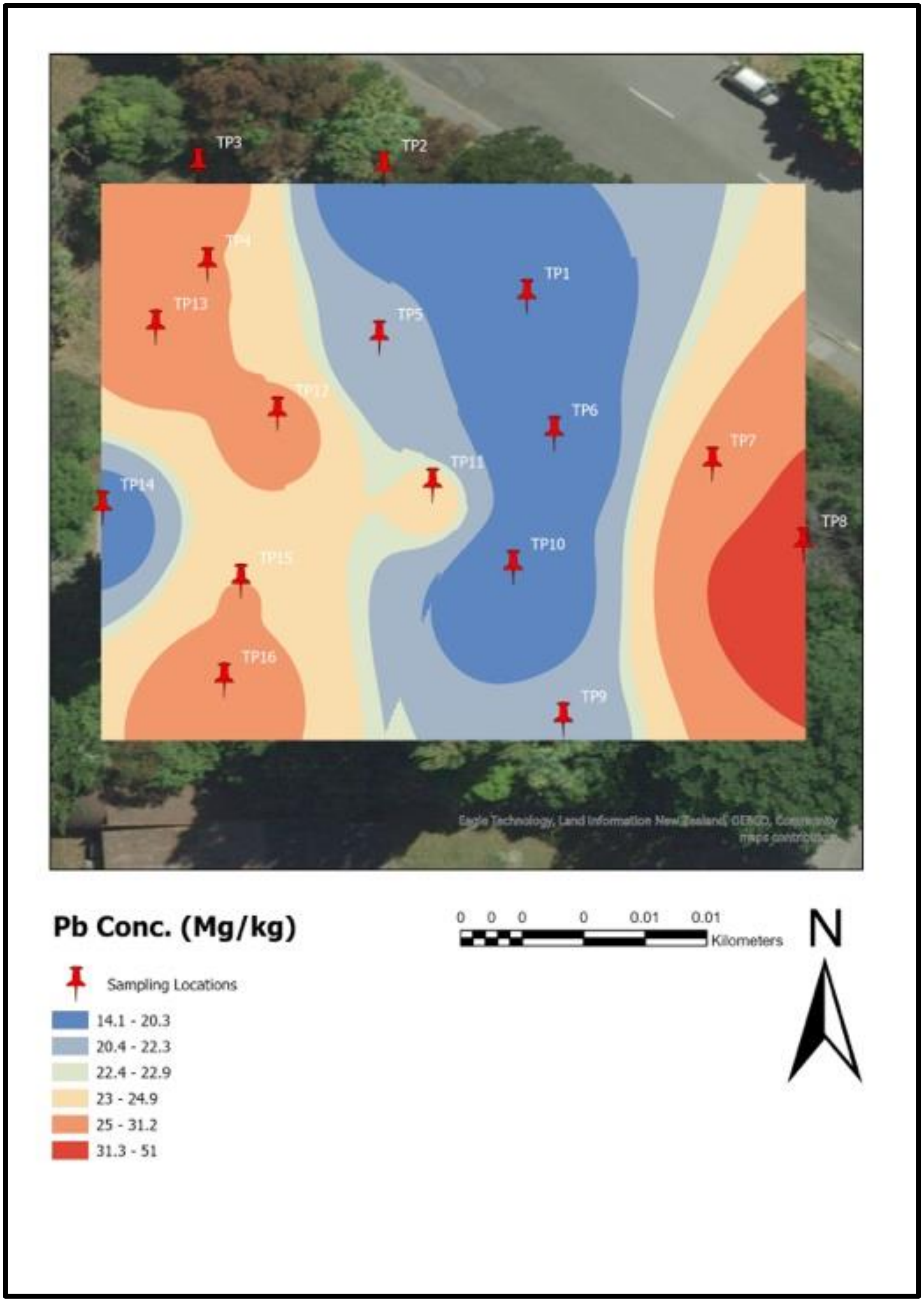

Figure 7. IDW Interpolation Map of Lead Concentrations

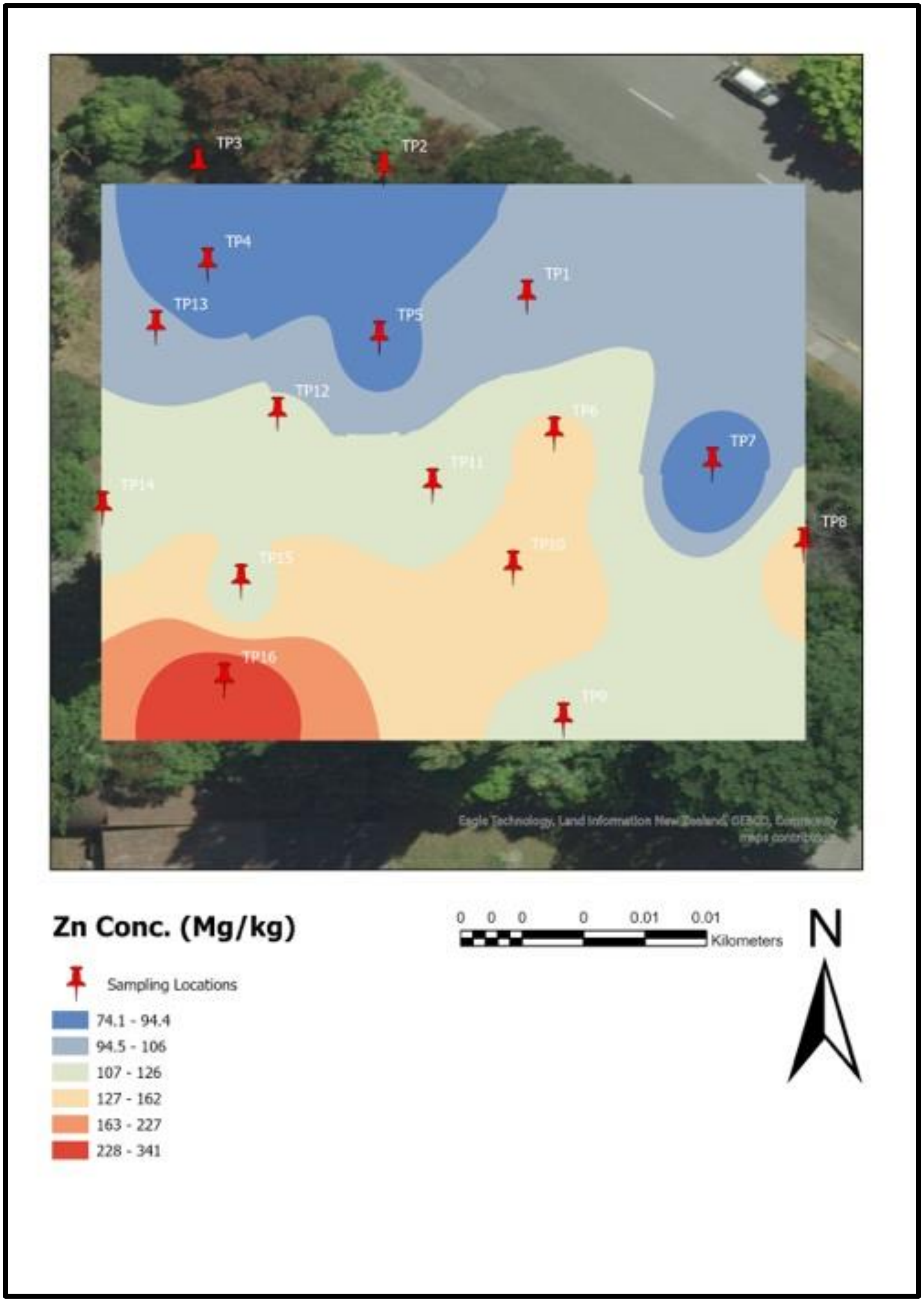

Figure 8. IDW Interpolation Map of Zinc Concentrations

6. Discussion

6.1 Contamination Extent

Our research aim was “to determine if the soil in the Beckenham Bike Pump Track was contaminated. If so, to what extent, and what mitigation strategies could be implemented that align with the interests of the community?”

After our research and analysis, we concluded that there were heavy metals and bitumen present in the soil, however they were not at a concerning level for human health. Across our 16 randomly selected sampling sites, the concentrations of lead, arsenic, copper and zinc were all below the National Environmental Standards for Assessing and Managing Soil Contamination to Protect Human Health. Of these elements, copper and zinc were present above their background concentration of recent soil in the area but were not present at a concerning level. Our findings showed that although residue from the gasworks affected Hunter Terrace and bitumen was consistently found at a depth of 10–20 cm, the heavy metal concentrations in the soil were not a health concern. This means there is no risk to the children using the site as a pump track. The ICP-MS results confirmed this, with all additional elements tested also at a safe level. This second layer of testing provided further certainty that the site is safe for recreational use.

6.2 Mitigation Strategies

From an analysis of our results, propose two recommendations for the Beckenham Neighbourhood Association as they continue with this initiative. These recommendations were guided by the review done on mitigation techniques (Dickinson et al. 2009; EPA 2013; Lui et al. 2018).

Our first recommendation is to cap the track with asphalt, which aligns with the current pump track design. While contaminant levels are mostly safe, asphalt adds extra protection, particularly to mitigate risks of potential at-depth contamination. Though asphalt costs more upfront than dirt, it lasts about 20 years longer and requires less maintenance, making it a more cost-effective option overall (Tranent & Officer 2016).

Our second recommendation is to use phyto-management in uncapped areas of this land as an extra strategy to mitigate potential at-depth contamination and exposure pathways. Adding plants to the site also enhances greenspace and aesthetics, which is beneficial to community wellbeing, and aligns with the desires of the community (Howat et al. 2013; King et al. 2021; White et al. 2010).

6.3 Limitations

One limitation was the impact that the presence of bitumen had on our research, making it impossible to dig deeper than 10-20cm with just the spade we had. This meant we could not test soil any deeper than this and would require proper excavation if we did, which we did not have the resources for. This means for the Beckenham pump track, there is the unknown risk that when digging and testing at depth, higher contamination may be present.

Due to contaminant mobility, contamination is a case-specific issue (Jayaneththi et al. 2024; Weigand et al. 2001). However, we know that soil has been moved in our area, therefore there is uncertainty whether or not our pump track area may have higher contamination at a greater depth. If the council intends to disturb the soil for the development of the proposed pump track, humans and plants could potentially become exposed to contamination. In this case, they should conduct sampling at depth beforehand to mitigate this unknown risk.

Throughout the course of our project, we have identified some knowledge gaps that would be useful to pursue before progressing with the proposed bike pump track. These include testing for PAHs, depth sampling and determining the best plant species for Phyto management.

Limited resources and time meant we were unable to sample and test for the presence of PAHs, a common byproduct of historic gas works, relevant to the residue deposited in the area previously. PAHs, particularly benzo-a-pyrene, are highly carcinogenic and should be investigated before plans are undertaken in the future.

Regarding our recommendation of Phyto management, there are currently limited studies on what plants specifically are recommended to use, which highlights an important gap in research that could be useful in further steps for this and future projects (Meister et al. 2023).

7. Conclusion

Our research combined historical site evaluation, field sampling, and data analysis to assess potential contamination at the Beckenham pump track site. Utilising a range of resources such as historical records, imagery from Retrolens and Canterbury Maps, geological data from S-map, and past community surveys we established a comprehensive understanding of the site's background, past land use, and present opinions on the land. XRF testing and ICP-MS lab analysis measured heavy metal concentrations, and the results were mapped using ArcGIS Pro for spatial interpolation. These findings, guided by NESCS guidelines for human health and the background concentrations of these heavy metals in the area, informed us that this land is not contaminated at the depths we sampled at. This analysis will inform future decision-making to ensure the safe development of the site into an official community facility.

8. Acknowledgements

We would like to acknowledge and thank the ongoing support from Georgie Rule, Brett Robinson and our community partners, Mike Fisher and Dave Kelly, for contributing their time and expertise to our project. We would also like to acknowledge Chris Grimshaw who assisted with laboratory inductions and ICP-MS testing.

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10. Appendices

Appendix 1: ICP-MS Results

Sample Name	7 Li [No Gas]	11 B [No Gas	23 Na [He]	24 Mg [He]	27 Al [He]	39 K [He]	31 -> 47 P [O	44 -> 60 Ca [	52 -> 68 Cr [	55 -> 55 Mn [	57 Fe [He]	59 Co [He]	60 Ni [He]	63 Cu [He]	66 Zn [He]
	Conc. [ug/l]	Conc. [ug/l]	Conc. [ug/l]	Conc. [ug/l]	Conc. [ug/l]	Conc. [ug/l]	Conc. [ug/l]	Conc. [ug/l]	Conc. [ug/l]	Conc. [ug/l]	Conc. [ug/l]	Conc. [ug/l]	Conc. [ug/l]	Conc. [ug/l]	Conc. [ug/l]
1	8.4	1.848	67.193	915.991	1975.424	448.196	159.001	1095.399	5.466	93.273	4153.159	1.788	3.805	4.183	25.183
4	9.453	2.192	61.68	961.571	2153.716	533.115	192.603	1275.004	5.832	121.71	4601.393	2.162	3.679	4.493	25.623
8	9.493	2.464	76.67	1010.626	2390.967	628.574	176.906	1523.999	10.565	107.977	4681.318	2.306	4.605	4.468	27.492
12	10.228	2.69	72.852	993.409	2241.17	599.516	187.121	1433.637	8.32	104.207	4719.887	1.874	3.644	3.902	27.912
14	8.226	3.599	62.914	893.77	1872.196	495.672	191.238	1808.893	5.246	123.26	4885.343	2.118	3.839	4.388	36.599
Recalculated values into mg/kg															
1	29.68827	4.46582279	193.138565	3245.10194	6998.93435	1588.54279	563.36	3847.71392	18.6820253	330.525823	14713.6787	6.12455696	13.4730802	13.3159494	87.6648101
4	35.518565	6.04197309	184.497399	3620.52179	8109.92251	2008.14619	725.300448	4765.81345	21.2335426	458.393274	17325.8224	7.91784753	13.8443049	15.3196413	94.8258296
8	30.8303876	6.10790698	208.273333	3289.07969	7782.18434	2046.52	575.800465	4929.96977	33.7627907	351.496047	15235.6411	7.31255814	14.9810853	13.16	88.0469767
12	33.2234109	6.84372093	195.842636	3233.02434	7294.47318	1951.91256	609.058605	4635.76791	26.4534884	339.221628	15361.2146	5.90604651	11.8522481	11.3172093	89.4144186
14	29.5706438	10.8551073	181.027811	3220.7018	6746.93528	1786.97202	689.250644	6486.02215	18.2096137	444.307725	17605.9073	7.41939914	13.8269528	14.2836052	130.32618
Average for each element tested (mg/kg)															
	31.7662555	6.86290622	192.555949	3321.68591	7386.48993	1876.41871	632.554032	4933.05744	23.6682921	384.788899	16048.4528	6.93608166	13.5955342	13.479281	98.0556431

Sample Name	69 Ga [He]	75 -> 91 As [	80 -> 96 Se [	88 -> 104 Sr [	90 -> 106 Zr [	107 Ag [He]	111 -> 111 Cd	115 -> 115 In	138 Ba [He]	205 Tl [He]	206 Pb [He]	207 Pb [He]	208 Pb [He]	209 Bi [He]	103 Rh (ISTD) [He]
	Conc. [ug/l]	Conc. [ug/l]	Conc. [ug/l]	Conc. [ug/l]	Conc. [ug/l]	Conc. [ug/l]	Conc. [ug/l]	Conc. [ug/l]	Conc. [ug/l]	Conc. [ug/l]	Conc. [ug/l]	Conc. [ug/l]	Conc. [ug/l]	Conc. [ug/l]	ISTD Recovery %
1	2.488	1.365	0.03	6.96	0.859	<0.000	0.038	<0.000	10.911	0.02	8.386	8.933	8.796	0.013	108.6
4	3.156	2.474	0.061	8.817	0.974	<0.000	0.029	<0.000	14.314	0.028	12.444	13.173	13.108	0.009	108.3
8	3.131	1.898	0.062	10.945	1.589	<0.000	0.038	<0.000	13.754	0.03	14.667	15.752	15.514	0.013	108.5
12	3.062	2.253	0.044	10.506	0.974	<0.000	0.04	<0.000	13.48	0.029	9.897	10.547	10.515	0.011	109.9
14	3.079	2.536	0.028	12.533	1.179	<0.000	0.065	<0.000	14.676	0.022	13.166	14.193	13.948	<0.000	109.1
Recalculated values into mg/kg															
1	8.81822785	4.83797468	0.10632911	24.5608439	1.54531646	#VALUE!	0.13468354	#VALUE!	38.6718987	0.07088608	29.7225317	31.6612658	31.1756962	0.04607595	
4	11.8880718	9.31910314	0.22977579	33.0977579	2.0755157	#VALUE!	0.10923767	#VALUE!	53.9182063	0.10547085	46.8742601	49.6202691	49.375426	0.03390135	
8	10.1939535	6.17953488	0.20186047	35.536124	3.79627907	#VALUE!	0.12372093	#VALUE!	44.7804651	0.09767442	47.7530233	51.2855814	50.5106977	0.04232558	
12	9.96930233	7.33534884	0.14325581	34.1068217	1.79395349	#VALUE!	0.13023256	#VALUE!	43.8883721	0.09441861	32.2227907	34.3390698	34.2348837	0.03581395	
14	11.1002575	9.14266094	0.10094421	45.0739914	2.72549356	#VALUE!	0.23433476	#VALUE!	52.9091846	0.07931331	47.4654077	51.167897	50.2846352	#VALUE!	
Average for each element tested(mg/kg)															
	10.3939626	7.3629245	0.15643308	34.4751078	2.38731165	#VALUE!	0.14644189	#VALUE!	46.8336254	0.08955265	40.8076027	43.6148166	43.1162678	#VALUE!	