

# Using Data Visualisation to Determine the Sources of Plastic Pollution in Port Phillip Bay

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We acknowledge the Kulin Nation as the traditional and continuing custodians of the land  
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## Introduction

Beginning at 2 million metric tonnes in 1950 and increasing to over 400 million metric tonnes in 2015, plastic production has grown faster than most other industrial materials (University of Georgia, 2017). Globally, plastic pollution has been an issue of increasing concern. The Ellen MacArthur foundation conducted a study that estimated 8 million tonnes of plastics enter the ocean each year (Ellen MacArthur Foundation, 2016). They equate this “to dumping the contents of one garbage truck into the ocean per minute, and if no action is taken, this will increase to two per minute by 2030 and four per minute by 2050” (Ellen MacArthur Foundation, 2016). Plastic pollution in the ocean has widespread negative effects on humans, the environment, and marine organisms.

Plastic pollution is a complex social, environmental, and economic problem with no easy solution (United Nations Environment Programme, 2016). The physical properties of plastic make it ideal for mass consumerism and the health industry. “Single-use plastic products that prevent the spread of infection are crucial in the medical industry. Instruments such as syringes, applicators, drug tests, bandages and wraps are often made to be disposable” (Plastics Industry Association, 2018). While single-use plastics are necessary for industries such as the medical industry, in many cases single-use plastics are used solely for convenience. Plastic products are often found littered on the side of the road, in nature, and in the ocean (Charko et al., 2018). One famous example of plastic pollution is the Great Pacific Garbage Patch, a floating patch of pollutants between Hawaii and California that was discovered by Charles J Moore (The Ocean Cleanup, 2018). It is estimated that there are 1.8 trillion pieces of plastic in the Great Pacific Garbage Patch alone (The Ocean Cleanup, 2018).



Figure 1. Aerial view of the Great Pacific Garbage Patch (Rothert, 2018)

Plastic pollution in the ocean has large negative impacts on marine environments such as Port Phillip Bay. Port Phillip Bay (referred to as “the bay” in following passages) is an inland embayment located in Victoria, Australia with a large catchment area and small estuary. All of the plastic waste improperly disposed of by the 3 million people within the 10,000 square kilometre catchment area ultimately travels into the bay. Since the bay’s opening into Bass Strait is only 3.2 kilometres wide, it is difficult for pollutants to escape. Ultimately, this means that the bay is at high risk of becoming contaminated and contaminants are unlikely to leave the bay by natural means. An estimated 828 million pieces of litter enter the bay each year through the Yarra and Maribyrnong rivers (Charko et al., 2018). This plastic pollution negatively affects the diverse ecosystem residing in the bay. By monitoring and controlling the levels of plastic pollution in Port Phillip Bay catchment area, organisations can have a profound impact on the health of marine wildlife in Port Phillip Bay.

Funded by the Port Phillip EcoCentre (referred to as “the EcoCentre” in following passages), the Clean Bay Blueprint project is an ongoing effort to keep Port Phillip Bay clean and free of microplastics and other plastic pollution (Port Phillip EcoCentre, 2017). The EcoCentre is a not-for-profit organisation whose mission is “to build relationships to

inspire, educate and demonstrate sustainable environmental practice and reconnect people to the natural world” (Port Phillip EcoCentre, 2017). Since 2012, the EcoCentre has been gathering pollution data using street, beach, and river litter audits (Charko et al., 2018). The EcoCentre aims to demonstrate the scope of plastic pollution in Port Phillip Bay’s catchment area in order to reconnect the community to pressing environmental issues and inform government policy. Similar organisations, such as the Victoria Litter Action Alliance, Tangaroa Blue, and the 5 Gyres Institute, have been collecting plastic pollution data in other areas of Australia.

This project aims to support the Port Phillip EcoCentre in their mission by providing in depth research into the sources of plastic pollutants entering Port Phillip Bay. The project will determine correlations between the existing pollution data and other factors in the Greater Melbourne area. Geographic Information Systems mapping (referred to as “GIS mapping” in the following passages) will be used to visualise and analyse correlations and causations. A case study was presented to the EcoCentre ranking and comparing different GIS mapping softwares, so they were able to select the best tool for their needs. Using this tool, we created a system that allows the EcoCentre to analyse plastic pollution data and continue to do this after our project has ended. Information about local waste management regulations, plastic mitigation efforts, and the status of current research will come from interviews with local council representatives and experts in the field. Ultimately, our goal was to discover correlations and causations between pollution levels in Port Phillip Bay and environmental and human factors, as well as produce a data visualisation that will support current and future EcoCentre efforts.

## Background

### Plastics

Plastic shopping bags take 20 to 1,000 years to decompose because of their chemical properties (ABC, 2018). Plastic is “a synthetic material made from a wide range of organic polymers... that can be moulded into shape while soft and then set into a rigid or slightly elastic form” (Oxford University Press, 2018). Polymers are chemicals made of repeating units, known as monomers. The polymers that make up plastics are derived from oil and natural gas and contain chemical additives to enhance their properties. Most polymers are hydrocarbons, meaning they are composed of carbon and hydrogen (American Chemistry Council, 2018). In these hydrocarbons, each carbon atom has four covalent bonds giving it a full octet and making these bonds difficult to break (BCcampus, 2018). The chemical additives that are added to plastics enhance these properties by manipulating the molecular structure of the compound (American Chemistry Council, 2018). As a result of these chemical properties and additives, plastics do not readily decompose in the environment. These qualities make plastic pollutants harmful to the environment.

### Microplastics

Microplastics are small plastics less than five millimetres in size (Charko et al., 2018). There are two categories of microplastics: primary and secondary. Primary microplastics are plastics that are created at this size intentionally and are used in various aspects of everyday life. Secondary microplastics are created through the degradation of plastic over time.

Primary microplastics are typically manufactured for use in other products. The main source of primary microplastics is plastic resin pellets also known as nurdles (United Nations Environment Programme, 2016). A nurdle, as shown in Figure 2.1, is a small plastic pellet, typically two to three millimetres in diameter, that is used to make a wide range of plastic items (Maillard et al., 2013). The most common way that industrial

practices contribute to microplastic pollution is through the escape of nurdles at various stages of the plastic production process (Beaman et al., 2016). Another example of a primary microplastic is a microbead, which is used as an abrasive agent in a wide range of personal care and cosmetic products (United Nations Environment Programme, 2016). One key example of this is small beads found in face exfoliants. Wastewater treatment plants often do not have equipment that is able to filter these microbeads or plastic fibers from the wastewater which results in the microbeads being discharged into a local body of water (Beaman et al., 2016). The image below is of nurdles, which are primary microplastics made for manufacturing purposes, that were found during a beach litter audit next to Port Phillip Bay.



*Figure 2.* Nurdles collected on a beach bordering Port Phillip Bay.

Secondary microplastics are created through degradation. While plastic pollutants are floating on top of the water they are exposed to a weathering process. Microplastics are formed from the “fragmentation of larger items through a combination of physical, chemical and biological processes” (United Nations Environment Programme, 2016).

Degradation of plastics has been a research topic for hundreds of different agencies in over 60 countries worldwide (plastic pollution coalition, 2018). Rates of degradation among different types of plastic debris vary, where thicker types of plastic are expected to persist in aquatic environments for hundreds of years (Beaman et al., 2016).

Photodegradation is caused by the absorption of photons by molecules in plastic, which breaks bonds within the polymer (Pollution Solutions, 2015). Photons are found in ultraviolet (UV) light, a key component in sunlight (Pollution Solutions, 2015). UV light from the sun causes oxygen molecules to be absorbed into the plastic, known as oxidation (Pollution Solutions, 2015). As more oxygen molecules are absorbed into the plastic, they react with the polymers ultimately weakening it, making the plastic more brittle and easier to break (Pollution Solutions, 2015). After UV light affects the plastic molecules, the plastic is more brittle and this increases the potential for plastic to break into smaller pieces when it is stepped on or run over by a car.

Quantifying the amount of microplastics present in the marine environment is difficult because most plastics have a higher specific gravity than water (Beaman et al., 2016). As a result, most plastics sink and are out of the range of human sight, making it difficult to determine the total number of plastic pollutants in the ocean (United Nations Environment Programme, 2016). However, in a study conducted by 5 Gyres Institute, it was estimated that 5.25 trillion plastic particles are floating in the marine environment (Eriksen et al., 2014). This estimate is based on various trawls done at the surface of the ocean, and visual surveys of large plastic debris. A trawl is a pollutant collection method consisting of a net that is pulled behind a boat that catches floating particles (Food and Agriculture Organization of the United Nations, 2018). In the conclusion of the 5 Gyres

Institute report, the researchers state that they believe their estimate to be an underestimate as they only collected plastics that were found on the surface, and then extrapolated their data using the vertical distribution equation to encompass plastics in all depths and areas of the ocean (Eriksen et al., 2014). 5 Gyres Institute has furthered their studies by creating a program known as “TrawlShare” which enables citizen scientists, which are a subset of amateur scientists, from around the world to perform trawls in their respective regions (5 Gyres, 2018). The platform that 5 Gyres has created enables accurate collection of data using citizen science and also enables people to contribute to a robust global dataset of trawling data. The results of these manta trawls are used to update 5 Gyre’s global estimate of marine plastic pollution.

### **Effects of Plastic Pollution on Marine Organisms**

The chemical composition of plastic allows plastics to adsorb toxins that are harmful to marine organisms. Persistent organic pollutants (POPs) are one example of toxic chemicals that last for years in the environment due to their low solubility. POPs are man made and primarily come from pesticides and industrial chemicals. POPs are lipophilic, meaning they are attracted to the fatty tissue of living organisms (United Nations Environment Programme, 2018b). POPs can affect organisms in various ways, such as damaging organ systems or causing cancer (United Nations Environment Programme, 2018b). Plastics can act as “a ‘sponge’ to remove and concentrate contaminants from the water column. If an animal, such as a fish, bird or marine mammal, ingests plastic particles then there is the potential for transfer of these adsorbed chemicals into the tissue” (United Nations Environment Programme, 2016). The result of a study on the sorption of POPs implies that some plastics pose greater risks to marine wildlife than others due to higher concentrations of hazardous chemicals (CM, E, BT, & S, 2013).

One study showed that there are 2.73 pieces of microplastic (sized 2-5mm) in the ocean per one zooplankton (Collignon, Hecq, Galgani, Collard, & Goffart, 2014). One

problem with this is that animals can confuse plastics as food and intentionally digest them. When marine organisms consume plastic they are ingesting both the plastic itself, and the pollutants that have been adsorbed (Lockwood, 2012). It has been found that fish who consume plastics are more likely to have tumor or liver problems (Maillard et al., 2013), (Barclay, 2013). When these plastics are consumed, chemicals are absorbed off the plastic and into the bloodstream and tissues of smaller organisms. Since plastics are not digestible and can not be excreted, they remain in the organisms stomach thus shrinking the effective size of the organism's stomach. This means that organisms are unable to consume adequate amounts of food which affects energy levels, blocks internal organs, and can result in death. After certain organisms consume plastics, these chemicals travel up the food chain through a process known as bioaccumulation, where they eventually reach humans (Michigan Department of Community Health, 2018). Due to the inability of plastics to degrade and the potential for plastics to absorb harmful chemicals, the pollution of plastic items poses a great threat to marine ecosystems and human health.



*Figure 3.* (left) Seabird found dead on beach with stomach full of plastic (Estrada, 2017). (right) 800g of plastic found in Minke whale that washed up dead on a beach in Normandy (BBC, 2016).

The images above show the affects that plastic have on organisms stomachs. Approximately 92% of marine debris is plastic and plastic pollution affects at least 693 species worldwide including “all known species of sea turtles, 54% of all species of marine mammal, and 56% of all species of seabird” (Gall & Thomson, 2015). Of the species that are affected, 17% are on the International Union for Conservation of Nature’s Red List for being threatened, vulnerable, endangered, or critically endangered (Gall & Thomson,

2015). The ingestion of plastic by marine animals has the potential to cause significant biological problems by blocking gastric enzyme secretion, diminishing feeding stimulus, lowering steroid hormone levels, delaying ovulation, and causing reproductive failure (Gall & Thomson, 2015). Even if plastic pollution is not ingested, marine organisms can get entangled in items such as plastic rings or bags. For these reasons, plastic pollution in marine environments poses a great threat to the health of marine ecosystems.

It is only within the last decade that people have begun to realise microplastic pollution is a problem (United Nations Environment Programme, 2016). Most of the research that exists focuses on the effects that microplastics have on marine organisms and, in many cases, the research done focuses on specific species. For example, a study by Gall and Thompson attempts to quantify the current state of research on the effects that plastics have on marine organisms (Gall & Thomson, 2015). They found that there are 340 original publications reporting the encounters between organisms and marine debris (Gall & Thomson, 2015), however, research is lacking when it comes to quantifying the amount of microplastics present in the marine environment (Fraunhofer-Institute for Environmental, Safety, and Energy Technology UMSICHT, 2015).

## Prevalence of Plastics

Plastic consumerism gained popularity following World War II, when the large production capacity of the United States pivoted towards the mass consumer market (Knight, 2014). As a result, the global production of plastics rose from 2 million metric tons in 1950 to 400 million metric tons of plastic in the year 2015 (University of Georgia, 2017). This increase in plastic production has accumulated to the generation of 8.3 billion metric tons of plastic (University of Georgia, 2017). For comparison, this is the same weight as 80 million blue whales (University of Georgia, 2017).

Plastic revolutionised society by greatly impacting the packaging industry (Hall, Berry, Rintoul, & Hoogenboom, 2015). Most packaging products are single-use plastics.

Single-use plastics are meant to be used once and then disposed of. Some examples of single-use plastics include grocery store bags, water bottles, straws, plastic packaging, and disposable cups. Today it is socially acceptable to use single-use plastic items rather than using reusable items.

“When we buy our groceries our snacks come within a plastic wrapped box with plastic wrapped individual granola bars or chips. Our baked goods come in new plastic containers. This practice is not just applied to unhealthy ‘processed’ food but every aspect of our lives. When we buy fruit and vegetables we place apples or lettuce in thin plastic bags. Even worse we place pre-peeled and sliced apples, oranges, or carrots in a plastic container” (McDermott, 2016).

Grocery stores try to mitigate the effects of single-use plastic bags by collecting and recycling them. However, it is estimated that 4 trillion plastic bags are used annually worldwide, and that only 1% of these are returned for recycling (Earth Day Network, 2018). Along these same lines, humans buy approximately 1 million plastic bottles per minute and, in Australia, only about 11.8% of these plastic bottles are recycled (O’Farrell & Australian Government: Department of the Environment, 2018). This shows that current efforts to enforce recycling practices are ineffective against today’s single-use consumer culture. The most commonly polluted items found in the ocean are plastic bottles and plastic bags, both of which are single use plastics. However, clothing, lighters, polystyrene, containers, and plastic shoes which are intended for multiples uses are also found in large quantities in the ocean (Guern, 2018). This “multitude of plastic pollution is not just attributed to the odd ignorant man directly dropping a plastic cup into the river but has everything to do with the overconsumption of single use plastics” (McDermott, 2016).

While plastics are typically recyclable, many user items containing plastics are not. One example of this is single-use coffee cups, which are not easily recyclable due to their polyethylene lining which disencourages the coffee to soak into the paper cup (Gabbatiss, 2018). Only 1% of coffee cups ever end up being recycled properly (Gabbatiss, 2018).

Another item that is frequently littered and contains plastic is a cigarette. The plastic lining in the filter is comprised of thousands of particles of plastic (). These two user items are examples of partially plastic products that are frequently used in everyday life and can not be easily recycled.

## **Journey of Plastic Pollution**

According to Jenna Jambeck, a researcher at of the University of Georgia, 80% of plastic pollution begins on land(University of Georgia, 2017). Pollutants can be littered either intentionally or unintentionally. Intentional litter is litter that is polluted by a user consciously. Unintentional litter is litter that is attempted to be properly disposed of, however due to unforeseen factors, gets littered. When plastics are littered on the streets or beaches, wind and rain can cause them to enter storm drains or local rivers. Plastic pollution can enter local waterways through unintentional littering which can be due to improper waste management (Beaman et al., 2016). This includes plastics falling out of overflowing litter bins and plastics falling out of garbage trucks. Improper waste management and unintentional litter are especially a problem after large public gatherings because disposal systems may not be equipped to handle such large volumes of plastics. Volumes beyond system capacity result in overflows that allow wind and wildlife to carry them into local waterways (Beaman et al., 2016).

Neil Blake of the Port Phillip EcoCentre has coined the term, "Burbs2Bay" to describe the transport of litter from local suburbs to bodies of water. When items are littered on streets in urban suburbs, they are influenced by natural and human elements to ultimately travel to the nearest body of water. Heavy rainfalls and strong winds can cause littered items to move from sidewalks to storm drains and ultimately into Port Phillip Bay through stormwater drains. Neil Blake states that "many people aren't aware that stormwater drains connect the streets to the bay. If you can't see a bay or a creek many people just wouldn't understand that connection... the idea is that choices people make no

matter where they live will have a direct impact on the bay even if they don't know it" (Neil Blake, personal communication, 12 November, 2018).

## **State of Current Research**

Ultimately, all of the pollutants that are littered on land, may end up in the sea. One study conducted in Tasmania, Australia focused on researching the sources of marine litter. The three hypotheses that were studied were: (1) direct deposition by beachgoers, (2) transport from surrounding areas via storm water drains and coastal runoff, and (3) onshore transport from the marine system (Willis, Hardesty, Kriwoken, & Wilcox, 2017). Ultimately, they found that most marine litter is deposited locally and that "local interventions are likely to be the most effective in reducing land-based inputs into the ocean" (Willis et al., 2017). One major conclusion from their study was the correlation between location of stormwater drains and amount of pollutants on shores nearby. Specifically, there was "greater amounts of debris on shores with a greater number of stormwater drain outflows within a 5 km radius, even when we controlled for local population density. The greater number of stormwater drains, the higher probability that litter will exit a drain and be deposited on the shore" (Willis et al., 2017).

The research done to understand why pollutants are so commonly found in nature is sparse (Eriksen et al., 2013). A group of researchers concluded that the "focus has been primarily on the symptoms (the animals or environments harmed by the litter) rather than the causes (how the litter enters the environment, and plastic use in society)" (Pahl, Wyles, & Thompson, 2017). The United Nations Environmental Programme (UNEP) is the leading global environmental authority, with the primary objective of establishing the global environmental agenda (United Nations Environment Programme, 2018a). Their publication, Marine Plastic Debris and Microplastics: Global lessons and research to inspire action and guide policy change, compiles leading global data to generate consensus between key organisations, with the goal of guiding policy change to generate positive

outcomes. One conclusion that this report draws is that until the extent of plastic pollution is more widely understood, policy makers should take precautions to limit the widespread use of plastics (United Nations Environment Programme, 2016). According to UNEP, “there is a sufficient body of knowledge to argue convincingly of the need to invoke the precautionary approach, in reducing the input of plastics into the ocean and minimising the risk” (United Nations Environment Programme, 2016). Despite the significant studies that have already been conducted, more research is required to better understand the scope of plastic pollution in marine environments so that different organisations can appropriately mitigate pollution.

As part of the effort to better understand the extent of plastic pollution, the Port Phillip EcoCentre has been collecting data on plastic pollution across beaches, streets, and rivers within the Melbourne area since 2012 (Maillard et al., 2013). Citizen science has been an invaluable tool in collecting data through street, beach, and river litter audits (Charko et al., 2018). This data has been used to draw the conclusion that plastic pollution is a prevalent issue in the water leading to Port Phillip Bay. The next step towards mitigation is to identify primary sources of plastic pollution within the Port Phillip Bay catchment area.

## **Port Phillip Bay**

Port Phillip Bay is a 2,000 square-kilometre large marine embayment south of Melbourne (State Government of Victoria, 2013). Since the bay is almost entirely surrounded by land, its catchment area is extremely large and is estimated at 10,000 square-kilometres. In June 2015, there were an estimated 4.53 million people living in the Greater Melbourne area, and approximately 3 million of those live and work in the Port Phillip Bay catchment area (Australian Bureau of Statistics, 2015), (Harris et al., 1996). Because of the large population within the catchment area, the bay is exposed to a high volume of plastic pollutants. As shown in Figure 2.2, the mouth of Port Phillip Bay is a 3.2

kilometre wide opening laterally stretching from Point Nepean to Point Lonsdale. Due to this small opening, the majority of pollution items that are introduced into the bay are unlikely to escape through the Bass Strait, making Port Phillip Bay highly susceptible to plastic pollution.

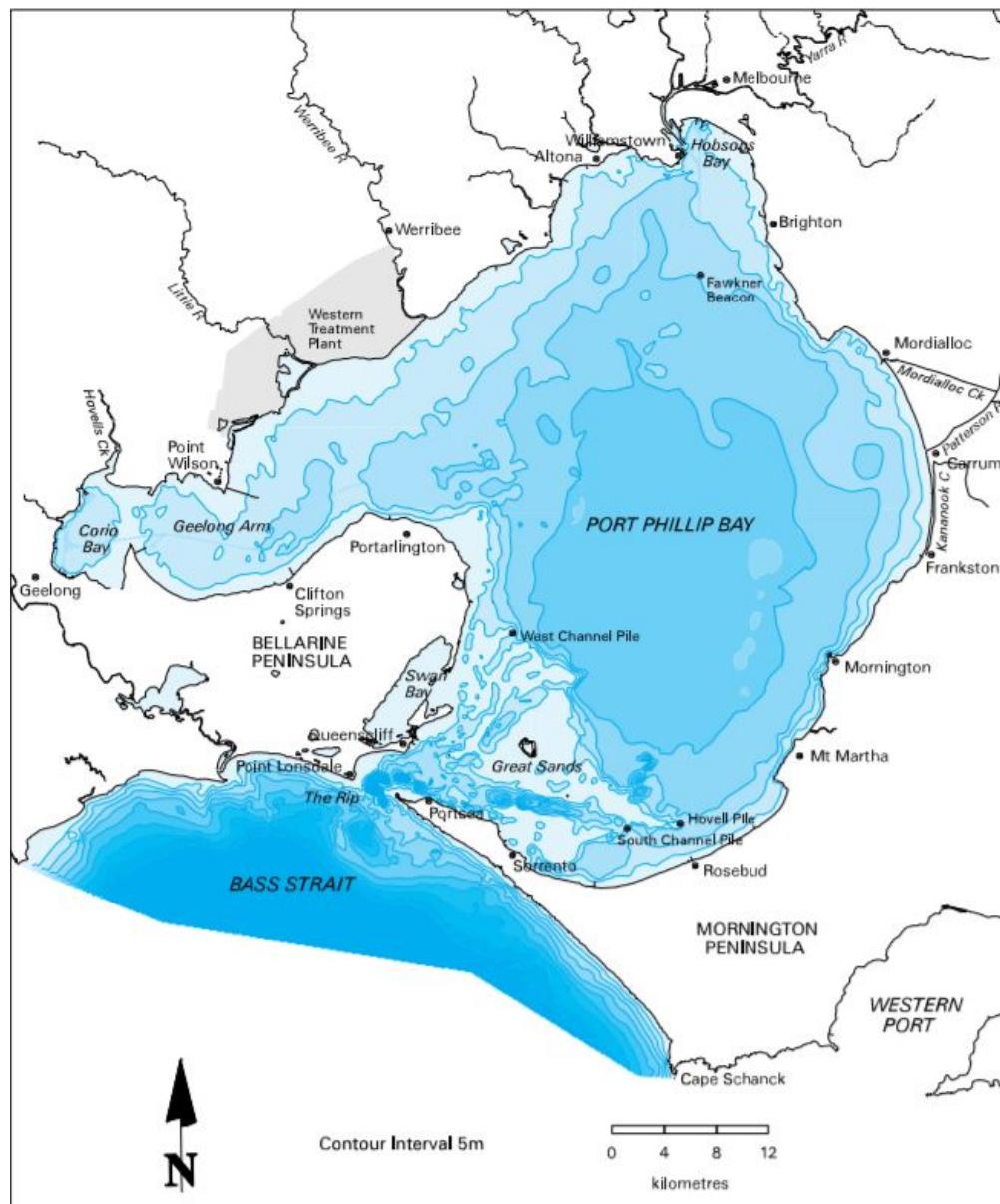


Figure 4. Locality map of Port Phillip Bay (Harris et al., 1996)

In order to fully understand how society affects marine pollution in Port Phillip Bay, it is necessary to identify which regions the pollution may be coming from and details regarding the catchment area. The Greater Melbourne and Greater Geelong areas land

lock Port Phillip Bay and comprise the majority of the bay's catchment area. These areas have a higher population density than the rest of Victoria and are likely sources of plastic pollution because having more people in an area creates the potential for more pollution. In 2015, the average population density in Victoria was 26 people per square-kilometre, while the population density in Greater Melbourne was 450 people per square-kilometre (Australian Bureau of Statistics, 2015). There are many local government areas (also commonly known as councils) within Port Phillip Bay catchment area, and waste management policy and regulations can diverge significantly from council to council. It is possible that these differences in policy are another source of variation in plastic pollution. These waste management policies, and how well they are maintained, can have a large impact on the prevalence of plastic pollution in that area. As such, the relationship between plastic pollution and waste management policy has been analysed throughout this project.

In order to understand where the pollution originates we need to understand the geography of the bay's catchment area. The catchment area comprises 21 natural drainage basins, eight of which directly feed into the bay. Melbourne Water's Healthy Waterways Strategy divides Port Phillip Bay catchment area into five major areas of focus, one of which is the Yarra catchment (Melbourne Water, 2018). Seven drainage basins contribute runoff to the Yarra catchment (Harris et al., 1996). This makes the Yarra River a major contributor to water inflow into the bay and an area of focus for pollution research. Only 11% of Port Phillip Bay catchment area is urbanized, however, this urbanization occurs predominantly along the lower Yarra River, Maribyrnong River, Moonee Ponds, and Merri Creeks (Harris et al., 1996). These areas of urbanization pose the greatest risk for plastic pollution. Based on trawling data collected by the Port Phillip EcoCentre, it is estimated that 828 million pollution items flow into Port Phillip Bay each year from the Yarra and Maribyrnong rivers (Charko et al., 2018).

It is approximated that 10,000 marine species are living in Port Phillip Bay. In addition to supporting stable communities of local species, the bay also supports a number

of species that move into and out of the bay (State Government of Victoria, 2013). Benthic species remain native to the bay and form the basis for important commercial and recreational fisheries (State Government of Victoria, 2013). Many of the benthic and mollusk species found in the bay are a large part of the local fishing industry. In order to ensure the health and well-being of consumers and to protect local fishing, it is imperative that the bay remains free from pollution as much as possible. Port Phillip Bay has more endemic species than the Great Barrier Reef, therefore, the preservation of its natural state should be made a priority (*Baykeepers*, 2017).

### **Port Phillip EcoCentre**

One of the many organisations that work on protecting Port Phillip Bay is the Port Phillip EcoCentre located in St. Kilda. Their mission is “to build relationships to inspire, educate and demonstrate sustainable environmental practice and reconnect people to the natural world” as well as to “spread awareness of the environmental issues through educational programs directed towards the public and to address these issues by involving the community to take action” (Port Phillip EcoCentre, 2018). One way they meet their mission is through the Clean Bay Blueprint project.

The Clean Bay Blueprint project began as the LitterHotspots program in 2015, and will continue into 2020. This project aims to keep Port Phillip Bay clean and free of plastic pollution (Port Phillip EcoCentre, 2017). The Clean Bay Blueprint project is spearheaded by Neil Blake, Port Phillip Baykeeper, and Fam Charko, a marine biologist working at the EcoCentre (Port Phillip EcoCentre, 2018). This project team collaborates with Mr. Blake and Ms. Charko on the Clean Bay Blueprint project.

A major part of the Clean Bay Blueprint project is to monitor plastic pollution levels. The Clean Bay Blueprint project is important for many reasons, one being that pollution is not currently a pollutant that the Government of Victoria monitors in their assessment of the water quality for the Yarra and Maribyrnong Rivers or for Port Phillip

Bay. Methods of monitoring plastic pollution that the Ecocentre employs include street, beach, and river litter audits(Port Phillip EcoCentre, 2017). This project will use plastic pollution data from these sources. Beach and street litter audits were created and designed as part of a previous Interactive Qualifying Projects (referred to as “IQP” in the following passages) with Worcester Polytechnic Institute (referred to as “WPI” in the following passages). The project titled *A Citizen Science Platform for Long-Term Monitoring of Microplastic Pollution in Port Phillip Bay* took place in May of 2017 created procedures for the use of citizen science in performing beach pollution audits (Bayas, M., Ford, & Lawes, 2017). Citizen science is the use of citizens in collecting long term data while maintaining a high quality of data and increasing public awareness (Bergstrom, Duquette, Healey, & Sorenson, 2017). The project titled *From Streets to Sea: Evaluating Citizen Science Programs with the Port Phillip EcoCentre* took place in December of 2017 created a rubric to evaluate the citizen science programs that the EcoCentre runs. The group used this rubric as a guideline to improve the Beach Pollution Audits as well as develop the Street Pollution Audits (Bergstrom et al., 2017). River litter audits are performed using trawling at the head of Port Phillip Bay and along the Yarra and Maribyrnong Rivers is performed by EcoCentre scientists in collaboration with the Yarra Riverkeepers Association.

## **Project Statement**

Plastic production has been increasing at a rapid rate over the past 65 years (United Nations Environment Programme, 2016). Unfortunately, as plastic production increases, the potential for it to end up as pollution in streets, rivers, or Port Phillip Bay increases as well. The goal of our project is to determine the sources of plastic pollution in the bay as well as what factors cause humans to pollute. This project is focusing on Port Phillip Bay’s catchment area which includes streets, beaches, and rivers that surround the bay.

The EcoCentre began their research on microplastics in Port Phillip Bay in late 2012 following the discovery of an abundance of nurdles at Middle Park Beach (Maillard et

al., 2013). Since then, the EcoCentre's research in terms of the Clean Bay Blueprint project has focused on quantifying and researching microplastic pollution through street, beach, and river litter audits. A crucial research gap that exists is determining the source of these microplastics. This project aims to fill this gap by using data visualisation to determine the sources of plastic pollution entering Port Phillip Bay. GIS mapping will be used to visualise the data to find correlations between human and environmental factors and pollution.

The goal of this project is to use GIS mapping to visualise and analyse plastic pollution data in order to determine the sources of plastic pollution entering Port Phillip Bay. The project has three objectives: (1) conduct a case study on GIS mapping softwares, (2) gather human and environmental data relevant to plastic pollution and the geospatial regions surrounding the bay, and (3) use GIS mapping to identify sources and causes of plastic pollution.

## Methods

### Project Goals

The goal of this project is to find the sources of plastic pollution entering Port Phillip Bay. We identified three objectives in order to accomplish this goal. First, we conducted a case study on different GIS mapping tools in the form of an analysis matrix and discussion. Second, we collected information about plastic pollution through interviews, observations, and research and collection of supplemental data that may contribute to plastic pollution. This consisted of interviews with council representatives and experts in the field and observations of different street usage areas. Finally, we used GIS mapping to visualise the plastic pollution and supplementary datasets in order to identify the correlations and causations of plastic pollution entering Port Phillip Bay and enable viewers to see the correlations.

### Case Study of GIS Mapping Softwares

**GIS Mapping Rubric.** In order to accommodate the EcoCentre's growing efforts to understand plastic pollution, the EcoCentre desired a GIS mapping tool to visualise the data they have been collecting. The purpose of this tool is to aid them in identifying relationships between plastic pollution and other variables. It was important to thoroughly investigate a wide variety of commercially available software packages and to understand the needs of the EcoCentre so we could present some options of tools to meet their needs. The selection process consisted of researching eight GIS mapping software packages, and evaluating each software package based on important criteria using a rubric.

To complete the rubrics we had each member of the team download a tool, use it, and attempt to add our data to it. This was the baseline for how far to go with each of the tools for ranking. Afterwards, we also had a different member of the team use the same tool so we could get a more standardized ranking. The criteria used to rank the tools were cost, ease of download, usability, customisability, and quality. The GIS mapping case study

contains rubrics for all eight software packages, and can be found in Appendix A.

After the GIS rubrics were completed, we used an analysis matrix to display the data in a more concise way. This involved displaying the qualitative data in a quantitative manner and allowed for a more objective comparison of the various tools. This quantification occurred using coloured labels corresponding to how well the tool meets the needs of a specific category. For example, if a tool's user interface was extremely intuitive and easy to use, the cell in the analysis matrix describing its characteristics was coloured green. In contrast, a tool with a poor user interface may have a cell coloured yellow or red. In this way, a user can glance briefly at the analysis matrix and a legend to understand which tool may be best for their use case. The GIS mapping case study contains the analysis matrix and can be found in Appendix A. The analysis matrix was used to identify the best software packages for the EcoCentre to use, and the reasoning behind the final selection can be found in the GIS mapping case study. Ultimately, Tableau was selected to be used because of its easy user interface, available features, and high quality output.

## Gather Relevant Data

**Selecting Pollution Datasets.** The EcoCentre and their volunteers have been collecting street, beach, and river pollution data since 2012 (Charko et al., 2018). The team used the street litter audit data which was collected by EcoCentre staff, volunteers, and Scouts Victoria. The collection methods for street litter audits can be found in Appendix B and they were designed by the EcoCentre. The team also used the beach litter audit data. The collection methods for this can be found in Appendix C and were also designed by the EcoCentre. Finally, the team used the river litter audit data collected by the EcoCentre using trawling.

After gathering the datasheets for the previous audits from the EcoCentre, the team needed to reformat the data so it could be input into the GIS mapping tool, Tableau. This process involved finding latitude and longitude coordinates for each of the audit locations

and storing them within the datasheet. The team made a *How to Continue Data Collection* document so that new data can easily be added to the GIS mapping tool in the future. This document can be found in Appendix D.

**Selecting Supplementary Datasets.** For supplementary datasets, the team identified potential human and environmental sources of plastic pollution. These potential sources were identified by researching other organisations' opinions on the sources of plastic pollution. They were also derived from discussions with experts in the field. The sources the team identified can be found in the table below.

Data	Reason	Methodology
Human		
Sporting Events: Locations and Frequency	The street audits performed with Scouts Victoria have shown that sporting events are a leading cause of plastic pollution. We want to visualise the locations of the sporting grounds that host events and dates of large events and try to correlate this with large pollution levels.	When selecting sporting events, large sporting events that occurred annually were chosen. Additionally, major sporting events were given priority over more minor sporting events. A major event was defined as one that is internationally famous, appeared in multiple news stories, or occurred at a large venue. In order to also represent sporting events played by local clubs, the grounds at which these local clubs play were also found. Most of the sporting grounds were found through council websites, but in some instances councils did not list sporting grounds. When this happened, Google Maps was used to find sporting venues by searching for cricket ovals, tennis courts, and other common sports fields.

Markets: Locations and Frequency	<p>Melbourne has lots of farmers markets. These markets tend to attract crowds of people. These crowds of people could be contributing to plastic pollution. We want to visualise the locations of these events and try to correlate the dates they occur with spikes in pollution levels.</p>	<p>The Melbourne Farmers Markets website lists all the farmers markets in the Greater Melbourne area. The location of each of these markets was plotted on a map. The markets that took place in large venues or are tourist destinations such as the Queen Victoria Market, and Dandenong Market were chosen. Additionally, smaller markets that were located close to the rivers or bay were chosen. Once the markets were chosen, the days of the week that these markets had operated during between 2013 and 2018 were found and recorded in the spreadsheet.</p>
Wastewater Discharge Locations	<p>It is known that filters at wastewater discharge plants are not fine enough to capture microplastics. It is possible that microplastics, and specifically nurdles, are able to escape into bodies of water via wastewater discharge locations. It is possible that beach audits conducted near wastewater discharge locations may see larger quantities of nurdles and other microplastics.</p>	<p>The location of the two wastewater treatment plants for Melbourne were found. Melbourne Water's website was used to determine the location that each of these plants discharge. Google maps was used to find the latitude and longitude coordinates of each location.</p>

Tourism Levels	<p>Tourism is a major industry in Victoria and contributes \$24.8 to the Victorian economy annually. As a result of tourism, the effective population of towns and cities can double or triple during certain times of the year. An increased number of people can mean increased levels of pollution in popular areas for tourism, such as beaches, national parks, and other attractions.</p>	<p>Tourism data was obtained from the Australian Bureau of Statistics on tourism levels in Australia. The monthly arrivals data was plotted in a line graph to identify seasonal trends in tourism levels.</p>
Hotels and Large Apartment Buildings	<p>Hotels are important because they have a high population density, and residents are likely to be either international or domestic guests. We can look at this from two perspectives, (1) how tourists/travelers treat the land around Melbourne, and (2) how high density population areas influence pollution. Travelers may lack certain amenities that they enjoy when at home, resulting in the use of more single-use plastics, which may be evident in audits conducted around these areas.</p>	<p>Travel websites were used to find hotels located near the street and beach audit locations. Hotels that multiple travel websites marked as popular were chosen as were hotels that were large chains such as Quest, or Sheraton properties. Google maps was used to find the latitude and longitude coordinates of each location.</p>
Environmental		

Wind, Rainfall, Sunlight, and Temperature	Wind can knock rubbish out of bins, and can transport rubbish along streets, which could affect data. Rainfall can transport rubbish from streets to stormwater drains. Sunlight and Temperature and Sunlight and temperature could affect the number of people who spend their day outside or walking around. The number of people outside in public areas may lead to more pollution.	Data on wind, rainfall, sunlight, and temperature were obtained from the Australian Bureau of Meteorology. We searched for monthly weather and climate data and then found the closest (within 20 km) weather station to each audit site. Then after finding the closest station, we recorded the mean 3pm wind speed, mean rainfall rainfall, mean daily hours of sunshine, and mean maximum temperature.
Other		
Council Boundaries	This is important because the boundaries could imply different legislative regulations.	The councils that are within Port Phillip Bay catchment area were chosen to be shown on our visualisation. Tableau has the ability to show council boundaries, so no external data source was required.

**Interviews.** Interviews were conducted with council and non-profit representatives as well as experts in the field of plastic pollution research. Before any interview, both in person or electronically, the team gave the interviewee a statement of consent to be interviewed, which can be found in Appendix E.

Council and non-profit representatives were interviewed to determine the waste management practices that exist in their councils, their awareness of plastic pollution, and their awareness of current efforts to reduce plastic pollution. The council representatives that we interviewed were chosen based on discussions with the EcoCentre staff and Jessica Hand, an employee at the Metropolitan Waste and Resource Recovery Group. One of the factors in selecting council representatives is the proximity of councils to the Yarra and Maribyrnong rivers. Due to the bay's large catchment area, it was not feasible to interview

all councils that reside within the catchment area. When the team was unable to conduct in person interviews due to different blockers, council representatives were given the option to complete an online form with the interview questions. For a list of interview questions for council and non-profit representatives see Appendix F and for a list of council and non-profit representatives that were interviewed see Appendix G.

Experts in the field include scientists researching plastic pollution as well as people who work for organisations who explore plastic pollution mitigation techniques. Since experts may have insight into the sources and causes of plastic pollution that the project team does not, experts were interviewed about how they address plastic pollution in their work as well as what they think are potential sources of plastic pollution. A full list of interview questions can be found in Appendix H and for a list of experts in the field that were interviewed see Appendix I.

**Observations.** In addition to interviews, observations of the Greater Melbourne area were used to determine potential sources of plastic pollution. Observations were conducted at one site for each of the six street usage types. These six street usage types are business, industrial, parks, public, residential, and sporting grounds. The audit sites chosen for each usage were Iddy Biddy Bar, B & F Cabinet Makers, St. Kilda Botanical Gardens along Blessington Street, St. Kilda Library, 76-78 Chaucer Street, and Peanut Farm, respectively. While at these sites, we looked for visual signs of plastic pollution and also performed street litter audits following the EcoCentre's street litter auditing procedures. These sites were chosen due to their proximity to the EcoCentre and based on discussion with Neil. In addition, observations on prevalence of litter before, directly after, and a day after the Melbourne Cup were conducted, so as to compare normal levels to those of major sporting events. The team's devised rubric for observations can be found in Appendix J. The completed rubric and audit sheet for each of the six audits that were conducted can be found in Appendices K, L, M, N, O, P, Q, R, S, T, U, and V.

## Use GIS Mapping to Identify Sources of Plastic Pollution

**Choose a tool.** The case study on GIS mapping was presented to the EcoCentre. A discussion between Neil Blake, Fam Charko and the project team was used to select a GIS mapping tool. This discussion used the analysis matrix to determine which GIS mapping tool best fulfilled the needs of the EcoCentre. Tableau was chosen as the GIS mapping tool.

**Create a GIS map.** There are a few key steps that go into successfully producing a visualisation. To make the interactive visualisation there are some technical processes that need to be completed before analysing the data. We formatted and managed the data, so it could easily put into the GIS mapping tool, this process is described in Appendix D. Then, we then analysed the visualisation to draw conclusions about plastic pollution.

Ultimately, our design will need to be understandable by a wide variety of people. We defined our intended audience based on the discussion with the EcoCentre's. In this way we ensured that we designed the visualisation with the proper considerations in mind. We used an iterative process with the EcoCentre staff to tailor the visual and interactive aspects of the design. This ensured the sustainability of our visualisation tool after the project is complete. These visualisation iterations can be found in Appendix W.

**Use the GIS map to determine correlations and causations.** The preliminary steps discussed above provided us with the data we needed to draw conclusions. This also gave us the background we needed to choose and implement an effective and usable GIS map of plastic pollution and corresponding sources and causes of plastic pollution in Port Phillip Bay. Once the GIS map had been created, we visually compared different variables to determine if there was a correlation between plastic pollution levels and various qualitative variables over time.

## Results / Discussion

### **Interview Results**

We conducted interviews with waste management educators from councils (referred to as council representatives in following passages) located within Port Phillip Bay's catchment area as well as experts in the field of plastic pollution. The council representatives that we interviewed were Nick Dunstan and Emily Richards of the City of Port Phillip Council, Shaun Young of Hobsons Bay Council, April Williams of City of Monash Council, and Kirsty Richards of the City of Yarra Council. The experts in the field of plastic pollution that we interviewed were Randall Lee of EPA Victoria, Peter Kennedy of Scouts Victoria, Neil Blake of the Port Phillip EcoCentre, Fam Charko of the Port Phillip EcoCentre, Jodi Jones of Tangaroa Blue, and Annette Finger of Boomerang Alliance. Interview transcripts can be found in Appendices X, Y, Z, AA, AB, AC, AD, AE, AF, and AG.

From the council interviews, we gained insight into the perception of the prevalence of plastic pollution within councils in Victoria. When asked how serious of a problem plastic pollution is on scale from 1 (not a problem) to 10 (immediate solution is required), all council representatives ranked plastic pollution as an 8 or higher. April Williams said, “I think [plastic pollution] is probably one of the worst types of pollution since it doesn’t break down or, if it does, then it goes into microplastics which are very harmful. We as a society have a very consumerist tendency. A lot of what they buy is crap and junk. The top level of the waste hierarchy is avoiding waste and we don’t talk about it a lot because council thinks it’s too much of a societal issue and nobody wants to tell people how they need to live their lives” April Williams, personal communication, 13 November, 2018. Emily Newton said that she thinks plastic pollution is “pretty serious, I think given the recent news articles about plastic in everything. It’s a huge scale problem and I don’t think people are aware of it yet. The reason I started working in waste management is because of plastic pollution” Emily Newton, personal communication, 9 November, 2018. From our

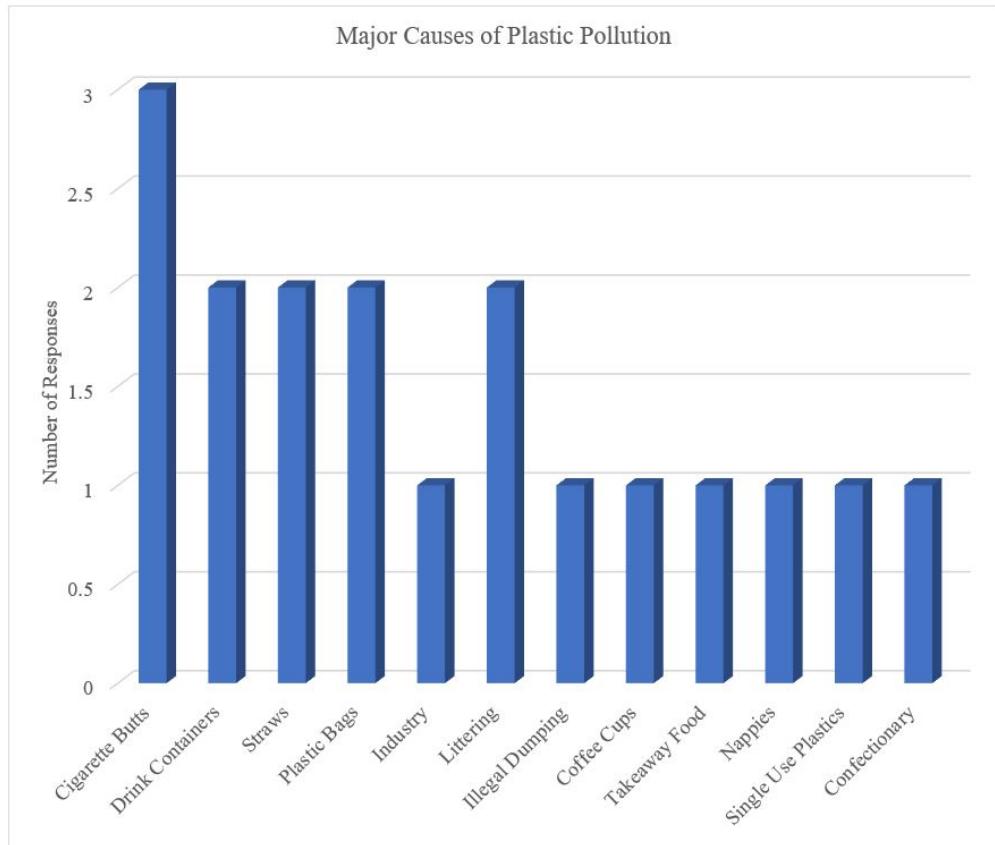
interviews with councils, we found that increasing general awareness of plastic pollution is important, because a solution can not be found if people do not know it is a problem.

Different councils have different plastic usage regulations and this may affect the prevalence of plastic pollution in this council's boundaries. Many of the council people were in support of plastic use bans. The City of Port Phillip requires that event holders "have a meaningful commitment to minimising their impact on the environment" and discourages single-use plastics from being used at public events and, in the future, a regulation may be coming that prevents disposable plastics from being used at public events Nick Dunstan and Emily Newton, personal communication, 9 November, 2018. Hobsons Bay Council supports and advocates for the ban of single-use plastics in legislation as well as hosts anti litter campaigns in the summer Shaun Young, personal communication, 13 November, 2018. City of Monash Council has a regulation prohibiting the use of single-use plastics or balloons during events that take place on public lands. Additionally, they are working with staff members, caterers, and cafes that work for the council to move away from soft plastics. If they are successful at removing it from their own everyday practices, they plan on giving recommendations to the public April Williams, personal communication, 13 November, 2018. City of Yarra Council encourages traders to move away from single-use plastics, and support a ban of plastic straws and balloons. They are also working with companies who are developing new methods of recycling within the country Kirsty Richards, personal communication, 14 November, 2018. All the council representatives we interviewed spoke about the plastic bag ban in Victoria that will come into effect in late 2019. The Andrews Labor Government of Victoria will sign this ban which will prohibit single-use plastic shopping bags that are less than 35 microns thick.

In addition to plastic use regulations, different councils have different waste management practices. All the councils that we interviewed offered curbside pickup of rubbish and recycling bins for residences. The City of Port Phillip Council and the City of Yarra Council also offer this service to businesses Nick Dunstan and Emily Newton,

personal communication, 9 November, 2018 Kirsty Richards, personal communication, 14 November, 2018. Monash City Council provides curbside rubbish pickup for businesses, and charges extra for recycling pickup April Williams, personal communication, 13 November, 2108. All councils offer public rubbish bins and increase the frequency of collection during summer and large events. The City of Port Phillip Council is trialing solar compactor bins that will compact the rubbish in the bins so that it does not need to be collected as frequently. Additionally, these bins are equipped with sensors that send a signal with GPS coordinates to the collection staff when the bin is getting close to full. In this way, the City of Port Phillip Council hopes to avoid overflowing bins Nick Dunstan and Emily Newton, personal communication, 9 November, 2018. The City of Yarra Council is taking a different approach by performing Blitz's. During a Blitz, the in-house crew goes to a specific area in the council to clean it thoroughly. The following week they will do this with a different area, until the major areas of the council have been cleaned. This idea stemmed from the concept that clean areas are not polluted as frequently as already dirty areas Kirsty Richards, personal communication, 14 November, 2018. Similarly, all the councils perform street sweeping at regular intervals. Areas that have more traffic, such as busy retail areas, are swept more frequently. In addition to street sweeping, the City of Port Phillip's in-house crew performs mechanical beach cleanings where a machine combs the top few centimeters of the sand for plastics as well as manual hand picking of litter at the tidelines. Both of these sweepings occur daily Nick Dunstan and Emily Newton, personal communication, 9 November, 2018. The City of Monash Council performs footpath and laneway sweeping in addition to their street sweeping April Williams, personal communication, 13 November, 2108.

Many council representatives thought cigarette butts, littering, drink containers, straws, and plastic bags were the most common causes of plastic pollution. The graph below demonstrates the overall opinion on what is causing the abundance of plastic pollution.



*Figure 5.* Waste management educators view on major causes of plastic pollution

While the council people are aware, many of them stated that educating the public is a major barrier to reducing plastic litter as shown in the following quote from Kirsty Richards. “I am aware that there is heaps of it in the sea and that it’s in the Yarra. The Yarra runs through the suburbs and I’m trying to make people aware that if it’s in the gutter it goes into the Yarra and then into the sea. It opens people’s world to understand the concept of how far the effect of what they do does” Kirsty Richards, personal communication, 14 November, 2018. Similarly Fam Charko of the Port Phillip EcoCentre stated that she thinks a major cause of plastic pollution is “lack of understanding by consumers on what plastic does, what kind of material it is and what kind of effect it has on the environment. There are a lot of people who throw plastic in the bin and they don’t see it anymore so they think it goes away” (Fam Charko, personal communication, 22 November, 2018).

From our interviews with experts in the field of plastic pollution we gained insight into what they thought the major sources and causes of plastic pollution in the Port Phillip Bay are as well as human and environmental factors they think contribute to plastic pollution. This information gave things to look for when analysing the data and our visualisation as well as information on what data we should include in our visualisation.

Randall Lee of EPA Victoria identified packaging as a major cause of plastic pollution. He reasons this is because “we throw that stuff away and there is a more fundamental issue that we don’t value the resource that plastic is and that we don’t reuse it we just throw it away. If some packaging or nurdles escape we don’t go and clean them up because we just think we can go and get some more” (Randall Lee, personal communication, 12 November, 2018). He identified stormwater drains as a major source of plastic pollution as drains serve as a transportation mechanism for plastics from streets into bay (Randall Lee, personal communication, 12 November, 2018). For human and environmental factors, Randall Lee listed illegal dumping, socioeconomic factors, wind, and improperly managed landfills (Randall Lee, personal communication, 12 November, 2018). He also mentioned that work is beginning to be done in the Mediterranean Sea to determine the ratio of microplastics found in the stomach of plankton. This is important because it uses a method other than extrapolating data from the surface of the ocean to quantify microplastics. It also illustrates that microplastics are infiltrating the most basic component of the marine food chain.

Peter Kennedy of Scouts Victoria identified littering, bad habits, inadequate storage facilities, and people’s inability to care for the environment as major causes of plastic pollution (Peter Kennedy, personal communication, 12 November, 2018). For sources of plastic pollution he said that the street audit data he has collected thus far shows commercial retail areas such as supermarkets as well as sporting fields to be major sources of plastic pollution (Peter Kennedy, personal communication, 12 November, 2018). When asked to list environmental and human factors that he thought contributed to plastic

pollution, Peter Kennedy responded “I am not sure there is environmental or human factors. There are those people who litter and those who don’t I’m not sure that changes or is circumstantial (Peter Kennedy, personal communication, 12 November, 2018).” Peter Kennedy and Scouts Victoria are going to continue collecting street audit data for the EcoCentre. Because of this, after our interview we spoke with Peter Kennedy about how this new data will need to be formatted in order for the EcoCentre to include it in future visualisations. We formatted this information into a document titled “How to Continue Data Collection” which we sent to Peter Kennedy and the EcoCentre. This document can be found in Appendix \*\*\*\*\*.

Neil Blake of the Port Phillip EcoCentre identified inadequate or irresponsible disposal as a major cause of plastic pollution (Neil Blake, personal communication, 12 November, 2018). He thinks that sporting events, industrial precincts, retail precincts, recent winds and people’s belief that councils will pick up their litter are major sources of plastic pollution (Neil Blake, personal communication, 12 November, 2018). Neil also mentioned that single use food and drink containers are a major contributor as “when people are on the move, they often leave a trail behind them (Neil Blake, personal communication, 12 November, 2018). Neil would like us to include sporting events in our visualisation as he thinks there is cultural acceptance of litter after sporting events. For example during a marathon, runners grab plastic cups of water from the water station, throw them on the ground when they are finished drinking and then continue running. Similarly, during spectator sports many people leave their food and drink litter under their seat as they think someone else will clean it up (Neil Blake, personal communication, 12 November, 2018).

Fam Charko of the Port Phillip EcoCentre identified overconsumption as the major cause of plastic pollution because “the more plastic gets consumed, the more it gets into the environment” (Fam Charko, personal communication, 22 November, 2018). She thinks that this overconsumption stems from a lack of understanding by consumers “on what

plastic does, what kind of material it is and what kind of effect it has on the environment” (Fam Charko, personal communication, 22 November, 2018). Fam thinks that it is very hard to pinpoint a source of plastic pollution since it is different for every location. However, she thinks that the suburbs of metropolitan Melbourne and the users of plastic there are likely the sources of plastic pollution in the Port Phillip Bay (Fam Charko, personal communication, 22 November, 2018). When asked about human and environmental factors that may contribute to plastic pollution she told us she thinks the weather is an important factor. For example, on a nice sunny day more people go outside and they get takeaway or they bring picnics all of which include plastic (Fam Charko, personal communication, 22 November, 2018).

Jodi Jones of Tangaroa Blue Foundation was unable to meet with us in person, however she did respond to our survey that contained our interview questions. Tangaroa Blue Foundation thinks the major cause and source of plastic pollution is single use plastics (Tangaroa Blue Foundation, personal communication, 12 November, 2018). They think that humans are responsible for the manufacture of plastics and the release of it into the environment (Tangaroa Blue Foundation, personal communication, 12 November, 2018). The release of plastic pollution into the environment is due to humans making bad decisions, but the nature of these bad decisions differ between spaces places, organisations, industries and processes (Tangaroa Blue Foundation, personal communication, 12 November, 2018).

Each of the experts had differing views on the causes and sources of plastic pollution as can be shown in the two figures below. The most common responses for causes of plastic pollution were mismanagement of waste, littering, and a lack of understanding of the resource that plastic is. The most common responses for sources of plastic pollution were wind and industry.

## Street, Beach, and River Audit Data Analysis Results

### *Street Audit Data Analysis Results*

At the beginning of the project, we conducted street litter audits so we could fully understand the process of auditing and also collect consistent data in order to compare the six street usage types. The team set out to do one street litter audit of each type of street usage. These street usages include (1) Business / Retail, which is a privately owned business or retail store, (2) Industrial, which is a business that constructs a product, (3) Park, which includes public parks or green space, (4) Public, which includes town buildings such as libraries or town halls, typically which host events five or six days in a week, (5) Residential, and (6) Recreation / Sports, which are grounds for sporting matches. The locations that were selected for our street audits were selected based on proximity to the EcoCentre and Neil Blake's knowledge of sites that he had visited previously. These sites were as follows:

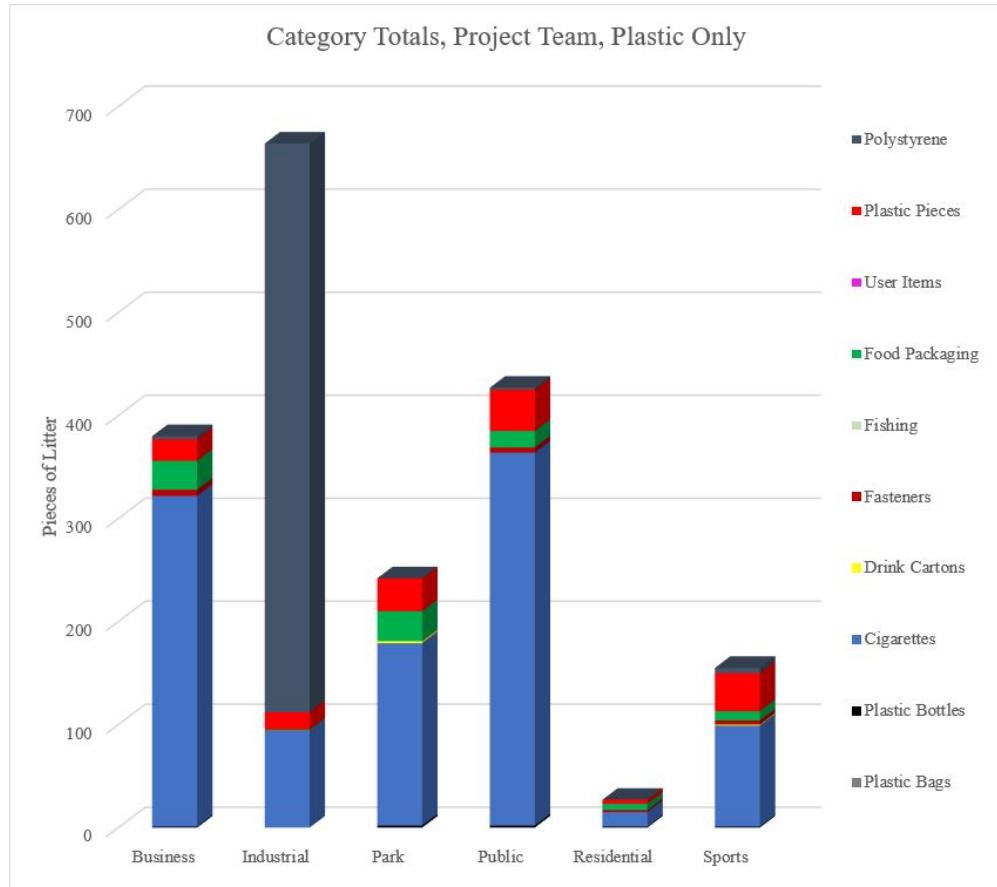
Business / Retail	Iddy Biddy Bar
Industrial	B&F Cabinet Makers
Park	St Kilda Botanical Gardens, Blessington St
Public	St Kilda Library
Residential	76-78 Chaucer St
Recreation / Sports	Peanut Farm

The fact that street audits were conducted by the same people on the same day allows us to make some assumptions about the data. Despite the street audit methodology being well documented, there are still instances where divergences can occur. For example, the number of items collected can vary greatly depending on the amount of time and effort applied by the auditors. Because the same group of people conducted these six audits, we can assume that they applied the same amount of effort and searched with the same level of care. This implies that all data collected is representative of the audited location at that day and time and is not influenced by human factors. Another assumption made is that the street sweepers did not affect the data collection. We chose to conduct our audits the

day before street sweepers were scheduled to run in St. Kilda. This means that data collected is representative of maximum pollution levels in the area.

These street litter audits do have some potential flaws though. For example, the same 1-2 people did the same quadrat for each of the six audits. This potentially exposes bias within the group, however the bias has a much smaller chance of affecting the data in comparison to two different groups doing the audits. To mitigate this bias, we had a training session with Neil before the audits and learned the standardized way to conduct the audits. The last potential flaw is that we only got to collect this data for one of each street usage type. These could all be outlier audits, and we would not have the ability to know with only our data. To mitigate this potential flaw we are going to be comparing our data to data collected by other groups.

These larger categories for items found in the street audits are plastic bags, fishing, glass, plastic bottles, food packaging, cigarettes, user items, rubber / elastic, drink cartons, plastic pieces, fasteners, polystyrene and other. In the chart below, for each street usage type we graphed the total of each of these categories that were plastic pollutants that we found during our audits.



*Figure 6. Project Team Street Audit Results, Category Totals*

Overall, the most commonly polluted item as seen in the chart above is cigarettes. The cigarettes category consists of cigarette butts, lighters, and cellophane packaging. Cigarettes were found consistently in every street usage type which is interesting to note. We noticed the most cigarette butts in front of public and business properties, which are both areas in this scenario that had trash bins readily available and not overflowing. In the case of our business area there were six trash bins and two recycling bins that were within seconds of walking from most of the cigarette butts. In front of the public property, there was a tram stop and a cafe. There were also many small areas where a user could easily stick their cigarette butt into and hide it there. A lot of the cigarette butts within this area were out of reach of the auditors. The image below shows the areas that were missed during the street audit.



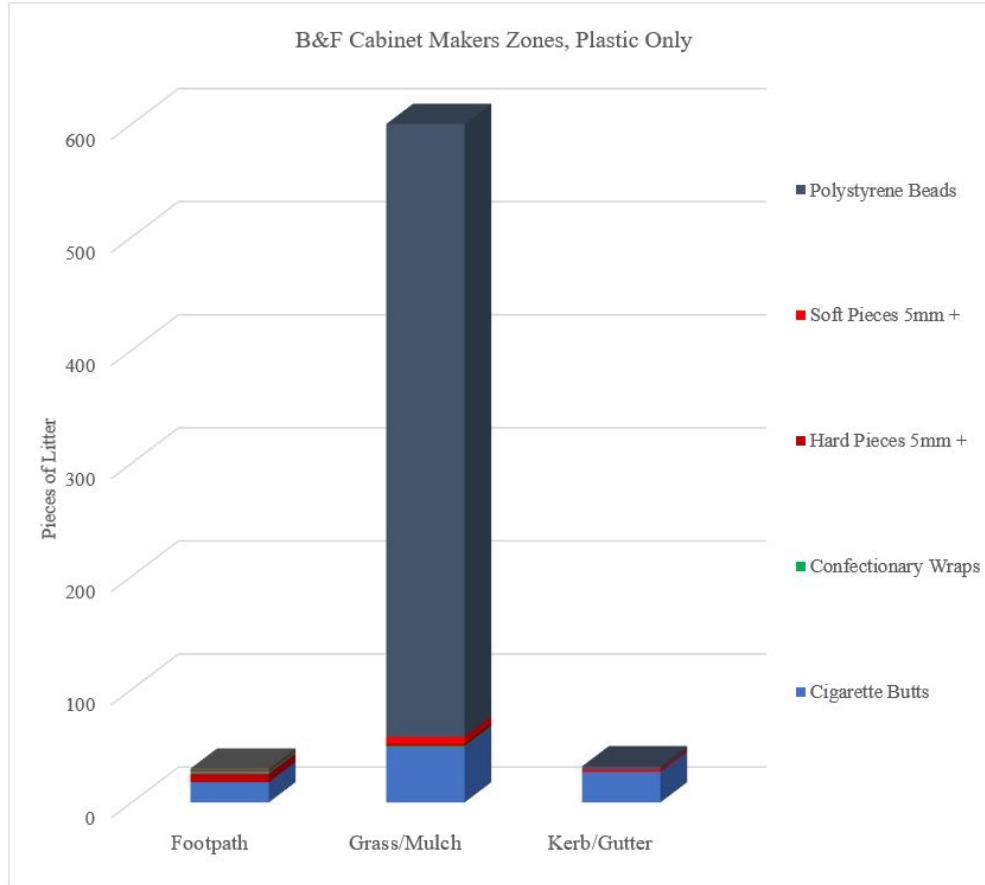
*Figure 7.* Picture from Team's Street Audits of St Kilda Library

Another standout item from the audits is the number of polystyrene beads within the industrial area. One thing to note is that we only collected our data between the public sidewalk and the road. The image below shows the area that was missed during this process.



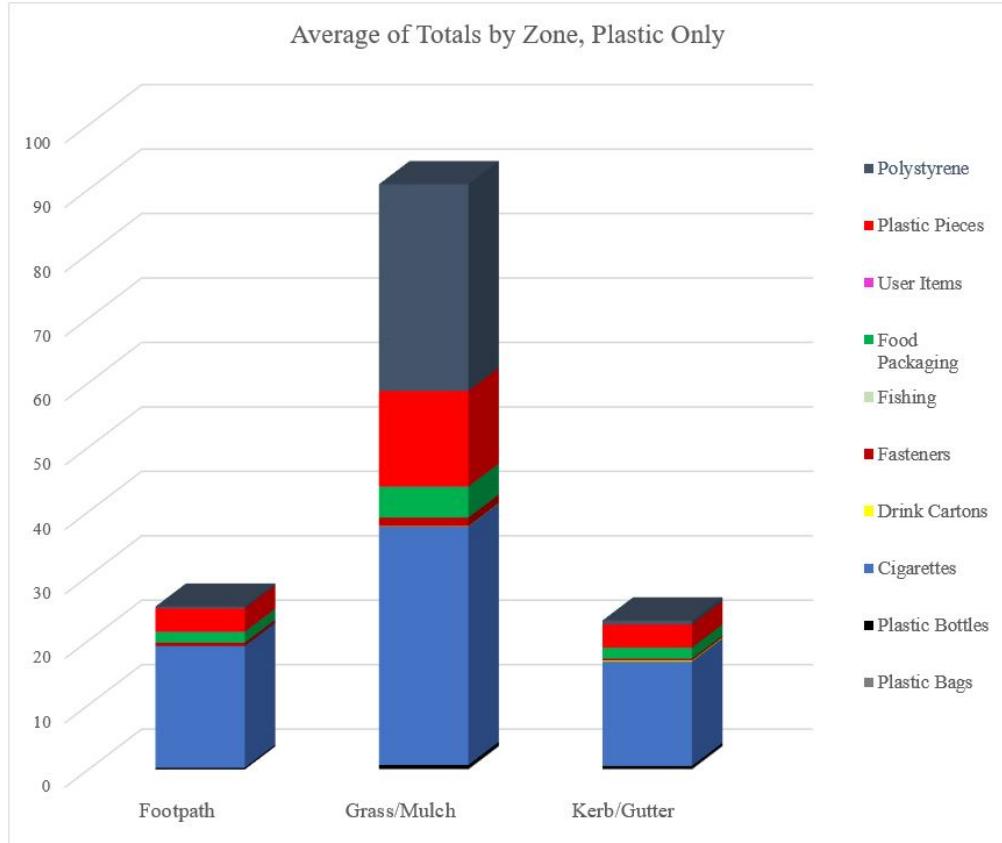
Figure 8. Picture from Team's Street Audits of B&F Cabinet Makers Lawn

This industrial business had a large front yard in which we could see a lot of pollutants, but these were not collected as they were on private property. One thing that stood out to us about this area during collection was that it was very difficult to find all the polystyrene within the grass area. The image below shows the proportion of pollution in front of the industrial area based on the quadrat that it was found in.



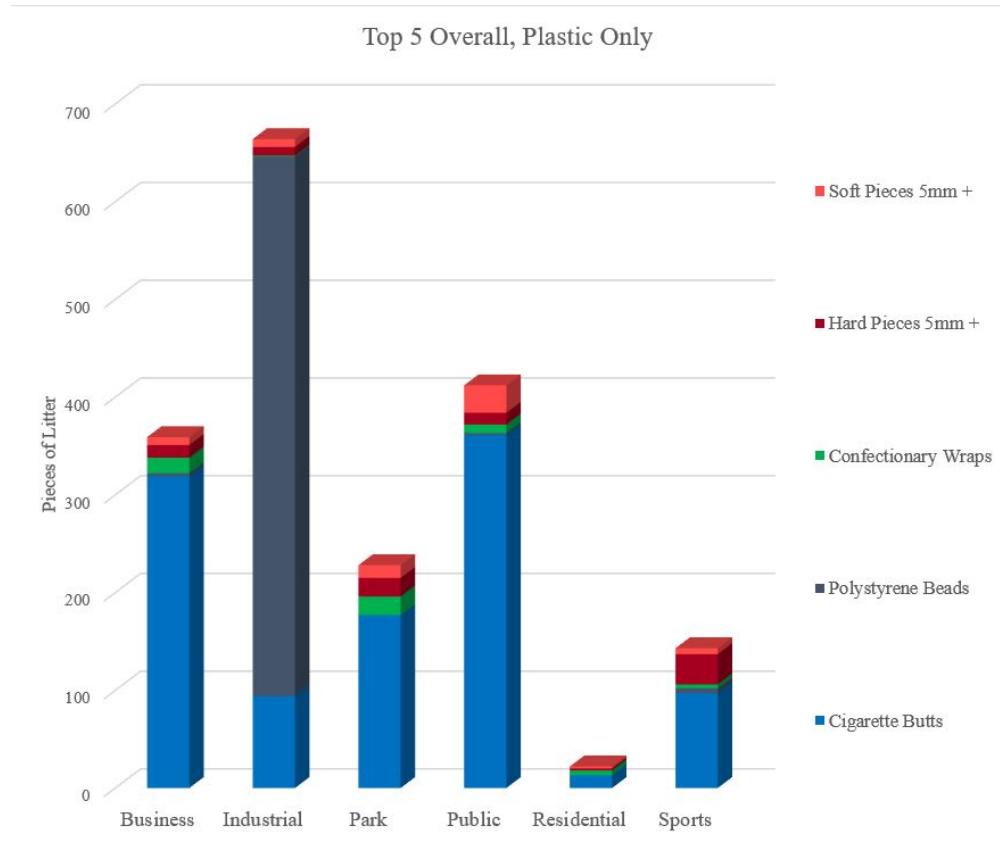
*Figure 9. B&F Cabinet Makers Audit Data by Zone*

As you can see, the polystyrene beads are the most prevalent in the grass/mulch in front of the industrial area. The other two zones did not have nearly as much pollution. This observation leads us to question whether these polystyrene beads ever leave the grass / mulch area. If they do, what conditions would blow them out of the grass area? One potential is lawn mowing tendencies. The lawn mowing machines may kick up polystyrene beads as the grass is cut and blow the beads around. We think industrial zones had high levels of polystyrene beads because of all the packaging and deliveries that they get to their store. Most of these beads were found near the trash bins in the grass. There was a storm drain right next to the survey area, which leads us to believe that if these polystyrene beads get blown around, that industrial sites are a large contributor to the number of polystyrene beads in the ocean.



*Figure 10. Average of Totals by Zone*

Another observation we made is that, overall, the most polluted items are cigarette butts, polystyrene beads, hard plastic pieces 5mm+ and soft plastic pieces 5mm+. The graph below shows the distribution of these pollutants based on the different street usage types.



*Figure 11. Top 5 Pollutants per Street Usage Type*

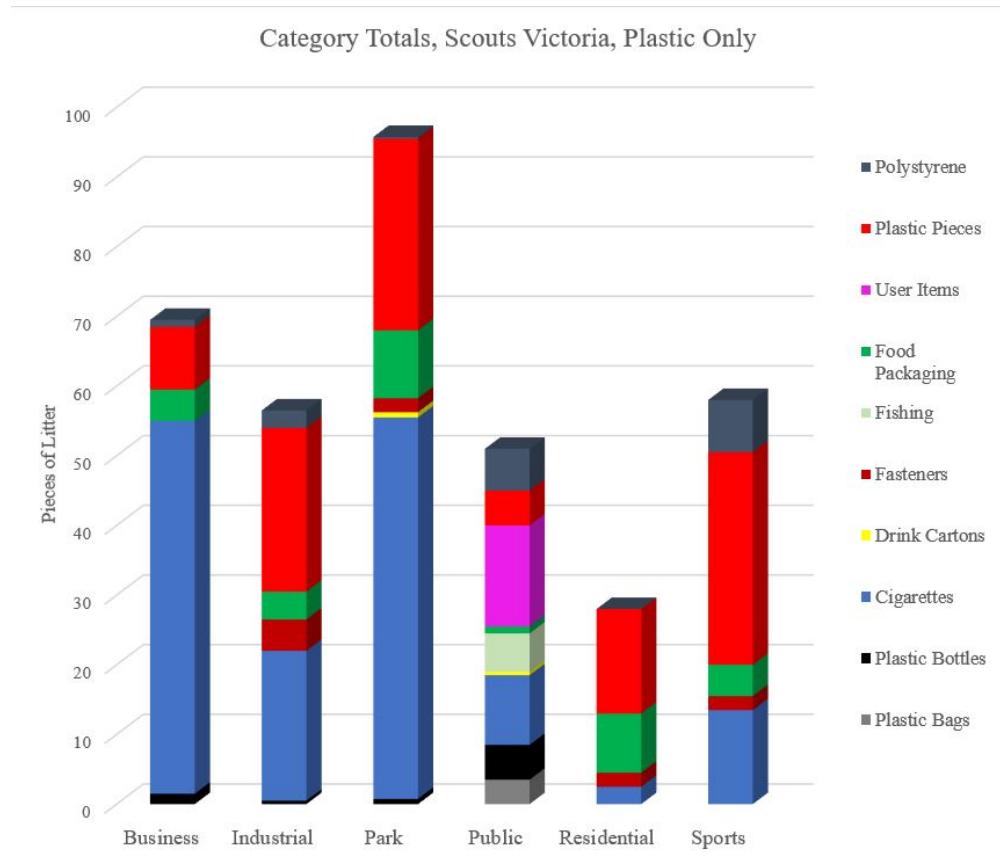
As you can see in the chart, polystyrene beads are most prevalent in the industrial area. Another observation to be made here is the consistent prevalence of cigarette butts. The confectionery wraps, plastic pieces, hard and soft, 5mm+ are less apparent in the street litter audits. However, these findings could be skewed based on the locations we chose.

This data shows us that polystyrene beads in front of industrial areas and cigarette butts in public, business, and industrial areas are the main problem. Out of the six street usage types, we could conclude that industrial and public areas are of the biggest concern when considering the plastic pollutants that were collected during the street litter audits. In order to get a better idea of this data though, it must be combined with other audit data to understand the full picture and ensure that there were no outliers within our data. To do this, we used the data collected by Scouts Victoria in conjunction with the data we collected.

To combine the Scouts Victoria data and our audit data, we need to ensure that this is done fairly and consistently to eliminate any bias. To do this, for each street usage, we decided to select other locations that were audited for that street usage category, to ensure that any one particular location is not an outlier and that we are properly representing each street usage category. We have selected the following locations from the Scouts Victoria data to be averaged with our data to get a better representation of the street usage pollutant levels.

Business / Retail	Woolworths, Church St	Woolworths, Church St
Industrial	46 Middle Crescent	46 Middle Crescent
Park	Wilson Reserve, Middle Crescent	Wilson Reserve, Middle Crescent
Public	Sol Green Community Center	Rec Center, Outer Crescent
Residential	4A Bright St, Brighton East	4A Bright St, Brighton East
Recreation / Sports	Wilson Reserve, Outer Crescent	Wilson Reserve, Outer Crescent

These were selected as the locations to average with because they vary in auditor and location. We were hoping to get more variety in location sites originally. However, these twelve audits provided us with the information shown in the chart below.



*Figure 12.* Scouts Victoria Data per Street Usage

As we can see in this chart, Scouts Victoria found that park locations have a larger quantity of litter items than the other street usage types. Within the park street usage type, cigarettes and plastic pieces tend to be the most prevalent items. Parks and businesses tend to experience more littering from cigarettes than the other street usage types. Public street usage types tend to experience a wide variety of litter items, such as user items, plastic bottles, and fishing gear. It appears that residential areas do not experience as much litter as the other street usage types. Within residential areas, food packaging and plastic pieces tend to be seen the most.

The goal of adding more audits to our sample size aims to eliminate any bias or outliers we may have had when making conclusions with solely our six audits. The updated chart of the total for each pollutant category is below with both our data and the Scouts Victoria data.

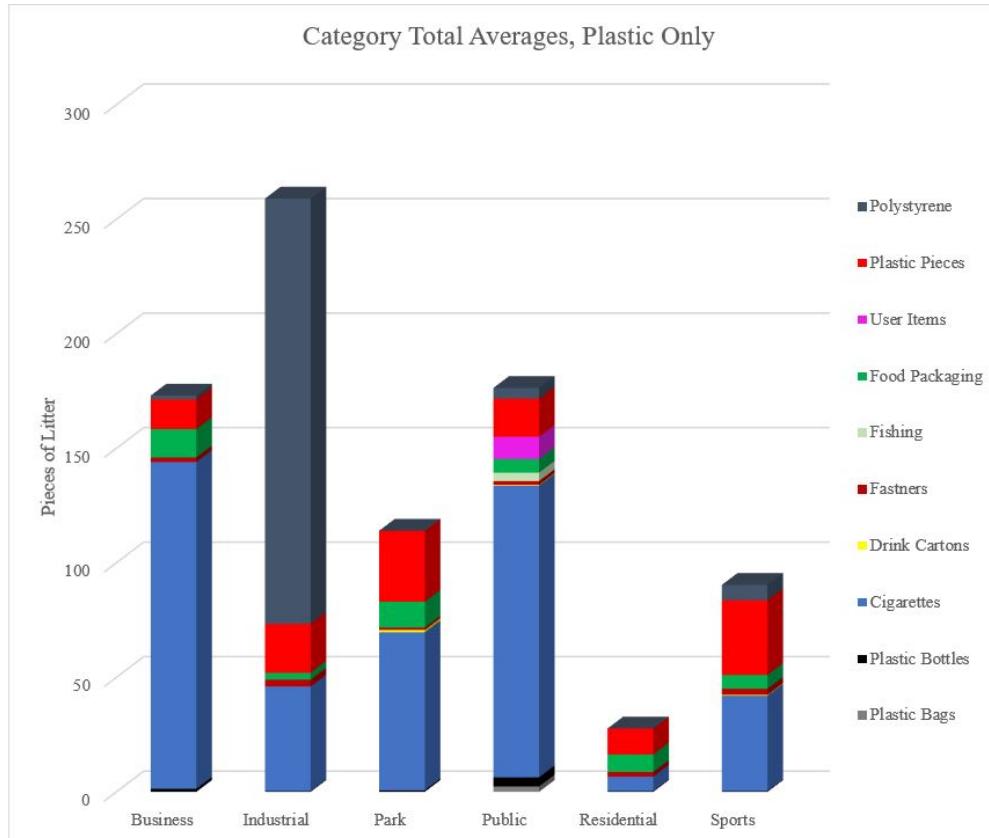


Figure 13. Averaged Team and Scouts Victoria Data per Street Usage

This chart is representing the average of our six audit sites and twelve audit sites from Scouts Victoria. As we can see, public pulled ahead of park when we added Scouts Victoria data. Residential remained low in litter. Sports, public and business levels all raised. One main difference between our data and the Scouts Victoria data is the quantity found in sports and residential areas.

Another main difference that can't be seen in the chart is the number of polystyrene pieces that were found at industrial sites. It may be that the auditing methods varied between groups as we found 552 pieces, and they found 4 and 1 at their two sites. Along these same lines, our cigarette counts were on average 12x higher than the Scouts Victoria cigarette counts.

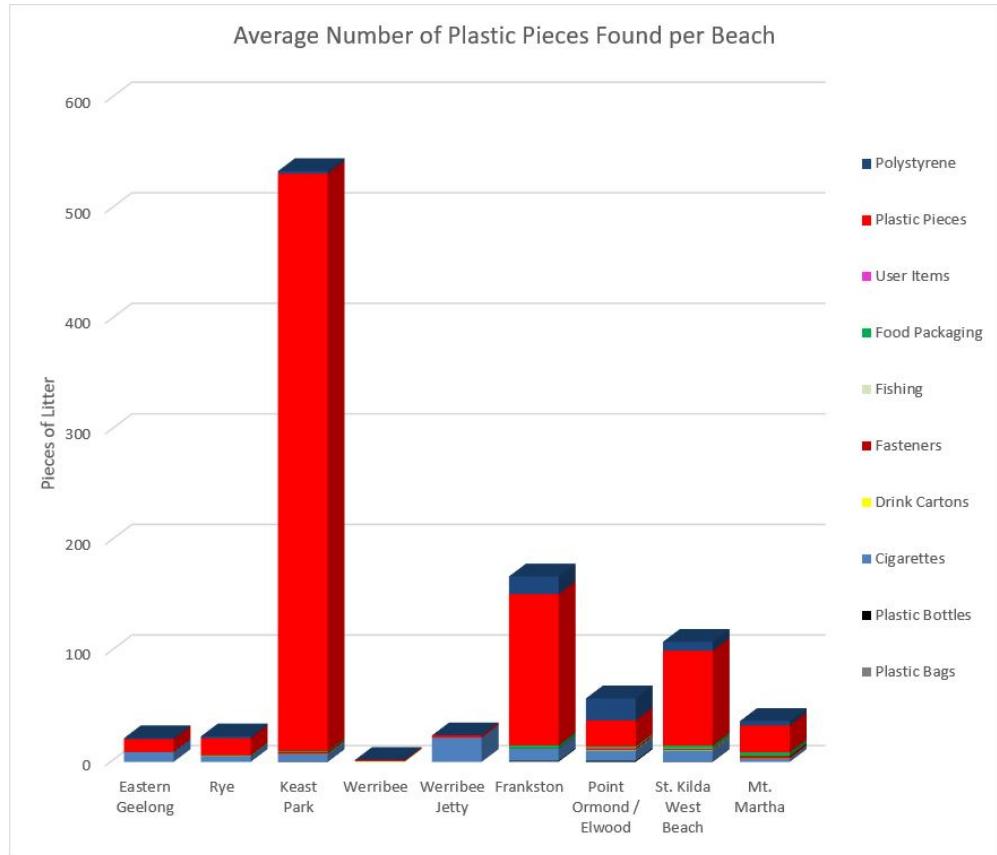
Overall, it is clear to see that cigarette butts, polystyrene, and plastic pieces are the main contributors to plastic pollution in street audit data. Although there were readily

available trash bins in each of the locations that the team surveyed, the quantity of these plastics found in that area was high.

Street auditing includes collecting all pollutants, not just plastic, that are found at an audit zone. We use that data to find the prevalence of plastic pollutants in the audited zones. From street audit data we found that 81.68% of the audit was plastic pollutants. The remaining 18.32% is glass, rubber, metal, and other. This shows the prevalence of plastic pollutants in street audit locations in comparison to other pollutants such as glass or rubber.

#### *Beach Audit Data Analysis Results*

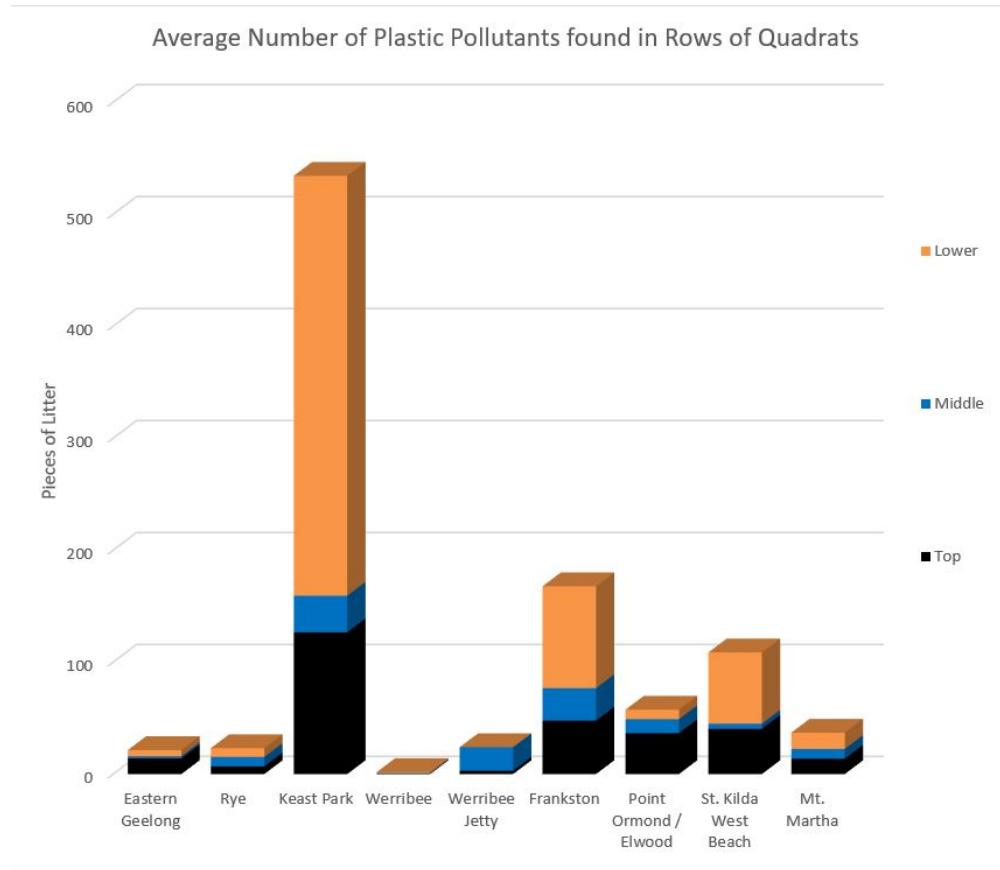
The team conducted one beach litter audit to understand and get hands on experience with the process. However, we relied on the EcoCentre's data to analyse beach litter audits due to the extensive amount of audits they have. First we wanted to compare the nine beaches that were audited to see if any of them stood out from another. The chart below shows the average plastic pollution levels found at the beaches that were audited.



*Figure 14.* The average number of plastic pieces found per beach.

As we can see here, plastic pieces are the most prevalent item found during audits on the beaches. The beach audit data the EcoCentre has shows that 99.16% of pollutants are plastic. The beaches are only audited in the sand area and this could be the reason for finding so many microplastics during these audits. When visiting beaches, the larger items were often found in the park area surrounding the beach and this could be a reason those items aren't represented in this data. Another reason mainly plastic pieces are found could be due to the location of wastewater or stormwater drains. However, the data is not complete enough to make any concrete conclusions about the reason of the prevalence of plastic pieces yet.

To further understand the distribution of plastic pollutants on beaches, we broke the data down to see which of the quadrats (top, middle, or lower) contained the most amount of plastic pollutants.



*Figure 15.* The average number of plastic pieces found per row of quadrat per beach.

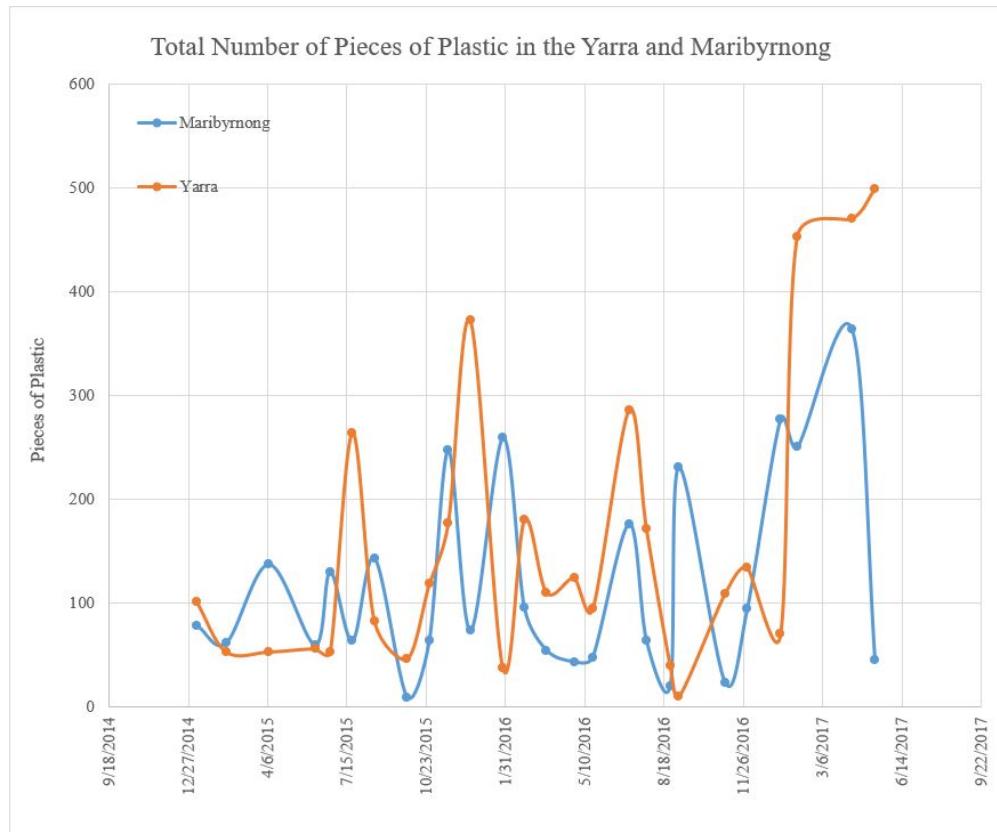
Generally speaking, items found along the high tide line, the lower section of the beach, are those that were already in the bay (Neil Blake, personal communication, 12 November, 2018). As we can see in this chart, the low tide area typically had the most plastic pollutants in it. This could be from the larger plastic items that entered the bay, became degraded, and then were washed up onto the beach from the tide. Items found along the top quadrats of the beach are representative of littered items that are dropped by pedestrians, or are progressing towards the water. Items in any of the quadrats could potentially enter the bay and contribute to the existing collection of harmful plastic debris through either environmental factors such as wind or human factors such as intentional or unintentional littering on these areas of the beach.

#### *River Audit Data Analysis Results*

We did not have the opportunity to participate in a river trawling, so we relied on

the data that had been collected between the EcoCentre and Yarra Riverkeepers. However, we did have the opportunity to participate in the organisation of trawl collections. This involved separating plastic pollutants, such as microplastics, from organic material that was captured within the manta net. This process opened our eyes to the size of microplastics that are found within the rivers. Each categorisation session took approximately one hour with four people dedicating themselves to it. This involved tedious work to ensure that no microplastics were missed when organising the data. The process was almost completely formalised. To be trained the volunteers must have a session with Fam, the expert in organising and separating trawl samples, and be taught the process in a thorough manner. In this way, each trawl organiser produces the same results and the data is more standardised.

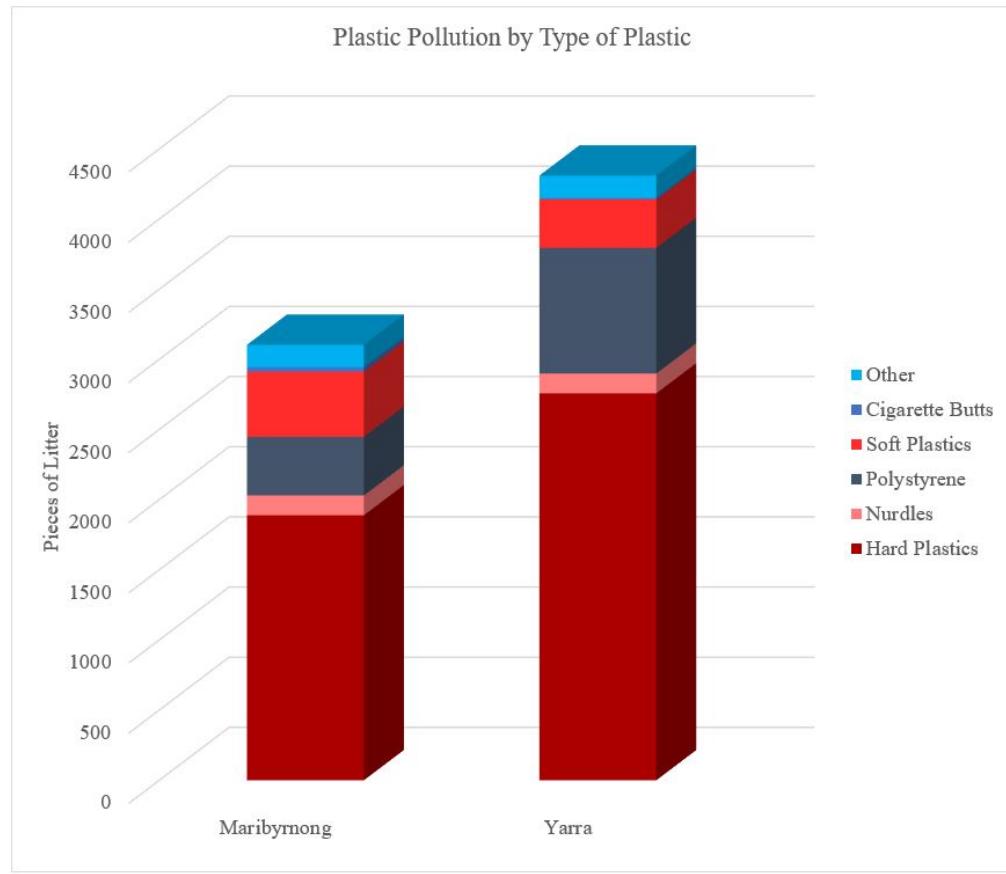
To analyse the data, the first thing we wanted to look at was plastic pollution in the Yarra and Maribyrnong rivers throughout the time that trawling has been conducted which is shown in the following figure.



*Figure 16.* The plastic pollutants found during river trawls over time.

As can be seen in the figures above, the Maribyrnong generally experiences peak plastic pollution levels during the summer months whereas the Yarra generally experiences peak plastic pollution levels during spring and summer. Both the Maribyrnong and the Yarra river experienced the highest levels of plastic pollution in April of 2017.

The next thing we wanted to look at was if the rivers contained similar categories of plastic pollution or if they differed. The graph below shows the total number of plastics of hard plastics, nurdles, polystyrene, soft plastics, cigarette butts, and other that were found throughout all the trawls in each river.



*Figure 17.* Pollutant Levels per River

As can be seen in this graph, hard plastics, polystyrene and soft plastics were the most common categories in both rivers. Overall, hard plastics were the most commonly

found category of plastic pollution in the rivers. This may be because hard plastics are subject to photodegradation and thus break down into microplastics more easily. The Yarra had approximately double the amount of polystyrene that the Maribyrnong had. This is likely due to the fact that there is extensive manufacturing, retail, and hospitality precincts along the banks of the Yarra river (Charko et al., 2018). Both rivers have reasonably high levels of soft plastics, however the Yarra river has more soft plastics than the Maribyrnong. Both rivers had low levels of cigarette butts which is likely due to the fact that cigarette butts are less buoyant than water and thus sink (Charko et al., 2018).

## Visualisation

To fully understand plastic pollution and its sources into Port Phillip Bay, the team created a GIS map to visualise data. To do this, we used an iterative process to edit the visualisation to cater to the audience the EcoCentre had in mind.

To start off, we researched similar work that other organisations have done in the GIS mapping realm. The map below was created using ArcGIS and reflects the quantity of plastic pollutants in the world's oceans (*Estimate of Plastic Pollution in the World's Oceans*, 2018). This design was interesting to us because of the use of points rather than geospatial shapes within the oceans.

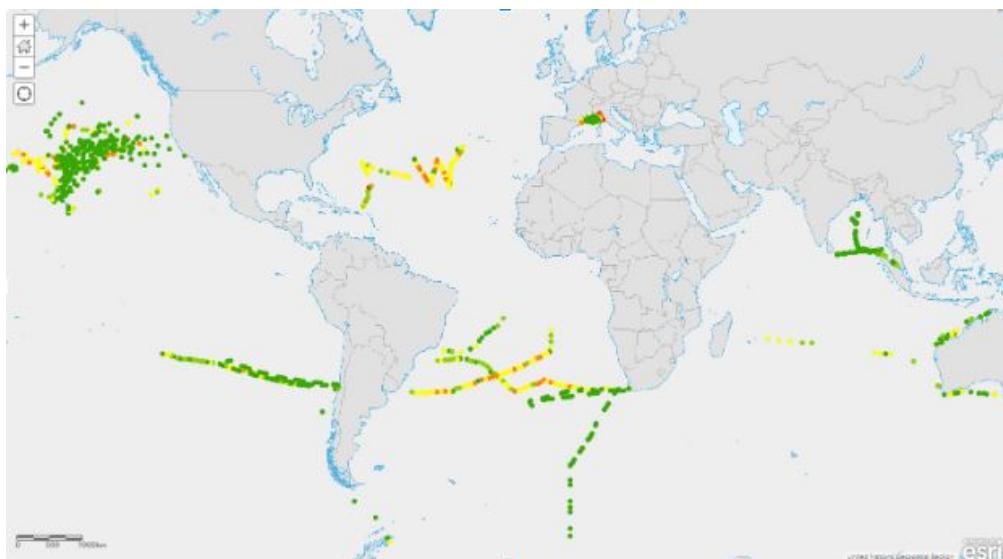


Figure 18. ArcGIS Visualisation of Pollution Levels in Ocean

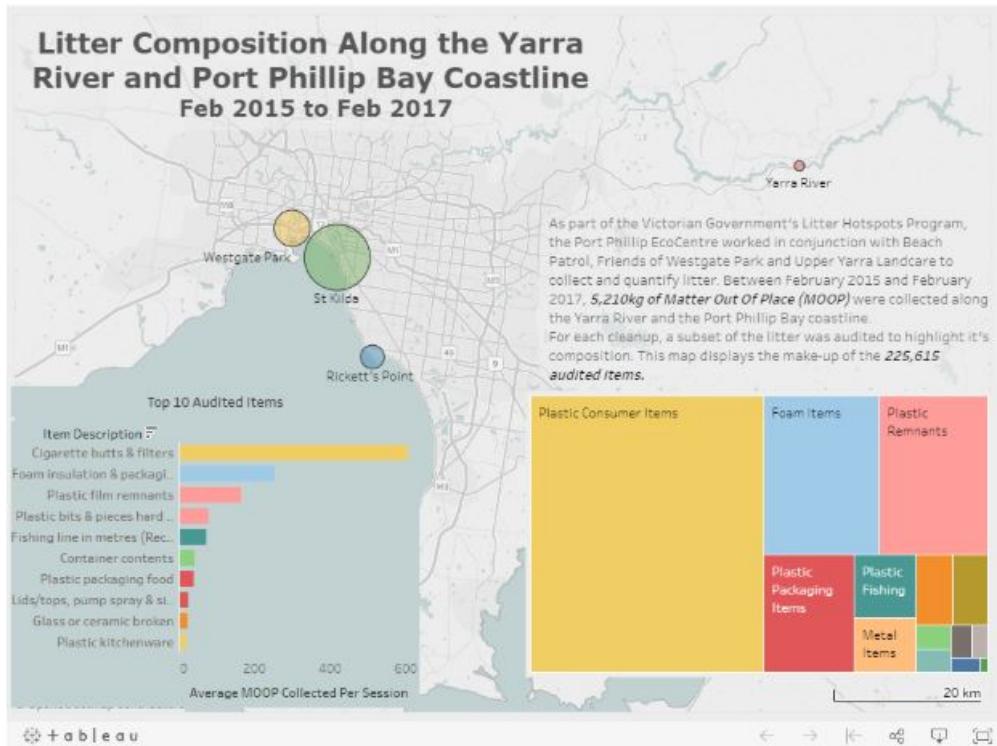
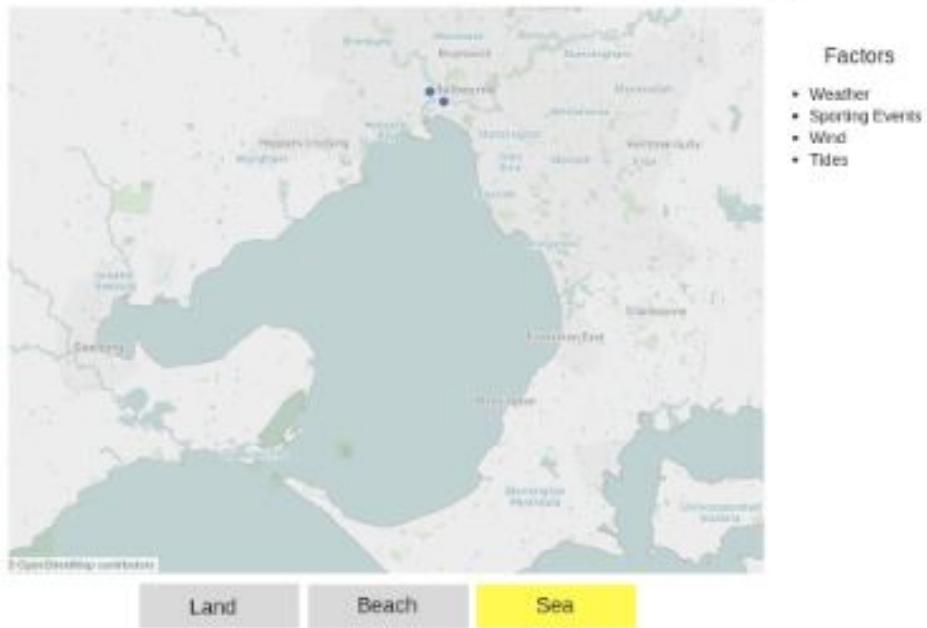


Figure 19. Tableau Visualisation of Pollution Levels on Port Phillip Bay Coast (Tregillis, 2017)

We were especially interested in the above visualisation because of its relevance to our project. This project showed the plastic pollution levels in the bay's coastline and we liked the fact that it integrated geospatial data as well as some charts that show the breakdown of the individual points.

For our design, we considered the benefits of each of the visualisations we had previously researched and started with the following design.

## Pollution in Port Phillip Bay



## Pollution in Port Phillip Bay

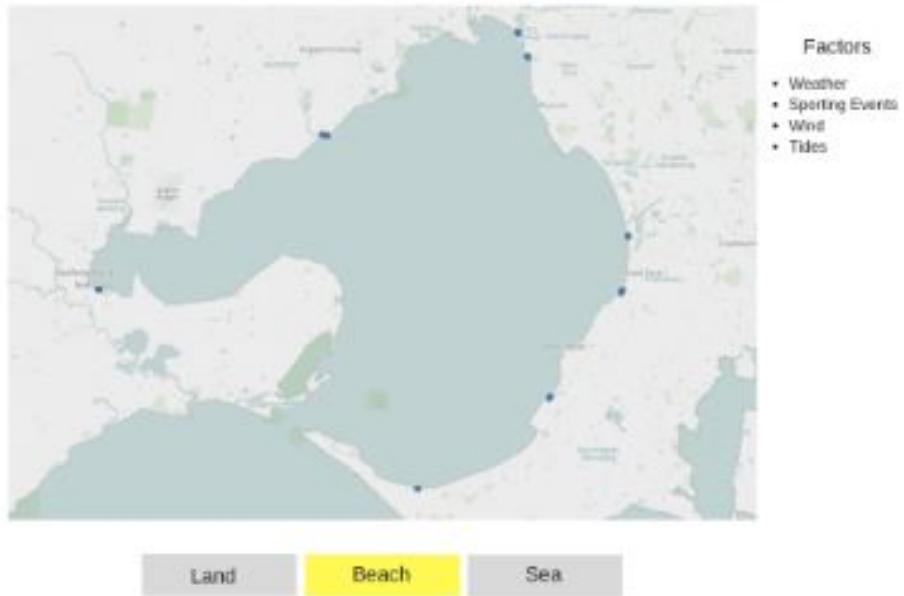


Figure 20. Iteration One

The goal for this iteration was to represent the layout of the GIS map in relation to the supplementary and pollution datasets that we had chosen. We wanted to have two

different selector areas: one for pollution data located at the bottom, and one for factor data on the right of the map. The goal of this was to allow the user to select and see what supplementary and pollution data were currently selected on the map. In this visualisation we stuck with the bullet point method of representing the plastic pollution levels. The second iteration came short after and appears below.

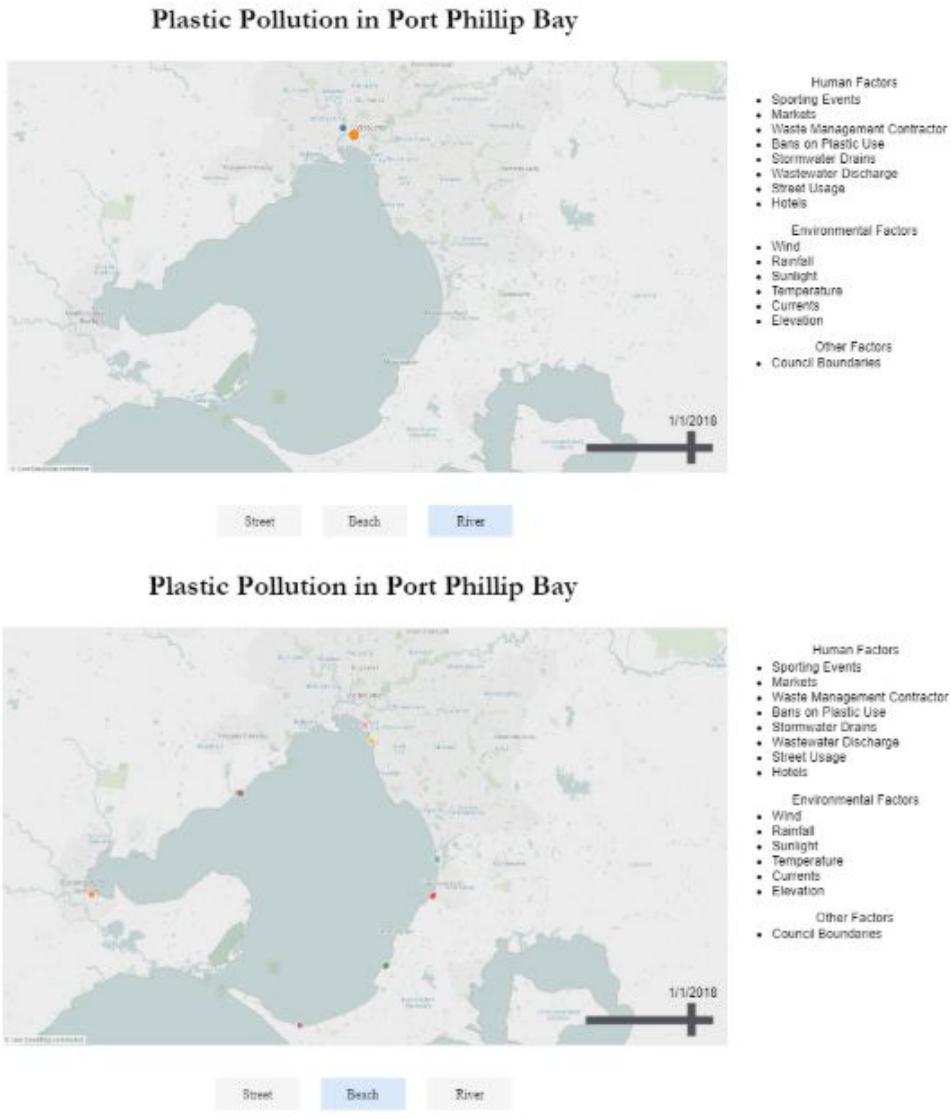


Figure 21. Iteration Two

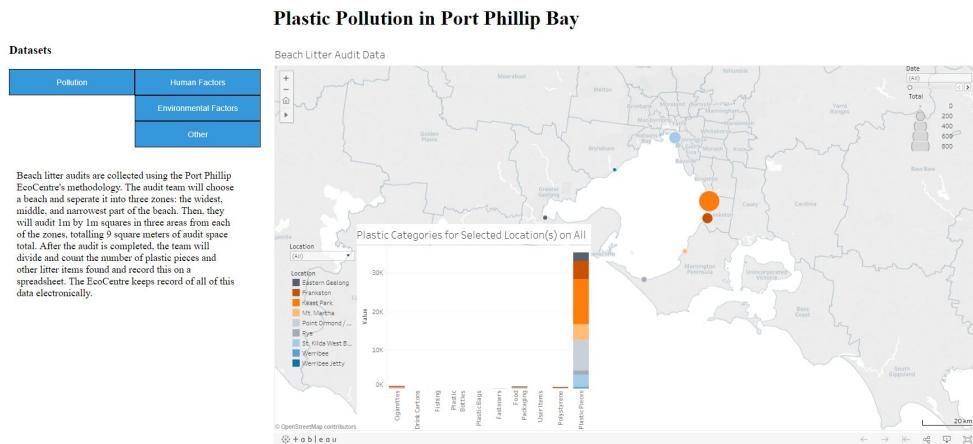
This iteration we made some changes such as adding all our supplementary data, changing the color scheme, adding a date selector, and also changing some wording issues.

For the third iteration we decided to try something completely different so we could test other styles and see which was ultimately the most pleasing.



*Figure 22.* Iteration Three

For this iteration, we consulted a professional in the field of website development, Mrs. Gallagher. By consulting a professional, we were hoping to receive critical feedback on some concepts we may have been overlooking. This inspired us to change our visualisation to the following.



*Figure 23.* Iteration Four

In this visualisation we changed a lot of things. Firstly, the menus on the side are drop down menus which allow the user to select both their pollution dataset and their supplementary dataset. When no supplementary dataset is selected, the chart displayed shows a GIS map overlayed with a chart representing the break down of plastic pollution.

Since there are many more colors in these maps, we decided to do in depth research on how to design for people with color blindness. This lead us to use a variety of shades of blues and oranges throughout our visualisation since monochrome and complementary colors are easy for people with color blindness to distinguish (Collinge, 2017).

**\*Finish this once our visualisation has been completely designed and used to analyse data\***

### Sources and Causes of Plastic Pollution

**\*write about what we determine the causes and sources to be once we have these results\***

Plastic pollution is a complex problem because it involves understanding how people live their lives. Plastic usage is so ingrained in the fabric of society that it is nearly impossible to concretely quantify. This project not only focuses on what items are polluted and where they are polluted, but also how littered items move. All items polluted within the catchment area will ultimately travel into the bay. Understanding variables that contribute to the motion of this plastic can be just as valuable as understanding sources of plastic pollution.

Intentional / Unintentional litter and Primary / Secondary Microplastics

## References

5 Gyres. (2018). *Trawlshare program*. Retrieved from

<https://www.5gyres.org/trawlshare/> (This is the website for an NGO called Five Gyres Institute. The organization seeks to build a global database of marine plastic pollution in order to influence wide scale change. The program called “TrawlShare” enables organizations to contribute to the global dataset by replicating the five gyres data collection process.)

18

ABC. (2018). *No bag, thanks!* Retrieved from

<http://www.abc.net.au/science/features/bags/default.htm> (This is an article from ABC about plastic bags. This article discusses the impacts that plastic bags have on the environment as well as how long they take to decompose. It also discusses the production of plastic bags, the management of plastic bag usage, recycling of plastic bags, reuse of plastic bags, and alternatives to plastic bags.)

15

American Chemistry Council. (2018). *The basics: Polymer definition and properties*.

Retrieved from

<https://plastics.americanchemistry.com/plastics/The-Basics/> (This is a page on the American Chemistry Council’s website that discusses the chemistry of plastics. It explains polymers, the structure of plastics, and how the molecular arrangement of polymers affects the properties of plastics.)

15

Australian Bureau of Statistics. (2015). *Regional population growth, australia, 2014-15*.

Retrieved from <http://www.abs.gov.au/ausstats/abs@.nsf/Previousproducts/3218.0Main%20FeatureS252014-15> (This is a web page published by the Australian Bureau of Statistics showing population data from 2014 to 2015. It talks about the population growth, change and density in various regions. The source provides plenty

of text, charts, and maps to display content. While this data is relatively outdated, it is still useful to build background knowledge of the area, keeping in mind that specific numbers and distributions may have changed.)

24, 26

Barclay, E. (2013, December 13). *How plastic in the ocean is contaminating your seafood.*

Retrieved from <https://www.npr.org/sections/thesalt/2013/12/12/250438904/how-plastic-in-the-ocean-is-contaminating-your-seafood> (This is an article that speaks about chemicals in the ocean that are ingested by fish. Aside from mercury, there are many other chemicals that fish absorb. Chemicals dumped in the ocean are directly ingested by fish, some chemicals are absorbed through plastic debris the fish ingest. Scientists have known for years know that chemicals absorbed by smaller fish are in turn ingested by predators. Plastics are a sponge for chemicals and when ingested by fish are transferred into their bloodstream or tissue. Fish who consume a lot of plastic are also more likely to have tumor and liver problems.)

19

Bayas, A., M., B., Ford, C., & Lawes, J. (2017). *A citizen science platform for long-term monitoring of microplastic pollution in port phillip bay* (Tech. Rep.). Worcester Polytechnic Institute. (This is the report of a previous IQP titled A Citizen Science Platform for Long-Term Monitoring of Microplastic Pollution in the Port Phillip Bay. This IQP took place during D term of 2017, and had the same sponsor as our project does, the Port Phillip EcoCentre. This project updated the beach litter audit methods that the Port Phillip Baykeeper had created in order to allow citizen scientists to perform these audits. The use of citizen science allows for a greater number of audits to occur, however, care must be taken to make sure that the data collected by citizen scientists is all of the same quality and is still accurate.)

28

*Baykeepers.* (2017). (This short documentary, BayKeepers, was produced by the Port

Phillip EcoCentre in conjunction with other organisations to educate viewers about microplastic pollution in the Port Phillip Bay. The documentary conducted interviews with employees at zoos and the EcoCentre and focused on why plastic pollution has such a large effect on the world. Since plastic breaks into smaller pieces, microplastics, over time, small animals at the bottom of the food chain are eating them. This later affects every other animal in the food chain in an unhealthy manner. The documentary also discussed some current methods of cleaning up plastic pollution and followed some citizen scientists around as they manually collected and categorized plastic pollution.)

27

BBC. (2016, November 23). *The animals that are being harmed by plastic bags*. Retrieved from <http://www.bbc.co.uk/newsbeat/article/38063952/the-animals-that-are-being-harmed-by-plastic-bags> (This report talks about marine animals being harmed by plastic bags and the number found per meter in the UK and the fact that the number has been dropping over the years. When animals eat plastic bags, they stay in the stomach which can lead to disease, starvation, or death. Researchers looked at sea birds from the netherlands and discovered 96% of them had plastic in their stomach. Turtles, whales and albatross often mistake plastic bags for food and eat them.)

8, 19

BCcampus. (2018). *Hydrocarbons*. Retrieved from <https://opentextbc.ca/chemistry/chapter/20-1-hydrocarbons/> (This is a page from a university in British Columbia's website about hydrocarbons. Hydrocarbons are compounds made of only carbon and hydrogen. This article talks about the different kinds of hydrocarbons, the structures of hydrocarbons, and the bonding of hydrocarbons. Most plastics are hydrocarbons, so the properties of hydrocarbons are similar to those of plastics.)

15

Beaman, J., Bergeron, C., Cook, A., Gallagher, K., Ho, K., Hoff, D., & Laessig, S. (2016).

*State of the science white paper: A summary of literature on the chemical toxicity of plastics pollution to aquatic life and aquatic-dependent wildlife* (Tech. Rep.). United States Environmental Protection Agency. (This is a paper about chemical toxicity of plastic pollution in wildlife and marine environments. The problem of plastic entering the marine ecosystems is being recognized as an emerging environmental issue.

Plastic can be found in marine environments as either macroplastics or microplastics. Any kind of plastic absorbs chemicals in the water and is affecting organisms through ingestion or entanglement. Further research is still needed to be able to confirm the chemical absorption of plastics as well as the process of bioaccumulation.)

16, 17, 22

Bergstrom, N., Duquette, S., Healey, M., & Sorenson, N. (2017). *From streets to sea:*

*Evaluating citizen science programs with the port phillip ecocentre* (Tech. Rep.).

Worcester Polytechnic Institute. (This is a report of a previous IQP project titled From Streets to Sea: Evaluating Citizen Science Programs with the Port Phillip EcoCentre. This project occurred in B term of 2017 and had the same sponsor that our project has, the Port Phillip EcoCentre. This project created street litter auditing methods. They used citizen science to allow for more audits to occur. They created a rubric to analyze their audit methods and ensure that the data that the citizen scientists collected was still accurate and all of the same quality. Our team also spoke to this project team at the beginning of the term and they gave us advice and guidance about our sponsor and our project.)

28

Charko, F., Blake, N., Kowalczyk, N., Johnstone, C., Seymore, A., & Quek, Y. (2018).

*Microplastics in the maribyrnong and yarra rivers, melbourne, australia* (Tech. Rep.).

Port Phillip EcoCentre. (This is the report published by the Port Phillip EcoCentre

in May 2018 on their trawling data, collected from January 2015 to June 2017. The trawling and corresponding data collection was completed as a study under the “Turn off the Tap” project. In July 2017, the Victorian Government granted the Port Phillip EcoCentre funding for an additional three years of research under the project title, “Clean Bay Blueprint”. The report outlines the methods, results, and analysis of the data collected during these monthly trawls. The analysis of the data primarily focuses on the comparison of the data collected for the two rivers, and notes fluctuations in certain plastic litter throughout the year. The report postulates causal factors for pollution variation: industrial usage, population density along the rivers, and local sporting events. The report concludes that further data should be collected in order to better understand pollution variation, and that further interpretation of the data may yield causal factors for pollution. The data analysis for this report was performed by Christopher Johnstone.)

12, 13, 14, 15, 24, 26, 31, 61

CM, R., E, H., BT, H., & S, K. (2013, Feb 5). *Long-term field measurement of sorption of organic contaminants to five types of plastic pellets: implications for plastic marine debris.* Retrieved from <https://www.ncbi.nlm.nih.gov/pubmed/23270427> (This paper discusses the relationship and sorption rates of different plastics and persistent organic pollutants in San Diego Bay. It also talks about how various materials have higher concentrations among plastic types and locations.)

18

Collignon, A., Hecq, J.-H., Galgani, F., Collard, F., & Goffart, A. (2014). Annual variation in neustonic micro- and meso-plastic particles and zooplankton in the bay of calvi (mediterranean–corsica). *Marine Pollution Bulletin*, 293-298. (This report was a study of the plastic particles and their relationship to the number of zooplankton between 2011 and 2012. They classified the plastic particles into three sizes, small micro (0.2-2mm), large micro (2-5mm) and meso (5-10mm). 74% of the samples had

plastic particles which made for an average concentration of 6.2 particles per 100 m squared. The large micro (2-5mm) per plankton ratio was 2.73 to one plankton. They concluded that not only is this harmful to the plankton that could ingest these, but also that larger prey may be mistaking the microplastics as plankton and intentionally ingesting the microplastics.)

18

Collinge, R. (2017, January 17). *How to design for color blindness*. Retrieved from <https://usabilla.com/blog/how-to-design-for-color-blindness/> (This website by Collinge makes suggestions on how to design websites for color blindness. It states the most common colorblindness is between red/green colors. It suggests using color and symbols to represent things and also to avoid bad color combos such as green/brown, blue/purple, green/yellow etc.)

66

Earth Day Network. (2018). *Fact sheet: Single-use plastics*. Retrieved from <https://www.earthday.org/2018/03/29/fact-sheet-single-use-plastics/> (This source provides nine facts about how large the problem of single-use plastics are and how most people contribute to the problem. Plastic pollution is a growing problem and trillions of pieces of plastic pollute land and harm wildlife today. The nine facts listed in this source are good starting points for further research, as the article gives links to the sources of these facts.)

21

Ellen MacArthur Foundation. (2016, January 19). *The new plastics economy: Rethinking the future of plastics*. Retrieved from <https://www.ellenmacarthurfoundation.org/publications/the-new-plastics-economy-rethinking-the-future-of-plastics> (This is an initiative to head in the direction of recyclable plastics and less plastics overall. The initiative is led by the Ellen MacArthur Foundation. It focuses on five building blocks

to create a design for the system. These building blocks include: dialogue mechanism, global plastics protocol, innovation moonshots, evidence base, and stakeholder engagement.)

12

Eriksen, M., Lebreton, L., Carson, H., Thiel, M., Moore, C., Borerro, J., ... Reisser, J. (2014). Plastic pollution in the world's oceans: More than 5 trillion plastic pieces weighing over 250,000 tons afloat at sea. *PLoS*. (This is an article from the journal PLOS One and the main goal of this article was to estimate the volume of pieces of plastic pollution currently in the ocean. This had not previously been done as it is difficult because plastic pieces occupy all trophic levels of the ocean even those that humans cannot easily access. This study chose to measure the weight and abundance of plastic pieces that they found during 24 voyages across the five subtropical ocean gyres, coastal Australia, Bay of Bengal, and the Mediterranean Sea. They used surface net trawls as well as visual inspections to collect the data. This article estimated that there are 5.25 trillion particles of floating debris currently in the ocean. Plastic's buoyancy and durability causes it to inhabit all parts of the ocean including remote islands.)

17, 18

Eriksen, M., Maximenko, N., Thiel, M., Cummins, A., Lattin, G., Wilson, S., ... Rifman, S. (2013). Plastic pollution in the south pacific subtropical gyre. *Marine Pollution Bulletin*, 71-76. (This source discusses how gyres are formed and how these pollutants build up from land and sea sources. Gyres are large islands of marine pollutants. This source states that plastic pollution enters the marine environment via rivers, beaches, maritime activities and illegal dumping at sea. It states that there is not much conclusive data on the sources of plastic pollution which creates a problem when modelling.)

23

*Estimate of plastic pollution in the world's oceans.* (2018). Retrieved from

<https://www.arcgis.com/home/webmap/>

<viewer.html?webmap=0a84536e5172481c971f6b81c49d3b3e> (An ArcGIS

visualisation that shows the plastic pollution levels in the world's oceans.)

61

Estrada, O. (2017). *More than just trash ... how chemicals that come with plastic pollution*

*harm you and animals.* Retrieved from <https://www.onegreenplanet.org/environment/how-chemicals-in-plastic-pollution-harm-you-and-animals/>

(There have been 17 studies shown that every ocean in the world is negatively affected by humans in some way. Scientists estimate that there are over 5 trillion plastic pieces in the ocean worldwide. Plastic is durable and buoyant which makes it easier for the ocean to move it all over the place. Plastic affects wildlife both physically by choking and what not but also chemically through the POPs it adsorbs. These chemicals do not break down and are attracted to plastic so it is very easy for them to get adsorbed. Plastic does not disappear, over time it just gets smaller and turns into a microplastic. POPs and trace metals can cause liver damage, inhibit reproduction and even cause death. In one study conducted, 90% of fledgling birds had plastic in their body. According to the EPA, POPs can cause numerous problems in humans and marine organisms alike. POPs make their way up the food chain through bioaccumulation and can get all the way to humans. The best way to avoid this problem is to just not buy single use plastics and reuse as often as you can.)

8, 19

Food and Agriculture Organization of the United Nations. (2018). *Trawls.* Retrieved from

<http://www.fao.org/fishery/geartype/103/en> (This is a part of the Fisheries

and Aquaculture Department's website that discusses different types of fishing gear.

The specific page that was relevant to our paper was the page that discussed what trawling was. We used this to make sure we had accurate background knowledge on

the process of trawling since that is how a lot of the data we will be looking at is going to be collected.)

17

Fraunhofer-Institute for Environmental, Safety, and Energy Technology UMSICHT.

(2015). *Fraunhofer umsicht takes position topic: Microplastics* (Tech. Rep.).

Fraunhofer UMSICHT. (This is a position paper about microplastics written by a university. They believe there is a strong need to do more research on microplastics because they are becoming increasingly popular and showing up throughout the food chain. The problem requires an early development of sustainable solutions. The impact of physical and chemical factors break down plastics and research on this in aquatic environments is just beginning. These studies on microplastics should include fresh and salt water as well as in drinking water and regard the whole system so more than just rivers and seas. In the future, new materials need to be developed that are biodegradable to reduce this problem. The UNEP estimates there are 100 million tonnes of plastic waste in the oceans and 6 million tons are added annually. There also needs to be more research done of methods of removing microplastics from the water.)

20

Gabbatiss, J. (2018, January 5). *Disposable coffee cups: How big a problem are they for the environment?* Retrieved from <https://www.independent.co.uk/environment/disposable-coffee-cups-how-big-problem-environment-landfill-recycling-incinerate-export-rubbish-a8142381.html> (This article discusses the misconceptions surrounding recycling. It discusses the differences in different companies and how the coffee cups are produced. Some are recyclable, however, often times they are not or are not recycled due to ignorance. Since coffee cups are lined with polyethylene they can not be recycled at standard recycling plants and must be taken to special areas.)

21

Gall, S., & Thomson, R. (2015). The impact of debris on marine life. *Marine Pollution Bulletin*, 170-179. (This is a journal article from the Marine Pollution Bulletin. This article is a literature review about the current research that has been done on the effects that marine debris has on organisms. This article allowed us to determine the state of current research. Additionally, it included some up to date statistics about the number of species that are affected by marine debris.)

19, 20

Guern, C. (2018, March). *When the mermaids cry: The great plastic tide*. Retrieved from <http://plastic-pollution.org/> (This is an article on plasticpollution.org. This article talks about plastic pollution and the most commonly polluted items. It also discusses the scope of the problem of plastic pollution and how 80% of plastic pollution comes from land based sources.)

21

Hall, N., Berry, L., Rintoul, L., & Hoogenboom, M. (2015). Microplastic ingestion by scleractinian corals. *Marine Biology*, 725-732. (This is a newspaper article from the Guardian about the impacts that throwaway culture has had on the environment. The main thing this article talks about is plastic packaging. Plastic packaging is meant to only be used once and then discarded. The problem with this is that there is now a surplus of plastic packaging waste.)

20

Harris, G., Batley, G., Jernakoff, P., Newell, B., Fox, D., Molloy, R., ... Skyring, G. (1996, June). *Port Phillip Bay environmental study*. Retrieved from <https://publications.csiro.au/rpr/pub?pid=procite:1e941c7a-3303-4b90-ba69-ecad2a810020> (This report was created by CSIRO, a federal organization responsible for scientific research. This environmental study was conducted from 1992 to 1996, and constituted 47 research tasks that were contracted

out to 30 different organizations. The report gives an overview of all of the research tasks, compiled into primary topic areas such as nutrients, toxicants, and the ecology of the bay. This source has plenty of statistics, and while dated, provides some background on past research that has been conducted in the bay.)

8, 24, 25, 26

Knight, L. (2014, May 17). *A brief history of plastics, natural and synthetic*. Retrieved from <https://www.bbc.com/news/magazine-27442625> (This is an article from BBC about the history of plastics. This source was used to define plastics as well as define the technical terms used in this definition. This source also discussed the boom of the plastic industry that occurred during World War II and how the plastic industry switched their focus to mass consumerism after the war.)

20

Lockwood, D. (2012, August 22). *Ocean plastics soak up pollutants*. Retrieved from <https://cen.acs.org/articles/90/web/2012/08/Ocean-Plastics-Soak-Pollutants.html> (Plastic debris in the ocean can absorb organic pollutants for months in the ocean. When fish eat plastic, they are ingesting the particle as well as the chemicals in it. Scientists measured concentrations of different organic pollutants for a year.)

19

Maillard, K., Sgardelis, P., Ng, Y., Kearney, Y., Franchi, E., Charko, F., & Blake, N. (2013, October). *Nurdle soup?* Retrieved from <http://www.ecocentre.com/sites/ecocentre.com/files/neil/Nurdle%20Soup%20booklet.pdf> (This is a report written by the Port Phillip EcoCentre after a school group found a large amount of nurdles during a beach audit. Nurdles are the small plastic pellets that form the base of many industrial plastics. They are typically between 2 and 3 millimeters in size and are thus categorized as microplastics. Due to their small size they are easily transported by wind and water. This preliminary discovery of nurdles on beaches in

Port Phillip Bay prompted the EcoCentre to investigate the prevalence of microplastics in Port Phillip Bay. Two methods of data collection were used in this report: close visual inspection of beaches, and boat trawls in the Bay as well as in the Yarra and Maribyrnong rivers. The report outlines the methods that were used to collect both of these categories of data. The data for the number of nurdles found at specific beach locations during beach audits and trawling data for the Yarra and Maribyrnong rivers is broken down by type of plastic is included in this report.)

15, 19, 24, 28

McDermott, K. (2016). *Plastic pollution and the global throwaway culture: Environmental injustices of single-use plastic* (Tech. Rep.). Salve Regina University. (This is a study from Salve Regina University in Rhode Island about the environmental injustices of single-use plastics. 80% of the plastics that enter the ocean each year are single use plastics. This study talks about the injustices these single use plastics impose on marine life, and humans. It also discusses how removing this plastic pollution from the ocean is not feasible since the pollution is so widely scattered throughout the ocean. This article says that the best way to deal with the plastic pollution is to change our habits so that more pollution does not end up in the ocean.)

21

Michigan Department of Community Health. (2018). *Bioaccumulative persistent chemicals*. Retrieved from [https://www.michigan.gov/documents/mdch/Bioaccumulative\\_\\_Persistent\\_Chemicals\\_FINAL\\_354016\\_7.pdf](https://www.michigan.gov/documents/mdch/Bioaccumulative__Persistent_Chemicals_FINAL_354016_7.pdf) (Bioaccumulation is the chemical buildup in fish which is then passed along throughout the food chain. As chemicals end up in water, they are ingested by smaller fish which are then eaten by bigger fish who ultimately get these chemicals passed onto them. These chemicals that are ingested are persistent chemicals that are stable and don't break down over time.)

19

O'Farrell, K., & Australian Government: Department of the Environment. (2018). *2016-17 australian plastics recycling survey* (Tech. Rep.). Envisage Works, Sustainable Resource Use. (This is a survey of recycling in Australia that was conducted by the Department of Environment and Energy. This source provided us with statistics on recycling in Australia. It talks about the amount of plastics consumed in Australia in 2016-17. It also talks about the amount recycled, the national recycling rate and how many plastics were reprocessed.)

21

Oxford University Press. (2018). *plastic*. Retrieved from

<https://en.oxforddictionaries.com/definition/plastic> (This is Oxford Dictionary's definition of plastic. We used this source to define plastic in a way that is easy the general public to understand.)

15

Pahl, S., Wyles, K. J., & Thompson, R. C. (2017, October). *Channelling passion for the ocean towards plastic pollution* (Tech. Rep.). Nature Human Behaviour. (This research report focuses on studying the difference between the symptoms of plastic pollution and the sources of plastic pollution. It discusses the methodologies for promoting a cleaner ocean and the reasons they do or don't work to address the underlying cause. For example, they discuss emotional social media images of animals being hurt by plastic pollutants. How this may be effective, they discuss that it doesn't address the broader society systems and habits that coincide with plastic use. In one section they discuss the role of behavioural science and how humans need to accept the responsibility for the plastic pollution before they will feel motivated to change their underlying values. Finally, they discuss the important role of NGO campaigns and research that is being conducted on recent bans in different countries: such as the microbead and plastic bag bans.)

23

plastic pollution coalition. (2018). *Plastic pollution coalition*. Retrieved from  
<https://www.plasticpollutioncoalition.org/the-coalition/> (This is the Plastic Pollution Coalition's website. The Plastic Pollution Coalition is a global alliance of businesses, individuals, and countries that are all working towards a plastic free ocean. They have quite a few research articles that allowed us to determine how many agencies were doing research on plastic pollution.)

17

Plastics Industry Association. (2018). *The purpose of single-use plastics*. Retrieved from  
<http://www.thisisplastics.com/environment/the-purpose-of-single-use-plastics/> (This is an article from the Plastics Industry Association's website about single use plastics. This article talks about the benefits of single use plastics and why they were introduced into society. It discusses which single use plastics are necessary, such as those in the medical industry. The article then talks about the importance of properly disposing of single use plastics.)

12

Pollution Solutions. (2015, August 19). *What is plastic photodegradation*. Retrieved from  
<https://www.pollutionsolutions-online.com/news/waste-management/21/breaking-news/what-is-plastic-photodegradation/35801> (This is an article from Pollution Solutions that explains photodegradation. The durability of plastics is one of its most desirable properties, however this means that plastics do not easily degrade in the environment. One of the ways that plastics do degrade is through photodegradation. Photodegradation occurs when the UV radiation of the sun oxidizes the plastics. This oxidation makes the plastics more brittle and allows them to be easier to break into smaller and smaller pieces.)

17

Port Phillip EcoCentre. (2017). *Clean bay blueprint*. Retrieved from  
<http://www.ecocentre.com/cleanbayblueprint> (This is the section of the Port

Phillip EcoCentre's website that discusses the Clean Bay Blue Blueprint Initiative. The Initiative began in 2017 and will continue until 2020. Part of this Initiative is the collection of data on the prevalence of plastic pollution entering the Port Phillip Bay from the Yarra and Maribyrnong rivers. This data is most of the data that our project will be analysing.)

13, 14, 27, 28

Port Phillip EcoCentre. (2018). *Welcome to the port philip ecocentre!* Retrieved from <http://www.ecocentre.com/> (This is the Port Phillip EcoCentre's website. We used it in our project to learn more about our sponsor the Port Phillip EcoCentre and what they stand for.)

27

Rothert, G. (2018). *The great pacific garbage patch.* Retrieved from <http://georgerothert.com/the-great-pacific-garbage-patch/> (George Rothert was the scientist who discovered the Great Pacific Garbage Patch. He posts pictures and notes about it on his website.)

8, 13

State Government of Victoria. (2013). *Bay and catchments.* Retrieved from <https://yarralandbay.vic.gov.au/assets/bay-and-catchments> (Report card for the water in Port Phillip bay from 1 July 2016 to 30 June 2017 based on nutrients, water clarity, dissolved oxygen, salinity, pH, metals and algae. Water quality declined over the year in the Yarra and Port Phillip Bay but improved in the Maribyrnong. Annual rainfall has been decreasing over the years as noted since the 1970s. Because of this, since 2000 there has been an overall increase in water quality in the Port Phillip bay. This is due to the fact that less rainfall means the amount of urban and rural runoff decreases. Water quality improved in Maribyrnong after wet conditions due to returned flows to waterways in upper catchments that had reduced to isolated pools or dried river beds. The Yarra is the only catchment to show a decline in water

quality due to increased runoff to tributaries in rural areas of the mid and upper catchment. Controlled releases of water proved helpful to water quality because they flush out sediment and simulate breeding of fish. The government, authorities, and community implemented some initiatives to improve waterway health.)

24, 27

The Ocean Cleanup. (2018). *The great pacific garbage patch*. Retrieved from <https://www.theoceancleanup.com/great-pacific-garbage-patch/> (This is a page on the Ocean Cleanup's website about the Great Pacific Garbage Patch. The Ocean Cleanup is a nonprofit organisation that is trying to use technology to rid the oceans of plastic pollution. The Great Pacific Garbage patch is a famous example of ocean pollution. It is the largest accumulation of ocean pollution and is located between Hawaii and California. The Great Pacific Garbage Patch is estimated to be twice the size of Texas.)

12

Tregillis, B. (2017, May 13). *Litter composition along the yarra river and port phillip bay coastline*. Retrieved from [https://public.tableau.com/views/MOOP2/Dashboard1?:embed=y&:display\\_count=yes](https://public.tableau.com/views/MOOP2/Dashboard1?:embed=y&:display_count=yes) (A Tableau visualisation showing plastic pollution levels along Port Phillip Bay's coastline and the Yarra River. A breakdown of plastic pollutants per audit source is shown as well as category breakdown of these plastic pollutants.)

8, 62

United Nations Environment Programme. (2016). *Marine plastic debris and microplastics: Global lessons and research to inspire action and guide policy change*. Retrieved from <https://wedocs.unep.org/handle/20.500.11822/7720> (This is the United Nations Environmental Programme's (UNEP) report on plastic debris and microplastics. This report provides valuable background information about microplastics and how to guide policy change. Recognizing the issue of plastic waste

in the marine environment happened recently and research on it is still in the beginning stages. Plastic waste is a complex problem that can be represented by a three legged stool. There are social, economic and environmental facets to this problem and solutions must satisfy all the legs of the stool in order for them to stand the tests of time. This paper discusses how to balance the social, economic and environmental factors when conducting research on microplastics in the marine environment.)

12, 15, 16, 17, 18, 20, 24, 28

United Nations Environment Programme. (2018a). *About un environment*. Retrieved from <https://www.unenvironment.org/about-un-environment> (This is the website for the United Nations Environmental Programme. It contains information about the program and how they are the leading global environmental authority and that they serve as an authoritative advocate for global environment. The website has many topics they talk about such as oceans and seas. This program also promotes the protection and sustainable management of marine and coastal environments in the world.)

23

United Nations Environment Programme. (2018b). *Persistent organic pollutants (pops) and pesticides*. Retrieved from <http://www.cep.unep.org/publications-and-resources/marine-and-coastal-issues-links/persistent-organic-pollutants-pops-and-pesticides> (POPs are toxic chemicals that last in the environment for years and circulate all around the world. They accumulate in the fatty tissue of living animals and human beings because they are lipophilic. In fatty tissue, the levels can be magnified up to 70,000 times the normal amount. There has been research done on POPs that focused on twelve, which is referred to as the dirty dozen. They can negatively affect the health of humans and animals in many ways. Monitoring POPs varies from country to

country but they are banned in some countries.)

18

University of Georgia. (2017, July 19). *More than 8.3 billion tons of plastics made: Most has now been discarded.* Retrieved from

<https://www.sciencedaily.com/releases/2017/07/170719140939.htm> (This is a news article that was based on research done by the University of Georgia. This article provides statistics that illustrate the magnitude of plastic pollution. For example, from the time that plastic production began in the 1950s until 2015, 8.3 billion metric tons of plastic have been created. Of that 8.3 billion metric tons, 6.3 billion tons are now waste. It is estimated that 8 million metric tons of plastics entered the ocean in 2010 alone. The majority of these plastics came from packaging which is meant to be used once and discarded. The article insinuates that the majority of plastic pollutants are single use products.)

12, 20, 22

Willis, K., Hardesty, B., Kriwoken, L., & Wilcox, C. (2017, March 10). *Differentiating littering, urban runoff and marine transport as sources of marine debris in coastal and estuarine environments* (Tech. Rep.). Scientific Reports. (This was a study conducted in Tasmania, Australia researching the sources of marine debris. They explored three hypotheses: direct deposition by beachgoers, transport from surrounding areas, and onshore transport from the marine system. To study this they conducted 224 surveys at 67 sites along the open coast in Tasmania. The results suggested that most marine debris is deposited locally onto beaches and that is the main reason most litter is not reflected in the statistics of the amount of pollution in the marine environment.)

23

## Appendix A: GIS Mapping Case Study

# GIS Mapping Case Study

Cameron Collins, Samantha Comeau, Brendan Gallagher, Gina Visser

11 October 2018

### Introduction

Graphical Information Systems (GIS) Mapping is a mapping technique that relies on geospatial data and displays it in a map. GIS mapping can be a powerful tool for viewing and analysing the relationships between locations and data points. These data points could be related to anything. Specifically for this project, we will be using GIS mapping to correlate trends between plastic pollution and other factors. These factors will include environmental factors such as weather patterns and elevation levels and they will also include human factors such as sporting event schedules, different business locations and land use policy.

To identify an appropriate tool for comparing plastic pollution data to these other factors we identified a few key objectives. First, we need to download these tools and use a rubric to rank them based on different factors. Second, we need to standardize our rankings so there aren't any skewed data points. Finally, we need to provide recommendations based on our research for the EcoCentre.

### Methods

In order to evaluate the software in an impartial way, a general procedure was established for investigating the tools.

First, a rubric was created with general criteria we deemed to be important to the EcoCentre. These criteria included cost, ease of download, usability, customisability, and quality. Research was conducted in order to identify eight to ten viable tools. Each of these tools was downloaded, and a rubric was completed analysing the quality of each of these

softwares. These completed rubrics can be found in the appendices. There were a few tools that did not provide any quality features and were completely unusable such as GRASS GIS, and these tools are not included in this report.

An attempt was made to load a standardized set of data into each tool, which was derived from the 2013-2014 trawling data. The dataset contained the same data points, but in some instances the data had to be reformatted in order to import it into the tool. This dataset was too large to be attached in an appendix so it is attached to this project separately in both Excel and Comma Separated Values formatting.

Next, we had different members of the team with different technical skills attempt to use the same tool. This gave us a better standard when we were ranking tools since multiple members with different expertise levels could contribute to one ranking.

Finally, the comments were grouped into three main categories for our analysis matrix: sophisticated, competent, and not yet competent. These categories were assigned colors so that viewers could easily interpret the results. This analysis matrix is included in the results section. The goal of using an analysis matrix is to make these tools easier to compare based on the different variables we used to rate the tools. This should give the user an easy way to glance at the analysis matrix and choose a GIS tool based on the features they find most important.

By doing this, the team was able to experience the user interface of the tool firsthand, instead of relying on third party reviews. General comments and concerns were recorded in the rubrics.

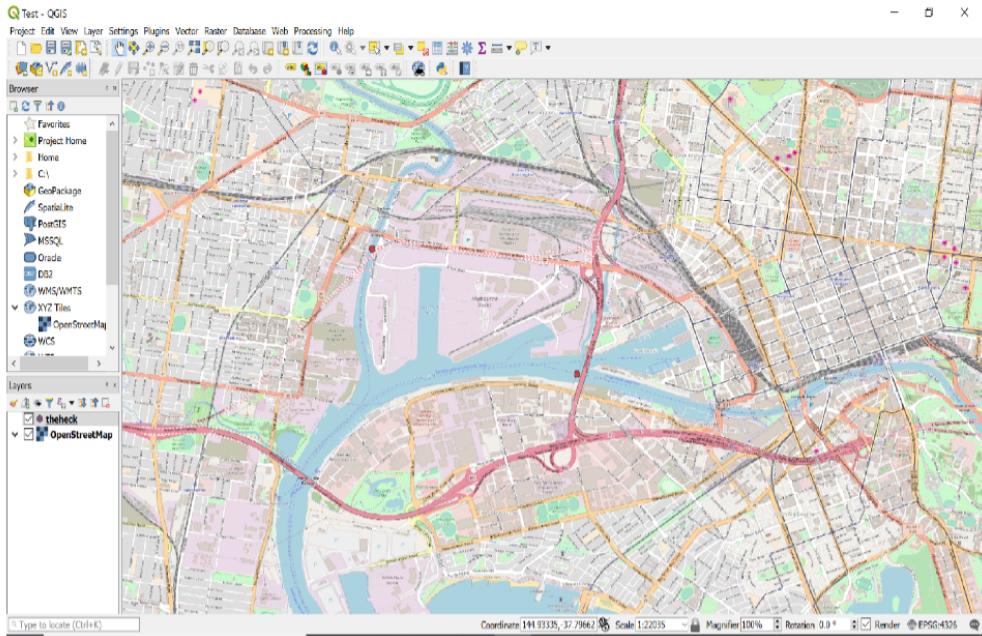
## Results

**Google Earth Pro.** is a free tool that is easy to download and use. The tool had many customisation features such as the ability to input points, lines, and polygons for different types of data. It is simple to input data as a CSV file as long as the file contains longitude and latitude values for each row. After inputting data, points at the same

location can be visually separated and renamed to differentiate the dates. Google Earth uses satellite imagery to create a 3D representation of earth. This allows the user to zoom so they can see all of the points from a distance or get closer and see the exact location of each data point. One unique feature is street view. This allows the user to drop a pin on a street so they can visualise the area from a citizen's perspective. However, Google Earth is not up to date with all of its satellite imagery and in street view, the imagery is blurry. This can be a problem if there are new buildings or the landscape changed since the Google Earth imagery was captured. For the rubric see Appendix A.1.

**QGIS.** is a free tool that is easy to download. Inputting the data into the tool is slightly challenging at first because finding the proper input values for different rows is not represented properly. For example, attempting to allow the tool to recognize which rows were longitude and latitude was difficult. However, once everything is set up the tool becomes much easier to use. The only downside to the customisation features is that we would need to create the files to import into the tool; the tool does not create these customisations for us. The graphics that this tool outputs are very clear and easy to understand on the data side, however the map output is not as high quality as some of the other tools. For the rubric see Appendix A.2.

The image below shows an example of the user interface for interacting with the data in QGIS.



*Figure 24.* QGIS user interface

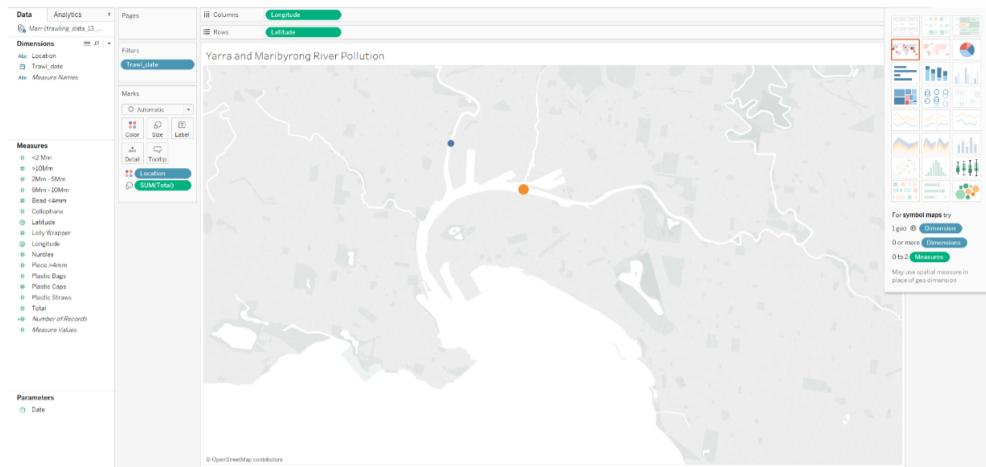
**MapWindow 5.** is another free tool that is relatively easy to download. The company that creates this tool, MapWindow, offers three other GIS tools in addition to MapWindow 5. The user must be conscious of which software is being downloaded. Data can be entered manually through the tool’s “attribute table” or can be imported from a .shp file. Files can be converted from the .csv file type to the .shp file type easily using online converter tools such as MyGeodata Converter. There are a great number of formatting options for labels, and plugins are readily available to customise the tool. Despite the graphic quality being relatively low, the labelling options and ease of data input make this tool usable for non-technical audiences. The rubric for MapWindow 5 can be found in Appendix A.3.

**Tableau.** is a tool that requires a license for businesses to use it at 70 USD a month. Although it isn’t free, the tool offers an option for non-profits and NGO’s to request a donated license. The qualifications include that the non-profit must be:

1. Officially recognized tax-exempt organisation in one of the countries on the site (including Australia)

2. Operate with an annual budget under \$5 million (or equivalent in local currency)
3. Not be a school, college, mutual organization, healthcare organization, or government agency
4. Not be a religious organization incorporated exclusively for the promotion of the religion

Assuming the EcoCentre could gain access to a license, the tool is incredible in terms of all the other features we ranked. The tool is easy for non-technical users to use with minor guidance. The data does need to be input in a specific way, however it did not take long to format the data properly. There are many customisation features such as layered charts, color selectors, etc. Some are shown in the image below. This is the layout of the tool when the user is editing the different graphs.



*Figure 25.* Tableau developer platform

As you can see in the figure there are options to modify what different features, such as total plastic pollution, are represented as, such as size of data point on the map. Integrating these features is as easy as dragging the measure on the left and dropping it on the method of displaying that feature. For example dragging total and dropping it onto the size option. This would make the data point larger for larger totals and vice versa for smaller total plastic counts. For the rubric see Appendix A.4.

**ArcGIS.** is another tool that costs money, however it does not provide NGO license pricing without signing up for more information on their discounts for NGOs. This tool is also easy to use in terms of data input and manipulation. It is a web-based platform which is nice because it does not require the user to have an advanced computer setup. Also, this tool has many layer customisation features, however it is hard to filter by date with this tool. It would be easy to add spatial layers to convey data with this tool and overall it is a quality tool. For the rubric see Appendix A.5.

**DIVA GIS.** is a free GIS mapping software that can be easily downloaded. The data must be formatted into TXT format and any maps must be imported as a separate file. Inputting the data is slightly challenging, however the tool is easy to use once the data has been imported. There is the ability to add climate and terrain information if you download their climate and terrain database. However, this tool plots the data based on latitude and longitude, so multiple data points that all occur at the same location would show up as a singular point, not as multiple points. This software also has some basic data analysis features built in. The image quality of the final product is pretty basic, and there are no legends on the map so it is difficult to understand what is being visualised. The rubric for this tool can be found in Appendix A.6.

**Map Express.** is easily downloaded from the CadCorp website. The majority of the other tools that have been reviewed come loaded with background maps, however, Map Express requires the user to import a raster file in order to generate a baseline map. This introduces added complexity and the appearance of the finished product will be highly dependent on the quality of the raster file used. Data can be imported from a variety of file types, but the user interface on the left side of the screen can sometimes make it difficult to control and manipulate data and labels. The rubric can be found in Appendix A.7.

**Simple GIS.** costs \$50 per license, meaning that a user could use the software on a single computer for an indefinite period of time after a one-time payment. The software includes background images already, but it was difficult to navigate the user interface to

import data. Geolocation was easy to figure out for non-technical users, but it was unclear how to import other data. Error messages occasionally appear on the screen, either by user error or not. The tool doesn't offer any features that would be relevant to the scope of this project, and overall the image quality was quite poor. The rubric can be found in Appendix A.8.

### **Analysis Matrix**

To combine all of these analyses, we created an analysis matrix ranking the GIS mapping tools which can be seen below.

Name	Cost	Ease of Download	Usability	Customisability	Quality
Google Earth	Green	Green	Green	Green	Yellow
Q GIS	Green	Green	Yellow	Green	Yellow
MapWindow 5	Green	Yellow	Green	Green	Yellow
Tableau	Red	Green	Green	Green	Green
ArcGIS	Red	Green	Green	Yellow	Yellow
DIVA GIS	Green	Green	Yellow	Yellow	Yellow
Map Express	Green	Green	Red	Yellow	Yellow
Simple GIS	Red	Green	Yellow	Red	Red

*Figure 26. Analysis Matrix*

## Discussion

Our top four choices based on the analysis matrix are Google Earth Pro, Tableau, QGIS and MapWindow 5. We came to this conclusion as a group and used the analysis matrix as well as personal experience with the tools to determine which tools were the best for our application.

Specifically comparing these four tools, we think Google Earth Pro beats QGIS and MapWindow 5 because of the ease of download and usability features, which we deemed are important to the EcoCentre. The quality of these tools can be easily compared in the screenshots below.

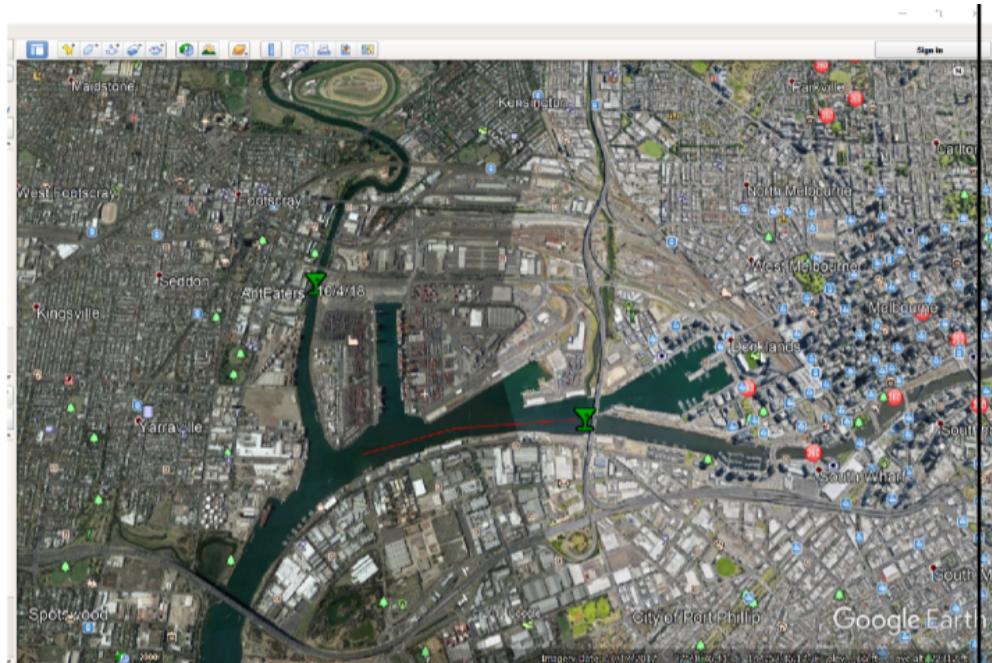


Figure 27. Google Earth Pro

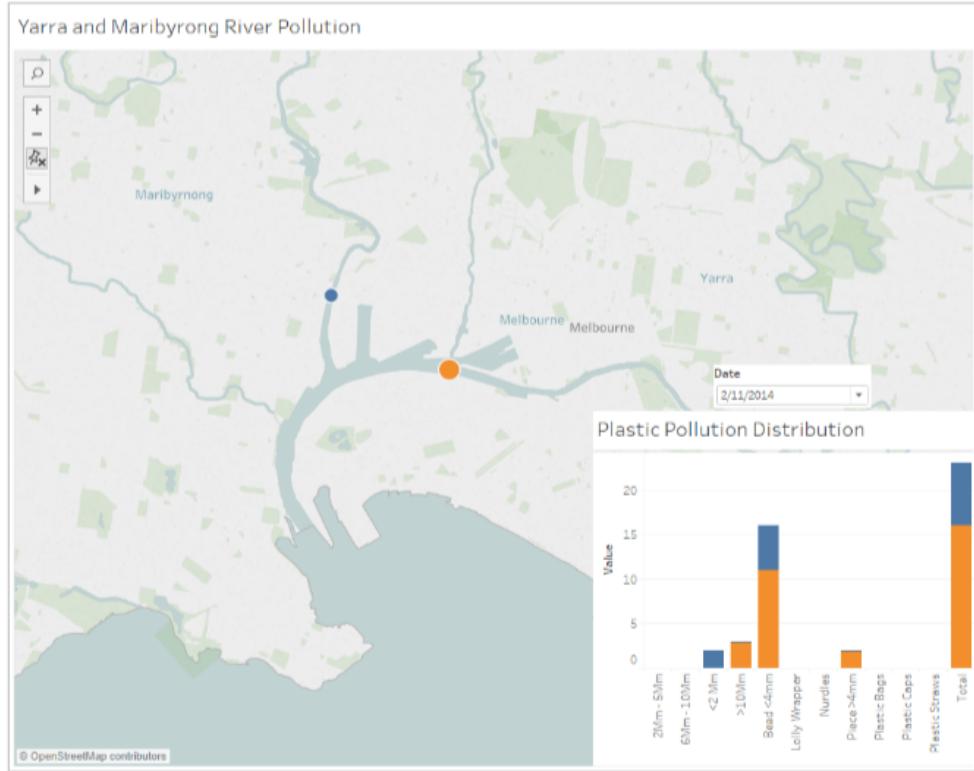


Figure 28. Tableau

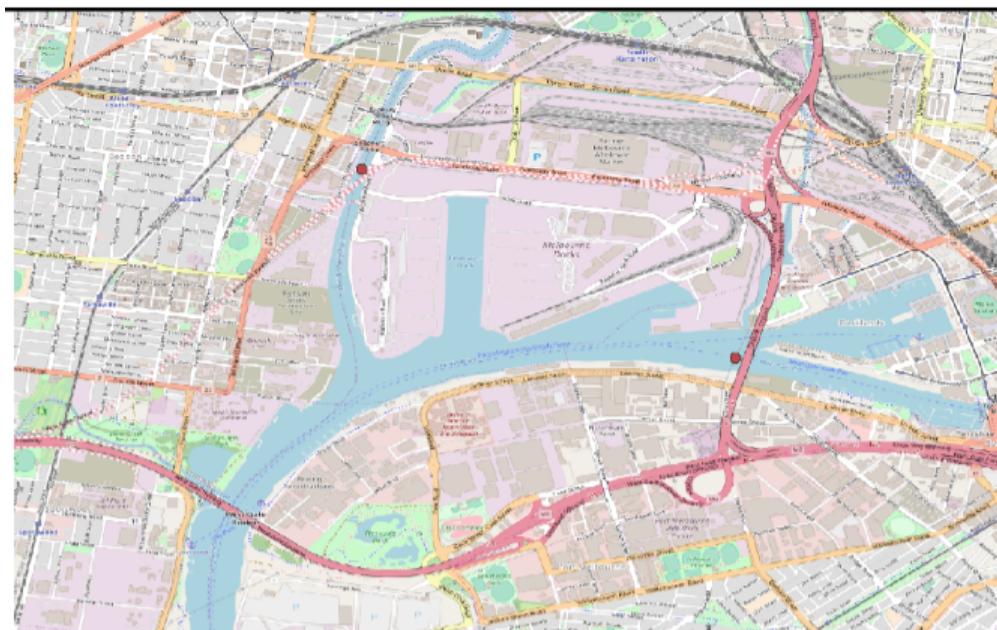
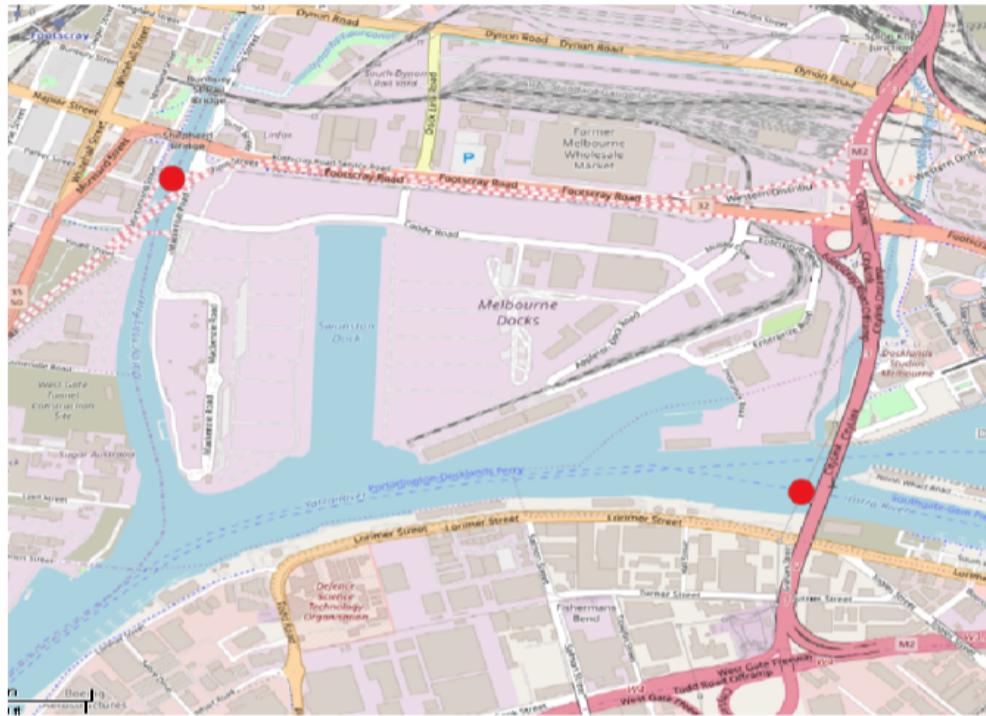


Figure 29. QGIS



*Figure 30. MapWindow5*

#### Comparing quality of output for the four tools

In our opinion, Google Earth Pro and Tableau provide the easiest to understand basemaps. One benefit of Tableau is the simplicity in adding all of these features once the initial data has been formatted. QGIS and MapWindow 5 have built in colored maps with descriptive labels.

The fact that MapWindow 5 only accepts .shp files when importing data may serve as a detriment; however, the user interface is easy to understand and manipulate. Tableau has the option to import multiple file types and can also import multiple data files at once, to layer or display multiple maps in one visualisation. After importing data, all of the tools ranked well in terms of usability.

One feature we know is important to this project is the ability to view data over time on our maps. We defined manual data manipulation as a method of filtering by date, but only in the developer platform of the program. An ingrained date filtering would

provide a way to manipulate the date being shown after the visualisation is exported for the user. Below we provide the manual and ingrained methods for the tools, if they exist.

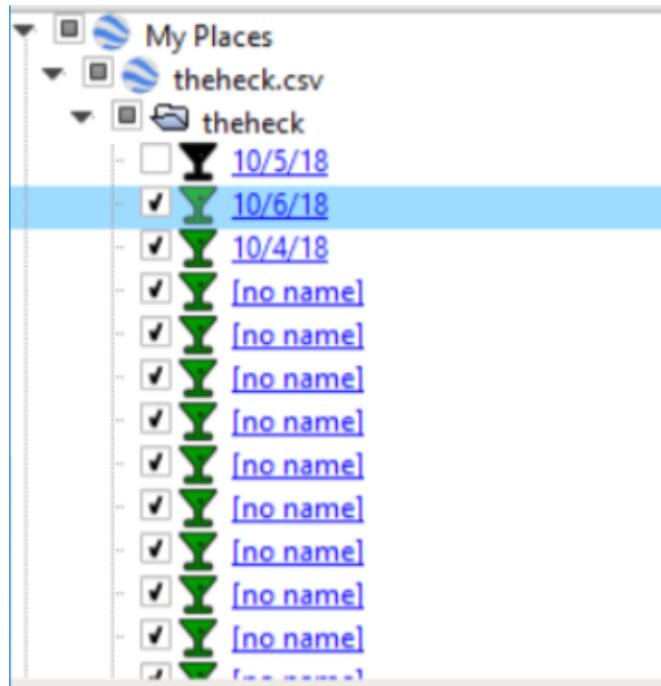


Figure 31. Google Earth Pro: Manual date filtering

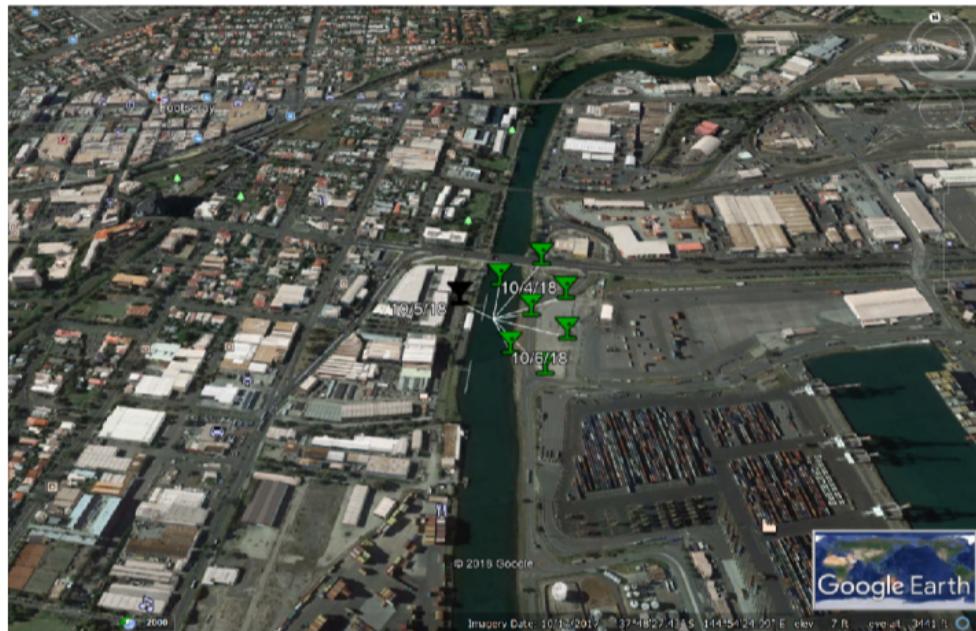


Figure 32. Google Earth Pro: Automatic date filtering

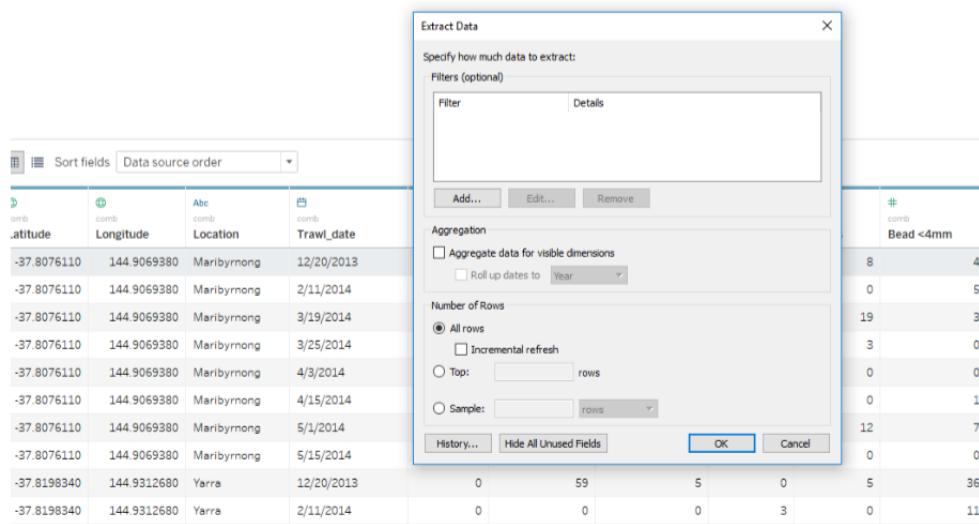


Figure 33. Tableau: Manual date filtering



Figure 34. Tableau: Automatic date filtering

Ultimately, we would recommend Google Earth Pro or Tableau for the EcoCentre to use. Compared to the other software packages, Google Earth Pro and Tableau offer a greater number of features, create a higher quality output, and make data creation and manipulation easy. It is our hope that the EcoCentre already has, or will be able to obtain, a free Tableau license due to their status as a non-profit organization. If this happens, we feel that Tableau would be a slightly easier tool to use for this project than Google Earth Pro. If the EcoCentre cannot obtain a free Tableau license however, we feel that both of these tools are simple enough to learn, easy enough to understand, and will provide the best opportunity for the EcoCentre to build upon their existing datasets in the future.

## Conclusion

Ultimately, the goal of this case study was to present the EcoCentre with multiple options for GIS mapping tools for the use of this project. We have found that our top four tools are Google Earth Pro, Q GIS, MapWindow 5, and Tableau. If the EcoCentre could receive a Tableau license for non-profits, we would recommend Tableau over all other GIS mapping tools.

We have come to this conclusion due to the tools' rankings which can be seen in the analysis matrix that we included. We think that the output of these tools is quality and can provide us with the opportunity to create an intuitive and useful geographic representation of plastic pollution in the Yarra and Maribyrnong rivers.

### Appendix A.1: Rubric for Google Earth Pro

Name	Google Earth Pro	
Source	<a href="https://earth.google.com/download-earth.html">https://earth.google.com/download-earth.html</a>	
Cost	Free	
Availability	Is it easily downloadable?	Yes
Usability	In terms of data input, is it easy to format and input data into the tool?	Data must be in CSV format in order to input with longitudes and latitudes. Step by step process to do so will be included
Usability	Overall, how usable is this tool? Will the Port Phillip EcoCentre be able to use this tool after our team leaves?	Yes, it is simple to add data and visually separates multiple data points at same location. Can easily rename data points to easily distinguish dates and titles
Customisability	What customisation features does the tool have?	3D visualisation maps, and geocoding
Customisability	Are there any standout features that would bring this visualisation to the next level?	Able to import data from excel spreadsheets, ability to zoom and see data points from a distance
Quality	What quality is the output of the program? Consider graphic quality and appearance.	Average to below average quality of imagery, not up to date images
Quality	Is it clear what the data is conveying?	Yes, you can see what types of plastics are imported and what date
Other		<a href="https://support.google.com/earth/answer/176685?hl=en">https://support.google.com/earth/answer/176685?hl=en</a> Instructions to import data

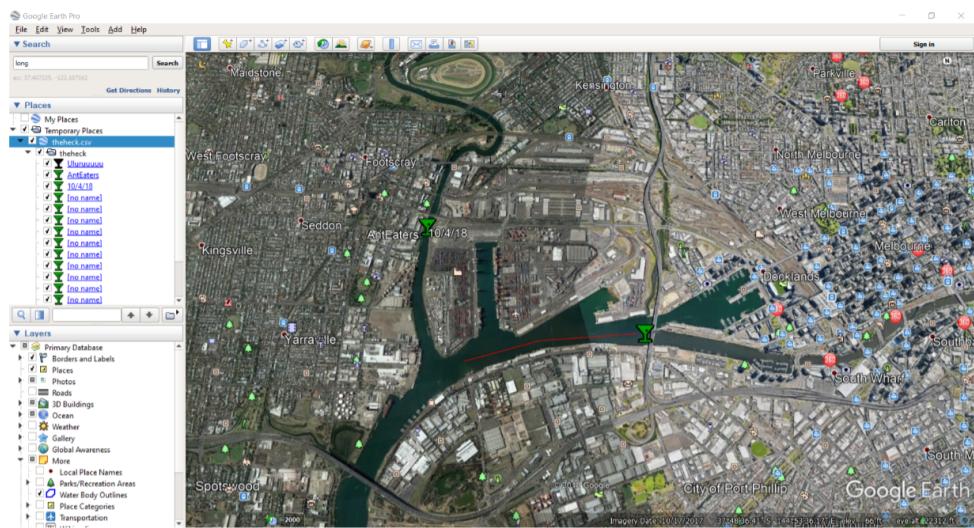


Figure 35. Google Earth Pro Output

### Appendix A.2: Rubric for QGIS

Name	QGIS	
Source	<a href="https://www.qgis.org/en/site/">https://www.qgis.org/en/site/</a>	
Cost	Free	
Availability	Is it easily downloadable?	Yes
Usability	In terms of data input, is it easy to format and input data into the tool?	Pretty easy
Usability	Overall, how usable is this tool? Will the Port Phillip EcoCentre be able to use this tool after our team leaves?	It is a little difficult to set up, but gets easier once it is set up
Customisability	What customisation features does the tool have?	Seems to have a ton of customisation options but we would need to create the files to import
Customisability	Are there any standout features that would bring this visualisation to the next level?	Yes there are a lot of different geospatial customisation tools
Quality	What quality is the output of the program? Consider graphic quality and appearance.	It is okay... not the best
Quality	Is it clear what the data is conveying?	It is good in terms of data
Other		

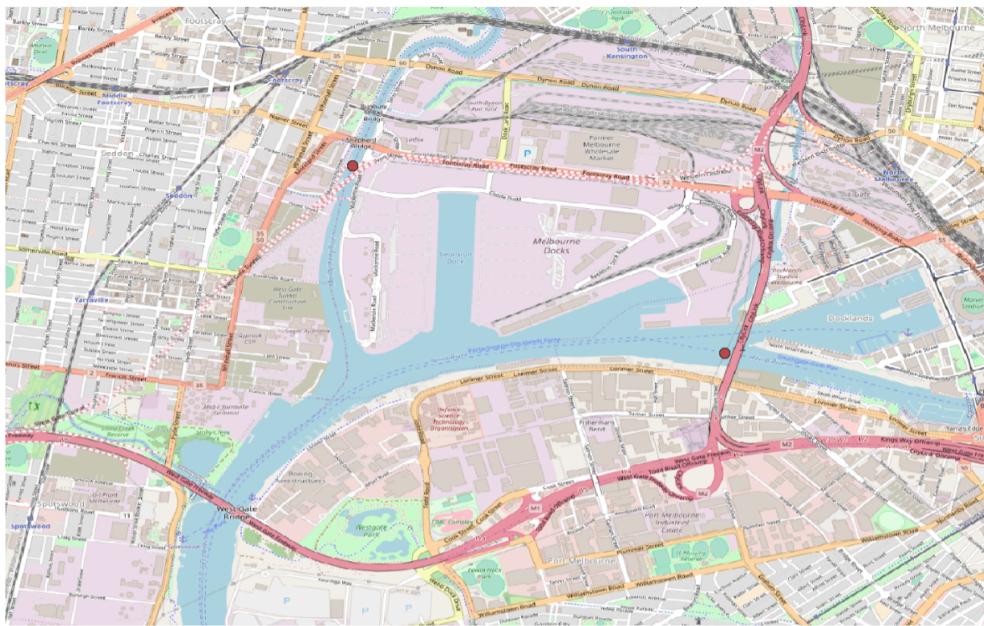


Figure 36. QGIS Output

### Appendix A.3: Rubric for MapWindow5

Name	MapWindow5	
Source	<a href="https://www.mapwindow.org/">https://www.mapwindow.org/</a>	
Cost	Free	
Availability	Is it easily downloadable?	Yes but you need to download the correct software. There are 4 different types of software: MapWinGIS, MapWindow5, HydroDesktop, and DotSpatial
Usability	In terms of data input, is it easy to format and input data into the tool?	Data can be entered into the tool via the “attribute table”, and can be imported from a .shp file. File can easily be converted from .csv files to .shp files through online conversion tools. The data can be modified through the “table” editor very easily. When editing shapes and labels, the user can see previews of their changes, and plenty of options exist.
Usability	Overall, how usable is this tool? Will the Port Phillip EcoCentre be able to use this tool after our team leaves?	Because there aren't readily available tutorials, it is difficult to grasp how to use the software. The user interface seems basic, but learning where buttons are and how to modify shapes and data is a time consuming process.
Customisability	What customisation features does the tool have?	Multiple plugins are available for the tool, but it appears as though these plugins provide basic functionality that should be expected from the software, such as editing shapes and data values from inside the tool.

Customisability	Are there any standout features that would bring this visualisation to the next level?	A plugin is available to enable the user to query the data easily.
Quality	What quality is the output of the program? Consider graphic quality and appearance.	The graphic quality is relatively low, but there are a number of labels present on the stock maps. The labels adapt to the user's zooming, and it is easy to see key landmarks and shapes.
Quality	Is it clear what the data is conveying?	The user has a great deal of control over how the data is displayed.
Other		Documentation for the tool is still under construction, but there are some open source video tutorials available.

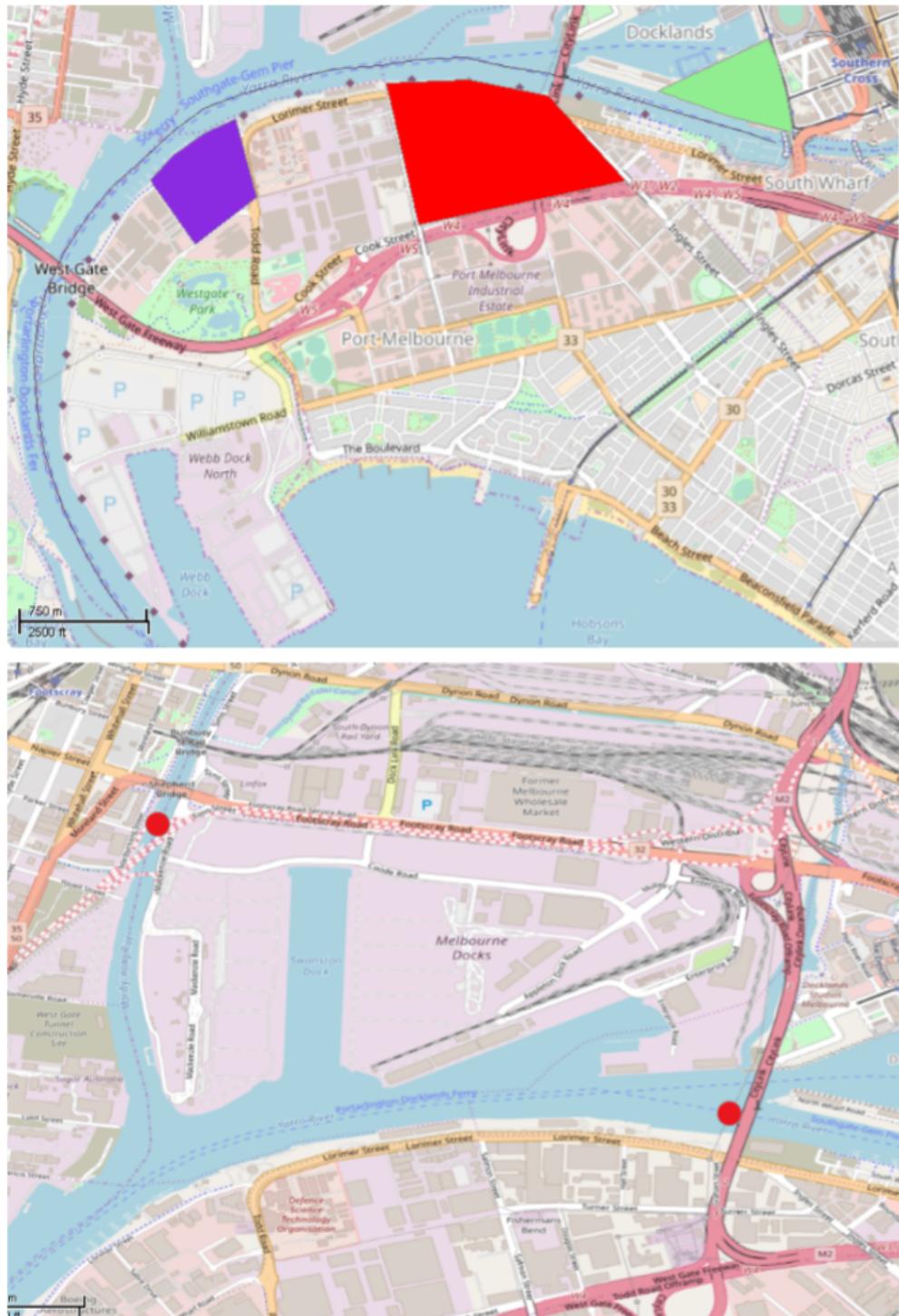


Figure 37. MapWindow5 Output

#### Appendix A.4: Rubric for Tableau

Name	Tableau	
Source	<a href="https://www.tableau.com/">https://www.tableau.com/</a>	
Cost	70 USD / month, or non-profit donated license	
Availability	Is it easily downloadable?	Yes
Usability	In terms of data input, is it easy to format and input data into the tool?	Data needs to be specifically formatted so the tool can recognize different attributes. Overall, once it's formatted it's easy to move data around.
Usability	Overall, how usable is this tool? Will the Port Phillip EcoCentre be able to use this tool after our team leaves?	They would be able to import new data by putting data into the data sheet easily, however they probably wouldn't have as much expertise as needed for changing formatting within the tool.
Customisability	What customisation features does the tool have?	Easily customisable and ability to layer multiple charts on top of each other which is nice. Color selectors and other features make this tool stand out as well and they are really easy to use.
Customisability	Are there any standout features that would bring this visualisation to the next level?	Layered charts.
Quality	What quality is the output of the program? Consider graphic quality and appearance.	Takes a little to load the full quality but afterwards it's good.
Quality	Is it clear what the data is conveying?	Need to manually add labeling or coloring to the map.
Other		EcoCentre has a visualisation using it already, so they might have a license or preference for it.

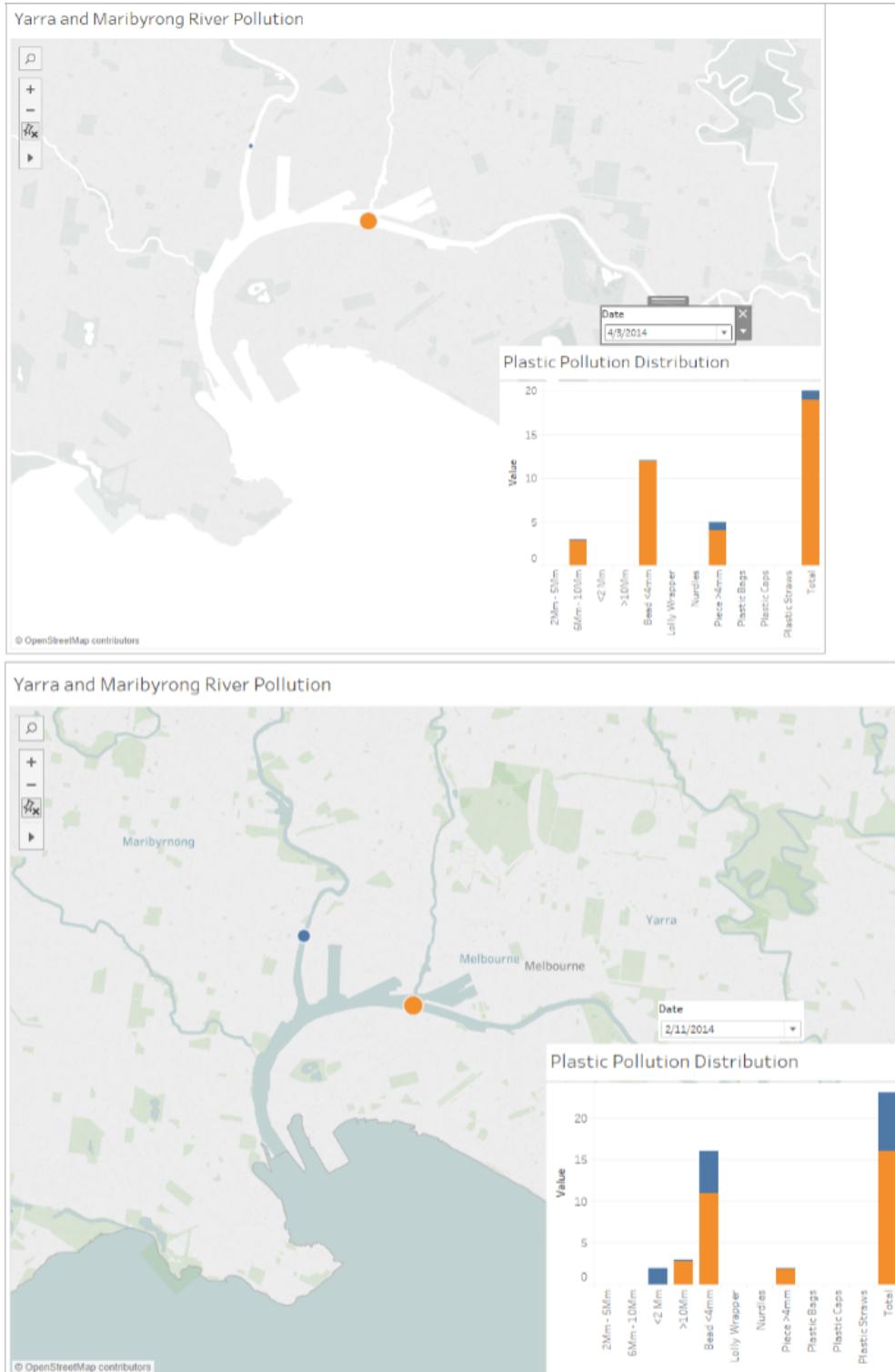


Figure 38. Tableau Output

### Appendix A.5: Rubric for ArcGIS

Name	ArcGIS	
Source	<a href="https://www.esri.com/en-us/arcgis/">https://www.esri.com/en-us/arcgis/</a>	
Cost	500USD per user per year	
Availability	Is it easily downloadable?	It's online so you don't need to necessarily download it
Usability	In terms of data input, is it easy to format and input data into the tool?	Yes, takes in a CSV
Usability	Overall, how usable is this tool? Will the Port Phillip EcoCentre be able to use this tool after our team leaves?	Very usable, importing data and layers is insanely easy
Customisability	What customisation features does the tool have?	Seems to have lots of customisation features with different layer options and adding filters to the variables
Customisability	Are there any standout features that would bring this visualisation to the next level?	n/a
Quality	What quality is the output of the program? Consider graphic quality and appearance.	Image quality is pretty bad unless you use the default base map
Quality	Is it clear what the data is conveying?	Yes, it would be easy to add spatial layers to convey data
Other		Cloud based, easy for multiple contributors

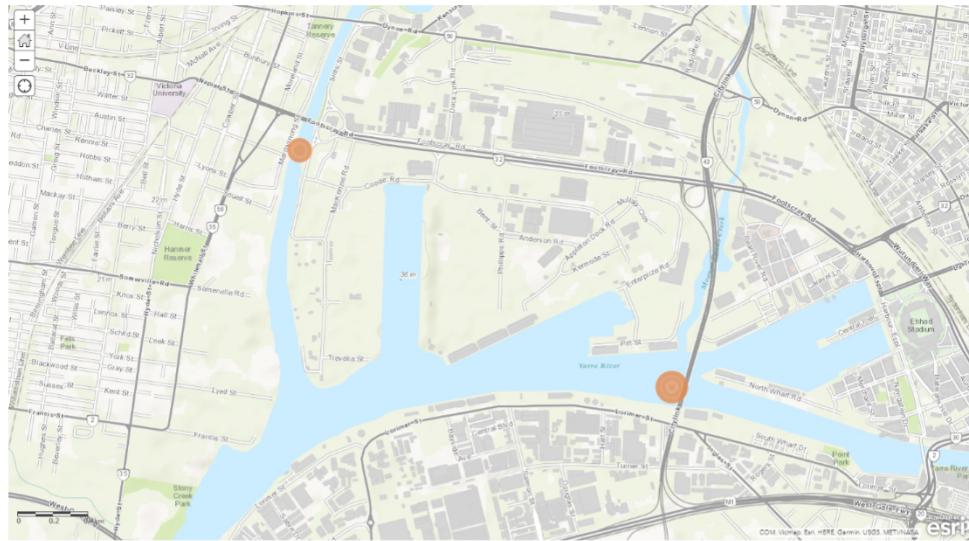
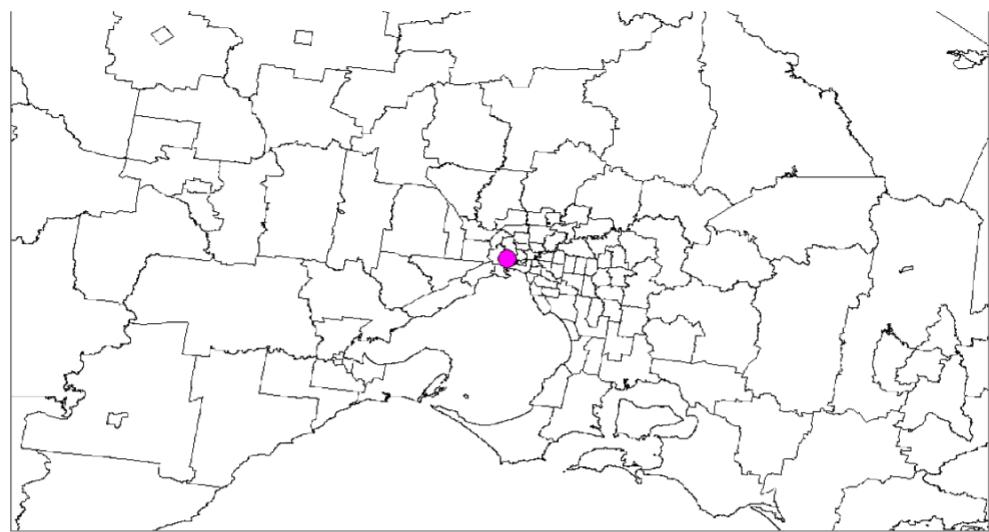


Figure 39. ArcGIS Output

### Appendix A.6: Rubric for Diva GIS

Name	Diva GIS	
Source	<a href="http://www.diva-gis.org/documentation">http://www.diva-gis.org/documentation</a>	
Cost	Free	
Availability	Is it easily downloadable?	Yes
Usability	In terms of data input, is it easy to format and input data into the tool?	The data must be in a TXT file, so you just have to convert it from excel
Usability	Overall, how usable is this tool? Will the Port Phillip EcoCentre be able to use this tool after our team leaves?	Once the data is input, using the tool is pretty easy to use, but it took me a while to figure out how to input the data
Customisability	What customisation features does the tool have?	Ability to add climate and terrain layers from their websites database
Customisability	Are there any standout features that would bring this visualisation to the next level?	Ability to zoom and see data points from a distance, has some data analysis features built in
Quality	What quality is the output of the program? Consider graphic quality and appearance.	Average, basically just an outline of a map with a few lines and colored dots on it
Quality	Is it clear what the data is conveying?	There isn't any legends or anything on the map. There is only the single dot for the data.
Other		This tool plots based on latitude and longitude, so there is not a way to separate the different kinds of plastic in a particular sample that I have been able to figure out <a href="http://www.diva-gis.org/docs/DIVA-5_Tutorial.pdf">http://www.diva-gis.org/docs/DIVA-5_Tutorial.pdf</a> basic tutorial on how to use this software



*Figure 40.* Diva GIS Output

### Appendix A.7: Rubric for MapExpress

Name	MapExpress	
Source	<a href="https://www.cadcorp.com/products/free-mapping-software/">https://www.cadcorp.com/products/free-mapping-software/</a>	
Cost	cost	
Availability	Is it easily downloadable?	Yes
Usability	In terms of data input, is it easy to format and input data into the tool?	You can load raster files (.ecw) to create maps, and can load data from .tab, .dgn, .dwg, .dxf, .bds, .mdb, and .mif file types.
Usability	Overall, how usable is this tool? Will the Port Phillip EcoCentre be able to use this tool after our team leaves?	The tool is very slow to load and update. In addition, many of the colors change during zooming and panning, and is not very user friendly.
Customisability	What customisation features does the tool have?	As far as I'm aware, there are no plugins or add-ons available for this software to make it more customisable.
Customisability	Are there any standout features that would bring this visualisation to the next level?	The tool can support 3D visualisations, but is mostly equivalent to many other softwares in that the user can zoom, pan, add data, and perform formatting operations.
Quality	What quality is the output of the program? Consider graphic quality and appearance.	The tool can support 3D visualisations, but is mostly equivalent to many other softwares in that the user can zoom, pan, add data, and perform formatting operations.
Quality	Is it clear what the data is conveying?	There are a number of style/formatting options for labelling. Through good formatting, the data can probably be presented in a clear way.

Other		Details aren't clear at the lowest zoom levels; however, this may be a function of poor map quality.
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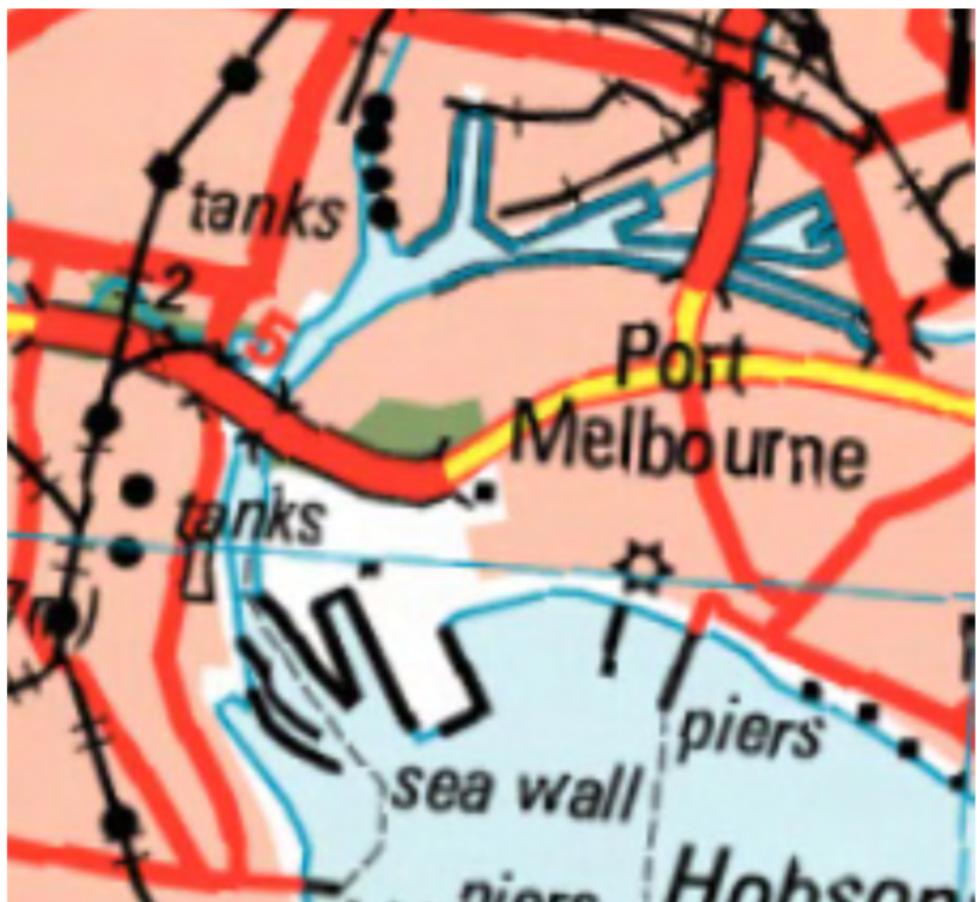


Figure 41. MapExpress Output

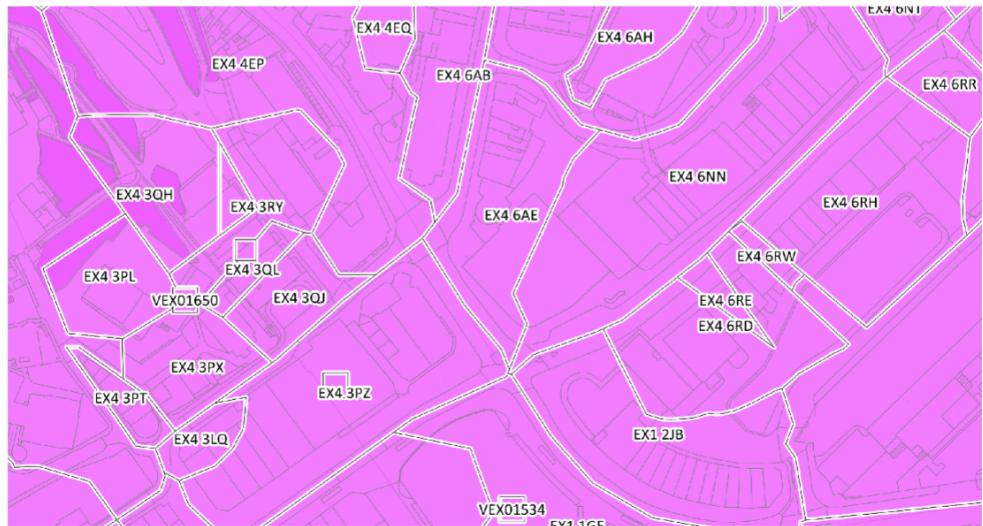


Figure 42. MapExpress Output 2

### Appendix A.8: Rubric for Simple GIS

Name	Simple GIS	
Source	<a href="https://www.simplegissoftware.com/simple-gis-client.html">https://www.simplegissoftware.com/simple-gis-client.html</a>	
Cost	50 USD per license	
Availability	Is it easily downloadable?	Yes
Usability	In terms of data input, is it easy to format and input data into the tool?	Example maps come with the tool. Importing the data was hard, the Geolocation was somewhat easy but I cannot figure out how to input the other relevant data
Usability	Overall, how usable is this tool? Will the Port Phillip EcoCentre be able to use this tool after our team leaves?	The tool isn't very usable, as error messages commonly pop up, and data entry and formatting options are scarce.
Customisability	What customisation features does the tool have?	Very difficult to use and doesn't seem to have any features
Customisability	Are there any standout features that would bring this visualisation to the next level?	No
Quality	What quality is the output of the program? Consider graphic quality and appearance.	Image and picture quality aren't good at all
Quality	Is it clear what the data is conveying?	Not really, hard to customise
Other		

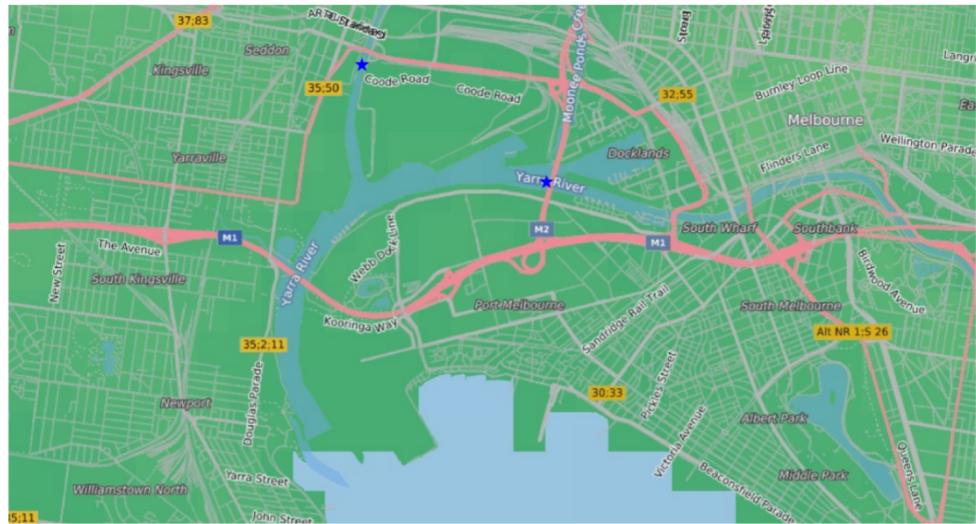


Figure 43. Simple GIS Output

## Appendix B: How to Use Tableau

### Downloading and Setting up

**Download.** Visit <https://public.tableau.com/en-us/s/>, enter your email, and download the app.

**Language Settings.** To ensure your workbook is understanding the proper date and time settings you will need to edit the date and time settings within Tableau.

1. First, click "File" -> "Workbook Locale" -> "More..."
2. Use the dropdown menu to select “English (Australia)”.
3. A pop-up will show up, click "Yes" so Tableau will interpret dates in the new specified format.

### Inputting Data

1. Click the leftmost bottom tab called “Data Source”
2. Click on “Microsoft Excel” and this should open up a file explorer window
3. Navigate to the excel file that you’d like to visualise in Tableau. Select the excel file and click "Open".
4. To select a sheet from your excel file, click and drag it to the area that says “Drag sheets here”.

You should see the data populate in the lower rectangular area. If data does not appear here, it means that the data may be formatted incorrectly.

5. In the bottom left of the screen, click on "Sheet1". Right click on the tab and rename it to something meaningful. After you rename it, left click on the tab to select it.

## Creating a Graph

- First, create a workbook using the input data instructions. For this example, we will be using the EcoCentre\_Audits.xlsx file.

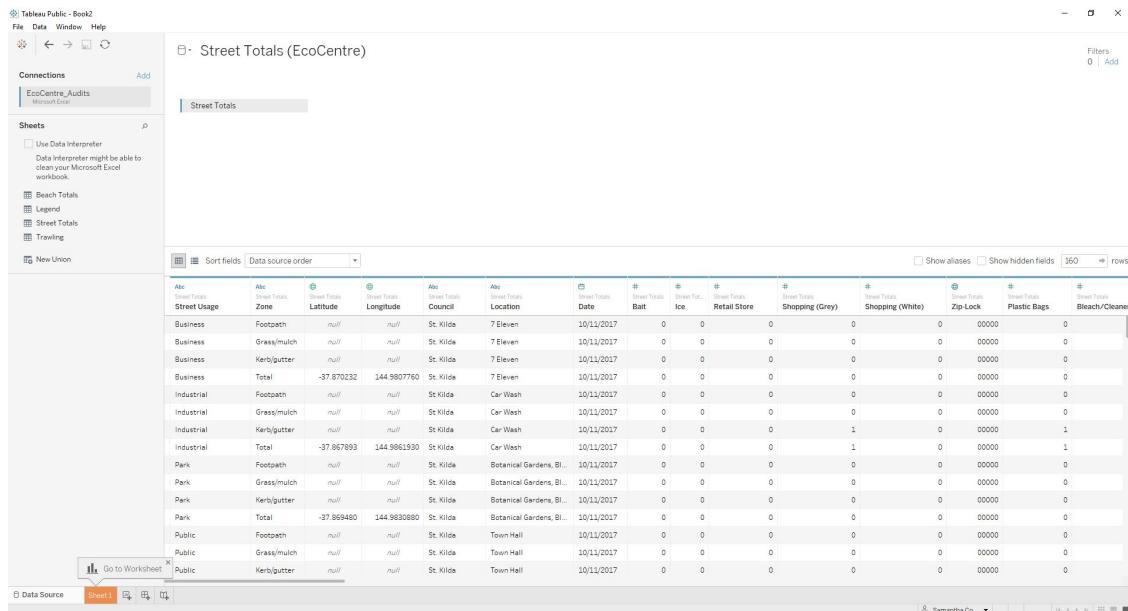


Figure 44. EcoCentre Audits File Upload

- Create a new worksheet by clicking “Sheet1”. This can be renamed by right clicking and choosing “Rename”.
- Here we want to graph the total plastic pollutants found per each street usage type. To do this, we will first define our rows and columns.  
Drag “Street Usage” from “Dimensions” to the columns in the top of the screen.  
Drag "Total" from “Measures” to the rows in the top of the screen.

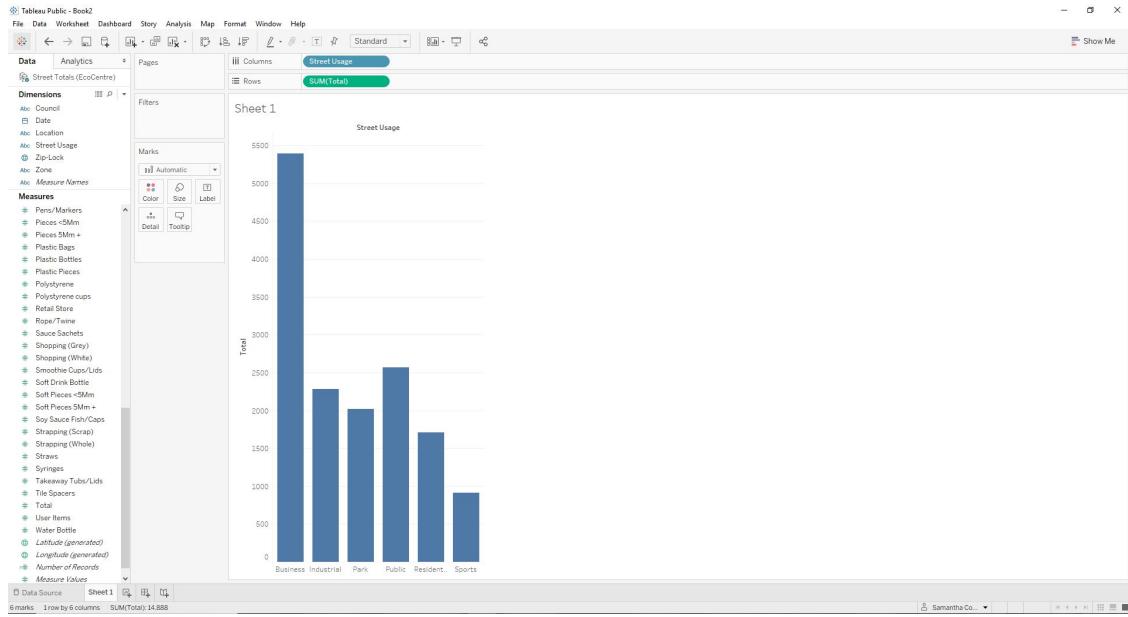


Figure 45. Simple Bar Chart in Tableau

It is important to note that when we added “Total” to the graph, it automatically added "SUM(Total)". This value represents the sum of all the totals found for each street use category. If we wanted the average of these values instead so we could visualise the average of each street usage's total values we must select the "Total" value from the rows box. A small arrow as shown in the picture below should show up and upon clicking it will show the drop down box.



Figure 46. How to Edit the Values

To change it to average select “Measure” and “AVG”.

### Changing Chart Type.

1. To change the chart type, select the menu item in the top right of the screen that says “Show Me”. Depending on the type of values that are in the "Column" and "Row" at the top of the chart, different charts will be available and these are shown in full color.

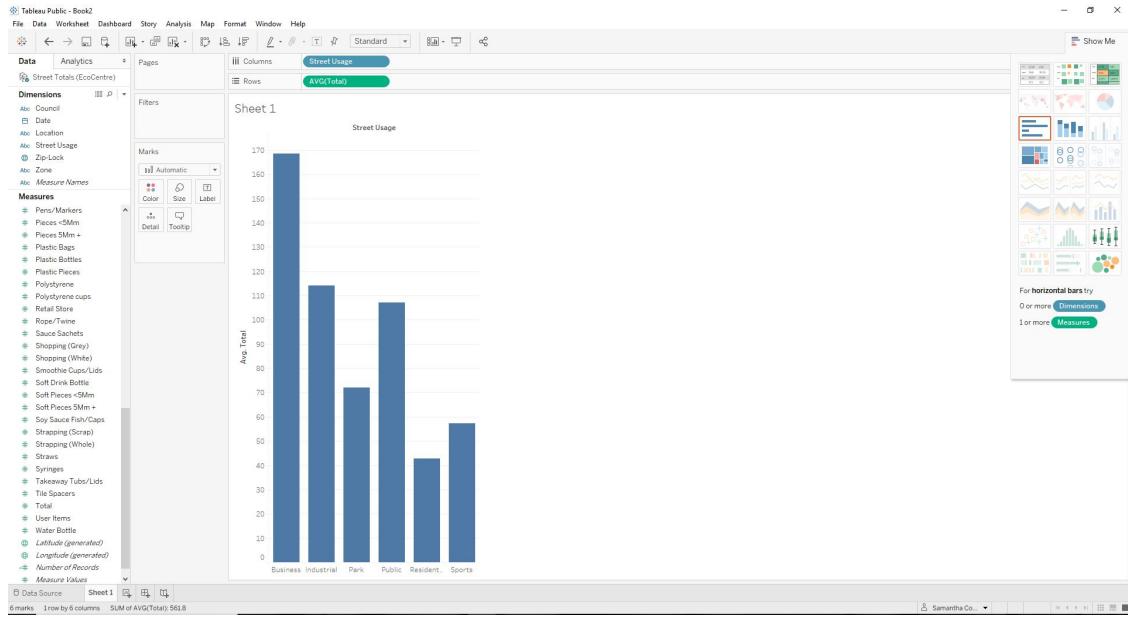


Figure 47. How to change a chart using the "Show Me" box

2. To figure out how to create a chart you desire, hover over the chart type and read the values at the bottom, which represent what type of data needs to be available in your "Column" and "Row" boxes to create that chart. To create a GIS map go to the *Creating a GIS Map* section of this document.

## Customising a Graph

There are many customisation features within Tableau. Using the graph created above we will demonstrate some of these.

To change the title simply click on the title and change it to the title that is more fitting for your chart.

The “Marks” box shows the options for customising the current chart.

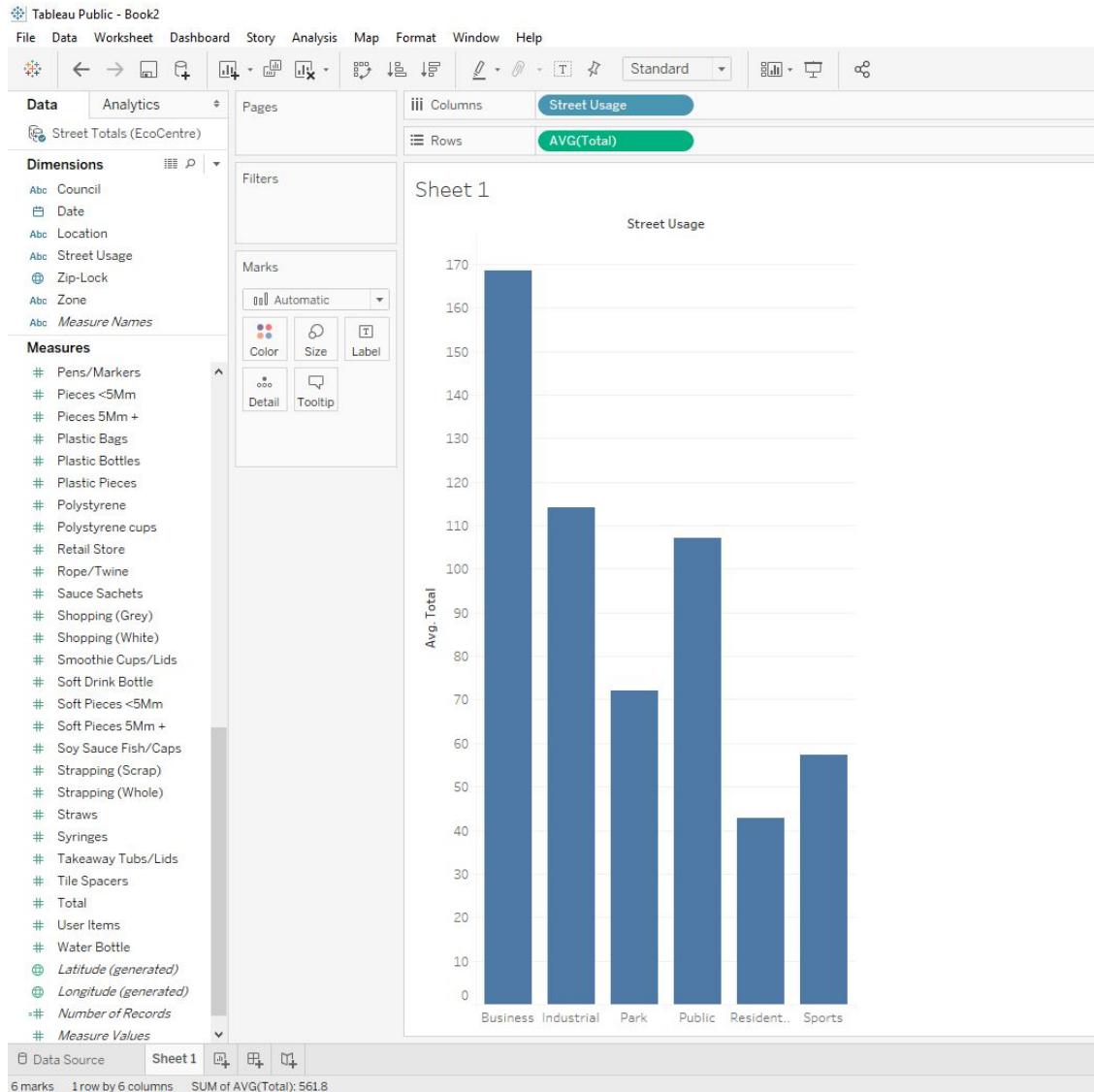


Figure 48. Simple Chart to Customise

## 1. Color

To change what the color represents in the chart, drag an item onto the "Color" box within the "Marks" menu. For this visualisation we will be showing the location data as the color so we can see which locations are represented within the street types.

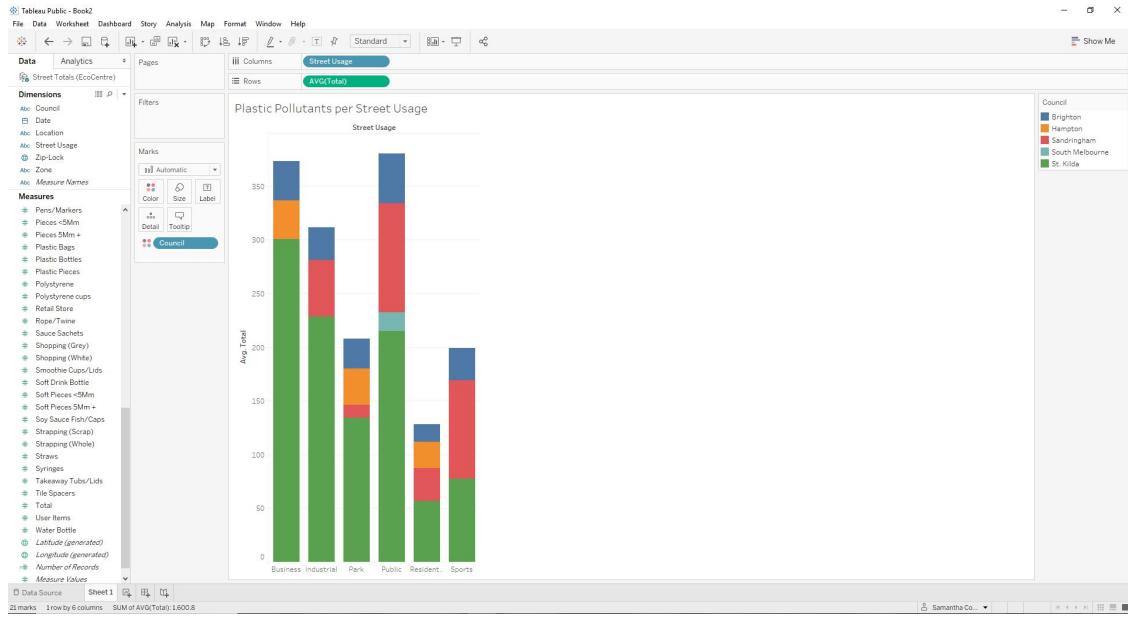


Figure 49. Adding Color to a customisable chart

To change the colors that are used in the chart, you can select the box on the right that shows the colors selected now. To change them, click the arrow and choose “Edit Colors”. Here we can change the colors and choose “Ok”. We choose to use the Color Blind sensitive colors.

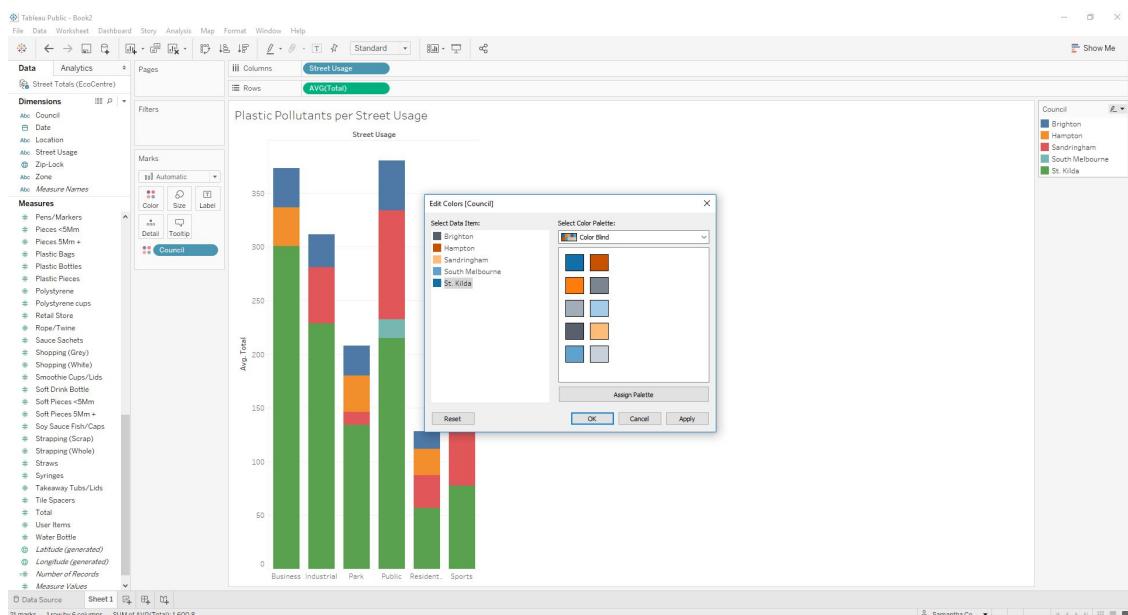


Figure 50. Selecting colors for the chart

## 2. Tooltips

To add a tooltip drag the value you'd like to see when you hover over a bar to the "Tooltip" box in the "Marks" menu. You can add multiple tooltips by doing the same thing multiple times.

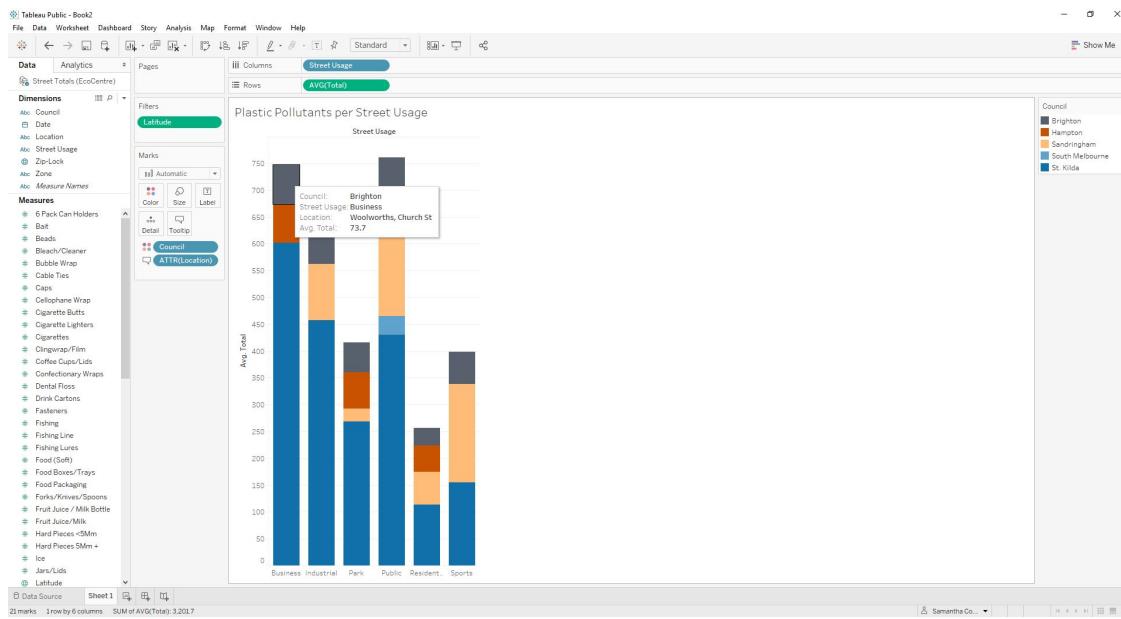


Figure 51. Adding tooltips to the chart

3. The rest of these can be edited the same way. Depending on the type of chart, different options are available for customisation. For example, if we had chosen a “Shape” chart we would be able to change the shape of the points on a GIS map.

## Filtering Data in a Graph

Sometimes you will want to interact with the data dynamically, rather than within your excel spreadsheet. To do this we will add a filter to the chart created in the *Create a Chart* section. For this we will be filtering on date.

1. Drag the "Date" value from the "Dimensions" tab to the "Filter" box.
2. Select “Individual Dates” or whichever represents how you would like to view the dates.

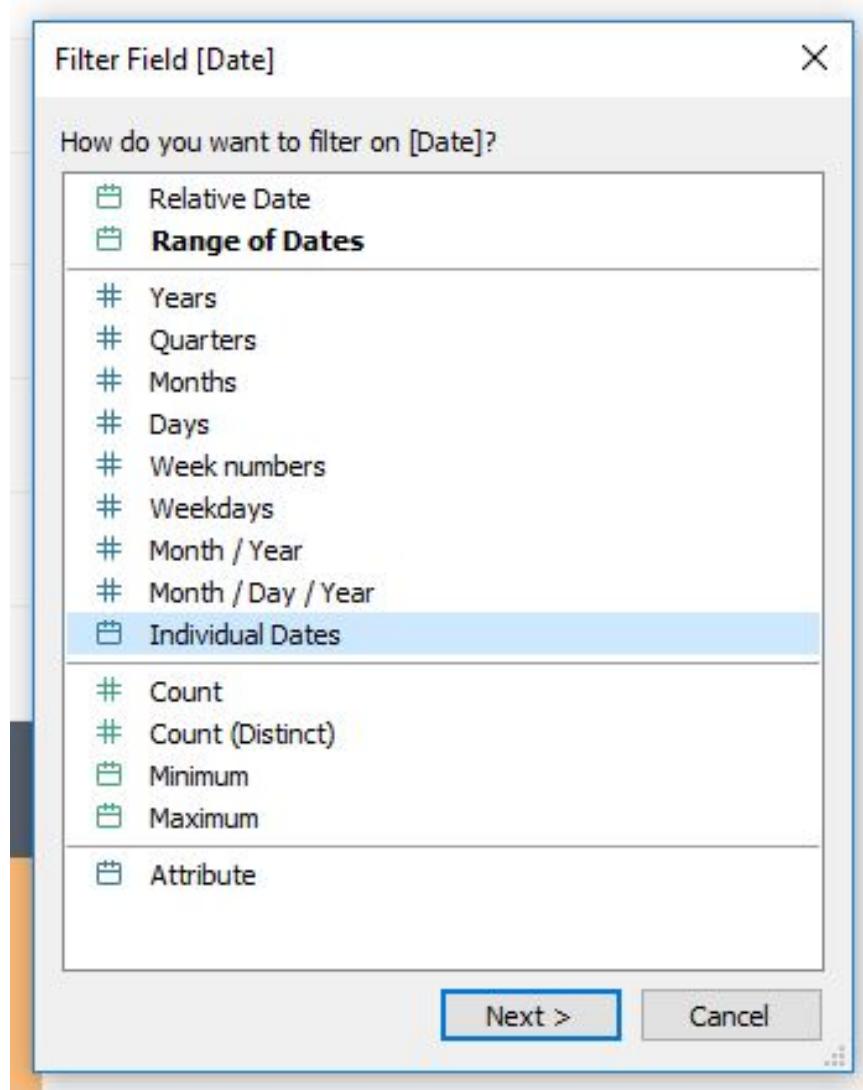


Figure 52. Filtering on date options

3. Here we will be using all the dates so we select “Use All”.

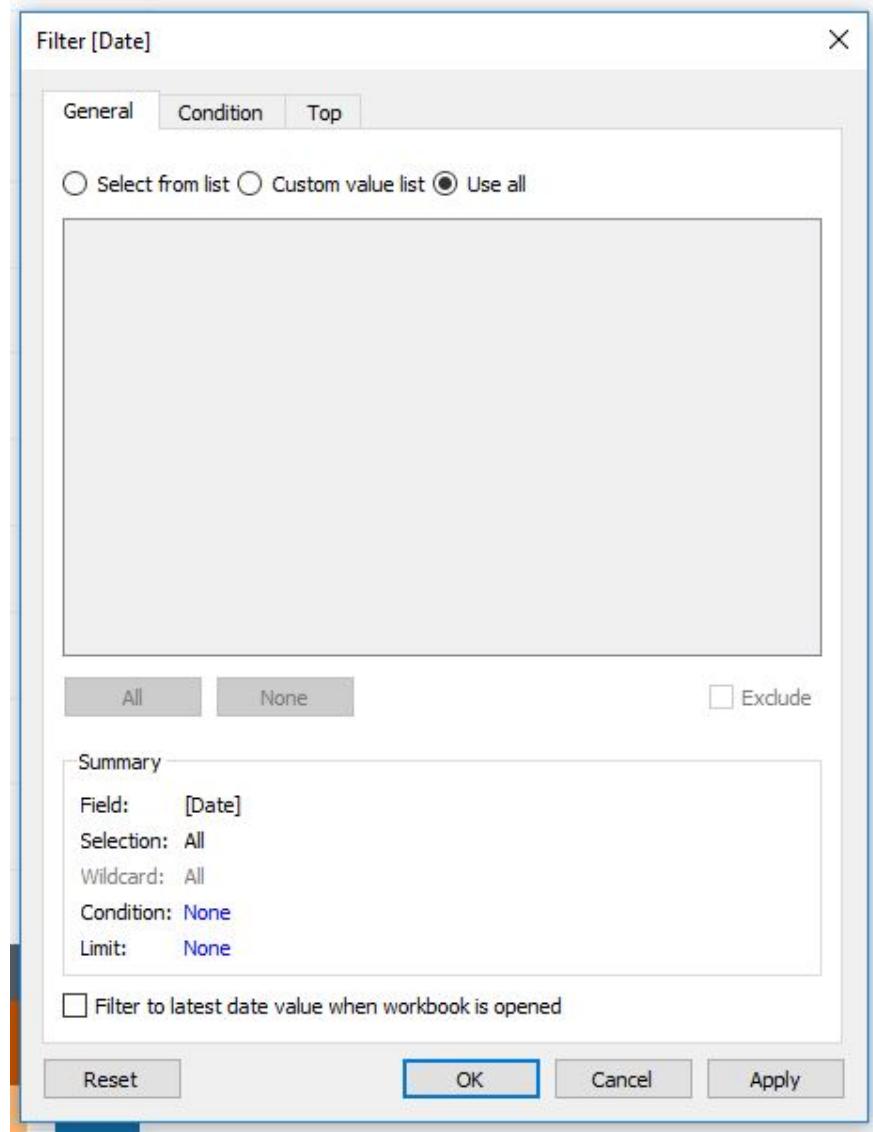


Figure 53. Choosing which dates to use for the filter

4. Now we must select the dropdown on the Date from the "Filters" box and choose "Show Filter".

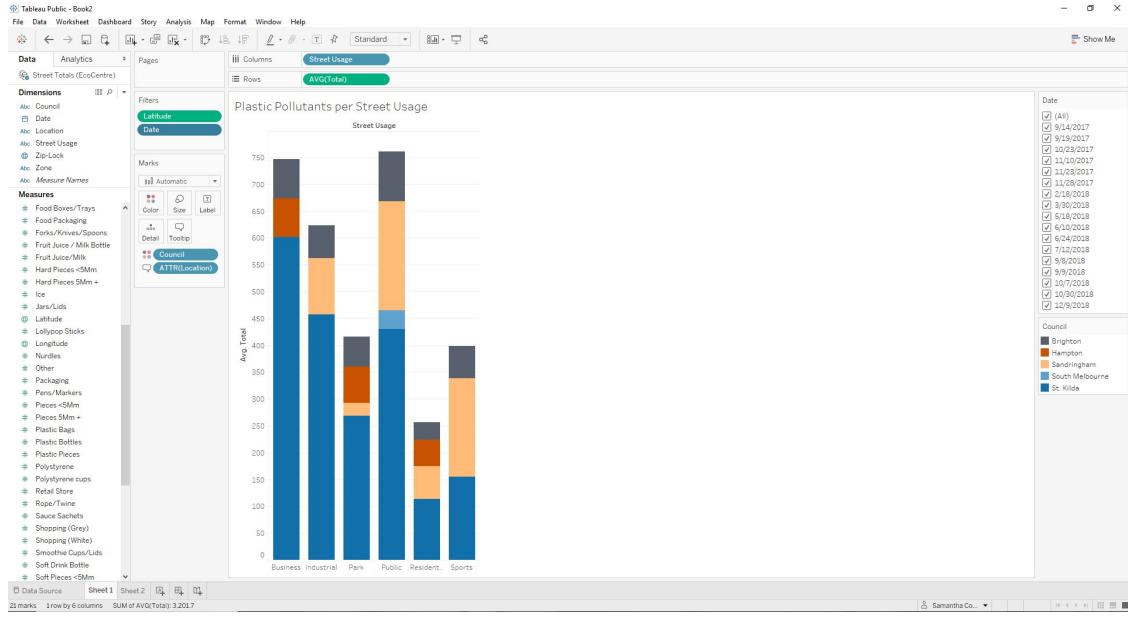


Figure 54. Showing the date filter on the right

5. We can reformat the date selector by choosing the drop down menu on it and reformatting it based on the style you are trying to achieve. Here we chose a slider and also selected “Only Relevant Values” which will filter the available dates based on what is shown in the current visualisation.

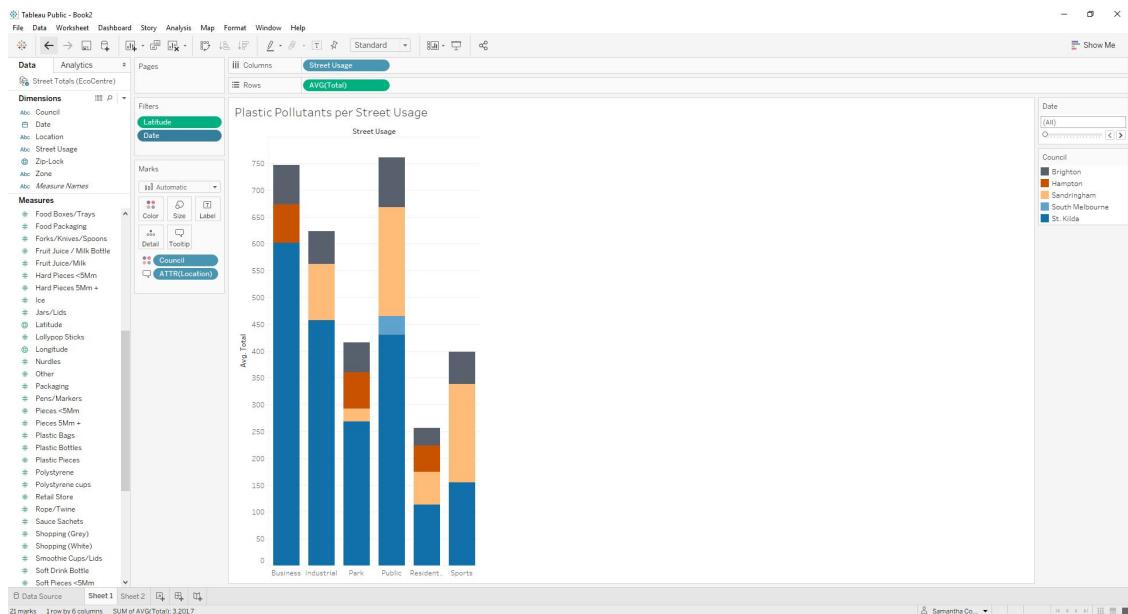
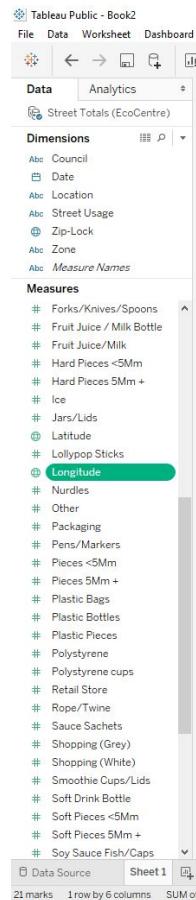


Figure 55. Reformattting the date selector

## Creating a GIS Map

1. Input data that has "Latitude" and "Longitude" columns and ensure that they were input properly. To do this you will need to locate the measures in the "Measures" box on the left of the screen and ensure that they say “Geometric Role -> Latitude” or “Longitude”, depending on the value.



*Figure 56.* Finding values in the "Measures" box

2. Drag the "Longitude" value to the "Row" box and the "Latitude" value to the "Column" box. Then change both of them to “Dimensions” rather than “AVG”s.

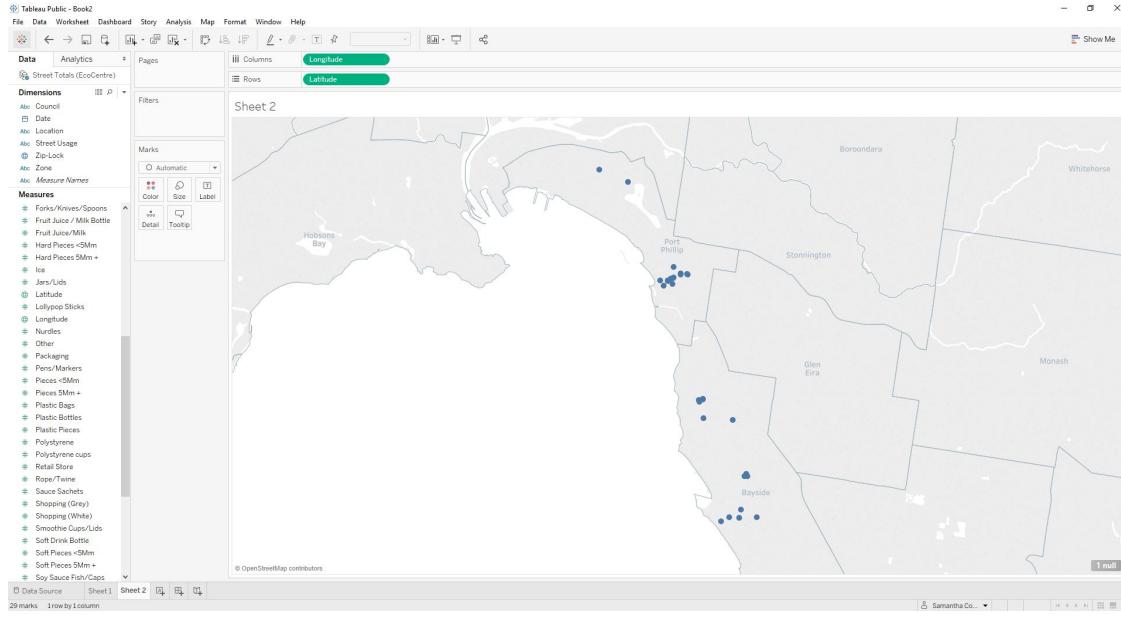


Figure 57. The simple outcome of the GIS map in Tableau

3. To customise the GIS Map, we will make the total represent the size and the street usage represent the color. This is shown below.

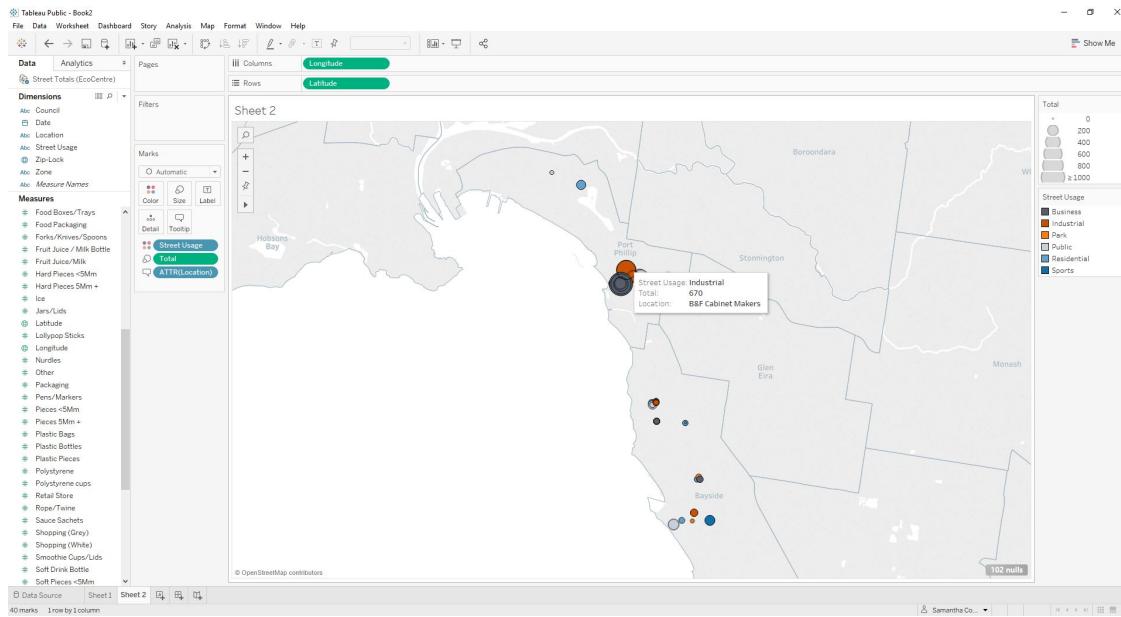
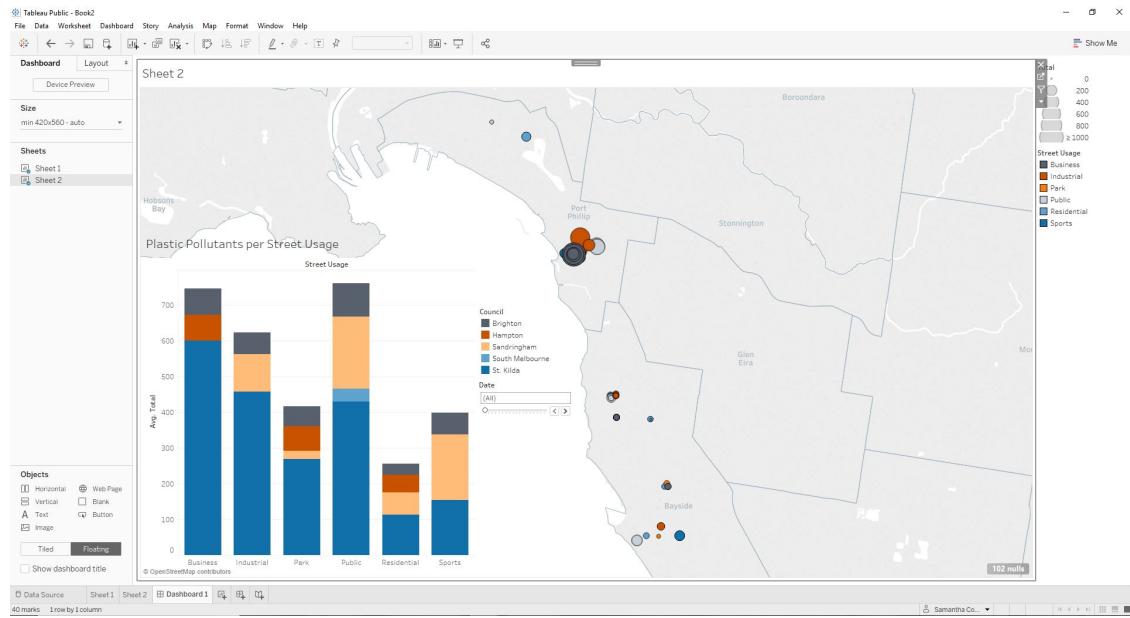


Figure 58. Customising the GIS Map

## Creating a Tableau Dashboard

1. Create a new dashboard by clicking “Dashboard” and “New Dashboard” in the toolbar.
2. Drag the sheets that you want to overlay into the area that says drag sheets here. In this case we will drag “Sheet1”, the bar chart, and “Sheet2”, the GIS Map.



*Figure 59. Combining charts into a dashboard*

Here we dragged the map onto the sheet, then chose “Floating” at the bottom and dragged “Sheet 1” onto it afterwards.

To move things around just select them and move them using the bars that appear on the top.

3. To apply any filters to both of the sheets simply select the filter, choose the drop down menu, "Apply to Worksheets", "Selected Worksheets", and select the worksheets you want the filter to apply to.

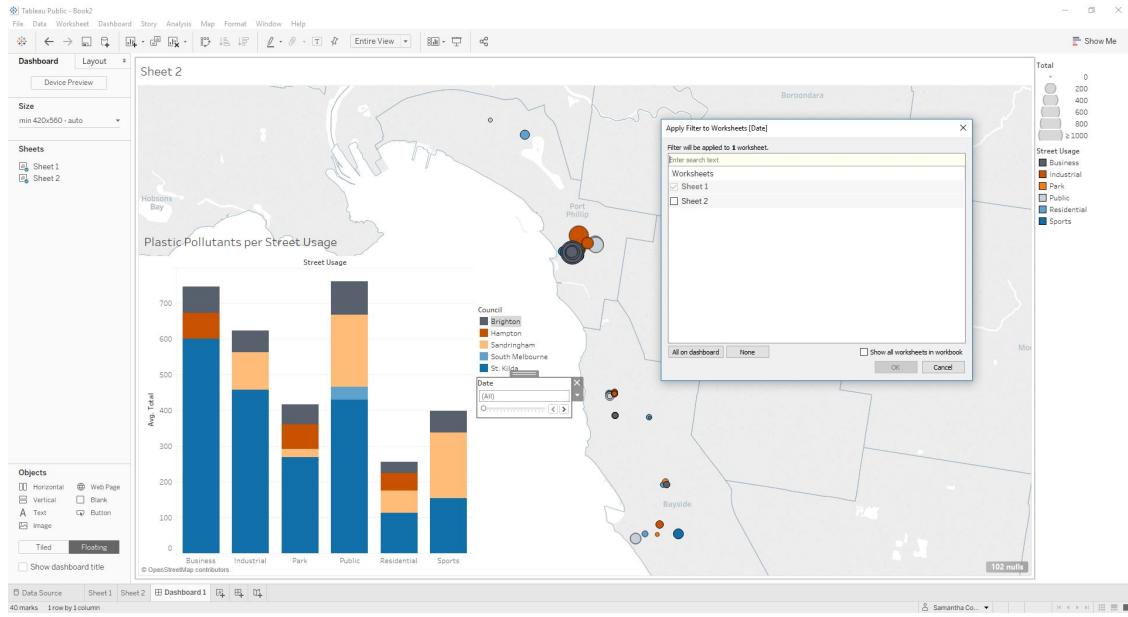


Figure 60. Applying a filter to multiple worksheets in a dashboard

## Creating a Tableau Story

The difference between a story and a dashboard is the ability to add tabs to a story.

In this way the user is not viewing a crowded visualisation.

1. Create a new story by clicking “Story” and “New Story”.
2. Double click or drag sheets/dashboards onto the storyboard and rename the tabs based on what you want the tab for that sheet to be.

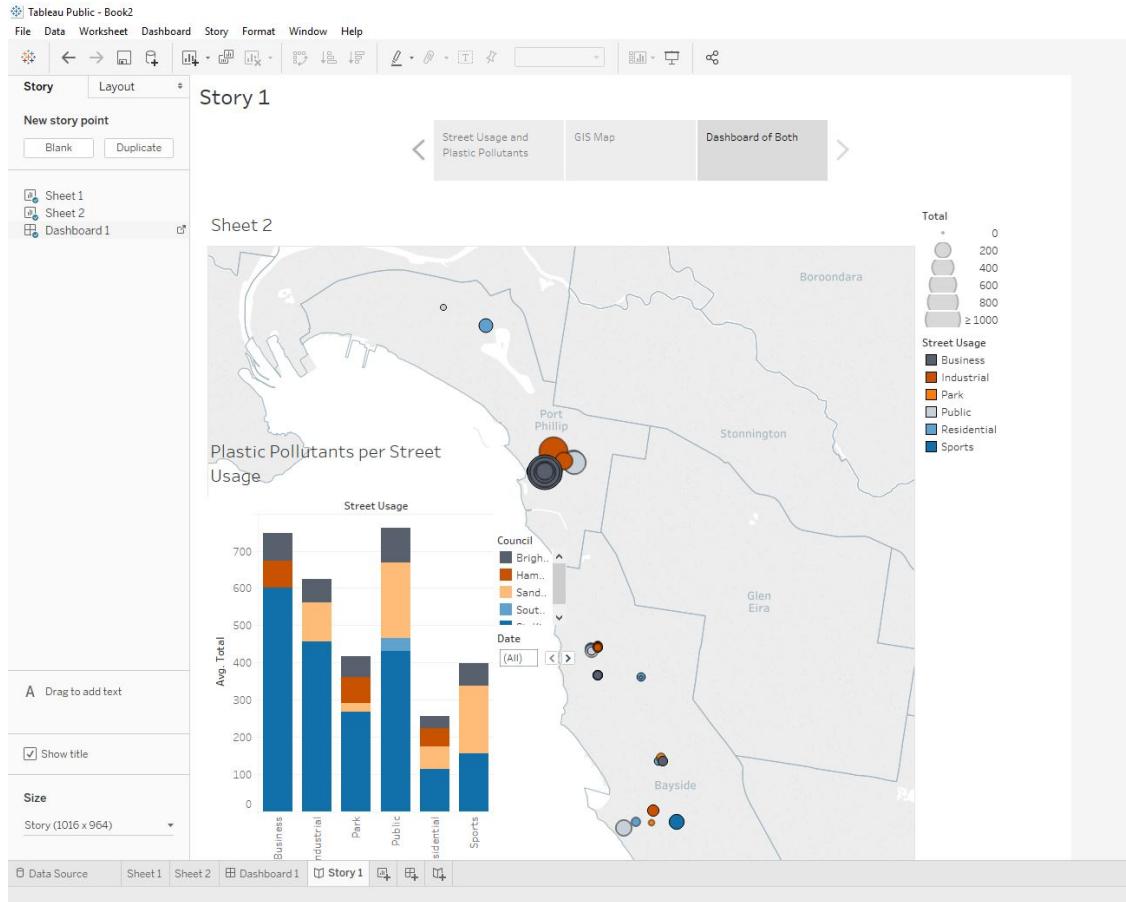


Figure 61. Creating a story with tabs in Tableau

## How to Overlap Data Sources

1. Repeat the steps listed in the *To Input Data* section to input the shape and excel files.
2. We will need to create a data union.

Drag the relevant files to the right.

Click on the union and ensure it is all inclusive and use two of the fields that are relevant to each other creating a "<>" relationship to include everything.

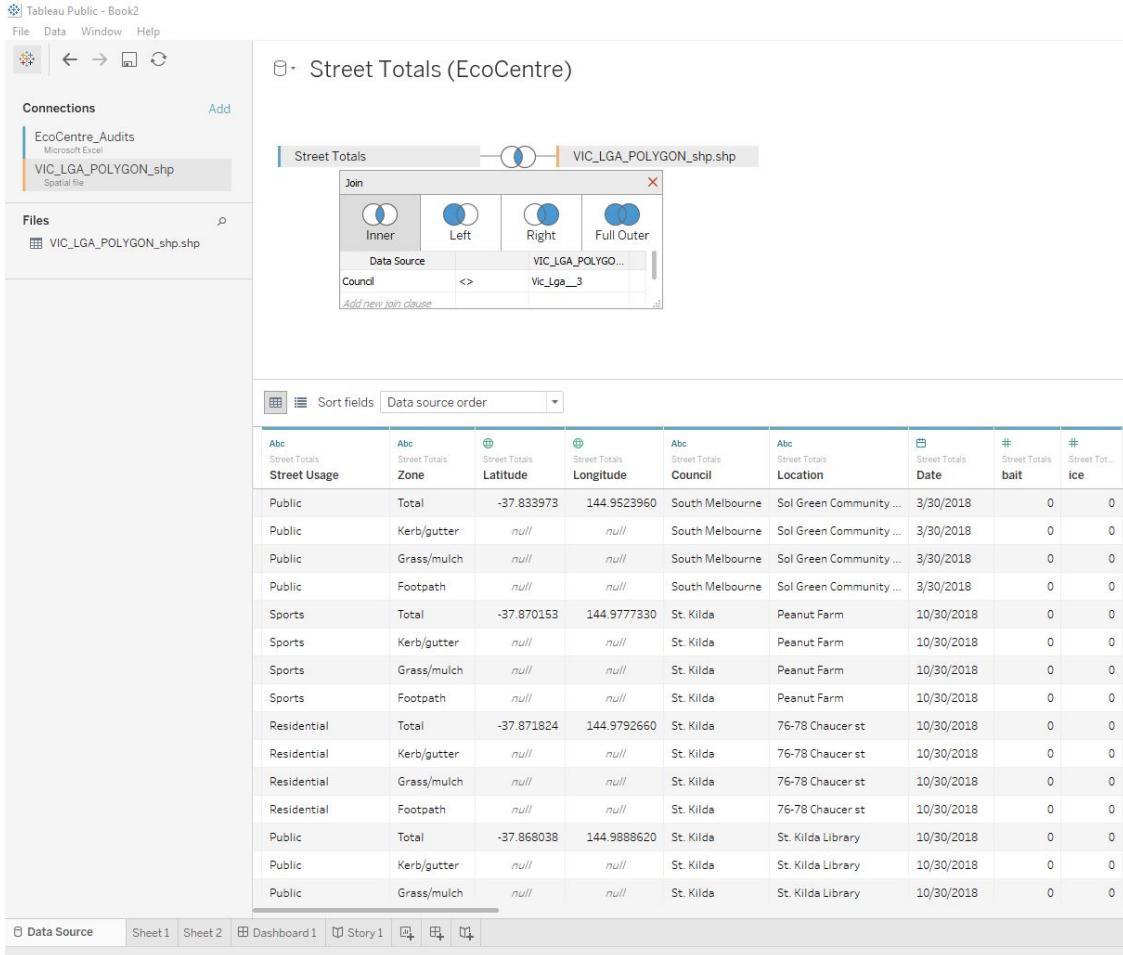
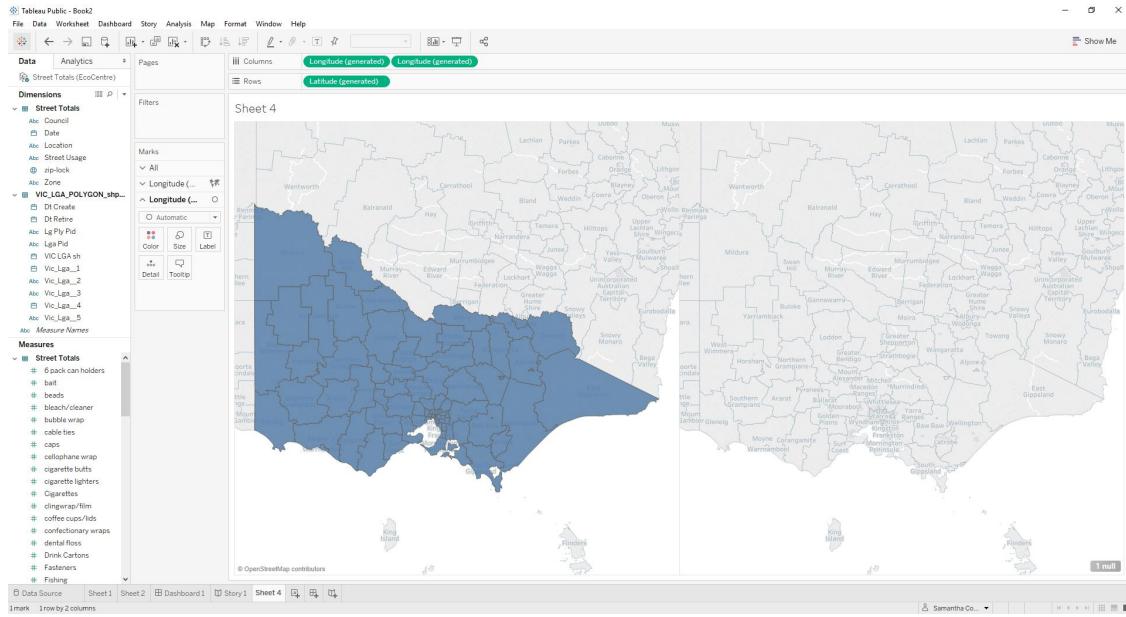


Figure 62. Creating a Union by overlaying shape and excel files

3. In order to overlay a shape file and an excel file, we will begin by creating two maps, side by side.

First, drag the "Latitude (generated)" and "Longitude (generated)" values to the "Column" and "Row" section respectively. We will add the geometry to the chart from the LGA file for Victoria.

Next, to create two charts, hold CTRL and drag the "Longitude (generated)" value so there are two longitude values in the "Column" box.



*Figure 63.* Creating two maps to soon be customised and overlaid

Originally, this had two of the same exact map. To replace those map features with the new features of the beach audits, we remove the label and detail customisation we added by dragging the two selectors away from the "Marks" options.

To add new details for the beach audits, we drag the "Latitude" and "Longitude" values from the "Measures" area to the detail on the second "Longitude(2)" in the "Marks" options. Ensure the longitude and latitude values are dimensions by clicking the drop down and changing it from "AVG()" to "Dimension". Then we can add the "Total (Dimension)" to the "Size" and the "Location" to the "Color" to add more features.

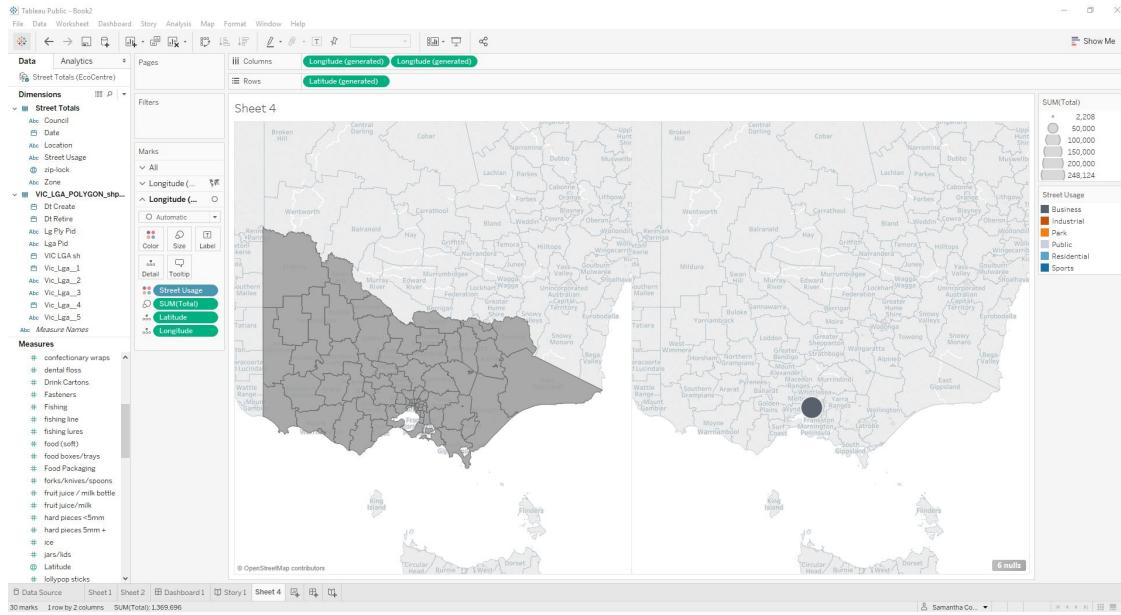


Figure 64. Customising the second map to have the EcoCentre Audit data

- To combine the maps, select the drop down from the "Longitude (2)" in the "Column" tab, and choose "Dual Axis"

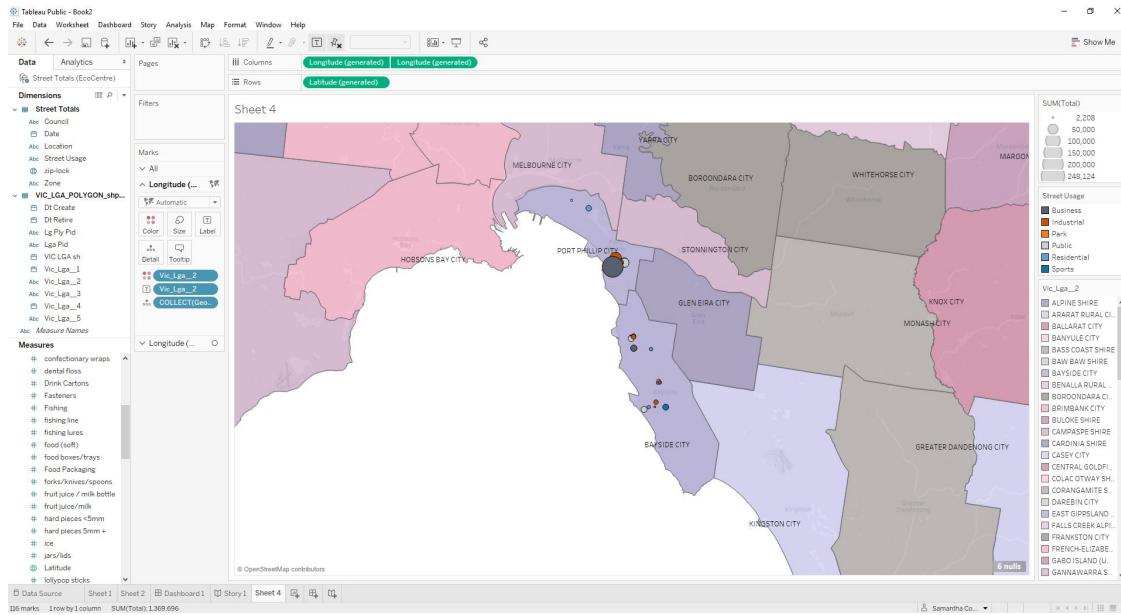


Figure 65. The final overlay of the two datasheets using the union

To access all the examples referenced within this document visit: [https://public.tableau.com/profile/samantha.comeau#!/vizhome/IntroToTableau\\_2/Story](https://public.tableau.com/profile/samantha.comeau#!/vizhome/IntroToTableau_2/Story)

## Editing an Existing Tableau Visualisation

Sometimes, instead of creating a map from scratch you will want to edit an existing map. This is applicable when you want to add new data to a map. To do this, you will need a Tableau Public account and the Tableau Public Application downloaded onto your computer.

1. Find the visualisation you would like to edit online. You will need to download it to your computer using the download workbook button.

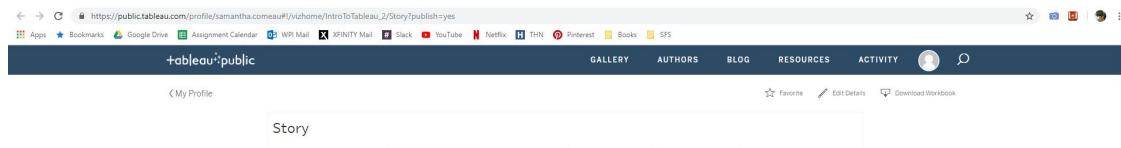


Figure 66. Downloading an existing Tableau workbook off of Public Tableau websites

2. To edit the existing data you will need to go to the "Data Source" tab in the bottom left. To update one of the datasheets, hover over it, select the dropdown and choose "Edit Connection". Then select your updated datasheet.

Business	Footpath	null	null	St. Kilda	7 Eleven	10/11/2017	0	0	0	0
Business	Footpath	null	null	St. Kilda	7 Eleven	10/11/2017	0	0	0	0
Business	Footpath	null	null	St. Kilda	7 Eleven	10/11/2017	0	0	0	0
Business	Footpath	null	null	St. Kilda	7 Eleven	10/11/2017	0	0	0	0
Business	Footpath	null	null	St. Kilda	7 Eleven	10/11/2017	0	0	0	0
Business	Footpath	null	null	St. Kilda	7 Eleven	10/11/2017	0	0	0	0
Business	Footpath	null	null	St. Kilda	7 Eleven	10/11/2017	0	0	0	0
Business	Footpath	null	null	St. Kilda	7 Eleven	10/11/2017	0	0	0	0
Business	Footpath	null	null	St. Kilda	7 Eleven	10/11/2017	0	0	0	0

Figure 67. Modifying data using the drop down that appears when you hover over the datasheet and "Edit Connection"

This should automatically update your spreadsheet and data in the charts, if the new sheet is in the same format as the original sheet.

See the *How to Continue Data Collection* document to make sure your data is in the proper format for the EcoCentre Tableau workbooks.

## Appendix C: How to Continue Data Collection

# How to Continue Data Collection

Cameron Collins, Samantha Comeau, Brendan Gallagher, Gina Visser

15 November 2018

In order to understand trends in plastic pollution, it is important that the EcoCentre is able to add data to the visualisation. The visualisation was created in a GIS mapping software called Tableau and information on how to use Tableau \*\*\*\*\* or edit the current data within a Tableau visualisation can be found in the How to Use Tableau document. In order for the software to understand the data, it must be formatted in a specific way and this document will cover the necessary formatting of street, beach, and river audit data for use in EcoCentre Tableau visualisations.

	A Street Usage	B Zone	C Latitude	D Longitude	E Council	F Street / Business Name	G Date	H Litter	I Be	J Hab store	K Shopping centre	L Shop/lock	M Plastic Bag	N House/Motor	O Drinking bottle	P Food/ice cream	Q Water bottle	R Phone/other	S Cigarette butt	T Cigarette butt	U Sachet/paper wrap	V Plastic bottle	W Glass bottle	X Y	Z Drink Can/box	AA Straw	AB Straw wrap
2	Business	Fernpath	-37.816399	144.990718	St Kilda	7 Heaton	10/11/17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	Business	Grass/mulch	-37.813232	144.990718	St Kilda	7 Heaton	10/11/17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	Business	Kemogutter	-37.813232	144.990718	St Kilda	7 Heaton	10/11/17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	Business	Total	-37.816399	144.990718	St Kilda	7 Heaton	10/11/17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	Industrial	Footpath	-37.817919	144.986119	St Kilda	Car Wash	10/11/17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	Industrial	Grass/mulch	-37.817803	144.986119	St Kilda	Car Wash	10/11/17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	Industrial	Kemogutter	-37.817803	144.986119	St Kilda	Car Wash	10/11/17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	Industrial	Total	-37.817803	144.986119	St Kilda	Car Wash	10/11/17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	Park	Footpath	-37.88945	144.983038	St Kilda	Botanical Gardens, Bessington St	10/11/17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	Park	Grass/mulch	-37.88945	144.983038	St Kilda	Botanical Gardens, Bessington St	10/11/17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	Park	Kemogutter	-37.88945	144.983038	St Kilda	Botanical Gardens, Bessington St	10/11/17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	Park	Total	-37.88945	144.983038	St Kilda	Botanical Gardens, Bessington St	10/11/17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	Public	Footpath	-37.886205	144.989128	St Kilda	Town Hall	10/11/17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	Public	Grass/mulch	-37.886205	144.989128	St Kilda	Town Hall	10/11/17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Figure 68. This shows the first 28 rows of the formatted street litter audit datasheet.

Since GIS tools use the first row as a header for the data below, each of the categories of litter must be a different column with each street audit as a row. In addition to all these fields, the latitude and longitude of each audit location must be recorded since this is how Tableau knows where on the map to place the data points. An example of the different columns that are included in the current datasheet can be seen above. As you can see, the information recorded for each of the audits is stored as headers along the top row. These headers are applicable for the street litter audits only.

For each of the street, beach, and river audits there are different headers that apply. We created a sample spreadsheet for each of the audits. The sample spreadsheet for the street litter audits can be found in Appendix C.1, beach litter audits can be found in Appendix C.2, and river litter audits can be found in Appendix C.3.

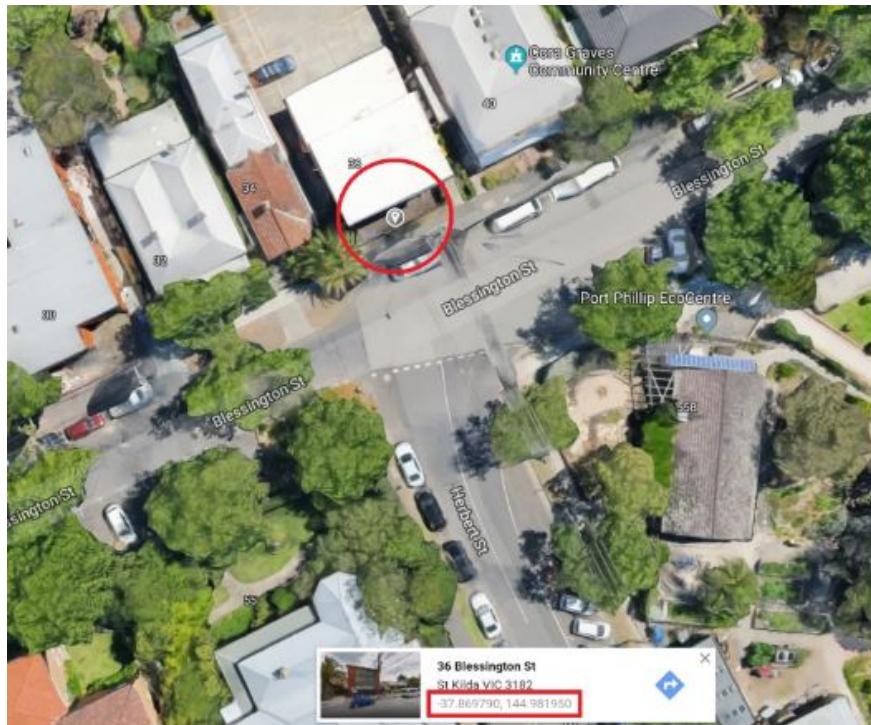
For street litter audits, there are four rows, one for each of the quadrats: footpath, grass / mulch, and kerb / gutter; and one row for the total amounts of the audit. For beach litter audits, there are 13 rows, one for each of the quadrats: narrowest top, narrowest middle, narrowest lower, middle top, middle middle, middle lower, widest top, widest middle and widest lower, and then for the totals of each of the transects and the total total for the entire audit. For a river audit, there is only one row representing the river and the audit data.

The sample sheets attached represent the bare minimum of the columns that must be included for the GI software. More columns could be added before the start of the coloured columns if the auditor chose to store more data. For example, the auditor could add a row after *Date* called *Number of Volunteers* that keeps track of the number of volunteers that completed that audit.

It is important to note that the datasheet has multiple columns shaded grey which denote totals of categories of plastic pollutants. For each audit completed, we needed to keep track of the total for the pollutant category since we thought this was an important statistic. The totals are calculated using an excel or google sheets formula. The formula to calculate the sum of cells is `=sum()` with the cells to include in the parenthesis. This formula was used by typing `=sum(` into the cell that the auditor wanted to store the sum in and then pressing *CTRL+the cell(s)* to include in the sum and finally typing the `)` end parenthesis and hitting enter. An important thing to note is the total at the end of the column for the entire audit at that quadrat is calculated excluding these grey shaded columns. This avoids the data points being added twice to the final total. If the auditor was not feeling inclined to type these formulas, they could copy the four rows that represent

a single audit and paste them at the end of the document and the formulas would transfer.

The visualisation uses latitudes and longitudes to place data points on the basemap. For many of the audit sites that the EcoCentre currently samples, the latitudes and longitudes have already been determined. As the EcoCentre expands the scope of their data collection, it may be necessary for employees or volunteers to determine the latitude and longitude of new audit sites. The existing latitudes and longitudes were determined using Google Maps. If the auditor is recording a previously audited site, they can copy the latitude and longitude values from that audit. In other cases, Google Maps is a free software that can be used to accurately determine the geographic location of buildings. A screenshot from Google Maps is shown below.



*Figure 69.* Google maps screenshot.

To determine the location of the area in question, simply click on the map location. The user's cursor should change to a gray pointer, circled in red above. This shows that the user has selected a position. Google Maps will access information about that position as accurately as possible. The dialog at the bottom will appear, showing an approximate

street address, a picture of the location, and the geographic coordinates of the position. It is these coordinates that will be recorded as the latitude and longitude, respectively. These latitudes and longitudes are displayed to six decimal places, so the results are accurate to a few degrees. This means that the coordinates are accurate enough to distinguish between the footpath, grass/mulch, and kerb/gutter zones. The existing coordinates were obtained by first identifying the approximate center of the property frontage that was audited. The approximate center of these points should be used by looking at the “start landmark” and “end landmark” points written on paper audit sheets. By zooming in as much as possible, the user can distinguish between the three zones.

When no litter items of a particular category were found, a 0 was placed in the respective cell. This is because all the cells must have values in them in order for a GIS software to read the data. If a cell is empty, a GIS software could interpret the value as null, which can affect the creation of graphs. The colors in the spreadsheet above are simply to help the auditor keep track of the category of pollutant they are recording. This way, cells with values as well as total columns, stand out to the human eye. We recommend continuing with this color coordinating to allow the spreadsheet to be more easily read by people who are entering data into it or are doing manual data analysis.

### Appendix C.1: Street Litter Audit Sample Spreadsheet

**Street Usage**

Business	Footpath	Zone	Latitude	Longitude	Council	Date
Business	Grass/mulch				St Kilda	10/11/2017
Business	Kerb/gutter				St Kilda	10/11/2017
Business	Total	-37.870232	144.980776		St Kilda	10/11/2017

**Detail Audit Sheet (Top)**

Item	Count
bait	0
ice	0
retail store	0
shopping (grey)	0
shopping (white)	0
Zip-lock	0
Plastic Bags	0
bleach/cleaner	0
caps	0
soft drink bottle	0
fruit juice / milk bottle	0
water bottle	0
Plastic Bottles	0
cigarette butts	0
cellophane wrap	0
cigarette lighters	0
Cigarettes	0
fruit juice/milk	0
straws	0
Drink Cartons	0
bubble wrap	0
cable ties	0
rope/wire	0
strapping (scrap)	0
strapping (whole)	0
tile spacers	0
Fasteners	0
Fishing line	0
fishing lures	0
Fishing	0
Total	0

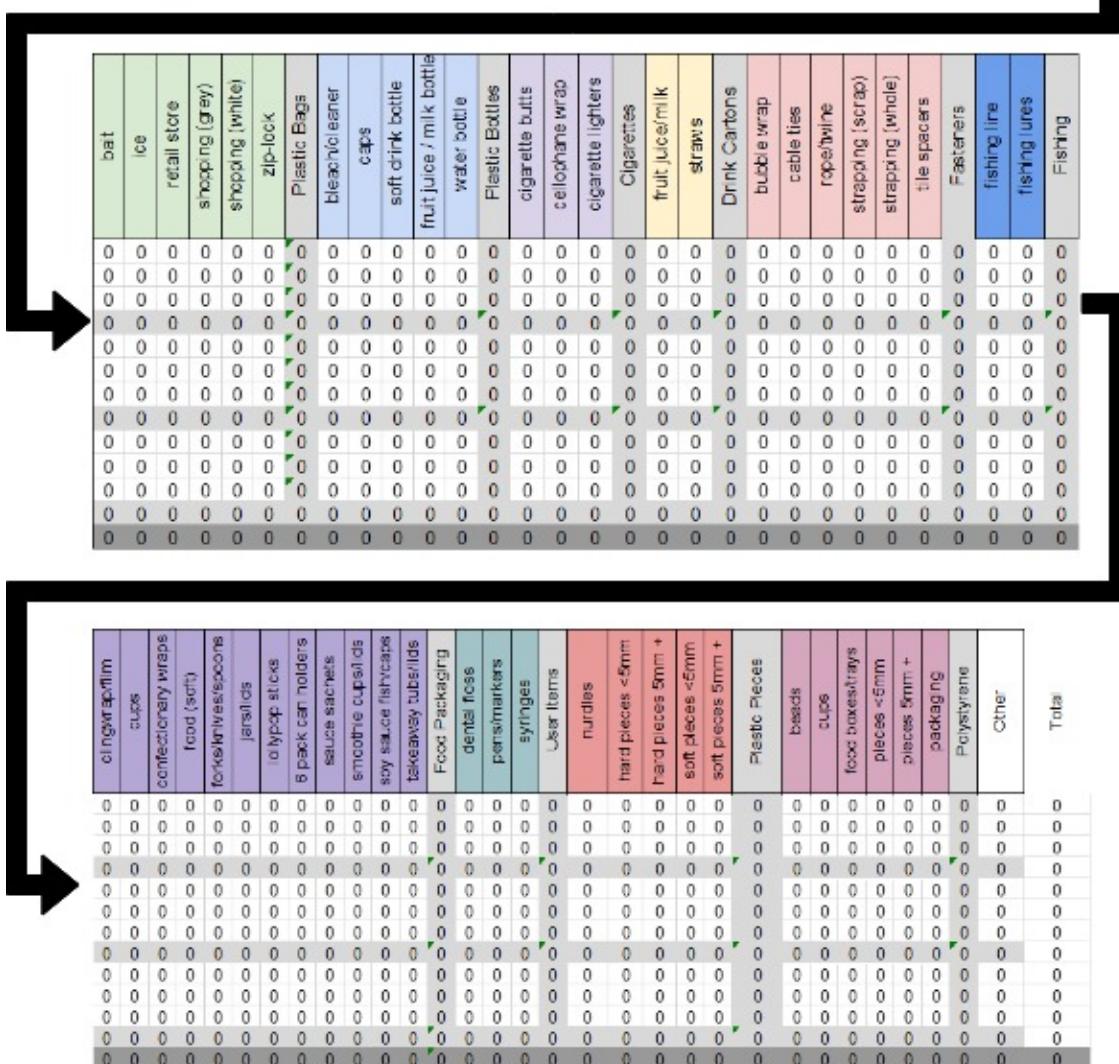
**Detail Audit Sheet (Bottom)**

Item	Count
clingwrap/film	0
coffee cups/lids	0
confectionary wraps	0
food (soft)	0
forks/knives/spoons	0
jars/lids	0
lollipop sticks	0
6 pack can holders	0
sauce sachets	0
smoothie cups/lids	0
soy sauce fish/caps	0
takeaway tubs/lids	0
Food Packaging	0
dental floss	0
pens/markers	0
syringes	0
User Items	0
nurdles	0
hard pieces <5mm	0
hard pieces 5mm +	0
soft pieces <5mm	0
soft pieces 5mm +	0
Plastic Pieces	0
beads	0
Polystyrene cups	0
food boxes/trays	0
pieces <5mm	0
pieces 5mm +	0
packaging	0
Polystyrene	0
other	0
Total	0

Figure 70. Sample Street Audit Spreadsheet

## Appendix C.2: Beach Litter Audit Sample Spreadsheet

Transect	Quadrat	Latitude	Longitude	Location	Date
Narrowest	Top			Eastern Geelong	03/11/2017
Middle	Top			Eastern Geelong	03/11/2017
Widest	Top			Eastern Geelong	03/11/2017
<b>Top Total</b>	<b>Top</b>			Eastern Geelong	03/11/2017
Narrowest	Middle			Eastern Geelong	03/11/2017
Middle	Middle			Eastern Geelong	03/11/2017
Widest	Middle			Eastern Geelong	03/11/2017
<b>Middle Total</b>	<b>Middle</b>			Eastern Geelong	03/11/2017
Narrowest	Lower			Eastern Geelong	03/11/2017
Middle	Lower			Eastern Geelong	03/11/2017
Widest	Lower			Eastern Geelong	03/11/2017
<b>Lower Total</b>	<b>Lower</b>			Eastern Geelong	03/11/2017
<b>Total Total</b>	-38.146563	144.36924		Eastern Geelong	03/11/2017



*Figure 71.* Sample Beach Audit Spreadsheet

### Appendix C.3: River Litter Audit Sample Spreadsheet

**Header Row:**

WATERWAY	SOCK	ID	Date	Season	Start lat	Start long	Finish lat	Finish long	Average lat	Average long
Maribyrnong	Blue	M1	07/01/2015	Summer	-37.81782	144.90614	-37.805803	144.90776	-37.811812	144.90695

**Litter Audit Data:**

Category	Count
Hard <2	36
Hard 2-5	2
Hard 6-10	7
Hard 10+	1
PlasticCaps	0
Hard Plastics	46
Nurdles	2
Poly <4	6
Poly 4+	24
Polystyrene	30
soft plastic <5	0
Soft Plastic 5+	0
Cello <5	0
Cello 5+	0
Soft Plastics	0
Cigarette Butts	0
PlasticStraws	0
Sponge	0
Twine/line	0
Lolly	0
Other Other	0
Other	0
Total	78
Total Micro <5	46
Micro for report	46

Figure 72. Sample River Audit Spreadsheet

## Appendix D: Collection Methods for Street Litter Audits

PORT PHILLIP BAY CATCHMENTS - STREET LITTER AUDIT DATASHEET									
Street address:				Suburb:				Date:	
Street use (circle):	<input checked="" type="radio"/> Business (day & night)			<input type="radio"/> Public building				<input type="radio"/> Industrial	
	<input type="radio"/> Residential			<input type="radio"/> Recreation/sports				<input type="radio"/> Park	
Start landmark:	Finish landmark:								
Audit area (length X width)	Footpath:	m X	m Gutter:	m X	m Grass / mulch areas:	m X	m		
Street direction (compass):				Start time:				Finish time:	
Survey by:				Email/phone:				# Volunteers:	
MATERIAL TYPE	footpath	grass/ mulch	kerb/ gutter	Total	MATERIAL TYPE	footpath	grass/ mulch	kerb/ gutter	Total
<b>PLASTICS</b>					-6 pack can-holders				
<b>BAGS</b>					-sauce sachets				
-bait					-smoothie cups / lids				
-ice					-soy sauce fish / caps				
-retail store					-takeaway tubs / lids				
-shopping (grey)					<b>USER ITEMS</b>				
-shopping (white)					-dental floss				
-zip lock					-pens / markers				
<b>BOTTLES</b>					-syringes				
-bleach/cleaner					<b>PLASTIC PIECES</b>				
-caps					-nurdles				
-fruit juice / milk					-hard pieces <5mm				
-softdrink					-hard pieces 5mm +				
-water					-soft pieces <5mm				
<b>CIGARETTES</b>					-soft pieces 5mm +				
-butts					<b>POLYSTYRENE</b>				
-cellophane wrap					-beads				
-lighters					-cups				
<b>DRINK CARTONS</b>					-food boxes / trays				
-fruit juice / milk					-pieces < 5mm				
-straws					-pieces 5mm +				
<b>FASTENERS</b>					-packaging				
-bubble wrap					<b>GLASS</b>				
-cable ties					-bottles (beer)				
-rope / twine					-bottles (soft drink)				
-strapping (scrap)					-broken pieces				
-strapping (whole)					-jars				
-tile spacers					-wine bottle				
<b>FISHING</b>					<b>METAL</b>				
-line					-aluminium foil				
-lures					-bottle tops/ ring pulls				
<b>FOOD PACKAGING</b>					-cans (aerosol)				
-clingwrap/film					-cans (beer/ spirits)				
-confectionary wraps					-cans (soft drink)				
-coffee cups / lids					<b>RUBBER/ELASTIC</b>				
-food (soft)					-balloons and/or ties				
-forks/knives/spoons					-hair ties				
-jars / lids					-foam rubber pieces				
-lollipop sticks					-rubber bands				
NOTES FOR EACH ZONE - Record any ecologically harmful litter items not listed on datasheet									
footpath	grass/ mulch			kerb/ gutter	litter on road / car park zone				

Figure 73. Street Audit Page 1

**GUIDE TO STREET LITTER AUDITS**

**BEFORE YOU START:** Do Street2Bay Audits Summary Checklist. Have First Aid Kit and gloves on-site. Check entire site to note possible hazards. As this audit involves data collection near roads and car park bays a JOB SAFETY OBSERVER MUST BE APPOINTED to

WARN DATA COLLECTORS OF ANY CAR MOVEMENTS (INCLUDING CAR DOORS OPENING).

Warn all collectors: DON'T PUT YOUR FINGERS WHERE YOU CAN'T SEE THEM! DO NOT COLLECT SYRINGES. Use dustpan for glass. REMAIN ON KERB WHEN COLLECTING FROM GUTTER AREA. DO NOT STAND ON STREET OR IN GUTTER or CAR PARK AREA.

**PURPOSE:** Reference sites on streets are regularly audited to track any increase or decrease of litter items that are known to threaten wildlife and/or human health, or are the subject of ongoing campaigns, eg Container Deposit Legislation. The data will help make a case for legislation, education, infrastructure and enforcement to reduce these items in our waterways.

The data is entered into the Port Phillip Bay Litter Database and the 'Australian Marine Debris Initiative Database'.

Litter is recorded as collected from 3 zones (defined areas for which observations/records are made) located at the footpath, grass and/or mulch beds, and gutter zones of the street frontage to quantify litter from source to the stormwater system.

**EQUIPMENT:** safety checklist, tape measure, dustpan/broom, compass, clip board, datasheet, pen, chalk, gloves, 3 buckets (1 per zone).

**GUIDE TO AUDIT SET-UP**

1. Each audit zone (footpath, gutter and car park) runs the entire length of the property frontage. Permanent landmark structures at the property boundaries serve as the starting point for repeated surveys.
2. Describe the survey start & finish points (at the property boundary) in the 'Start Landmark' and "Finish landmark" fields at top of the datasheet.
3. Measure and record the length between the property boundary landmarks; then the width of each zone.
4. At the start landmark, use a compass to record the direction along the street. Record the direction on the datasheet.
5. Use chalk to mark the ends of the audit area at the property line and gutter.
6. Begin litter data collection in zone 1 (footpath), proceeding to zone 2 (grass and/or mulch beds) and zone 3 (kerb & gutter).

**TIPS ON LITTER COLLECTION**

**TO SAVE TIME:** Divide group into 3 (1 for each zone). Teams collect and put all litter in the bucket for their zone. Counting and data recording should be done after all litter is collected.

Litter in audit area zones is to be collected, recorded, bagged, and responsibly disposed.

*Note: Any litter collected from outside the audit zones is NOT TO BE RECORDED ON THIS DATASHEET.*

Do not record food and paper as they ARE NOT ECOLOGICALLY HARMFUL.

**TIPS ON DATA RECORDING**

**Be sure to complete all details at the top of datasheet!**

Please write clearly! Any errors should be crossed out with an X (not squiggly lines). Record the number of each item in the correct zone column (Footpath, Grass/mulch or Kerb & gutter). Any harmful litter items found that are not on the datasheet can be recorded in NOTES FOR EACH ZONE.

**Take photos of litter collected from each zone and the completed audit sheet and send to: baykeeper@ecocentre.com**  
Questions: Call Neil Blake on 0409 138 565

**More Information:**

Australian Marine Debris Initiative Database	<a href="http://tangaroablue.org/database.htm">http://tangaroablue.org/database.htm</a>
Victorian Litter Action Alliance	<a href="http://www.litter.vic.gov.au/">http://www.litter.vic.gov.au/</a>
CSIRO  Australia	<a href="http://blog.csiro.au/tag/marine-debris">http://blog.csiro.au/tag/marine-debris</a>
Yarra Riverkeeper	<a href="http://www.beachpatrol.com.au/">http://www.beachpatrol.com.au/</a>
Werribee Riverkeeper	<a href="http://www.yarrariver.org.au">http://www.yarrariver.org.au</a>
<a href="http://www.werribeeriver.org.au">http://www.werribeeriver.org.au</a>	

Street to Bay Project sponsored by DEWLP

Figure 74. Street Audit Page 2

## Appendix E: Collection Methods for Beach Litter Audits

PORT PHILLIP BAY CATCHMENTS - BEACH LITTER AUDIT DATASHEET									
Beach name:	Date								
Beach transect:	<b>Widest</b>								
Start landmark:	Transect direction (compass reading)								
Distance from start landmark (top of beach) to last high tide line:	Number of vols:								
Survey by:	Email/phone: Start & Finish times:								
Note: use the blank fields under each MATERIAL TYPE to record harmful items not already listed on the datasheet.									
MATERIAL TYPE	Quadrat 1	Quadrat 2	Quadrat 3	Total	MATERIAL TYPE	Quadrat 1	Quadrat 2	Quadrat 3	Total
<b>Plastics</b>					- smoothy cups / lids				
<b>BAGS</b>					- soy sauce fish / caps				
- bait					-takeaway tubs / lids				
- ice					-takeaway tubs / lids				
- retail store					-takeaway tubs / lids				
- shopping (grey)					<b>USER ITEMS</b>				
- shopping (white)					- dental floss				
- zip lock					- pens / markers				
<b>BOTTLES</b>					- syringes				
- bleach / cleaner					<b>PLASTIC PIECES</b>				
- caps					nurdles				
- fruit juice / milk					pieces - hard <5mm				
- water					pieces - hard 5mm +				
<b>CIGARETTES</b>					pieces - soft <5mm				
- butts					pieces - soft 5mm +				
- cellophane wrap					<b>POLYSTYRENE</b>				
- lighters					beads				
<b>DRINK CARTONS</b>					pieces <5mm				
- fruit juice					pieces 5mm +				
- milk					packaging				
- straws					<b>GLASS</b>				
<b>FASTENERS</b>					- beer bottles / stubbies				
- cable ties					- broken pieces				
- strapping (scrap)					- jars				
- strapping (whole)					- soft drink bottle				
- tile spacers					- wine bottle				
<b>FISHING</b>					<b>METAL</b>				
- line					- aluminium foil				
- lures					- bottle tops				
<b>FOOD PACKAGING</b>					- cans (aerosol)				
- cling wrap / film					- cans (beer / spirits)				
- confectionery wraps					- cans (soft drink)				
- coffee cups / lids					- fish hooks				
- forks, knives, spoons					<b>RUBBER / ELASTIC</b>				
- jars / lids					- balloons & or ties				
- lollipop sticks					- hair bands / ties				
- 6 pack can-holders					-foam rubber pieces				
- sauce sachets									
<b>1. TOP OF BEACH</b>	<b>2. MID BEACH</b>	<b>3. HIGH TIDE</b>			<b>OTHER NOTES</b>				
<i>Has the beach been raked or cleaned in the past 24 hours (tick)</i>					Yes	No	Not sure		

Figure 75. Beach Audit Page 1

PORT PHILLIP BAY CATCHMENTS - BEACH LITTER AUDIT DATASHEET									
Beach name	Date								
Beach transect (tick):	<i>Mid section</i>								
Start landmark	Transect direction (compass reading)								
Distance from start landmark (top of beach) to last high tide line									
Start & Finish times	Number of collectors:								
Survey by	Email/phone								
Note: use the blank fields under each MATERIAL TYPE to record harmful items not already listed on the datasheet.									
MATERIAL TYPE	Quadrat 1	Quadrat 2	Quadrat 3	Total	MATERIAL TYPE	Quadrat 1	Quadrat 2	Quadrat 3	Total
<b>Plastics</b>					- smoothy cups / lids				
<b>BAGS</b>					- soy sauce fish / caps				
- bait					- takeaway tubs / lids				
- ice					-takeaway tubs / lids				
- retail store					-takeaway tubs / lids				
- shopping (grey)					<b>USER ITEMS</b>				
- shopping (white)					- dental floss				
- zip lock					- pens / markers				
<b>BOTTLES</b>					- syringes				
- bleach / cleaner					<b>PLASTIC PIECES</b>				
- caps					nurdles				
- fruit juice / milk					pieces - hard <5mm				
- water					pieces - hard 5mm +				
<b>CIGARETTES</b>					pieces - soft <5mm				
- butts					pieces - soft 5mm +				
- cellophane wrap					<b>POLYSTYRENE</b>				
- lighters					beads				
<b>DRINK CARTONS</b>					pieces <5mm				
- fruit juice					pieces 5mm +				
- milk					packaging				
- straws					<b>GLASS</b>				
<b>FASTENERS</b>					- beer bottles / stubbies				
- cable ties					- broken pieces				
- strapping (scrap)					- jars				
- strapping (whole)					- soft drink bottle				
- tile spacers					- wine bottle				
<b>FISHING</b>					<b>METAL</b>				
- line					- aluminium foil				
- lures					- bottle tops				
<b>FOOD PACKAGING</b>					- cans (aerosol)				
- cling wrap / film					- cans (beer / spirits)				
- confectionery wraps					- cans (soft drink)				
- coffee cups / lids					- fish hooks				
- forks, knives, spoons					<b>RUBBER / ELASTIC</b>				
- jars / lids					- balloons & or ties				
- lollipop sticks					- hair bands / ties				
- 6 pack can-holders					-foam rubber pieces				
- sauce sachets									
<b>1. TOP OF BEACH</b>	<b>2. MID BEACH</b>			<b>3. HIGH TIDE</b>	<b>OTHER NOTES</b>				
Has the beach been raked or cleaned in the past 24 hours (tick)      Yes      No      Not sure									

Figure 76. Beach Audit Page 2

PORT PHILLIP BAY CATCHMENTS BEACH LITTER AUDIT DATASHEET									
<b>Beach name</b>	<b>Date</b>								
<b>Beach transect (tick):</b>	<b>Narrowest</b>								
<b>Start landmark</b>	<b>Transect direction (compass reading)</b>								
<b>Distance from start landmark (top of beach) to last high tide line</b>									
<b>Start &amp; Finish times</b>	<b>Number of collectors:</b>								
<b>Survey by</b>	<b>Email/phone</b>								
<i>Note: use the blank fields under each MATERIAL TYPE to record harmful items not already listed on the datasheet.</i>									
MATERIAL TYPE	Quadrat 1	Quadrat 2	Quadrat 3	Total	MATERIAL TYPE	Quadrat 1	Quadrat 2	Quadrat 3	Total
<b>Plastics</b>					- smoothy cups / lids				
<b>BAGS</b>					- soy sauce fish / caps				
- bait					- takeaway tubs / lids				
- ice					- takeaway tubs / lids				
- retail store					- takeaway tubs / lids				
- shopping (grey)					<b>USER ITEMS</b>				
- shopping (white)					- dental floss				
- zip lock					- pens / markers				
<b>BOTTLES</b>					- syringes				
- bleach / cleaner					<b>PLASTIC PIECES</b>				
- caps					nurdles				
- fruit juice / milk					pieces - hard <5mm				
- water					pieces - hard 5mm +				
<b>CIGARETTES</b>					pieces - soft <5mm				
- butts					pieces - soft 5mm +				
- cellophane wrap					<b>POLYSTYRENE</b>				
- lighters					beads				
<b>DRINK CARTONS</b>					pieces <5mm				
- fruit juice					pieces 5mm +				
- milk					packaging				
- straws					<b>GLASS</b>				
<b>FASTENERS</b>					- beer bottles / stubbies				
- cable ties					- broken pieces				
- strapping (scrap)					- jars				
- strapping (whole)					- soft drink bottle				
- tile spacers					- wine bottle				
<b>FISHING</b>					<b>METAL</b>				
- line					- aluminium foil				
- lures					- bottle tops				
<b>FOOD PACKAGING</b>					- cans (aerosol)				
- cling wrap / film					- cans (beer / spirits)				
- confectionery wraps					- cans (soft drink)				
- coffee cups / lids					- fish hooks				
- forks, knives, spoons					<b>RUBBER / ELASTIC</b>				
- jars / lids					- balloons & or ties				
- lollipop sticks					- hair bands / ties				
- 6 pack can-holders					-foam rubber pieces				
- sauce sachets									
<b>NOTES FOR EACH QUADRAT - Record any plastic items not listed on datasheet</b>									
<b>1. TOP OF BEACH</b>	<b>2. MID BEACH</b>		<b>3. HIGH TIDE</b>		<b>OTHER NOTES</b>				
<i>Has the beach been raked or cleaned in the past 24 hours (tick)</i>				Yes	No	Not sure			

Figure 77. Beach Audit Page 3

**GUIDE TO BEACH LITTER AUDITS**

**BEFORE YOU START:** Have First Aid Kit and gloves on-site. Check entire site to note possible hazards.  
**Warn all collectors: DON'T PUT YOUR FINGERS WHERE YOU CAN'T SEE THEM!**

**PURPOSE:** Reference sites on beaches are regularly audited to track any increase or decrease of litter items that are known to threaten wildlife and/or human health, or are the subject of ongoing campaigns, eg Container Deposit Legislation. The data will help make a case for legislation, education, infrastructure and enforcement to reduce these items in our waterways.

The data is entered into the Port Phillip Bay Litter Database and the 'Australian Marine Debris Initiative Database'. Litter is recorded as collected from 3 transects (lines along which observations/records are made) located at the Widest, Narrowest and Mid sections of the beach to give **representative samples of all conditions** on the beach. Each transect has 3 quadrats (1m x 1m square) located at the top of the beach, the last high tide line, and midway between.

Shoreline graphic and legend by Michael Beasley

**EQUIPMENT:** 50m tape measure, compass, clip board, datasheet, pen, 12 tent pegs, gloves, collection bags or buckets.

**GUIDE TO AUDIT SET-UP**

1. A permanent structure at the top of the beach serves as the starting point for repeated surveys of the 3 transects.
2. Describe the **permanent landmark** at the top of the beach in the "Start landmark" field at top left side of the datasheet.
3. Run the tape measure across the beach towards the closest point on the shoreline to set the transect direction.
4. At the **start landmark**, use a compass to find the transect direction across the beach. Record the direction on the datasheet. Use the same direction for all 3 transects.
5. As you cross the beach look for the last high tide line (usually a trail of seaweed along the beach). Each transect runs from the permanent landmark at the top of the beach to 1m past the last high-tide line.
6. Record the distance from top of beach to last high tide at the top left of the datasheet.
7. Mark the end of the transect with a peg 1m past the last high-tide line.
8. Leave tape measure in place across the beach and insert pegs 0.5m either side of start and end points.
9. Divide the distance from transect start to finish by 2 in order to calculate the location of the middle quadrat.
10. At the top of the beach, place tent pegs to mark each corner of the 1m X 1m square quadrat (litter data collection zone).
11. Begin litter data collection in quadrat 1 (top of the beach), proceeding to quadrat 2 (middle) and quadrat 3 (high-tide line).

**TIPS ON LITTER COLLECTION**

**TO SAVE TIME:** each collector should target a particular item, eg 'cigarette butts' and collect and count 5 of them before telling the Data Recorder as they put the litter into the collection bag.

All litter in audit area quadrats is to be collected, recorded, bagged, and responsibly disposed.

**NOTE:** If any litter is collected from outside of the quadrats please don't record it on this datasheet.

**TIPS ON DATA RECORDING**

A separate datasheet is required for each transect. Be sure to complete all details at the top of datasheet!

Be sure to record the number of items in the correct quadrat column (1,2 or 3).

Blank fields under each **MATERIAL TYPE** column are for recording **harmful litter items** found that are not listed on the sheet.

If you run out of space in a quadrat column for a particular item, write the name of the item in one of the blank fields.

Any additional unlisted items are to be recorded in the appropriate column under **NOTES FOR EACH QUADRAT**.

To save time and space, record items in groups of 5 as they go in the bag.

Put a comma after each entry so it's clear that 5,5 means 10 (not 55).

<b>Send completed audit to:</b>	<b>Any queries? Phone Neil Blake 0409 138 565</b>
Port Phillip Baykeeper Port Phillip EcoCentre 55A Blessington St St Kilda VIC 3182 <a href="mailto:baykeeper@ecocentre.com">baykeeper@ecocentre.com</a> <a href="http://www.bay-keeper.com">www.bay-keeper.com</a>	<b>More information:</b>  Australian Marine Debris Initiative Database <a href="http://www.tangaroablue.org/database.html">http://www.tangaroablue.org/database.html</a> Victorian Litter Action Alliance <a href="http://www.litter.vic.gov.au/">http://www.litter.vic.gov.au/</a> CSIRO <a href="https://blog.csiro.au/tag/marine-debris/">https://blog.csiro.au/tag/marine-debris/</a> Beach Patrol Australia <a href="http://www.beachpatrol.com.au/">http://www.beachpatrol.com.au/</a>

Figure 78. Beach Audit Page 4

## Appendix F: Observations Rubric

Location		
Start Landmark		
End Landmark		
Date		
Orientation of Street		
Street Use Category		
Pollution maintenance	Number of trash cans	
Pollution maintenance	Number of recycling bins	
Effectiveness of pollution maintenance	Number of overflowing trash cans	
Effectiveness of pollution maintenance	Number of overflowing recycling bins	
Summary of Street Litter Audit Trial Datasheet	Zone with the most litter by volume displacement	
Summary of Street Litter Audit Trial Datasheet	Most commonly littered material	
Summary of Street Litter Audit Trial Datasheet	Most common item	
Other noteworthy observations		

### Appendix G: Street Litter Audit - Business

PORT PHILLIP BAY CATCHMENTS - STREET LITTER AUDIT DATASHEET									
Street address: <u>Iddy birdy</u>			Suburb: <u>Public building</u>			Date: <u>30.10.18</u>			
Street use (circle): <u>Business (day &amp; night)</u>			Residential			Industrial			
Start landmark: <u>Lennias Anything</u>			Recreation/sports			Park			
Audit area (length X width)			Footpath: <u>m X m</u>			Gutter: <u>m X m</u>			Grass / mulch areas: <u>m X m</u>
Street direction (compass):			Start time:			Finish time:			
Survey by: <u>NPI + Neil</u>			Email/phone: <u>gr-ecob18@wpi.edu</u>			# Volunteers:			<u>5</u>
MATERIAL TYPE	footpath	grass/ mulch	kerb/ gutter	Total	MATERIAL TYPE	footpath	grass/ mulch	kerb/ gutter	Total
<b>PLASTICS</b>					<b>-6 pack can-holders</b>				
<b>BAGS</b>					<b>-sauce sachets</b>				
-bait					-smoothie cups / lids				
-ice					-soy sauce fish / caps	1	1		
-retail store					-takeaway tubs / lids			1	
-shopping (grey)					<b>USER ITEMS</b>				
-shopping (white)					-dental floss				
-zip lock					-pens / markers				
<b>BOTTLES</b>					<b>-syringes</b>				
-bleach/cleaner					<b>PLASTIC PIECES</b>				
-caps	1				-nurdles				
-fruit juice / milk					-hard pieces <5mm				
-softdrink					-hard pieces 5mm +	4	7	2	
-water					-soft pieces <5mm				
<b>CIGARETTES</b>					<b>-soft pieces 5mm +</b>				
-butts	74	157	88		1	5	2		
-cellophane wrap	2				<b>POLYSTYRENE</b>				
-lighters					-beads	3			
<b>DRINK CARTONS</b>					<b>-cups</b>				
-fruit juice / milk					-food boxes / trays				
-straws					-pieces < 5mm				
<b>FASTENERS</b>					<b>-pieces 5mm +</b>				
-bubble wrap					-packaging				
<b>FISHING</b>					<b>GLASS</b>				
-cable ties	1	1	1		-bottles (beer)				
-rope / twine	2	1	1		-bottles (soft drink)				
-strapping (scrap)					-broken pieces	42	26	*	
-strapping (whole)					-jars				
-tile spacers					-wine bottle				
<b>METAL</b>									
-line					-aluminium foil	1	4	6	
-lures					-bottle tops/ ring pulls		4		
<b>FOOD PACKAGING</b>					<b>-cans (aerosol)</b>				
-clingwrap/film					-cans (beer/ spirits)				
-confectionary wraps	1	11	4		-cans (soft drink)				
-coffee cups / lids	1				<b>RUBBER/ELASTIC</b>				
-food (soft)		8			-balloons and/or ties				
-forks/knives/spoons					-hair ties				
-jars / lids					-foam rubber pieces				
-lollipop sticks					-rubber bands				
<b>NOTES FOR EACH ZONE</b> - Record any ecologically harmful litter items not listed on datasheet									
footpath	grass/ mulch		kerb/ gutter	litter on road / car park zone					
1 orange sucker	1 Rubber-ish thing 1 screw		1 screw 1 nut						

Figure 79. Business Audit

### Appendix H: Observation - Business

Location	Iddy Biddy Bar	
Start Landmark	Lentil as anything	
End Landmark	Corner	
Date	30 October 2018	
Orientation of Street	Business/Retail	
Street Use Category	Lentil as anything to corner	
Pollution maintenance	Number of trash cans	6
Pollution maintenance	Number of recycling bins	2
Effectiveness of pollution maintenance	Number of overflowing trash cans	0
Effectiveness of pollution maintenance	Number of overflowing recycling bins	0
Summary of Street Litter Audit Trial Datasheet	Zone with the most litter by volume displacement	Grass/Mulch
Summary of Street Litter Audit Trial Datasheet	Most commonly littered material	Plastic
Summary of Street Litter Audit Trial Datasheet	Most common item	Cigarette butts
Other noteworthy observations		

## Appendix I: Street Litter Audit - Industry

PORT PHILLIP BAY CATCHMENTS - STREET LITTER AUDIT DATASHEET									
Street address: <b>B&amp;F cabinet makers</b>		Suburb: <b>Public building</b>		Date: <b>30.10.18</b>					
Street use (circle): <input checked="" type="radio"/> Business (day & night) <input type="radio"/> Residential		Recreation/sports		<input checked="" type="radio"/> Industrial <input type="radio"/> Park					
Start landmark: <b>left fence</b>		Finish landmark: <b>right fence</b>							
Audit area (length X width)		Footpath:	m X	m Gutter:	m X m				
Street direction (compass): <b>WPLHNEI</b>				Grass / mulch areas: m X m					
Survey by: <b>gr-ecobis@up.edu</b>				Start time: <b>10:00</b> Finish time: <b>11:00</b>					
Email/phone:				#Volunteers: <b>5</b>					
MATERIAL TYPE	footpath	grass/ mulch	kerb/ gutter	Total	MATERIAL TYPE	footpath	grass/ mulch	kerb/ gutter	Total
<b>PLASTICS</b>					-6 pack can-holders				
<b>BAGS</b>					-sauce sachets				
-bait					-smoothie cups / lids				
-ice					-soy sauce fish / caps				
-retail store					-takeaway tubs / lids				
-shopping (grey)					<b>USER ITEMS</b>				
-shopping (white)					-dental floss				
-zip lock					-pens / markers				
<b>BOTTLES</b>					-syringes				
-bleach/cleaner					<b>PLASTIC PIECES</b>				
-caps					-nurdles				
-fruit juice / milk					-hard pieces <5mm				
-softdrink					-hard pieces 5mm +	<b>167 2</b>			
-water					-soft pieces <5mm				
<b>CIGARETTES</b>					-soft pieces 5mm +	<b>6 2</b>			
-butts	<b>18</b>	<b>49</b>	<b>27</b>		<b>POLYSTYRENE</b>				
-cellophane wrap					-beads	<b>1 548 3</b>			
-lighters					-cups				
<b>DRINK CARTONS</b>					-food boxes / trays				
-fruit juice / milk					-pieces <5mm				
-straws					-pieces 5mm +				
<b>FASTENERS</b>					-packaging				
<b>GLASS</b>									
-bubble wrap					-bottles (beer)				
-cable ties					-bottles (soft drink)				
-rope / twine					-broken pieces	<b>1</b>			
-strapping (scrap)					-jars				
-strapping (whole)					-wine bottle				
-tile spacers									
<b>METAL</b>									
-line					-aluminium foil			<b>2</b>	
-lures					-bottle tops/ ring pulls	<b>1</b>			
<b>FOOD PACKAGING</b>					-cans (aerosol)				
-clingwrap/film					-cans (beer/ spirits)				
-confectionary wraps	<b>1</b>				-cans (soft drink)				
-coffee cups / lids					<b>RUBBER/ELASTIC</b>				
-food (soft)					-balloons and/or ties				
-forks/knives/spoons					-hair ties				
-jars / lids					-foam rubber pieces				
-lollipop sticks					-rubber bands				
NOTES FOR EACH ZONE - Record any ecologically harmful litter items not listed on datasheet									
footpath	grass/ mulch		kerb/ gutter	litter on road / car park zone					
<b>battery</b>	<b>1 tea bag</b>	<b>1 bracelet</b>	<b>25 screws</b>	<b>1 random wire metal</b>					

Figure 80. Industrial Audit

### Appendix J: Observation - Industry

Location	B&F Cabinet Makers	
Start Landmark	Fence on left	
End Landmark	Right fence	
Date	30 October 2018	
Orientation of Street	Unknown	
Street Use Category	Industrial	
Pollution maintenance	Number of trash cans	5
Pollution maintenance	Number of recycling bins	0
Effectiveness of pollution maintenance	Number of overflowing trash cans	1
Effectiveness of pollution maintenance	Number of overflowing recycling bins	0
Summary of Street Litter Audit Trial Datasheet	Zone with the most litter by volume displacement	Grass/Mulch
Summary of Street Litter Audit Trial Datasheet	Most commonly littered material	Polystyrene
Summary of Street Litter Audit Trial Datasheet	Most common item	Polystyrene Beads
Other noteworthy observations		

## Appendix K: Street Litter Audit - Park

PORT PHILLIP BAY CATCHMENTS - STREET LITTER AUDIT DATASHEET									
Street address:		Suburb:		Date:					
Street use (circle):		Public building		30-10-18					
Residential		Recreation/sports		Industrial					
Start landmark: corner		Finish landmark: gate		Park					
Audit area (length X width)		Footpath:	m X	m Gutter:	m X	Grass / mulch areas:	m X	m	
Street direction (compass):		Start time:		Finish time:					
Survey by: NPI-Mel		Email/phone: gr-eccb15@upi.edu		# Volunteers:		5			
MATERIAL TYPE	footpath	grass/ mulch	kerb/ gutter	Total	MATERIAL TYPE	footpath	grass/ mulch	kerb/ gutter	Total
<b>PLASTICS</b>				-6 pack can-holders					
<b>BAGS</b>				-sauce sachets					
-bait				-smoothie cups / lids					
-ice				-soy sauce fish / caps		1			
-retail store				-takeaway tubs / lids					
-shopping (grey)				<b>USER ITEMS</b>					
-shopping (white)				-dental floss					
-zip lock				-pens / markers					
<b>BOTTLES</b>				-syringes					
-bleach/cleaner				<b>PLASTIC PIECES</b>					
-caps	1			-nurdles					
-fruit juice / milk				-hard pieces <5mm					
-softdrink				-hard pieces 5mm +	2	14	3		
-water	1			-soft pieces <5mm					
<b>CIGARETTES</b>				-soft pieces 5mm +	5	6	2		
-butts	28	106	43	<b>POLYSTYRENE</b>					
-cellophane wrap				-beads					
-lighters				-cups					
<b>DRINK CARTONS</b>				-food boxes / trays					
-fruit juice / milk				-pieces < 5mm					
-straws			2	-pieces 5mm +					
<b>FASTENERS</b>				-packaging					
-bubble wrap				<b>GLASS</b>					
-cable ties				-bottles (beer)					
-rope / twine				-bottles (soft drink)					
-strapping (scrap)				-broken pieces		16	400		
-strapping (whole)				-jars					
-tile spacers				-wine bottle					
<b>FISHING</b>				<b>METAL</b>					
-line				-aluminium foil	2	7	3		
-lures				-bottle tops/ ring pulls	1	2	3		
<b>FOOD PACKAGING</b>				-cans (aerosol)					
-clingwrap/film				-cans (beer/ spirits)					
-confectionary wraps	19			-cans (soft drink)			2		
-coffee cups / lids	1	1	1	<b>RUBBER/ELASTIC</b>					
-food (soft)	1	1	14	-balloons and/or ties					
-forks/knives/spoons			1	-hair ties					
-jars / lids				-foam rubber pieces					
-lollipop sticks				-rubber bands					
<b>NOTES FOR EACH ZONE</b> - Record any ecologically harmful litter items not listed on datasheet									
footpath	grass/ mulch		kerb/ gutter	litter on road / car park zone					
1 lysol wipe	1 metal rod	2 condom wrapper							
	1 screw	1 condom							
	2 washers	1 screw							
	1 fridge magnet/ pin	1 felt							
		1?							
		1 hair clip							
	3 metal wires	4 lysol wires							

Figure 81. Park Audit

### Appendix L: Observation - Park

Location	St. Kilda Botanical Gardens	
Start Landmark	Corner	
End Landmark	Gate	
Date	30 October 2018	
Orientation of Street	Park	
Street Use Category	Gate to corner	
Pollution maintenance	Number of trash cans	1
Pollution maintenance	Number of recycling bins	2
Effectiveness of pollution maintenance	Number of overflowing trash cans	0
Effectiveness of pollution maintenance	Number of overflowing recycling bins	0
Summary of Street Litter Audit Trial Datasheet	Zone with the most litter by volume displacement	Kerb/Gutter
Summary of Street Litter Audit Trial Datasheet	Most commonly littered material	Glass
Summary of Street Litter Audit Trial Datasheet	Most common item	Broken Glass Pieces
Other noteworthy observations		

## Appendix M: Street Litter Audit - Public

PORT PHILLIP BAY CATCHMENTS - STREET LITTER AUDIT DATASHEET									
Street address: <b>Library</b>			Suburb: <b>Public building</b>			Date: <b>30.10.18</b>			
Street use (circle): <b>Business (day &amp; night)</b>			Residential			Industrial			
Start landmark: <b>Genovese corner</b>			Recreation/sports			Park			
Audit area (length X width)			Footpath:	<b>m X</b>	Gutter:	<b>m X</b>	Grass / mulch areas:	<b>m X</b>	m
Street direction (compass):			Start time:	Finish time:					
Survey by: <b>WP1 + Neill</b>			Email/phone: <b>gr-e-wobbs@upi.edu</b>	# Volunteers: <b>5</b>					
MATERIAL TYPE	footpath	grass/ mulch	kerb/ gutter	Total	MATERIAL TYPE	footpath	grass/ mulch	kerb/ gutter	Total
<b>PLASTICS</b>					-6 pack can-holders				
<b>BAGS</b>					-sauce sachets				
-bait					-smoothie cups / lids				
-ice					-soy sauce fish / caps	<b>1</b>	<b>1</b>		
-retail store					-takeaway tubs / lids				
-shopping (grey)					<b>USER ITEMS</b>				
-shopping (white)					-dental floss				
-zip lock					-pens / markers				
<b>BOTTLES</b>					-syringes				
-bleach/cleaner					<b>PLASTIC PIECES</b>				
-caps		<b>1</b>			-nurdles				
-fruit juice / milk					-hard pieces <5mm				
-softdrink	<b>1</b>				-hard pieces 5mm +	<b>3</b>	<b>6</b>	<b>3</b>	
-water					-soft pieces <5mm				
<b>CIGARETTES</b>					-soft pieces 5mm +	<b>1</b>	<b>24</b>	<b>3</b>	
-butts	<b>112</b>	<b>220</b>	<b>29</b>		<b>POLYSTYRENE</b>				
-cellophane wrap		<b>1</b>			-beads	<b>1</b>	<b>1</b>		
-lighters					-cups				
<b>DRINK CARTONS</b>					-food boxes / trays				
-fruit juice / milk					-pieces < 5mm				
-straws					-pieces 5mm +				
<b>FASTENERS</b>					-packaging				
-bubble wrap					<b>GLASS</b>				
-cable ties					-bottles (beer)				
-rope / twine					-bottles (soft drink)				
-strapping (scrap)					-broken pieces	<b>8</b>	<b>20</b>		
-strapping (whole)					-jars				
-tile spacers		<b>5</b>			-wine bottle				
<b>FISHING</b>					<b>METAL</b>				
-line					-aluminium foil		<b>1</b>		
-lures					-bottle tops/ ring pulls	<b>1</b>	<b>189</b>	<b>1</b>	
<b>FOOD PACKAGING</b>					-cans (aerosol)				
-clingwrap/film					-cans (beer/ spirits)				
-confectionary wraps	<b>1</b>	<b>8</b>			-cans (soft drink)				
-coffee cups / lids					<b>RUBBER/ELASTIC</b>				
-food (soft)	<b>82</b>	<b>3</b>			-balloons and/or ties				
-forks/knives/spoons					-hair ties				
-jars / lids					-foam rubber pieces		<b>1</b>		
-lollipop sticks					-rubber bands	<b>2</b>			
<b>NOTES FOR EACH ZONE</b> - Record any ecologically harmful litter items not listed on datasheet									
footpath	grass / mulch			kerb / gutter	litter on road / car park zone				
2 stickers 2 washers	ashtrays clothing tag Scout poster			1 tape					

Figure 82. Public Audit

### Appendix N: Observation - Public

Location	St. Kilda Library	
Start Landmark	Genovese corner	
End Landmark	Public library brown sign	
Date	30 October 2018	
Orientation of Street	Public	
Street Use Category	Probably, corner to sign	
Pollution maintenance	Number of trash cans	0
Pollution maintenance	Number of recycling bins	0
Effectiveness of pollution maintenance	Number of overflowing trash cans	0
Effectiveness of pollution maintenance	Number of overflowing recycling bins	0
Summary of Street Litter Audit Trial Datasheet	Zone with the most litter by volume displacement	Grass/Mulch
Summary of Street Litter Audit Trial Datasheet	Most commonly littered material	Plastic
Summary of Street Litter Audit Trial Datasheet	Most common item	Cigarette butts
Other noteworthy observations	Stuff caught in cracks a lot/underneath benches and out of the way	

## Appendix O: Street Litter Audit - Residential

PORT PHILLIP BAY CATCHMENTS - STREET LITTER AUDIT DATASHEET									
Street address: <b>Chaucer</b>			Suburb: <b>Public building</b>			Date: <b>30.10.18</b>			
Street use (circle): <b>Business (day &amp; night)</b> <input checked="" type="radio"/> Residential			Recreation/sports			Industrial Park			
Start landmark: <b>76</b>		Finish landmark: <b>78</b>							
Audit area (length X width)		Footpath: <b>m X m</b>		Gutter: <b>m X m</b>		Grass / mulch areas: <b>m X m</b>			
Street direction (compass):		Start time:		Finish time:					
Survey by: <b>(WPHN)11</b>		Email/phone: <b>gr-e-wub@wpn.org.au</b>						Volunteers: <b>5</b>	
MATERIAL TYPE	footpath	grass/ mulch	kerb/ gutter	Total	MATERIAL TYPE	footpath	grass/ mulch	kerb/ gutter	Total
<b>PLASTICS</b>					-6 pack can-holders				
<b>BAGS</b>					-sauce sachets				
-bait					-smoothie cups / lids				
-ice					-soy sauce fish / caps				
-retail store					-takeaway tubs / lids				
-shopping (grey)					<b>USER ITEMS</b>				
-shopping (white)					-dental floss				
-zip lock					-pens / markers				
<b>BOTTLES</b>					-syringes				
-bleach/cleaner					<b>PLASTIC PIECES</b>				
-caps					-nurdles				
-fruit juice / milk					-hard pieces <5mm				
-softdrink			<b>1</b>		-hard pieces 5mm +				<b>2</b>
-water					-soft pieces <5mm				
<b>CIGARETTES</b>					-soft pieces 5mm +				<b>32</b>
-butts	<b>2</b>	<b>3</b>	<b>8</b>		<b>POLYSTYRENE</b>				
-cellophane wrap			<b>1</b>		-beads				
-lighters					-cups				
<b>DRINK CARTONS</b>					-food boxes / trays				
-fruit juice / milk					-pieces <5mm				
-straws					-pieces 5mm +				
<b>FASTENERS</b>					-packaging				
-bubble wrap					<b>GLASS</b>				
-cable ties					-bottles (beer)				
-rope / twine	<b>1</b>		<b>1</b>		-bottles (soft drink)				
-strapping (scrap)					-broken pieces				<b>29</b>
-strapping (whole)					-jars				
-tile spacers					-wine bottle				
<b>FISHING</b>					<b>METAL</b>				
-line					-aluminium foil	<b>1</b>		<b>1</b>	
-lures					-bottle tops/ ring pulls		<b>1</b>	<b>1</b>	
<b>FOOD PACKAGING</b>					-cans (aerosol)				
-clingwrap/film					-cans (beer/ spirits)				
-confectionary wraps	<b>2</b>		<b>3</b>		-cans (soft drink)				
-coffee cups / lids					<b>RUBBER/ELASTIC</b>				
-food (soft)			<b>1</b>		-balloons and/or ties				
-forks/knives/spoons					-hair ties				
-jars / lids					-foam rubber pieces	<b>9</b>			
-lollipop sticks					-rubber bands				
<b>NOTES FOR EACH ZONE</b> - Record any ecologically harmful litter items not listed on datasheet									
footpath	grass/ mulch		kerb/ gutter		litter on road / car park zone				
	<b>1 nail metal</b>		<b>1 mylar wrap</b>						

Figure 83. Residential Audit

### Appendix P: Observation - Residential

Location	Chaucer St	
Start Landmark	Tree 76	
End Landmark	78	
Date	30 October 2018	
Orientation of Street	Residential	
Street Use Category	Unknown	
Pollution maintenance	Number of trash cans	0
Pollution maintenance	Number of recycling bins	0
Effectiveness of pollution maintenance	Number of overflowing trash cans	0
Effectiveness of pollution maintenance	Number of overflowing recycling bins	0
Summary of Street Litter Audit Trial Datasheet	Zone with the most litter by volume displacement	Grass/Mulch
Summary of Street Litter Audit Trial Datasheet	Most commonly littered material	Glass
Summary of Street Litter Audit Trial Datasheet	Most common item	Broken Glass Pieces
Other noteworthy observations		

### Appendix Q: Street Litter Audit - Sport

PORT PHILLIP BAY CATCHMENTS - STREET LITTER AUDIT DATASHEET									
Street address:	Peanut farm			Suburb:	Date: 30.10.18				
Street use (circle):	<input checked="" type="radio"/> Business (day & night)			<input type="radio"/> Public building	<input type="radio"/> Industrial				
	<input type="radio"/> Residential			<input checked="" type="radio"/> Recreation/sports	<input type="radio"/> Park				
Start landmark:	meter			Finish landmark:	meter				
Audit area (length X width)	Footpath:	m X	m Gutter:	m X	m Grass / mulch areas:	m X	m		
Street direction (compass):			Start time:		Finish time:				
Survey by:	NP1 + Neil			Email/phone:	36ecub18@wp1.net				
# Volunteers:	5								
MATERIAL TYPE	footpath	grass/ mulch	kerb/ gutter	Total	MATERIAL TYPE	footpath	grass/ mulch	kerb/ gutter	Total
<b>PLASTICS</b>					-6 pack can-holders				
<b>BAGS</b>					-sauce sachets				
-bait					-smoothie cups / lids				
-ice					-soy sauce fish / caps				
-retail store					-takeaway tubs / lids				
-shopping (grey)					<b>USER ITEMS</b>				
-shopping (white)					-dental floss				
-zip lock					-pens / markers				
<b>BOTTLES</b>					-syringes				
-bleach/cleaner					<b>PLASTIC PIECES</b>				
-caps			1		-nurdles				
-fruit juice / milk					-hard pieces <5mm				
-softdrink					-hard pieces 5mm +	5	12	14	
-water					-soft pieces <5mm				
<b>CIGARETTES</b>					-soft pieces 5mm +		4	2	
-butts	2	26	69		<b>POLYSTYRENE</b>				
-cellophane wrap			1		-beads			5	
-lighters					-cups				
<b>DRINK CARTONS</b>					-food boxes / trays				
-fruit juice / milk					-pieces < 5mm				
-straws			1		-pieces 5mm +				
<b>FASTENERS</b>					-packaging				
-bubble wrap					<b>GLASS</b>				
-cable ties		3			-bottles (beer)				
-rope / twine			1		-bottles (soft drink)				
-strapping (scrap)					-broken pieces		12	3	
-strapping (whole)					-jars				
-tile spacers					-wine bottle				
<b>FISHING</b>					<b>METAL</b>				
-line					-aluminium foil		2	1	
-lures					-bottle tops/ ring pulls	4			
<b>FOOD PACKAGING</b>					-cans (aerosol)				
-clingwrap/film					-cans (beer/ spirits)		1		
-confectionary wraps	2	2			-cans (soft drink)				
-coffee cups / lids					<b>RUBBER/ELASTIC</b>				
-food (soft)	1	1	2		-balloons and/or ties				
-forks/knives/spoons			1		-hair ties		1	1	
-jars / lids					-foam rubber pieces		2	1	
-lollipop sticks					-rubber bands				
NOTES FOR EACH ZONE - Record any ecologically harmful litter items not listed on datasheet									
footpath	grass / mulch			kerb/ gutter	litter on road / car park zone				
4 screws	1 wire 1 screw tip plastic 2 receipts 1 stake, metal			1 tile 4 metal randoms					

Figure 84. Sport Audit

### Appendix R: Observation - Sport

Location	Peanut Farm	
Start Landmark	Parking meter entrance	
End Landmark	Parking meter 5th tree	
Date	30 October 2018	
Orientation of Street	Recreation/Sports	
Street Use Category	Unknown	
Pollution maintenance	Number of trash cans	2
Pollution maintenance	Number of recycling bins	0
Effectiveness of pollution maintenance	Number of overflowing trash cans	0
Effectiveness of pollution maintenance	Number of overflowing recycling bins	0
Summary of Street Litter Audit Trial Datasheet	Zone with the most litter by volume displacement	Kerb/Gutter
Summary of Street Litter Audit Trial Datasheet	Most commonly littered material	Plastic
Summary of Street Litter Audit Trial Datasheet	Most common item	Cigarette butts
Other noteworthy observations		

## Appendix S: Interview Statement of Consent

Investigators: Cameron Collins, Samantha Comeau, Brendan Gallagher, Gina Visser

Contact Information: gr-ecoB18@wpi.edu

Title of Research Study: Using Data Visualisation to Identify the Sources of Plastic Pollution in Port Phillip Bay

Sponsor: Port Phillip EcoCentre

- I agree to participate in an interview at \_\_\_\_\_ on \_\_\_\_\_ date about plastic pollution in Port Phillip Bay.
- I understand that this interview is expected to take less than an hour.
- I understand that this interview is part of a research project that is exploring the sources of plastic pollution in the Port Phillip Bay and the causes for fluctuating levels of plastic pollution.
- I understand that I am under no obligation to participate and that I may leave at any time. I understand that my participations (or decision not to participate) in this interview will in no way affect my standing with the Port Phillip EcoCentre.
- I understand that this research is expected to bring no harm to me and that it also will be of no substantial benefit to me personally.
- I understand that the findings from the interview will be published but will not identify me, personally, in any way unless I give consent and that efforts will be made to present findings in ways that will not permit a reader to identify the particular source of any information.
- I agree to have all proceedings \_\_\_\_\_ typed or \_\_\_\_\_ recorded. I understand that all members of the project team (including faculty advisors) from Worcester Polytechnic

Institute will have access to the recordings if I choose to allow this interview to be recorded.

---

Name (print) and Date

---

Signature

## Appendix T: Council / Non-profit Interview Questions

Hello, we are students working with the Port Phillip EcoCentre. We are currently working on a project that is intended to help the EcoCentre determine the sources of plastic pollution in Port Phillip Bay and causes of fluctuating levels of plastic pollution. This interview will be completed in under an hour.

Your participation in this interview is voluntary and you do not have to answer anything you do not want to. Additionally, we will keep your answers confidential upon request.

Otherwise can we quote you? \_\_\_\_\_ Yes \_\_\_\_\_ No

If so, do you prefer that we refer to you by name or by organisation? \_\_\_\_\_ Name \_\_\_\_\_ Organisation

If you have any questions or concerns you can contact us at gr-ecoB18@wpi.edu

1. What area or business within Victoria do you represent?
2. Are you aware of microplastic pollution and the existence of it within your area or business?
3. Does this area or business provide recycling facilities? If you could, describe the availability of these facilities. *For example, providing recycling in park zones but not residential zones*
4. What waste management regulations are in place for this area or business? *For example, do you have a street sweeping schedule?*
5. What factors go into these waste management regulations? *For example, collecting litter more frequently during different parts of the week due to high volume visitors*
6. Is there a specific company or contractor that is used for waste management in this area?
7. Are there waste management regulations specific to different zones within your area or business? *For example, banning smoking in public parks, but not outside businesses*

8. On a scale from 1 [very ineffective] to 10 [very effective], can you rate how effective the current waste management process is at preventing lingering pollution and explain your reasoning?
9. Who do you think is responsible for cleaning up lingering plastic pollution in this area? *For example, councils, consumers, private companies, waste management companies*
10. How serious do you think the problem of plastic pollution is? If you could, rate the seriousness on a scale of 1 [not a problem] to 10 [immediate solution is required] and explain.
11. Are there any plastic use regulations currently in place in your area or business and, if so, when were they implemented? *For example, banning the use of plastic bags or disposable cups*
12. Are there any changes to these regulations coming in the future?
13. What are your thoughts on plastic pollution in this area?
14. Have you personally seen any high pollution areas? This could be anywhere or specifically in this area.
15. What do you think are the major causes of plastic pollution? If you could, think of the three most major causes.
16. Does your area or business fund any campaigns discouraging the use of plastics? *For example, advertisements educating the public of the harmful effects of pollution*
17. Are you aware of the state funded street litter audit program?
18. Does this area or business sponsor any litter audit programs? If so, what methodologies are involved? *For example, do you record the area you are auditing, do you measure the amount of litter by weight or count or other, etc.*

**Appendix U: Council / Non-profit Interviewees**

Organisation	Interviewee(s)
City of Port Phillip Council	Nick Dunstan and Emily Richards
Hobsons Bay Council	Shaun Young
City of Monash Council	April Williams
City of Yarra Council	Kirsty Richards

## Appendix V: Experts in the Field Interview Questions

Hello, we are students working with the Port Phillip EcoCentre. We are currently working on a project that is intended to help the EcoCentre determine the sources of plastic pollution in Port Phillip Bay and causes of fluctuating levels of plastic pollution. This interview will be completed in under 45 minutes.

Your participation in this interview is voluntary and you do not have to answer anything you do not want to. Additionally, we will keep your answers confidential upon request.

Otherwise can we quote you? \_\_\_\_\_ Yes \_\_\_\_\_ No

If so, do you prefer that we refer to you by name or by organisation? \_\_\_\_\_ Name \_\_\_\_\_ Organisation

If you have any questions or concerns you can contact us at gr-ecoB18@wpi.edu

1. What organisation are you from?
2. What research does this organisation primarily focus on?
3. Have you or your organisation worked with the Port Phillip EcoCentre in the past?
4. What previous or present projects relating to plastic pollution has this organisation worked on?
5. What do you think are the major causes of plastic pollution? If you could, think of the three most major causes.
6. What do you think the main source of this plastic pollution is?
7. If you could, list some environmental or human factors that you think contribute to this pollution. *For example, environmental would be rainfall, wind, elevation and human would be sporting event schedules, flea markets etc.*
8. Do you have any advice for effectively communicating research findings with the public?

9. Do you recommend that we contact any other people who have knowledge about plastic pollution that may help our project?
10. What are your thoughts on plastic pollution in this area?

**Appendix W: Experts in the Field Interviewees**

Organisation	Interviewee(s)
EPA Victoria	Randall Lee
Scouts Victoria	Peter Kennedy
Port Phillip EcoCentre	Neil Blake
Port Phillip EcoCentre	Fam Charko
Tangaroa Blue	Jodi Jones
Boomerang Alliance	Annette Finger

## Appendix X: Interview - City of Port Phillip

Interviewees: Nick Dunstan and Emily Newton

1. What area or business within Victoria do you represent?

City of Port Phillip. There is no difference between cities and councils. Generally, shires are rural but cities and councils are the same thing. We are the City of Port Phillip Council. There used to be a bunch of cities that conglomerated to become a council but now we are the same thing.

2. Are you aware of microplastic pollution and the existence of it within your area or business?

Yes. Neil has probably done a lot more work than we have.

3. Does this area or business provide recycling facilities? If you could, describe the availability of these facilities. *For example, providing recycling in park zones but not residential zones*

Yes, to both. In general, we have a household curbside recycling program. Businesses are entitled to the same collection program. It does not cost any extra cost to them. In general, for most businesses the residential sized bin is not going to be useful for them. Offer 4ish curbside bins in addition to regular recycling collection. We don't charge for recycling. We do charge for extra bins. There is the drop off centre across the road which is a hard waste booking service. 70% of this is recycled. 4-6 bookings per year per property are allowed. Weekly garbage collection and recycling each week. Each zone (there are 5) has its own schedule and goes on its own day. Schedule is on City of Port Phillip website. Spillage is something that happens. We try and get the guys to go back and collect what is spilled while they are picking up. I wouldn't be surprised if there was a bit of correlation between the two. Also during events. Port Phillip is end of greater cities storm water drains. Storm water comes out of the bay and then washes back onto the beach.

4. What waste management regulations are in place for this area or business? *For example, do you have a street sweeping schedule?*

No regulation to it. Residents have to use their bins properly. Anti-Littering laws exist that are all enforceable. EPA has variations that apply to constructions, individuals, etc. Fines available through them. We have made the move to ban all single use plastics at events. We have previously banned plastic bags at shopping centres but more as an agreement between vendors. Not necessarily enforceable. Have recycling facilities that are well used and well maintained in all new buildings. Main one is really the events. Probably move to ban all single use plastics flat out. Many places within council where events are to be held. St Kilda is highly used. Big park near the beach is often used for events. If it's a particularly warm day population in City of Port Phillip will triple. We have a plan in place for summer and these extra warm days. Extra pickup of bins during summer and install extra bins to cope with the increased volumes. Each event has to submit waste management plans that they must submit before approval. Use solar compactor bins to better maintain the litter in addition to pick up 3 times a day. Solar powered and they compact the litter within. Won't get much pickup saving but do avoid bin overflowing. Linked via GPS to tell when the bin will overflow or is getting close. They are very expensive though.

5. What factors go into these waste management regulations? *For example, collecting litter more frequently during different parts of the week due to high volume visitors*  
We have got a lot of bins that have been there for a while. There will always be new bins placed in new areas that exist. We respond to people asking for bins placed. We monitor area for a few months and if see a problem then we install a new bin. That's our system at the moment but it will probably change as we move towards solar compactor bins.

6. Is there a specific company or contractor that is used for waste management in this

area?

We do most of data collection over summer we will do 300-400 litter audits over the summer in parks, shore, etc. This year we will use Tangaroa blue's app/database. We will add our data to that. Keep lots of data on what litter is collected and volume we don't do as many audits not over summer. Process for audits are identified by Tangaroa blue. Whatever the meterage is in transect, categorize the material within that transect some people pick up the stuff afterwards and some don't. Can trace the source of some of the litter through tangaroa's app and barcode scanning.

7. Are there waste management regulations specific to different zones within your area or business? *For example, banning smoking in public parks, but not outside businesses*  
 Four seasons waste. Have in house teams that pick up on street and beach are done by in-house crew. They also do street sweeping and emptying bins in the city. Also a street sweeping schedule. The aim is to get to each street each fortnight. All the schedules are on the website. Beach cleaning is generally done every day in St. Kilda, but other locations are rotated each week. Beaches are handpicked every day at the tidelines (done by in-house crew). 50 staff in street and beach cleaning, 14 staff in picking up bins. Contractors have a lot more staff. Schedule is established on a need basis. In general, we have guys drive past every day and double check the bins. Have a lot of traders filling up bins with their rubbish. Nov-April goes afternoon and normal daily. It seems to be kinda enough most of the time

8. On a scale from 1 [very ineffective] to 10 [very effective], can you rate how effective the current waste management process is at preventing lingering pollution and explain your reasoning?

In general, I'd give us a decent score. We are pretty good given the number of visitors. Given nature of the sudden unmanaged, unscheduled events lead to worse things. 95% of the time we do very well. It's the popup events that make it hard or

on really hot days where people stay out on the beach all night. Idk what pretty good is. Maybe like an 8. As soon as the party goers leave the crew is out there cleaning. In general, we have a good response. We spend lots of money on it. Unscheduled events summer holidays, especially nice days, etc. We have specific plans around public holidays to cut down on impacts of the litter and the overflowing stuff. The multiple super nice days are harder since St. Kilda is the closest beach to the city and if everyone in Melbourne wants to go to the beach it gets harder to control the litter. Looking at doing a microplastics campaign this summer so that people can decrease single use plastics since we all know it contributes to microplastics in the long run.

9. Who do you think is responsible for cleaning up lingering plastic pollution in this area? *For example, councils, consumers, private companies, waste management companies*
10. How serious do you think the problem of plastic pollution is? If you could, rate the seriousness on a scale of 1 [not a problem] to 10 [immediate solution is required] and explain.

Pretty serious. I think given the recent news articles about plastic in everything it's a huge scale and I don't think people are aware of it yet. The reason I work in waste management is because of plastic pollution (EMILY). The biosphere impact is huge, but the human health impacts are huge and it's going to gain traction and bring the envi impacts along with it. It's going to be an interesting one to convey to people without putting them in terror mode. Trying to show here is a fact off the scale of the problem please do something about it.

11. Are there any plastic use regulations currently in place in your area or business and, if so, when were they implemented? *For example, banning the use of plastic bags or disposable cups*

No single use plastic are used at public events. Australian product stewardship

scheme covers e waste but also single use plastics. When gov policies come up from review we put in comments about reducing single use plastic.

12. Are there any changes to these regulations coming in the future?

In the future at public events not disposable plastics will be used. Its either already in or its coming they are educating private event companies. Balloons are gone and single use plastics are either gone or on the way. Can only enforce so much through permits.

13. What are your thoughts on plastic pollution in this area?

There are a bunch of ways you can look at where the source is. There are numerous sources for a city like Port Phillip. We are the end of the storm water drains. We have an opportunity to trap a bunch of litter before it gets into the bay. All of drains are fitted with pollution catching filters. Education campaigns and enforcement come in for people dropping litter. And managing events litter is where we come in we can advocate for reducing plastics. We can educate, we can stop things coming in, pick stuff up, advocating for broader problem to be solved, supporting community groups working on the issue. Lots of waste education programs about reducing plastic and litter

14. Have you personally seen any high pollution areas? This could be anywhere or specifically in this area.

Yeah sure. Depends on the big storm. Will find lots of stuff comes up after weather or big events. Every day the guys pick up a lot of dropped litter from the beach and the streets. We don't have massing industrial areas. Across river is large plastic producers that will have nurdle spills but we don't have that. Foreshore is for big events, or on parks next to foreshore or shopping districts

15. What do you think are the major causes of plastic pollution? If you could, think of the three most major causes.

Can comment more on litter items: cigarette butts, drink containers, straws that kind of stuff. That would be the top two. Food based plastics I guess you could say. Also plastic bags but I guess they have been kinda banned. State gov is inducing a ban across all stores in Victoria by 2019 (or at least starting then)

16. Does your area or business fund any campaigns discouraging the use of plastics? *For example, advertisements educating the public of the harmful effects of pollution*  
Yeah. We spend a substantial amount of money over summer on litter education.  
Depends on what you mean by fund programs. All that stuff is part of our anti-litter campaigns over the summer. Support community groups in terms of managing events. involved in all the state gov education campaigns.
17. Are you aware of the state funded street litter audit program?
18. Does this area or business sponsor any litter audit programs? If so, what methodologies are involved? *For example, do you record the area you are auditing, do you measure the amount of litter by weight or count or other, etc.*

## Appendix Y: Interview - Hobsons Bay Council

Interviewee: Shaun Young

1. What area or business within Victoria do you represent?

Part of Hobsons Bay city council we represent the city of Hobsons bay which represents 6-7 suburbs (Williamstown to Leviton).

2. Are you aware of microplastic pollution and the existence of it within your area or business?

Yeah definitely we've run a few programs about it over the years. We've done various projects around cigarette butts and we do a lot of community cleanups and tend to focus on microplastics and the impacts that plastic and litters have. Particularly at schools. Try to talk about it whenever we are doing any sort of community engagement

3. Does this area or business provide recycling facilities? If you could, describe the availability of these facilities. *For example, providing recycling in park zones but not residential zones*

All residents have curbside recycling (comingled), we include flexible plastics in curbside recycling (aka single use). We don't have any public place recycling bins at this stage. We are putting in some trial ones here in Altona this summer and the idea is to try and expand that. We have temporary ones that we put out along beaches during peak times but they are not permanent. Big issue with public place is contamination level an that's the biggest issue we are trying ot get around at this stage. Waste is weekly, fortnight is recycling, green waste is the alternating fortnight. Green waste all gets brought to a composting facilities (does not include food waste, but that's an area we might expand upon)

4. What waste management regulations are in place for this area or business? *For example, do you have a street sweeping schedule?*

I am more the education side of things. The cleansing department does street sweeping, bin pickup. We do have street sweeping, I'm not sure what the schedule is but I would assume it is every day. I can get those details if that would be helpful.

5. What factors go into these waste management regulations? *For example, collecting litter more frequently during different parts of the week due to high volume visitors*

6. Is there a specific company or contractor that is used for waste management in this area?

Done in house

7. Are there waste management regulations specific to different zones within your area or business? *For example, banning smoking in public parks, but not outside businesses*  
In eating areas in Victoria you can't smoke anymore. You have to be a certain (10m) away from that area. That's enforced by the health team. That's across all of Victoria. Playground is another one, not sure if that's a local or state one. And some beaches you can't smoke either. Smoking regulation came in through last year.

8. On a scale from 1 [very ineffective] to 10 [very effective], can you rate how effective the current waste management process is at preventing lingering pollution and explain your reasoning?

In some commercial areas council doesn't service them, they have to get their own waste management contractors. Those contractors may have different rules. Council mainly deals with residential collection. We won't pick up bins if its overflowing we have made that clear to residents. I think it's pretty good about preventing litter. I think its more of an education thing to teach people to avoid overflowing bins. We are at the mouth of the Yarra, we get a lot of litter coming down the yarra and washing up on our foreshore. There is always room for improvement with waste management. I think construction is probably an issue. Metropolitan waste recovery group is doing some things with inner city council upstream about preventing litter

there. We do clean beaches, collect some seaweed and obviously litter gets collected up during that. I'd have to check with our cleansing group to see if they handpick beaches. We have two beach patrol organizations within our council that are very active. A lot of the time it's very reactive, we get a call and we will go and pick it up. It gets a bit tricky with who is managing the land (Melbourne water vs council)

9. Who do you think is responsible for cleaning up lingering plastic pollution in this area? *For example, councils, consumers, private companies, waste management companies*

I would say it should be a joint effort. Everyone should be involved in trying to tackle it. That's the challenging part is trying to have everyone take ownership.

10. How serious do you think the problem of plastic pollution is? If you could, rate the seriousness on a scale of 1 [not a problem] to 10 [immediate solution is required] and explain.

I would say its pretty serious. Whenever we conduct our cleanup days the majority of what we collect is plastics of some form. I would say it's a pretty significant problem across Victoria.

11. Are there any plastic use regulations currently in place in your area or business and, if so, when were they implemented? *For example, banning the use of plastic bags or disposable cups*

Ban on plastic bags will be big when that comes into enforcement. It has been in the public eye over the last few months. Container deposit legislation schemes is one that is always being thrown around. It would be great if it came from a national level rather than every state trying to figure out their own policies. Council supports plastics bans and we have advocated for the banning of single use plastics for many years now. We will have an anti littering campaign in the summer to try and put across the keep Altona beautiful message. In terms of the in your face stuff, I save

that more for schools with the images. It does have shock factor; I personally feel we need to be making the change with the younger generations. The older people have already developed their habits.

12. Are there any changes to these regulations coming in the future?

Recycling labels are changing on a lot of products. Recycling is still quite confusing to a lot of people. There is still a bit of perception in the community that stuff doesn't actually get recycled, that it all just goes to landfill anyways. Nurdles is a big problem that we have here. We have a few plastic manufacturing companies here in Altona. Reducing pellet losses is something we would really like to address in the future.

13. What are your thoughts on plastic pollution in this area?

It's a problem but I don't think its focused just here, it's a nationwide problem really. Because we are on the coast we can see it here, generally speaking its relatively clean but you can see it in the remote areas. The biggest issue from us is the mouth of the yarra and everything coming from the inner city. That's a joint problem with us and everyone in Melbourne really.

14. Have you personally seen any high pollution areas? This could be anywhere or specifically in this area.

Mouth of the yarra, Wader beach: there is a report that the ecocentre helped with, Beaches are probably where its seen the most because that is where all the storm water and everything leads to. When we have big storm events the bay tends to get highly polluted. We have days where you can't go in the water and we put up warnings about it. Industry zones: pellet loss and illegal dumping (industrial zones are hotspots)

15. What do you think are the major causes of plastic pollution? If you could, think of the three most major causes.

Single use plastics. Confectionary, chips, plastic bags, drink bottles. It's hard to just pinpoint any source. I would say a lot of it comes down just to people throwing it on the ground. I don't know whether you can pinpoint the industry or manufacturers, it needs to be a joint thing and educating everything. Maybe manufacturers should take a little more ownership of their products

16. Does your area or business fund any campaigns discouraging the use of plastics? *For example, advertisements educating the public of the harmful effects of pollution*

We try to promote reusable stuff. Internally we try and promote it to all the staff and things. Boomerang bags has been extremely popular. Council helped get that up and running and support it. We have various types of grants that community groups can apply for. Australian program but its run by individual communities. There is no lead that helps set them up around Australia. It has been good because it's brought the community together. And they support all our other campaigns that we do as well.

17. Are you aware of the state funded street litter audit program?

No I am not.

18. Does this area or business sponsor any litter audit programs? If so, what methodologies are involved? *For example, do you record the area you are auditing, do you measure the amount of litter by weight or count or other, etc.*

We do have a program for community groups to do litter audits (follow Tangaroa blue). Not so much council things, but some of our friends of groups have cleanup days. We try and promote them to do audits and actually sort through stuff. People generally just want to pick up stuff and go home. The community groups keep the data and put it right into the Tangaroa blue database.

## Appendix Z: Interview - City of Monash

Interviewee: April Williams

1. What area or business within Victoria do you represent?

From the city of Monash and the senior sustainability officer. I've worked here for 7 years and I only started this year since 8 months. Previous to that I was in the waste area.

2. Are you aware of microplastic pollution and the existence of it within your area or business?

Yes

3. Does this area or business provide recycling facilities? If you could, describe the availability of these facilities. *For example, providing recycling in park zones but not residential zones*

City of Monash provides curbside recycling for residents. Public litter and recycling bins strategically placed where there is high volume of people. We have a recycling center where you can take items that don't go in your curbside bin. At civic center we have a hub for e waste. We have a waste bin, recycling bin, green waste for residents. Businesses only have waste bin included in rates and they have to pay extra for a recycling bin. In our main shopping center, we have cardboard collection for traders

4. What waste management regulations are in place for this area or business? *For example, do you have a street sweeping schedule?*

All of our cleaning operation are in house. Street sweeping (every residential every 5 weeks), main activity centers every 6 days, run sweeping services 23 hours a day. Footpath sweeping, laneway sweeping, collect all the street litter bins in house. Award winning litter collection model called Monash Pride Crew. There is a person at each specific zone all day that takes care of cleaning and bin emptying. That way

people know council is present and then the traders get to know the staff. Residential collection every week, fortnight green and recycling. Public bins are collected 7 days a week (busy shopping area), in parks every fortnight, schedule collection depends on feedback from drivers and how busy the bins are. No way to check if bins are overflowing. Trialed bin sensors at strategic spots (5 bins), we haven't pursued that as an option. The city of Monash is quite small, one truck for litter bins and one truck for recycling 3 days and 2 days litter bins. They sort of cover all the same ground together all the time. We can get around to the bins we need to. We have looked into a technology that helps map your cycle but we determined that the cost of purchasing your software would not weigh out the benefits

5. What factors go into these waste management regulations? *For example, collecting litter more frequently during different parts of the week due to high volume visitors*  
We have heavy leaf fall that in autumn and summer drop a lot of leaf material. We have to do extra sweeping during those times. In summer there is the risk of smelly bins and the perception of that so we have to empty those more frequently. We do litter pickups, dump rubbish (near university move outs)

6. Is there a specific company or contractor that is used for waste management in this area?

Household litter is contracted out. Public bins are all in house. Solo is contractor at the moment. That expires in 2020. They only do residential

7. Are there waste management regulations specific to different zones within your area or business? *For example, banning smoking in public parks, but not outside businesses*  
We have a pretty good relationship with them. They do a pretty good. We have cameras on the trucks so If its overflowing, or there is litter around it, or contaminated they can take a picture of it and send it to us. We have issues with university areas, so we are constantly trying to target those populations and educate

them. State gov has banned smoking where people are serving food. Our envi health officers enforce that law. Local law can't smoke within 10-15m of council building or school.

8. On a scale from 1 [very ineffective] to 10 [very effective], can you rate how effective the current waste management process is at preventing lingering pollution and explain your reasoning?

We have got a waste management strategy that was just endorsed last year for the next 10 years. I think we are quite good in our responsiveness and areas like that. I think we could improve on education. We have a good record of getting grants and then having great education campaigns but then as soon as the grant funding ends those programs taper off. Introduce food and organics recycling for residents is coming (talked about in the strategy), Introduction of e waste ban in Victoria, Trying to work with people living in apartments, etc

9. Who do you think is responsible for cleaning up lingering plastic pollution in this area? *For example, councils, consumers, private companies, waste management companies*

I think everyone should be responsible. The way legally it works its whoever is the land owner is responsible. But I think if we all wait for someone else to pick up rubbish then it's never going to happen. We have two staff whose job is to pick up litter. Once litter gets into the waterways it's harder to get out. We do have a lot of community support with cleanup Australia day, and lots of community groups. Community groups always want to go to parks and council already maintains parks so it's a bit of a catch 22.

10. How serious do you think the problem of plastic pollution is? If you could, rate the seriousness on a scale of 1 [not a problem] to 10 [immediate solution is required] and explain.

In Monash: I would have to say it's probably, cigarette butts are always most littered item, it's about an 8 for Monash. In general Victoria: I would say 9 because plastic never breaks down and its ubiquitous in society. Even though we have the plastic bag ban, society has a long way to go to embrace that as the norm. I think until legislation comes in a federal level to ban single use plastics (which federal gov has said they will, by 2025 I think) our society needs those legislative changes to come in for us to adapt. If its voluntary it doesn't seem to work

11. Are there any plastic use regulations currently in place in your area or business and, if so, when were they implemented? *For example, banning the use of plastic bags or disposable cups*

Plastic bag ban across Victoria. Soft plastic use within council, it was approved that we would look at reducing soft plastics and single use plastics within council and then if we could reduce that then we would look to reducing them in the community. We have a 12-month plan. We have put in guidelines to force. Anyone holding events on public lands can't use single use plastics or balloons. Working with catering and cafes that operate on council land and look at changing the way they use plastics to try and get them away from plastics and soft plastics. Installed solar compactor bin in fleet store area since that's the biggest source of soft plastics. I really want to do a war on waste kind of thing since those kinds of things that are on national tv and we get a lot of residents contacting us about that and seeing if they can do anything about the scale of it. Trying to work with engineers and try and buy recycled plastic materials for our construction products, etc. trying to create that circular economy. Red-cycle: Coles and Woolworths have soft plastic collection points. all melted down and makes plastic that councils will buy (durable outside furniture, signs, etc). they have a much greater supply of plastics than they have demand for their products. So they have stockpiles of soft plastic and made agreements with people saying they won't accept your recycling unless you buy more in weight than the plastic you send.

There is a lot of companies working with red-cycle to do this.

12. Are there any changes to these regulations coming in the future?

No there aren't. What we would really like to do is to get more recycled products bought but I don't know whether we can legislate for that. We have asked that when we purchase something we don't just look at the cost we also look at the lifecycle cost.

13. What are your thoughts on plastic pollution in this area?

I think it's probably one of the worst types of pollution since it doesn't break down or if it does then it goes into microplastic which are very harmful. We as a society have a very consumerist tendency. A lot of what they buy is crap and junk. The top level of the waste hierarchy is avoiding waste and we don't talk about it a lot because council thinks it's too much of a societal issue and nobody wants to tell people how they need to live their lives. At end of lives nobody wants to have responsibility for the end of life processes. I think there needs to be a cultural shift as to whose responsibility waste is and what a problem plastic.

14. Have you personally seen any high pollution areas? This could be anywhere or specifically in this area.

We get a lot of cigarette butt litter in main shopping areas. We have a lot of illegal dumping in certain hot spots. Monash is within region that is called national employment innovation cluster. It's an area that's considered the highest employer outside CBD. I don't know how much pollution they produce. From time to time you have a spill with companies of polystyrene or things like that. That would more be EPA, that issue wouldn't really go to us. Illegal discharge into creek is also EPA but I have heard a little bit about that. We have an app in Victoria where if you see someone litter outside of their car you can report them using license plate and they get a fine. You can get taken to court on it. There must be a way that they can verify that but I don't know what that is

15. What do you think are the major causes of plastic pollution? If you could, think of the three most major causes.

Cigarette butts, Industry, Littering, Illegal dumping

16. Does your area or business fund any campaigns discouraging the use of plastics? *For example, advertisements educating the public of the harmful effects of pollution*

We haven't done anything like that before apart from that internal thing I was talking about. Partly because we don't tell people what to do with their lives. We have never really looked at it as a council issue and I don't know that we would get much support from council if we did try to do that. Unless you count polystyrene recycling and have done a little bit about that

17. Are you aware of the state funded street litter audit program?

Is that the dumping data app?

18. Does this area or business sponsor any litter audit programs? If so, what methodologies are involved? *For example, do you record the area you are auditing, do you measure the amount of litter by weight or count or other, etc.*

We have done a few audits from time to time. Victorian litter alliance developed a rating system of how much litter there is at an audit site. We've been using that method for a while. We don't do anything with that data. They also have an app for recording any litter you find when gets mapped. We don't currently use that because it doesn't interface with our council reporting systems. The state gov is thinking about changing that app so that it can interface with council software. We tend to do audits when they relate to campaigns or products in order to measure the success of the project. We don't tend to audit in mass throughout the municipalities. Cleanup Australia day we do an audit of everything they have collected

## Appendix AA: Interview - City of Yarra Council

Interviewee: Kirsty Richards

1. What area or business within Victoria do you represent?

I work with Yarra city council which is an inner city council. A bunch of little suburbs that have come together. Small tight houses. They don't have parks. Inner city.

2. Are you aware of microplastic pollution and the existence of it within your area or business?

Yeah I am aware that there is heaps of it in the sea and that it's in the Yarra. The Yarra runs through the suburbs and I'm trying to make people aware that if it's in the gutter it goes into the Yarra and then into the sea. It opens people's world to understand the concept of how far the effect of what they have does. More and more they talk about the gyres of plastic and it's a bit hard to comprehend.

3. Does this area or business provide recycling facilities? If you could, describe the availability of these facilities. *For example, providing recycling in park zones but not residential zones*

Every home or resident has a recycling bin which we encourage them to use. We have been developing more and more signage about what goes in what bin. That has been one of the biggest pushes to not use plastic bags. Every project we do whether with school or community project that is with school, Collingwood children's farm (close connection to river and animals you love). We do have problems with recycling in large apartment complexes because its large communal bins. We are doing a lot of work with those about recycling. We used to offer same for business (2 recycling and a rubbish), as you can imagine businesses have a lot of recycling. We are cutting that back to 1 rubbish and 1 recycling, if they need more they need to pay for another one. They are being very good about what they put in the recycling. There have been several program about what goes in the right bin and staff have more ownership

of the whole thing. Every week they get picked up. For business that's usually not enough and they need a commercial service. There is one café that has it serviced every day. There are also been encouraging them to use the reground coffee service (coffee grounds are composted).

4. What waste management regulations are in place for this area or business? *For example, do you have a street sweeping schedule?*

We have daily street sweeping, retail areas are everyday twice a day. The residential days I'm not sure frequency but they would be more in autumn. We have hard waste collection (2 collections a year: couches, computer, etc). if we let people dump it they will and then more people will put stuff there and that will make things worse. We encourage people to work together. Two or three homes can work together on one collection.

5. What factors go into these waste management regulations? *For example, collecting litter more frequently during different parts of the week due to high volume visitors*  
Because recycling is of more and more importance to people we are getting more feedback from residents and councilors about what they want. That has lifted what we do, we are now looking to employ someone to see if there is a way we can reuse the hard waste that we are picking up. The problem is we would need a warehouse, people, truck, and safety. A lot of the stuff we collect is recycled anyways. At the depot we have a section for electrical, precious metals, plastics, etc. there is now a recycle thing for mattresses. With the electrical waste there is a ban on taking that to landfill starting June next year so we are upping the fact that it doesn't go to the rubbish bin, take it to the depot. We have places for it at libraries or enabled houses. That would be ban, it will stop stuff leaking from landfill into the water. We definitely have more litter and cleanup collection in summer when it gets hot and people get out and do stuff. We have done a lot of work with the bins and people

through signage. We want it to be part of this whole Yarra culture where we just do the right thing. Summer definitely, footie if there is a final there is stuff everywhere, festivals in the summer we have to bring in special cleaning regimes. The cleaning guys have brought in a new regime in the last 6 months they get together once a month and everybody comes in and does a blitz on an area and then go back to the normal stuff. Its worked. The cleaner it is the cleaner it will stay. You have different areas of the culture keeping it clean, recycling more, understanding the consequence, and having fun doing it.

6. Is there a specific company or contractor that is used for waste management in this area?

Somebody does recycling, rubbish (pick it up), there are standards they have to meet. They have to go beyond this. These companies we have to make them care more about what they are doing. We also employ contractors to pick one area (say 200 households) early morning see what's in their recycling, give them a little sticker. Go back 2 weeks later and see how they are doing and if they have improved they get a reward (worm farm, compost, or tickets). Its working and people are doing the right thing. It's a lot of work, so trying to spread that across Yarra. There are suburbs that will get a better result in and some are harder. Visy does recycling, Four seasons does waste and rubbish

7. Are there waste management regulations specific to different zones within your area or business? *For example, banning smoking in public parks, but not outside businesses*  
Can't smoke within 2 m I think. We have put butt bins on most of the bins. I have just developed some art about making it fun about making people noticing butt bins. There are still a lot of butts in parks, outside pubs, that kind of thing. We have got a lot of work to do. Amount of cigarettes put in ocean in year is equal to weight of 120,000 elephants. If you can get that across to people and school kids, they will

change their behavior phenomenally. With butt bins: we have seen people using the butt bins. There are still tables outside of pubs covered in cigarette butts. Different cultures and difference races have different cultures where some will go for a bin and others won't

8. On a scale from 1 [very ineffective] to 10 [very effective], can you rate how effective the current waste management process is at preventing lingering pollution and explain your reasoning?

Its definite improving, we have had a radical change in understanding within the last year with everything we have done behavior wise its improving, but you still have the parties outside pubs or a hot day in the park. It's hard to measure across the whole thing, but its improving. Its helped by the amount of work that the EcoCentre has done. The bay grants have raised the profile. I think the envi minister could make some profiles or activities to get the message across. Local high school introduced a subject about litter. At the end we took them canoeing on the Yarra to see this is what's done in Yarra and this is what your peers do. And it's working. Little kids tell me my mum tells me to pick up litter. The bad spots are still bad after a hot night or whatever

9. Who do you think is responsible for cleaning up lingering plastic pollution in this area? *For example, councils, consumers, private companies, waste management companies*

I would say the people. There is a famous Australian environmentalist (Flannery). The struggle is the solution. Council will lead and will follow, so it's up to the people and the council. If we can inspire that then the champions will do it on their own.

10. How serious do you think the problem of plastic pollution is? If you could, rate the seriousness on a scale of 1 [not a problem] to 10 [immediate solution is required] and explain.

I would say 10. It's getting more obvious how serious it is. It's definitely in this council, I'm not sure about all over. There are more affluent suburbs with less space and time. You can't fit in enough bins so you notice it more. Yarra is under greater pressures and responds better to them than other councils

11. Are there any plastic use regulations currently in place in your area or business and, if so, when were they implemented? *For example, banning the use of plastic bags or disposable cups*

Ban of plastic bags which is coming in. there are notices in supermarkets. A lot of schools are making their own boomerang bags. The supermarkets have plastic bag recycling. There is talk about plastic straws and balloons (blow bubbles not balloons). It was about 6 months ago, driven by the zoo and well received by the kids. It's time to have a campaign. People are ready to do stuff, to use less plastic. There has been a lot of stuff about coffee cups since they are lined and they can't be recycled. In a sense you would probably achieve more with a behavior change campaign than a regulation. We encourage traders not to use single use plastics during campaigns. We supply bins, we have people who tell festival goers to recycle, we monitor and empty the bins. We are looking at the solar compactor bins. We could use those in places like a big park on a big day. In a way we know already when they need to be emptied, but sensors would good.

12. Are there any changes to these regulations coming in the future?

I don't know of any definite ones. Once they are confident that people will accept the response then they will push it through. They need to drift through the communication to see if people will accept the regulation and change their behavior first. More and more industries are looking at doing more in Australia with recycling since china has stopped accepting industries. They are living up to what they should be doing and doing it.

13. What are your thoughts on plastic pollution in this area?

It can still be terrible at events, hot summer days. There is less of it. You actually see people picking stuff up and putting it in the bins. People are getting passionate about it. People are littering less. Its improving. We still have issues if people have had a lot to drink or are in a large group

14. Have you personally seen any high pollution areas? This could be anywhere or specifically in this area.

Big park, Victoria street: lots of Vietnamese restaurants. Old area, old kitchens, etc. there can be a lot of pollution at that place. I think that's half cultural and half logistics, Big events, Footie games: a lot of people put things under their seats, Bars and pubs, especially late night ones. You can't speak with someone who has a lot to drink. That's going to be a long term behavior change and with peer pressure. It's going to be tough

15. What do you think are the major causes of plastic pollution? If you could, think of the three most major causes.

Cigarette butts, Coffee cups, Food containers (takeaway) \*\*\*, Straws, Nappies, but that's only in certain areas

16. Does your area or business fund any campaigns discouraging the use of plastics? *For example, advertisements educating the public of the harmful effects of pollution*

We are building it into everything we do. I always tell people what things come back as (in terms of recycling). We are targeting the schools, total community. (little kid cigarette picking up and making sign, huge social media response). We can also apply for the litter innovation fund that gives out funds for programs. We apply for a grant that helps us do what we want to do (signage, bins, promotion, cleanup, etc)

17. Are you aware of the state funded street litter audit program?

No. I guess have been doing that intuitively

18. Does this area or business sponsor any litter audit programs? If so, what methodologies are involved? *For example, do you record the area you are auditing, do you measure the amount of litter by weight or count or other, etc.*

We run litter audits as part of the campaigns we do. Especially if we get funding. We got funding to do litter campaigns on two business streets. We do a litter audits of the street before, mid, and after the campaign. The data goes into the report for the grant. She said she would send us her data. We can send you an email to remind you. We have a litter cleanup early in the morning and at night, so the hard part is catching it between those times.

## Appendix AB: Interview - EPA Victoria

Interviewee: Randall Lee

1. What organisation are you from?

EPA Victoria, state based pollution protection department in Australia instead of federal one in US would have. I am in the applied science directorates division, science is a direct voice at the top level of the EPA, so the executives can make science based decisions. We are second oldest EPA in world after US EPA. In the water team within the applied science directorates

2. What research does this organisation primarily focus on?

Deal with everything atmospheric, protecting envi and human health (human health is relatively recent). Do a lot of R and D into emerging contaminants, microplastics, PFAS (or maybe PVAS), other high profile stuff, endocrine disruptors, new chemicals in the envi that we don't have a handle on what the chemicals are other than nasty, more effective ways of defining envi conditions (including more effective ways of monitoring), more emergency response work and modeling/forecasting efforts so we can better respond to that. Get involved in projects such as research into seagrass health in bay as an indicator as to health of the bay, and recently we have revised policies that are 15 years old and have established bio indicators. Applied science is what we do, we might work with other fringe groups who are doing blue sky science. It's not that different than what universities do. Public expectations dictate a lot of what we do. A lot more stuff on water quality, the scare that the bay would become like Chesapeake Bay and that has been driving a lot of R and D on algae blooms and nitrogen. Looking at nitrogen budgets into the bay and this is sort of the last unsolved issue into that and understanding all the contributors and how to distribute the nutrients into the bay. Mt. Martha is a bit of a collection hotspot for plastics (my modeling has shown that). Lots of weathered microplastics that come from

remote sources that wash up on the west coast of Victoria, but that might be outside your scope. New microplastics project: (Allison Kemp is head of project), she will give us summary copy of the project, its just in the first phases. She was here in voice only. Its only desktop looking at the literature and quickly evaluate some of the literature. Look at recent research and try and decide what that means for EPA and regulation of microplastics. Part of what the project is looking at is categorizing different sources within Victoria. Looking at diffuse sources vs point source. Point source example = wastewater. Not necessarily trying to point finger at those source but looking to see what's available to regulate those sources. We are really hoping this is phase one and that there will be a phase two with possible partnerships with other organization and authorities to do some more targeted research. We are currently trying to work out what EPA's role is in this issue Look at this issue overall and try and separate it into parts and more specific problem based issues. (Have worked with a few outside organisations to collect data in other unrelated projects, but not officially through EPA.) This project is more tangible and looking at areas where EPA can have direct effects, such as permits or license premises. They have been raising awareness for a few years, we've done a fair amount of education in the past, but we are trying to do something a little bit more tangible. We would be really interested in your results. Have hard rubbish collection days in councils that is just like people put stuff out on the street and other people can go through it and stuff gets everywhere. We deal with multiple issues relating to water: microplastics all the way through to algal blooms. Its difficult to delve deeper into specific projects, that where we've struggled and are a little bit behind, but we are working to get some momentum into that. Its been a slow start.

3. Have you or your organisation worked with the Port Phillip EcoCentre in the past?

Provided modeling support to help provide guidance on beach cleanups in the past to try and help optimize cleanup efforts.

4. What previous or present projects relating to plastic pollution has this organisation worked on?
5. What do you think are the major causes of plastic pollution? If you could, think of the three most major causes.

I would say packaging is a pretty big one. We are also doing a study on the characterization based deposit scheme. Looking at a mangrove site in Melbourne and plastics there and categorizing them on a monthly basis. I have experience there seeing all the packaging material that gets caught up in the mangroves. Both industrial and normal packaging. We find a lot of packaging in the envi but I think its actually linked to the fact that we throw that stuff away and there is a more fundamental issue that we don't value the resource that plastic is and that we don't reuse this we just throw it away. Ellen MacArthur foundation has been doing a lot of research into looking at circular plastics economy and how to use plastics as a resource better. If some packaging or nurdles escape we don't go and get it because we just think we can go and get some more. Victoria banned plastic bags in supermarkets starting in July, but the interpretation of that is different. Plastic bags from Coles are made from recycled bags from Germany since Europe has a policy where the companies who make the plastics have to pay for the recycling, so now I guess they are just exporting their plastics elsewhere. There are solutions elsewhere in the world for how to deal with plastic packaging, I guess we just have to look at the effective means that are being take elsewhere. We have some engagement with our industry influenced people and they do have some influence as to what the industry does, but not much and ultimately industry drives how much plastics. We need to be aware that we shouldn't just look at the surface intervals. We may start looking at plankton or shrimp and seeing how much plastics are in their stomachs as part of monitoring how much microplastics are in the water column as an emerging pollutant. As well as the ratio of plankton to microplastics in the water. Thiolates

are a byproduct of plastics degradation and at the moment we don't know much about the concentration of that in the envi and the possible issues that could have. From the bit of education we have done, people just want to know what can they do. They want to know from a domestic scale, not just let some giant waste water plant deal with it for you. People are looking for something that they can do to help.

6. What do you think the main source of this plastic pollution is?

Storm water is probably a very big area. I am not quite sure what the quantities are coming out of wastewater treatment systems, but I am sure its significant. Storm water isn't necessarily the source its more of the transport mechanisms. After huge storms you will see huge quantities of plastics in the local creeks. That's mainly from littering or mismanaging of waste management systems. I don't know that we don't have the answer to that yet, that's part of why we got the extra funding for this microplastics projects. It's a really key question and I don't know that we know the answer to that yet. At least from an EPA perspective, I think what posed the most risk is more important than what is the largest source. Maybe Cam's suggestion of a risk index for different litter and types of plastic would be helpful to help up profile the different litter types.

7. If you could, list some environmental or human factors that you think contribute to this pollution. *For example, environmental would be rainfall, wind, elevation and human would be sporting event schedules, flea markets etc.*

Illegal dumping, a lot of people illegally dump, it's pretty common since there is a financial disincentive to go and do it properly. Trying to help councils develop a way to deal with this since EPA is so busy with other things. I think there was some research done about socioeconomic factors (at a neighborhood level with container deposits (maybe in NSW), littering, etc). I'm not aware of anything in Victoria doing research on the effectiveness of the plastic bag ban. Wind can definitely pick up a lot

of stuff. You see these plastic bags heading up to space sometimes on very windy days. Improperly managed landfills are also a problem.

8. Do you have any advice for effectively communicating research findings with the public?

Think of other coms of engagement you could do in addition to the report (brochure, online products, looking for opportunities at events where you can engage directly with the public, trying to transport what you are doing here back to the states).

Look at the audiences you are trying to target. Engaging with schools or friends of groups. Tap into networks that already exist that are also trying to make the messages you are trying to convey. EPA is interested in our report once its finished and could potentially help carry some of the messages after our report is finished. Might be worth doing some parallels to different bays around the world since they are similar systems and similar systems may have similar issues. They could also be years ahead of what we are doing here.

9. Do you recommend that we contact any other people who have knowledge about plastic pollution that may help our project?

Ben Rowland- also at EPA who deals with waste and regulations (industry guidance unit) Some info on EPA website about site practices, Mark Brown-University of NSW (done lots of research on microplastics), Heidi at Tangoara Blue. Doing some pilot studies trying to identify repeat offenders for nurdles spills. Using storm drain filters as data collection to gain information about who has good on-site practices that could be used as examples for others who do not have as good practices.

10. What are your thoughts on plastic pollution in this area?

Plastic bag ban is mostly just a financial disincentive to make people bring their own bag rather than the money charged for the bags being used towards research.

## Appendix AC: Interview - Scouts Victoria

Interviewee: Peter Kennedy

1. What organisation are you from?

I guess I represent Scouts Victoria. My official title is Venture leader for Australia Scouts, I am affiliated with Brighton Sea Scouts. We run one project the beach auditing through Brighton Sea Scouts. We are running another project on behalf of Scouts Victoria for the streets to bay audits.

2. What research does this organisation primarily focus on?

3. Have you or your organisation worked with the Port Phillip EcoCentre in the past?

Have been working with the EcoCentre for the past few years

4. What previous or present projects relating to plastic pollution has this organisation worked on?

Not relevant

5. What do you think are the major causes of plastic pollution? If you could, think of the three most major causes.

Littering, bad habits, inadequate facilities, overflow from storage areas, inability to care for the environment

6. What do you think the main source of this plastic pollution is?

For me the two are commercial retail areas (supermarkets) and sporting fields. Bars vs. retail stores: in my opinion I think it's more commercial hubs that are frequented by a lot of people and it's not just a bar or a supermarket or a railway station. Its that its a hub and people are moving from one place to the other. We've definitely seen huge spikes during very communal areas where people are moving about, hanging out, etc.

7. If you could, list some environmental or human factors that you think contribute to this pollution. *For example, environmental would be rainfall, wind, elevation and human would be sporting event schedules, flea markets etc.*

Inclined to litter: I am not sure there is envi or human. Maybe a pub if you've had a few drinks but I don't have any data on that. There are people who litter and people who don't, i'm not sure that changes or is circumstantial. Three types of people those two throw and out of sight out of mind, people two notice it, and those who pick it out. Transportation I think the more rain, the more that gets washed off. It's more of a timing thing, it was going to get there anyways. It may just be bursts of litter going but it was always going to get there anyways. Envi effects when it's going to get there. The most litter is in the grass area and i don't think street sweepers mow the grass. If there is x percentage of people who are going to litter, if you have a large group you are going to litter. It's just more concentrated.

8. Do you have any advice for effectively communicating research findings with the public?

9. Do you recommend that we contact any other people who have knowledge about plastic pollution that may help our project?

10. What are your thoughts on plastic pollution in this area?

11. Added questions.

How would you track plastic pollution over time?

We are first people as far as i know of to go count litter, and pick it up. The first time you expect a lot, after you go back it's just going to be what got there during that time period. We went to one location and the second time there was more litter the second time than the first time and it was no more than 8 weeks between the two audits. It gets there and it turns over frequently. Don't take street sweeping schedules into account. We've been out the day after very heavy rain and there has

been just as much litter. I think there is more litter than we know, we collect things every few months and its possible most of it has washed away.

After heavy rain vs wind have you noticed that grass is more populated than other areas?

The grass areas is the obvious trap and that's where we find the most street litter.

We also find lots of stuff in the path.

Do you have reasonings behind what is the most common plastics?

Statistically we probably don't have enough data at the moment. The thing that gets me is that cigarettes are always the most. Nothing stands out as being different in different areas. Personal opinion i think that smokers that throw things in the city will throw things anywhere. We are finding cigarette bars everywhere. We are finding hundreds in little strips. There has gotta to be something about education.

Difference in areas where trash bin has cigarette vs not?

No. one of the biggest areas we have hit is outside coles and there was trash bins there and right across the board. Litter in general was just incredible.

## Appendix AD: Interview - Port Phillip EcoCentre

Interviewee: Neil Blake

1. What organisation are you from?

I'm with the Port Phillip EcoCentre

2. What research does this organisation primarily focus on?

Primarily the programs that relate to litter and microplastics but also breach profiling and mollusks stuff. We also do research on local biodiversity too and I'm involved in that as well, but litter and microplastics is taking up most of my time

3. Have you or your organisation worked with the Port Phillip EcoCentre in the past?

Yes

4. What previous or present projects relating to plastic pollution has this organisation worked on?

Street to bay program involves the beach audits which are currently funded by the state gov, the river trawls also currently funded by the state gov, and the street audits in partnership with the scouts. The scouts are being funded by state gov, I'm just helping them. I also have audit methods for river banks and school grounds but not much has been done with that yet

5. What do you think are the major causes of plastic pollution? If you could, think of the three most major causes.

Technically the main one is inadequate or irresponsible disposal. Plastic in the wrong place comes down to the way it's handled and inadequacies. I think cigarette butts are often there because cigarette smokers have a grim view of the world and don't care. Most other times I think people want to do the right thing, but do something like put their trash in an overflowing bin. There are occasions that will all the best intentions things will happen. I think humans are herd animals and they will do what

the herd does because they don't want to stand out or seem to be a nerd. People are used to having things cleaned up after them. Some people think of littering as a job creation program because now someone can have a job to clean that up. I think people allow that mindset to seep out into other areas

6. What do you think the main source of this plastic pollution is?

Sporting events, Industrial sources, Domestic. There is no doubt that stuff it put on the streets with the idea that the council will clean it up with the idea that the local council will clean it up, There seems to be a major component of convenience food and drink containers. When people are on the move they often leave a trail behind them. Recent winds, We need to look at the street cleaning regime. The data we have so far is fairly preliminary in terms of the trends that we will show up.

7. If you could, list some environmental or human factors that you think contribute to this pollution. *For example, environmental would be rainfall, wind, elevation and human would be sporting event schedules, flea markets etc.*

Sporting events it seems to me that in all religions (because sport is a religion), [referenced marathons and throwing of cups] litter is seen as part of the culture and its perfectly acceptable to behave that way. Because people are unaware of plastic as a pollutant it's hard for them to do the right thing. The mindset is about aesthetics rather than this is pollution so people just don't have an idea about how serious that issue is. Our campaign with microplastics is to shift that viewpoint that it's not just about keeping things clean. I think that's where we need to have a campaign that really gets to the heart of the issue and get a better understanding of the problem and that it is a pollutant. I suspect that the kind of people who are the protagonists don't care about the animals unless maybe they are fishing and it's in the stuff they are trying to eat

8. Do you have any advice for effectively communicating research findings with the

public?

I'm hopeful that the Tableau things will be a really helpful way to do that. I think the one thing that we have as an advantage is that we are applying and approach that we are applying to an entire region that's going to be relevant to a whole load of people. Particularly to the people in the clean network. Getting them to understand that micropalisc is not just a coastal council issue. Make sure graphic takeaways are very clear with no ambiguity. I would think the visualston would be going online as well as an education tool because I'm sure it will be good and we will want it to be as easy for the most amount of people to see

9. Do you recommend that we contact any other people who have knowledge about plastic pollution that may help our project?

10. What are your thoughts on plastic pollution in this area?

Challenging. Things are improving even though there are more people consuming plastic products and probably dispersing them inappropriately. There is a growing awareness in the community and I'm hoping that this project is helping to have people change their behavior. There is a constant need in my view of finding ways of communicating to the wider audience. Our challenge is finding ways to communicating to people who don't already travel the paths we do. In the meantime we do need to keep advocating for product stewardship. Single use plastics should be phased out. If we can't get people to dispose of things properly then maybe those things shouldn't exist. I have to express about a little bit of frustration about people who are campaigning about just one specific thing (ex plastic bags) rather than about the bigger picture. It's almost as though some of those campaigns are put downs and part of embarrassing people rather than appealing to people's intellectual but i could be an old fart though. I think communication is key though.

11. Additional questions.

### Burbs to bay

Many people aren't aware (from Dolphin research institute survey 3-4 years ago) that stormwater drains connect the streets to the bay. If you can't see a bay or a creek many people just wouldn't understand that connection. People are unaware of the physical connection of where they are in the suburbs because they just can't see it. Idea is that choices that people make and choices of where they live in the suburbs will have a direct impact on the bay even if they don't know it. Educational programs to get them to understand it. Choices made in suburbs make an impact on the bay even if people are unaware.

What is worse large sporting events once a year or multiple

Multiple would be more of a problem because I would assume there is a cleanup team after major events to come in and pick up all the litter. Pokemon go could be a source because people congregate there and then drop their litter. Fun runs or marathon events when people drop their cups on the side of the road

## Appendix AE: Interview - Port Phillip EcoCentre

Interviewee: Fam Charko

1. What organisation are you from?

EcoCentre, I also work for Tangaroa Blue foundation. They specialize in plastic pollution that is all that they do. They have a big database AMDI and they are a national not for profit organisation that works with reducing plastic pollution. I have been running a project for them as a project manager.

2. What research does this organisation primarily focus on?

Clean Bay Blueprint, the plastics research quantifying the plastic pollution going into the Yarra, Maribyrnong, and the bay. That's my main project. I have another one that is seasonal where I was contracted by RMIT to take seawater samples in the bay and they are analysed by RMIT researchers to look at the chemicals in sunscreen. I also do human resources and financial stuff for the EcoCentre, you have to wear a lot of hats when you work for a non-profit. At Tangaroa Blue I do a lot of event organisation. Getting passionate people into the room and brainstorming how we can prevent the most commonly littered items that they find in their particular council. It's a workshop on making source reduction plans and how they can take that back to their own councils to implement their projects in their council. Tangaroa Blue works with the EcoCentre a lot. Mainly with nurdles and getting plastic companies to adopt nurdle spill manuals. We audited 85 plastic factories and found evidence of their nurdles and then Tangaroa blue is opening those conversations with factories management.

3. Have you or your organisation worked with the Port Phillip EcoCentre in the past?

4. What previous or present projects relating to plastic pollution has this organisation worked on?

Clean Bay Blueprint. Program before was called Turn Off the Tap, it was part of the Litter Hotspots Program funded by the previous gov that's where we started the trawls (2015-2017). Then we changed gov and the labor gov came up with the Clean Bay Fund. Neil is doing a lot, working with the scouts. Over the years he has worked on his audits really and the microplastics really. It's all about the data collection and not just cleaning it up.

5. What do you think are the major causes of plastic pollution? If you could, think of the three most major causes. Overconsumption, that's the biggest cause of plastic pollution the more it gets consumed the more it gets into the environment. I think it's about 10% of plastics that get lost into the environment. Sometimes it's wind, birds, garbage people spilling things, people littering, but really the problem is overconsumption. If you can't use it then you can't lose it. Lack of understanding by consumers, on what plastic does, what kind of material it is and what kind of effect it has on the environment. There is a lot of people who throw the plastic in the bin and they don't see it anymore so they think it goes away. There is a lot of education on what the material is, how to handle it properly and the repercussions of what happens if they don't handle it correctly. Industry gets away with the produce produce model that is unsustainable. The attitudes of people and either their indifference in disposing plastics properly or their lack of education on how to properly dispose. There is no difference between natives and visitors because everyone seems clueless.

6. What do you think the main source of this plastic pollution is?  
That's a really hard one. Sources are different for every country, or state, or patch. The biggest source for the bay is what comes out of the Yarra and Maribyrnong. If you are looking at the Yarra and the Maribyrnong well that's what you guys are looking at. In Port Phillip Bay it would be the suburbs of metropolitan Melbourne

and the users of plastic there.

7. If you could, list some environmental or human factors that you think contribute to this pollution. *For example, environmental would be rainfall, wind, elevation and human would be sporting event schedules, flea markets etc.*

I spoke with Ross of Beach Patrol and he told me he sees a spike in pollution at his beach after a nice sunny day or a nice sunny week. Because people go outside and they get lunch or bring a picnic or whatever. I don't necessarily see rain as a cause of it, rain is something that plastic pollution gets moved by. I reckon the nice days are the causes.

8. Do you have any advice for effectively communicating research findings with the public?

Executive summary is the best thing ever. Use normal peoples language, it is so important not to use super industry or science specific words that people don't understand. Think about who your audience is, who is going to see your results, who wants to know about it, who are you going to communicate your findings to. What does my audience need to really fully grasp those contexts. It's really important to know your audience. I think the map is really good because there are a lot of people who are visual learners. I always like to use a combination of visual tools and written things for people with different learning styles

9. Do you recommend that we contact any other people who have knowledge about plastic pollution that may help our project?

Ross Headifen from beach patrol. He is very into beach patrol Australia, he does his own beach patrol and he is a biochemist so he knows everything about plastics. He has a company that produces landfill biodegradable plastic. Carolyn from City of Melbourne. Send me an email to remind me and I will send you her details. You might have to ask her who the right person to talk to is. Also send me an email with

info for the person from Docklands

10. What are your thoughts on plastic pollution in this area?

I think they are very lucky to have a Ecocentre here. The City of Port Phillip does what they can. They are doing a good job, but is it what we need to concentrate on? They spend \$4000 a year to pay people to clean up the beaches with plastics that come from other suburbs. It's just a bandaid because people don't see the reality of what's happening because nobody knows the city does anything about it. The sustainability department used to be really well funded, and then the gov changed everything and now they can't do much of anything now a days. I think the best thing for sustainability they are doing is funding the Ecocentre.

11. Additional questions

Tangaroa Blue's Auditing

Tangaroa Blue is a national organization so they organize audits and cleanups all around Australia (3,000 locations). They are even overseas as well. They have also just launch the app which helps to make it easier. It is the biggest litter database in Australia, possibly in the southern hemisphere. It is well established but that doesn't mean it is suitable to answer every specific scientific research question. For what Neil is trying to do here in Victoria it doesn't give him the information that he wants and that's why he's come up with his own method. There is no single method of counting litter, and it depends on what you are trying to find.

Litter traps or gross pollutant traps that Tangaroa Blue has 19 floating litter traps by Parks Victoria. Some councils have nets that they use to catch pollutants. It works, but you have to deal with lots of organic material. They have to put substantial funding into paying people to empty those and that's where it usually falls flat. I think litter traps are okay as long as you can get it emptied enough times for it to be effective. Microplastics fall through all the holes so its not

helpful for that. And it's kinda putting a bandaid on the issue. In 2051 Melbourne is going to have twice as many people than they do now, and that correlates to twice as much plastic pollution and no amount of litter traps is going to handle that.

## Appendix AF: Interview - Tangaroa Blue

Interviewee: Jodi Jones

If you have any questions or concerns you can contact us at gr-ecoB18@wpi.edu

1. What organisation are you from?

TANGAROA BLUE FOUNDATION Australian Marine Debris Initiative

2. What research does this organisation primarily focus on?

Marine Debris and Litter source reduction

3. Have you or your organisation worked with the Port Phillip EcoCentre in the past?

Not directly

4. What previous or present projects relating to plastic pollution has this organisation worked on?

The Tangaroa Blue Foundation manages the Australian Marine Debris Database and also takes an active role in removal of litter through facilitating clean-up activities across Australia and the south pacific.

5. What do you think are the major causes of plastic pollution? If you could, think of the three most major causes.

Single use plastics being discarded.

6. What do you think the main source of this plastic pollution is?

Single use plastics

7. If you could, list some environmental or human factors that you think contribute to this pollution. *For example, environmental would be rainfall, wind, elevation and human would be sporting event schedules, flea markets etc.*

There is no known source of plastic pollution that occurs. Naturally, humans are responsible for the manufacture of plastic pollution and for the release of the

pollution into the environment. It is important that we recognise that humans are the sole source of plastic and plastic pollution. How the release of plastic pollution occurs is again an act of humans making bad decisions in many different ways. These differ between spaces and places, organisations and events, industries and processes. Natural disasters and weather events can cause plastics to wash up on beaches in greater quantities, but these items need to be already present in the environment, already littered. Often runoff during high rainfall events will carry plastics quickly into the ocean. Some remote areas of Australia are heavily impacted by debris transported via oceanic currents from foreign lands where plastics are treated differently and often dumped. Sporting and community recreational areas often specifically reflect litter data sets for single use food and beverage packaging. Sources of litter range from Individuals, groups to industry practices. It is a diverse and challenging issue to address.

8. Do you have any advice for effectively communicating research findings with the public?

The Tangaroa Blue Foundation, facilitates source reduction workshops and manages source reduction plans that strategically target items of litter by locations. Using data to as a driver for change in practices and for public education.

9. Do you recommend that we contact any other people who have knowledge about plastic pollution that may help our project?
10. What are your thoughts on plastic pollution in this area?

Sadly Plastic pollution is a man made problem that we are only just starting to understand the magnitude of. Action across many spaces and places is needed to divert plastics from our environment.

## Appendix AG: Interview - Boomerang Alliance

Interviewee: Annette Finger

1. What area or business within Victoria do you represent?

Boomerang alliance is not for profit alliance group of 47-48 alliance members. We are Australian, founded in 2003 and have always focused on waste and helping communities moving towards a zero waste community. Container deposit, e waste, mattress recycling, and marine pollution. Communities taking control, going out into communities that are taking control and work together on creating a plastic free community, council, neighborhood, etc. Noosa and Wollongong (NSW) is the pilot project. They have been going gangbusters and replacing so many single use plastics with other alternatives. I think we chose these cities based on the people who were working there. I am the only staff member in Victoria, my campaign is more of trying to get Victoria to adapt a container deposit scheme.

2. Are you aware of microplastic pollution and the existence of it within your area or business?

Yes. One of my daughter's friend at school has a farm near a private beach. Because of the way its situated it gets the current (Cape Liptrap) from Bass Strait but all Port Philip Bay (southwest current) and over the last 5 years he has noticed more and more microplastic pollution on the beach. Clearly its coming from the Port Phillip Bay because only 5 families have access to this beach and they all know each other and are conscious about plastic pollution and that kind of stuff. The high tide line is covered with things. I can show you pictures later. Stephen Price, the project, on TV. He said yesterday that he goes anywhere and never sees any plastic. And I really want to take him to this pristine beach and show him the plastic pollution. Because once you see it you can't unsee it.

3. On a large scale how well do you think councils manage waste? Both public facilities

as well as private rubbish collection, etc.

I think councils are doing a really good job in Victoria. Compared to other states, Victorian councils are doing a great job. But there are jurisdictions in Stal which is 3 hours west from here towards the Grampians. Its more rural area, there is no curbside recycling. There are areas in Victoria that are a bit more remote. The other thing I wanted to say is that while they are good at collecting the recycling, at the moment they are having trouble having those materials actually being recycled and brought back into a circular economy. Because as we know with China not accepting the contaminated waste, and its plunged Victoria into a bit of a recycling crisis. I know my local council is a very progressive council and they are doing a very good job of sorting things out, even things that most people wouldn't collect. They have really passionate people and they are putting so much effort into this depot and they have about 6 months left before they are busting at the seams with recycling and will have nowhere to send, sell, or give away the recycling. Indonesia or Malaysia has announced they are going to do the same as China. Nobody wants our recycling anymore, so we are in a real pickle. And the councils are in a hard situation because they can't just keep increasing rates to store all this recycling until local recycling companies get up and going, or other alternatives exist. This is a real big issues for council at the issue, a lot of councils have called on the government to put in a container deposit program because it takes out most of the glass and what is left in the curbside is cleaner. We need to encourage new recycling business to start up and we need to protect them (through grants or procurement policy so that the products they are producing are actually being sold). We need the pull of consumerism and demand for those products. They need to be protected from oil price crashes when it becomes cheaper to buy virgin plastic than recycled plastic. I think there needs to be a plastic tax on virgin plastic because people think through their hip pocket. The money from that tax can go towards local recycling. The problem is our political

system because someone saying they are going to introduce a tax they don't get elected. I am from the City of Yarra. A drink container (mostly what you would take out of the house, not like milk or wine bottles. Includes water bottles, beer bottles, cans, etc) those get a deposit put on them before they are produced and they will have a stamp or something on them will say container deposit. And when you go to deposit them, it's like a reverse vending machine where you put in your bottles, it totals them up and gives you a docket that can be redeemed for that money or could be donated to charity. And that vending machine sorts everything out by material so you don't get any of that contamination or damaged bottles. In this way the material is more valuable.

4. Are there any plastic use regulations currently in place in your area or business and, if so when were they implemented?

Victoria doesn't have plastic bag ban yet but we have been promised one next year. There is fined against littering. Close the loop for fishing line. Blow bubbles not balloons. There have been a lot more campaigns and education events. Formula 1. Lots of local council stuff about festivals/large public events. There isn't that much, there should be more. We want the bag ban to be written very cleverly so that it can be amended to those people who are producing 36 micron bags. And we reserve the right to add if they are seeing a lot of the thicker bags littered that we can ban those too. We are massively missing a container deposit scheme in Victoria. All the other states have one or are working on getting one. We are the only ones who keep saying Victoria is the cleanest state.

5. What are your thoughts on plastic pollution in this area?

Global issue, on par with climate change. Its gaining more publicity thanks to war on waste, documentaries like plastic ocean, blue (the film, It doesn't just deal with the plastic pollution, it also looks at over fishing, sharks, beach debris and plastic

pollution) Here is my own philosophy behind it. Chemistry is a marvelous thing but those polymers were not meant for this. It's something that nature has no idea what to do with. Because these don't exist in nature, nature has no idea how to incorporate it into their circle of life. We are producing and we keep producing because it's such a marvelous material. Because of its qualities that make it great it's an absolute nightmare in the envi once it gets displaced. The proportion of material being produced as packaging have increased and those are the ones that have entered the waste management area in the same year that they were produced. We cannot keep up with the amount that we are producing in terms of managing the end of life of all these products. That's why we have all these rivers of plastic going into the ocean and once it's in the ocean it's a nightmare to produce. We can learn from the climate change issue. It's getting more and more dire with climate change but we have enough scientific issue to prove that plastic pollution is a problem. Cleaning up alone is not the solution, recycling alone is not the solution, we need to go back to the equivalent to leaving the coal in the ground we need to change something drastically about the way we are consuming plastic. We cannot live without plastic yet. Maybe we can save the 30 years we wasted trying to convince people climate change is an issue and make people do this.

6. What do you think are the major causes of plastic pollution? If you could, think of the three most major causes?

Mostly stuff that comes through the storm water drains isn't it. And that comes from streets. We haven't even started talking about microfibers and microbeads. They are pretty much impossible to get out of our water at water treatment plants. The larger pieces are mismanaged from the consumer to the recycling or the bin. Weather events like what we had last night. There has been some illegal dumping of nurdles, there might be some accidental or semi irrespirable dumping of nurdles. Sure there is people tossing stuff out of the car or going for a picnic and leaving it but I

don't think there is too many of those people. There is commercial and recreational fishing. Overall I would say the largest chunk would be things that get blown out of bins and blow away and end up somewhere in the creek and from there its downhill.

7. Who do you think is responsible for plastic pollution?

We are all responsible I think but we need to get a proper product stewardship responsibility scheme happening. There is a product stewardship on a federal level and it's just went up for submission and they have never received so many submissions as they received this year. Break free from plastic just did brand auditing for what brands contribute to marine litter (just published report a few weeks ago). They need to be held responsible and they are the ones who can afford to pay for it. Ideally whoever produced the product is responsible from the moment its produced until the end of its life. There should be tax on that, people shouldn't have to do these cleanups for free, people should be paid for it. I don't know how you would get that happening, short of a revolution. Product stewardship: some companies are doing quite well; Officeworks is taking back batteries. McDonalds is doing this thing where they have to go around their block and clean up all their litter. There is a certain radius that they have been told that their staff has to go around and clean up. I think it's also councils to come extent, you have all these beautiful restaurants along the harbors and they are all selling single use plastics and stuff and the ocean is right there. There should be some sort of barrier. They should also help businesses transition away from single use plastics. We all have responsibilities not to litter. Schools have a responsibility to instill that education. Europe has banned polystyrene packaging for white goods. The same plant in China is producing white goods and depending on what market its gong to its packaged in polystyrene or cardboard. Why can't we just say we don't want polystyrene and package it all in cardboard. I don't think there is a more damaging material than polystyrene. Yarra blitz is this Sunday. I'm going to be there. They focus on

polystyrene but they find a lot of drink containers, tennis balls.

#### 8. Auditing methods that go on when you do these events

I've audited with Heidi Taylor at the last Yarra blitz. She's incredibly fast with her hand held device. The auditing can be really quite laborious. What we usually do especially when there is a system that picks up a lot of stuff really fast and you have people trying to categorize what is in it. If you can do a subset, say 10% and then extrapolate its really good if you can follow Heidi's system. Heidi is Tangorao Blue which goes into AMDI database which is biggest and best database that we have in Australia. We want to expand that to when we do audits on the streets. The issue is that its laborious and there are a lot of subcategories. And a lot of the things we need to lobby for in legislation is hidden in all these subcategories (straws for example, there are not a category for them). I think it is important for the integrity and reliability of the database that we all do this. One of the issues I've had in my campaigning in gov that I've talked to where they say that Victoria is the least littered state. They are using the national litter index (NLI) which is executed by keep Australia beautiful which is co-funded by Coca-Cola. They go to different sights and all the different states and a fixed number of sites. You would look at it and go awesome, but not so because their numbers are ridiculously low compared to every other organization. I don't know what they are doing but it's not representative of the litter that's actually out there. They can't explain what they have done and people keep referring to this NLI and this number is bogus. They are secret sights and they don't tell you when they go.

#### 9. Spring clean the city

300 volunteers, 2 hours and we went through the city

People were given a little map and they would go and clean up a specific block and then we all collected and put our litter in one location. We sorted out coffee cups and

lids, straws, some tried to do cigarette butts, other cups and lids, drink containers that would be covered under container deposit schemes, other recyclable materials, the rest went into landfill. I've made this chart where you look by volume about what each category makes up. About 7 cubic meters of litter and 1/3 of it was drink containers. The drink containers, people went through and counted by brand at the end. I can get you those numbers and those charts.

We didn't have time to do an audit or even do a subsection. I would like to do that this time. This was the first time we have done this and we really wanted to focus on those 5 main categories of litter we find and we wanted to try and find the volume this makes up. We wanted to use that as a catalyst for action.