

LARGE SCALE DESK STUDY ASSESSMENT OF SKIN AND WOOL PROCESSING SITES WITHIN THE WAIKATO REGION

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Introduction

Waikato Regional Council (WRC) is committed to maintaining a register of known or potentially contaminated sites within the region (the 'Land Use Information Register') which is based on Ministry for the Environment's Hazardous Activities and Industries List (HAIL list). As part of WRC's ongoing programme of work to improve the information held on the register, Tonkin & Taylor Ltd (T+T) were engaged to complete a large scale desk top assessment of the potential for ground contamination from skin and wool processing sites within the Waikato Region.

Skin and wool processing sites are included on the Ministry for the Environment's (MfE's) HAIL list under classification A16 which is described as '*Skin or wool processing including tannery or fellmongery, or any other commercial facility for hide curing, drying, scouring, or finishing or storing wool or leather products*'.

Activities which occur within these industries are known to include the use of a wide range of hazardous substances such as chromium (III and VI), formaldehyde, and cyanide (DOE, 1995; MfE, 2012). Anthrax is also known to have originated from the disposal of animal carcasses at processing facilities overseas; although as far as we are aware no such cases have yet been documented in New Zealand. Many of the chemicals that were used at these sites can present a risk to human health and the environment if not appropriately managed.

WRC has already identified a total of eighteen individual sites on their Land Use Information Register as HAIL activity A16. The level of information held by WRC for each of the sites was variable, ranging from a significant amount of information for some active sites, to uncertainty about the actual location or validity of some historical sites. Most of the sites were no longer operational as skin or wool processing facilities.

This paper includes a brief history of the industry and details of process methods, and associated potential waste products and contamination. The study was undertaken to provide additional information on the operation and use of each of the eighteen sites where A16 activities are known to have, or suspected of having, occurred. The study established the operational dates and the presence of other associated HAIL activities at the individual sites. Importantly, it collated information about where HAIL activities were likely to have occurred for the purposes of narrowing the 'piece of land' identified spatially, which can be used by territorial authorities for implementation of the NES. It also involved an assessment of the potential for contamination and associated imminent or urgent risks to the environment. The study is a good example of how council's registers of contaminated sites can include erroneous historically generated data, which has been collated for different purposes under different policy frameworks. The findings of this study have been used to improve the information held on WRC's Land Use Information Register.

Methodology

A review of environmental setting information was undertaken for each site. The reviewed information included WRC and district planning maps, topographical and geological maps, and the New Zealand Freshwater Fish Database (NIWA, 2013). This information was used to establish surrounding land uses, published geology, groundwater and surface water information, and relevant ecological details, and ultimately to assess potential imminent or urgent contaminated land risks at each site.

A review of site history information was undertaken for each site to establish historical site uses including details of potentially contaminating activities, with particular focus on A16 activities and their locations. Site history sources included WRC files, historical certificates of title, historical aerial photographs, district council property files, and other readily available data sources (online searches, and discussions with industry professionals) for particular sites where additional information was required.

Environmental setting, site history, and potential contamination information was presented in individual 'site summary sheets'. Site sketches were prepared for the sites where A16 activities were confirmed. Where possible, the site sketches showed locations of identified

A16 operational areas. This information was provided to WRC in GIS format for mapping purposes.

A review of published literature was undertaken to establish the history of the industry in both New Zealand and abroad, and identify particular process methods, and associated potential waste products and contamination. A summary of the findings is provided below.

Background to the skin and wool processing industry

The economy of New Zealand (and specifically the Waikato) is, and has historically been, dominated by agriculture. In the early 1970s meat and wool farming comprised more than half of the country's total export income, with the pastoral industry as a whole contributing more than 80% of exports (Ward, n.d.) Consequently, associated industries, including skin and wool processing, have been inherently widespread across the country (Packer et al., 1998). In the UK (and presumably also in New Zealand), higher concentrations of these type of facilities are located in sheep and cattle-rearing areas, where most towns had a slaughter house/abattoir and often facilities for processing the inedible animal products and offal (DoE, 1995). Because the tanning process uses a large volume of freshwater (around 400 L per hide) (ARMANZ and ANZECC 1999), the sites have typically been located near rivers (DoE, 1995).

History

Tanning originally used natural, plant-based tannic acid sourced from tree bark and roots and dates back as early as 400 BC. By the start of the High Middle Ages (11th century) three basic agents were in use; plant extracts, oil, and naturally occurring potash alum. The tanning process began using chromium salts during the 1800s and in 1893 bath chrome tanning began (DoE, 1995). Tanning involving synthetic organic compounds (including phenols, cresols, and later naphthalene) was in use by the early 1900s (DoE, 1995).

Wool was exported from New Zealand as early as 1834, and wool scouring began in Otago in the 1860s as part of the gold rush boom (Bremner, 1985). Wool processing 'mills' were first established in Otago in 1871, before the industry slowly developed in Christchurch (Carter & Macgibbon, 2003) and throughout the rest of New Zealand. The fellmongery and tannery industries began around the same time as wool scouring in New Zealand, with facilities known to have been in operation as early as 1866 (T+T, 2012).

No information regarding the history of the skin and wool processing industry in the Waikato Region specifically was obtained as part of the literature review. However, based on the timing of European settlement and associated cattle and sheep farming operations, it is expected that these industries would have been well established in the region by the late 1800s to early 1900s (The Encyclopedia of New Zealand, n.d.).

Process methods

A summary of the process methods of particular A16 activities including tanning, fellmongery, wool scouring, and wool finishing is provided below. Further details of the process methods are provided in full in the T+T investigation report (T+T, 2015).

Tanning defines the process of converting raw hides and skins to finished leather and, unlike fellmongery, did not always involve the removal of hair or wool (DoE, 1995). The tanning process varies depending on the type of leather produced (ARMANZ and ANZECC 1999). The typical tanning process, according to the DoE (1995), is summarised below.

- 1) *Pre-tanning* is undertaken to prepare the skin or hide for tanning by removing dung, blood, tissue and hair, curing salt, and soluble proteins. Pre-tanning includes degreasing and softening the hide – using solvents for particularly greasy hides (such as sheepskins or pigskins). The hair and epidermis is then dissolved using chemicals such as lime and sodium sulphide (or arsenic sulphide historically). ‘Deliming’ of the hide and pH adjustment is then carried out using weak and dilute acids (typically acidic ammonium and sulphuric acid respectively).
- 2) *Tanning* (or treating) the hide involves the use of an agent to remove water and combine with the collagen fibres to restrict degradation by heat, hydrolysis, and micro-organisms. The tanning agent changes the characteristics of the skin by replacing or modifying the protein structure (Packer et al., 1998). Chromium (III) sulphate (most commonly used in New Zealand) and plant based products are the main tanning agents. Synthetic products are sometimes used together with chromium or plant based agents to provide a particular finish. One other common tanning method is used, which uses formaldehyde and fish oils to produce chamois leather (DoE, 1995). The tanning process previously took place in submerged baths or pits.

However, the modern process uses large vessels which mechanically agitate the hides to accelerate the chemical tanning reactions (DoE, 1995).

- 3) *Post-tanning* (surface coating) is undertaken to achieve the desired nature of the finished product including flexibility, thickness, and appearance. The hides are mechanically trimmed and split to the correct size and thickness. Surface coatings are then applied by pad or spray. The surface coatings include dyes or pigments within a protein or acrylic based binding agent. (DoE, 1995).

Fellmongery, involves a similar process to tanning, but specifically involves removal of hair or wool from the hide and treatment of the skin prior to tanning (NZIC, n.d.). The process involves separation of wool from skin by spraying a solution of sodium sulphide, sodium hydroxide, and/or calcium hydroxide (lime) on to the flesh side of the hide and removing the wool mechanically. The remaining wool and epidermis is then removed using a lime solution. The pH of the hide is lowered, typically using carbon dioxide and ammonium in New Zealand. Skin proteins are then modified or removed and enzymes are used to soften the hide. If required, the hide may be preserved using salt, acids, and pesticides (NZIC, n.d.).

Wool scouring involves washing shorn wool to remove dirt, water soluble contaminants (suint), and wool grease prior to further processing. Although later stages of wool processing is often carried out offshore, around 80% of the wool produced in New Zealand is scoured prior to export (Nicol & Saunders, n.d.). The scouring process conventionally involves passing the wool through a series of bowls, separated by large pressurised squeeze rollers used to minimize cross contamination between bowls. The first series of bowls contain a hot detergent solution (until the 1960s soap and an alkali was used), while the last series are cold rinse bowls. The wool is then bleached, typically using hydrogen peroxide in New Zealand. Bleaching is usually undertaken in the final scouring bowl stages either under neutral or acidic conditions (typically pH 4 to 5, using formic acid). The wool is then put through a drier, in which the bleaching reaction occurs (Packer et al., 1998).

Chemical finishing of wool may involve soaking wool in sulphuric acid, bleaching the wool (if not done previously) using either sodium sulphite, sulphur dioxide, sodium chlorite, or hydrogen peroxide. Moth proofing was historically undertaken using dieldrin. Water repellents (such as silicones or a wax and metallic salt emulsion) are then added.

Mildew proofing is undertaken using copper, chromium, or (historically) pentachlorophenol (PCP), and finally dyes are added to colour the wool (Young, 1965).

Waste products and potential contaminants

In the modern tanning process the tanning solution is recycled and waste effluent is either applied to land, treated in evaporation ponds, discharged to sewer, or disposed to a landfill or liquid waste disposal facility. Solid waste is generally disposed to landfill or composted (ARMANZ and ANZECC 1999).

The pre-tanning process produces reasonably innocuous solid wastes; however, liquid wastes can contain organic matter, salts, grease, and residual process chemicals (such as degreasers/solvents). Waste produced during tanning and wool processing typically comprises liquid effluent with a high biochemical oxygen demand (BOD, around 3 g/l). Some of the effluents are acidic (approximately pH 4) and can contain chromium (III and VI) (DoE, 1995). The effluent can also include pesticides, surfactants, high total dissolved solid (TDS, primarily from curing salt), nitrogen, ammonia, sulphide, sulphate, manganese (ARMANZ and ANZECC 1999) alkalis, and dyes (Packer et al., 1998).

Insecticides (primarily lindane which was used historically) can occur at both fellmongers and tannery sites from use on site as a hide preserving agent or from the import of treated hides. PCP and sodium pentachlorophenoxide (NaPCP) have also been used historically to treat raw hides or as an addition to the preservation solution (DoE, 1995). In New Zealand, acids (typically sulphuric acid) are generally used for preservation of hides prior to tanning (NZIC, n.d.).

Based on the above information, potential contaminants associated with A16 activities are summarised by particular activity in Table 1.

Table 1: Summary of potential contaminants typically associated with HAIL A16 activities

Activity	Potential contaminants
<i>Tanning</i>	<i>Metals and metalloids (arsenic, chromium III and VI, manganese, copper), potassium alum, acids, alkalis, lime, ammonia, nitrate, sulphides and sulphates, formaldehyde, solvents, vegetable oils, fuel oil, oil tans, dye stuffs, binders, enzymes, lacquers, phenols, cresols, naphthalene, salts, pesticides (lindane, dieldrin, PCP, NaPCP), and pathogens</i>
<i>Fellmongery</i>	<i>Acids, lime, salts, ammonia, pesticides (lindane, dieldrin, PCP, NaPCP), enzymes, pathogens, fuel oil</i>
<i>Wool scouring</i>	<i>Detergents, bleaching agents (typically hydrogen peroxide), acids, sulphites, solvents, fuel oil</i>
<i>Wool finishing</i>	<i>Acids, dyes, bleaching agents (typically hydrogen peroxide), sulphites, pesticides (lindane, dieldrin, PCP, NaPCP), copper, chromium, salts, dye stuffs</i>

Results and discussion

This study confirmed that A16 activities have occurred at 11 of the 18 sites which were suspected to have been used for skin and wool processing. No evidence of A16 activities was identified at seven of the sites previously shown on the Land Use Information Register. A16 operational periods and on site locations were established for the 11 confirmed A16 sites based on the reviewed site history information.

All but three of the sites where A16 activities were confirmed showed other HAIL uses. These HAIL uses varied between sites, but most commonly included ‘*storage tanks or drums for fuel, chemicals or liquid waste*’ (HAIL activity A17) and ‘*Waste disposal to land*’ (HAIL activity G5) which are activities associated with the skin and wool processing industry.

All the sites where A16 activities were confirmed are indicated to be currently used for industrial or commercial purposes and no evidence of significant pollution incidents were identified. No particular indication of an urgent or imminent risk to human health or the environment was identified over and above the potential for contaminants associated with skin and wool processing to be present in the ground at the sites. No residential dwellings were identified on the sites where A16 activities were confirmed. However, potential environmental receptors, including streams, rivers and wetlands, are located on or immediately adjacent to many of the sites and there is potential for these receptors to have been impacted by the adjacent A16 activities in terms of contamination.

It is expected that based on the likely commencement of A16 activities in the region (late 1800s to early 1900s), and given that the site history information only dates back to the 1940s (with the exception of historic certificates of title) other unknown A16 sites, not included in this study, may have been present across the Waikato historically.

Conclusion

This study was undertaken as part of ongoing improvements to WRC's Land Use Information Register to provide additional information on the operation and use of 18 known or suspected skin and wool processing sites in the Waikato region. The study was used to also improve existing spatial data to better enable territorial authorities to implement the NES for these sites. Details of the history of the industry, particular process methods, and associated potential waste products and contamination have been established. Site specific information, including operational dates and locations, was confirmed and presented as individual Site Summary Sheets and site sketches. This study confirms that A16 activities have occurred at 11 of the 18 sites, while no evidence of A16 activities was identified for the remaining seven sites. Other HAIL activities were often found to have occurred in conjunction with the confirmed skin and wool processing activities.

No particular indication of an urgent or imminent risk to human health or the environment was identified over and above the potential for contaminants associated with skin and wool processing to be present in the ground at the sites. However, potential environmental receptors, including streams, rivers and wetlands, were identified on or immediately adjacent to many of the sites. There is potential for these receptors to have been impacted by the adjacent A16 activities in terms of ground contamination.

This study is a good example of how council's registers of contaminated sites can include erroneous historically generated data; collated under different purposes. The findings of this study have been used to improve the information held on WRC's Land Use Information Register.

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