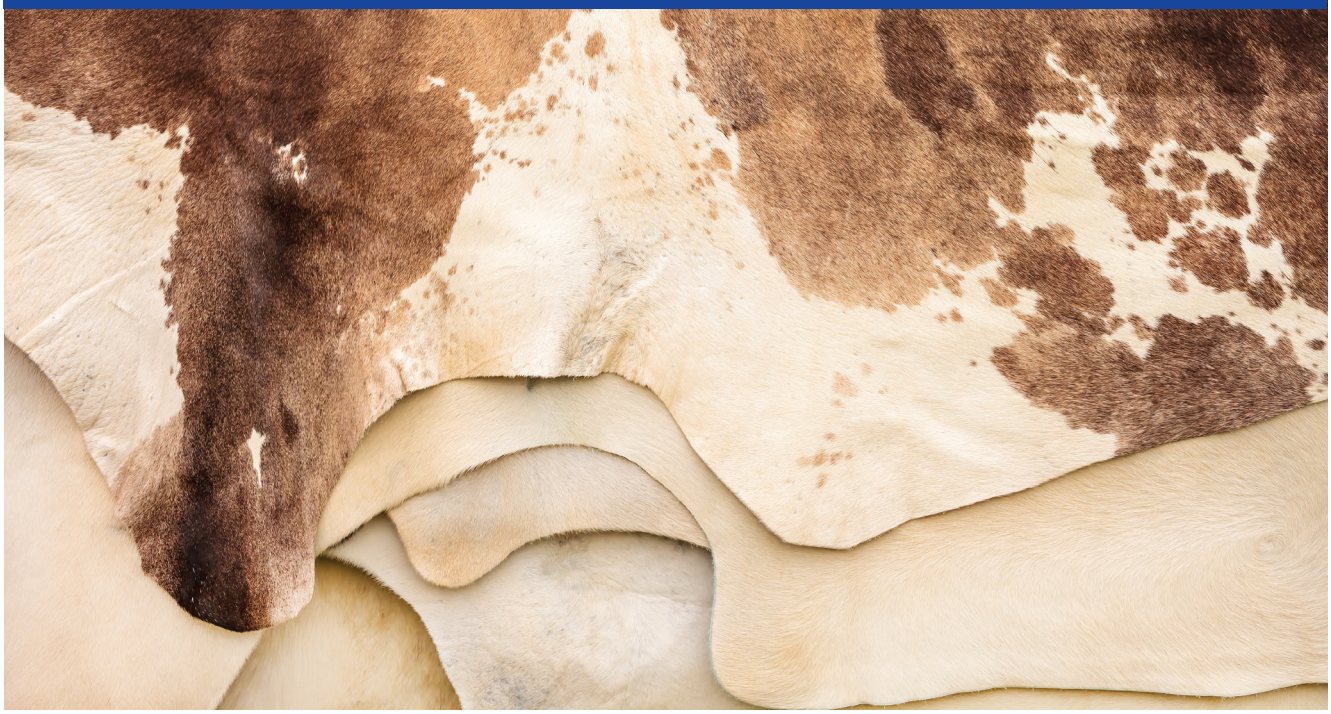
# INDUSTRIAL WATER USE

## National survey highlights how tanneries have stepped up their water game

*The latest in the Water Research Commission (WRC) National Survey (NATSURV) series of reports on industrial water and wastewater management focuses on the tanning and leather-finishing industry. Article by Sue Matthews*



The WRC's association with the tanning and leather-finishing industry dates back to 1977, when it began funding surveys and treatment trials on tannery wastewaters. This was at a time when the tanneries were struggling to meet increasingly stringent standards for discharging effluent into natural watercourses or municipal sewers. Most had been built alongside rivers and streams, from which they could abstract the water they required in large quantities and – prior to the promulgation of South Africa's first Water Act in 1956 – return it as highly polluted, untreated effluent.

The research was conducted by the now defunct Leather Industries Research Institute in Grahamstown, initially in collaboration with Binnie & Partners, which merged with Steffan Robertson and Kirsten (SRK) in 1988. Recommendations emanating from the research were published as a WRC 'technology transfer' report entitled ***Guide to Wastewater Management in the Tanning and Fellmongering Industries*** (**WRC Report No. TT 27/87**), and SRK was subsequently commissioned to undertake the first national survey of the sector's water and wastewater management in 1989, published as NATSURV 10 (**WRC Report No. TT 44/90**).

This exercise has recently been repeated by a small project team led by consulting water utilisation engineer, Chris Swartz. The second edition of NATSURV 10 outlines the changes that have taken place in the tanning and leather-finishing industry over the intervening 28 years, provides information on water consumption and wastewater generation – including typical pollution loads – and gives recommendations on best practices. Tanning has always been a water- and waste-intensive process, but apart from its socio-economic importance in terms of employment, domestic revenue and foreign exchange, it serves a vital function for abattoirs, as pointed out in the report.

"Tanneries play an important role in processing a byproduct or waste from the meat industry, namely the hides and skins," the report states. "Without the tanning industry, these hides and skins would have to be disposed in landfill sites or incinerated. Tanneries therefore solve one pollution problem, but create many others during the processing of hides or skins into leather or partially processed forms of leather."

The term 'hide' refers specifically to the skin of large animals such as cows, oxen and large game, while 'skin' is used for sheep and goats, as well as small game, ostriches, crocodiles and other reptiles destined for so-called 'exotic leather' products. The tanning process can be divided into three main stages:

- Wet blue or fellmongery processing, which converts raw hides and skins into a tanned product known as 'wet blue' or raw sheepskins into pickled sheepskins, respectively.
- Dyehouse operations, which include splitting and shaving skins or hides to a defined thickness, neutralising, retanning, dyeing and fatliquoring.
- Leather finishing, which involves applying a film to the leather surface to give the leather protection and durability for its intended purpose.

The project team found that while the number of operators in the tanning and leather-finishing industry had grown from 20 to 35 since the first survey in 1989, there are actually fewer tanneries today. This is because there has been an increase in the number of facilities that purchase pickled sheepskins or wet blue for further processing, rather than doing the tanning themselves. At the same time, misfortunes in the ostrich and automotive leather sectors have resulted in the closure of a number of wet blue tanneries, although some new ones linked to feedlots have been established.

**NATSURV Reports then and now**

In 1984 the Water Research Commission, in collaboration with the Department of Water Affairs (now the Department of Water and Sanitation), initiated a programme of national surveys (NATSURVs) to determine the water requirements of particular industries, assess their wastewater quality and quantity, and identify research needs to assist them in improving water and wastewater management. The surveys culminated in the publication between 1987 and 1993 of reports on water and wastewater management for the malt-brewing, metal finishing, soft drink, dairy, sorghum malt and beer, edible oil, red meat, laundry, poultry, tanning and leather finishing, sugar, pulp and paper, textile, fruit and vegetable, and pelagic fishing industries. In 2005, two additional reports were produced for the oil refining and power generating industries. In 2013 a process began to update the NATSURV reports and include recommendations on best practices. As of August 2017, nine of these 'second editions' have been published, together with a new report on the iron and steel industry.

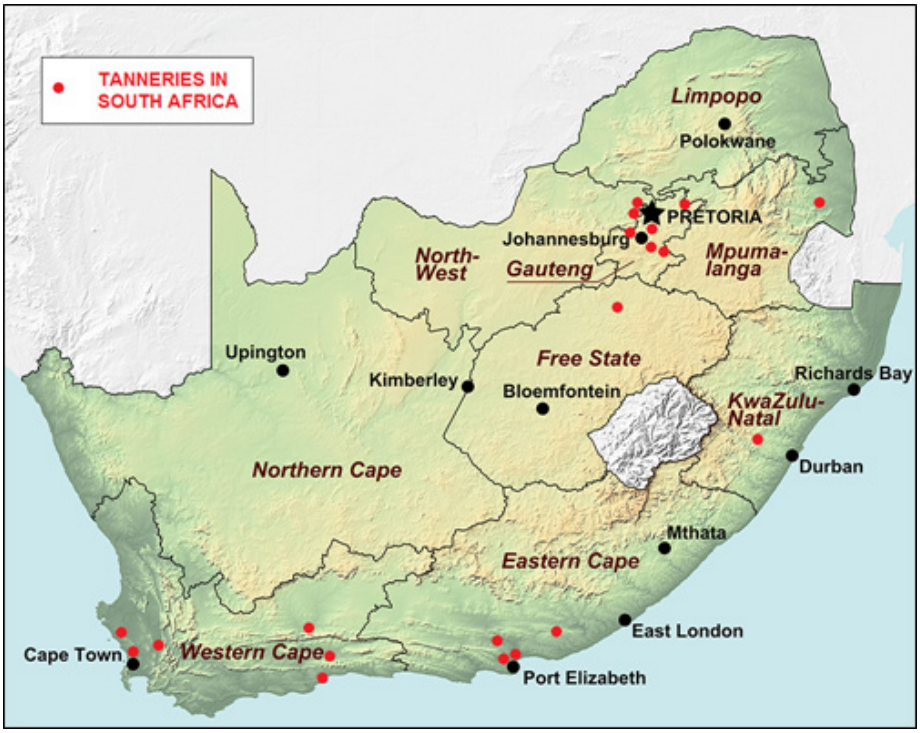
The project team visited 10 tanneries and leather finishers of different size, type and location to gather information. Water consumption data was used to calculate the specific water intake (SWI) – the water intake for a particular period divided by the quantity of hides produced for the same period – which ranged between 170 and 550 litres per hide for the full tanning process encompassing all three stages. This represents a significant improvement from the 320 to 744 litres per hide recorded in the first NATSURV in 1989, but the project team has proposed a target encouraging 'full-house' tanneries to further reduce water consumption and limit SWI to 500 litres per hide.

"Retanning and leather-finishing tanneries consume less water than full-house tanneries because the downstream processes are less water intensive," note the project team. "They also produce less polluted and smaller volumes of wastewater than full-house tanneries."

Considering the various steps and array of chemicals used in wet blue processing, it is not difficult to see why. Traditionally, raw hides have been cured with salt at the abattoir so that they do not start decomposing before their arrival at the tannery. The first step is therefore to soak the hides in water to wash out the salt, as well as dirt and blood. This highly saline water is then drained off and replaced with fresh water dosed with lime and sodium sulphide, which removes hair and epidermis, and opens up the collagen fibres to allow penetration of the tanning agents. This is followed by fleshing, which entails scraping off the fatty tissue on the inside of the hides, and then deliming and bating. Ammonium sulphate is typically used to remove lime and lower the pH for the bating enzymes, which break down proteins and soften the hide.

Next is the pickling step, in which sulphuric acid is added to lower the pH for better penetration of the tanning agents, together with enough salt to prevent damage to the hides from acid swelling. This is the final step in fellmongery processing to produce pickled sheepskins, but tanning requires immersion in a solution containing the tanning agent, with subsequent addition of a weak alkali – usually magnesium oxide or sodium bicarbonate – to raise the pH and ensure the tanning agent binds to the hide. The tanning agent most commonly used in industrial tanneries is chromium, which imparts the characteristic pale blue colour of wet blue. Where alternative tanning agents such as glutaraldehyde, aluminium and zirconium are used instead, the tanned hide is known as wet white because it remains an off-white colour.

*"Retanning and leather-finishing tanneries consume less water than full-house tanneries because the downstream processes are less water intensive. They also produce less polluted and smaller volumes of wastewater than full-house tanneries."*




*Tanneries in South Africa*

Further processing at the dyehouse and leather-finishing stages involves a suite of chemicals too, including those in surfactants, degreasers, dyes, polymers, oils, resins and lacquers. Not surprisingly, then, the combined effluent from all these processes contains high organic loads, high concentrations of dissolved and suspended solids, as well as varying levels of sulphates, sulphides, chlorides and chromium.

Municipalities place restrictions on industrial effluent accepted into their wastewater treatment works, so that they are able to meet the final discharge limits set by the Department of Water and Sanitation. Large volumes of highly polluted industrial effluent could potentially disrupt the biological processes necessary for sewage treatment, or simply exceed the capacity of the wastewater treatment works to reduce particular parameters to within the final discharge limit. The project team found that such restrictions vary considerably between municipalities though. For example, Mossel Bay Municipality requires that the chemical oxygen demand (COD) of inflowing industrial effluent does not exceed 3000 mg/L, while Nelson Mandela Bay Municipality in Port Elizabeth has set the limit at 10 000 mg/L. The limit for sulphates ranges between 250 mg/L set by Oudtshoorn Municipality and 1800 mg/L required by Gauteng's City of Tshwane and City of Ekurhuleni, which both have a chlorides limit of only 100 mg/L, compared to 1500 mg/L at City of Cape Town. And the maximum permissible concentration of chromium varies between 5 and 20 mg/L depending on the municipality.

In an effort to adhere to such restrictions and avoid incurring penalty fees, tanneries treat their effluent prior to discharge to the WWTW. This begins with a pretreatment step, comprising mechanical screening and preliminary settling to remove much of the solids. Primary treatment via physico-chemical processes follows, in which fats are separated out and chemical coagulants and/or flocculants added to facilitate sedimentation of suspended solids in primary settling tanks. This is generally all that is done by operators that purchase wet blue for retanning and leather-finishing, but full-house tanneries also include a secondary treatment step, which involves biological treatment by micro-organisms to further reduce the biological oxygen demand (BOD). The larger tanneries use conventional activated sludge (CAS) systems, operated as completely mixed systems with extended aeration, while smaller ones rely on ponding systems. The treated wastewater is then diverted to the municipal wastewater treatment works, and the sludge – made up of solid matter separated out during the treatment process – is dried in the sun for a few days before disposal at landfills.

*"The tanneries were really good about providing information – even sitting round the same table and comparing notes – so that as an industry they can improve on their effluent quality."*

The project team note that tanneries have made considerable improvements in wastewater management since the first NATSURV. Many have heeded recommendations to segregate the waste streams of beamhouse processes – the initial soaking, liming, unhairing and fleshing – from those of the tanyard so that the effluents can be treated separately. This is important because most of the organic load originates from beamhouse processes, whereas tanyard effluent contains high concentrations of inorganics, including chromium. Chromium is precipitated during primary treatment, but this is inhibited to some degree by organic matter, fats and suspended solids,

which compromises the ability to meet wastewater discharge limits for chromium, and reduces the efficiency of chromium recovery from the sludge for reuse, where this is done.

Furthermore, since the unhairing step uses lime and sodium sulphide, its effluent is very alkaline and contains high concentrations of sulphur compounds. It is preferable to keep this effluent separate from the acidic effluent emanating from the pickling and tanning steps, because hydrogen sulphide will be released if the pH falls below 9.5. This gas not only creates odour problems, but is also toxic and corrosive. Anaerobic or anoxic conditions in wastewater streams likewise result in hydrogen sulphide formation because they create a favourable environment for sulphate-reducing bacteria.

Apart from segregating wastewater streams to improve the quality of the final effluent, many of the larger wet blue tanneries have stopped processing salt-cured hides because the soak water contributes hugely to effluent salinity. Instead they use 'green' hides, fresh from the abattoir – providing it is close by – or chilled hides, cooled rapidly with ice, cold water or blast chillers and transported in refrigerated containers.

"Chilling reduces salt by about 60% in effluent, reduces the water requirement for processing and hence also reduces the wastewater requiring treatment," note the project team. In fact, this kind of relationship applies to all tanning and leather-finishing processes.

"Water use, wastewater generation and cleaner production technologies are inextricably linked, and should be considered holistically by industries seeking to become more sustainable. Reduced water consumption translates into reduced wastewater generation; reduced chemical usage or less toxic chemicals improves wastewater quality."

*The specific water intake of the tanneries surveyed ranged between 170 and 500 litres per hide for the full tanning process – a considerable improvement over the previous survey.*

The final chapter of the report includes various ways of conserving water in the different processing steps and substituting chemicals for those that have less impact on the environment. Of course, plant-derived tannins preceded chromium as tanning agents and are still used today, but the effluent produced from so-called vegetable tanning is dark and turbid, and contains a higher load of poorly biodegradeable COD than chrome-tanning effluent.

In fact, it is interesting to consider that the historical legacy of vegetable tanning in South Africa negatively impacts our water resources on a far wider scale than chrome tanning ever has. The black wattle, ***Acacia mearnsii***, was introduced to this country from Australia in the 1860s and was initially planted for firewood, shade and shelter, but the first plantations were established about 20 years later, after its bark was recognised to be a particularly good source of tannin for leather production. Demand for leather goods during the two World Wars resulted in rapid expansion of the area under plantation, peaking at about 300 000 hectares in the early 1960s. Today, black wattle plantations cover some 110 000 hectares and commercial emphasis has shifted from bark to timber, but the species has proven to be an aggressive invader. The National Invasive Alien Plant Survey, published in 2010, indicates that the area covered by invasive populations of black wattle is just under 475 000 condensed hectares – if density estimates are adjusted to the 100% cover equivalent – making it the plant species with the most extensive invasions. According to a recent paper by Le Maitre et al. (2016) in the WRC's journal, ***Water SA***, this implies that black wattle accounts for a third of the estimated 1 444 $m^3$/yr reduction in water flows due to invasive alien plants!

The findings and recommendations of the NATSURV report have already been shared at three stakeholder workshops in Gauteng, KwaZulu-Natal and the Western Cape, and will also be presented at upcoming leather industry conferences. Dr Jo Burgess, the WRC Research Manager overseeing the NATSURV reports, says that this was one of the easier surveys in terms of getting data from the industrial stakeholders.

"The tanneries were really good about providing information – even sitting round the same table and comparing notes – so that as an industry they can improve on their effluent quality," she remarks. "This highlights the point that the better the participation from the industry, the more value the NATSURV will be to that industry in providing them with information they can use to their own advantage."


To order the report, ***Water and wastewater management in the tanning and leather finishing industry: NATSURV 10*** (2nd edition) (**WRC Report No. TT 713/17**), contact Publications at tel: (012) 761 9300; email: orders@wrc.org.za or visit: www.wrc.org.za to download a free copy.