# Dairy Biosecurity Risk Profile

## June 2006

# 1 Executive Summary

The potential conveyors, pathways for the spread of foot and mouth disease through the dairy industry in New Zealand, and their significance, are described. The scientific literature is reviewed to determine the amount of foot and mouth disease virus present and its survival in milk, the impact of control measures such as pasteurisation, and the role of the dairy industry in previous outbreaks of foot and mouth disease throughout the world. Major knowledge gaps are identified including the evaluation of the effect of commercial processing and large milk quantities from infected and uninfected cows on FMDV, the efficacy of double HTST treatment in reducing levels of FMDV in milk, and the importance and characteristics of aerosols of milk produced during tanker and silo filling in the spread of FMDV.

Five pathways resulting in potential exposure of susceptible animals to FMDV were identified during the collection of milk, and 9 pathways during the processing of milk on a dairy-processing site. Of these, 2 were determined to represent a significant risk: feeding leftover milk samples to animals, and feeding of untreated waste (separator sludge) to pigs. 5 pathways were determined to have a remote risk, and 7 negligible risk of spreading FMDV. 5 processes/products with one or less 'kill step' for FMDV during processing were identified: milk collection and transport, initial milk processing, retail cream, butter (Fritz method), and waste and effluent. Options to manage risk, both before and during a response to an outbreak of FMD, are presented. Industry sites should use this information to prioritise exotic disease response planning, starting with the highest risk pathways.

# 2 Contents

# 3 List of Tables and Figures

# 4 Glossary

| | |
|---|---|
| Fomites | Inanimate object or material on which disease-producing agents may be conveyed, eg faeces, bedding, harness |
| $ID_{50}$ | Infectious dose of FMDV resulting in disease in 50% of animals exposed to that dose |
| pfu | Plaque forming unit – number of infectious virus particles per unit volume |
| FMD | Foot-and-mouth disease |
| FMDV | Foot-and-mouth disease virus |
| CIP | Cleaning in Place |

# 5 Introduction

## 5.1 Scope and Methodology

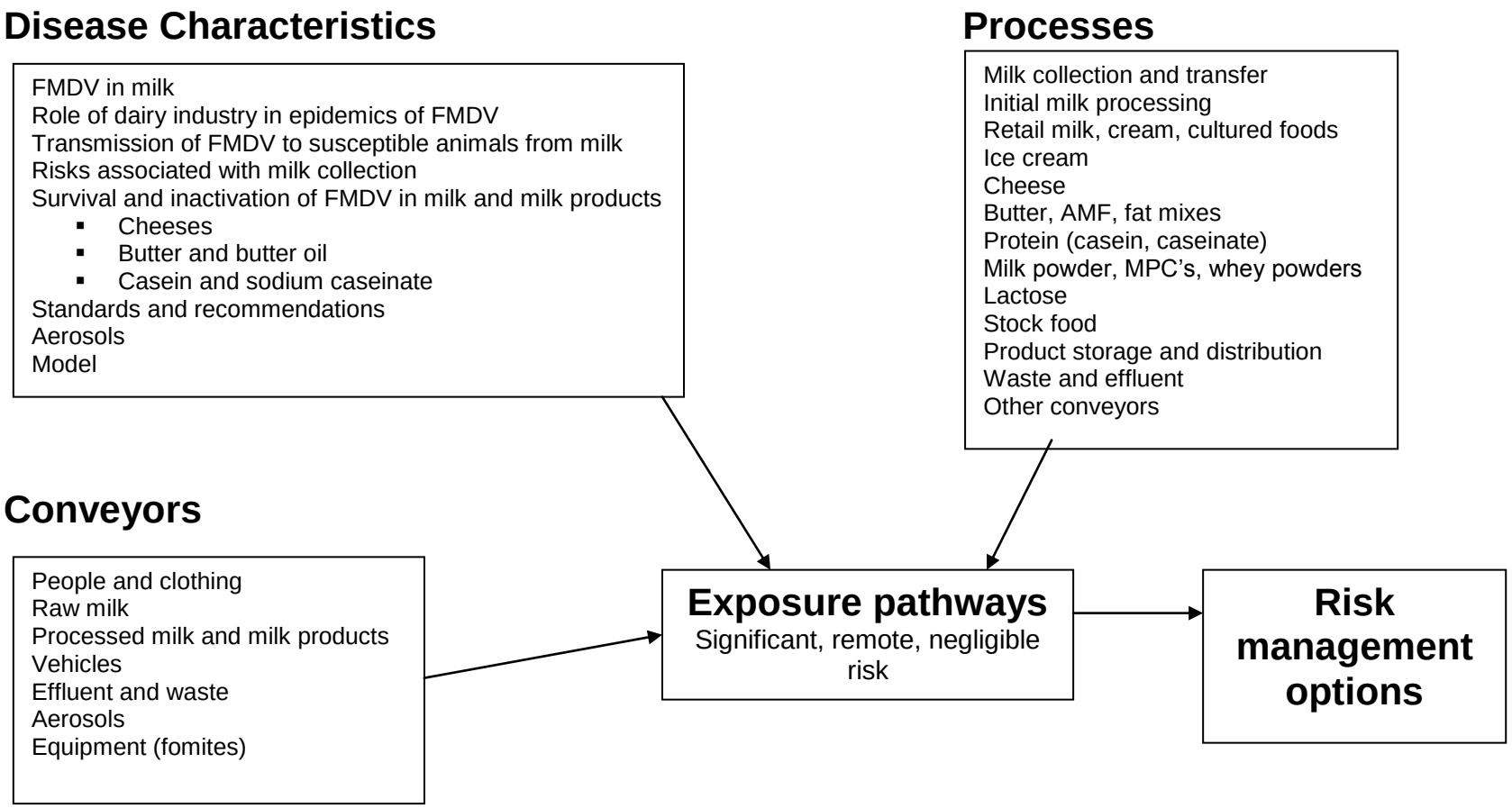
This Risk Profile will determine the risk associated with the spread of Foot and Mouth Disease Virus (FMDV) in cow's milk and products derived from cow's milk, beginning at the point the dairy tanker picks up milk and ending with the finished product and its potential use. Where milk is processed on the farm on which it is collected, the risk will be evaluated from the point milk enters the factory for processing.

The Risk Analysis methodology described by Murray (2002) will be adapted as a basis for the examination of risk. An exposure assessment will describe the biological pathways necessary for exposure of susceptible animals to infection with FMDV, estimate the likelihood of such exposure occurring, and identify measures to mitigate the risk of exposure. The analysis will be largely qualitative, using quantitative data where available to inform or illustrate the results. Important knowledge gaps will be identified.

Consideration of risks on dairy farms (other than milk collection or on-farm factories), within other animal milk industries (eg goat milk), bioterrorism, ingredients added to milk products, or of imported milk products are excluded from this analysis. Milk collected for feeding to calves on another farm is excluded as this activity does not involve the dairy processing industry and will be managed under existing procedures for tracing and surveillance during an outbreak of FMDV. Risks associated with people will be restricted to those directly involved with the dairy processing industry, such as milk tanker drivers and farm service staff employed by dairy processing companies, and farmers visiting a processing site to collect waste or product to feed to animals.

An overview of how the risk profile is structured is shown in Figure 1.

**Figure 1. Risk Profile Overview**



## 5.2 Industry Sector under Consideration

### 5.2.1 Industry size and characteristics

The National Dairy Statistics for 2004/05, published on the Livestock Improvement Corporation's website (all websites are listed in Appendix 12.1), provide the following statistical detail about the New Zealand dairy industry.

Between 1 June 2004 and 31 May 2005, dairy companies in New Zealand processed 14.1 billion litres of milk, and 1.21 billion kilograms of milk solids, a 3.3% decrease on the previous year.

At June 2006, there were 76 dairy processing sites recorded in the Processing Industry Response Procedures, 49 in the North Island and 27 in the South Island (see maps, Appendix 12.2). A regional breakdown is given in Table 1. Also recorded are transport companies contracted to the industry to collect and transport milk (10 not directly associated with a processing company, plus Fonterra transport and Toll Rail), and laboratories processing milk samples.

| Location | Number processing sites (%) | Number dairy herds (%) | Number dairy cattle (%) |
|---|---|---|---|
| **North Island:** | **49 (64.5%)** | **10,010 (81.6%)** | **2,804,190 (72.5%)** |
| Northland | 6 (7.9%) | 1118 (9.1%) | 285,040 (7.4%) |
| Auckland/Waikato/Bay of Plenty | 24 (31.6%) | 5700 (46.5%) | 1,642,855 (42.5%) |
| Central | 19 (25%) | 3192 (26%) | 876,295 (22.6%) |
| **South Island:** | **27 (35.5%)** | **2,261 (18.4%)** | **1,063,469 (27.5%)** |
| Marlborough Nelson and West Coast | 9 (11.8%) | 657 (5.4%) | 208,905 (5.4%) |
| Canterbury | 13 (17.1%) | 654 (5.3%) | 402,201 (10.4%) |
| Otago/Southland | 5 (6.6%) | 950 (7.7%) | 452,363 (11.7%) |
| **Total** | **76** | **12,271** | **3,867,659** |

**Table 1. Descriptive statistics for the New Zealand Dairy Industry by Region**

Table 2 shows the volume of milk received at Fonterra sites during the peak of the season.

| Raw milk received/day at peak (litres) | >10 million | 5-10 million | 1-5 million | 500,000-1 million | >500,000 |
|---|---|---|---|---|---|
| Number of sites | 3 | 1 | 13 | 1 | 3 |

**Table 2. Milk received/day at peak (Fonterra sites)**

The number of dairy herds reduced by 480 to 12,271 between 2003/04 and 2004/05. Average herd size has more than doubled over the past 20 years to reach 302 in 2003/04, and 315 in 2004/05. There were more than 3.8 million dairy cows grazed

on 1.41 million total effective hectares of land. 82% of dairy herds and 73% of dairy cows are located in the North Island (see Table 1).

The average dairy cow produced approximately 3570 litres of milk, including 176 kg of milkfat and 132kg of protein during an average lactation length of 265 days. Monthly production peaked in October at 21.15 litres per cow per day. The industry in New Zealand is highly seasonal, the main calving occurring in spring and herds drying off in the autumn. Herds producing milk for the domestic market usually have two calving periods, in the spring and autumn, and produce milk all year.

### 5.2.2 Processing

Fonterra dominates milk processing and collection in New Zealand. The company has more than 19,000 employees and 12,000 farmer shareholders, processes more than 14 billion litres of milk and produces >1000 product ingredients, totalling 1.8 million tonnes of product annually. Products include milk and whey proteins, milk powders, cream products, cheese and cheese ingredients. Fonterra is responsible for a third of international trade in dairy product. Fonterra was formed in 2001 when farmer shareholders voted for a merger between Kiwi Co-operative Dairies Limited and The New Zealand Co-operative Dairy Company Limited, incorporating the New Zealand Dairy Board.

Other companies include Tatua Co-operative Dairy Company Limited (138 farmer shareholders, 100 million litres of milk processed per year), Westland Milk Products New Zealand (370 farmer shareholders, 350 million litres of milk processed per year) and smaller companies, ranging from those collecting and processing several thousand litres of milk per day to on-farm dairies milking less than 10 cows. There are a number of companies that purchase milk from Fonterra for further processing.

### 5.2.3 Exports

New Zealand exported $5.879 billion of dairy products in the year ended June 2004, from total agricultural exports of $13 billion (MAF website). The breakdown of products is given in Figure 2:

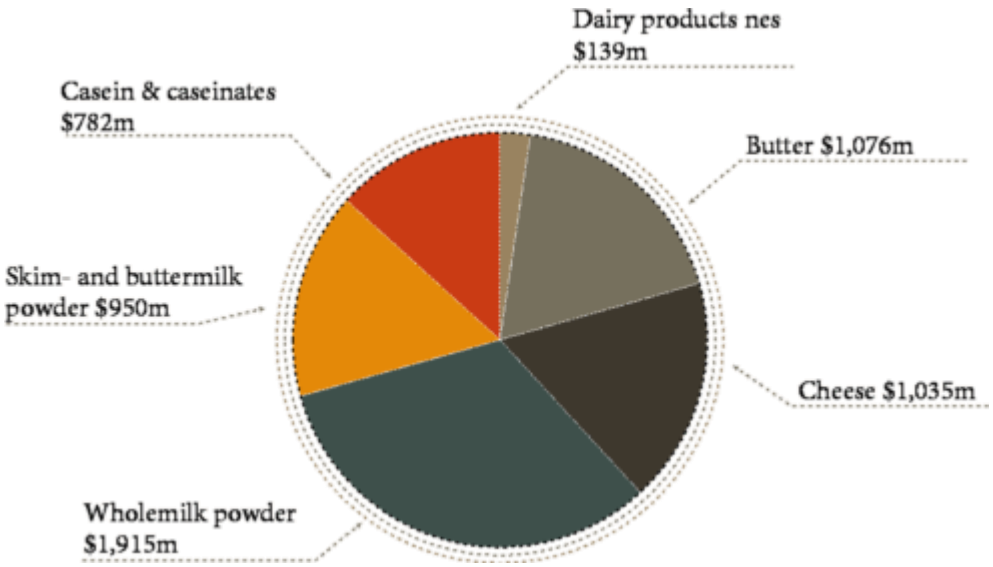



**Figure 2. New Zealand's Dairy Exports ($NZ million fob, MAF website)**

# 6 Disease Under Consideration

## 6.1 Agent

The agent under consideration is Foot and Mouth Disease Virus (FMDV), an aphthovirus within the Picornaviridae family (Geering, Forman and Nunn 1995: Sanson 1994). There are seven serotypes of FMDV: A, O, C, SAT1, SAT2, SAT3 and Asia 1, which can be further divided into approximately 60 subtypes. Types can be differentiated by serological tests, and infection or vaccination with one serotype will not confer immunity against another.

## 6.2 New Zealand's Status

New Zealand's animal health situation with regard to foot and mouth disease was described by Peter Thomson (2005):

- New Zealand has never had a case of foot and mouth disease
- Vaccination for foot and mouth disease is not and has never been permitted
- New Zealand does not allow the importation of risk goods from countries with foot and mouth disease
- The Ministry of Agriculture and Forestry investigates all suspected cases until foot and mouth disease has been ruled out
- New Zealand is a developed country with a highly educated farming community and rural veterinary infrastructure.

New Zealand is recognised by OIE as one of 57 'FMD free countries where vaccination is not practised' (OIE Website).

## 6.3 Epidemiology/Agent Characteristics

### 6.3.1 FMDV in milk

FMDV can be released in the milk of infected cows up to 4 days before the onset of clinical signs (Burrows 1968, cited by Sanson 1994). Milk collected from bottles, churns, farm bulk tanks and bulk tankers before disease had been diagnosed in animals contained infective FMDV (Hedger & Dawson 1970). Levels of FMDV detected in the milk of 6 clinically normal cows during an outbreak at Hamstead Farm, Isle of Wight, in 1981 ranged from $10^{0.7}$ to $10^{6.6}$ $ID_{50}$/ml, and a bulk milk sample contained $10^{2.2}$ $ID_{50}$/ml (Donaldson et al 1982). 50ml of that bulk milk would be sufficient for oral infection of a pig, and approximately 0.1ml could cause infection in sheep, pigs or cattle via the respiratory route.

6 cows that were exposed to pigs inoculated with FMDV excreted detectable levels of virus in milk 1 to 7 days after exposure, and the virolactia persisted for 7 days. Viral excretion was detectable usually 1-2 days prior to clinical symptoms developing, with maximum infectivity titres of $10^{2.3\text{-}5.4}$ pfu/ml one to three days after onset of virolactia followed in 2 cases by a second peak on day 6 or 7. Virus is present in highest

concentrations in sedimented debris, followed by cream and skim milk (Blackwell et al 1982). Blackwell et al (1982) also suggested that replication by progeny virus in infected secretory epithelial cells of the mammary gland occurred after the milk had been collected, resulting in a temporal increase in virus titre.

Milk from one of 400 retail pint bottles of untreated milk distributed by 21 retailers over South Cheshire and North Shropshire had a virus titre of $10^4$ $ID_{50}$ per ml and therefore contained more than five million infective doses (Hedger & Dawson 1970).

Donaldson (1997) identified several factors reducing the quantity of FMDV in milk:

1. Hypogalactia (milk production may reduce by 30-50% on the day lesions are first seen (Burrows et al 1971));
2. A high degree of surveillance of milking animals making it improbable that all cows would be infected before disease is detected, resulting in dilution of milk from infected with that from uninfected animals on a farm;
3. Dilution with milk from uninfected farms in the tanker;
4. Further dilution with milk from uninfected farms, and filtration to remove coarse particles, at the processing site.

### 6.3.2 Role of the dairy industry in epidemics of FMDV

Donaldson (1997) described an outbreak attributed to the movement of infected milk including calves in transit that were fed infective milk leading directly to 101 new outbreaks during the 1951-52 UK epidemic (citing Brooksby 1959). Dawson (1970) investigated outbreaks of FMDV in Shropshire during the 1967-68 UK epidemic and found that 24.8% of premises visited after collection of milk from a 'source premises' contracted disease, and that movement of 'infective' milk from 25 infected premises may have resulted directly in 22 subsequent outbreaks of disease. Hugh-Jones (1976) subsequently showed that for random infections generated by his spatial simulation model, 21% could be attributed to movement of milk lorries on the basis of timing of infection and order of visit of the lorry and concluded that much of the infection attributed to milk lorries by Dawson could be due to other factors. During an outbreak of FMDV in Denmark in 1982, milk tanker spread was implicated in 3 of 22 IPs (13.6%) before filters were attached to tanker air outlets and portable sprayers supplied (Westergaard 1982). The milk lorry/tanker was the reported cause of spread for 16 of 2,365 IPs (0.7%) during the 1967-68 UK epidemic (Tinline 1972), and the most likely method of spread for 11 of 1849 cases (0.6%) detected by mid-July during the 2001 epidemic in Great Britain (Gibbens et al. 2001). Tinline also reported that 10 IPs (0.4%) in the 1967-68 UK epidemic were caused by feeding contaminated milk to pigs.

These studies suggest that milk and tankers can spread FMDV during outbreaks, but are not the most important method of spread. The importance of transmission of FMDV by milk in New Zealand is likely to be lower than reported elsewhere as the method of milk collection reduces exposure to susceptible animals to a minimum, and there is discussion about the relative importance of vacuum (UK) and pumping (New Zealand) methods of emptying the vat in the creation of potentially infectious aerosols. The use of filters on the air outlets of milk tankers to reduce the amount of FMDV escaping while the tanker is filling has been advocated in both Australia and New Zealand to reduce the risk of transmission. In New Zealand, filters for this purpose are not readily available, and for those that are available their effectiveness in filtering FMDV has not been evaluated.

### 6.3.3 Transmission of FMDV to susceptible animals from milk

Sellers (1971) described three methods by which susceptible animals could be infected with FMDV from milk:

- inhalation of aerosols from milk splashes;
- drinking the milk, or;
- contamination of people (or their clothing) with milk who subsequently handle animals.

Sellers (1971) thought it not unreasonable that an infectious dose via the respiratory route ($10^1$ $ID_{50}$) could be achieved when milk is splashed. Direct contact with the muzzle, mouth or udder, and damaged epithelium would be required to transmit infection from contaminated people to susceptible animals (Donaldson 1997).

Sanson (1994) identified two mechanisms by which milk could spread FMDV: feeding raw milk to susceptible animals, and movement of milk tankers.

There is also the possibility that people could inhale infected milk resulting in nasopharyngeal carriage of FMDV. Sellers, Hernimann & Mann (1971) experimentally demonstrated that people exposed to infected animals, followed by showering and changing of clothing then close contact with a susceptible animal (coughing and breathing into the muzzle of cattle), could transmit infection.

### 6.3.4 Risks associated with milk collection

A number of spread mechanisms related to milk collection during the British epidemic of 1967-68 were postulated by Dawson (1970):

1. Spillage or leakage of infected milk on route or at a collection site; and
2. Contamination of the vehicle, the vehicle driver, or equipment carried on the vehicle by infected milk;
3. Milk collection usually requires the tanker to enter the farm increasing the probability of contact between the driver, the vehicle and the animals;
4. Spillage of milk remaining in the connecting pipe on subsequent farms;
5. Dip stick measurement of volume of milk collected contaminates the driver and clothing; and
6. Displacement of air during tanker filling and agitation resulting in the creation of infective aerosols.

In the New Zealand situation, all of these mechanisms are relevant except for the dip stick measurement of milk volume (measured electronically). Additional risks in the New Zealand context include exposure to susceptible animals following spillage of milk during accidents, either from tankers or trains, and sample collection, transport and disposal.

### 6.3.5 Survival and inactivation of FMDV in milk and milk products

Callis et al (1975) identified 4 important factors for the survival of FMDV in milk and milk products:

- Initial concentration of virus in the milk or product
- Storage temperature
- Bacterial content of the milk
- Hydrogen-ion concentration (pH).

FMDV can survive in milk for up to 7 days at 18°C, and up to 15 days at 4°C (Hedger and Dawson 1970, citing Galloway 1931).

Inactivation of FMDV in milk subjected to a range of temperatures and pH changes is biphasic, with an initial phase of rapid inactivation followed by a period of protracted inactivation (Sellers 1969, Donaldson 1997). A temperature or pH resistant FMDV fraction has been detected when treated product was injected into animals. This is a very sensitive method of detecting small quantities of FMDV, but an improbable method of infection for farmed animals with the exception of products incorporated into pharmaceutical preparations (Donaldson 1997).

Sellers (1969) added FMDV to milk and measured the reduction in virus concentration at various combinations of time, temperature and pH, in a laboratory environment. The combinations required to achieve a 99.999% reduction in quantity of FMDV are shown in Tables 3 & 4.

| Temperature | pH 6.7 | pH 7.6 |
|---|---|---|
| 56°C | 6 minutes | 30 minutes |
| 63°C | 1 minute | 2 minutes |
| 72°C | 17 seconds | 55 seconds |
| 80°C | <5 seconds | <5 seconds |

**Table 3. Time and temperature to achieve 99.999% FMDV inactivation in milk (Sellers 1969)**

| pH | 4°C, HCl or NaOH |
|---|---|
| 2.0 | 1 minute |
| 4.0 | 2 minutes |
| 5.5 | 30 minutes |
| 5.8 | 18 hours |
| 11.0 | 2 hours |
| 12.0 | 2.5 minutes |

**Table 4. Time and pH to achieve 99.999% FMDV inactivation in milk (Sellers 1969)**

It was postulated by Sellers (1969) that the initial rapid phase of inactivation was of free virus, and the protracted phase due to FMDV present in and protected by cells. The pH of milk from cows infected with foot-and-mouth disease may vary from 6.7 to 7.7, but the effect of increased pH on FMDV infectivity after heat treatment of milk at a farm or bulk collection level would be reduced by dilution with milk from uninfected cows and farms.

FMDV can survive in milk for 7 days at 18°C and up to 15 days at 4°C (Hedger and Dawson 1970, citing Galloway 1931). Milk harvested in New Zealand must be cooled to 7°C within 3 hours of milking and held at less than 7°C until collection or the next milking (MAF Standard D104.1, "Milk Cooling", NZFSA), milk is usually collected within 24 hours of harvesting (maybe up to 48 hours when production is low), and transported to the factory within another 24 hours. FMDV is likely to survive with minimal reduction of titre in raw milk under these conditions.

One of the findings commonly quoted is that for milk at pH 6.7 (the typical pH of New Zealand milk) and a temperature of 72°C, 99.999% of virus is inactivated in 17 seconds. This finding is used as the basis for asserting the efficacy of pasteurisation (75°C for 15 seconds) for inactivation of FMDV. We can find no research carried out

in milk obtained from infected cows or on a commercial scale to support this finding. Much of the research has been carried out on milk or milk products to which FMDV has been added, not milk derived from infected cows. Some research uses milk from infected cows, but makes no allowance for dilution with milk from uninfected cows, which would be expected in an outbreak of FMDV, and is processed using laboratory equipment on a small scale.

#### 6.3.5.1 Cheeses

Schjerning-Thiesen (1979) added FMDV to milk and made cheddar cheese (final pH 5.8) and camembert (final pH 5.2). No infectivity was detectable following inoculation of unweaned mice with a preparation of the cheddar after 14 days and camembert after 3 days. Blackwell 1976 (cited by Tomasula and Konstance 2004) manufactured cheddar, mozzarella, and camembert cheeses with milk from infected cows. Inoculation of steers with cheddar cheese produced from raw or subpasteurised milk was able to transmit FMDV even at a final curd pH of 5.1. FMDV also survived camembert processing at a pH of 5.2 after 21 days, but not after 35 days. No infectivity was demonstrated in mozzarella. FMDV was also detected in sweet whey from a preparation of cheddar and camembert cheeses. Donaldson (1997) cites further work by Blackwell, where FMDV survived in cheddar cheese produced from infected milk that was not preheated, at pH 5.0 for 60 days, but not 120 days.

#### 6.3.5.2 Butter and Butter Oil

Butter and butter oil was made from milk collected from cows between 1 and 4 days post-inoculation with FMDV. Samples of the butter and butter oil were able to infect cattle via inoculation into the tongue epithelium up to 45 days after manufacture, despite heat treatment of the cream (93$^{o}$C for 16s), a mean pH of 5.9, and a final pH of 5.4 after 45 days (Blackwell 1978). Blackwell did not put forward any hypotheses about why FMDV should survive under these conditions, however Blackwell and Hyde (1976) found that FMDV survived heating cream at 93$^{o}$C for 15 seconds and suggested that butter fat was protective.

#### 6.3.5.3 Casein and Sodium Caseinate

Cunliffe and Blackwell (1977) used milk from cows preclinically infected with FMDV, and added FMDV to uninfected milk, to make casein and sodium caseinate. They demonstrated that cattle could be infected with FMDV via inoculation into the tongue epithelium with suspensions prepared from casein and sodium caseinate. Survival of FMDV in the products was suggested to be due to protection of FMDV within casein micelles.

### 6.3.6 Standards and recommendations

OIE (the World Organisation for Animal Health) specify the following treatment requirements when importing milk or milk products from FMD infected countries or zones with an official control program, from herds or flocks not suspected of infection with FMD (Figure 3):

*Article 2.2.10.25.*

*When importing from FMD Infected countries or zones where an official control programme exists, Veterinary Administrations should require:*

***for milk, cream, milk powder and milk products***

*the presentation of an international veterinary certificate attesting that:*

*1. these products:*

*a. originate from herds or flocks which were not infected or suspected of being infected with FMD at the time of milk collection;*

*b. have been processed to ensure the destruction of the FMD virus in conformity with one of the procedures referred to in Article 3.6.2.5. and in Article 3.6.2.6.;*

*2. the necessary precautions were taken after processing to avoid contact of the products with any potential source of FMD virus.*

*Article 3.6.2.5.*

***Milk and cream for human consumption***

*For the inactivation of viruses present in milk and cream for human consumption, one of the following procedures should be used:*

1. *a sterilisation process applying a minimum temperature of 132°C for at least one second (ultra-high temperature [UHT]), or;*
2. *if the milk has a pH less than 7.0, a sterilisation process applying a minimum temperature of 72°C for at least 15 seconds (high temperature - short time pasteurisation [HTST]), or;*
3. *if the milk has a pH of 7.0 or over, the HTST process applied twice.*

*Article 3.6.2.6.*

***Milk for animal consumption***

*For the inactivation of viruses present in milk for animal consumption, one of the following procedures should be used:*

1. *the HTST process applied twice;*
2. *HTST combined with another physical treatment, e.g. maintaining a pH 6 for at least one hour or additional heating to at least 72°C combined with dessication;*
3. *UHT combined with another physical treatment referred to in point 2 above.*

**Figure 3. OIE treatment specifications for milk and milk products for FMDV (OIE, viewed 23 March 2006)**

We have found no evidence in the literature to support the effectiveness of double HTST for the inactivation of FMDV.

In the Australian review 'Persistence of Disease Agents' (Williams 2003) it was concluded that milk from infected herds should be heat-treated. The AUSVETPLAN Foot and Mouth Disease Strategy, Version 1, Edition 3 specifies the following requirements for management of milk and dairy products (Figure 4):

> *2.2.6 Treatment of animal products/by-products*
>
> *An extremely cautious approach to the salvage of animal products and by-products will be required.*
>
> *Milk heated to 75°C for 15 seconds or 135°C for one second may be used for any purpose except for feeding (as whole milk, other products, by-products or waste) to susceptible livestock.*
>
> *Appropriate filters should be fitted to the air exhaust of milk tankers operating in the RA (Restricted Area) and CA (Control Area).*

**Figure 4. Ausvetplan requirements for managing milk and dairy products during an outbreak of FMDV**

Tomasula and Konstance (2004) concluded from their review that measures should be implemented to prevent spread of FMDV in raw milk, and that only pasteurised milk should be fed to animals.

Sanson (1994) determined that for New Zealand, the risks associated with milk tanker spread will be slight once precautions such as filtration systems attached to milk tanker air outlets, drivers wearing waterproof clothing and carrying disinfection equipment for themselves and any spills, and the ability to trace infected milk along tanker routes and through factories were in place. While the traceability of milk in New Zealand is very good, the practical application of filters on tankers and measures taken by tanker drivers has not been tested.

### 6.3.7 Aerosols

Aerosol production during collection, transport, unloading and movement of milk through a dairy processing plant is a potential means of exposure of susceptible animals to FMDV. Donaldson (1973) found that FMDV added to milk and aerosolised under laboratory conditions retained a reasonable level of viability for 60 minutes at 55% relative humidity after an initial reduction. Some work has been done to assess the viability of bacteria in milk aerosols, which showed that it was possible to recover bacteria from aerosols, we have found no evidence of similar experiments for viruses.

There is very little research reported on the importance of aerosols from the dairy industry in spreading FMDV. It is likely that aerosols are created during the filling of milk tankers on farm. For this to result in infection in a new herd, the tanker must have:

- collected milk from an infected herd;
- travelled to another, currently uninfected farm;
- collected milk at that farm causing aerosols of milk containing FMDV from the infected farm to develop ;
- been parked close to a group of susceptible animals so the aerosol virus reaches them in high enough concentration to cause infection.

Information to determine the minimum distance animals should be from the tanker when it is filling is not available.

According to Donaldson (1986), aerosols produced during filling of milk tankers are unlikely to represent a serious hazard for the spread of FMDV. Kitching (pers. comm.) refers to the spread of FMDV associated with milk tankers during both the 1967-68 and 2001 outbreaks, and considers that the most likely route of infection was aerosols created during milk collection. He also cites circumstantial evidence from the Middle East that cattle became infected with FMDV via aerosols produced at a nearby dairy factory processing infected milk. He recommends the use of risk mitigation measures to prevent spread of FMDV via milk aerosols during milk collection on farm and from silos at the factory.

### 6.3.8 Model

A simple spreadsheet model has been developed to determine the amount and concentration of virus and infectious volume of raw milk for cattle, sheep and pigs for variable numbers of lactating cows infected with FMDV. Fixed parameters used in the model are:

- milk viral concentration of $10^{5.7686}$ $ID_{50}$/ml, the average of 6 infected cows from which milk samples were collected (Donaldson et al, 1982).
- infectious doses for susceptible species (Table 5).
- 99.999% inactivation of virus following pasteurisation at 72$^{o}$C for 15 seconds (Sellers 1969).

Parameters that may be varied to suit the analysis are:

- Tanker or silo volume
- Average daily milk production per infected cow
- Number of infected cows contributing milk to the tanker or silo

Outputs of the model are the number of $ID_{50}$'s produced, $ID_{50}$'s per litre in the tanker or silo, and the amount of milk required to constitute an infectious dose for cattle, sheep or pigs, via oral or respiratory infection, before and after pasteurisation. The model will be used to provide input to the risk analysis, and to help determine the effectiveness of processing in reducing the risk.

Table 5 shows the infectious dose of FMDV by species and route of infection (oral or respiratory), and the amount of milk from an infected cow this represents. For example, for a pig to become infected via the oral route, it would need to ingest 8000 $ID_{50}$, equivalent to 0.01ml of milk from an infected cow.

| Species | Infectious dose ($ID_{50}$) | Amount of milk from infected cow for one $ID_{50}$ (ml) | Reference |
|---|---|---|---|

| | | | |
|---|---|---|---|
| Cattle – oral | 1,000,000 | 1.7 | Sanson (1994) |
| Cattle – respiratory | 12 | 0.00002 | Sanson (1994) |
| Pigs – oral | 8000 | 0.01 | Sanson (1994) |
| Pigs – respiratory | 20 | 0.00003 | Sanson (1994) |
| Sheep – oral | 158,489 | 0.27 | Kitching (personal communication) |
| Sheep – respiratory | 10 | 0.00002 | Sanson (1994) |

**Table 5. Infectious dose of FMDV and amount of milk from an infected cow containing an infectious dose**

# 7 Conveyor Definitions

Conveyors are things capable of transmitting infection from an Infected place to another place. Those of importance to the dairy risk profile include:

## 7.1 People and clothing

Persons in contact with milk, milk products, or effluent and waste derived from the dairy processing industry, and their clothing that may come into contact with milk or milk products. Includes factory staff, tanker drivers, contractors and maintenance staff and farmers collecting waste for feeding to animals.

## 7.2 Raw milk

Milk that has not been subjected to any form of treatment or processing.

## 7.3 Processed milk & milk products

Milk and milk products that have been subjected to treatment such as separation, heat and/or pressure. Includes products destined for stock food.

## 7.4 Vehicles

Vehicles associated with the dairy processing industry, including milk tankers, milk trains, and farm service vehicles.

## 7.5 Effluent and waste

All waste and effluent generated within the scope of this risk profile. Includes effluent and waste generated from washing and cleaning processes at a dairy reception or processing site, and waste and effluent resulting from milk transfer or the manufacturing process.

## 7.6 Aerosols

A colloid system in which solid or liquid particles are suspended in a gas (Blood & Studdert, 1988). Airborne particles generated during milk collection and processing.

## 7.7 Equipment (Fomites)

Inanimate objects or materials on which disease-producing agents may be conveyed (Blood & Studdert, 1988), eg feeding equipment, clothing. For the purposes of this analysis people, clothing and vehicles are considered separately from other equipment or fomites due to their significance in the dairy industry.

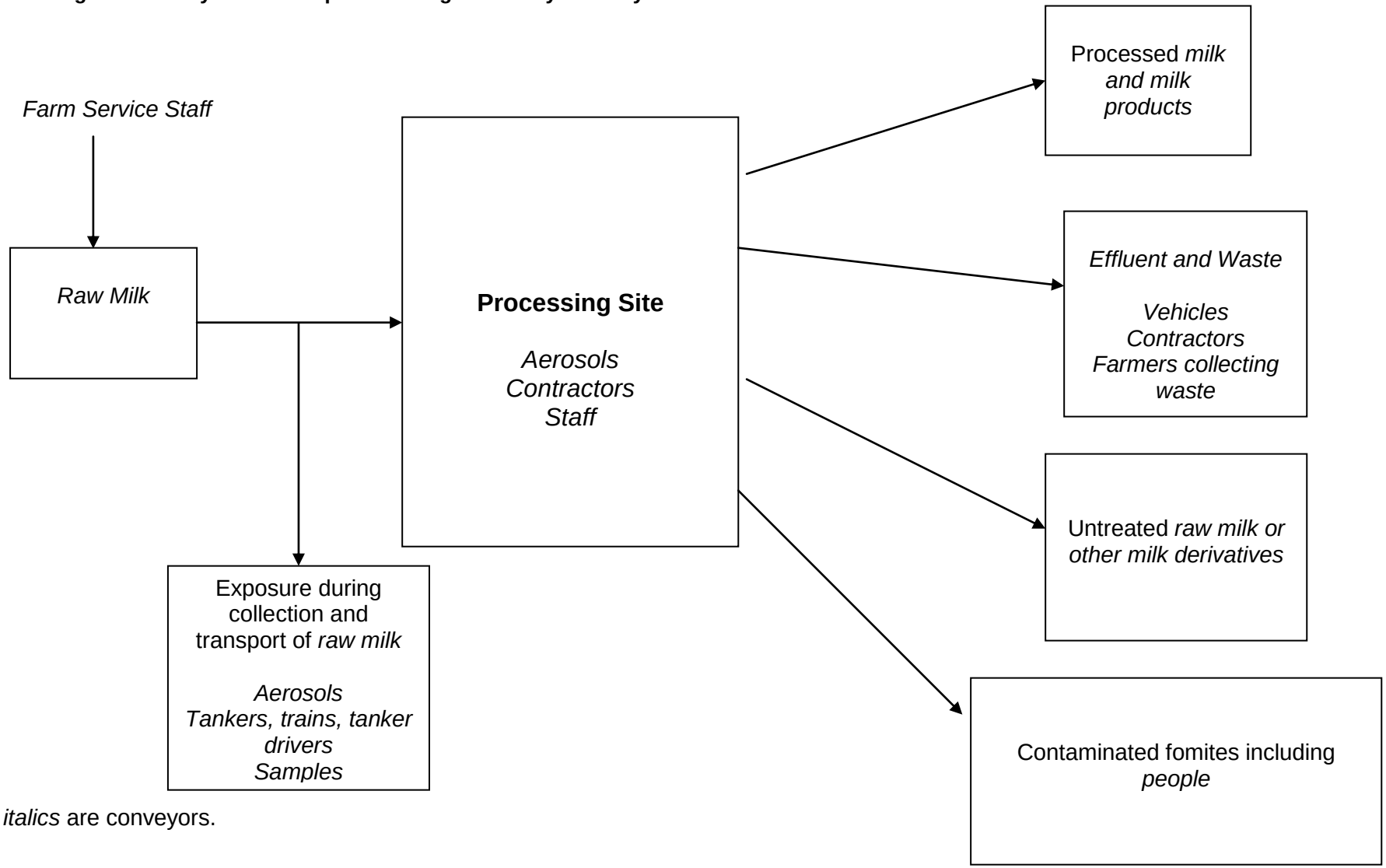
# 8 Biosecurity Risks Determination

This section will describe the biological pathways along which conveyors can transmit FMDV to susceptible animals in the dairy industry. Industry processes will be examined to describe important conveyors, treatment steps within the process, and the level of risk remaining at the end of the process. This will be a basis for evaluation of risk and recommendations for risk management in Section 9.

## 8.1 Biological Pathways

Conveyors of FMDV, by definition, are a potential risk for the infection of susceptible animals. The risks for each conveyor will be described and the level of risk for each exposure pathway (Figures 20 & 21) will be assessed to provide an overall picture of the risk associated with the dairy industry. An overview of the biological pathways and conveyors that could potentially spread FMDV in the dairy industry is in Figure 5.

**Figure 5. Biological Pathways for FMD spread through the dairy industry**




Items in *italics* are conveyors.

### 8.1.1 People and clothing

People rarely become infected with FMDV. They can act as fomite conveyors when skin, clothing or footwear become contaminated with FMDV. The virus can survive in the nasopharynx for short periods of time and under experimental conditions can be transmitted to susceptible animals (Sellers, Herniman & Mann, 1971).

When people leave the factory or farm there is the potential for susceptible animals they contact to be exposed to FMDV, for example people living or working on farms. There is also a risk that people could contaminate product that has been treated before it is sealed into its final packaging.

Farm service staff, staff who live or work on farms, and farmers who pick up waste product to feed stock visit farms and may travel between farms, potentially contacting susceptible animals. There is a risk that they, their clothing and equipment could become contaminated with infectious material (saliva, faeces, milk) and transfer infectious material to another farm, or contaminate people who may contact susceptible animals or treated product. Very close contact with an animal's muzzle, mouth or udder, and damage to the epithelium of these tissues, would be required to transmit FMDV in this way (Donaldson 1997).

A scenario is examined where a person and/or their clothing is splashed with 20ml of milk from the vat of a 315 cow herd, producing an average of 21.15 litres per cow per day, with 5 infected cows. A decay rate of log $10^{4.2}$ per hour at 40% relative humidity (Donaldson 1986) is used, however this is likely to be a conservative estimate as the effect of desiccation on viral survival as the milk dries would be expected to increase the rate of decay (at 60% humidity the rate of decay is $10^{0.6}$ per hour). Using the model the number of $ID_{50}$'s via the oral route for each species over time is shown in Table 6:

| | 10 min | 20 min | 30 min | 40 min |
|---|---|---|---|---|
| Cattle | 0.0 | | | |
| Sheep | 0.2 | 0.0 | | |
| Pigs | 4.7 | 0.9 | 0.2 | 0.0 |

**Table 6. Number of $ID_{50}$'s remaining over time after a milk splash onto clothing**

The amount of virus remaining on clothing after 10 minutes will not be sufficient to result in infection in cattle or sheep, however a splash as described could be infectious to pigs for up to 20 minutes. The risks are multiplied as the number of infected cows or the volume of milk splashed increases, for example a splash volume of 20ml would remain be infectious to a pig for up to 20 minutes, but a splash of 100 litres would only be marginally infectious for pigs by the oral route at 60 minutes. Evaporation of the splash will only contain water, not virus, therefore infection via the respiratory route is not possible (Kitching, personal communication).

The number of infectious doses will be reduced where transfer of contaminated material to another person's clothing or contamination of treated product occurs. This is not likely to result in an infectious dose being present on the clothing or product.

Sellers, Herniman and Mann (1971) found that FMDV could be transmitted from humans (after examination of infected pigs, showering and changing clothes) to cattle through sneezing, snorting, coughing and breathing at their muzzles for 30

seconds. Using the same scenario as before, a person inhales 0.1ml (2 small drops) of milk into their nasopharynx. A rate of reduction of $10^{1.8}$ log units per hour is used (Sellers 1970). Using the model the number of infectious doses remaining in the nasopharynx over time is shown in Table 7:

| | 0 min | 10 min | 20 min | 30 min | 40 min | 50 min | 60 min | 70 min |
|---|---|---|---|---|---|---|---|---|
| Cattle | 37.1 | 18.6 | 9.3 | 4.7 | 2.3 | 1.2 | 0.6 | 0.3 |
| Sheep | 93.2 | 46.7 | 23.4 | 11.7 | 5.9 | 3.0 | 1.5 | 0.7 |
| Pigs | 2.3 | 1.2 | 0.6 | 0.3 | 0.1 | 0.1 | 0.0 | 0.0 |

**Table 7. Number of infectious doses remaining over time in the human nasopharynx**

After inhaling 0.1ml of infected milk, a person could be infectious via the respiratory route for cattle for approximately 50 minutes, sheep for 60 minutes, and pigs for 10 minutes.

This analysis could be considered a worst case scenario where prolonged and unusual contact with animals is required to initiate infection, and will be affected by the volume of milk splashed or inhaled, the amount of FMDV in the milk, and the rate of decay of infective virus. In summary, people who have been exposed to milk infected with FMDV via splashes (Table 6) should avoid immediate contact with susceptible animals (particularly pigs) until the splash has dried, clothing has been changed or the splash disinfected, or a suitable period of time has elapsed (dependant on the volume of milk splashed, 30 minutes should be adequate). People who have inhaled an aerosol of (potentially) FMDV infected milk (Table 7) should not have contact with susceptible animals for a period of at least 1 hour. Basic biosecurity measures, such as disinfecting splashes and spills, should be implemented by tanker drivers to reduce risk and to demonstrate good biosecurity practice.

### 8.1.2 Raw milk

Susceptible animals may be exposed to raw milk through ingestion (intentional or accidental) or inhalation.

Risks are associated with milk collection, transfers of raw milk between factories, leaks and spills during collection and processing, feeding of raw milk (and waste or milk products containing raw milk) to susceptible animals, and the collection, transportation, testing and disposal of samples by laboratories.

Processing of raw milk into product involves treatment steps that will be evaluated in Section 8, to determine the effect of treatment on the final level of risk for the product. For products such as stock food or waste (that may be fed to susceptible animals), evaluation of risk will include consideration of the high likelihood of exposure to susceptible animals.

Using the spreadsheet model, the milk from one infected cow can make a 26,000 litre tanker of milk highly infectious for cattle, sheep and pigs (less than 1 ml required to initiate infection via the respiratory route).

Table 8 shows the amount of milk (ml) required to initiate infection assuming 1, 5 or 20 infected cows contributing milk to one 26,000 litre tanker load of milk (using the model, Section 6.3.8).

| | Number of infected cows | | |
|---|---|---|---|
| | **1** | **5** | **20** |
| Cattle oral | 2094 ml | 418 ml | 104 ml |
| Cattle respiratory | 0.03 ml | 0.005 ml | 0.001 ml |
| Sheep oral | 332 ml | 66.4 ml | 17 ml |
| Sheep respiratory | 0.02 ml | 0.004 ml | 0.001 ml |
| Pigs oral | 16.8 ml | 3.9 ml | 0.84 ml |
| Pigs respiratory | 0.04 ml | 0.008 ml | 0.002 ml |

**Table 8. Amount of milk required to initiate infection**

If the milk of 5 infected cows is in a 26,000 litre tanker load of milk, a pig would need to drink 3.9ml of the milk to receive 1 $ID_{50}$ of FMDV, and would receive 10 $ID_{50}$ if 390 ml was ingested.

The mechanisms by which raw milk could initiate infection in susceptible animals are described in Section 8.

### 8.1.3 Vehicles

Dairy tankers and trains carry raw milk, which is a conveyor of FMDV. Tankers can spill milk on the farm track, on the road, or at the factory. Trains can create spills at loading, on the tracks or at the factory. They may be involved in accidents resulting in large quantities of milk being spilt, potentially exposing nearby susceptible animals. Train tracks can run through farms, therefore if the tanker spills milk of a sufficient volume to create a milk puddle in a nearby paddock, there is an opportunity for susceptible animals to be exposed. The risks associated with spills are the same as the risks for raw milk, except the virus could be expected to deteriorate more rapidly when exposed to environmental conditions.

Tankers can also become contaminated with faeces when travelling on farm tracks and carry potentially infectious material to other farms, although it is a general rule of the industry that animals do not graze or enter tanker tracks. The number of farms visited by a tanker per trip has reduced from an average of 8 in the early 1990's (range 1-22), to 5.39 (range 1-11, median 5) in November 2004 (during the peak of collection in the Waikato) (R Sanson, pers. comm.). Information from Fonterra (Figure 6) for the 2005/06 season show that an average of 4.8 farms were visited during one tanker trip, and the average tanker collected 5.6 loads of milk per day, for a combined average of almost 27 farm visits per tanker per day (23.5 – 28.5). An average of 336 trucks were deployed per shift (247 – 404).

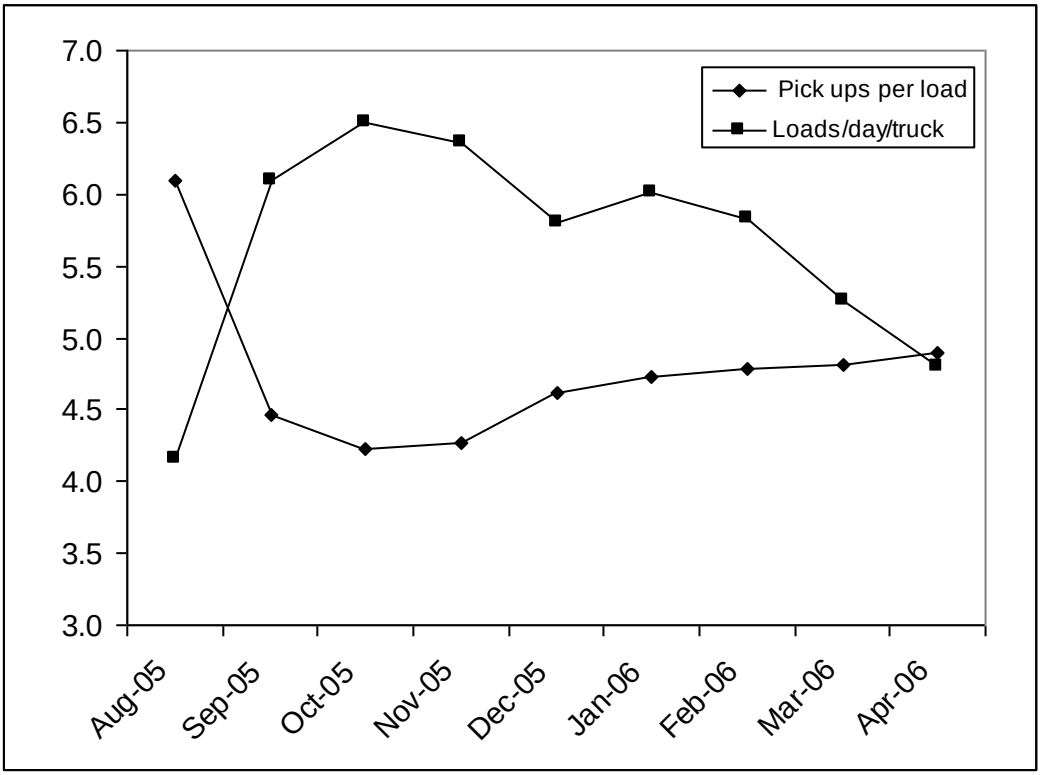



**Figure 6. Number of tanker loads per day and number of pick ups per load (Fonterra)**

Farm service staff travel to and between farms. Their vehicles may become contaminated with infectious material when driven onto a farm, or when contaminated people, clothing or equipment contact the vehicle.

Vehicles transporting stock food from the factory to farms, for example Proliq, may spread FMDV in the product or through contamination of the vehicle (Section 8.6.2.5).

Factory service vehicles, for example contractors vehicles, may become contaminated with raw milk (Section 8.1.2) or infectious material such as faeces brought onto the site by other vehicles or people. These vehicles may travel to farms or contact susceptible animals.

Courier vehicles transport raw milk samples to laboratories. The samples should be securely packaged minimising the chance of breakage or leaks. Unexpected events such as accidents may result in spillage (Section 8.3.4).

The maximum concentration of FMDV in bovine faeces as reported by Sellers (1971) is $10^{5.5}$ $ID_{50}$ per gram (citing Parker 1971). Cattle would need to ingest approximately 3 grams, or inhale 0.04 mg, of bovine faeces to receive an infectious dose (Table 9).

| | Oral (grams) | Respiratory (milligrams) |
|---|---|---|
| Cattle | 3.2 | 0.04 |
| Sheep | 0.5 | 0.03 |
| Pigs | 0.03 | 0.06 |

**Table 9. Amount of bovine faeces containing one $ID_{50}$**

Parker (1971) found that virus titre in cattle faeces reduced by 1 log in 2 weeks, 2 logs in 3 weeks, and 3 logs in 6 weeks. FMDV survives well in bovine faeces.

Therefore faecal contamination of vehicles, clothing or people present a risk if they transmit infected faecal matter to susceptible animals, either orally (contamination of foodstuffs or licking/nuzzling contamination) or by inhalation (using high pressure hoses to clean contaminated surfaces, faecal matter flicking off tyres as the tanker travels up the tanker track adjacent to susceptible animals).

### 8.1.4 Dairy Processing Site Effluent

Effluent from processing sites is derived from cleaning and washing, and will contain some raw milk. It also contains chemicals used for cleaning (often very high pH), and will be diluted in a large volume of water. The effluent may be disposed to watercourses, the sea, or sprayed onto pasture.

Effluent is derived from all areas of a dairy factory. The risk will depend upon the proportion of raw milk, characteristics of the effluent (pH for example), dilution, and disposal method.

### 8.1.5 Dairy Processing Site Waste

Waste product, such as sludge from separators, waste milkfat extracted from fat traps, and whey may be collected for feeding to susceptible animals, particularly pigs. Product that cannot be sold for human consumption may be diverted to stock food and possibly reworked, or disposed of for example by burial.

Waste that is fed to animals is a potential pathway for the spread of FMDV infection. If the waste has received no heat or other treatment, the risks will be the same as for raw milk (Section 8.1.2). If the waste has been subjected to some form of treatment the risk may be reduced. The level of risk reduction will depend upon the treatment.

Waste may be buried in or near sites where susceptible animals graze. There is a risk the animals will become exposed to the product through their own activity, or if scavengers move product from the burial site to the grazing animals. The risk will depend upon the level of treatment the product has received and the effectiveness of burial. These activities are monitored by local authorities.

### 8.1.6 Aerosols

Dairy tankers, trains, and on-site silos are filled with large volumes of milk, requiring the displacement of equivalent volumes of air. The displaced air is under pressure and potentially will contain aerosols of raw milk. The level of risk from aerosols will depend upon:

- the amount of air released
- the volume of milk released as aerosol
- the concentration of FMDV in the milk
- atmospheric conditions determining the dispersal of the plume, and the survival time of FMDV
- the proximity and density of susceptible animal species.

Aerosols released within buildings may potentially be incorporated into product when for example air sourced from buildings is used in product transfer systems.

## 8.2 Exposure Assessment

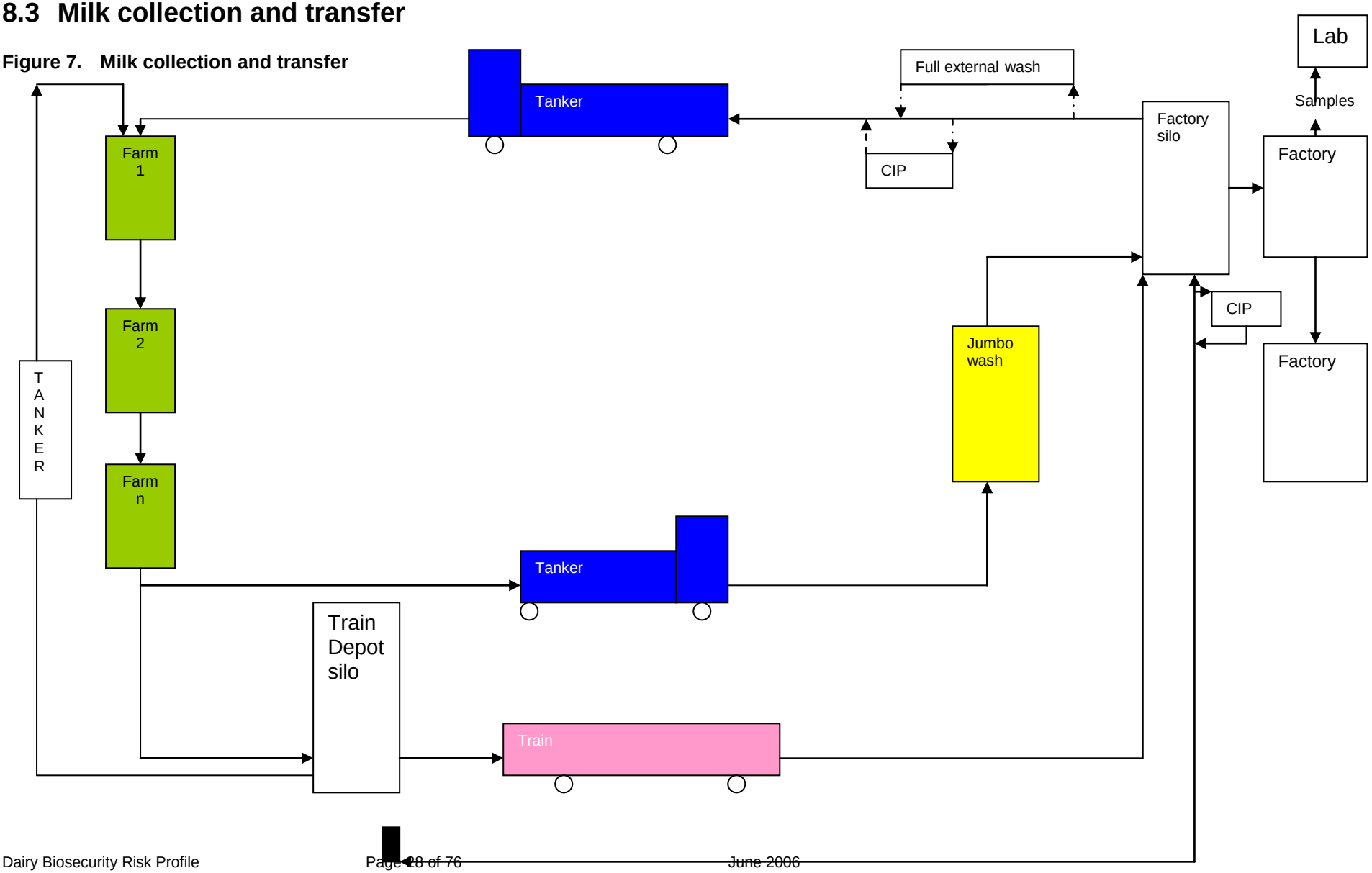
Process descriptions are given for:

- milk collection and transfer (Section 8.3)
- processing and manufacture of major milk products (Section 8.4)
- product storage and distribution (Section 8.5)
- waste and effluent (Section 8.6)
- other conveyors (Section 8.7).

Each process will be evaluated to determine potential routes for exposure of susceptible animals to milk or milk products, and the effect of treatment steps that reduce infectivity of milk. The results of the exposure assessment are summarised in Table 10.

## 8.3 Milk collection and transfer

**Figure 7. Milk collection and transfer**



### 8.3.1 On-farm collection

#### 8.3.1.1 Scope

This process begins when the tanker enters the farm to collect milk from the vat into the tanker, and ends when the tanker leaves the farm.

#### 8.3.1.2 Dispersal Potential (Risk Evaluation)

Raw milk from cows infected with FMD is very infectious for susceptible animals. The milk from one infected cow can render a whole tanker load of milk infectious (less than 0.05 ml is enough to infect cattle, sheep or pigs via the respiratory route).

Potential routes of transfer include aerosol from the tanker during milk pumping, spills and leaks, contaminated drivers contacting susceptible animals during milk collection or at home after a shift has ended, and susceptible animals having access to a contaminated tanker during milk collection. Tankers can also become contaminated with other infectious materials (eg faeces) and transport these to other farms.

Traceability of milk from the farm to the factory by Fonterra is facilitated by computerised systems requiring drivers to enter a supplier number before they can begin to pump milk out of the farm vat, and recording date, time, and volume of milk collected. This information is available centrally for tracing purposes.

### 8.3.2 Transport to factory

#### 8.3.2.1 Road

#### 8.3.2.1.1 Scope

This includes all times the tanker is on the road, between farms, and between the factory and the farm(s).

#### 8.3.2.1.2 Dispersal Potential (Risk Evaluation)

The routes of potential dispersal include aerosol, spills and leaks, and accidents releasing milk into an environment where an infectious episode could occur if susceptible animals come into contact with them. Tankers and drivers may be contaminated with faecal and other material containing FMDV and spread the infection to new farms.

#### 8.3.2.2 Rail

#### 8.3.2.2.1 Scope

Included in this process are the risks associated with transfer of milk from the tanker to the silo, transfer from silo to train, transport on the train to the factory, and unloading at the factory.

#### 8.3.2.2.2 Dispersal Potential (Risk Evaluation)

A large amount of milk is transferred around New Zealand by rail, for example during the peak of the season (October/November) a train travels 4 times daily from Oringi

to Fonterra's Whareroa site at Hawera carrying up to 800,000 litres of milk per trip in 16-20 rail tankers each containing 50,000 litres.

The routes of potential dispersal include aerosol, spills and leaks, and accidents releasing milk into an environment where susceptible animals could come into contact with them. Rail tracks often travel through farmland, so spills, leaks aerosols can be in close proximity to susceptible animals. Transfer of milk from tanker to silo and silo to train could expose susceptible animals in the vicinity of the silo to aerosols or spills.

Maintenance of traceability of milk from farm, to silo, to train, to factory, is very important for tracing purposes.

### 8.3.3 Inter-factory transfers

#### 8.3.3.1 Scope

Includes all transfers of raw milk between factory sites, where milk is transferred from silos to be transported to another site.

#### 8.3.3.2 Dispersal Potential (Risk Evaluation)

The potential routes of dispersal include aerosol, spills and leaks, and accidents releasing milk into an environment where susceptible animals could come into contact with them. Where milk from an infected cow was involved in an inter-factory transfer, both factory sites would be considered infected.

Maintenance of traceability of milk from farm, to silo, to tanker, to factory, is important for tracing purposes.

### 8.3.4 Sample collection

#### 8.3.4.1 Scope

Includes all steps between collection of samples on farm to the disposal of milk after laboratory analysis has been completed.

#### 8.3.4.2 Dispersal Potential (Risk Evaluation)

Samples are collected for analysis of milk composition (protein and fat), somatic cell counts, and residues (such as antibiotics). Samples are collected during milk collection on farm, identified to the farm of origin by bar code labels stored on farm, and returned to the factory when the tanker unloads its milk. The samples are couriered to the laboratory for analysis.

After testing, samples are disposed of by various means including treatment at a processing plant, or landfill. Samples may be forwarded to other laboratories for further testing or calibration.

At the Livestock Improvement Corporation (LIC) laboratory which processes raw milk samples, milk remaining after analysis is collected for feeding to calves. Records are kept detailing how much milk was collected, by whom and the date to facilitate traceback.

## 8.4 Processing

The major processes are described and examined for potential routes of exposure to susceptible animals in Sections 8.4.1 – 8.4.9.

Milk processing in New Zealand is governed by the Animal Products Act 1999. Milk processing areas are defined by three levels:

- Level 1 – outside the processing plant (eg milk reception areas);
- Level 2 – inside the processing plant, areas where there is raw milk (eg milk treatment), or treated (pasteurised) milk that is fully enclosed and not exposed to the environment;
- Level 3 – inside the processing plant where treated milk is exposed to the environment.

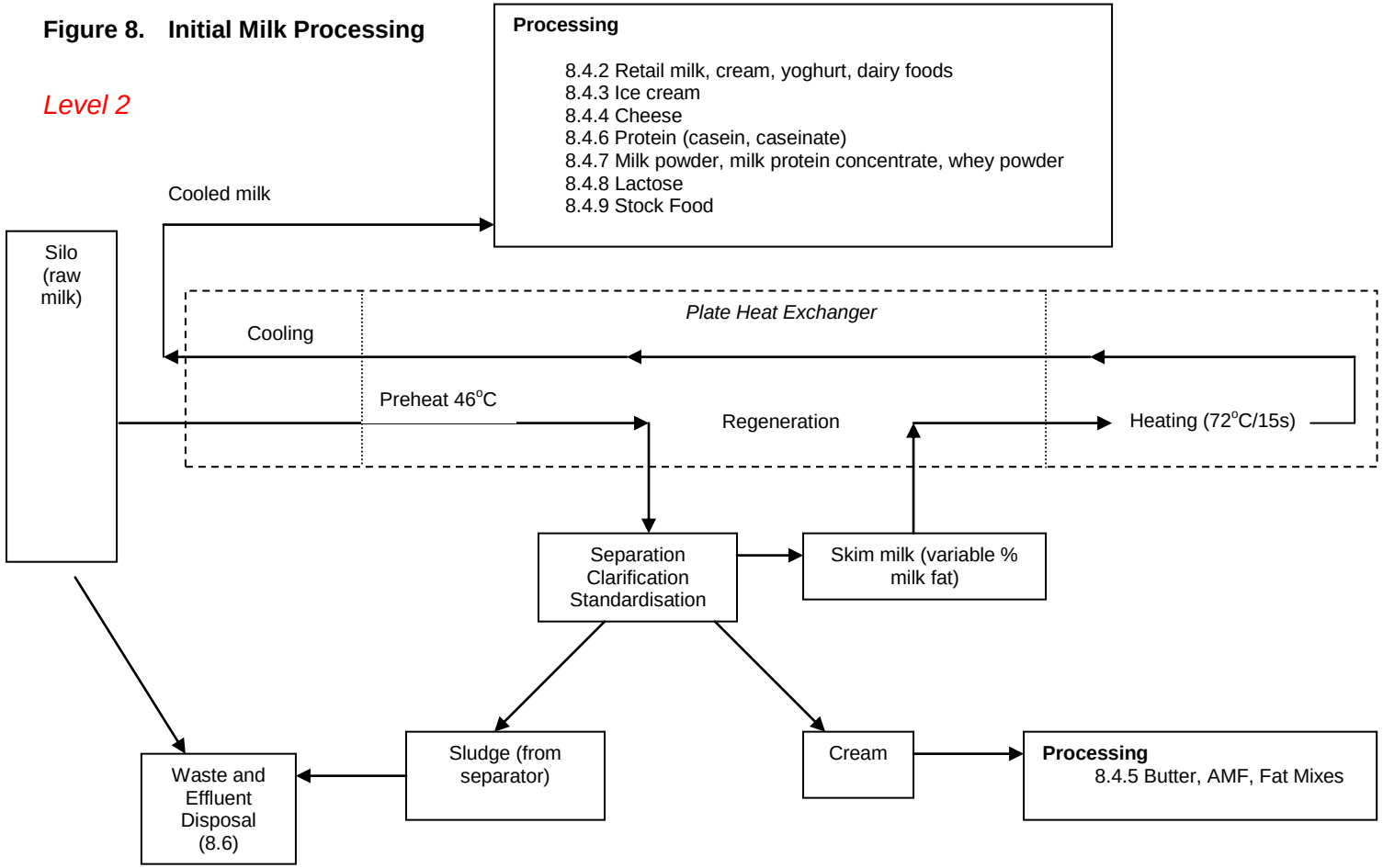
The movement of people into level 3 areas are 'red-lined' and should be accompanied by changes in outer clothing and washing of hands. This should be effective in preventing cross contamination of treated product with FMDV but may not be for other agents causing exotic diseases.

Treatment steps during processing are analysed for their effectiveness in reducing the level of FMDV infectivity in milk and milk products.

## 8.4.1 Initial Milk Processing

**Figure 8. Initial Milk Processing**

*Level 2*



### 8.4.1.1 Scope

Initial milk processing begins with the raw milk in the bulk milk collection silo at the processing site, and ends when the milk is distributed for further processing.

The physical location of the steps will vary between sites, for example some sites have dedicated facilities for receiving, separating and pasteurising milk before it is distributed to specialised plants or further processing, and other sites will incorporate pasteurisation as the first step in the factory where the specialised process occurs. For the purposes of this profile, initial milk processing includes the steps shown in Figure 8, regardless of whether this occurs in a dedicated location or as the initial step at the specialised plant.

Pasteurisation of cream will be considered in Butter, AMF and fat mixes, Section 8.4.5.

### 8.4.1.2 Dispersal Potential (Risk Evaluation)

Prior to pasteurisation (72$^{o}$C/15s), milk that has been derived from animals infected with FMDV will retain a high level of infectivity (Section 8.1.2). This will be diluted by milk from uninfected cows in the tanker, and with other tanker loads that do not contain milk from infected cows in the bulk collection silo(s). Assuming a tanker contains milk from one infected cow, and a 10-fold reduction in virus concentration due to dilution with uninfected milk in the bulk collection silo (Donaldson 1997), the amount of milk required to infect cattle, sheep or pigs via the respiratory route will be less than 0.5ml, and 168ml will contain enough virus to infect a pig via the oral route.

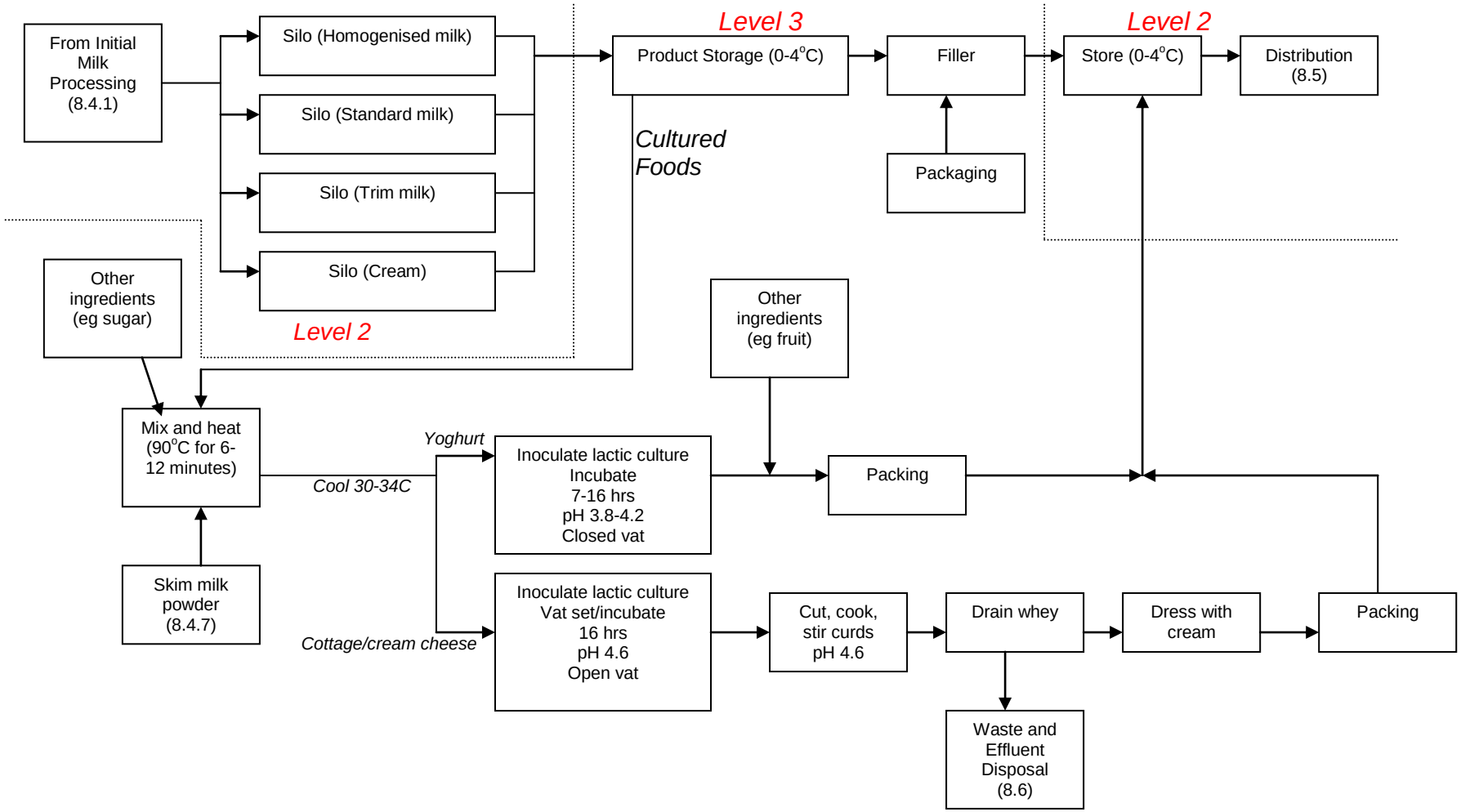
The practice of feeding sludge from the separators to pigs therefore represents a potential route for the transmission of FMDV and initiation of infection in a new herd, maybe in a geographically separate area. Any waste water derived from this area, for example tanker washes, will contain infectious FMDV at a concentration reduced by dilution with water, and other effects (for example, extremes of pH). See discussion in Waste and Effluent Disposal, Section 8.6.

Following pasteurisation only 0.001% of FMDV infectivity should remain (Sellers 1969). Using the scenario described earlier, 50 litres of milk will be required to initiate a respiratory infection, and 16,800 litres to infect a pig via the oral route. Therefore products, waste or effluent produced after effective pasteurisation are unlikely to result in transmission of disease to a new herd, unless recontaminated with raw milk, or there are a large number of infected cows supplying milk.

Pasteurisation is a critical control point within the dairy industry, and is closely monitored and controlled. Automatic diverts are in place to divert milk that has not reached the appropriate temperature/time combination. Time and temperature settings, diverts and the efficacy of pasteurisation is regularly checked by operators, and reviewed during internal audits, audits by independent engineers and at the annual validation of the Risk Management Programme.

## 8.4.2 Retail milk, cream, and cultured foods

**Figure 9. Retail milk, cream, and cultured foods**



### 8.4.2.1 Scope

This process starts with the receipt of milk (standard, homogenised or trim) and cream from initial milk processing, and ends with packaged product (liquid milk/cream or cultured foods) ready for distribution to retail outlets.

### 8.4.2.2 Dispersal Potential (Risk Evaluation)

Milk is received for this process post-pasteurisation (8.4.1). The potential for cross contamination of treated product with raw milk is minimal as the process is usually fully enclosed.

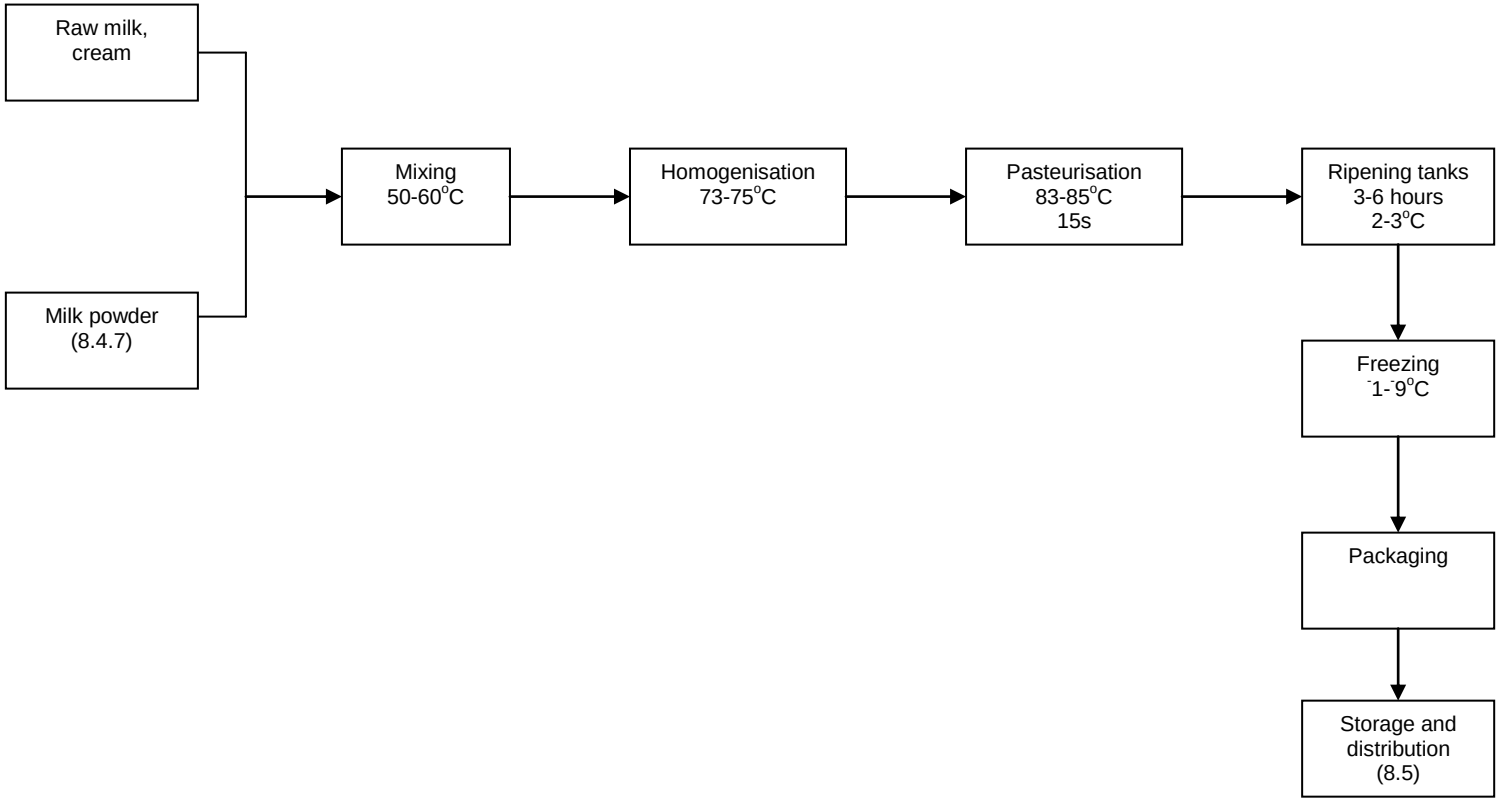
Cream pasteurisation for retail cream is at a higher temperature than milk (75$^{o}$C for 15 seconds). Survival of FMDV after heating cream at 93$^{o}$C for 15 seconds was shown by Blackwell and Hyde (1976), demonstrating that cream may retain a higher level of infectivity than milk.

There are several steps in the cultured foods stream involving extremes of heat (90$^{o}$C) and pH (<5) that will further reduce the level of infectivity of these products.

These products are unlikely to be exposed to susceptible animals, with the exception of disposal of product that has reached its 'Use By' date that may be collected for feeding to pigs. This will be discussed in Product Storage and Distribution (8.5).

### 8.4.3 Ice cream

**Figure 10. Ice cream**



### 8.4.3.1 Scope

This process starts with the receipt of raw milk and cream and milk powder (8.4.1, 8.4.7) and ends with packaged product ready for distribution to retail outlets.

### 8.4.3.2 Dispersal potential (Risk Evaluation)

The product is heat treated at increasing temperatures, finally reaching the pasteuriser at 83-85$^{o}$C for 15 seconds. FMDV in milk has a survival time of less than 5 seconds at temperatures above 80$^{o}$C therefore the amount of FMDV remaining in the milk is expected to be minimal.

Susceptible animals are not usually exposed to ice cream.

## 8.4.4 Cheese

**Figure 11. Dry Salted Cheeses (Cheddar, Colby, Egmont, Edam, Curd)**

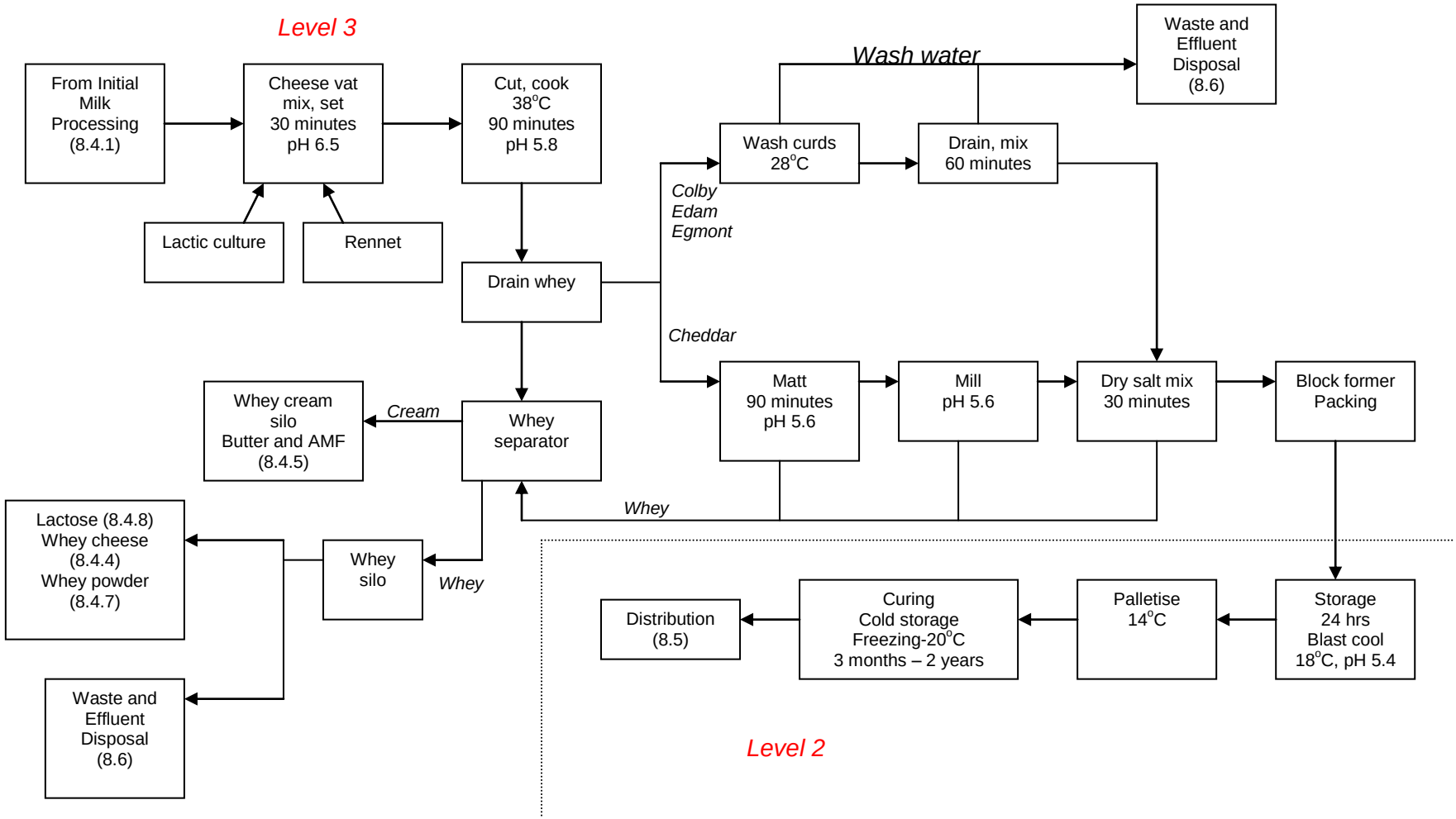
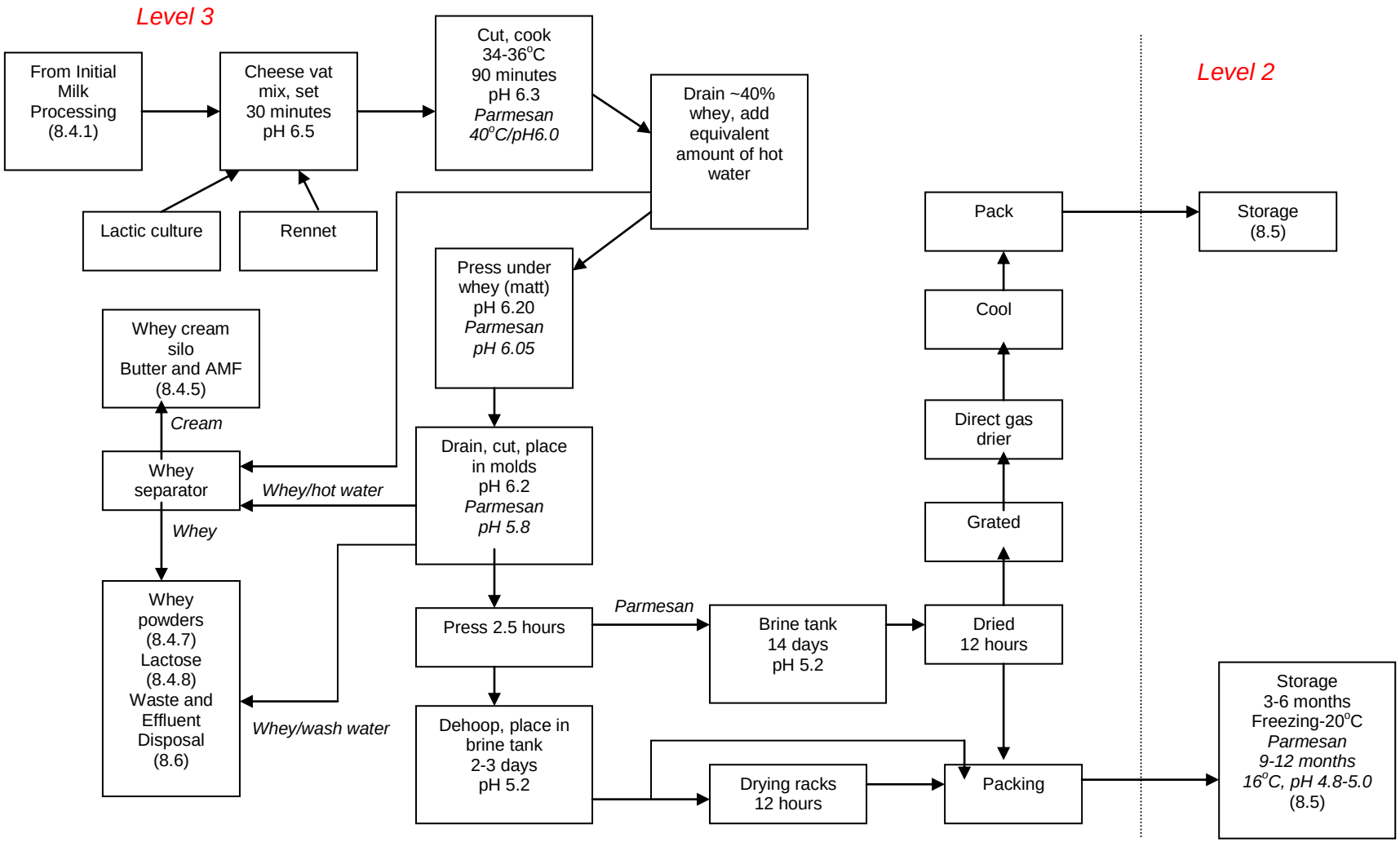


**Figure 12. Brine Salted Cheeses (Gouda, Edam, Parmesan)**



### 8.4.4.1 Scope

Two methods of producing cheeses are described: dry salted, and brine salted. Both receive milk from Initial Milk Processing (8.4.1).

### 8.4.4.2 Dispersal Potential (Risk Evaluation)

Both processes include further heat treatments (34-38$^{o}$C, 90 minutes) and reductions in pH (5-6). FMDV can probably survive up to several hours under these conditions (Tables 3 & 4). Product is stored for a minimum of 3 months after manufacture, at a pH of 4.8-5.4 and temperatures of 5-16$^{o}$C, which would be expected to kill most of the remaining FMDV. See Section 6.3.5.1 for discussion of research applicable to transmission of FMDV in cheeses.

Whey, wash water, and scraps for stock food produced during cheese manufacture will be discussed in Waste and Effluent (Section 8.6).

## 8.4.5 Butter, AMF, fat mixes

**Figure 13. Butter (Fritz process)**

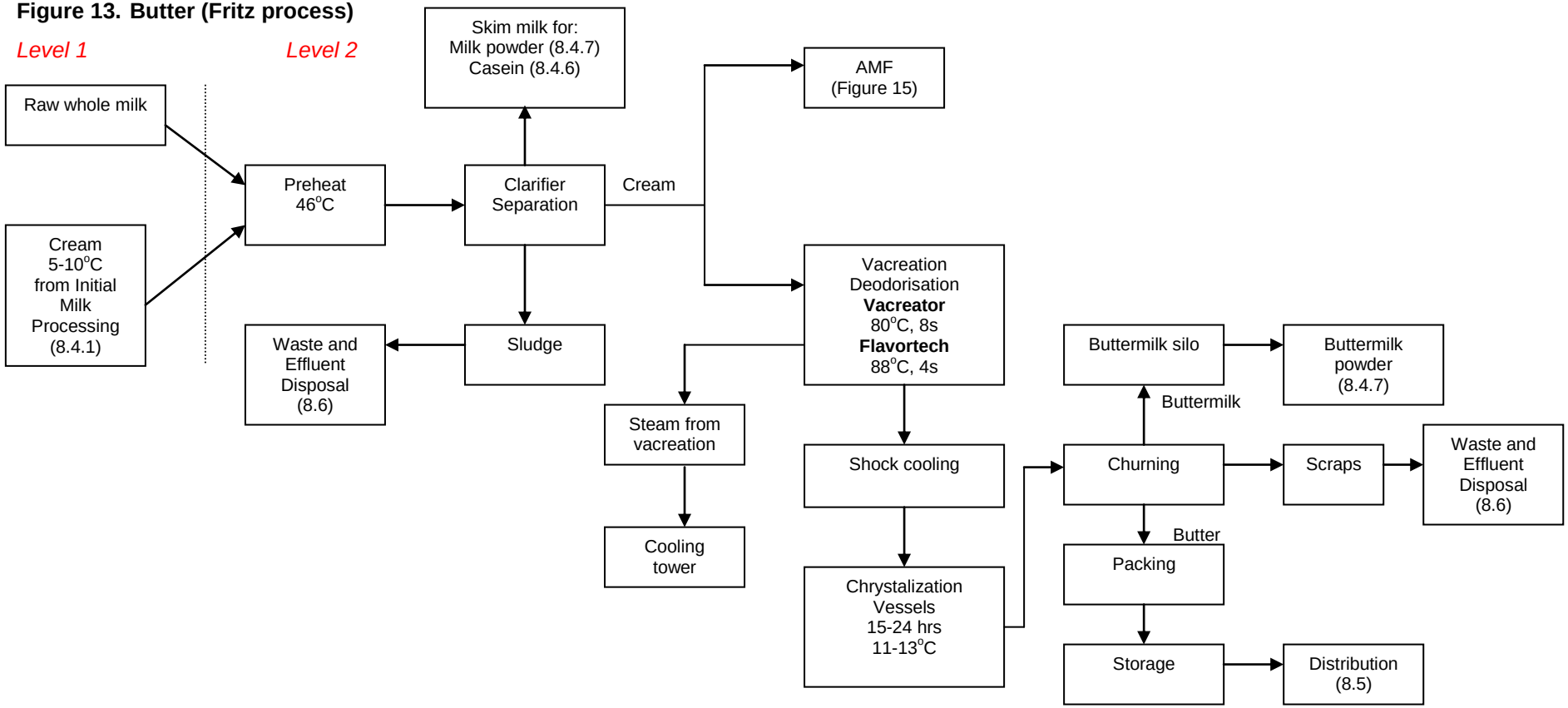


**Figure 14. Butter (Ammix process)**

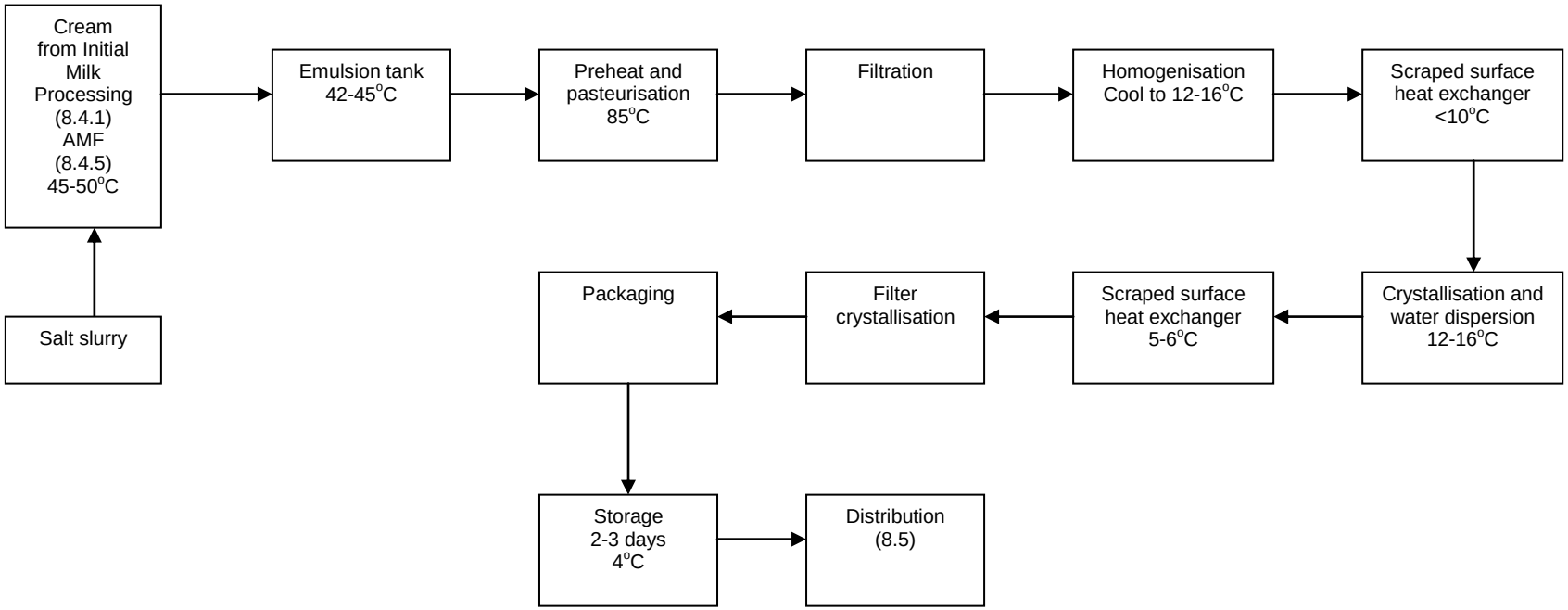
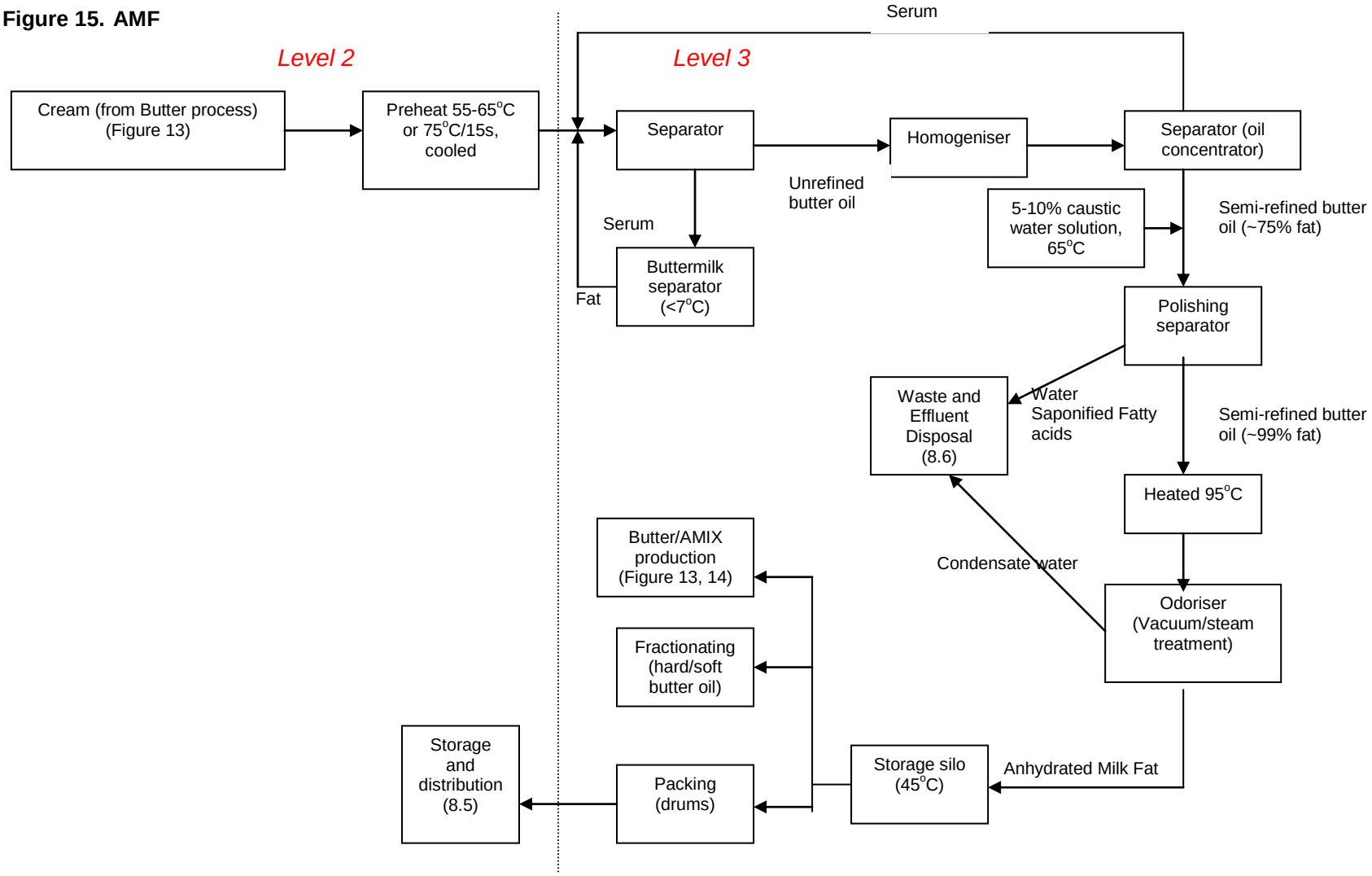


**Figure 15. AMF**



### 8.4.5.1 Scope

Cream is received post-separation but pre-pasteurisation from Initial Milk Processing (8.4.1), therefore this process includes pasteurisation of the cream (here termed Vacreation and deodorisation).

### 8.4.5.2 Dispersal Potential (Risk Evaluation)

Sludge is generated from the separation step prior to pasteurisation, and may be collected for feeding to pigs in the same way as sludge derived from Initial Milk Treatment, or disposed of in the factory effluent system. This will be discussed in Waste and Effluent, Section 8.6.

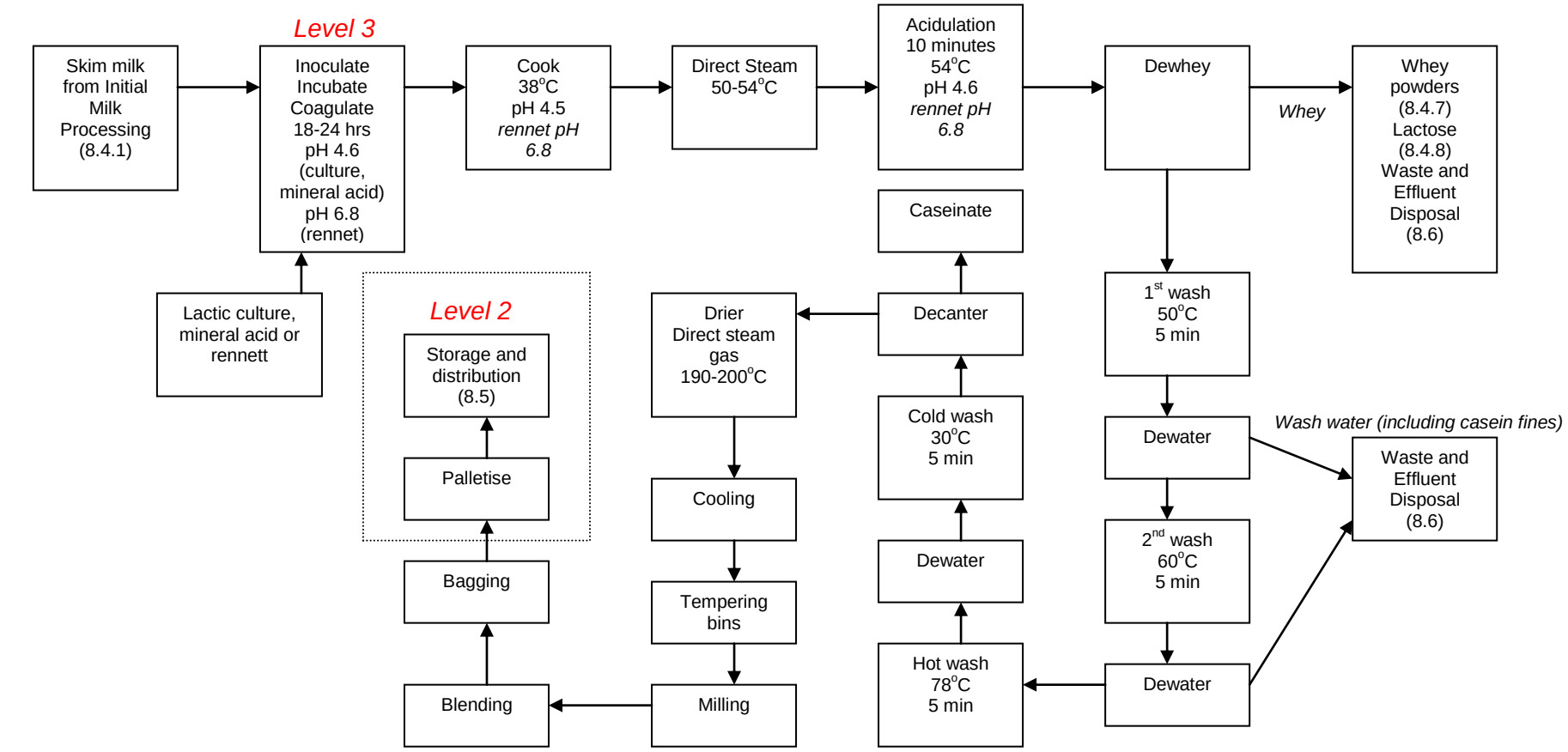
Reduction in viable FMDV in cream is generally less effective, at the same temperature and time treatment, than whole or skim milk (Blackwell & Hyde 1976). It could be expected therefore that more FMDV would survive the heat treatment step (Vacreation and deodorisation) than would be expected for pasteurisation of whole milk. If the survival of FMDV was 100 times that of whole milk, heat treatment would be expected to reduce the quantity of infectious virus to 0.1% of its original level.

Assuming ten infected cows supplying milk for one tanker load of milk, a 10-fold dilution of the tanker load when milk arrives at the factory, and an even distribution of FMDV through skim milk and cream, an oral infectious dose would be approximately 15 litres, and >20ml would be required to provide an infectious dose via the respiratory route. See Section 6.3.5.2 for a discussion of research relating to FMDV in butter and butter oil.

Scraps and waste water will be discussed in Waste and Effluent, Section 8.6.

## 8.4.6 Protein (casein, caseinate)

**Figure 16. Casein**



### 8.4.6.1 Scope

Begins when milk is received from Initial Milk Processing (8.4.1), and ends with the production of casein.

The process for production of caseinate is the same as casein until the decanting step. Caseinate production will not be considered further because caseinate products are not routinely exposed to susceptible animals. Evaluation of treatment steps for casein production should be sufficient to establish the risk from caseinate.

### 8.4.6.2 Dispersal Potential (Risk Evaluation)

There are three methods for the manufacture of casein:

- Lactic casein involves adding lactic cultures to skim milk to reduce the pH;
- Mineral acid casein using sulphuric acid added to skim milk;
- Rennett casein, where rennett is added to skim milk.

Pasteurised skim milk received from milk processing is reduced to a pH of 4.6 (lactic and mineral acid casein) for 18-24 hours. FMDV would be expected to survive less than 30 minutes under these conditions (Table 4).

The pH at which rennett casein is manufactured is 6.8-6.9: FMDV can survive for long periods at pH near 7, dependant on the temperature.

The casein is then subjected to further heat treatments, including a hot wash at 78$^{o}$C for 5 minutes (FMDV survival time of seconds at 78$^{o}$C, Table 3).

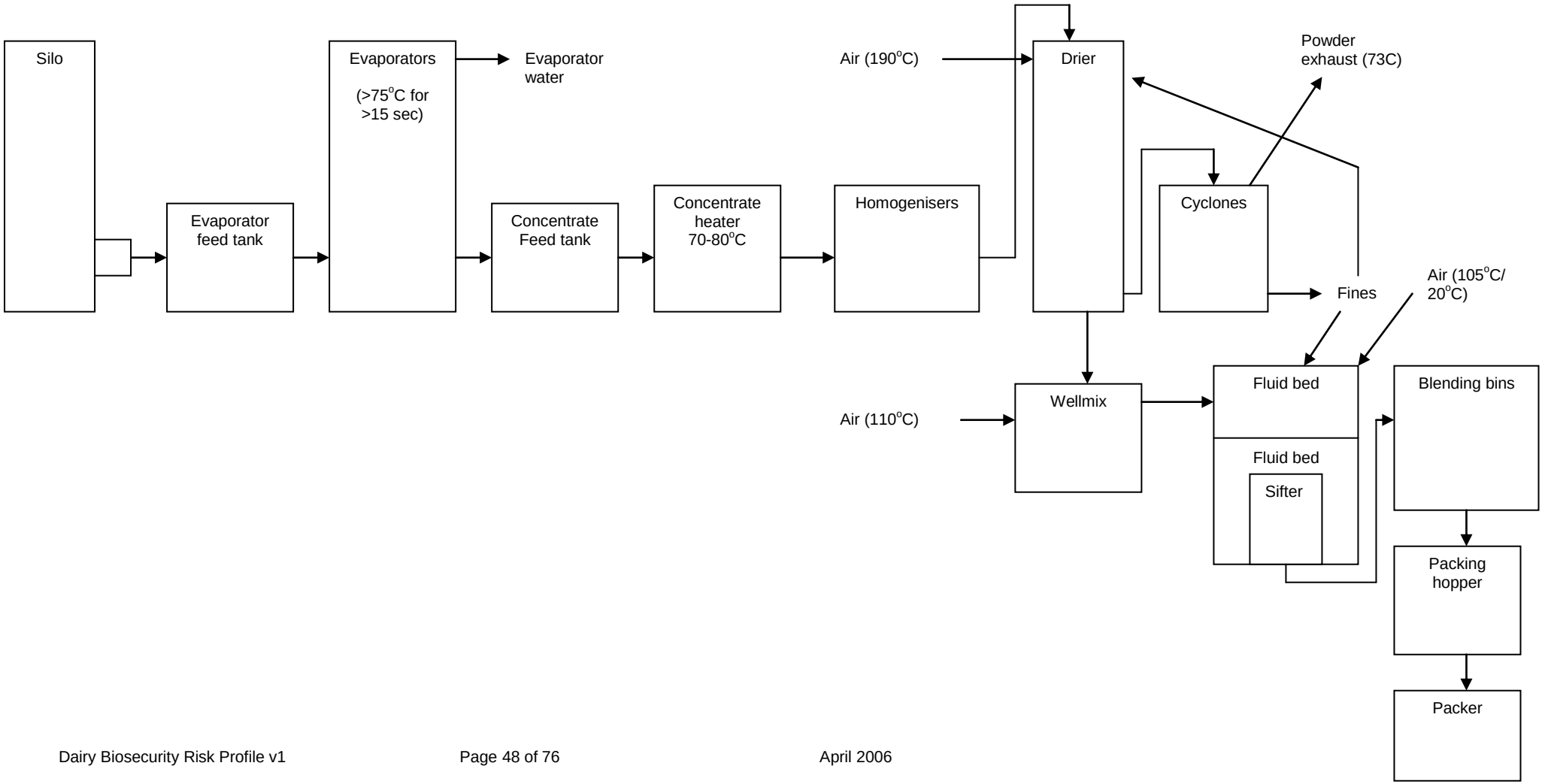
There are minimal opportunities for recontamination of processed casein with raw milk as the process is enclosed and there is no raw milk associated with it. The final product is not routinely used for stock feed.

A discussion of the scientific research applicable to casein production is in Section 6.3.5.3. The production process used by Cunliffe & Blackwell (1976) was different to that shown in Figure 16. Raw and pasteurised skim milk from infected cows, and skim milk from uninfected cows to which FMDV was added, was used. Hydrochloric acid was added to precipitate the casein at 25-32$^{o}$C and pH 4.5-4.6, the curds were washed with water at pH 4.7 three times for 10 minutes each, and dried. The casein was at pH 4.5-4.7 for 2 to 3 hours. Pasteurisation, the inoculation step in Figure 16, high temperatures, and the effects of dilution would reduce the level of infectivity more than the process described by Cunliffe & Blackwell (1976).

## 8.4.7 Milk Powder, Milk Protein Concentrate, Whey Powder

**Figure 17. Milk powder process**

*Level 3*



### 8.4.7.1 Scope

The milk powder, milk protein concentrate, and whey powder process begins with the silo supplying the milk powder plant and ends with packaging of the product for storage and distribution.

### 8.4.7.2 Dispersal Potential (Risk Evaluation)

Milk (raw, pasteurised, or a combination) is pumped from the silo into the plant. The first treatment step occurs either in the pasteuriser or at the evaporator, where the milk is typically heated to a minimum temperature of 75$^{o}$C for at least 15 seconds (more than the required 72$^{o}$C for 15 seconds for pasteurisation), but this will vary dependent on the powder type or specification being manufactured by the factory. The product will receive additional heat treatment in the concentrate heater (70-80$^{o}$C for unknown time), and in the drier (air temperature 190$^{o}$C).

Milk protein concentrate (MPC) is subjected to a series of heat treatments, generally at a lower temperature than standard milk powders. This would be expected to reduce the amount of viable FMDV in the product

Whey powders are produced in a similar fashion to milk powders (Figure 17). The key differences are that the input material is whey derived from other processes (cheese (8.4.4) including cottage and cream cheese (8.4.2), and casein (8.4.6)) and a Reverse Osmosis or Ultrafiltration step occurs before entering the evaporator feed tank. The resulting products are:

- Retentate, which is processed largely as for milk powder to produce whey powder; and
- Permeate, predominantly soluble lactose which enters the lactose process (8.4.8).

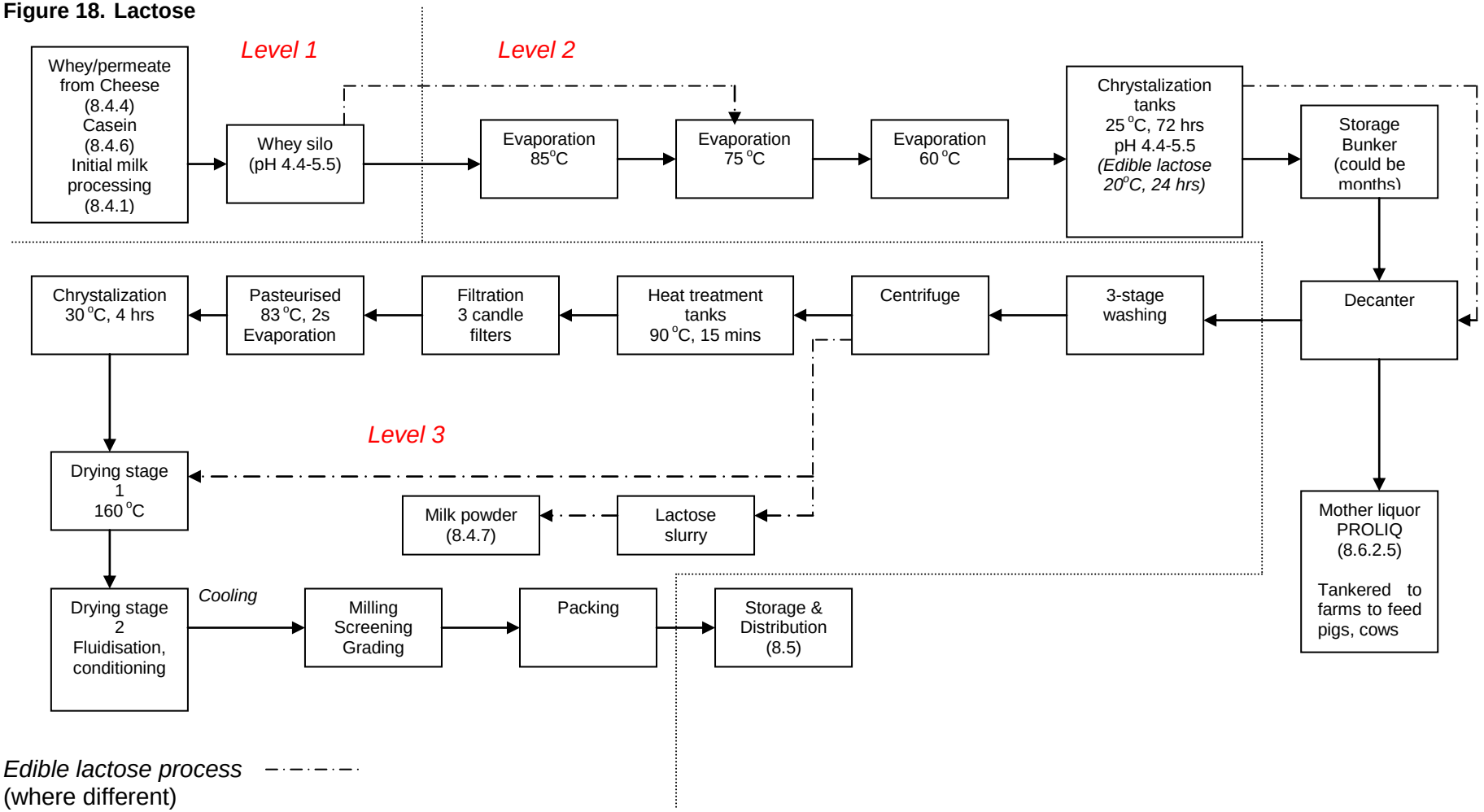
Before entering the whey powder process, whey has already been subjected to pasteurisation, and heat and pH steps during cheese and casein production. The additional heat steps during manufacture into whey powder are similar to those in the milk powder process.

People moving between raw milk and product processing areas may result in the contamination of processed product. For this process, recontamination is most likely to occur in areas of the plant where product may be exposed to human contact, including the wellmix, second fluid bed (for checking of the sifter), or at the packing head.

Effluent and waste produced in this process will be considered in Section 8.6.

## 8.4.8 Lactose

**Figure 18. Lactose**



### 8.4.8.1 Scope

Whey and permeate is received from the cheese (8.4.4), casein (8.4.6), and initial milk processing (8.4.1) processes for manufacture into lactose. It also includes byproducts of lactose manufacture.

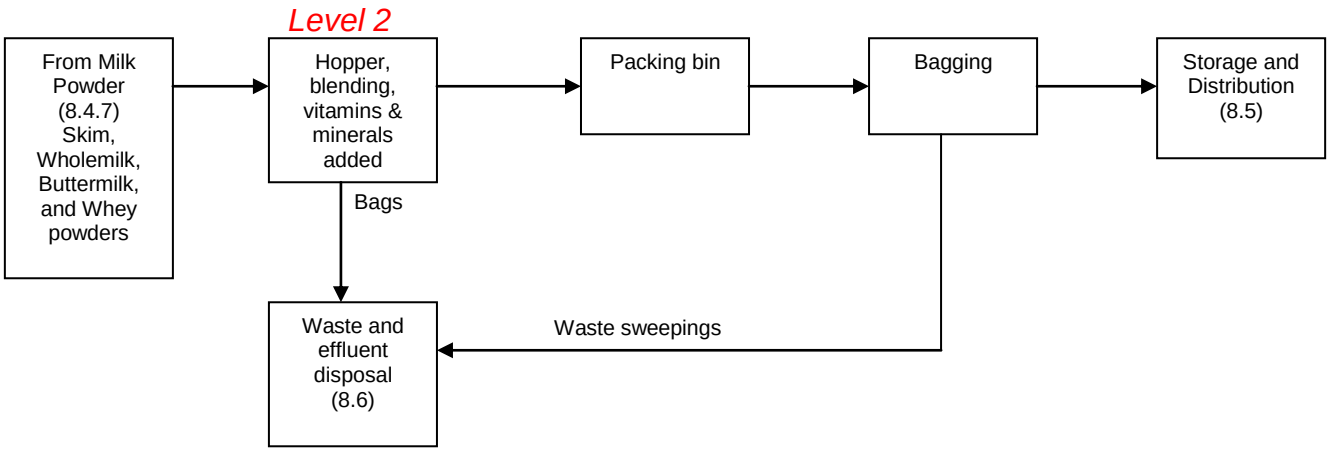
### 8.4.8.2 Dispersal Potential (Risk Evaluation)

Whey from cheese and casein processes has already been pasteurised and subjected to heat treatment and reduced pH. The pH of whey upon entry to this process is low (<6.1). The whey is then subjected to evaporation steps at high temperature. Mother liquor is a byproduct produced after these steps, risks associated with this product include the product itself because it is fed directly to animals, and transportation of the product from farm to farm.

The lactose then goes on to receive further heat treatments, is dried, and packed for storage and distribution.

## 8.4.9 Stock food

**Figure 19. Calf milk replacer**



### 8.4.9.1 Scope

Milk products that are manufactured specifically for stock food are considered in this section. In the New Zealand context, these will be predominantly calf milk replacers.

### 8.4.9.2 Dispersal Potential (Risk Evaluation)

Milk powders are received after manufacture (see Section 8.4.7). The production of calf milk replacer involves blending ingredients, adding vitamins and minerals, packing, bagging, and storage and distribution. Manufacturing plants maintain reasonable controls on external sources of contamination of the product, such as staff and visitors wearing overclothing provided, and pest control.

Risks include receipt of milk powder or other ingredients contaminated with FMDV, contamination of the product during processing (for example by staff living or working on farms infected with FMDV), and disposal of waste and packaging.

## 8.5 Product storage and distribution

### 8.5.1 Scope

Includes storage, and product distribution, under the immediate control of the processing site. Where a product is determined to present a significant risk for the spread of FMDV, the potential routes beyond are evaluated for opportunities for the processor to reduce the risk.

### 8.5.2 Dispersal Potential (Risk Evaluation)

Product storage is regulated by the Animal Products Act 1999 and is subject to regular independent audits. Potential routes of exposure of susceptible animals during product storage and distribution are limited because of these controls – animals and unauthorised people cannot access stores, and product is stored in packaging or enclosed vehicles.

Once the product has left the store for distribution, the potential for exposure of susceptible animals to the product will depend upon the product, its intended and actual use, and the treatments it has received. Contamination of product with FMDV is possible, for example vehicles contaminated with milk or faeces from a susceptible animal contaminating the product or packaging, but will still require exposure to susceptible animals to initiate a new infection. This will not be considered further in this risk analysis as the risks will be similar to any other animal feed contaminated with FMDV.

Farmers visit the calf milk replacer factory to collect the product. There is a possibility they could carry FMDV on their clothing, boots, or hands, and contaminate product or packaging on the site. This will not be considered further in this risk analysis as the risks will be similar to any other animal feed contaminated with FMDV.

Retail milk and cream are rapidly and widely distributed with in New Zealand. There is the potential for FMDV to be present in pasteurised milk and particularly cream manufactured for human consumption dependant upon the initial concentration of virus in the tanker, the degree of dilution with uninfected milk, the effectiveness of pasteurisation, and the strain of FMDV. Survival of FMDV in cream appears to be enhanced relative to milk, so the risks would be higher with this product. Milk and cream that has passed its Use By date may be disposed of by feeding to calves or pigs. Records of farmers who have received this milk is kept by processing sites when they manage disposal, but this may not be the case at retail outlets.

## 8.6 Waste and effluent

### 8.6.1 Scope

Includes effluent and waste produced as a result of processing of milk and milk products at a dairy factory site.

Waste and effluent is derived from these processes:

| Process | Section | Waste/effluent |
|---|---|---|
| Milk Collection and Transfer | 8.3 | Sample disposal<br>Wash water from tanker, train, milk collection area |
| Initial Milk Processing | 8.4.1 | Sludge from separators pre-pasteurisation |
| Retail Milk, Cream, Cultured Foods | 8.4.2 | Whey from cottage and cream cheese |
| Cheese | 8.4.4 | Whey<br>Wash water<br>Scraps |
| Butter & AMF | 8.4.5 | Butter scraps<br>Water, saponified fatty acids, condensate water from AMF |
| Protein (Casein, Caseinate) | 8.4.6 | Whey<br>Wash water (including casein fines) |
| Milk Powder | 8.4.7 | Evaporator water |
| Lactose | 8.4.8 | Waste water<br>Mother liquor<br>Dry product waste |
| Stock Food (Calf Milk Replacer) | 8.4.9 | Packaging<br>Sweepings |

When considering the risks, account will be taken of:

- treatment received during processing;
- volume/dilution of the waste or effluent
- additional treatment of the waste or effluent; and
- likelihood of exposure to susceptible animals.

### 8.6.2 Dispersal Potential (Risk Evaluation)

Methods of waste and effluent disposal for the dairy industry and their characteristics are described for each 'product'.

#### 8.6.2.1 Sludge

When milk is initially separated for processing, usually in a high-speed centrifuge, sludge is produced consisting largely of milk solids and foreign matter. Sludge is often used for pig food, or spread on land, sometimes mixed with other waste products such as whey, permeate, and lactic wash water. More than twenty thousand cubic metres of sludge from Waikato Fonterra sites is fed to pigs each year.

The risks for spreading FMDV associated with sludge are that the product is not pasteurised, and pig farmers and contractors come to the processing site to collect the sludge. Sometimes one farmer will collect and distribute sludge on behalf of others. Farmers and/or contractors may bring FMDV onto the site, and spread it from the site via the sludge, equipment, vehicles, and clothing to new farms, including their own.

#### 8.6.2.2 Waste water & effluent treatment systems

Some high protein and/or fat effluent streams are directed to dissolved air floatation (DAF) plants to recover fat and protein prior to waste water discharge. The DAF process is carried out at a low pH (~4.6), then the solids (5-10%) are either composted at temperatures of up to 75$^{o}$C for approximately one month, or are applied to land. This should be sufficient to inactivate any remaining FMDV. Waste water is disposed of as described in Section 8.6.2.3.

Biological treatment of some effluent results in sludge waste, which is applied to land for cultivation or grazing, and waste water at an approximate pH of 8.5 which is monitored daily on a 24 hour composite sample.

Transportation and disposal of solid wastes from these processes may be carried out by contractors. In some cases, sludge from the DAF process is added to liquid stock food for feeding to animals. Records of waste disposal sites are kept by the contractors for at least 14 days.

#### 8.6.2.3 Waste water

Disposal of waste water may be to an existing body of water (estuary, marine outfall, river or stream), to the municipal sewer, or to irrigation (flood or spray). Monitoring of the pH may be required by local authorities to meet the conditions of resource consents. The waste water may have undergone treatment described in 8.6.2.2 prior to discharge.

#### 8.6.2.4 Whey

Whey that is not used for the production of lactose may be spread on farmland as liquid fertiliser, or used as stock food for dairy cows or pigs. Transportation may be by contractors, and records kept for at least the previous 14 days of the destination of the product.

#### 8.6.2.5 Mother liquor

A byproduct of lactose manufacture, transported by tanker to farms as animal food. There are two risks associated with mother liquor: the product itself, and its transportation between farms (Section 8.7).

Mother liquor is subjected to 5 steps that could be expected to reduce FMDV at least 99.999%, so the product is unlikely to contain enough virus to infect a susceptible animal unless it has become contaminated with infectious material.

#### 8.6.2.6 Other waste

Other sources of waste include processing waste (for example cheese scraps, milk powder sweepings) and anhydrous milk fat serum. These are often used for stock food. Some could be sent for disposal at animal rendering plants.

## 8.7 Other conveyors

### 8.7.1 Scope

This section covers people (and their vehicles and equipment) who visit or work on dairy processing sites, but are not staff working in the factory.

For example, maintenance contractors, disposal contractors or farmers collecting waste for animal feed, company staff who have an on-farm role.

### 8.7.2 Dispersal Potential (Risk Evaluation)

People, vehicles and equipment can transmit FMDV in two ways:

- bringing FMDV onto the processing site to contaminate products;
- carrying FMDV off the site on their clothing and boots, vehicles, equipment, or products.

Rules about visitors to dairy sites, their access to products, and hygiene requirements will reduce the risk that a person could contaminate milk or milk products on site.

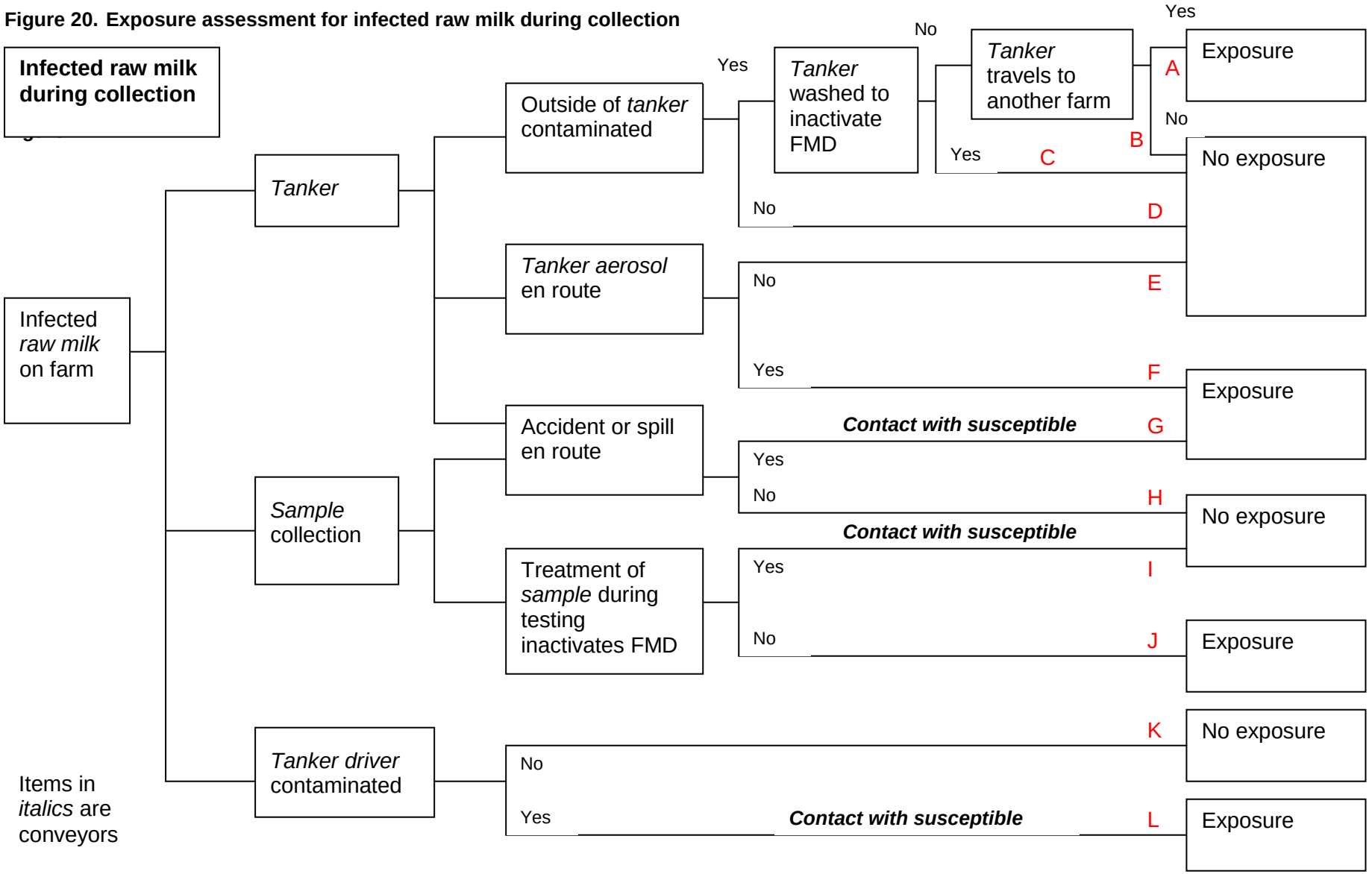
The risks associated with taking FMDV off the site are only relevant for people having direct exposure to susceptible animals, or where the contaminated clothing, vehicles, equipment or product is exposed to susceptible animals. The risks will depend on the amount of FMDV contamination (a combination of concentration of FMDV in the milk and level of contamination), time between contamination and exposure, and the nature of the exposure. High risk people are those who have contact with susceptible animals.

## 8.8 Exposure Assessment - Summary

The exposure assessment has been broken down into two components: infected raw milk during collection and transport to the factory, and on the processing site. These are shown in the diagrams in Figures 20 and 21.

The ‘kill steps’ (treatments which will be effective in substantially reducing the amount of FMDV in the product) are identified for each product in Table 10. A summary of milk processing based on Table 10, showing the highest risk products in red, is presented in Figure 22.

**Figure 20. Exposure assessment for infected raw milk during collection**



**Exposure assessment for infected milk on a processing site**

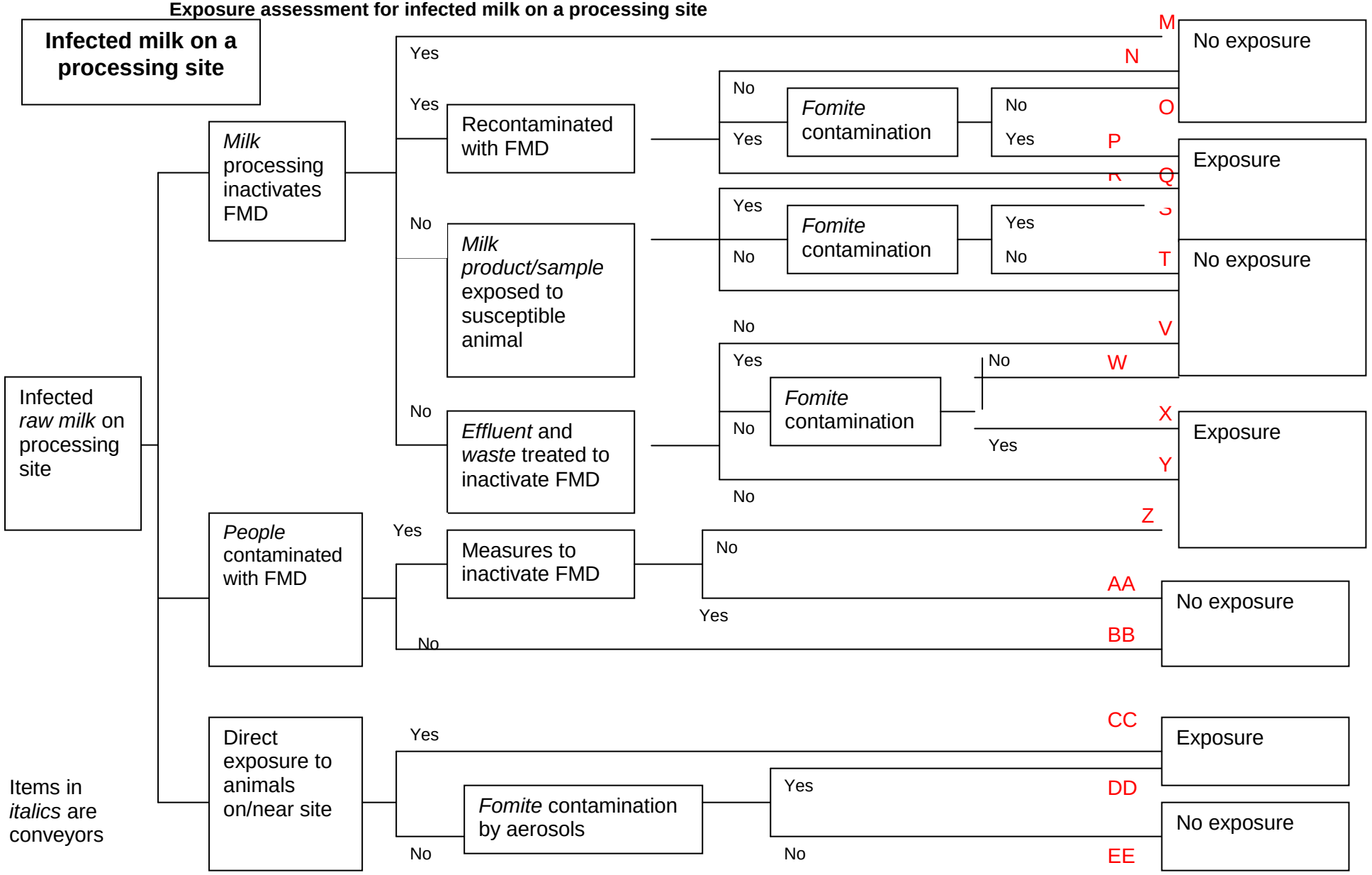


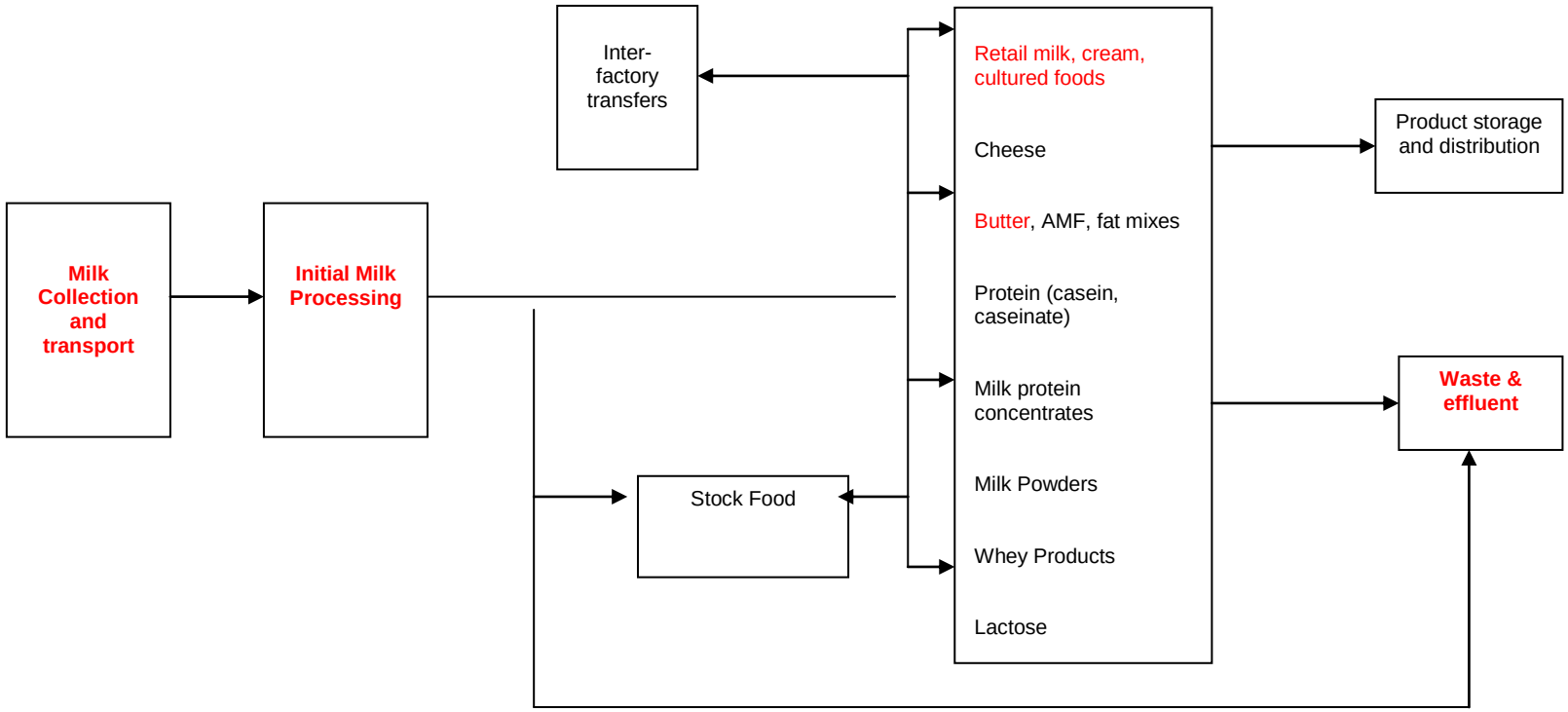
**Table 10. Kill steps for FMDV during processing *(Waste products in italics at the step where they are removed)***

| Product/Process | Step 1 | Step 2 | Step 3 | Step 4 | Step 5 | Step 6 | Step 7 | Step 8 |
|---|---|---|---|---|---|---|---|---|
| Initial milk processing | 72°C/15s pH 6.7-6.8 | | | | | | | |
| Retail milk | 72°C/15s pH 6.7-6.8 | | | | | | | |
| Retail cream | 72°C/15s pH 6.7-6.8* | | | | | | | |
| Cultured foods (yoghurt, dairy foods, cream and cottage cheeses) | 72°C/15s pH 6.7-6.8 | 90°C, 6-12 minutes | pH<4.6, >17 hours (*Whey*) | Cream added to cottage cheese* | | | | |
| Ice cream | 50-60°C | 73-75°C | 83-85°C 15s | | | | | |
| Dry salted cheese | 72°C/15s pH 6.7-6.8 (*Whey, wash water*) | 24 hours, 18°C, pH 5.4 | | | | | | |
| Brine salted cheese | 72°C/15s pH 6.7-6.8 (*Whey)* | 2-3 days, pH 5.2 | | | | | | |
| Parmesan cheese | 72°C/15s pH 6.7-6.8 (*Whey)* | 14 days, pH 5.2 | 16°C, 9 – 12 months, pH 4.8-5.0 | | | | | |
| Butter (Fritz method) | 80°C, 8s or 88°C, 4s | | | | | | | |
| Butter (Ammix method) | 72°C/15s pH 6.7-6.8 AMF | 85°C | | | | | | |
| AMF | 55-65°C or 75°C, 15s | 5-10% caustic solution, 65°C (*Water, saponified fatty acids*) | 95°C | | | | | |

| Product/Process | Step 1 | Step 2 | Step 3 | Step 4 | Step 5 | Step 6 | Step 7 | Step 8 |
|---|---|---|---|---|---|---|---|---|
| Casein (culture, mineral acid) | 72°C/15s pH 6.7-6.8 | 18-24 hours, pH 4.6 | 38°C, pH 4.5 | 50-54°C, 10 minutes, pH 4.6 (*Whey, wash water*) | 60°C, 5 minutes (*Wash water*) | 78°C, 5 minutes | Drier, 190-200°C | |
| Casein (rennet) | 72°C/15s pH 6.7-6.8 (*Whey, wash water*) | 60°C, 5 minutes (*Wash water*) | 78°C, 5 minutes | Drier, 190-200°C | | | | |
| Milk powders | >75°C, >15 s (*Evaporator water*) | 70-80°C | Drier, air 190°C | Drier, air 110°C | Drier, air 105°C | | | |
| Milk protein concentrates | 72°C/15s pH 6.7-6.8 | 60°C | Drier | | | | | |
| Whey products | Whey from cheese and casein | >75°C, >15 s (*Evaporator water*) | 70-80°C | Drier, air 190°C | Drier, air 110°C | Drier, air 105°C | | |
| Lactose | 72°C/15s pH 6.7-6.8, or whey from cheese and casein | pH 4.4-5.5, 85°C | 75°C | 60°C | 25°C, 72 hours, pH 4.4-5.5 (*Mother liquor)* | 90°C, 15 minutes | 83°C, 2s | Drier 160°C |
| Edible lactose | 72°C/15s pH 6.7-6.8, or whey from cheese and casein | pH 4.4-5.5, 75°C | 60°C | 25°C, 24 hours, pH 4.4-5.5 (*Mother liquor*) | 90°C, 15 minutes | 83°C, 2s | Drier 160°C | |

* Reduction of FMDV in cream is less effective than for milk at the same time and temperature

**Figure 22. Summary of milk processing exposure assessment**




Steps with zero or one kill step for FMDV in RED

### 8.8.1 Infected Raw Milk during Collection

The pathways of exposure during collection of milk are:

| | |
|---|---|
| A | Outside of tanker contaminated |
| F | Tanker aerosol |
| G | Tanker, train or sample accidental spill |
| J | Sample disposal |
| L | Contaminated tanker driver |

### 8.8.2 Infected Milk on Processing Site

The pathways of exposure during processing of raw milk on site are:

| | |
|---|---|
| P | Fomite contamination with recontaminated product |
| Q | Recontamination of non-infectious product |
| R | Exposure of susceptible animals to infectious product |
| S | Fomite contamination with infectious product |
| X | Fomite contamination with infectious waste or effluent |
| Y | Susceptible animal contact with infectious effluent and waste |
| Z | Contaminated people in contact with susceptible animals |
| CC | Direct exposure to animals on or near a processing site |
| DD | Fomites contaminated by aerosols generated at a processing site |

#### 8.8.2.1 Untreated or single treated product, effluent and waste

Products/processes that are subjected to zero or one kill steps for FMDV (Table 10, Figure 23) are:

- Milk collection and transport
- Initial milk processing
- Retail cream and cultured foods
- Butter (Fritz method)
- Waste and effluent

Therefore these products, and products or wastes derived from these steps in processing will have the highest concentration of FMDV and if exposed to susceptible animals are more likely to result in infection.

# 9 Risk Management

## 9.1 Risk Evaluation

For each pathway, the qualitative probability of exposure and the concentration in the conveyor will be determined. The overall risk for a pathway will be based on the combination of risks for exposure and concentration (Table 11).

For those pathways for which no exposure was determined to be the outcome (Section 8.8), there will be no further consideration of their importance in this risk profile.

For those pathways for which exposure was determined to be the outcome (Section 8.8), the level of risk will be evaluated according to the criteria in Appendix 12.3. The objective is to rank the pathways according to their level of risk and determine which ones are the most important or risky for the spread of FMDV through the dairy industry. This will also allow determination of the most important and effective risk mitigation measures.

| Exposure Pathway | Probability of exposure | Probability of infectious dose of virus in conveyor | Likelihood of infectious episode* | Comments |
|---|---|---|---|---|
| A. Outside of tanker contaminated | Remote | Significant | Remote | Sections 8.1.2 (raw milk), 8.1.3 (vehicles). |
| F. Tanker aerosol | Remote | Remote | Remote | Sections 6.3.7, 8.1.6 (aerosols). |
| G. Accidental spill | Remote | Remote | Remote | Section 8.1.2 (raw milk), 8.1.3 (vehicles). Exposure of animals to milk and contaminated vehicle (faeces etc). |
| J. Sample disposal | Significant | Significant | Significant | Sections 8.1.2 (raw milk), 8.3.4 (sample collection). Untreated samples fed to animals. |
| L. Contaminated tanker driver | Negligible | Remote | Negligible | Section 8.1.1 (people and clothing). |
| P. Fomite contamination with recontaminated product | Negligible | Negligible | Negligible | |
| Q. Recontamination of non-infectious product | Remote | Negligible | Negligible | Section 8.4.11 (stock food). |
| R. Exposure of susceptible animals to infectious product from processing site | Remote | Remote | Remote | Sections 6.3.5 (survival and inactivation of FMDV in milk), 8.1.2 (raw milk). |
| S. Fomite contamination with infectious product | Remote | Negligible | Negligible | Sections 6.3.5 (survival and inactivation of FMDV in milk), 8.1.2 (raw milk). |
| X. Fomite contamination with infectious effluent and waste | Negligible | Negligible | Negligible | Section 8.6 (waste and effluent). |
| Y. Susceptible animal contact with infectious effluent and waste | Significant | Significant | Significant | Section 8.6 (waste and effluent). Separator sludge collected pre-pasteurisation for feeding to animals, retail cream fed to animals |
| Z. Contaminated people in contact with susceptible animals | Remote | Negligible | Negligible | Section 8.1.1 (people and clothing). |
| CC. Direct exposure to animals on or near a processing site | Remote | Remote | Remote | Sections 6.3.7, 8.1.6 (aerosols). |
| DD. Fomites contaminated by aerosols generated at a processing site | Negligible | Negligible | Negligible | Sections 6.3.7, 8.1.6 (aerosols). |

* combined risk of Probability of exposure and Probability of infectious dose in conveyor

**Table 11. Evaluation of biological pathways and level of risk for the spread of FMDV**

## 9.2 Option Evaluation

These measures are recommended to mitigate the risk of transmission of FMDV by the dairy industry during an outbreak. The level of risk of an exposure pathway determines the priority that should be placed on mitigation of the risk. Some measures will also be helpful in preventing spread of endemic diseases and other exotic diseases, and additional measures may be required for a disease outbreak other than FMD.

### 9.2.1 Infected Raw Milk during collection

#### 9.2.1.1 Significant Risk

##### *J. Sample collection*

During a response:

- Treatment of milk that is to be fed to animals
- Disposal by a route that prevents exposure to susceptible animals

Before a response:

- Records of recipients and dates milk collected for feeding to animals

#### 9.2.1.2 Remote Risk

##### *A. Contamination of the outside of the tanker*

During a response:

- Prevent access of animals to tanker track, or collect and dispose of faeces and disinfect after use
- Disinfect milk, faecal, or other potentially infectious contamination of the tanker before leaving farm

Before a response:

- Care when collecting milk from the farm vat to prevent spillage or spray of milk onto tanker or equipment
- Minimise animal use of the tanker track to prevent contamination with faeces and other potentially infectious materials

##### *F. Tanker aerosol*

During a response:

- Susceptible animals grazed away from the milking shed during milk collection
- Use of filters if available and practical

Before a response:

- Further research required to determine:
    - Magnitude of risk
    - Minimum distance between animals and tanker
    - Efficacy of filters in reducing risk

### *G. Accidents or spills*

During a response:

- Notify spills immediately to MAF and implement plan for managing spill.

Before a response:

- Develop procedures for managing spills during an exotic disease response, including preventing stock access, disinfecting spills, and notifying MAF Biosecurity New Zealand including details of animals exposed to the spill.

## 9.2.1.3 Negligible Risk

### *L. Contaminated tanker driver*

During a response:

- Prevent access of animals to tanker track, or collect and dispose of faeces and disinfect after use
- Disinfect milk, faecal, or other potentially infectious contamination of driver before leaving farm

Before a response:

- Care when collecting milk from the farm vat to prevent spillage or spray of milk onto driver
- Drivers to have no direct contact with susceptible animals when collecting milk

## 9.2.2 Infected Milk on Processing Site

## 9.2.2.1 Significant risk

### *Y. Susceptible animal contact with infectious effluent and waste*

During a response:

- Stop disposal of untreated waste (separator sludge) to feeding of animals
- Dispose of cream from retail outlets so there is no contact with susceptible species or treat to ensure FMDV no longer infectious

Before a response:

- Maintain records of destination of untreated wastes and retail cream
- Holding this material on-site for 4 or more days (FMDV can be produced in milk up to 4 days before clinical signs) after collection would maximise the opportunity to detect FMDV in the infected herd. Potentially infectious sludge could then be managed to prevent spread of infection to new herds

## 9.2.2.2 Remote risk

### *R. Exposure of susceptible animals to infectious product*

During a response:

- Do not feed products that have received less than 2 kill steps, or may have been recontaminated with raw milk, to animals

Before a response:

- Maintain records of destination of products that receive less than 2 kill steps, or may have been recontaminated with raw milk, to animals

### *CC. Direct exposure to animals on or near a processing site*

During a response:

- Keep susceptible animals as far away from processing site as possible
- House animals, particularly cattle, if possible
- Monitor animals several times a day for clinical symptoms of FMDV

Before a response:

- Further research required to determine:
    - Magnitude of risk
    - Minimum distance between animals and site
    - Efficacy of filters in reducing risk

## 9.2.2.3 Negligible risk

### *Q. Recontamination of non-infectious product*

During a response:

- Implement physical and procedural separation between raw and treated milk areas
- Access to treated product only after donning protective outer clothing and washing hands

Before a response:

- Develop plan to achieve separation between raw and treated milk areas

### *S. Fomite contamination with infectious product*

During a response:

- All fomites in contact with infectious product are regularly cleaned and disinfected and do not come into contact with susceptible animals

Before a response:

- Regular cleaning and disinfection of fomites in contact with infectious product, particularly if fomite contacts animals or feed intended for animals, eg separator sludge containers

### *Z. Contaminated people*

During a response:

- Prevent access to products by people who are not staff
- Prevent access to site by farmers or others who may bring on contaminated material
- Identify staff who have contact with susceptible animals outside of work and inform them of the risks and how to prevent transmission of FMDV

Before a response:

- Maintain a list of staff who live on farms or are regularly in contact with susceptible animals
- Ensure staff working in processing areas wash hands and wear clean outer clothing and boots before entering factory

### *P. Fomite contamination with recontaminated product*

During a response:

- All fomites in contact with product are regularly cleaned and disinfected and do not come into contact with susceptible animals

Before a response:
- Regular cleaning and disinfection of fomites in contact with product, particularly if fomite contacts animals or feed intended for animals, eg cheese scrap containers

### *X. Fomite contamination with infectious effluent and waste*

During a response:
- All fomites in contact with effluent and waste are regularly cleaned and disinfected and do not come into contact with susceptible animals

Before a response:
- Regular cleaning and disinfection of fomites in contact with effluent and waste, particularly if fomite contacts animals or feed intended for animals, eg separator sludge containers

### *DD. Fomites contaminated by aerosols generated at a processing site*

During a response:
- Keep susceptible animals as far away from processing site as possible
- Before moving fomites on farms near processing sites that may be contaminated by aerosols to new farms, ensure they are effectively cleaned and disinfected

Before a response:
- Further research required to determine:
    - Magnitude of risk
    - Efficacy of filters in reducing risk

# 10 Acknowledgements

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# 12 Appendices

## 12.1 Website References

Livestock Improvement Corporation http://www.lic.co.nz/113_8.cfm

Fonterra http://www.fonterra.com/default.jsp

Tatua http://www.tatua.com/

Westland Milk Products New Zealand http://www.westland.co.nz/)

MAF website export statistics: http://www.maf.govt.nz/mafnet/rural-nz/agriculture-forestry-horticulture-in-brief/2005/agriculture-03.htm - New%20Zealand's%20Dairy%20Exports

MAF New Zealand's Dairy Exports: http://www.maf.govt.nz/mafnet/rural-nz/agriculture-forestry-horticulture-in-brief/2005/agriculture-03.htm - New%20Zealand's%20Dairy%20Exports

Ausvetplan http://www.aahc.com.au/ausvetplan/fmdrevised.pdf

OIE 2005, *Recognition of the foot and mouth disease status of member countries*, http://www.oie.int/eng/info/en_fmd.htm

## 12.2 Maps

**Northland Dairy Sites:**
1. Top Milk/Fomage Nord
2. Mahoe Cheese
3. Fonterra – Kauri
4. Fonterra - Maungaturoto
5. Fresha Valley Processors
6. Good F – Puhoi/Art Cheese

**Waikato/BOP Dairy Sites:**
17. Fonterra - Edgecumbe
18. Fonterra - Hautapu
19. Fonterra - Lichfield
20. Fonterra - Morrinsville
21. Fonterra - Reporoa
22. Fonterra - Te Rapa
23. Fonterra - Te Awamutu
24. Fonterra - Tirau
25. Fonterra - Waitoa
26 Mercer Cheese
27. Waharoa Transport
28. Dairy Goat Co-Op
29. Ridge Processing
30. Meyer Gouda Cheeses
31. Ambreed
32. Matatoki Cheese
33. Porter Transport
34. SAITL
35. Tatua CDC
36. Livestock Improvement
37. Aroha Cheese

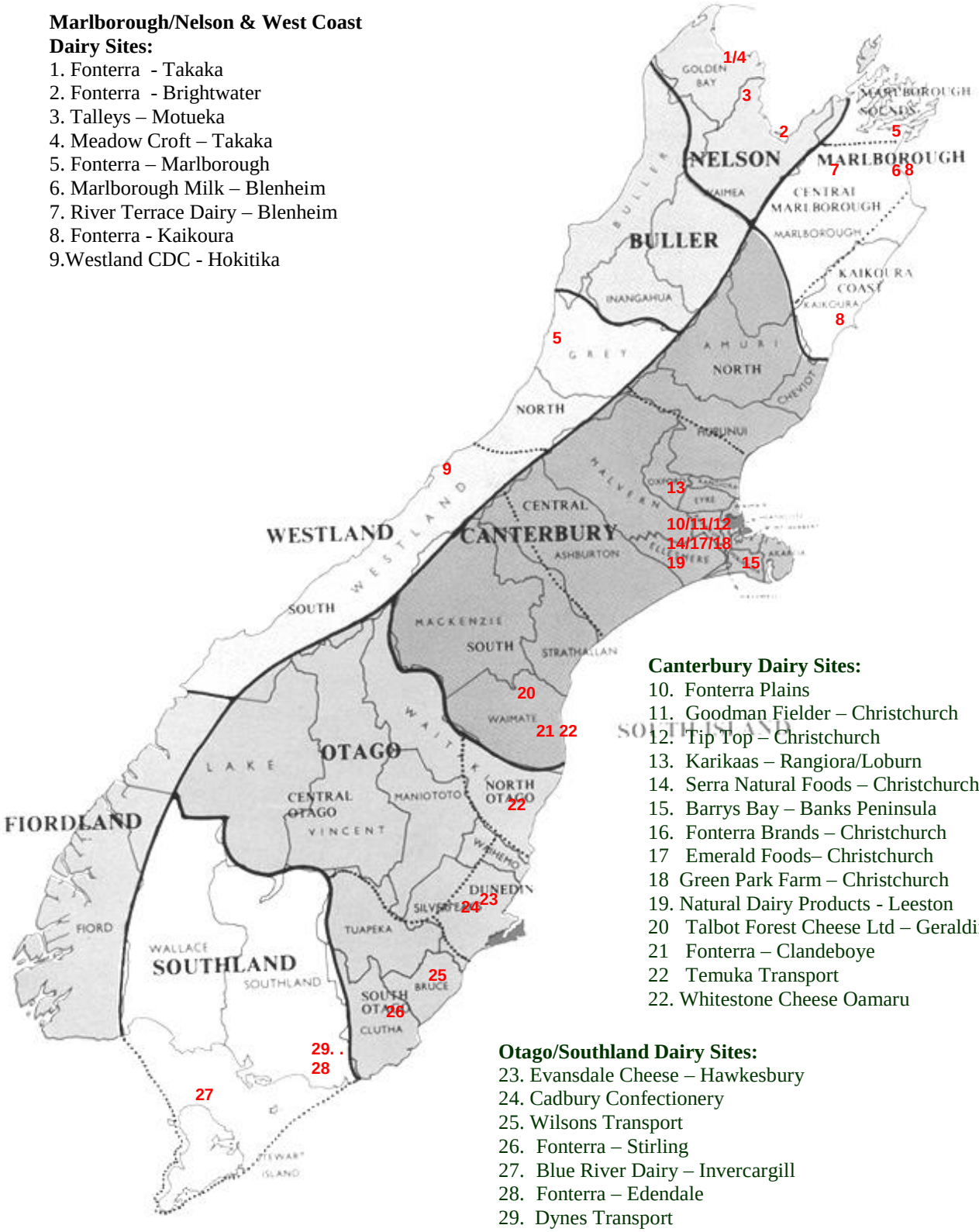
**Auckland Dairy Sites:**
7. Crescent Dairy Goats
8. Canaan Cheese
9. Emerald Foods
10. Delago products
11. L W Bonny & Sons
12. Fonterra Brands – Takanini
13. Independent Dairy Products
14. Tip Top Ice Cream
15. Tony Galbraith Ltd (Fluidex)
16. Green Valley Dairy


**Central Dairy Sites:**
38. Hooker Pacific Transport
39. Symons Transport
40. Taranaki Milk Products
41. Fonterra Brands – Eltham
42. RA Wallis Transport
43. Fonterra – Kapuni
44. Fonterra – Whareroa
45. Fonterra – Research (DRI)
46. Fonterra – Longburn
47. Goodman F – Longburn
48. International Fine Foods
49. Biofarm
50. Fonterra Brands/kapiti (Milk)
51. Fonterra Brands/kapiti (cheese)
52. Zany Zeus

**Central Dairy Sites:**
53. Fonterra - Pahiatua
54. Rangiuru Farm
55. Te Mata Cheese
56. Waimata Cheese
57. Gisborne Milk Co-op Ltd
58. Kingsmeade Cheese
59. Cwmglyn farm

**Marlborough/Nelson & West Coast Dairy Sites:**

1. Fonterra - Takaka
2. Fonterra - Brightwater
3. Talleys – Motueka
4. Meadow Croft – Takaka
5. Fonterra – Marlborough
6. Marlborough Milk – Blenheim
7. River Terrace Dairy – Blenheim
8. Fonterra - Kaikoura
9. Westland CDC - Hokitika




**Canterbury Dairy Sites:**

10. Fonterra Plains
11. Goodman Fielder – Christchurch
12. Tip Top – Christchurch
13. Karikaas – Rangiora/Loburn
14. Serra Natural Foods – Christchurch
15. Barrys Bay – Banks Peninsula
16. Fonterra Brands – Christchurch
17 Emerald Foods– Christchurch
18 Green Park Farm – Christchurch
19. Natural Dairy Products - Leeston
20 Talbot Forest Cheese Ltd – Geraldine
21 Fonterra – Clandeboye
22 Temuka Transport
22. Whitestone Cheese Oamaru

**Otago/Southland Dairy Sites:**

23. Evansdale Cheese – Hawkesbury
24. Cadbury Confectionery
25. Wilsons Transport
26. Fonterra – Stirling
27. Blue River Dairy – Invercargill
28. Fonterra – Edendale
29. Dynes Transport

## 12.3 Risk definitions

1. Negligible - not a realistic risk under any conditions
2. Remote - realistic but low frequency/probability event
3. Significant - realistic and high frequency/probability event

Determination of overall level of risk:

| Probability of exposure | Probability of infectious dose of virus in conveyor | Likelihood of infectious episode* |
|---|---|---|
| Negligible | Negligible | Negligible |
| Negligible | Remote | Negligible |
| Negligible | Significant | Negligible |
| Remote | Negligible | Negligible |
| Remote | Remote | Remote |
| Remote | Significant | Remote |
| Significant | Negligible | Negligible |
| Significant | Remote | Remote |
| Significant | Significant | Significant |

* combined risk of Probability of exposure and Probability of infectious dose of virus in conveyor