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Evaluation of Three Livestock Movement Reporting Options to Support Tracing Investigations Following a Sanitary Issue in Canada

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EXECUTIVE SUMMARY

Three movement reporting options implemented at farms, feedlots, intermediate sites and terminal sites were evaluated for their effectiveness to support tracing investigations following: (1) the detection of foot-and-mouth disease (FMD); and (2) bovine spongiform encephalopathy (BSE) in a bovine. Intermediate sites included, but were not limited to: auction markets, community pastures, assembly yards, fairs and rodeos. The species of concern for this evaluation were: cattle, bison, sheep, goats and cervids.

The following movement reporting options were explored when farmed ruminants moved from a departure site to a destination site:

- ***In Option 1 – “lot movement + one-step”:***
 - *Move-in Option 1:* The operator of the destination site reports the identification number of the departure and destination sites; the quantity of farmed ruminants received per load and their species; the date and time at which the farmed ruminants arrived at the destination site and; the license plate number of the conveyance used to transport the farmed ruminants.
 - *Move-out Option 1:* The operator of the departure site reports the identification number of the departure and destination sites; the quantity of farmed ruminants that left the departure site and their species; the date and time at which the farmed ruminants left the departure site and; the license plate number of the conveyance used to transport the farmed ruminants.
- ***In Option 2 – “sighting”:***
 - *Move-in Option 2:* The operator of the site reports the animal identification numbers of farmed ruminants received; the date and time at which the farmed ruminants arrived at the site and; the license plate number of the conveyance used to transport the farmed ruminants.
 - *Move-out Option 2:* The operator of the site reports the animal identification numbers of farmed ruminants that left the site; the date and time at which the farmed ruminants left the site and; the license plate number of the conveyance used to transport the farmed ruminants.
- ***In Option 3 – “animal ID read-in + one-step”:***
 - *Move-in Option 3:* The operator of the destination site reports the identification number of the departure and destination sites; the identification number of the indicators applied to the farmed ruminants received; the date and time at which the farmed ruminants arrived at the destination site and; the license plate number of the conveyance used to transport the farmed ruminants.
 - *Move-out Option 3:* The operator of the departure site reports the identification number of the departure and destination sites; the identification number of the indicators applied to the farmed ruminants that left the site; the date and time at which the farmed ruminants left the departure site and; the license plate number of the conveyance used to transport the farmed ruminants.

The three options were assessed in their ability to fulfill the requirements of tracing investigations following detection of FMD at a farm, feedlot or terminal site and the detection of BSE in a bovine. A qualitative score was attributed to each option by task. Considering the movement pathways of cattle, bison, sheep, goats and cervids in Canada, the only movement reporting combination that would fully support these investigations is:

Reporting	Farms	Intermediate sites	Feedlots	Terminal sites
Move-in	Option 3	Option 3	Option 3	Option 3

Key scientific considerations:

- Dual declaration at farms (move-in and move-out option 3) combined with option 1 move-in at intermediate sites and option 3 move-in at feedlots and terminal sites would provide similar results as the combination proposed above.
- A tag activation process at a time around birth would support both tracing investigations for FMD and is a critical requirement to support BSE investigations in order to identify birth and feed cohorts.
- Trace-out investigations can be severely impacted by the allowed 7 days for movement reporting. Requiring that a document describing the departure site ID, the destination site ID, the conveyance used, date and time of movement should accompany each movement of livestock in Canada and that a copy of this document remain at the departure site for consultation in the case of an investigation would improve support for these investigations. Ideally, the delay to reporting should be reduced to within 48 hours of arrival of animals.

Tracking Form

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Evaluation of Three Livestock Traceability Options Applied at Intermediate Sites To Manage a Sanitary Issue in Canada

1. INTRODUCTION

Amendments to Part XV of the *Health of Animals Regulations* are currently proposed that will impact livestock identification and traceability (CFIA, 2013). The purpose of these amendments is to contribute to the ability of the federal government to report and respond to any livestock disease outbreak in a timely and effective manner.

Livestock movements are associated with the spread of various highly contagious reportable diseases such as foot-and-mouth disease (FMD), one of the most contagious diseases of livestock or Classical Swine Fever (CSF). Infected animals moving from farm-to-farm represent the most important means of transmission of these diseases (Kitching *et al.*, 2006). As a result, following the detection of a disease like FMD it becomes critical to quickly identify all potentially exposed animals through tracing investigations of animal movements in order to stop further spread from taking place (Eames and Keeling, 2003; Haydon *et al.*, 2004; Kiss *et al.*, 2005). Hence the importance of having reliable and efficient livestock identification and traceability schemes in place.

In the case of a feed contamination or a disease like Bovine Spongiform Encephalopathy (BSE), identifying cohorts of animals which may have been exposed to the same contaminant, sometimes years before the detection of the contamination, will be required. A system which allows the identification of an animal's location throughout its life as well as the animal's birth and feed cohort is necessary to support such investigations.

The following performance targets for traceability were developed by the Federal, Provincial and Territorial Traceability Task Team (TTT; CFIA 2013):

"Within 48 hours of the relevant Chief Veterinary Officer or Competent Authority being notified of a sanitary issue or natural disaster or in the prevention or preparedness of such issue, it must be possible to...

- 1. Establish the location(s) where a specified animal has been kept during its life.*
- 2. Establish the location(s) from where farmed ruminants at a given site were received.*
- 3. Establish a listing of all farmed ruminants that have been kept on the same location as the specified animal at any stage during those farmed ruminants' lives.*
- 4. Determine the current location of all farmed ruminants that have been kept on the same site as the specified animal at any time duration those farmed ruminants' lives.*
- 5. Determine the identification number and movement history of all conveyances used to transport farmed ruminants to and from a given location.*
- 6. Establish the location of a specified animal immediately prior to importation in Canada or the location of a specified animal immediately subsequent to exportation from Canada.*
- 7. Establish the location and date at which deceased farmed ruminants were sent, transported, received and disposed of (both on- and off-site), and a listing of those farmed ruminants if identified individually."*

The current traceability situation in Canada is one of “book-end” in most provinces. This means that information is available on the birth farm of an animal and the site where the animal was disposed of or slaughtered. As this system does not provide any information on the movements in-between the origin and end of an animal’s life, it does not address the performance targets for traceability. Various options are currently being considered to improve this situation. Key factors must be taken into consideration in the development of a movement reporting program such as industry’s willingness and readiness to implement the program, the cost of the program, the cost of compliance verification and the program’s ability to improve the management of a sanitary issue or natural disaster.

1.1. Scope of Document

The purpose of this document was to assess, from an epidemiological perspective, the value of three different livestock movement reporting options for cattle, bison, sheep, goats and cervids for the purposes of managing a sanitary issue.

1.2. General Approach

Data collected in 2015 as part of a livestock demographic study (Serecon & CAHC, 2015) was used as the basis to describe the movements of cattle, bison, sheep, goats and cervids through the various sites such as farms, feedlots, intermediate sites and terminal sites.

Three movement reporting options were compared in tracing investigations that would take place in the context of the detection of FMD and BSE. These two diseases were selected because their respective needs for traceability are very different: FMD requires short-term urgent traceability information while BSE investigations may go back years before the detection of the disease. In the present study, it was assumed that a movement reporting system in place would provide all the tracing information required during disease investigations.

Animal movements were broken down into the following pathways in which the movement reporting options were evaluated:

1. Direct farm-to-farm, farm-to-feedlots, farm-to-terminal movements;
2. Indirect farm-to-farm, farm-to-feedlots, farm-to-terminal site movements through intermediate site(s);
3. Direct feedlot-to-terminal site movements;

Tracing needs were broken down into tasks for the two diseases (FMD and BSE), and each movement reporting option was assessed in how it could support these tasks. A qualitative score was then assigned to each traceability option based on how well they supported each task:

1. **Excellent:** Meets completely the task objectives without additional investigation outside of the database, except for the list of animal IDs to trace to be provided by the operator of the detected farm. Obtaining this list will increase the time required for these investigations.

2. **Good:** Meets completely the task objectives with limited additional searches outside of the database.
3. **Limited:** Partially or completely meets the task objectives but with extensive additional searches outside of the database.
4. **Inadequate:** Does not meet the task objectives.

The options were then ranked based on their overall qualitative score for each section evaluated. Various combinations of movement reporting options applied at different sites in the movement pathways of cattle, bison, sheep, goats and cervids are recommended based on their performance in supporting tracing investigations.

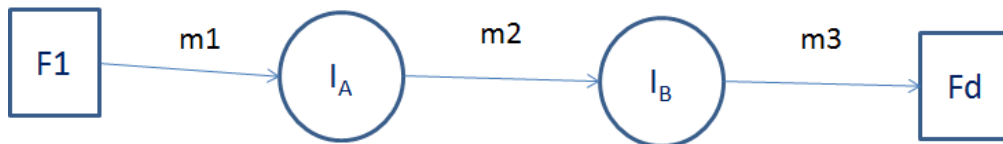
2. ANIMAL MOVEMENTS IN CANADA

DEFINITIONS:

We used the following definitions when the movements of cattle, bison, sheep, goats and cervids:

1. **Birth farm (F1):** this represents the farm of origin of livestock. These farms may also be destination farms, specifically for replacement stock and breeding purposes. Example: a cow-calf operation in beef cattle or the lactating barn in a dairy farm.
2. **Secondary farm (F2):** a farm that received livestock from any number of Departures.
3. **Feedlot (Fd):** an operation that feeds animals and is operated in whole or in part for the purposes of growing or finishing animals by means other than grazing but does not include (i) an overwintering site where cattle are fed and sheltered, or (ii) a site for breeding animals and their offspring. Example: backgrounder, feedlot.
4. **Intermediate site (I):** any site where animals or dead stock may be kept after leaving a farm and before being received at another farm or at a terminal site. These include: community pastures, auctions, fairs, test stations, assembly yards, competitive events, training and education facilities, rest stations, feed and watering stations, exhibits, reproduction centres, quarantine stations, rodeos, veterinary clinics and sites managed by dealers and order buyers. **Note that under this document, “intermediate sites” does not include ‘feedlots’.**
5. **Terminal site (T):** abattoir, rendering plant, dead-stock collectors.
6. **Movement pathway:** Each movement of animal(s) has a departure site and a destination site. A movement pathway combines all the movements that may have taken place between the *initial* departure and *final* destination sites. These include movements through intermediate sites.

Intermediate sites however can never be considered the initial departure site or the final destination site of a movement pathway. Below is an example:



In the example above, three movements (m1, m2, m3) and four sites (F1, I_A, I_B, Fd) compose the movement pathway. The farm F1 represents the initial departure site and the feedlot Fd is the final destination site. The intermediate site I_A is the destination site of movement 1 (m1) AND the departure site of m2. Intermediate site I_B is the destination site of m2 AND the departure site of m3. If disease was detected in Fd, the sites I_B, I_A and F1 would have to be identified and further tracing activities would have to be conducted from these sites.

2.1. The Cattle Industry

The cattle industry in Canada can be divided into two main sectors: (1) beef production which includes cow-calf and backgrounding operations, finishing feedlots and grain-fed veal production, and (2) the dairy sector which includes veal and milk production. There are regional differences associated with beef production with the majority (84%) of the production being located in Western Canada and with 84% of the Western production being done in Alberta and Saskatchewan. The majority of milk production takes place in Eastern Canada (77%) with most (92%) of this production being located in Ontario and Quebec. Each year, 14% of beef raised in Canada are slaughtered while another 5% are exported. Twelve percent of dairy cattle (including veal) that are raised in Canada are slaughtered each year while 0.2% of these are exported.

Individual identification of cattle is mandatory in Canada and this identification must be applied when the animal leaves its birth farm, at the latest, or when it arrives at its destination if imported. There is no reporting of this tag application process. There is reporting of which producer originally purchased the tags which enables indirect linkages of animal ID to its birth farm. This reporting is done through the Canadian Cattle Identification Agency (CCIA) in most Provinces. In the Province of Quebec however, cattle must be identified within 7 days of birth or when the animal leaves its birth farm, whichever comes first and this reporting is done to Agri-Traçabilité Québec (ATQ) who is the data administrator in this Province. There is a requirement to report the identification number of tags applied to animals and dead stock received at terminal sites such as abattoirs, renderers or when an animal dies at the farm (if identified) or is exported. This is known as a retirement event. In-between these events (tag issuance and retirement) there is no mandatory reporting of movement events in most provinces.

Under Quebec provincial regulations, all movements of cattle within the province must be reported to ATQ. In the Province of Alberta, feedlots with >1000 cattle are required to report the individual animal ID of cattle arriving onto their site. In addition, a transport manifest is required for the movement of cattle in Western Canada.

2.1.1. The beef cattle industry

As discussed above, most of the beef production occurs in the Western Provinces of the country. Breeding takes place mostly in Alberta and Saskatchewan which hold 47% and 33% of cow-calf operations in the region. Calves are then moved either to backgrounding operations or to finishing feedlots, most often after being sold at an auction market. Backgrounding and feeding is mostly done in Alberta which holds 73% of backgrounder cattle and 84% of feeder cattle in the region. There are significant differences in movement pathways of beef cattle between Western and Eastern Canada and for this reason, these are presented separately.

2.1.1.1. Movements of beef cattle in Western Canada

Figure 1 shows the movement patterns of beef cattle in Western Canada and Table 1 provides the importance of each pathway based on estimated total number of movements per year in the region (Serecon & CAHC, 2015). There are three main farm-types involved in beef cattle production in the region: cow-calf operations that produce calves for feeding, backgrounding operations that grow calves prior to feeding and finishing feedlots that produce finished beef for consumption.

In this region, cow-calf operations sell mostly to auction markets (70% of cattle moved out of cow-calf operations; Table 1) and to abattoirs but also sell directly to feedlots, and backgrounding operations. The auction markets in turn sell most of beef cattle to feedlots (80%). This represents the main use of auction markets in the region: to move cattle from cow-calf operations to feedlots.

Backgrounding operations will purchase mostly directly from cow-calf operations (49%) and the auction market (51%) and will sell cattle almost equally directly to feedlots (45%) and auction markets (39%). As discussed above, auction markets will mostly sell cattle to feedlots and to the abattoir. Finally, cattle at feedlots will be sold for slaughter directly to abattoirs (71%) and for export, again directly (29%).

The movements to and from community pastures are not included in the diagram below but these movements represent 22% of the beef cattle movements in Western Canada. They typically go from the birth farm (cow-calf operation) to the pasture and then back to the cow-calf operation.

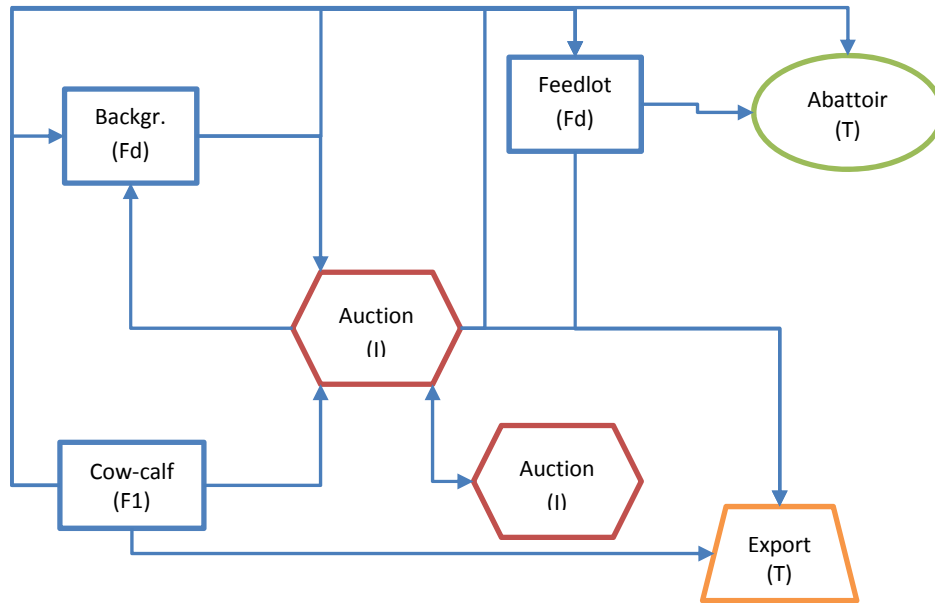


Figure 1. Movements of beef cattle in Western Canada based on data provided in Serecon & CAHC (2015).

Table 1. Importance of movement pathways for each departure and destination in the beef cattle movement network in Western Canada. Data is based on the Serecon & CAHC report, 2015.

Departure site of farmed ruminants by destination					
	Backgrounder	Feedlot	Intermediate Site	Abattoir	Export
Departure site					
Cow-calf (F1)	49%	24%	93%	3%	5%
Backgrounder (Fd)	0%	6%	6%	3%	0%
Feedlot (Fd)	0%	0%	0%	84%	90%
Intermediate Site (I)	51%	70%	1%	10%	5%

Destination of farmed ruminants by departure					
	Backgrounder	Feedlot	Intermediate Site	Abattoir	Export
Departure site					
Cow-calf (F1)	5%	21%	70%	3%	1%
Backgrounder (Fd)	0%	45%	39%	16%	0%
Feedlot (Fd)	0%	0%	0%	71%	29%
Intermediate Site (I)	7%	80%	1%	10%	2%

2.1.1.2. Movements of beef cattle in Eastern Canada

Figure 2 shows the movement patterns of beef cattle in Eastern Canada and Table 2 provides the importance of each pathway based on estimated total number of movements per year in the region (Serecon & CAHC, 2015). Two main farm types were identified in the Serecon & CAHC study: cow-calf operations and secondary farms (which most likely represent feedlot-type operations). The role of intermediate sites is different in this region with the addition of assembly yards to the role of auction markets.

Beef cattle leaving a cow-calf operation in Eastern Canada either go directly to a secondary farm (46% of movements from cow-calf operations) or an auction market (45%). Secondary farms will then sell mostly to auction markets (65%) and to assembly yards (21%). Assembly yard assemble cattle from a variety of departure sites to sell directly to secondary farms (92% of movements from assembly yard). These sites are not only important for moving calves from cow-calf operations to secondary farms, but there are also movements among secondary farms in Eastern Canada, which is typical of the region. Auction markets are also used to sell cattle to secondary farms (62%) and to assembly yards (29%) as well as abattoirs (6%). There is therefore an important role of intermediate sites in the movement of beef cattle in Eastern Canada with important links between auction markets and assembly yards.

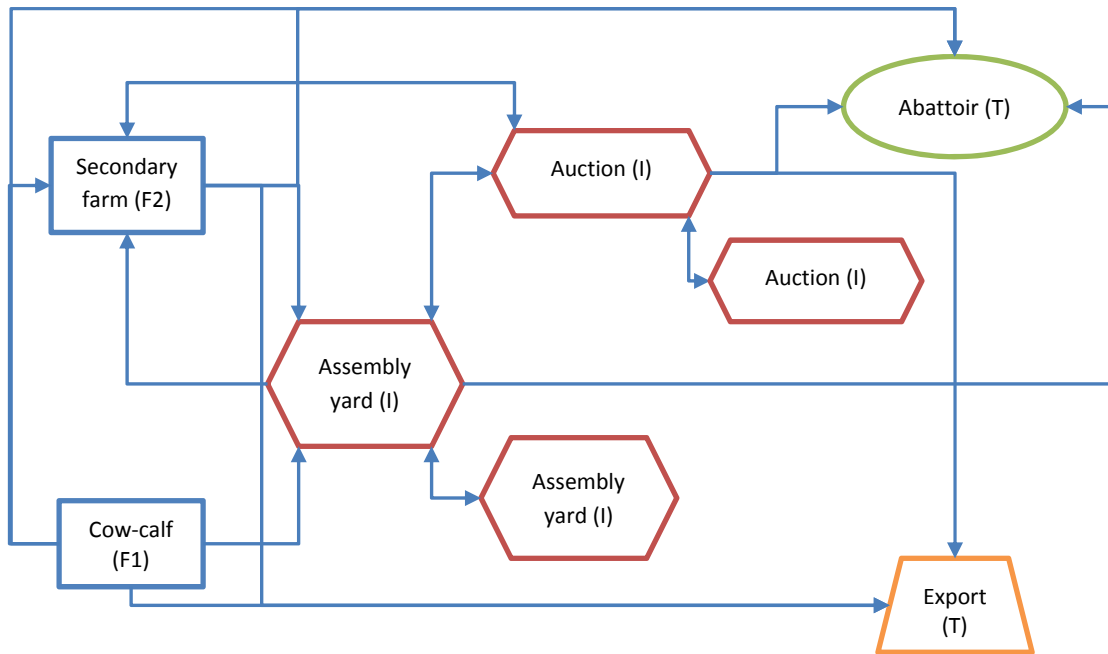


Figure 2. Movements of beef cattle in Eastern Canada based on data provided in Serecon & CAHC (2015).

Table 2. Importance of movement pathways for each departure and destination in the beef cattle movement network in Eastern Canada. Data is based on the Serecon &CAHC report, 2015.

Departure site of farmed ruminants by destination					
	Secondary Farm	Auction Market	Assembly yard	Terminal	Export
Departure site					
Cow-calf (F1)	23%	32%	5%	5%	21%
Secondary Farm (F2)	0%	65%	40%	43%	58%
Auction Market (I)	43%	0%	54%	49%	21%
Assembly yard (I)	34%	3%	1%	3%	0%

Destination of farmed ruminants by departure					
	Secondary Farm	Auction Market	Assembly yard	Terminal	Export
Departure site					
Cow-calf (F1)	46%	45%	3%	1%	5%
Secondary Farm (F2)	0%	65%	21%	5%	9%
Auction Market (I)	62%	0%	29%	6%	3%
Assembly yard (I)	92%	6%	1%	1%	0%

Summary of findings – beef cattle movements in Canada

- There are significant differences in the movement patterns of beef cattle between Western and Eastern Canada:
- In Western Canada:
 - Auction markets are used mostly to move cattle from cow-calf operations to feedlots. As a result, 93% of beef cattle sold through an auction market come from their birth farm.
 - Movements of beef cattle through intermediate sites represent 28% of all beef cattle movements in the region.
- In Eastern Canada:
 - There are two types of intermediate sites in the region: auction markets and assembly yards playing the same role as auction markets in Western Canada. However, these intermediate sites are highly related to each other in the east: auction markets provide 54% of beef cattle to assembly yard, making tracing back to the departure farm difficult without animal ID information at these sites. As a result, only 22% of beef cattle sold at an intermediate site come from their farm of origin.
 - Movements through intermediate sites represent 47% of all beef cattle movements in the region. Movements through intermediate sites in Eastern Canada account for 21% of all beef cattle movements in Canada.

2.1.2. The dairy industry

Data obtained from the Province of Quebec were used as a representative dataset for the main milk producing provinces (Ontario and Quebec) and was extrapolated to the National level (Serecon & CAHC, 2015). In the dairy industry network, there are no distinct breeding farms and milk producing farms as observed in the beef industry. However, there are important movements for the replacement of breeding stock. These farm-to-farm movements are represented by the movements from secondary farms (F2) to birth farms (F1). It is anticipated however that some of the F2 to F1 movements reported in the Serecon & CAHC report actually consists of F2 to F2 direct movements. It was not possible to distinguish these from F2 to F1 movements and these were left as proposed by the Serecon & CAHC report.

In the dairy industry, intermediate sites are used for farm-to-farm movements of cattle, movements from farm to slaughter and movements among intermediate sites are frequent. In fact, 34% of farmed ruminants arriving at assembly yards come from an auction markets.

Dairy cattle sold at auction markets are mostly purchased by secondary farms (36%), assembly yards (27%) and terminal sites (38%) as shown in Figure 3. Assembly yards will sell most (86%) of their cattle to farms.

The dairy industry is divided into veal production and dairy milk production. Veal follow a pattern that may resemble the beef cattle industry which may explain why there are some similarities in the movement patterns of dairy and beef cattle in Eastern Canada.

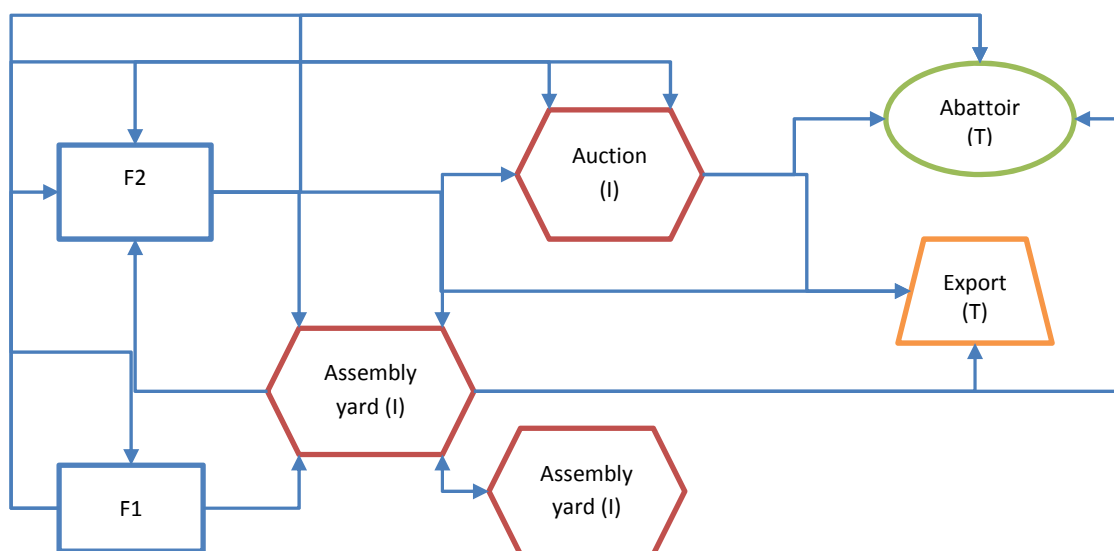


Figure 3. Movement pathways of dairy cattle in Canada based on data provided in Serecon & CAHC (2015).

Table 3. Importance of movement pathways for each departure and destination in the dairy cattle movement network in Canada. Data is based on the Serecon &CAHC report, 2015.

Departure site of farmed ruminants by destination						
	F1	F2	Auction Market	Assembly yard	Terminal	Export
Departure site						
F1	0%	19%	47%	4%	9%	0%
F2	100%	0%	49%	61%	40%	50%
Auction Market (I)	0%	36%	0%	34%	38%	25%
Assembly yard (I)	0%	45%	4%	1%	13%	25%

Distribution of destination of farmed ruminants by departure site						
	F1	F2	Auction Market	Assembly yard	Terminal	Export
Departure site						
F1	0%	34%	56%	4%	6%	0%
F2	21%	0%	33%	32%	14%	0%
Auction Market (I)	0%	53%	0%	27%	20%	0%
Assembly yard (I)	0%	86%	4%	1%	9%	0%

Summary of findings – dairy movements in Canada

- As the majority of dairy production takes place in Eastern Canada, the ATQ data was used as a surrogate for the movements of dairy in the country.
- The movements of dairy cattle through intermediate sites display similarities with the movements of beef cattle in Eastern Canada with the use of auction markets and assembly yards. They represent 43% of all movements of dairy cattle in Canada.
- Only 28% of dairy cattle sold at intermediate sites come from their farm of origin making tracing an auction markets and assembly yards difficult without recording of individual animal movements.
- Assembly yards acquire up to 34% of their farmed ruminants from auction markets, making tracing of farmed ruminants even more complex.

2.2. The Bison Industry

The bison industry is focussed on meat production and export of live bison. The majority of bison (96%) are raised in Western Canada, with 77% of this Western production located in Alberta and Saskatchewan. Each year, an average of 28% of the production is either slaughtered (42%) or exported as live bison (58%).

Individual identification of bison is mandatory in Canada and this identification must be applied when the animal leaves its birth farm, at the latest, or when it arrives at its destination if imported. There is no reporting of this tag application process. There is reporting (tag issuance) of which producer originally purchased the tag number which enables indirect linkage between the birth farm and the animal ID. There is however a requirement to report the identification number of tags applied to bison and dead stock received at terminal sites such as abattoirs, renderers or when an animal dies at the farm (if identified) or is exported. This is known as a tag retirement event in the CCIA database. In-between these events (tag issuance and retirement) there is no mandatory reporting of movement events in most provinces. The CCIA records all information related to bison identification in its national database.

Bison leaving their birth farm go directly to a secondary farm in 38% of cases while 23% go to slaughter and another 27% go for export. In 5% of movements off the birth farm, these bison go to an auction market and another 6% go to a broker. Auction markets and brokers are mainly used for sales for export: 72% of bison at an auction or a broker goes for export while only 8% goes for slaughter and the remaining 20% are purchased by a secondary farm. Approximately 64% of bison arriving at an auction or a broker comes from the birth farm. There are apparently no movements among intermediate sites, or these occur very rarely in the bison industry.

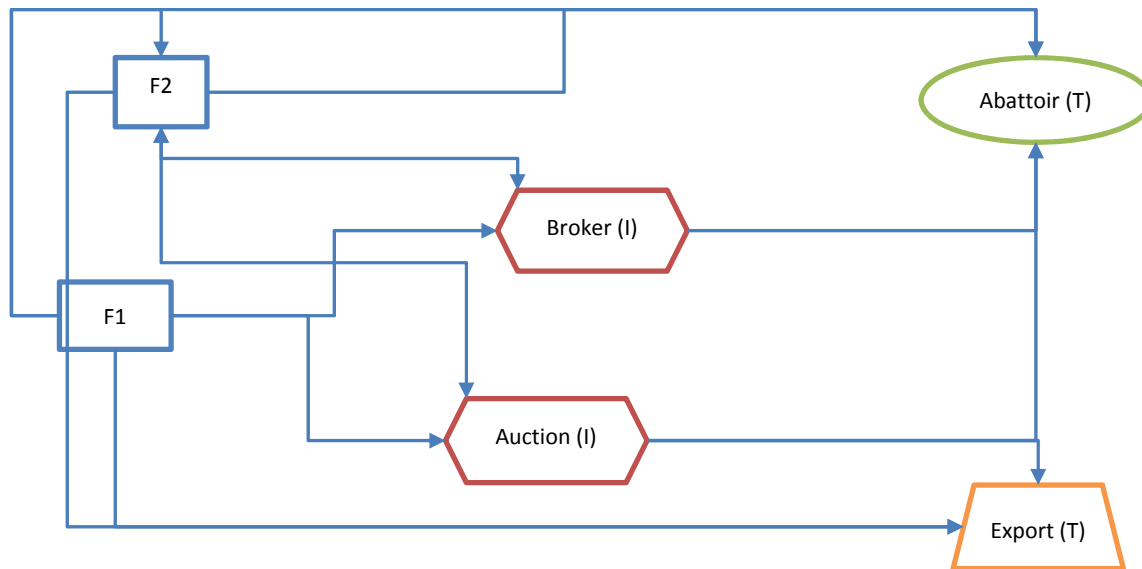


Figure 4. Movement pathways of bison in Canada based on data provided in Serecon & CAHC (2015).

Table 4. Importance of movement pathways for each departure and destination in the bison movement network in Canada. Data is based on the Serecon &CAHC report, 2015.

Departure sites of farmed ruminants by destination					
	F2	Auction Market	Dealer	Abattoir	Export
Departure site					
F1	92%	64%	63%	53%	44%
F2	0%	36%	37%	43%	36%
Auction Market (I)	4%	0%	0%	1%	9%
Dealer (I)	4%	0%	0%	3%	11%

Distribution of destination of farmed ruminants by departure site					
	F2	Auction Market	Broker	Abattoir	Export
Departure site					
F1	38%	5%	6%	23%	27%
F2	0%	6%	7%	40%	47%
Auction Market (I)	20%	0%	0%	8%	72%
Dealer (I)	17%	0%	0%	13%	70%

Summary of findings – bison movements in Canada

- Auction markets and brokers are used in 11% of all movements of bison in Canada.
- These intermediate sites are used mainly for movements to export, secondary farms and slaughter, in order of importance.
- Sixty-four percent of bison arriving at an auction markets or brokers come from their birth farm.
- There are no movements among intermediate sites.

2.3. The Cervid Industry

Of the total number of cervids in Canada, the majority are located in Alberta (27%) and Saskatchewan (40%). In Eastern Canada, Quebec and Ontario have the most cervids with 18% and 8% of the National herd in these two provinces respectively.

Individual cervid identification is a requirement under some provincial regulations. All movements of cervids are recorded in Canada. In the Province of Quebec, all movement of cervids is reported and tags are retired when an animal is slaughtered or disposed of on-site or through a renderer; the departure of cervids from Quebec is also required to be reported.

Approximately 44% of cervids that leave their birth farm will go to a secondary farm directly. Auction markets are used mainly for farm-to-farm movements, but this represents only 2% of all cervid

movements. Seven percent of cervids are exported each year and this is done directly from the farm (either the birth farm or a secondary farm). Movements to abattoir also occur directly from the farm.

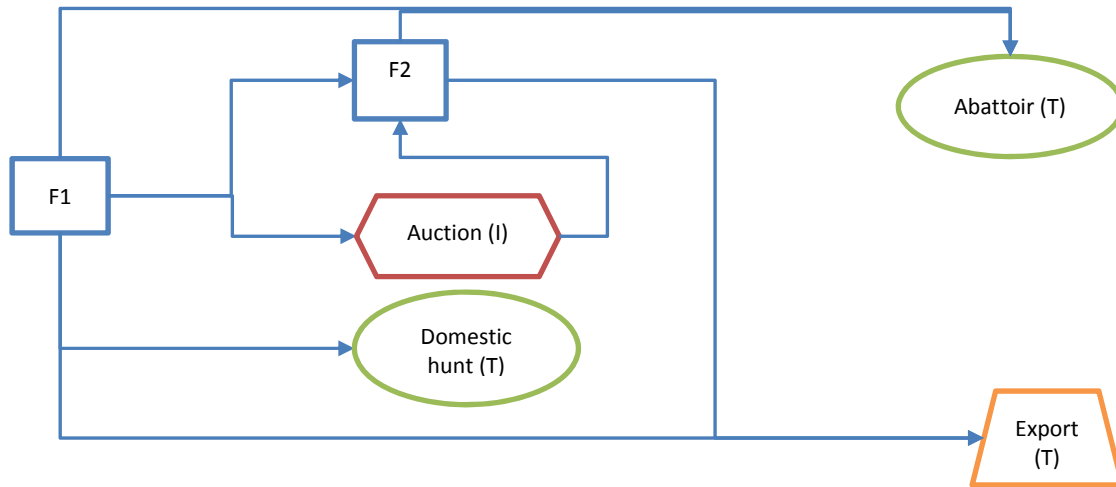


Figure 5. Movement pathways of cervids in Canada based on data provided in Serecon & CAHC (2015).

Table 5. Importance of movement pathways for each departure and destination in the cervid movement network in Canada. Data is based on the Serecon &CAHC report, 2015.

Departure site of farmed ruminants by destination					
	F2	Auction Market	Domestic Hunt	Abattoir	Export
Departure site					
F1	94%	100%	100%	50%	50%
F2	0%	0%	0%	50%	50%
Auction Market (I)	6%	0%	0%	0%	0%

Distribution of destination of farmed ruminants by departure site					
	F2	Auction Market	Broker	Abattoir	Export
Departure site					
F1	44%	3%	18%	5%	31%
F2	0%	0%	0%	14%	86%
Auction Market (I)	100%	0%	0%	0%	0%

Summary of findings – cervid movements in Canada

- Auction markets are used in only 2% of cervid movements in Canada and these take place for movements from the birth farm to a secondary farm.
- There are no reports of movements among intermediate sites.

2.4. The Goat Industry

Approximately 52% of the goat production in Canada takes place in Ontario, followed by Quebec (17%) and Alberta (13%). There are currently no regulations requiring the individual identification of goats, of premises housing goats and of course, no information on movements of goats in Canada. Based on discussions with industry representatives (Serecon & CAHC, 2015), it appears that most movements (68%) occur directly from the birth farm: 59% of these going to a secondary farm directly, 32% of these to an abattoir directly and the remaining 9% going through an auction market. At the auction market, goats are received from the birth farm (67%) and from secondary farms (33%). Goats sold through auction markets will go to slaughter in 57% of cases and to a secondary farm in 43% of cases. There does not appear to be movements among auction markets.

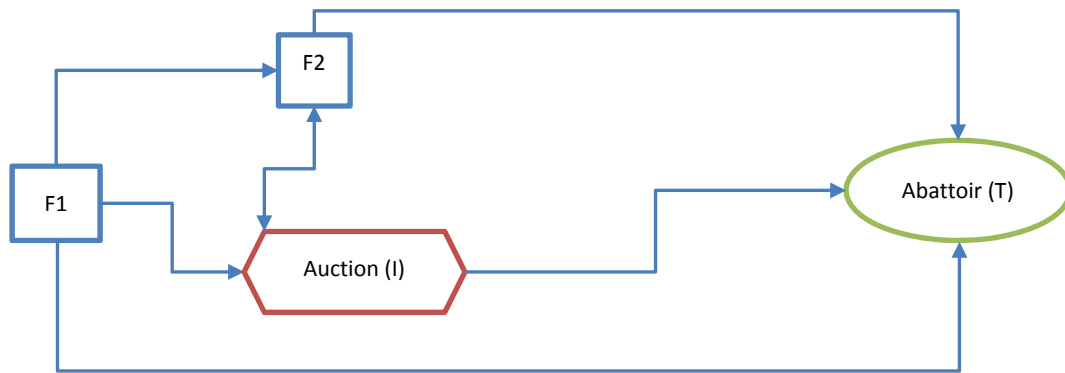


Figure 6. Movement pathways of goats in Canada based on data provided in Serecon & CAHC (2015).

Table 6. Importance of movement pathways for each departure and destination in the goat movement network in Canada. Data is based on the Serecon & CAHC report, 2015.

Departure site of farmed ruminants by destination			
	F2	Auction Market	Abattoir
Departure site			
F1	92%	67%	56%
F2	0%	33%	33%
Auction Market	8%	0%	11%

Distribution of destination of farmed ruminants by departure site			
	F2	Auction Market	Abattoir
Departure site			
F1	59%	9%	32%
F2	0%	20%	80%
Auction Market	43%	0%	57%

Summary of findings – goat movements in Canada

- Movements of goats through auction markets represent 8% of all goat movements in Canada.
- A total of 67% of goats sold at auction markets come from their farm of origin and most goats sold at auction markets will go to slaughter (57%) or to a secondary farm (43%).

2.5. The Sheep Industry

Approximately 60% of the sheep production is located in Eastern Canada. Discussions with industry representatives and ATQ database highlighted the importance of intra- and inter-provincial movements in this industry (Serecon, 2015).

Individual identification of sheep is a federal requirement in Canada and sheep must bear an approved tag before leaving their birth farm. Sheep movements within Quebec are tracked and recorded in the ATQ database while the CCIA holds the animal identification database. The retirement of approved tags applied to sheep is not currently required at the federal level.

Based on results from the Serecon & CAHC study (2015), intermediate sites involved in the movement of sheep include auction markets and assembly yards/assembly yards. Out of all sheep arriving at auction markets, an estimated 78% come from a birth farm, 20% from a secondary farm and 2% from an assembly yard (Table 7). A very small number of sheep are also received from another auction market. The auction market then sells 73% of sheep for slaughter, 8% to an assembly yard and the remaining 19% of sheep go for export, which could mean outside of the Province. Therefore auction markets are mostly used for selling to slaughter. Out of all sheep that arrive in an assembly yard, 90% of these come from an auction market while the remaining 10% arrive from the birth farm. Assembly yards are used mostly (68%) for export (including out-of-Province) and for selling to auction markets (22%). Most (97%) farm-to-farm movements within a Province do not involve an intermediate site.

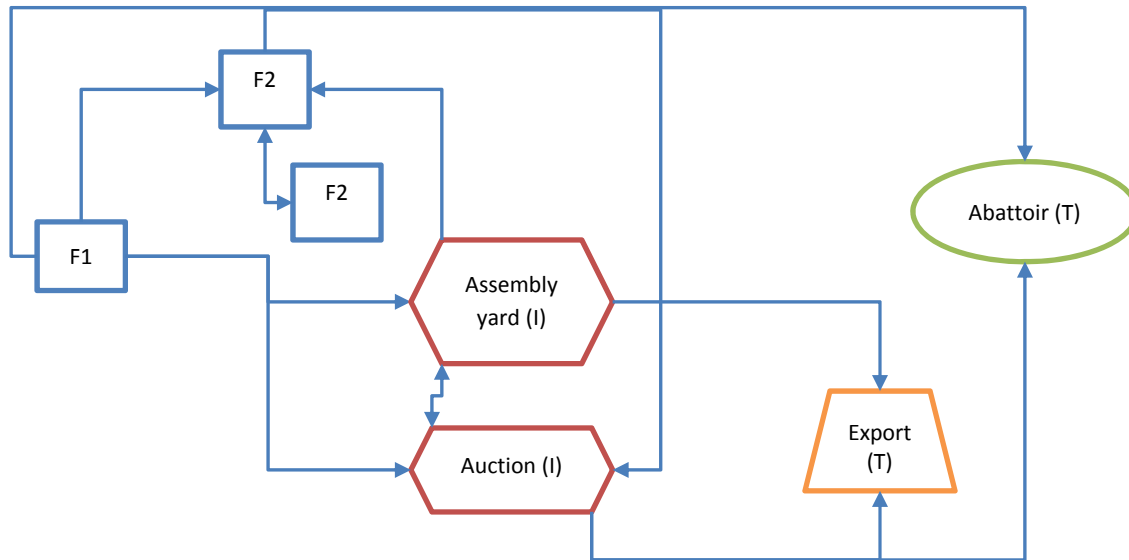


Figure 7. Movement pathways of sheep in Canada based on data provided in Serecon & CAHC (2015).

Table 7. Importance of movement pathways for each departure and destination in the sheep movement network in Canada. Data is based on the Serecon & CAHC report, 2015.

Departure site of farmed ruminants by destination					
	F2	Auction Market	Dealer	Abattoir	Export
Departure site					
F1	97%	78%	10%	32%	0%
F2	0%	20%	0%	8%	0%
Auction Market	0%	0%	90%	61%	76%
Dealer	3%	2%	0%	0%	24%

Distribution of destination of farmed ruminants by departure site					
	F2	Auction Market	Dealer	Abattoir	Export
Departure site					
F1	18%	55%	1%	26%	0%
F2	0%	67%	0%	33%	0%
Auction Market	0%	0%	8%	73%	19%
Dealer	10%	22%	0%	0%	68%

Summary of findings – sheep movements in Canada

- Movements of sheep through intermediate sites represent 35% of all sheep movements in Canada.
- A total of 78% of sheep sold at intermediate sites come from their farm of origin and most sheep sold at auction markets will go to slaughter.
- Auction markets are the main providers of sheep to assembly yards who will themselves either sell to other auction markets or sell for exports or outside Province movements.

3. MOVEMENT REPORTING OPTIONS EVALUATED

3.1. Definitions

In addition to the definitions found in Section 2, page 3, the following terms were used:

1. *Farmed ruminants*: cattle, sheep, bison, goats and cervids were referred to as farmed ruminants in this document to facilitate reading.
2. *Trace-in investigations*: identification of all departure sites of farmed ruminants introduced into a detected livestock holding during the critical period. The purpose of these investigations is to identify the Origin of infection, going back to the initial departure site.
3. *Trace-out investigations*: identification of all destination sites of farmed ruminants removed from a detected livestock holding during the critical period. The purpose of these investigations is to find potentially exposed farmed ruminants, going forward to the final destination site.
4. *Database of responsible administrators “the database”*: represents the database that will store information related to movement reporting events. We used the term “the database” to refer to it throughout the document.
5. *Departure site*: the site where farmed ruminants were loaded to be moved to a destination site. In all trace-in investigations, the initial departure site of a movement pathway must be identified. This is straightforward in the context of direct movements: farm-to-farm/feedlot, feedlot to terminal site for example. In this case the initial departure site is the farm or feedlot where the movement originated. In indirect movements more than one departure site will be involved and trace-in investigations must be done at intermediate sites to allow tracing all the way back to the initial departure site.
6. *Destination site*: the site of farmed ruminant arrival following movement. In all trace-out investigations, the final destination of a movement pathway must be identified. In direct farm-to-farm/feedlot or farm/feedlot to terminal site, the end recipient of the movement is the final destination site. In indirect movements, trace-out investigations must take place at all intermediate sites along the pathway to find the final destination site.

3.2. Basic Recommended Program Elements for Movement Reporting in cattle, bison, sheep, goats and cervids.

The following are the proposed requirements to report cattle, bison, sheep, goat and cervids (referred to as “farmed ruminants” in the remainder of the document to facilitate reading) movements in Canada:

1. The movement of farmed ruminants within their birth farm (under the same ownership) would not be reported.
2. The responsibility of reporting animal movements lies with the receiving site, not with the site of departure (with the exception of exportation). However, move-out reporting is also considered for farms only.
3. All import and export of farmed ruminants would be reported within seven days.
4. The sale of approved tags is cross-referenced to the identification number of the site where the tag will be applied, providing a physical address of the birth farm of tagged farmed ruminants.

3.3. Options Explored for Animal Movement Reporting and Study Assumptions

Three options have been proposed (Table 8) to address the issue of movement reporting throughout animal movement pathways and it is critical to compare their effectiveness in managing a sanitary issue. The options assume that the destination sites will report move-in information. However, in the case of farms, we explored both move-in and move-out reporting for each of the three options.




In 2013 a report was commissioned by Agriculture & Agri-Food Canada (AAFC) to evaluate the beef cattle supply chain from farm to slaughter as a first step towards a quantitative risk assessment of the epidemiological risk of co-mingling sites (Preston & Associates, 2013). Recommendations from this report included the need to evaluate various delays in time to reporting of animal movements: from 48 hours to seven days. Following the first rounds of industry consultations in 2013, it appears impossible that a delay of less than seven days would be considered as a feasible option. As a result, it was concluded that delays shorter than seven days would not be considered in the present qualitative study. This is addressed further in the discussion.

Feedlots in Alberta with >1000 head and terminal sites currently report according to option 2. We also explored option 3 at these sites. This was done for the purposes of exploring the most appropriate combinations of reporting options to recommend at the various sites along animal movement pathways. Even though feedlots are considered intermediate sites in the definitions used in the current CFIA consultation documents on livestock movement traceability, we explored them as a separate category of site in evaluating movement reporting options.

Movements of farmed ruminants to export were considered as part of a requirement of the animal identification regulations. These movements were not considered in the evaluation of the movement reporting options.

Finally, in order to address the performance requirements developed by the TTT task force (see section 1), we assumed that only the movement reporting system in place would support tracing investigations. The purpose is to have a system that will provide the most information with the least staff, time and research involved.

Table 8. Description of the 3 options explored for animal movement reporting at farms

Option 1: Lot movement + one-step		Option 2: Sighting		Option 3: Animal ID read-in + one-step	
<i>Move-in</i>	<i>Move-out¹</i>	<i>Move-in</i>	<i>Move-out¹</i>	<i>Move-in</i>	<i>Move-out¹</i>
<i>All sites</i>	<i>Farms only</i>	<i>All sites</i>	<i>Farms only</i>	<i>All sites</i>	<i>Farms only</i>
All sites along movement pathways report within 7 days of receipt/departure of farmed ruminants: <ul style="list-style-type: none"> • The date and time of arrival/departure, depending on the reporting in place (move-in vs move-out); and • The licence plate number of the conveyance or other identification of conveyance used to transport the farmed ruminants; 					
The operator of the destination site reports: <ul style="list-style-type: none"> • The identification number (ID) of the departure and destination sites; and • The quantity and species of farmed ruminants received per load. 	The operator of the farm reports: <ul style="list-style-type: none"> • The ID of the departure farm and destination site; and • The quantity and species of farmed ruminants received per load. 	The operator of the site reports: <ul style="list-style-type: none"> • Animal ID of farmed ruminants arriving at the site. 	The operator of the farm reports: <ul style="list-style-type: none"> • Animal ID of those farmed ruminants leaving the site. 	The operator of the destination site reports: <ul style="list-style-type: none"> • The ID number of the departure and destination sites; and • The animal ID of farmed ruminants received at the destination site; 	The operator of the farm reports: <ul style="list-style-type: none"> • The ID of the departure farm and destination site; and • The animal ID of farmed ruminants leaving the departure site;
Documentation accompanying loads of farmed ruminants required in a format for consultation by inspector would include: the identification number of the site where farmed ruminants or dead stock were loaded into conveyance; the quantity of farmed ruminants or dead stock being transported per species, and their species; the date and time that the farmed ruminants or dead stock were loaded into the conveyance; and the license plate number or, if there is no license plate, other identification of the conveyance.					
 Documentation required		 No documentation required		 Documentation required	
SUMMARY: ID of departure and destination site + quantity of farmed ruminants received (move-in) or that left (move-out) + documentation.		SUMMARY: animal ID of farmed ruminants received (move-in) or that left (move-out).		SUMMARY: ID of departure and destination site + ID of farmed ruminants received (move-in) or that left (move-out) + documentation.	

¹ Only considered for farms. All other sites applied move-in only.

3.4. Scenarios Explored for the Comparison of the Three Movement Reporting Options

3.4.1 Foot-and-Mouth Disease tracing investigations

The purpose of tracing investigations following the detection of FMD will be to determine the potential Origin of infection and to identify other potentially exposed/infected farmed ruminants as quickly as possible. This translates into *trace-in* and *trace-out* investigations for a period of up to 28 days prior to detection.

The most likely sites where detection of FMD could take place are:

- At a farm or a feedlot; or
- At a terminal site.

The following tracing scenarios were explored:

1. Scenario 1: trace-in investigations at a farm, feedlot or terminal site
2. Scenario 2: trace-out investigations at a farm or a feedlot.

3.4.2 Bovine spongiform encephalopathy tracing investigations

The purpose of tracing investigations when BSE is detected will be to (CFIA, BSE-MOP, 2014):

- (1) Confirm the origin of the sample that tested positive;
- (2) Trace-in the animal to the birth farm;
- (3) Identify all other cattle which may have been exposed to the same feed as the infected animal during their first year of life (feed cohort);
- (4) Identify all other cattle that were born on the same farm and within 12 months of the infected animal's birth (birth cohort); and
- (5) Identify and locate the infected animal's progeny.

The sample from the infected animal could have originated from an abattoir, a deadstock collector, a renderer, a landfill or a farm. For this reason, the following scenarios were evaluated in order to compare the three movement reporting options:

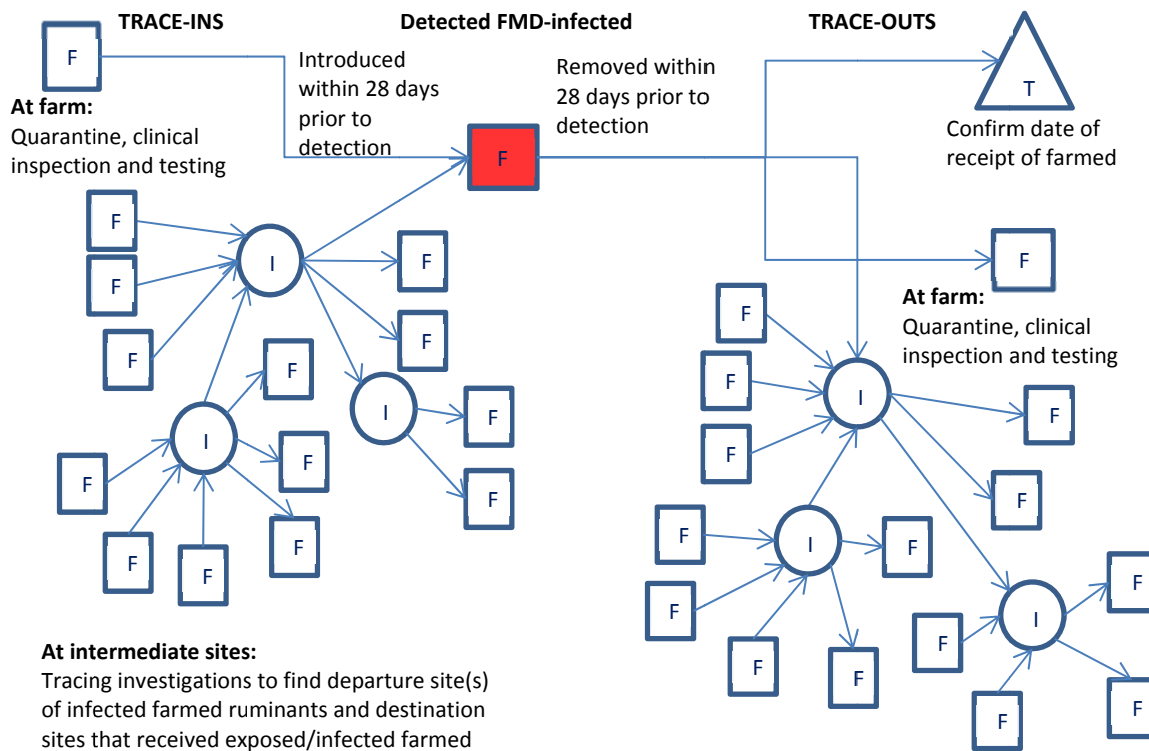
1. BSE detected at a farm; or
2. BSE detected at a terminal site.

4. ANALYSIS OF PERFORMANCE OF MOVEMENT REPORTING OPTIONS - FMD

This document applies to cattle, bison, sheep, goat and cervid movement reporting and only these are covered in the analysis. The word “farmed ruminants”² used throughout the document refers to these species.

4.1. Detection of FMD at a farm

The various steps of a tracing investigation when FMD is detected at a farm are shown in Figure 8. The first step will be to define the critical period over which tracing investigations will take place. This critical period may be as long as 28 days before the day of detection, in the case of FMD. All farmed ruminants introduced and removed from the herd within the critical period will have to be identified in order to determine potential Origins of infection for the farm (trace-ins) and also the potential for further spread from the infected farm (trace-outs). Investigators will also quickly want to determine if an intermediate site was involved in either shipping to the infected farm or received potentially infected farmed ruminants from the infected farm because of the potential intermediate sites represent in disseminating a disease agent: excreting farmed ruminants may have contacted other farmed ruminants at an intermediate site potentially disseminating the virus to a large number of destination site.



² It is recognized that in the consultation document for livestock traceability, the term “farmed ruminants” also includes pigs. The purpose of using this term in the present study is to facilitate reading.

Figure 8. Description of tracing events triggered by detection of FMD in a farm.

F - Farm; I - Intermediate site; T - Terminal site

When looking at the potential movement pathways coupled with trace-in and trace-out investigation requirements, figure 8 shows the potential number of sites that could be investigated, especially in the context of movements through an intermediate site where a number of departure and destination sites could have to be traced.

4.1.1. Trace-in investigations at a detected farm/feedlot

The main goal of trace-in investigations is to:

- TI1. Identify the initial departure site of each animal introduced in the detected farm during the critical period (28 days before detection of FMD on the farm) as well as any other departure and destination sites along the movement pathways; and
- TI2. Identify the conveyance used to transport farmed ruminants from their departure sites in all movements along the movement pathways in order to rule out other potential exposures or identify other Origins of infection.

When applied at a farm and considering the movement pathways of farmed ruminants in Canada, trace-in investigations could lead back to a farm or to an intermediate site. There are therefore two movement pathways to explore and Table 8 shows the proportion of each pathway observed by animal or production type. Also shown in Table 8 is the distribution of the type of departure sites of farmed ruminants in these movements (F1, F2 or I). As mentioned previously, in a trace-in investigation, all departure and destination sites of movement pathways have to be identified until the initial departure site of a movement pathway is identified as shown in Figure 9.

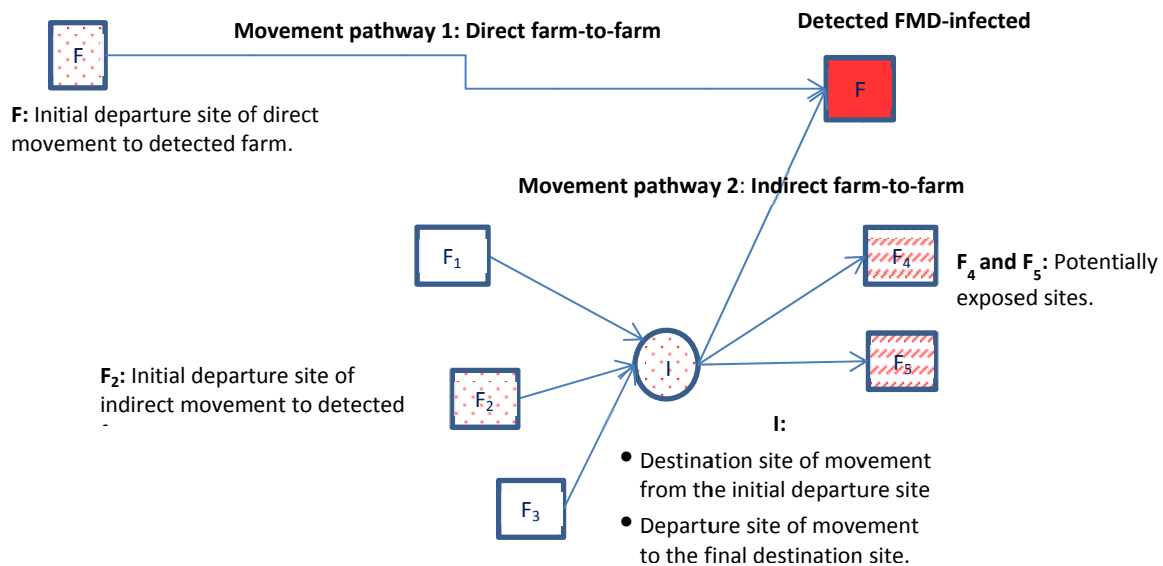


Figure 9. Representation of movement pathways to be traced in the context of a trace-in investigation at a detected farm.

For example, if a trace-in investigation leads back to an intermediate site as the departure site of farmed ruminants that were sent to the detected farm, investigations must go back another step to identify the initial departure site, or the farm where the animal was loaded prior to the intermediate site. In addition, in some cases trace-out investigations from the intermediate site may be considered if the risk of exposure of farmed ruminants at the intermediate site was considered high.

In Western Canada, movements from cow-calf operations to community pastures and back to cow-calf operations represent 22% of beef cattle movements in the region. We did not explore these in the tracing investigations specifically but the recommendations from these present analyses will cover these movements.

Table 8. Importance of direct and indirect movement pathways by animal and production type and distribution of type of departure sites by pathway. Data is based on Serecon & CAHC, 2015.

Movement pathways	Beef Western	Beef Eastern	Dairy	Bison	Cervids	Goats	Sheep
Pathway 1: Direct farm-to-farm movements	30%	22%	33%	92%	94%	92%	97%
Initial departure: F1	80%	100%	48%	100%	100%	100%	100%
Initial departure: F2	20%	0%	52%	0%	0%	0%	0%
Pathway 2: Indirect farm-to-farm movements	70%	78%	67%	8%	6%	8%	3%
Initial departure: F1	93%	22%	28%	64%	100%	67%	78%
Initial departure: F2	6%	57%	54%	36%	0%	33%	20%
Departure: I	1%	21%	16%	0%	0%	0%	2%

As described in the livestock movement section above, there is a high level of interaction among intermediate sites for movements of beef cattle in Eastern Canada and to a lesser degree in dairy. This must be considered when selecting movement reporting options to apply at intermediate sites..

We explored the following movement reporting options for Scenario 1: Option 1, 2 and 3 at farms exploring move-in vs move-out reporting. The results are as follows:

Scenario 1. Trace-in investigations at a detected farm – see Appendix, Section 1 for supporting diagrams

Move-out option 1: Departure farms report departure and destination site ID, quantity of animals leaving per load and conveyance information. Documentation accompanies each load of animals.

Task T11: Identify the initial departure site of each animal introduced in the detected farm/feedlot during the critical period as well as any other departure and destination sites along the movement pathways.

<i>Information available from database</i>	<i>Score</i>
<p>(a) Direct farm-to-farm movements</p> <ul style="list-style-type: none"> Searching for the detected farm ID in the database will identify a move-out report from one or more initial departure site(s). Since there are no animal ID reported, initial departure sites will have to be contacted to determine which animals originated from where. <p>(b) Indirect farm-to-farm movements through I-site:</p> <ul style="list-style-type: none"> The identification of initial departure sites will depend on the option applied at the intermediate site (I-site). <ul style="list-style-type: none"> If I-sites apply Option 1: It will not be possible to link an I-site with the detected farm. If I-sites apply Option 2: A link to the detected farm will not be established, but a list of animal IDs will be available at the I-site. If I-sites apply Option 3: A link to the detected farm will not be established. A list of animal IDs will be available at the initial departure site and I-site as a destination. <p>(c) If multiple I-sites were used in sequence, it would not be possible to link back to the initial departure site</p>	<p>Direct farm-to-farm movements: Limited, unless a list of animal ID is provided by detected farm. In which case: Good</p> <p>Indirect farm-to-farm movements:</p> <ul style="list-style-type: none"> If I-sites apply option 1: Inadequate. If I-site applies option 2: Inadequate unless the operator of DF provided a list of animal IDs to trace. In which case: Limited If I-site applies option 3: Inadequate for movements from F1, F2 unless the operator of DF provided a list of animal IDs to trace. In which case: Excellent
<p>Task T12: Identify the conveyance used to transport animals from their departure sites in all movements along the movement pathways.</p>	
<p>Only the conveyance used by departure site in the case of direct farm-to-farm movements will be available.</p>	<p>Limited</p>

Scenario 1. Trace-in investigations at a detected farm (continued) see Appendix, Section 2 for supporting diagrams

Move-in option 1: Destination farms report departure and destination site ID, quantity of animals received and conveyance information. Documentation accompanies each load of animals.	
Task T11: Identify the initial departure site of each animal introduced in the detected farm/feedlot during the critical period as well as any other departure and destination sites along the movement pathways.	
<i>Information available from database</i>	<i>Score</i>
<p>(a) The detected farm would have reported a list of departure sites that can be contacted for further investigations</p> <p>(b) Direct farm-to-farm: initial departure sites will be identified but animal IDs of those animals introduced into the detected farm will not be available.</p> <p>(c) Indirect farm-to-farm through I-site:</p> <ul style="list-style-type: none"> • The performance of this option will be dependent on the option applied at the I-site <ul style="list-style-type: none"> • If I-sites apply Option 1: all sites on the movement pathway will be identified but no links with animal IDs will be available. • If I-sites apply Option 2: a search for the animal ID in the database will provide a sighting report at the I-site of concern. However, a list of departure sites that sent animals to the I-site will not be available in the database. The link to the initial departure site will not be provided. • If I-sites apply Option 3: all sites on the movement pathway will be identified but no links with animal IDs will be available. <p>(d) If multiple I-sites were used in sequence: only option 3 at I-sites, combined with the list of animal IDs from the detected farms will fully support the task</p>	<p>Direct farm-to-farm movements: Limited, unless a list of animal ID is provided by detected farm. In which case: Good</p> <p>Indirect farm-to-farm movements:</p> <ul style="list-style-type: none"> • If I-sites apply option 1: Limited even if a list of animal ID is provided by the detected farm. • If I-site applies option 2: Inadequate unless tag issuance information is available for movements from F1. In which case: Limited. Inadequate for movements from F2. • If I-site applies option 3: Limited, unless a list of animal ID is provided by detected farm. In which case: Excellent
Task T12: Identify the conveyance used to transport animals from their departure sites in all movements along the movement pathways.	
<p>Conveyance used for movements to the detected farm for all movements (direct and indirect) will be available. Only in Option 3 will conveyance information be available for the movement from the initial departure site to the I-site of concern. For Option 1, it will be available but only once the initial departure site is identified, which will take significant resources.</p>	<p>Direct movements: Excellent</p> <p>Indirect movements:</p> <ul style="list-style-type: none"> • If I-sites apply option 1: Excellent, but only once the initial departure site has been identified. • If I-site applies option 2: Inadequate • If I-site applies option 3: Excellent

Scenario 1. Trace-in investigations at a detected farm (continued) see Appendix, Section 3 for supporting diagrams

Move-out Option 2 (Sighting): Departure farms report animal ID and conveyance information. No documentation available.	
Task T11: Identify the initial departure site of each animal introduced in the detected farm/feedlot during the critical period as well as any other departure and destination sites along the movement pathways.	
<i>Information available from database</i>	<i>Score</i>
(a) There will be no information in the database supporting trace-in activities from the detected farm.	<p>Direct farm-to-farm movements: Inadequate, unless a list of animal ID is provided by detected farm. In which case: Limited.</p> <p>Indirect farm-to-farm movements:</p> <ul style="list-style-type: none"> • If I-sites apply option 1: Inadequate, unless a list of animal ID is provided by detected farm. In which case: Limited. • If I-sites apply option 2 or 3: Inadequate, unless a list of animal ID is provided by detected farm. In which case: Excellent.
Task T12: Identify the conveyance used to transport animals from their departure sites in all movements along the movement pathways.	
No conveyance information available as there are no reports of animal arrival at the detected farm or no reports of the detected farm being a recipient of a movement.	Inadequate

Scenario 1. Trace-in investigations at a detected farm (continued) see Appendix, Section 4 for supporting diagrams

Move-in Option 2 (Sighting): Destination farms report animal ID and conveyance information. No documentation available.	
Task T11: Identify the initial departure site of each animal introduced in the detected farm/feedlot during the critical period as well as any other departure and destination sites along the movement pathways.	
Information available from database	Score
<p>(a) A list of the IDs of all the animals moved to the detected farm will be available but these IDs will not be linked to departure sites. Secondary farms (F2) will also have sighting reports of animal IDs that were moved in, which will enable a link to be made with the DF by matching animal IDs. Depending on the movement reporting option applied at intermediate sites, it may not be possible to determine whether the movement from F2 to DF was direct or indirect.</p> <p>(b) By definition, primary farms (F1) will not have sighting reports in the database. Therefore, direct movements from F1 to DF will not be traced. Depending on the movement reporting option applied at intermediate sites, it may be possible to trace some indirect movements from F1.</p> <p>(c) If I-sites apply option 1:</p> <ul style="list-style-type: none"> • If the initial departure site is an F2: the ID of the initial departure site will be obtained from the sighting report from that site, and will be matched to the move-in report from the I-site in the case of an indirect movement. If a move-in report is not available from an I-site, it means that the movement was direct farm-to-farm. However, there is no link in the database from the I-site to the detected farm. • If the initial departure site is an F1, option 1 applied at the I-site will only provide a list of potential departure sites but animal IDs will not be matched. Tag issuance information may be used to restrict the number of departure sites to contact. <p>(d) If I-sites apply Option 2:</p> <ul style="list-style-type: none"> • If the initial departure site is an F2: the IDs of the animals introduced at the detected farm will match sighting reports at I-sites in the case of indirect movements. If a sighting report is not available from an I-site, it means that the movement was direct farm-to-farm. However, there is no link in the database from the I-site to the detected farm. • If the initial departure site is an F1: the sighting reports will link the IDs of the animals introduced at the detected farm to the I-site but the initial departure sites will not be identified. <p>(e) If I-sites apply Option 3: will link the animal ID with the I-site and will provide initial departure site information by animal ID in the case of indirect movements from F1 or F2. The absence of a move-in report from an I-site, combined with a sighting report for F2, would confirm that the direct farm-to-farm movement from F2.</p>	<p>Depends on the Option applied at intermediate sites:</p> <ul style="list-style-type: none"> • If I-sites apply option 1: <ul style="list-style-type: none"> • Direct movements from F1: Inadequate unless tag issuance information was available in which case: Limited. • Indirect movements from F1: Inadequate unless tag issuance information was available in which case: Limited. • Direct and indirect movements from F2: Limited • If I-sites apply option 2: <ul style="list-style-type: none"> • Direct movements from F1: Inadequate unless tag issuance information was available in which case: Limited. • Indirect movements from F1: Inadequate unless tag issuance information was available in which case: Good. • Direct movements from F2: Limited • Indirect movements from F2: Excellent • If I-site applies option 3: <ul style="list-style-type: none"> • Direct movements from F1: Inadequate unless tag issuance information was available in which case: Good. • Indirect movements from F1: Excellent • Direct and indirect movements from F2:

Excellent	
(f) If multiple I-sites are used in sequence: only option 3 will fully support the investigations. Option 2 would have to be combined with tag issuance data for movements from F1.	
Task T12: Identify the conveyance used to transport animals from their departure sites in all movements along the movement pathways.	
A search for the detected farm/feedlot ID would provide the conveyance for transport to the detected farm. Then, depending on the options applied at I-sites, the conveyance used may be found for movements from the initial departure site to the I-site.	<p>Excellent for all movements arriving at the detected farm.</p> <ul style="list-style-type: none"> If I-sites apply option 1: Excellent for movements from F2. Inadequate for movements from F1 and I. If I-site applies option 2: Excellent for movements from F2 and I. Inadequate for movements from F1. If I-site applies option 3: Excellent for movements from F1, F2 or I.

Scenario 1. Trace-in investigations at a detected farm (continued) - see Appendix, Section 5 for supporting diagrams

Move-out Option 3: Departure farms report departure and destination site ID, animal ID and conveyance information. Documentation accompanies each load of animals.	
Task T11: Identify the initial departure site of each animal introduced in the detected farm/feedlot during the critical period as well as any other departure and destination sites along the movement pathways.	
<i>Information available from database</i>	<i>Score</i>
(a) This approach will only identify initial departure sites of direct movements from F1 or F2 that declared the detected farm as a destination site.	<p>Direct farm-to-farm movements: Excellent from F1 and F2</p> <p>Indirect farm-to-farm movements:</p> <ul style="list-style-type: none"> Inadequate for all movements unless a list of ID is obtained at the detected farm, in which case: Excellent.
Task T12: Identify the conveyance used to transport animals from their departure sites in all movements along the movement pathways.	
Conveyance information will be available for direct movements only from F1 or F2.	Excellent for movements from F1 or F2.

Scenario 1. Trace-in investigations at a detected farm (continued) - see Appendix, Section 6 for supporting diagrams

Move-in Option 3: Destination farms report departure and destination site ID, animal ID and conveyance information. Documentation accompanies each load of animals.	
<p>Task T11: Identify the initial departure site of each animal introduced in the detected farm/feedlot during the critical period as well as any other departure and destination sites along the movement pathways.</p>	
Information available from database	Score
<p>(a) Direct farm-to-farm movements</p> <ul style="list-style-type: none"> • The information reported by the detected farm will provide the initial departure site by animal. <p>(b) Indirect farm-to-farm movements through I-site</p> <ul style="list-style-type: none"> • The information reported by the detected farm or feedlot will provide a list of ID of I-sites that provided animals, by animal ID. • Searching for animal ID will also provide move-in reports by animal ID at F2 but not F1. • If I-sites apply Option 1: only a list of departure sites will be available at the I-site of concern. Only contacting F2 identified as destinations in move-in reports by animal ID will lead to identification of these farms as initial departure sites. These F2 IDs can be matched to the list of departure sites provided by the I-site of interest to identify those indirect movements. Movements from F1 and other I will not be able to be traced. • If I-sites apply Option 2: will confirm the list of animal ID by I-site which was identified with Option 3 move-in at the farm. It will also identify if multiple I-sites were involved by other sighting reports. Only F2 as initial departure sites will be identified. Movements from F1 will not be traced. • If I-sites apply Option 3: will provide initial departure site information by animal ID and will essentially cover 100% of indirect movements in a straightforward approach. • If multiple I-sites used in sequence: only option 3 will fully support the investigations. Option 2 would have to be combined with tag issuance data for movements from F1. 	<p>Direct farm-to-farm movements:</p> <ul style="list-style-type: none"> ○ Movements from F1 and F2: Excellent <p>Indirect farm-to-farm movements:</p> <ul style="list-style-type: none"> • If I-sites apply option 1: If from F1: Inadequate unless tag issuance data is available, in which case, Good. If from F2: Good • If I-site applies option 2: If from F1: Inadequate unless tag issuance data is available, in which case, Good. If from F2: Excellent • If I-site applies option 3: Excellent for movements from F1 and F2.
<p>Task T12: Identify the conveyance used to transport animals from their departure sites in all movements along the movement pathways.</p>	
<p>Conveyance information will be available for all movements to the detected farm. Conveyance information for those indirect movements will depend on the Option applied at the I-sites.</p>	<p>Excellent for all movements to the detected farm.</p> <ul style="list-style-type: none"> • If I-sites apply option 1-2: Good for movements from F2. Inadequate for movements from F1 and I. • If I-site applies option 3: Excellent for movements from F1, F2 or I.

4.1.1.1. Summary of the performance of movement reporting options for trace-in investigations at a detected farm

The summary of results of the performance of movement reporting options for trace-in investigations at a detected farm are shown in Table 9 for direct farm-to-farm movements and in Table 10 for indirect farm-to-farm movements.

Table 9. Summary of results of the performance of movement reporting option combinations applied at farms and intermediate sites to support trace-in investigations of direct farm to farm movements.

Direct farm-to-farm movements – trace-in investigations				
Option applied at farm	No list of animal ID available		List of animal ID or tag issuance information available	
	F1	F2	F1	F2
1: move-out	Limited		Good	
1 move-in	Limited		Good	
2: move-out	Inadequate		Limited	
2: move-in + 1 at I-site ³	Inadequate	Limited	Limited	Limited
2: move-in + 2 at I-site	Inadequate	Limited	Limited	Limited
2: move-in + 3 at I-site	Inadequate	Excellent	Good	Excellent
3: move-out	Excellent		Excellent	
3: move-in	Excellent		Excellent	

Only two movement reporting options combination would provide adequate support to tracing investigations of direct farm-to-farm movements without the need for a list of animal IDs or tag issuance information to be provided: **option 3 move-in or option 3 move-out at farms.**

If a list of animal IDs to trace is provided by the operator of the detected farm and tag issuance information is available, three more options also provide appropriate support, though with reduced efficacy:

- Option 1 move-out at farms with a list of animal IDs to trace provided;
- Option 1 move-in at farms with a list of animal IDs to trace provided; and
- Option 2 move-in at farm combined with option 3 at intermediate sites and tag issuance information.

³ The performance depends on the movement reporting option applies at intermediate sites to distinguish direct from indirect movements.

Table 10. Summary of results of the performance of movement reporting option combinations applied at farms and intermediate sites to support trace-in investigations of indirect farm to farm movements.

Option at farm	Option at I-site	No list of animal ID available or no tag issuance information		List of animal ID available or tag issuance information		I-sites used in sequence	
		F1	F2	F1	F2		
Departure sites:							
1: move-out	1	Inadequate					
	2	Inadequate		Limited		Inadequate	
	3			Excellent			
1: move-in	1	Limited				Inadequate	
	2	Inadequate		Limited	Inadequate	Inadequate	
	3	Limited		Excellent		Excellent if list available	
2: move-out	1	Inadequate		Limited		Inadequate	
	2			Excellent		Excellent if list available	
	3						
2: move-in	1	Inadequate	Limited	Limited	Limited	Inadequate	
	2	Inadequate	Excellent	Good	Excellent	Excellent if list available	
	3	Excellent					
3: move-out	1	Inadequate		Excellent		Excellent if list available	
	2						
	3						
3: move-in	1	Inadequate	Good	Good		Inadequate	
	2	Inadequate	Excellent	Good	Excellent	Excellent if list available	
	3	Excellent					

Only two movement reporting options provide adequate support for trace-in investigations of indirect farm-to-farm movements:

- **Option 2 move-in at farms and option 3 at intermediate sites; and**
- **Option 3 move-in at farms and option 3 at intermediate sites.**

However, if a list of animal IDs is provided, then nine combinations could provide adequate support for these investigations:

1. Option 1 move-in at farms, option 3 at intermediate sites and a list of animal IDs to trace provided;
2. Option 2 move-out at farms, option 2 or 3 at intermediate sites and a list of animal IDs to trace provided;
3. Option 2 move-in at farms, option 2 or 3 at intermediate sites and tag issuance information;
4. Option 3 move-out at farms, option 1,2 or 3 at intermediate sites and a list of animal IDs to trace provided; and
5. Option 3 move-in at farms, option 2 at intermediate sites and tag issuance information.

4.1.1.2. Recommendations for movement reporting to support trace-in investigations at a farm

Combining trace-in investigations of direct and indirect movements, the following combination would be appropriate to support investigations using only the database as a source of information:

- **Option 3 move-in at farms and option 3 at intermediate sites.**

When access to a list of animal IDs to trace is available, then the optimal combinations become:

- Option 1 move-in at farms, option 3 at intermediate sites and a list of animal IDs to trace provided;
- Option 2 move-in at farms, option 2 or 3 at intermediate sites and tag issuance information;
- Option 3 move-out at farms, option 1, 2 or 3 at intermediate sites and a list of animal IDs to trace provided; and
- Option 3 move-in at farms, option 2 at intermediate sites and tag issuance information.

4.1.2. If detection occurs at a feedlot or terminal sites

Movements of farmed ruminants to feedlots were reported specifically as taking place in Western Canada in the Serecon & CAHC study (2015) while in Eastern Canada, a clear distinction between secondary farm (F2) and feedlot was not made. Movements to feedlots and terminal sites take place from the farm directly or indirectly through an intermediate site. The ability to trace back to the initial departure site, which can be the birth farm, in most cases, or the backgrounding operation (that will apply the same movement reporting option as the feedlot) will depend on the movement reporting options applied at the farm, the feedlot/terminal site and the intermediate site. We therefore explored what would be appropriate combinations to cover trace-in investigations at a feedlot or a terminal site.

Feedlots and terminal sites will apply a move-in reporting option and we selected options 2 or 3 as potential options as it is already a requirement, in Alberta, that feedlots >1000 head report move-in according to option 2 and terminal sites are also currently required to report according to option 2.

4.1.2.1. Direct farm-to-feedlot/terminal site movements

If feedlots/terminal sites apply option 2 at animal arrivals, two options can be considered for appropriate support to trace-in investigations without the need for a list of animal IDs or tag issuance information to be provided as shown in Table 11:

- **Move-in option 2 at farms and option 2, 3 at intermediate sites to rule-out indirect movements through intermediate sites.**
- **Move-in option 3 at farms**

With access to tag issuance information or a list of animal IDs to trace, three more options can be considered:

- Option 1, 2 or 3 move-out at farms.

Table 11. Summary of performance of movement reporting options for trace-in investigations or direct movements at feedlots applying option 2 move-in.

Direct farm-to-farm movements – trace-in investigations				
Option applied at farm	No list/tag issuance information required		Tag issuance information available	
Departure site:	F1	F2	F1	F2
1: move-out	Good			
1 move-in	Inadequate		Limited	Inadequate
2: move-out	Good			
2: move-in + 1 at I-site ⁴	Limited			
2: move-in + 2 at I-site	Excellent			
2: move-in + 3 at I-site	Excellent			
3: move-out	Good			
3: move-in	Excellent			

If feedlots apply option 3 at animal arrivals, this will provide appropriate trace-in support, regardless of the option applied at the farm-level.

- All options at farms are supported

4.1.2.2. Indirect farm-to-feedlots movements

For indirect farm-to-feedlot/terminal site movements, considering only move-in options are possible at intermediate sites and applying option 2 at feedlots and terminal sites, the suitable combinations are shown in Table 12.

Nine options can be considered optimal for trace-in of indirect movements at feedlots or terminal sites, without the need for a list of animal IDs to trace or tag issuance information.

When option 3 is applied at feedlots and terminal sites (Table 13), 10 options provide adequate support for trace-in investigations of indirect movements to feedlots and terminal sites.

⁴ The performance depends on the movement reporting option applies at intermediate sites to distinguish direct from indirect movements.

Table 12. Summary of performance of movement reporting options for trace-in investigations or indirect movements at feedlots reporting according to option 2.

Option at farm	Option at I-site	Option at feedlot and terminal site	No list of animal ID available or no tag issuance information		List of animal ID available or tag issuance information	
			F1	F2	F1	F2
Departure sites:						
1: move-out	1	2	Inadequate			
	2		Limited			
	3		Excellent			
1: move-in	1		Inadequate			
	2		Inadequate		Good	Inadequate
	3		Excellent			
2: move-out	1		Limited			
	2		Excellent			
	3		Excellent			
2: move-in	1		Inadequate	Limited	Limited	
	2		Inadequate	Limited	Good	Excellent
	3		Excellent			
3: move-out	1		Excellent			
	2		Excellent			
	3		Excellent			
3: move-in	1	Inadequate	Limited	Limited		
	2	Inadequate	Limited	Good	Excellent	
	3	Excellent				

Table 13. Summary of performance of movement reporting options for trace-in investigations or indirect movements at feedlots reporting according to option 3.

Option at farm	Option at I-site	Option at feedlot and terminal site	No list of animal ID available or no tag issuance information		List of animal ID available or tag issuance information	
<i>Departure sites:</i>			<i>F1</i>	<i>F2</i>	<i>F1</i>	<i>F2</i>
1: move-out	1	3	Limited			
	2		Excellent			
	3		Excellent			
1: move-in	1		Inadequate	Good	Good	
	2		Excellent			
	3		Excellent			
2: move-out	1		Excellent			
	2		Excellent			
	3		Excellent			
2: move-in	1		Inadequate	Good	Good	
	2		Excellent			
	3		Excellent			
3: move-out	1		Excellent			
	2		Excellent			
	3		Excellent			
3: move-in	1	Inadequate	Good	Good		
	2	Excellent				
	3	Excellent				

4.1.2.3. Recommendation for movement reporting options to support trace-in investigations at feedlots and terminal sites

The recommended option to support trace-in investigations at feedlots and terminal sites without the need for a list of IDs to trace or tag issuance information is:

- **Option 2 or 3 at feedlots/terminal sites, option 2 move-in at farms and option 3 at intermediate sites.**

If a dual declaration process is in place at farms combined with a tag activation event (ideal) or if a list of animal IDs is provided with access to tag issuance information the following combinations could be considered:

- Option 2 or 3 at feedlots/terminal sites, option 1 move-out at farms and option 3 at intermediate sites
- Option 2 or 3 at feedlots/terminal sites, option 3 move-out at farms and options 1, 2 or 3 at intermediate sites.
- Option 2 at feedlots/terminal sites, option 2 move-out at farms and option 2, 3 at intermediate sites.
- Option 3 at feedlots/terminal sites, option 2 move-out at farms and option 1, 2 or 3 at intermediate sites.

4.1.3. Combined recommendations of movement reporting to support trace-in investigations at farms, feedlots and terminal sites.

Three combinations could support trace-in investigations at farms, feedlots and terminal sites. Combination 1 would not require supplementary information to be provided. Combinations 2 and 3 would require tag issuance information to be provided. The reliability of the tag issuance information could significantly impact the investigations. A formal tag activation event linking the animal to its actual birth farm would help the process.

Combination	Farms	Intermediate sites	Feedlots	Terminal sites	Tag issuance information required?
1	Move-in option 3	Option 3	Option 2 or 3	Option 2 or 3	NO
2	Move-in option 2	Option 3	Option 2 or 3	Option 2 or 3	YES
3	Move-out option 3	Option 1, 2 or 3	Option 2 or 3	Option 2 or 3	YES

4.1.4. Trace-out investigations at a detected farm

The main goal of trace-out investigations is to:

- TO1. Identify all destination sites of farmed ruminants removed from the detected farm during the critical period;
- TO2. Identify the conveyance of all farmed ruminants to their destination site(s) and determine if farmed ruminants from other departure sites and going to non-terminal sites could have been exposed during transport; and,
- TO3. If farmed ruminants were sent to a terminal site, confirm their arrival.

Trace-out of movements of farmed ruminants from farms could lead to other farms, feedlots, intermediate sites, terminal sites or export, depending on the species and type of production (Table 14). If the movement was to an intermediate site, the final destination of the farmed ruminants, the feedlot, farm or terminal site, must be identified.

Table 14. Type of destination for farmed ruminants removed from a detected farm by species and production type. Data based on Serecon & CAHC, 2015.

Type	Farm	Feedlot	Int. Site	Terminal Site	Export
Beef Western: non-feedlot	5%	21%	70%	2%	2%
Beef Western: feedlot	0%	0%	0%	71%	29%
Beef Eastern	19%	N/A	70%	4%	7%
Dairy	26%	N/A	63%	11%	0%
Bison	26%	N/A	12%	29%	33%
Cervids	32%	N/A	2%	58%	8%
Goats	47%	N/A	12%	41%	N/A
Sheep	15%	N/A	57%	28%	N/A

Terminal sites are currently required to report according to Option 2, move-in. They would therefore be able to confirm arrival of the animal (TO3) either by reporting or through their own documentation if within seven days of arrival. When farmed ruminants are exported, this event is recorded in the database and confirmation would be obtained that these farmed ruminants do not need to be traced. Movements of farmed ruminants sold to export are therefore not considered in the present evaluation.

We therefore explored how the three movement reporting options performed for trace-out investigations of non-exported farmed ruminants. The potential movements to be traced-out are direct farm-to-farm/feedlot, direct farm/feedlot-to-terminal site or indirect movements through one or more intermediate sites to farm/feedlot/terminal site. The performance of the movement reporting options was assessed according to these movement pathways and the ability to trace to the final destination of

farmed ruminants if indirect movements took place. The description of the frequency of each pathway is provided in Table 15.

Table 15. Potential destination of non-exported farmed ruminants removed from a detected farm or feedlot by type of production. Data is based on Serecon & CAHC, 2015.

	Beef Western Non-feedlots	Beef Western Feedlots	Beef Eastern	Dairy	Bison	Cervids	Goats	Sheep
Pathway 1: Direct movements (% of all movements)	32%	100%	24%	36%	82%	98%	88%	43%
To Farm (% of direct movements)	15%	0%	84%	70%	62%	35%	54%	36%
To Feedlot (% of direct movements)	73%	0%	n/a	n/a	n/a	n/a	n/a	n/a
To Terminal (% of direct movements)	12%	100%	16%	30%	38%	64%	46%	64%
Pathway 2: Indirect movements (% of all movements)	68%	0%	76%	64%	18%	2%	12%	57%
To Farm (% of indirect movements)	8%	0%	74%	68%	63%	100%	43%	0%
To Feedlot (% of indirect movements)	81%	0%	n/a	n/a	n/a	n/a	n/a	n/a
To I-site (% of indirect movements)	1%	0%	22%	17%	0%	0%	0%	12%
To Terminal (% of indirect movements)	10%	0%	4%	15%	37%	0%	57%	88%

Due to the allowed seven days delay in movement reporting at destination, trace-out investigations could be seriously limited. At most, 7 days could have to elapse before the appropriate movement information was reported. This delay is considered high-risk in the context of a fast-spreading disease like FMD. This could be addressed by ensuring that all animal movements required a document describing the departure and destination sites, the date and time of movement and conveyance used, and a copy be kept at the departure site. When the diagnostic team would visit the detected farm, these documents would be used to identify destination sites for tracing investigations.

For the purposes of this study, we assume the information was reported and is available for investigation. It is very important to note however that the scorings of the movement reporting options would be seriously affected if the information was not reported.

The three movement reporting options provided the following information:

Scenario 2. Trace-out investigations at a detected farm - see Appendix, Section 7 for supporting diagrams

Move-out option 1: Departure farms report departure and destination site ID, quantity of animals leaving per load and conveyance information. Documentation accompanies each load of animals.	
Task TO1: Identify the final destination site of each animal removed not for slaughter from the detected farm during the critical period. If the movement is through an intermediate site, identify the final destination of these animals, going one step forward from the I-site.	
<i>Information available from database</i>	<i>Score</i>
(a) The detected farm would have reported a list of destination sites that can be contacted for further investigations	
(b) Direct farm-to-farm: final destination sites will be identified but animal IDs of those animals removed from the detected farm will not be available.	Direct movements farm-to-farm: Limited , unless the DF can provide a list of animal ID for the movement. In which case: Good
(c) Direct farm-to-feedlot/terminal site: feedlots and terminal sites will report according to option 2 or 3. <ul style="list-style-type: none"> • If option 2: this will not link to the detected farm. • If option 3: will link to the detected farm by animal ID. 	Direct farm to feedlot or terminal site: <ul style="list-style-type: none"> • If these destination sites apply option 2: Limited unless a list of animal ID to trace was provided by the operator of the detected farm. In which case: excellent • Excellent if these sites apply option 3.
(d) Indirect farm-to-farm through an I-site: the movement from I-site to destination farm would not be reported by the destination farm nor the departure I-site. It would be impossible to trace these movements	Indirect farm-to-farm: Inadequate
(e) Indirect farm-to-feedlot/terminal through an I-site: These destination sites would apply option 2 or 3. The identification of all sites on the movement pathway will depend on the option applied at the I-site. <ul style="list-style-type: none"> • I-site applies option 1: will identify all sites on the pathway if option 3 applied at feedlot or terminal site, but will not link animal IDs. If option 2 was applied at feedlots or terminal sites, it would not be possible to trace movements. • I-site applies option 2: will identify all sites on the pathway but will not link animal IDs. • I-site applies option 3: will identify all sites and animal IDs on the pathway. 	Indirect farm-to-feedlot/terminal site: <ul style="list-style-type: none"> • Option 1 at I-site: Inadequate if option 2 at destination sites and no list of animal IDs to trace is available. Good with a list of animal IDs to trace. Limited if option 3 at destination. Excellent with a list of animal IDs to trace. • Option 2 at I-site: Limited, unless if a list of animal IDs to trace is provided, in which case: Good. • Option 3 at I-site: Excellent
(f) If multiple I-sites were used in sequence: all sites on the pathway would be identified but linkage to animal IDs would depend on option at I-sites <ul style="list-style-type: none"> • I-sites apply option 1: impossible to link animal IDs. • I-sites apply option 2: will identify all sites on the pathway but will not link animal IDs. • I-site applies option 3: will identify all sites and animal IDs on the pathway. 	Indirect movement via multiple I-sites: <ul style="list-style-type: none"> • Option 1 at I-site: Inadequate. If a list of animal IDs to trace is

	<p>available, could become limited.</p> <ul style="list-style-type: none"> • Option 2 at I-site: Limited, unless if a list of animal IDs to trace is provided, in which case: Excellent. • Option 3 at I-site: Excellent
<p>Task TO2: Identify all the conveyance used for transport of all animals removed from the infected farm to its final destination during the critical period.</p>	
<p>Once the destination site was identified, the conveyance information would be available.</p>	<p>Excellent</p>

Scenario 2. Trace-out investigations at a detected farm (continued) - see Appendix, Section 8 for supporting diagrams

Move-in option 1: Destination farms report departure and destination site ID, quantity of animals received and conveyance information. Documentation accompanies each load of animals.	
Task TO1: Identify the final destination site of each animal removed not for slaughter from the detected farm during the critical period. If the movement is through an intermediate site, identify the final destination of these animals, going one step forward from the I-site.	
Information available from database	Score
<p>(a) A search would be made on the ID of the detected farm.</p> <p>(b) Direct farm-to-farm movement:</p> <ul style="list-style-type: none"> • Destination farm would report the ID of the detected farm. <p>(c) Direct farm-to-feedlot/terminal movement:</p> <ul style="list-style-type: none"> • Destination feedlot and terminal sites applying option 2 could not be linked back to the detected farm. • Destination feedlot and terminal sites applying option 3 would be linked back to the detected farm, providing animal ID numbers. <p>(d) Indirect movement through an I-site: The performance of this option will be dependent on the option applied at the intermediate site.</p> <ul style="list-style-type: none"> • I-site applies option 1: <ul style="list-style-type: none"> ○ For movements to farms: the sites along the pathway would be identified but not animal IDs. ○ For movements to feedlots or terminal sites applying option 2: would not permit linkages with the detected farm or the I-site. ○ If option 3 was applied at the final destination sites, the sites along the pathway would be identified but will not link animal IDs. • I-site applies option 2: impossible to link back from the I-site to the detected farm using only the database. 	<p>Direct farm-to-farm movement:</p> <ul style="list-style-type: none"> • Limited, unless the DF can provide a list of animal ID for the movement. In which case: Good <p>Direct movements farm to feedlot or terminal site:</p> <ul style="list-style-type: none"> • Inadequate for feedlots and terminal sites applying option 2 unless the operator of the detected farm provided a list of animal IDs to trace, in which case the score would be limited (direct movement could not be confirmed). • Excellent for feedlots and terminal sites applying option 3. <p>Indirect farm-to-farm/feedlot/terminal site:</p> <ul style="list-style-type: none"> • If I-site applies option 1: <ul style="list-style-type: none"> ○ Limited for movements to farms. Significant searches would have to take place to locate animal IDs even if a list of animal ID was provided by DF. ○ Inadequate for movements to feedlots or terminal sites applying option 2 unless a list of animal IDs is available in which case: Good. ○ Limited if option 3 applied at feedlots or terminal sites. If a list of animal IDs available from detected farm: Excellent. • If I-site applies option 2: <ul style="list-style-type: none"> ○ Inadequate if a list of animal IDs to trace is not provided by detected farm.

<ul style="list-style-type: none"> • I-site applies option 3: the identification of the final destination would be made in all cases, but animal IDs will not be linked if movement to farm. <p>(e) If multiple I-sites were used in sequence, option 3 would be the only option applied at the I-site that could support the tracing of this movement pathway, and only to feedlots or terminal sites.</p>	<ul style="list-style-type: none"> ○ Limited if movement to farm even if a list of animal IDs to trace is provided. ○ Good if movement to feedlot or a terminal site and the list of animal IDs to trace is available from the DF. • If I-sites apply option 3: <ul style="list-style-type: none"> ○ Limited if movement to farm. ○ Excellent if movement to a feedlot or a terminal site. A list of animal IDs to be traced would not be required from the detected farm.
<p>Task TO2: Identify all the conveyance used for transport of all animals removed from the infected farm to its final destination during the critical period.</p>	
<p>Once the destination site was identified, the conveyance information would be available.</p>	<p>Excellent</p>

Scenario 2. Trace-out investigations at a detected farm - see Appendix, Section 9 for supporting diagrams

Move-out option 2 (Sighting): Departure farms report animal ID of animals leaving and conveyance information. No documentation available.	
Task TO1: Identify the final destination site of each animal removed not for slaughter from the detected farm during the critical period. If the movement is through an intermediate site, identify the final destination of these animals, going one step forward from the I-site.	
Information available from database	Score
<p>(a) The list of animal IDs to trace at the detected farm would be readily available.</p> <p>(b) Direct farm-to-farm/feedlot/terminal movement:</p> <ul style="list-style-type: none"> • Movements to farms would not be traced because there is no indication of animal arrival at destination farm. • Movements to feedlots or terminal sites applying option 3 would be traced. Animal IDs could be matched to destination sites applying option 2 but confirmation of a direct movement between I-site and destination would not be available. <p>(c) Indirect movement through an I-site: The performance of this option will be dependent on the option applied at the intermediate site.</p> <ul style="list-style-type: none"> • I-site applies option 1: the detected farm ID would be reported through a move-in report. If the final destination is a farm, it will not be traced. If the final destination is a feedlot or a terminal site, these will be traced by linking animal ID information. Confirmation would have to be obtained at the I-site that animals transited through the sites in the case where the destination site applies option 2 • I-site applies option 2: individual animal ID would be reported at each I-site. If the final destination is a farm, it will not be traced. If the final destination is a feedlot or a terminal site, these will be traced by linking animal ID sighting reports. Confirmation of a direct movement between I-site and destination would not be available if destination site applies option 2. Confirmation of a direct movement between DF and I-site will be available by matching dates of movement. • I-site applies option 3: individual animal ID and the I-site identification would be reported by the I-site. If the final destination is a farm, it will not be traced. If the final destination is a feedlot or a terminal site, these will be traced by linking animal ID move-in reports. Confirmation of a direct movement between I-site and destination would not be available if destination site applies option 2. <p>(d) If multiple I-sites were used in sequence, option 2 or option 3 would be the only options applied at the I-site that could support the tracing of this movement pathway, only to feedlots or terminal sites.</p>	<p>Direct and indirect movements farm-to-farm: Inadequate</p> <p>Direct farm to feedlot/terminal site: Limited for destination sites applying option 2 and excellent for sites applying option 3.</p> <p>Indirect movements to feedlot or terminal site:</p> <ul style="list-style-type: none"> • Option 1 at I-site: <ul style="list-style-type: none"> ○ Limited for option 2 at destination site ○ Excellent for option 3 at destination site • Option 2 or 3 at I-site: Excellent
Task TO2: Identify all the conveyance used for transport of all animals removed from the infected farm to its final destination during the critical period.	
<p>Once the destination site was identified, the conveyance information will be available.</p>	<p>Excellent</p>

Scenario 2. Trace-out investigations at a detected farm - see Appendix, Section 10 for supporting diagrams

Move-in option 2 (Sighting): Farms report animal ID and conveyance information. No documentation available.	
Task TO1: Identify the final destination site of each animal removed not for slaughter from the detected farm during the critical period. If the movement is through an intermediate site, identify the final destination of these animals, going one step forward from the I-site.	
Information available from database	Score
<p>(a) A search would be made on the ID of the detected farm.</p> <p>(b) Direct farm-to-farm movement:</p> <ul style="list-style-type: none"> • Destination farm would report the ID of the detected farm. <p>(c) Direct farm-to-feedlot/terminal movement:</p> <ul style="list-style-type: none"> • Destination feedlot and terminal sites applying option 2 could not be linked back to the detected farm. • Destination feedlot and terminal sites applying option 3 would be linked back to the detected farm, providing animal ID numbers. <p>(d) Indirect movement through an I-site: The performance of this option will be dependent on the option applied at the intermediate and destination sites.</p> <ul style="list-style-type: none"> • I-site applies option 1: the I-site would report load arrival with the detected farm ID reported as the departure site. A link to the destination site could only be available if it applies option 3. • I-site applies option 2: individual animal ID would be reported at the I-site. However there would be no indication of which animal IDs to trace therefore the destination site could not be traced. • I-site applies option 3: this option would fully support the trace-out investigation without the need for the list of animal ID to be provided by the operator of the detected farm. <p>(e) If multiple I-sites were used in sequence, option 3 would be the only options applied at the I-site that could support the tracing of this movement pathway without reliance on the operator to provide a list of animal IDs to trace. If such a list was provided, option 2 could also be applied at I-sites.</p>	<p>Direct farm-to-farm movement: Limited, unless the DF can provide a list of animal ID for the movement. In which case: Good</p> <p>Direct movements to feedlot or terminal site: Inadequate for feedlots and terminal sites applying option 2 unless the operator of the detected farm provided a list of animal IDs to trace, in which case the score would be limited (direct movement could not be confirmed).</p> <p>Indirect farm-to-farm/feedlot/terminal site:</p> <ul style="list-style-type: none"> • If I-site applies option 1: <ul style="list-style-type: none"> ○ If destination site applies option 2: Inadequate, unless a list of animal IDs to trace is provided. In which case: Limited ○ If destination site applies option 3 (feedlots or terminal sites only): Limited, unless a list of animal IDs to trace is provided. In which case: Excellent • If I-site applies option 2: Inadequate if list of animal IDs to be traced is unavailable. Otherwise: Excellent. • If I-site applies option 3: Excellent for all movements.
TO2: Identify all the conveyance used for transport of all animals removed from the infected farm to its final destination during the critical period.	
Once the destination site was identified, the conveyance information will be available.	Excellent

Scenario 2. Trace-out investigations at a detected farm - see Appendix, Section 11 for supporting diagrams

Move-out Option 3: Departure farms report departure and destination site ID, animal ID and conveyance information. Documentation accompanies each load of animals.	
Task TO1: Identify the final destination site of each animal removed not for slaughter from the detected farm during the critical period. If the movement is through an intermediate site, identify the final destination of these animals, going one step forward from the I-site.	
<i>Information available from database</i>	<i>Score</i>
<p>(a) Direct farm-to-farm/feedlot/terminal movement: the trace-out loop would be complete</p> <p>(b) Indirect movement through an I-site: Regardless of the option applied at the I-site, the following results would be obtained.</p> <ul style="list-style-type: none"> o Destination feedlots or terminal sites: would be traced if applied option 2 or 3. o Destination farms: not traced because there are no reports linking the I-site with the destination. <p>(c) If multiple I-sites were used in sequence, these would be identified, but destination farms could not be traced. Feedlots and terminal sites would be traced.</p>	<p>Direct movement to farm, feedlot or terminal site: Excellent.</p> <p>Indirect farm-to-farm/feedlot/terminal site: Excellent for movements to feedlots and terminal sites. Inadequate for movements to a farm.</p>
TO2: Identify all the conveyance used for transport of all animals removed from the infected farm to its final destination during the critical period.	
<p>Once the destination site was identified, the conveyance information will be available.</p>	<p>Excellent</p>

Scenario 2. Trace-out investigations at a detected farm - see Appendix, Section 12 for supporting diagrams

Move-in Option 3: Destination farms report departure and destination site ID, animal ID and conveyance information. Documentation accompanies each load of animals.	
Task TO1: Identify the final destination site of each animal removed not for slaughter from the detected farm during the critical period. If the movement is through an intermediate site, identify the final destination of these animals, going one step forward from the I-site.	
Information available from database	Score
<p>(a) Direct farm-to-farm/feedlot/terminal movement: the trace-out loop would be complete if all sites applied option 3. If feedlots or terminal sites applied option 2, the list of animal IDs to trace would have to be provided by the detected farm for these final destinations to be identified.</p> <p>(b) Indirect movement through an I-site: The performance of this option will be dependent on the option applied at the intermediate and destination sites.</p> <ul style="list-style-type: none"> ○ I-sites apply option 1: the I-site would report load arrival with the detected farm ID reported as the departure site. A link to the destination site could only be available if it applies option 3. ○ I-site applies option 2: individual animal ID would be reported at the I-site. However there would be no indication of which animal IDs to trace therefore the destination site could not be traced. ○ I-site applies option 3: this option would fully support the trace-out investigation without the need for the list of animal ID to be provided by the operator of the detected farm. <p>(c) If multiple I-sites were used in sequence, option 3 would be the only options applied at the I-site that could support the tracing of this movement pathway without reliance on the operator to provide a list of animal IDs to trace. If such a list was provided, option 2 could also be applied at I-sites.</p>	<p>Direct movement to farm, feedlot or terminal site:</p> <ul style="list-style-type: none"> • Excellent for movements to farms. • Excellent for movements to feedlots or terminal sites if apply option 3. • Inadequate for movements to feedlots or terminal sites if apply option 2, unless the operator of the detected farm provided a list of animal IDs to trace, in which case the score would be limited (direct movement could not be confirmed). <p>Indirect farm-to-farm/feedlot/terminal site:</p> <ul style="list-style-type: none"> • If I-site applies option 1: <ul style="list-style-type: none"> ○ If destination site applies option 2 (applies only to feedlots or terminal sites): Inadequate, unless a list of animal IDs to trace is provided. In which case: Limited ○ If destination site applies option 3: Limited, unless a list of animal IDs to trace is provided. In which case: Excellent • If I-site applies option 2: Inadequate if list of animal IDs to be traced is unavailable. Otherwise: Excellent <p>I-sites option 3: Excellent for all movements</p>
TO2: Identify all the conveyance used for transport of all animals removed from the infected farm to its final destination during the critical period.	
Once the destination site was identified, the conveyance information will be available.	Excellent

4.1.4.1. Summary of the performance of movement reporting options to support trace-out investigations at farms

The performance of each movement reporting option evaluated to support trace-out investigations of direct farm-to-farm/feedlot/terminal sites movements is summarized below in Table 16.

Table 16. Summary of results of direct movement trace-out investigations at a farm considering the option applied at farms, feedlots and terminal sites.

Option applied at farms	Option applied at Feedlot/terminal sites	Proportion of direct movements traced –out of the detected farm			
		List of animal IDs to trace is not available		List of animal IDs to trace is available	
<i>Destination site:</i>		<i>Farm</i>	<i>Feedlot/Terminal</i>	<i>Farm</i>	<i>Feedlot/Terminal</i>
1: move-out	2	Limited	Limited	Good	Excellent
	3		Excellent		
1: move-in	2	Limited	Inadequate	Good	Limited
	3		Excellent		Excellent
2: move-out	2	Inadequate	Limited	Inadequate	Limited
	3		Excellent		Excellent
2: move-in	2	Limited	Inadequate	Good	Limited
	3				
3: move-out	2	Excellent			
	3				
3: move-in	2	Excellent	Inadequate	Excellent	Limited
	3		Excellent		Excellent

The combination recommendations are highly dependent on the availability of a list of animal IDs to trace-out. Only two combinations would adequately support trace-out investigations without the need for a list of animal IDs to be provided by the operator of the detected farm:

- **Option 3 move-out at farms combined with option 2 or 3 at feedlots or terminal sites; and**
- **Option 3 move-in at farms combined with option 3 at feedlots and terminal sites.**

If a list of animal IDs to be traced-out is provided by the operator of the detected farm, then the following combination could also be considered:

- Option 1 move-in at farms and option 2 or 3 at feedlots and terminal sites;

Table 17 provides the summary of the performance of each movement reporting option evaluated to support trace-out investigations of indirect farm-to-farm/feedlot/terminal sites movements. Only two combinations provide appropriate support for trace-out investigations with the information available from the database. These combinations are also able to trace movements through multiple intermediate sites used in sequence.

- **Option 2 move-in at farms combined with option 3 at intermediate sites and option 2 or 3 at feedlots and terminal sites; and**

- **Option 3 move-in at farms combined with option 3 at intermediate sites and option 2 or 3 at feedlots and terminal sites.**

If a list of animal IDs to trace is provided by the operator of the detected farm, then the following two options are also appropriate:

- Option 2 move-in at farms, combined with option 2 at intermediate sites and option 2 or 3 at feedlots and terminal sites; and
- Option 3 move-in at farms, combined with option 2 at intermediate sites and option 2 or 3 at feedlots and terminal sites.

Table 17. Summary of results of indirect movement trace-out investigations at a farm considering the option applied at farms, feedlots and terminal sites.

Option at farms	Option at I-site	Option at Feedlot or terminal sites	Proportion of indirect movements traced-out of the detected farm				Multiple I-sites in sequence							
			List of animal IDs to trace is not available		List of animal IDs to trace is available		List of animal IDs to trace is not available	List of animal IDs to trace is available						
Destination site:			Farm	Feedlot/terminal	Farm	Feedlot/terminal	Intermediate site	Intermediate site						
1: move-out	1	2	Inadequate	Inadequate	Inadequate	Good	Inadequate	Limited						
		3		Limited		Excellent								
		2		2		Good			Limited	Excellent				
	2	3		Excellent		Excellent	Excellent	Excellent						
		2												
		3												
1: move-in	1	2	Limited	Inadequate	Limited	Good	Inadequate							
		3		Limited		Excellent								
		2		2		Good								
	2	3	Inadequate			Excellent	Excellent	Excellent for movements to feedlots or terminal sites						
		2	Limited	Excellent										
		3												
2: move-out	1	2	Inadequate	Limited	Inadequate	Limited	Inadequate							
		3		Excellent		Excellent								
		2		2		Excellent for movements to feedlots or terminal sites								
	2	3		Excellent			Excellent							
		2												
		3												
2: move-in	1	2	Inadequate	Inadequate	Limited	Limited	Inadequate							
		3		Limited		Excellent								
		2		2		Excellent			Inadequate	Excellent				
	2	3		Inadequate	Excellent	Excellent	Excellent							
		2												
		3												
3: move-out	1	2	Inadequate	Excellent	Inadequate	Excellent	Inadequate for farms Excellent only for movements to feedlots and terminal sites							
		3												
		2												
	2	3							Inadequate	Inadequate	Excellent	Excellent	Inadequate	
		2												
		3												
3: move-in	1	2	Limited	Inadequate	Excellent	Limited	Inadequate							
		3		Limited		Excellent								
		2		2		Inadequate			Excellent	Inadequate	Excellent			
	2	3	Inadequate	Excellent										
		2												
		3												

4.1.4.2. If detection takes place at a feedlot – trace-out investigations

The majority of movements from a feedlot go directly to a terminal site (70%) or for export (30%). In the case of movements to a terminal site, these sites will apply either option 2 or 3. If option 2 is used, a list of animal IDs that were removed from the feedlot during the critical period would have to be provided to quickly link the departure and destination site. If option 3 is applied, it will be able by itself to provide the trace-out information directly from the database.

4.1.5. Combined recommendations for movement reporting to support trace-out investigations at farms and feedlots

Only one combination could fully support trace-out investigations at farms and feedlots without the need for a list of animal IDs to trace to be provided.

Combination	Farms	Intermediate sites	Feedlots	List of animal ID required?
1	Move-in option 3	Option 2,3	Option 3	NO

4.2. Trace-out investigations at intermediate Sites

In 2011, the CFIA produced a report which classified intermediate sites (community pastures, auctions, fairs, test stations, feedlots⁵ and assembly yards) in the context of bovine movements (CFIA, 2011). All intermediate sites explored in the report ranked high for assortment of animals of different Origins, mixing of animals on the site and dispersal of animals to multiple sites (except feedlots which ranked low for dispersal⁵). A high ranking means that the site occupied a central place in the bovine movement network. These sites have a high risk of being exposed and disseminating a highly contagious disease. In fact, McLaws and Ribble (2007) showed the importance markets played in leading to extremely large outbreaks of FMD. In this study, of the 24 FMD epidemics that have occurred 1992-2003, they found that in the UK 2001 and Taiwan 1997 FMD outbreaks a market was involved in the early dissemination of the virus, which led to >1000 farms being infected. In the other 22 outbreaks, during the same time period, the total size remained <100 farms and a market was never involved in the dissemination of the virus.

Should tracing investigations determine that infected animals transited through an intermediate site, trace-out investigations will have to be done to find the final destination of exposed farmed ruminants. Exposed farmed ruminants can be those which were present on the same day as exposed animals, or a subset of these should investigations determine that a subset of animals were found to have been exposed to infected animals.

⁵ Given the findings of the 2011 CFIA report, for the purposes of this evaluation, feedlots were not classified as intermediate sites. They have their own category, which includes backgrounding operations.

The most appropriate option to ensure trace-out at intermediate sites is to have **option 3 move-in reporting at destination sites: farms, feedlots and terminal sites**. Having a mechanism in place to quickly determine if specific animal IDs transited through one of these sites is to have a record of IDs at the intermediate site as well as at destinations. **This would mean option 2 or 3 at the intermediate site.**

4.3. Overall Recommendations for Movement Reporting to Support Trace-in and Trace-out investigations at all sites

Trace-out and trace-in investigations require different moving reporting options to be applied at the farm: move-in option 2 or 3 or move-out option 3 to support trace-in investigations and move-in option 3 to support trace-out investigations. Based on the options evaluated, the combination that adequately supports trace-in and trace-out investigations following an FMD detection at a farm, feedlot or terminal site and trace-out investigations at an intermediate site, without requiring any information from other Origins is:

Reporting	Farms	Intermediate sites	Feedlots	Terminal sites
Move-in	Option 3	Option 3	Option 3	Option 3

In all the scenarios and movement reporting combinations explored, a single declaration process was evaluated: either reporting move-in or move-out. Recognizing that option 3 at intermediate sites may be a limiting factor in the implementation of the combination recommended above, we explored which reporting combination could support the implementation of option 1 at intermediate sites.

Two important issues had an impact on the performance of the reporting options for these tracing investigations:

- The absence of an animal ID activation process at F1 : in many trace-in investigations evaluated, tag issuance information has to be accessed to complete the trace-in loops and identify the initial departure sites of movements.
- The inability to quickly obtain the list of farmed ruminants introduced and removed from a detected farm by accessing the database. In many trace-out investigations evaluated a list of animal IDs to trace has to be provided for any trace-out to take place.

These two issues would have to be addressed together in order to maximize the movement reporting system and allow the implementation of option 1 at intermediate sites. This would be addressed with dual declarations at farms:

1. **Option 3 move-out at farms**, in addition to option 3 move-in at farms.

In addition to addressing the issues of tag activation and obtaining a list of animal IDs to trace, the dual declaration at farms would also support tracing investigations when two intermediate sites are involved in sequence, even if option 1 is applied at intermediate sites.

As a result, these two options are equivalent, from an epidemiological perspective, in supporting tracing investigations in farmed ruminants in Canada.

Table 18. Final recommendations of movement reporting options applied at all sites in farmed ruminant pathways in Canada.

Combination	Farms	Intermediate sites	Feedlots	Terminal sites
1	Option 3 move-in	Option 3 move-in	Option 3 move-in	Option 3 move-in
2	Option 3 move- in+out	Option 1 move-in	Option 3 move-in	Option 3 move-in

The last limiting factor for tracing investigation is the delay to reporting of 7 days. This delay has to be reduced to 48 hours at least in order to meet the performance requirements developed by the TTT group.

5. ANALYSIS OF PERFORMANCE OF MOVEMENT REPORTING OPTIONS - BSE

When an animal is detected as BSE-positive the main objectives of the investigation are to examine the infected animal's background and identify any susceptible animal that may have been exposed to the same Origin of contamination as the BSE-infected animal. The following steps would be taken which would require access to a traceability system (CFIA, BSE-MOP, 2014):

- (1) Trace-in the animal to the birth farm;
- (2) Identify all other cattle which may have been exposed to the same feed as the infected animal during their first year of life and trace-out these farmed ruminants (feed cohort);
- (3) Identify all other cattle that were born on the same farm and within 12 months of the infected animal's birth and trace-out these farmed ruminants (birth cohort); and
- (4) Identify the infected animal's progeny and trace-out these farmed ruminants.

These investigations therefore have the potential to go back several years and are not limited by time as BSE it is not a fast spreading disease as would be FMD. The following traceability tasks can therefore be evaluated:

- Task 1: Trace-in to the birth farm and identify all sites where the BSE-infected animal lived;
- Task 2: Trace-out all equivalent risk farmed ruminants (feed and birth cohorts); and
- Task 3: Trace-out the progeny of the infected animal if applicable.

The tag issuance database would be consulted in all three options. Having access to a tag activation event applied at a time around birth, as described in the FMD investigations would significantly improve BSE investigations: identification of birth farm as well as birth and feed cohorts. Without this information, it makes the identification of the infected animal's herd mates at and around birth impossible by using this database. In addition, a movement reporting option, by itself, would not be able to address this component.

The combination proposed in the FMD investigation would entirely support the investigations for BSE.

Scenario 3. Tracing investigations following detection of BSE - Summary

The movement reporting combinations recommended in FMD investigations would help trace-in to the birth farm, and would enable finding all the locations where the animal lived. However, implementing a tag activation process, at a time around birth, would be required to fully support these investigations. As discussed in the FMD section, this process would also help identify the birth farms of animals that move and would facilitate tracing investigations for FMD also.

Knowing the ID of the progeny of the infected animal, these farmed ruminants could be located.

6. DISCUSSION OF RESULTS

The purpose of this analysis was to evaluate three different movement reporting options implemented at various sites along the movement pathways of cattle, bison, sheep, goats and cervids in order to evaluate their effectiveness in supporting the management of a sanitary issue in Canada. The options were assessed in their ability to provide the required information associated with various tracing tasks for a highly contagious disease (FMD) and for BSE which represents a form of feed contamination. The options were evaluated individually in how they supported various tracing tasks and recommendations were made on the most effective combination of options applied at the different sites (farms, feedlots, intermediate sites and terminal sites) to support tracing investigations.

In the case of a highly contagious disease investigation, from all the combinations explored for trace-in and trace-out investigations, two combinations proved to be able to support all investigations for all species: (1) option 3 move-in at all sites or (2) dual declarations (move-in and move-out) option 3 at farms combined with option 1 at intermediate sites and option 3 at feedlots and terminal sites. However, all investigations could be significantly impacted by the allowed 7 days reporting delay. Trace-out investigations particularly could be affected: if an investigator has to wait seven days to determine where individual IDs have gone to, a high risk of spread to further destination sites can be expected in the case of a highly contagious disease like FMD. The recommendation would be to require that documentation containing the departure site, the destination site, the number of farmed ruminants transported by species, the conveyance information and the time and date of the movement, would be required for all movements and that a copy of this document be kept at the departure site for consultation, if required. Education and communication of the importance of rapid reporting of animal movements should be made to producer groups.

Time is critical to prevent further spread in the case of a highly contagious disease investigation. Furthermore, resources are limited and must be used as efficiently as possible. For this reason, the traceability system must provide the required information as accurately as possible, using the least resources and in the shortest timeframe possible. This would be addressed by implementing the two combinations presented above.

There are a number of studies documenting the potential for intermediate sites to represent a significant Origin of infectious disease dispersion in the livestock population, particularly auction markets and livestock dealers (Dubé *et al.*, 2010; Ortiz-Pelaez *et al.*, 2006; Robinson and Christley, 2007; Shirley and Rushton, 2005). In addition, McLaws and Ribble (2007) showed that a market was involved in the early dissemination of FMD in the two largest outbreaks (>1,000 farms infected) that occurred in 1992-2003. In all other outbreaks (22/24) a market was not involved initially and the size remained at <100 infected farms. In the data explored in this study in Canada, intermediate sites play an important role in the cattle (beef and dairy) and sheep industries. In addition, beef movements in Eastern Canada and some dairy movements also include the use of two intermediate sites in sequence. For these reasons, care must be used in selecting the movement reporting option that will facilitate tracing investigations which include intermediate sites.

In the case of a BSE investigation which could potentially go back years, the proposed combinations are also appropriate for these investigations. However, such investigations are limited due to the fact that farmed ruminants are not identified around the time of birth but rather when they leave their birth farm.

This makes the identification of an animal's birth cohort difficult without the support of the producer at the birth farm. Depending on the producer, this information may be difficult to obtain and could take a significant amount of time. Tag activation in the province of Quebec for cattle for example is required to take place within seven days of birth of the animal or within five months after birth at pasture, or before its departure from its birth farm, whichever comes first (Agri-traçabilité Québec, 2013). In the UK two tags are applied to calves. For dairy calves the first tag is applied within 36 hours of birth and a delay of 20 days is allowed to apply the second tag. In the case of beef calves, a delay of 20 days after birth is allowed for tag activation. In both cases, tag activation must be done when the animal leaves its farm of birth (The Scottish Government, 2013). This system enables the identification of birth cohorts and herd inventories at different points in time. It would be recommended to adopt a similar approach for tag activation in order to meet the needs of tracing investigations related to contaminants which could have taken place years before detection.

This analysis did not take into consideration issues of non-compliance. In reality, delays greater than seven days to report could be envisioned, especially if resources were not sufficient to ensure proper compliance verification. In addition, a certain percentage of omissions and errors would be anticipated with any of the three options explored. Finally, the tag issuance database could also include omissions and errors. This would lead to missing information on animal movements which could seriously impact tracing investigations and disease spread. As a result, infected farms may not be identified through tracing investigations but rather, through passive surveillance or active surveillance in the case of a disease like FMD where clinical signs in cattle and bison become apparent. However, the longer infected farms can operate as usual, the higher the probability that they are able to spread the virus to other farms in the population. Therefore, reducing reporting delays and ensuring compliance in reporting movements would contribute positively to the management of a sanitary issue. Also, ensuring that a document accompanies every load of farmed ruminants moved and that a copy of this document is kept at the departure site would facilitate tracing investigations in these conditions.

According to the performance targets developed by the TTT required that "within 48 hours of the relevant Chief Veterinary Officer or Competent Authority being notified of a sanitary issue or natural disaster or in the prevention or preparedness of such issue, it must be possible to...

1. Establish the location(s) where a specified animal has been kept during its life.
2. Establish the location(s) from where farmed ruminants at a given site were received.
3. Establish a listing of all farmed ruminants that have been kept on the same location as the specified animal at any stage during those farmed ruminants' lives.
4. Determine the current location of all farmed ruminants that have been kept on the same site as the specified animal at any time duration those farmed ruminants' lives.
5. Determine the identification number and movement history of all conveyances used to transport farmed ruminants to and from a given location.
6. Establish the location of a specified animal immediately prior to importation in Canada or the location of a specified animal immediately subsequent to exportation from Canada.
7. Establish the location and date at which deceased farmed ruminants were sent, transported, received and disposed of (both on- and off-site), and a listing of those farmed ruminants if identified individually."

The proposed movement reporting combinations would be able to address the following targets: 1, 2, 5, and 7. Due to reporting delays, the target of 48 hours set by the TTT may not be met. Performance target 3 would not be addressed through a movement database but rather, with a herd inventory mechanism. Being able to identify birth and feed cohorts of an animal is a component of a BSE investigation that could also be used during a contamination investigation or a natural disaster. There are no modifications to recommend for the movement reporting options to be able to address this performance target. However, tag activation at birth for all cattle and bison would enable this performance target to be met. Performance target 4 is also related to being able to have proper herd inventories but also having reports of the animal's locations throughout their life. The proposed reporting combinations could address the second portion of this objective. Finally, performance target 6 relates to animal identification more than movement reporting.

In setting the performance targets, the TTT group included preparedness activities in potential uses of the traceability data. By studying livestock movements in peacetime, surveillance systems and prevention activities may be implemented which will improve our ability to quickly detect disease incursions and hopefully reduce the level of spread which may have occurred prior to authorities identifying the presence of a highly contagious disease agent in the population. The combinations proposed in this analysis would offer the most information in a useful way to develop network analysis studies used for risk-based surveillance design and identification of high risk premises as well as disease spread simulation studies designed to explore the effectiveness of various control strategies.

Finally, this analysis was based on a livestock demographic study (Serecon & CAHC, 2015) which represents the first paper describing movement patterns of livestock in Canada. Livestock movement information is currently scarce in Canada and the authors held a high number of consultations and validation meetings in order to characterize as best as possible all the potential movement pathways. Certainly, the results may not include pathways that are not generally representative of the industries involved. The movement reporting combinations proposed in this paper however should enable tracing investigations for the large majority of pathways that could be encountered.

7. REFERENCES

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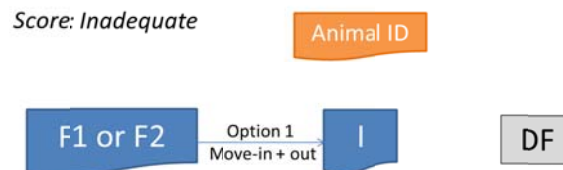
8. APPENDIX - FIGURES TO SUPPORT TRACE-IN AND TRACE-OUT INVESTIGATION ANALYSIS AT DETECTED FARMS

8.1. Section 1: Trace-in investigations at a farm, move-out option 1 at farms

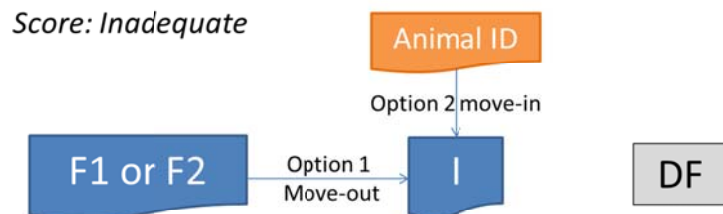
Direct farm-to-farm movement



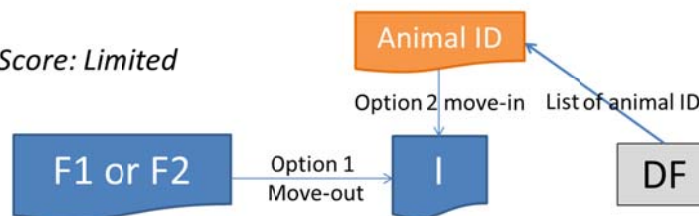
Indirect farm to farm movement (I-site option 1)



Indirect farm to farm movement (I-site option 2)

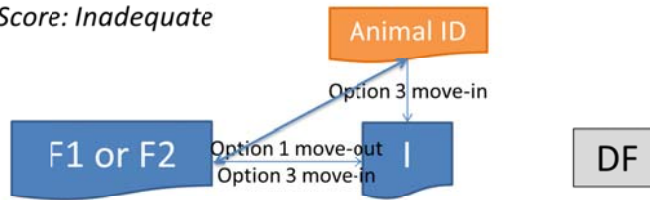


Score: Limited

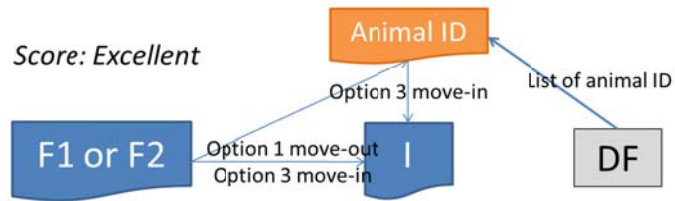


**Indirect farm to feedlot/terminal movement
(I-site option 3)**

Score: Inadequate



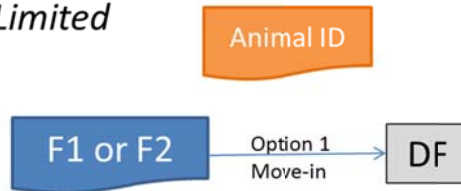
Score: Excellent



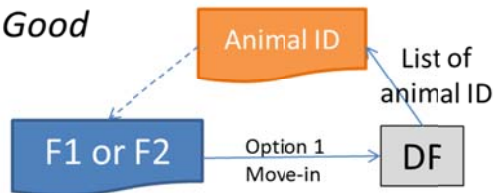
8.2. Section 2: Trace-in investigations at a farm, move-in option 1 at farms

Direct farm-to-farm movement

Score: Limited

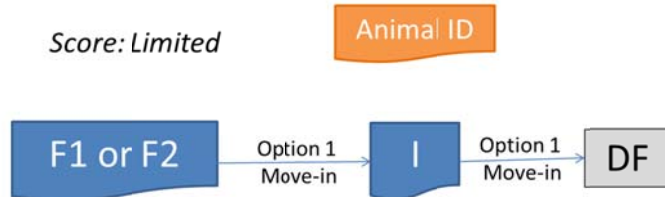


Score: Good

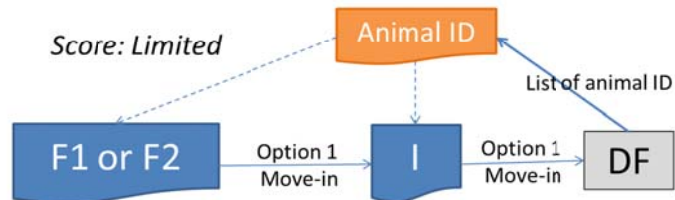


Indirect farm to farm movement (I-site option 1)

Score: Limited

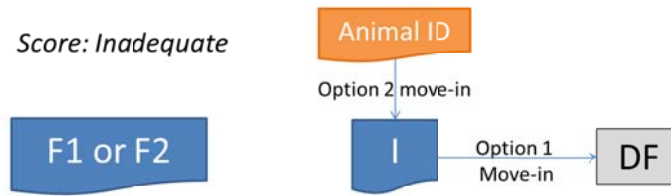


Score: Limited

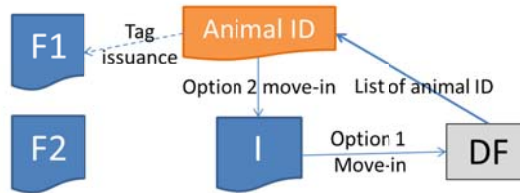


**Indirect farm to farm movement
(I-site option 2)**

Score: Inadequate



Score: Limited

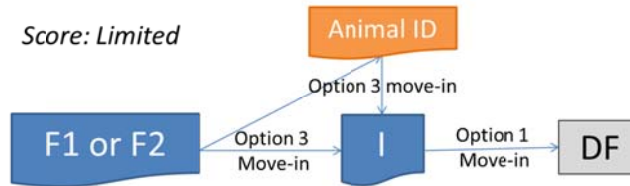


Score: Inadequate

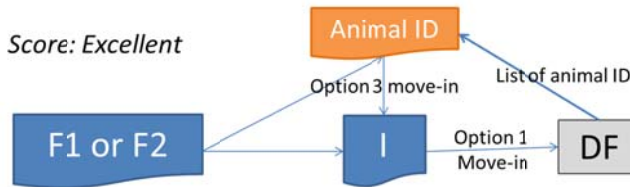


**Indirect farm to feedlot/terminal movement
(I-site option 3)**

Score: Limited



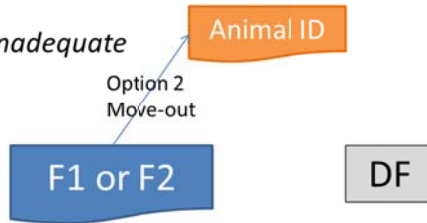
Score: Excellent



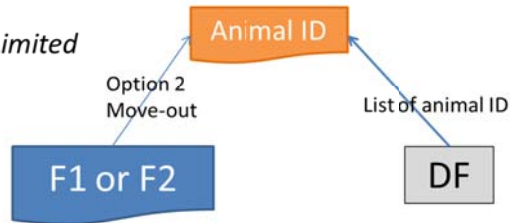
8.3. Section 3: Trace-in investigations at a farm, move-out option 2 at farms

Direct farm-to-farm movement

Score: Inadequate

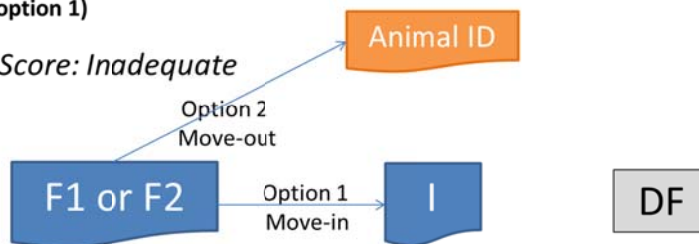


Score: Limited

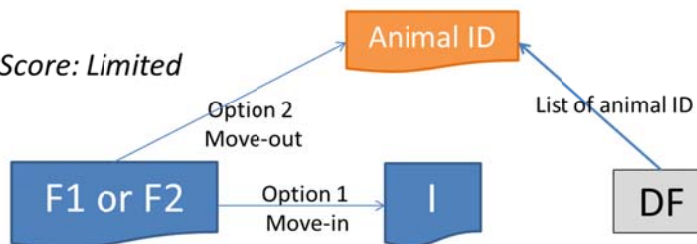


Indirect farm to farm movement (I site option 1)

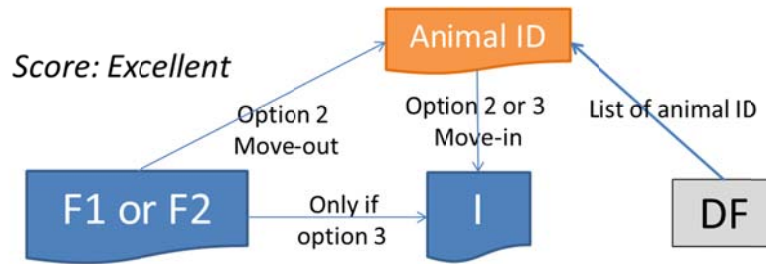
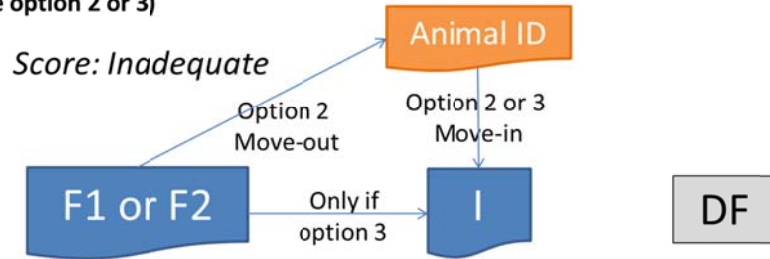
Score: Inadequate



Score: Limited

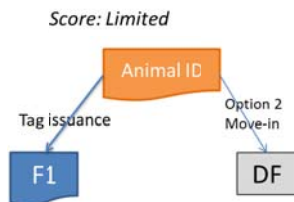
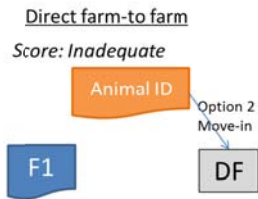


Indirect farm to farm movement
(I site option 2 or 3)

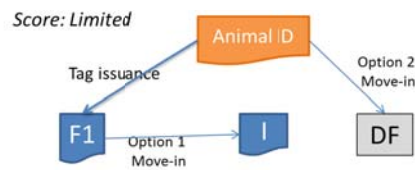
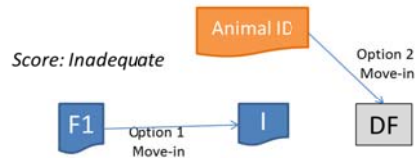


8.4. Section 4: Trace-in investigations at a farm, move-in option 2 at farms

**Movements from F1
(I-site Option 1)**

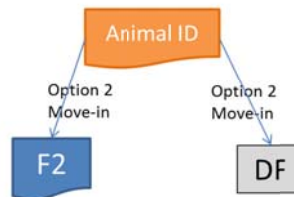


Indirect via I-site

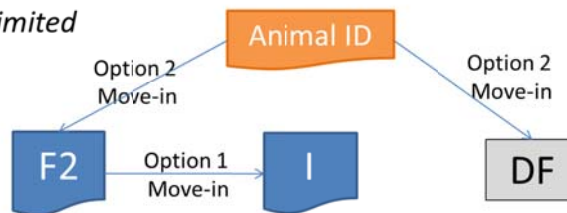


**Movements from F2
(I-site Option 1)**

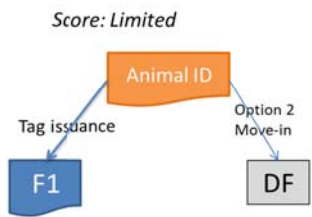
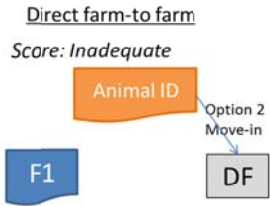
Score: Limited



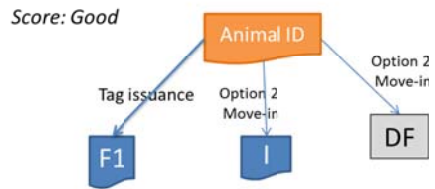
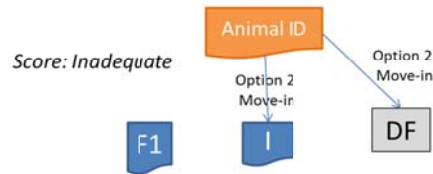
Score: Limited



**Movements from F1
(I-site Option 2)**

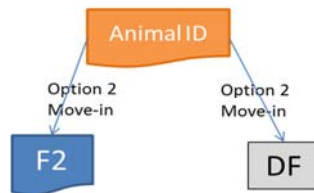


Indirect via I-site

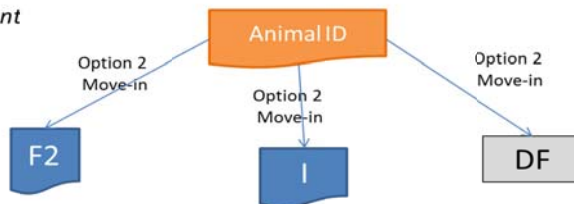


**Movements from F2
(I-site Option 2)**

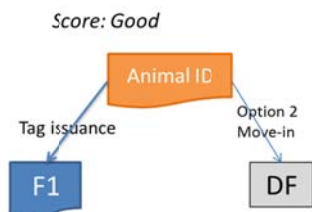
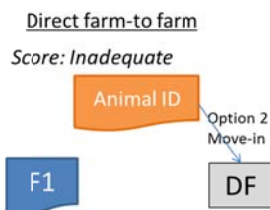
Score: *Limited*



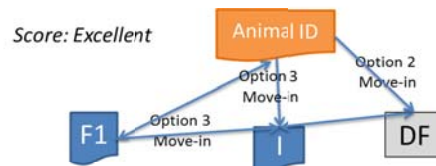
Score: *Excellent*



**Movements from F1
(I-site Option 3)**

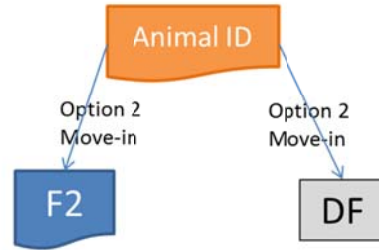


Indirect via I-site

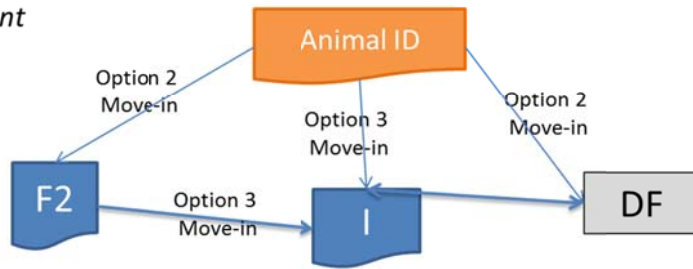


Movements from F2
(I-site Option 3)

Score: Excellent



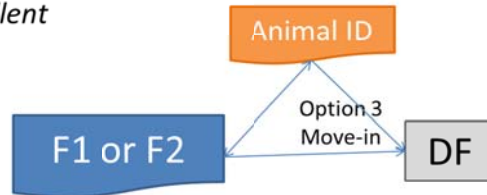
Score: Excellent



8.5. Section 5: Trace-in investigations at a farm, move-out option 3 at farms

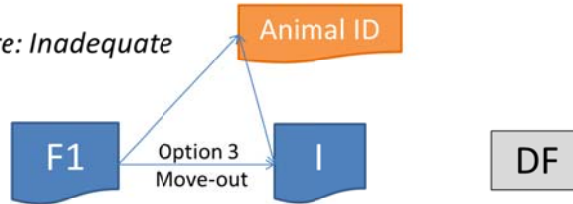
Direct farm-to-farm movement

Score: Excellent

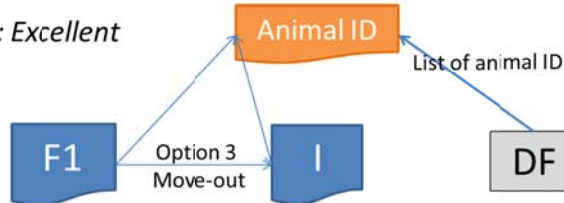


Indirect farm to farm movement

Score: Inadequate



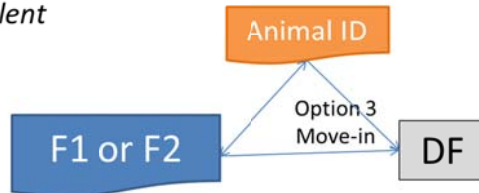
Score: Excellent



8.6. Section 6: Trace-in investigations at a farm, move-in option 3 at farms

Direct farm-to-farm movement

Score: Excellent

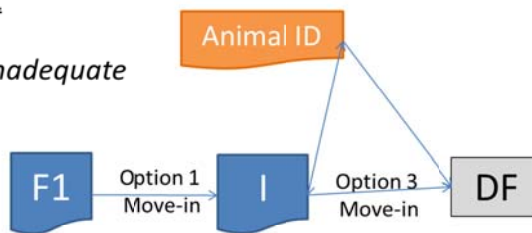


Indirect farm to farm movement

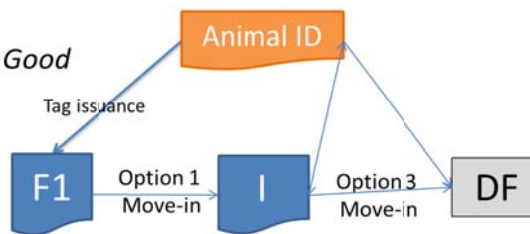
Movements from F1

(I-site Option 1)

Score: Inadequate



Score: Good

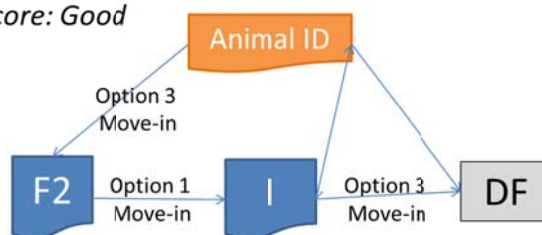


Indirect farm to farm movement

Movements from F2

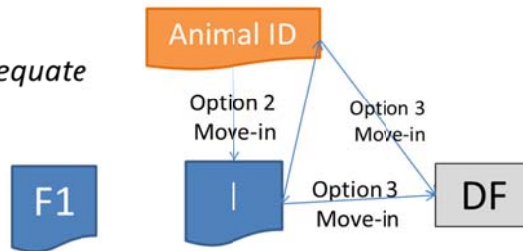
(I-site Option 1)

Score: Good

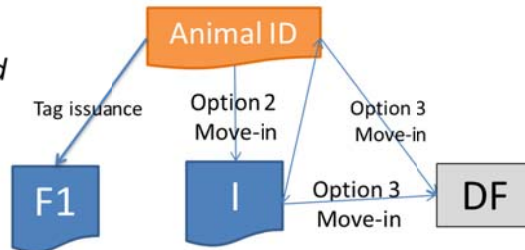


**Indirect farm to farm movement
(I-site Option 2)**

Score: Inadequate

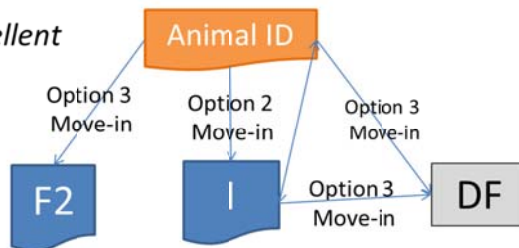


Score: Good



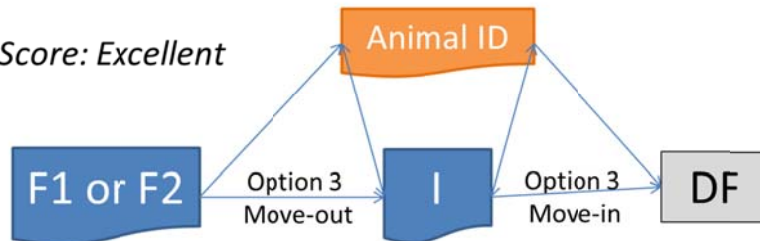
**Indirect farm to farm movement
(I-site Option 2)**

Score: Excellent



**Indirect farm to farm movement
(I-site Option 3)**

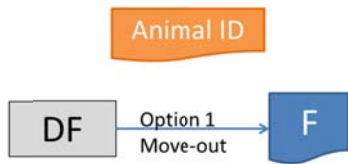
Score: Excellent



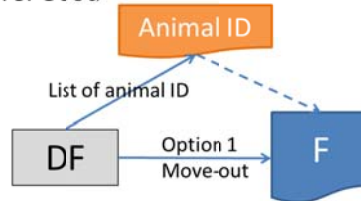
8.7. Section 7: Trace-out investigations at a farm, move-out option 1 at farms

Direct farm-to-farm movement

Score: Limited

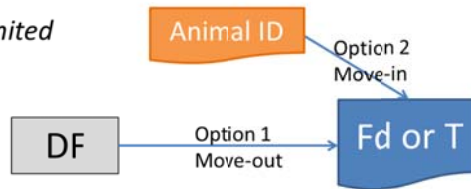


Score: Good

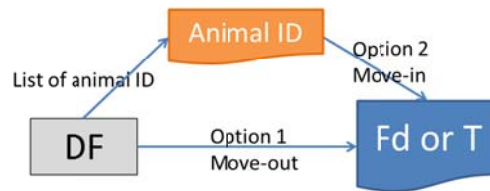


Direct farm to feedlot/terminal movement (option 2)

Score: Limited

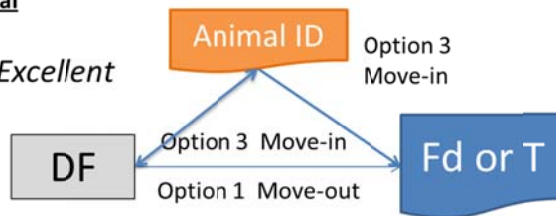


Score: Excellent



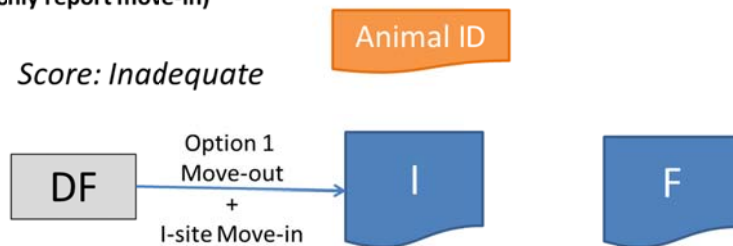
Direct farm to feedlot/terminal movement (option 3)

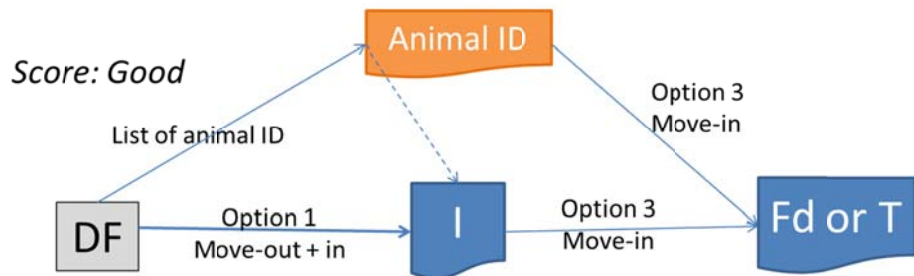
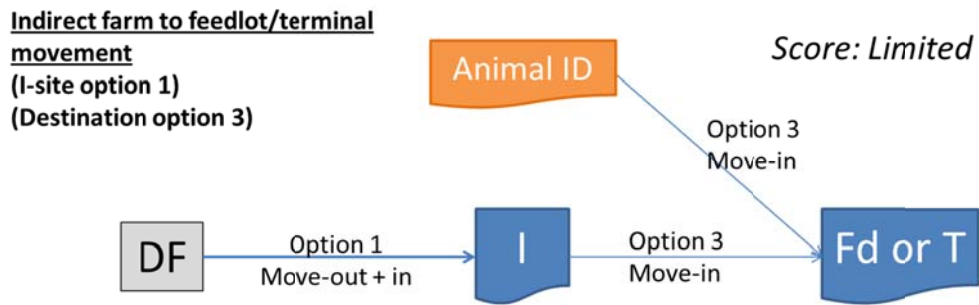
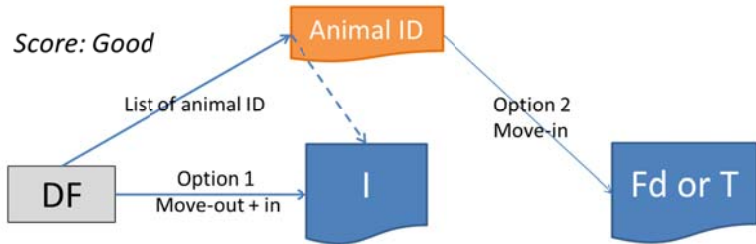
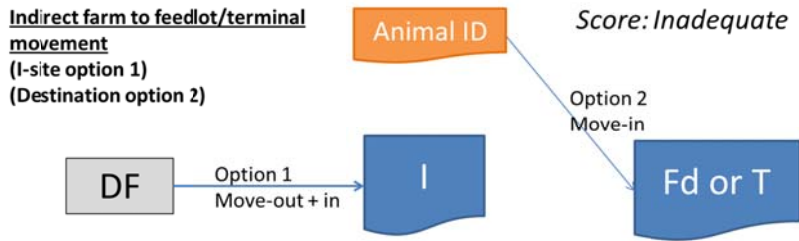
Score: Excellent



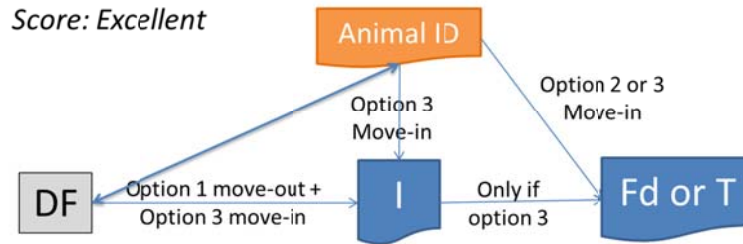
Indirect farm to farm movement (I-site only report move-in)

Score: Inadequate

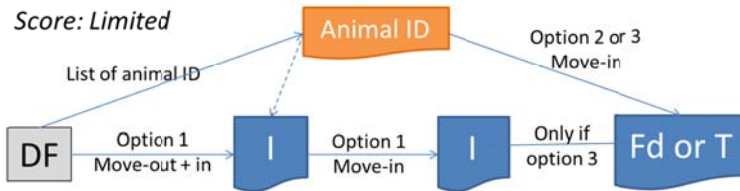
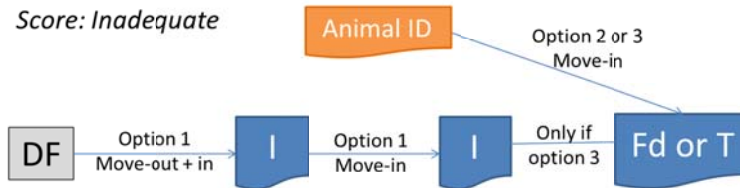




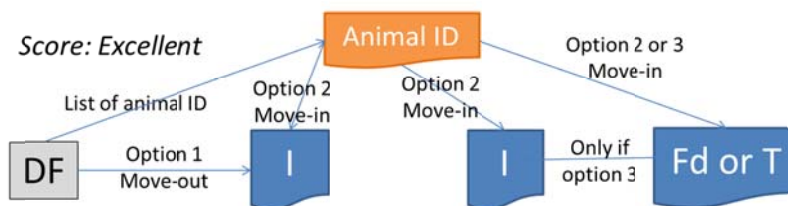
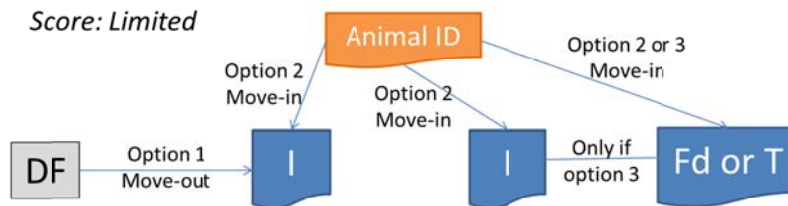
**Indirect farm to feedlot/terminal movement
(I-site option 3)**



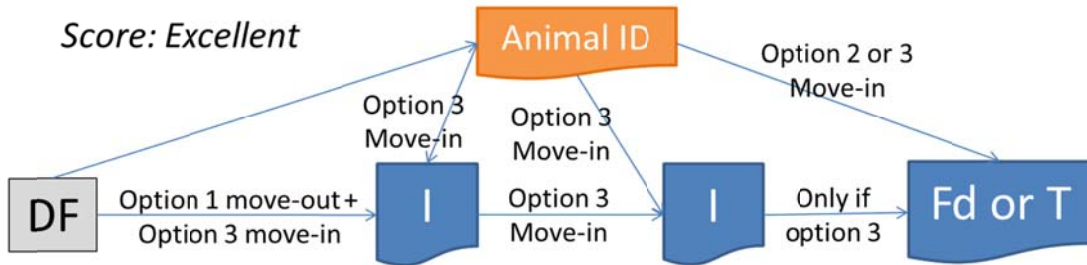
**Indirect farm to feedlot/terminal movement via multiple I-sites
(I-sites option 1)**



**Indirect farm to feedlot/terminal movement via multiple I-sites
(I-sites option 2)**



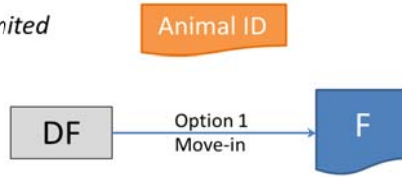
**Indirect farm to feedlot/terminal movement via multiple I-sites
(I-sites option 3)**



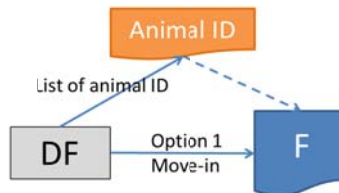
8.8. Section 8: Trace-out investigations at a farm, move-in option 1 at farms

Direct farm-to-farm movement

Score: Limited

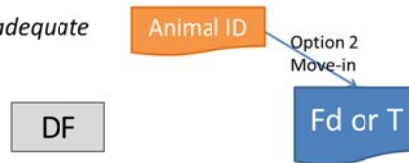


Score: Good

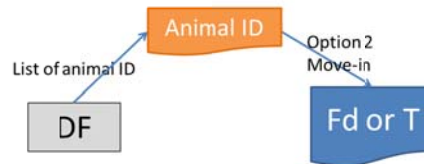


Direct farm to feedlot/terminal movement (option 2)

Score: Inadequate

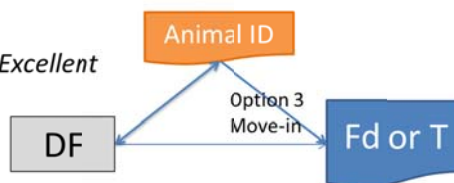


Score: Limited

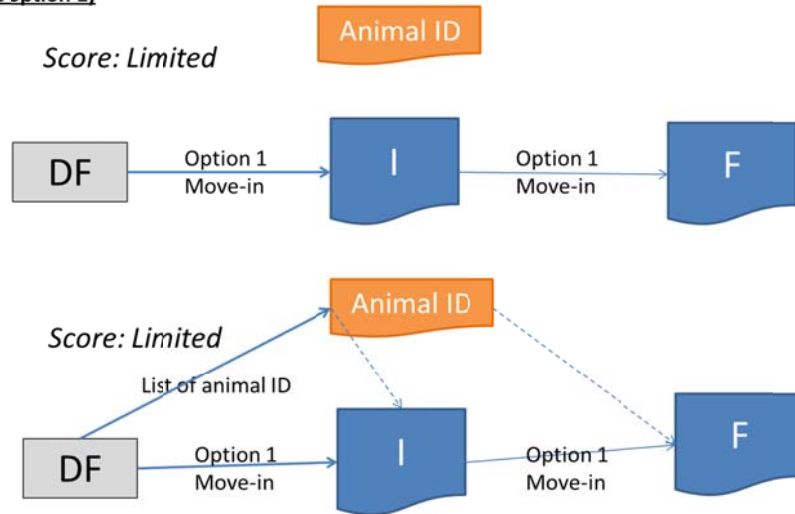


Direct farm to feedlot/terminal movement (option 3)

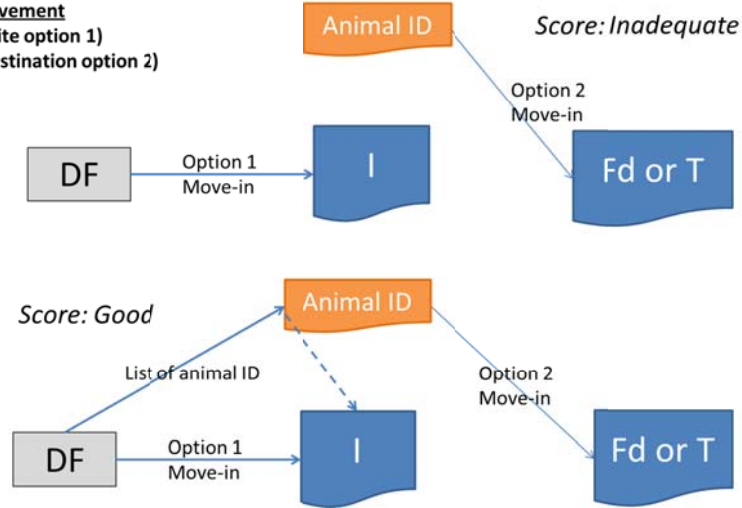
Score: Excellent



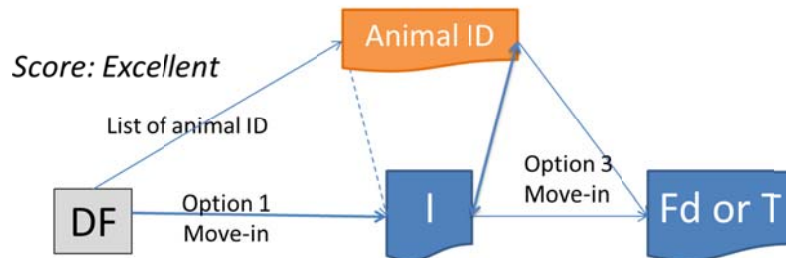
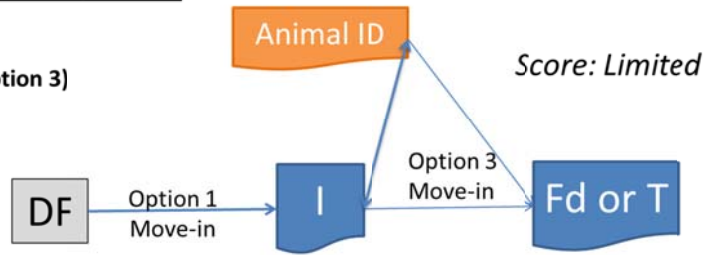
**Indirect farm to farm movement
(I-site option 1)**



**Indirect farm to feedlot/terminal
movement
(I-site option 1)
(Destination option 2)**

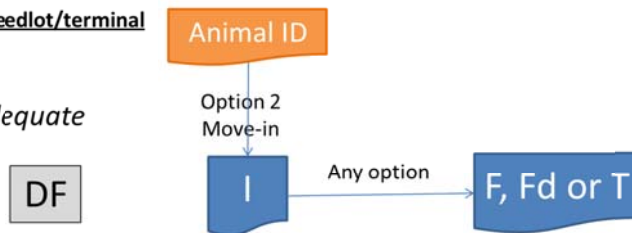


Indirect farm to feedlot/terminal movement
 (I-site option 1)
 (Destination option 3)

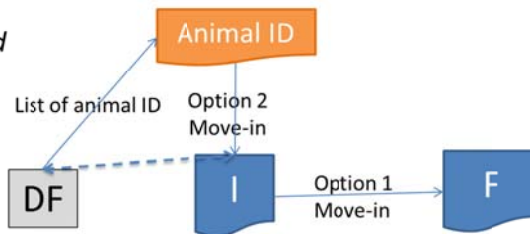


Indirect farm to farm/feedlot/terminal movement
 (I-site option 2)

Score: Inadequate

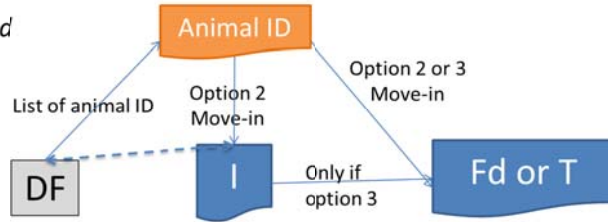


Score: Limited



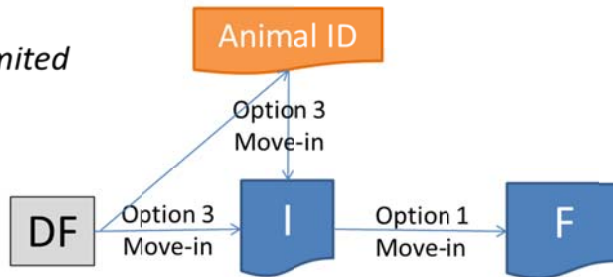
Indirect farm to farm/feedlot/terminal movement
(I-site option 2)

Score: Good



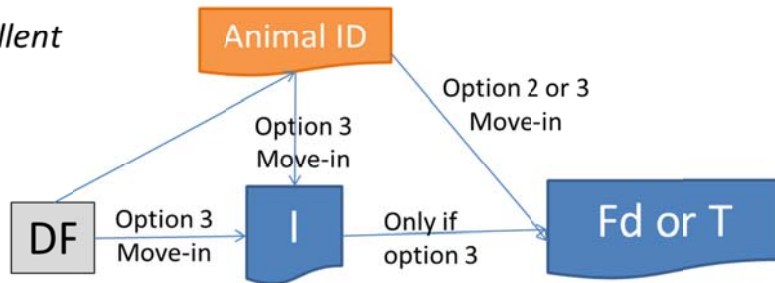
Indirect farm to farm movement
(I-site option 3)

Score: Limited



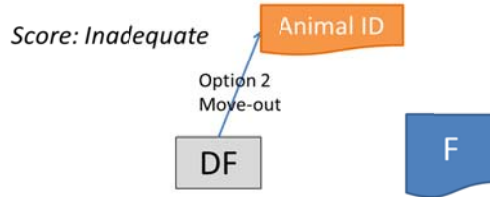
Indirect farm to feedlot/terminal movement
(I-site option 3)

Score: Excellent

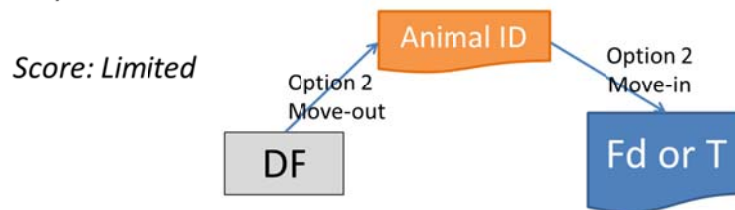


8.9. Section 9: Trace-out investigations at a farm, move-out option 2 at farms

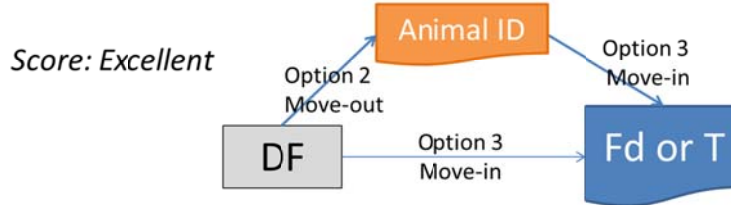
Direct farm-to-farm movement



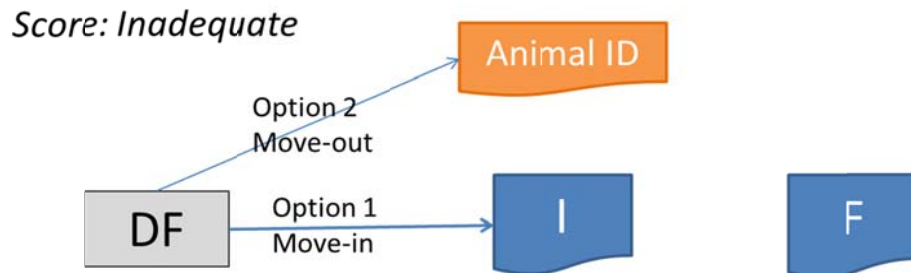
Direct farm to feedlot/terminal movement (Option 2)

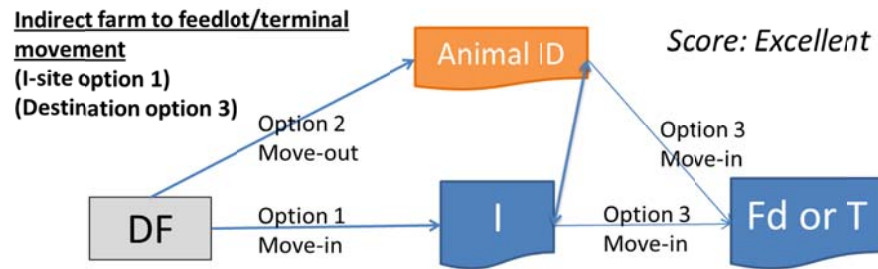
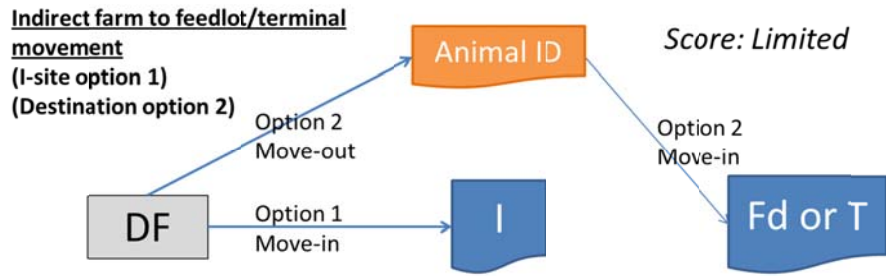


Direct farm to feedlot/terminal movement (Option 3)

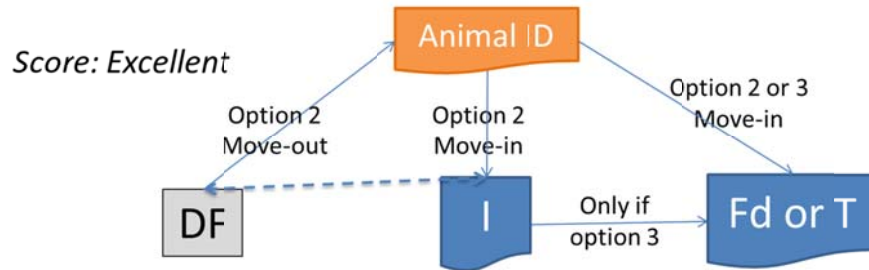


Indirect farm to farm movement (I-site option 1)

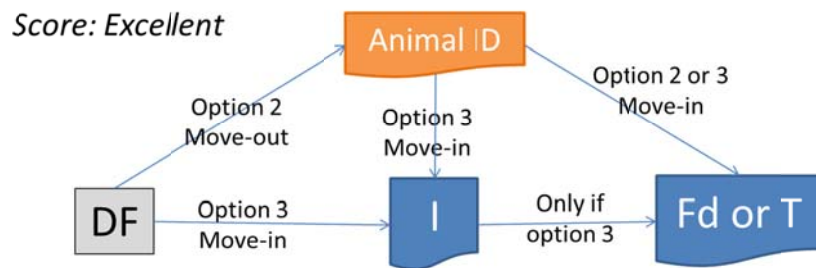




Indirect farm to feedlot/terminal movement
(I-site option 2)

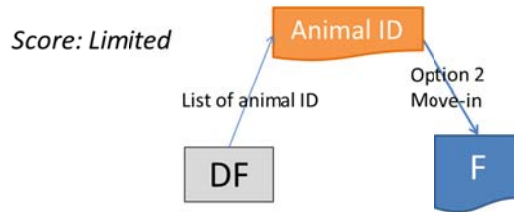
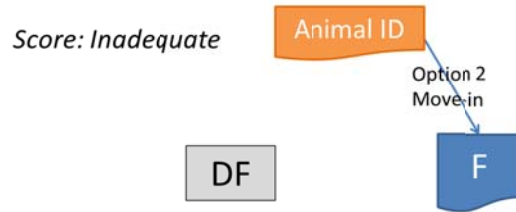


Indirect farm to feedlot/terminal movement
(I-site option 3)

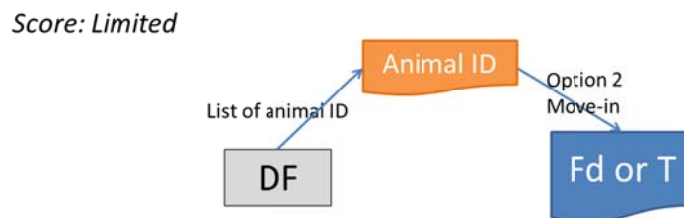
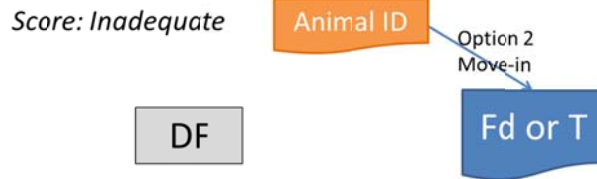


8.10. Section 10: Trace-out investigations at a farm, move-in option 2 at farms

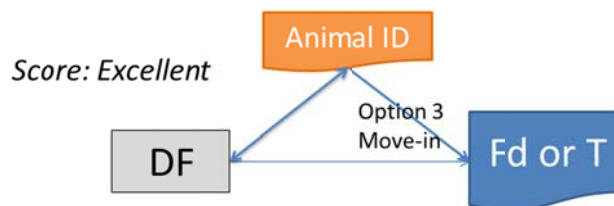
Direct farm-to-farm movement



Direct farm to feedlot/terminal movement (option 2)



Direct farm to feedlot/terminal movement (option 3)

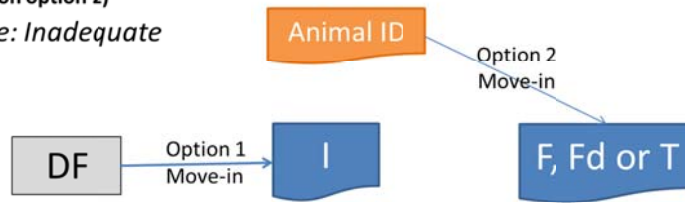


Indirect farm to farm/feedlot/terminal movement

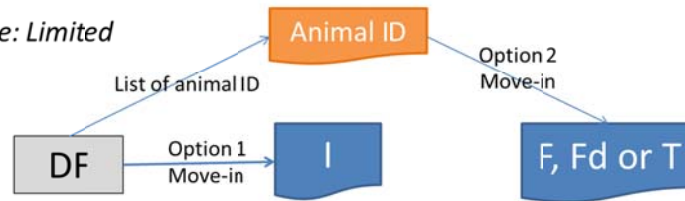
(I-site option 1)

(Destination option 2)

Score: Inadequate



Score: Limited

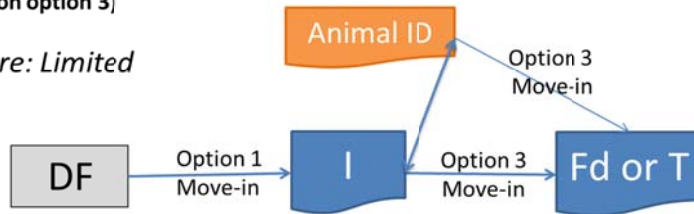


Indirect farm to feedlot/terminal movement

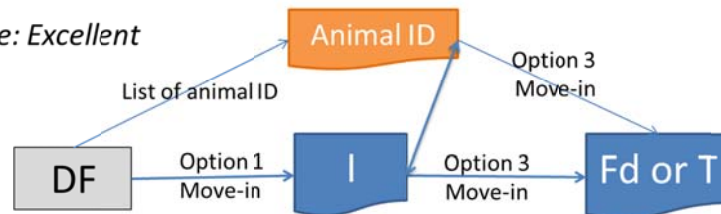
(I-site option 1)

(Destination option 3)

Score: Limited

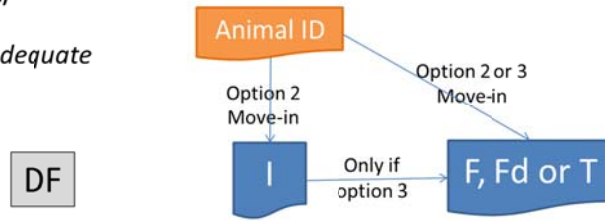


Score: Excellent

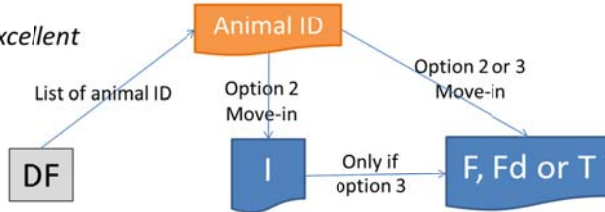


**Indirect farm to farm/feedlot/terminal movement
(I-site option 2)**

Score: Inadequate

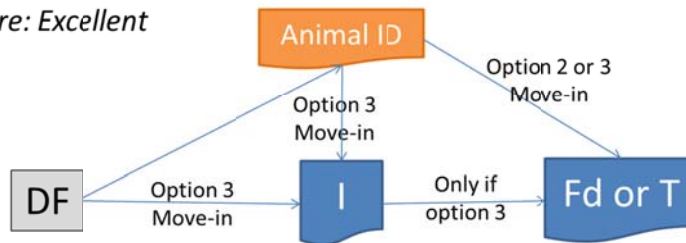


Score: Excellent



**Indirect farm to feedlot/terminal movement
(I-site option 3)**

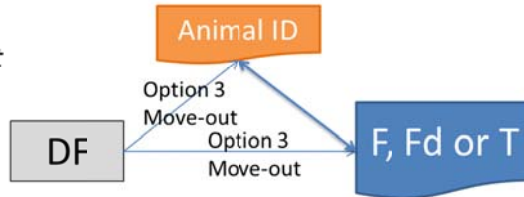
Score: Excellent



8.11. Section 11: Trace-out investigations at a farm, move-out option 3 at farms

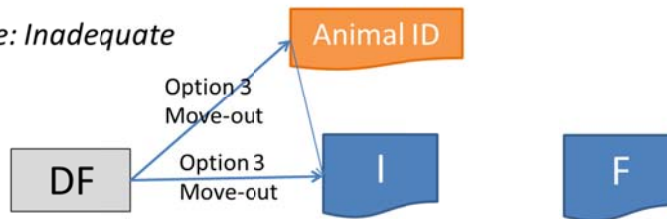
Direct farm to farm/feedlot/terminal movement

Score: Excellent



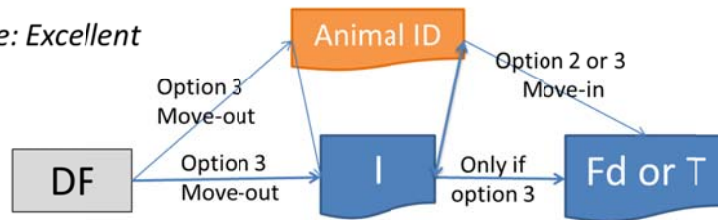
Indirect farm to farm movement

Score: Inadequate



Indirect farm to feedlot/terminal movement

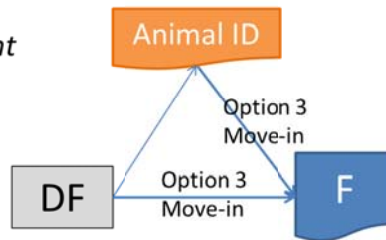
Score: Excellent



8.12. Section 12: Trace-out investigations at a farm, move-in option 3 at farms

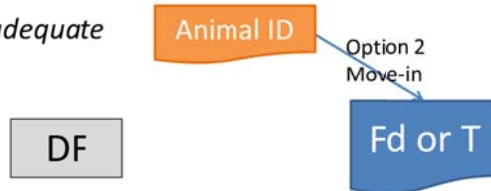
Direct farm-to-farm movement

Score: Excellent

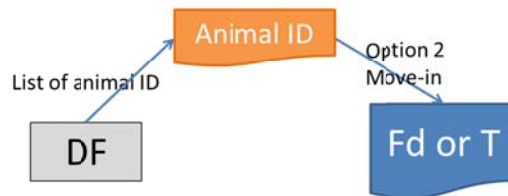


Direct farm to feedlot/terminal movement (option 2)

Score: Inadequate

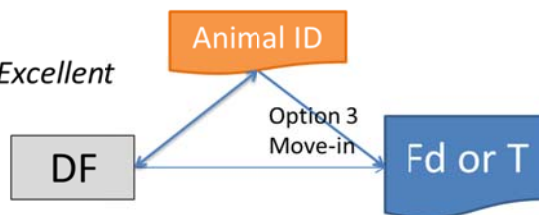


Score: Limited



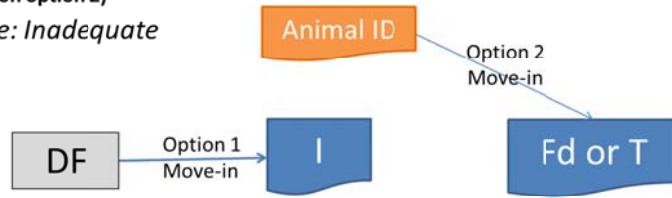
Direct farm to feedlot/terminal movement (option 3)

Score: Excellent

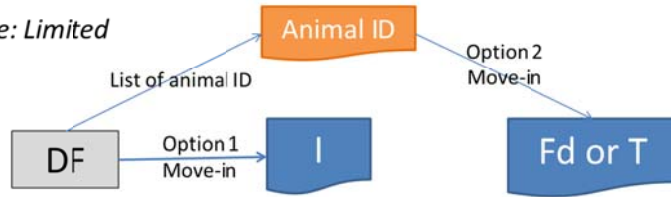


Indirect farm to feedlot/terminal movement
 (I-site option 1)
 (Destination option 2)

Score: Inadequate

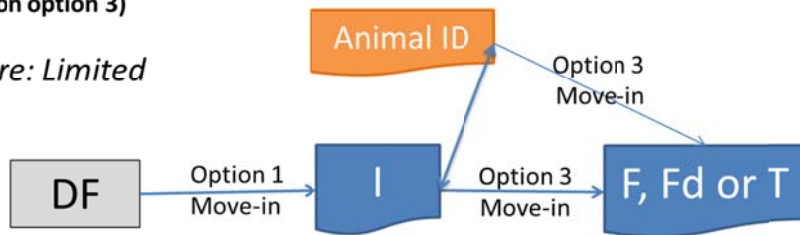


Score: Limited

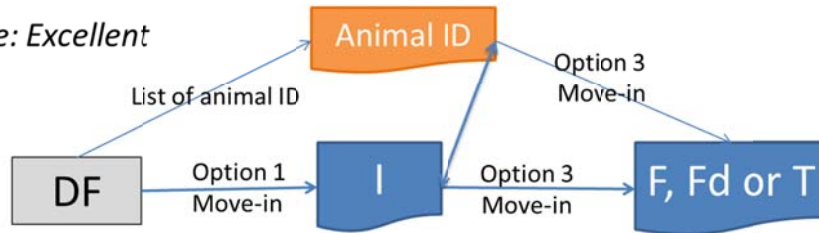


Indirect farm to farm/feedlot/terminal movement
 (I-site option 1)
 (Destination option 3)

Score: Limited

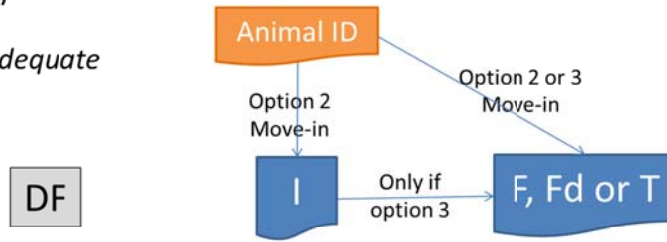


Score: Excellent

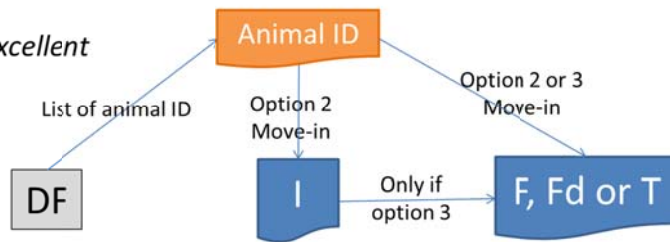


Indirect farm to farm/feedlot/terminal movement (I-site option 2)

Score: Inadequate

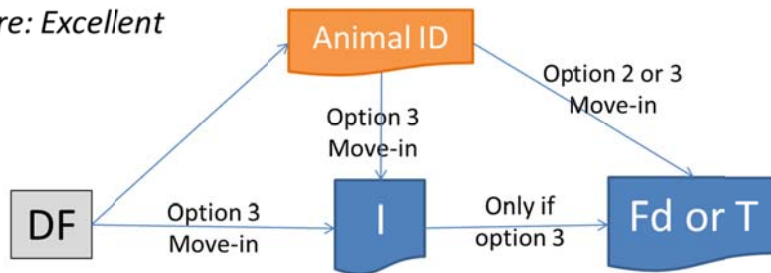


Score: Excellent



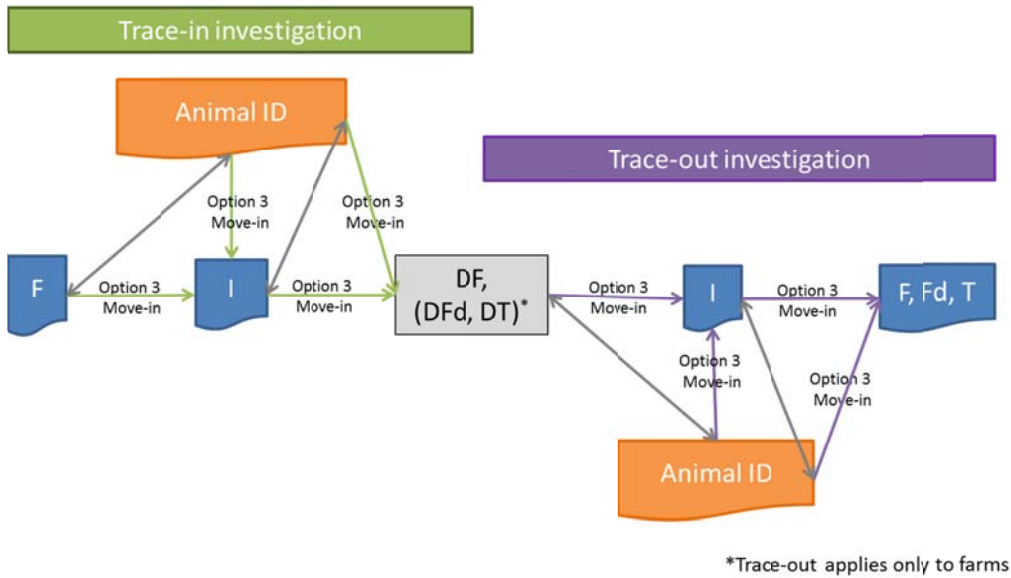
Indirect farm to feedlot/terminal movement (I-site option 3)

Score: Excellent



8.13. Overall recommended movement reporting pathways

Option 3 move-in at all sites



CIP + Option 3 move-out at farms

