Unpublished Report

Document ID:	SheepCRC_7_14
Title:	On-farm and sale yard single or multi-lane RFID tracking of sheep
Author:	Atkins, K.D.; Semple, S.
Key words:	sheep; RFID tracking; counting; eID

REPORT FOR

MEAT & LIVESTOCK AUSTRALIA LIMITED

AND

SHEEP CRC LTD

Milestone 4

Demonstrated ability for on-farm and sale yard single or multi-lane RFID tracking and traceability to achieve ≥99% accuracy at commercial speeds and volumes for sheep identified with a functioning RFID device

.

PROJECT NO. V.NLI.0054.3.1

NLIS (Sheep & Goats) Technical and Operational Barriers Reduction.

Steve Semple, NSW DPI , Orange

28/03/04

Background

This report describes the technical requirements and estimated costing for on-farm and sale yard sheep flow, ID capture, and roll-call event design for alternate RFID system as part of the objective of an overall project which includes the aim to:

- Identify the technical issues and resources required within the production, sale yard and processing sectors to allow NLIS (Sheep & Goats) to migrate from a visual tag identifier to RFID device (if required)

.

A. Sale yard tracing

Evaluation of the technical requirements and estimation of the cost of sale yard multi-lane RFID tracking and traceability, including segregation systems for non-tagged/non- read animals and will aim for 100% accuracy at commercial speeds and volumes for sheep identified with a functioning RFID device.

B. On-farm tracing

The option for on-farm roll-call of lots for despatch will be considered as an option to roll-call into the saleyard and for property to property sales where saleyards are not used.

A. Sale yard tracing

Evaluation of the technical requirements and estimation of the cost of sale yard multi-lane RFID tracking and traceability, including segregation systems for non-tagged/non- read animals and will aim for 100% accuracy at commercial speeds and volumes for sheep identified with a functioning RFID device

To identify the technical requirements for and estimate the cost of sale yard multi-lane RFID tracking and traceability, including segregation systems for non-tagged/non- read animals a number of steps have been conducted :

1. To study a selected sample of NSW sale yards (as representative of other Australian saleyards) to look at current sheep flow and the potential requirements for an RFID system across a range of yard designs (i.e. unload and load via the same ramps or flow through with unload at one end and load at the other).
2. Consider the system requirements to read RFID tags at commercial speeds and the availability or need for development of equipment to accomplish this.
3. Development and testing of equipment to allow reading of RFID tags at commercial speeds.
4. Estimate the cost of equipment required to achieve saleyard tracking and traceability.
5. Identify serious impediments to practical implementation of an RFID system in saleyards or on-farm.

Results:

1. Study of a selected sample of NSW sale yards (as representative of other Australian saleyards) to look at current sheep flow and the potential requirements for an RFID system across a range of yard designs (i.e. unload and load via the same ramps or flow through with unload at one end and load at the other).

The saleyards visited in Central and Southern NSW and the results were reported in Milestone 3.

The main sheep flow and handling practices are summarised below and are very similar to these reported in a previous MLA Victorian Saleyard Study.

- Most sheep arrive by truck or utility, and are unloaded via a series of unloading ramps.
- Most sheep are then drafted into sale lots by running them single file through a drafting race.
- Sale lots of sheep are counted into sale pens after drafting.
- After sale, sheep are counted onto trucks, mostly using the same ramps from where they were unloaded. Some saleyards have a flow through system with unloading and loading at opposite ends. This provides opportunity for a simpler setup for reading in and reading out.
- Some sale lots are split and sold to more than one buyer necessitating post-sale tag reading to record destination.
- Other lots are split after sale, coordinated by commission buyer's to "top-up" truck loads

2 Consider the system requirements to read RFID tags at commercial speeds and the availability or need for development of equipment to accomplish this.

Assuming the need to read RFID tags into and out of saleyards the requirements of a saleyard RFID system. based on individual animal identification, rather than a mob based system, would include:

a) Ability to read animals both into the yards (to ascertain property of despatch) and out of yards (to ascertain destination)
b) Achieve satisfactory accuracy of tag reads - ie ≥ 99% reads of functioning tags)
c) Fast throughput of animals (at least the same pace as manual drafting)
d) At time of tag reading, the ability to separate animals with missing or non-functioning tags to allow replacement
e) Ease of installation, operation and maintenance
f) Availability of equipment to achieve a) to f) above.

To examine the needs for a saleyard RFID system it is useful to look at the likely system needs of the other industry sectors to see if there are common components, duplications or antagonisms.

Possible Methods of RFID Tracking within sheep industry sectors

Property to Property

- **a. small mobs could be scanned with a handheld or stick RFID reader**
- **b. larger mobs with portal or race-side RFID reader, possibly in conjunction with a weigh scale or drafter**

Property to Abattoir

- **c. abattoir to read at slaughter**
- d. property to read at despatch as above in a)
- e. both ?

Property to Saleyards

- f. vendor to read RFID tags before leaving property (hand held or race reader) as in a) above
- g. **saleyard operator/agents to read on arrival at yards** (manually or through a system similar to that described below)

Saleyards to Abattoir

- **h. Saleyard operator/agents to read on departure from yards (manually or through a system similar to that below)**
- i. abattoir to read at slaughter

Saleyards to property

- j. **Saleyard operator/agents to read on departure from yards (manually or through a system similar to that below**

It is likely that the system components would be those highlighted by bold text. There is some duplication in the need to read RFID tags out of saleyards to abattoirs and then for them to be read again at slaughter. However as many mobs are drafted into a number of sale lots and/or aggregated with other mobs post-sale, this would allow more complete tracing . As there are a significant proportion of mobs sold through saleyards to re-stockers these would need reading out of the yards anyway.

a) Because of the impracticality of using stick readers with large numbers of sheep in pens, systems are required that can read large numbers of sheep quickly and can also draft off non-reading tags or untagged animals.

Because there are no commercial systems to achieve this currently the project has included the development of a an RFID reader / drafter that can effectively separate animals with functioning RFID devices from those with missing or non-functioning devices (described later in this report).

Potential siting of RFID tag reading equipment in saleyards.

From the saleyards surveyed, and also from a previously published DNRE report, it should be possible to read RFID tags as animals enter the saleyards from transports.

Pre-sale reading.

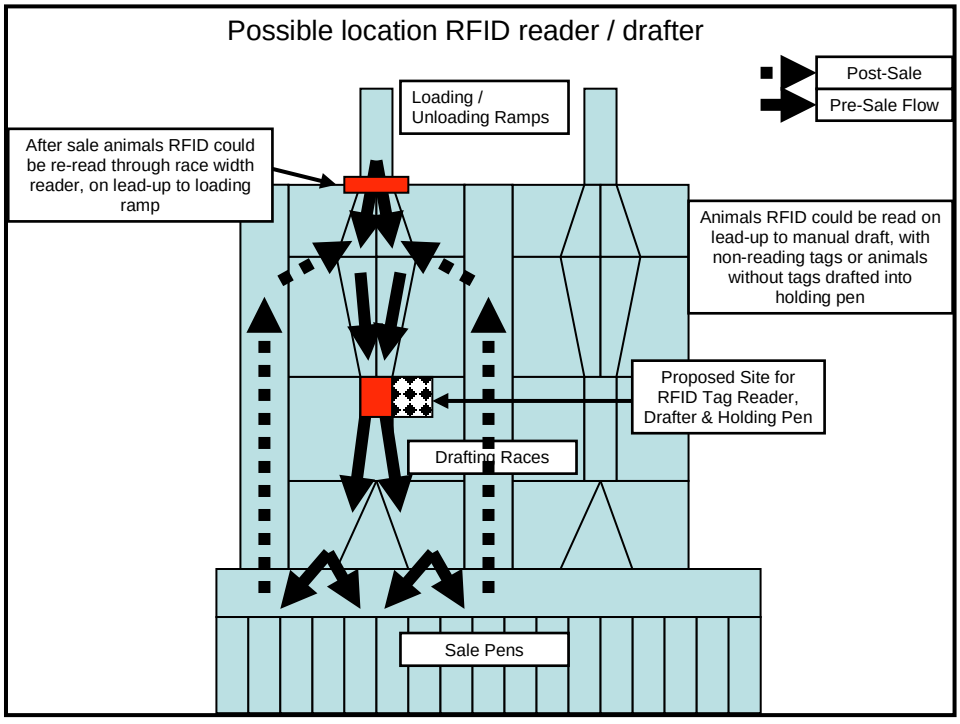
Most saleyards have animals unloading at centralised ramps, from where they are run along laneways to be drafted into sale lots (70% to 100% of animals drafted before sale depending on saleyard) and then are moved into pens for sale. After sale they are moved to loading ramps for trucking to various destinations. In some yards this process entails different sale lots being combined into groups to reach optimum truck carrying capacity.

Our recommendation is to read the RFID tags as the animals enter the manual drafting race, where they are split into sale lots. If an animal goes through the reader without a tag (or a non-functioning tag) it would be drafted into a holding pen for immediate tag replacement. The manual sale drafting operation could continue for the group of animals, and at its completion the small group could be re-tagged and rejoin their contemporaries. A prototype RFID reader / drafter is currently under construction that can test the feasibility of this Tag / No Tag draft operation.

This replacement option is critical to the successful operation of the system, as it is not very useful to know that ***most*** of the animals within a group have functioning tags. For traceability purposes in an individually numbered RFID system we would need to know that ***all*** animals have functioning tags. Once animals have been through the reader, if animals with lost/non-functioning tags have their tags replaced, we can confidently re-read the animals onto the destination trucks knowing that all devices are functioning.

Post-sale reading.

Following sale, the animals could be re-loaded onto transport for delivery while passing through a separate wide race reader (now that all animals have a valid RFID tag).



The diagram details an outline of sheep flow that happens in most yards- ie where the sheep are unloaded and loaded through the same ramps. This sheep flow may alter slightly depending on the specifics of any particular yard design, but the overall sheep flow system is fairly similar.

3) Development /Testing of equipment.

Testing has been carried out on a number of promising equipment prototypes, including portal readers for use in a race or for combination as multi-race readers.

As detailed in Milestone 3, the options that we considered possible for a saleyard reading system included

Option 1 .A wide race RFID reader, capable of reading animals back onto transports.
Option 2 Single lane or multi-lane portal readers capable of reading RFID tags in sheep at commercial speeds but without drafting capability.
Option 3 An RFID reader / drafter that can effectively separate animals with functioning RFID devices from those with missing or non-functioning devices.

Option 1 Wide Race Reader

Aleis / Allflex Wide Race Reader

A 1200 mm wide race reader has been developed with collaboration between Aleis and Allflex. This reader is designed to allow high flow rates of animals through a race / laneway with tags read into a reading module. The picture below shows the reader with a group of animals going through 3 – 4 animals wide. From testing done by Aleis (and observed 21st February 2008) the reader is capable of 100% accuracy of reading (with HDX tags) at a throughput at approximately 12,000 head per hour. While this is a very effective method of capturing the numbers of the working tags it does not allow capture / treatment of the non-reading or missing tag.

Option 2

Single Lane Allflex Portal Reader Test Results

Description:
An RFID reading test was undertaken at Orange Agricultural Institute with the objective of obtaining readability rates for Allflex HDX LW and FDX-B LW RFID tags.

A flock of 271 sheep were yarded and run 4 times in single file through an Allflex portal reader system.
The system comprised 2 x Allflex portal readers feeding data into individual Allflex Data Logger devices. Data from the first reader was shared with the second data collector.

The sheep had the FDX-B tags removed after 4 runs and were replaced with HDX tags. The portals were separated to effectively imitate 2 separate readers and the sheep were re-run through the same portal reader system a further 15 times.

Results:
1. The read rate of FDX-B LW tags achieved was 99.35%
    - There were 1075 successful reads out of a possible total of 1082, therefore the read rate was - (1075)/1082 *100 = 99.35%
2. The read rate of HDX LW tags achieved was 99.95%
    - There were 8126 successful reads out of a possible total of 8130, therefore the read rate was - (8126)/8130 * 100 = 99.95%
3. Average read time using a flock of 271 sheep was around 4 minutes and 30 seconds.
4. The average throughput was approximately 3364 per hour (single lane)

Multi Lane Allflex Portal Reader Test Results
This system was tested as a possible load-out system for saleyards where large numbers of sheep would need to be read in a short time – possibly 2 to 3 hours.

Description:
274 sheep were tagged with Allflex HDX lightweight sheep RFID tags and read through a series of portal readers, 4 separate times.
Three readers were set up in a staggered formation as per the photo, with animals allowed to move “en mass” through the portal laneway of their own choosing. The width of the 3 portal laneways was approximately 1500 mm’s, with sheep entering from a yard approximately 3500 mm’s wide.

Results:

1. The read rate achieved was 99.9%
    - There were 1095 successful reads out of a possible total of 1096, therefore the read rate was - (1095)/(1096) * 100 = 99.9%
2. Average read time using a flock of 274 sheep was around 2 minutes and 30 seconds.
3. The average throughput was approximately 7105 per hour (3 lanes)

I am unsure whether this time is realistic given the amount of time required to actually move 7000 individual sheep through this type of reader. It would largely depend on the setup of the yards and the logistical capacity of being able to move this number of sheep in a large mob through the ingoing and outgoing yards.

This testing was made possible with the assistance of Mr Pat Gunston from Allflex Australia.

Option 3 Reader/ Drafter

No commercial reader /drafter exists so a prototype unit was developed to test the technical requirements that would need to be met to allow high speed tag reading and drafting ina saleyard scenario.

The reader / drafter tested was designed and constructed by CAWD Engineering, Dubbo and consisted of

- a short lead-up race that contained an Allflex portal reader
- a series of sensors to monitor animal flow
- a pneumatically operated baulk gate to regulate animal flow
- a 2 way draft system to separate non-operational RFID tagged sheep from those that had correctly operating RFID tags.

Picture shows the prototype drafter set up in a sheep race where some of the testing was done. The leading animal has entered the RFID portal reader. In front of the portal is a motion sensor which indicates an animal is present.

If the controller receives a tag read and the sensor is triggered, the animal has a working tag and the sheep goes straight ahead.

If the sensor is triggered without a valid tag read, the animal has a non-functioning (or missing) RFID tag and is drafted to the left.

Reader/Drafter Reading Rates

The drafter was tested numerous times through the developmental stage on smaller groups of animals to try and get the correct positioning of readers, sensors and draft gates. After these positioning problems were controlled, 2 separate testing sessions were completed to get the read rates and times. The drafter was set up with an in-built bias to draft any animals of which the processor was unsure of (either from slow tag reading or increased animal speed) into the non tagged group. This should always be the smallest group and therefore easier to check.

The first test session was undertaken at Orange Agricultural Institute, Orange and consisted of 6 tests using 3 year old merino wethers mostly tagged with Allflex HDX lightweight sheep tags (some not RFID tagged) and some merino weaners that had no RFID tags.

The testing procedure involved counting a number of tagged animals into a yard, then adding some non-tagged animals to this group. The whole group was then run through the drafter, with a number of pieces of information recorded including

- number of correct RFID reads
- the number of tagged animals going the correct direction (and incorrect direction)
- the number of non tagged animals going the correct direction (and incorrect direction)
- the time taken to draft the group

The table below shows the results from the first testing run. It shows the number of animals present in each run and the number of animals that were drafted into non tagged group for that run. For the wethers, note that some of the wethers that were missed had no RFID tags and so were actually correctly drafted. The percentage of tagged animals that were incorrectly drafted was 5%. For weaners, the percentage missed (i.e. those animals that had no RFID but were put into the tagged group) was 4%. This appeared to be a function of the mix in animal size in the group and the temperament of these smaller animals.

Overall the correct read/draft rate was 95%.

Reader/Drafter Test 1- with HDX tags only

	Wethers		Number with RFID in non tagged group	Weaners			
	Total	Total Number drafted into non tagged group		Total	Total Number drafted into tagged group)	Time Taken (seconds)	Number per hour
Run 1	29	2	0	8	0	1.37	1620
Run 2	57	5	3	14	0	4.16	1024
Run 3	109	19	8	25	2	6.18	1301
Run 4	117	16	6	25	1	5.40	1578
Total	312	42		72	3	Average	1381
Percentage Missed			5%		4%		

The second testing session was undertaken at the Australian National Field Days site at Borenore and consisted of 498 3 year old wethers that are part of a mixed bloodline wether trial comparison. The animals were tagged with a mixture of both FDX-B and HDX tags from 7 different manufacturers.

The test procedure for this operation was a 3 step process involving

- the whole group was run through the drafter, with the drafter on the first read splitting the mob on correct reads or incorrect/missing
- the second read entailed reading the non tag read group back through the drafter to see if any more tags could be picked up
- the third read entailed using a stick reader in the race to confirm any readable tags within the non-read group to identify the tag types of these twice mis-drafted animals

A number of pieces of information were recorded including

- number of correct RFID reads
- the number of tagged animals going the correct direction (and incorrect direction)
- the number of non tagged animals going the correct direction (and incorrect direction)
- the time taken to draft the group

Reader/Drafter Test 2- with a mix of HDX and FDX-B tags

	FDX-B	HDX	TIRIS (HDX)	Total	FDX-B	HDX	TIRIS
	Counts				Percentage of reads		
First Read	200	127	76	403	50%	32%	19%
2nd Read	44	7	0	51	86%	14%	0%
Stick Read	33	5	3	41	80%	12%	7%
Lost tagged animals				3			
	277	139	79	498			

The table above details the number of tag reads and correct drafts for the operation, in this case the drafting accuracy (81%) based on the first draft is 403 of 495 (3 lost tags out of the

498). This low figure is compounded by the mixture of FDX-B and HDX tags. The shorter read range of the FDX-B tags quite often allowed the animals to trigger the sensor before their tag was read, forcing them to be drafted out to the non tagged group.

Of the 92 animals drafted into the non tagged group, 51 were able to be drafted the second time around (of these 44 were FDX-B tags).

The remaining 44 animals were put up a race and read with a stick reader, 33 of these were FDX-B, 3 had actually lost their tags and the remainder were HDX tags.

While drafting the whole group the read rate equated to 928 animals per hour. Compared to the read rate of over 3,300 per hour for the single lane portal reader this is slow and would need to be slowed even further to allow reading of individual sheep without error , even if sheep were tagged only with HDX RFID tags.

Discussion on reader/drafter

Overall the drafter worked reasonably well, in that it correctly put the 3 non tagged animals into the correct place. However, because of the read range problems with the mixture of tags far too many animals went into this group. We believe the only way to overcome this problem is to either

- Have a further attempt at singulating the animals with a baulk gate front and rear to ensure every tag is read before any drafting is attempted (this would cause a further loss in read rate because of the time taken to open and close both gates)
- Ensuring that all animals are tagged with HDX tags. The capacity of FDX-B tags is more than sufficient to carry out most on-farm tag reading situations where an animal is constrained within a crate or race, and the movement of the animal is restricted, but FDX does not appear to be appropriate technology to use in NLIS sheep roll-call events which require high accuracy at high speed. In a high flow sheep movement situation the extra read range of the HDX tags allows for better tag reading and therefore drafting result.

Conclusion

High rates of RFID tag reading are possible with single lane, multi-lane or wide-lane systems allowing high rates of animal throughput. Correct read rates were achieved for single lane, multi lane and wide race readers of ≥ 99% for both HDX and FDX –B tags at high flow rates.

More challenging is to identify and separate animals with missing or non-functioning RFID tags, at commercially required speeds. Flow rates were reduced to 900- 1,000 sheep /hour at read/draft rates of only 81-95% accuracy. The 95% rate was achieved when only HDX tags were used.

Further work would be required to achieve ≥ 99% read/draft rate with the reader/drafter tested. To achieve this the sheep flow would need to be significantly slower- perhaps down to 750 sheep/hour .This would need to be compared to the rate actually required per download unit in a saleyard when some sheep would need re-tagging and re-cycling for a re-read to allow association with the mob in which it was delivered.

4. Estimated Costing for saleyard RFID capture in an RFID system.

The costs below are based on a single unit (reading/drafting-in module & reading -out module) in a single yard, .With more units constructed the price should decrease due to economies of scale in manufacture.

Obviously, in larger yards, with numerous loading ramps, multiple units would be needed to get the required throughput of stock.

System	Cost /unit
Reading In module • This includes the portal reader and drafter, and all the associated electronic components required for the single unit to operate. It should be noted again that the system discussed is a prototype version of the reader / drafter and once a system was fully commercialised all the associated production costs should reduce from economies of scale. It would also be hoped that the maintenance costs would be minimised with a more rugged, fully commercially available unit.	$ 10,500
Reading Out module • This includes the reader and data logger, and all the associated electronic components required for the single unit.	This price is unknown at this time, but the device could eventually come from Allflex / Aleis

5) Impediments to practical implementation of an RFID system in saleyards .

While systems have been identified or developed to provide roll-call and drafting facilities for saleyards, impediments to the future implementation of an individual RFID based NLIS Sheep and Goats include:

- The ability to operate at commercial speeds in large saleyards with throughputs over 30,000- where unloading RFID reads/drafts/re-tags would need to be completed in 3 or 4 hours is questionable. Early estimates of roll-call speeds where drafting is also involved, because of the need to re- tag some sheep and allow for the reading of the re-tags , show that the read /draft speed achievable (less than 900 per hour and possibly 750 per hour to achieve ≥99%) is marginal for commercial speeds.
- Extra labour input that might be required to service tag reading and re-tagging in saleyards.
- Extra labour input that might be required to service the reader/drafter and load-out readers.

B. On-farm roll-call of lots for dispatch (as an option to roll-call into the saleyard) and for property to property sales.

1. System requirements to read RFID tags on-farm prior to transport and the availability of equipment to accomplish this.
2. Estimate the cost of equipment required to achieve on-farm tracking and traceability.
3. Impediments to practical implementation of NLIS roll-call of individually identified RFID sheep and goats on-farm.

1. System requirements for on-farm roll-call of lots for despatch as an option to roll-call into the saleyard and for property to property sales.

Two options exist for conducting NLIS roll-call events of sheep or goats on–farm, the use of a stick reader or a panel / portal reader. This assumes that all animals would be read and any replacements made before leaving the property to allow for property to property transfers and delivery to saleyards, where no roll-call would be required at unloading into the saleyard.

Stick reader
This would require producers (or their agents or perhaps a contractor) to read RFID tags a race at a time and to replace non-reading or missing tags. Sufficient time would need to be allowed before transport for this operation to be completed.
Records would then be down loaded to a computer and transferred to a central database. As estimates of the proportion of properties that have a computer varies from 55 to 75 % this would not be a universal possibility.
This option would not allow for tag loss within the truck or during unloading.

Portal or panel reader installed at raceside.
This system may not be appropriate as non-read or untagged animals would not be detected in time to draft off and re-tag prior to loading onto trucks, unless animals could be manually drafted based on the reader emitting a “beep” to indicate tag read. This is possible but logistically quite difficult given the noise level generated from sheep passing up a race.

2. Estimate of the cost of equipment required to achieve on-farm tracking and traceability.

System	**Cost /unit**
Stick reader,	$2,000
Computer	$2,000
Portal / panel reader	$2-3,000

3. **Impediments to practical implementation of NLIS roll-call of individually identified RFID sheep and goats on-farm**.

i) The major impediment against requiring all animals to be read before leaving the property (as against property to property transfers only) would be the capital expense required by all producers (or their agents or contractors) as against the limited number of saleyards where many consignments could be handled collectively.

ii) As suggested above the proportion of properties that have computers is limited (estimates vary between 55% and 75% of properties having a computer- the proportion actually used by producers in farm business is less understood) and the proportion of producers who can effectively use them for operations such as data uploads is even more limited.

iii) Inadvertent or deliberate boxing of animals on the truck would not be detected pre-sale in saleyards.

DISCUSSION

Ability for on-farm and sale yard single or multi-lane RFID tracking and traceability to achieve ≥99% accuracy at commercial speeds and volumes for sheep identified with a functioning RFID device

On-farm

Currently on-farm tracking and traceability to achieve ≥99% accuracy at commercial speeds could be achieved using a stick reader to allow non-tagged, non –read animals to be identified, drafted and re-tagged. However there would be major difficulties in achieving accurate and timely implementation.

The capability to achieve reading and drafting of sheep at reasonable speeds on-farm also exists using prototype equipment but the cost would be high (approximately $10,000 per unit)

From a practical point of view it is unlikely that on-farm reading of all animals prior to delivery to saleyards would be a cost efficient alternative to reading on entry to a saleyard.

Property to Property

For property to property transactions, on-farm reading would be required but would involve far less properties. Equipment could be supplied by and agent or contractor. Time commitment could be an issue for agents.

Saleyards

If saleyards were required to read all tags into the yards, separate and tag non-read/lost tags this operation is currently not possible at commercial speeds in large saleyards.
Wide race reading of animals out of a saleyard is currently possible, however only demonstrated by one prototype reader.

CONCLUSION

On–farm tracking and tracing is possible but is not a practical alternative to saleyard tracing of the approximately 50% of sheep and lambs that are sold through saleyards.

On–farm tracking and tracing is possible for property to property transfers if basic equipment such as stick readers were used . Computer access would need to be considered. Experience with cattle NLIS would be an indicator of the likely success of this operation.

More development is required before reading and drafting technology is available for saleyard use to achieve ≥99% accuracy at commercial speeds and volumes for sheep identified with a functioning RFID device.

Property to abattoir transfer (approximately 40% of all sheep and lambs) has not been covered in this project but would rely on tracing within the abattoir.