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A Feed Intake Monitoring System for Cattle

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Summary

A system for individual feed intake measurement was designed using off-the-shelf scales, radio frequency (RF) tags, RF readers, feed bunks and a wireless communications bridge. These items were coordinated using two custom software applications and technical assistance provided by I.D.ology of Eau Claire, WI for the purpose of measuring feed conversion to live weight gain in cattle. This system has been installed for a seedstock producer and at this time there have been three groups of cattle which have passed successfully through the system.

Concept

Individual feed intake measurement in cattle housed in group pens is a challenge. Automation of data collection in this process adds further difficulty in design. Four conceptual obstacles needed to be overcome to achieve this task: first to identify the animal, second to weigh the feed consumed from a typical ration for the class of cattle being fed, third to tie this feed weight with the animal's identification tag, and, fourth to easily summarize the logged data into a usable report.

An electronic ear tag was used to identify the animal and when the electronic tag passed into the field of the feed bunk, a RF reader captured the tag's unique number. The feed bunk itself was placed on an electronic floor scale that would be controlled by a central processor communicating with both the scale and the RF reader. The presence of an electronic ID in the reader's read field would initiate an intake event record. This record would close when the electronic tag left the RF field. Another bunk weight would be recorded then with the difference being the feed consumed by the animal bearing the electronic tag. These data are then stored in the central processor until downloaded for further processing to formulate a summary report which provides the feed dry matter consumed per animal per day.

Equipment

Refer to the items, labeled as A, B, C, etc. regarding the physical components of the feed intake system in Figures 1, 2 and 3.

The feed bunk (1-A) is a stock item made of polyethylene manufactured by Miraco Livestock Water Systems of Grinnell, Iowa. These bunks are used because of their durability, availability and their construction which does not interfere with the RF signal from the antenna. The bunk itself comes in eight foot sections. For our purpose, the bunk was sawed in half to provide a 4 foot bunk that would sit squarely on the scale base giving one animal at a time access to eat.

The bunk was placed on a Rice Lake Weighing Systems BenchMark™ series single point bench scale (1-B) and calibrated for 500 pound capacity. The scale was then wired to a Rice Lake 920i programmable scale indicator (1-C). The indicator was expanded to operate eight scales and communicate with the eight associated RF readers via the RS232 serial communication protocol. Additional memory was added to this indicator as well to allow for storage of the logged data.

I.D.ology of Eau Claire, Wisconsin coordinated the communication network as well as assembling the RF antenna / reader system. The antenna (1-D) was embedded into the upper ridge of the feed bunk. This antenna was then sealed into place with a bead formed by a plastic welder to achieve a water tight barrier. The antenna formed a 2 x 4 foot loop and was connected via a shielded cable (1-E) to the RF reader (1-F). The read range of this antenna system under the environment it was placed into was approximately 18 inches above the feed bunk. A half duplex livestock ear tag was used to identify the animal and trigger the system to generate a data record.

Downloading data from the indicator was facilitated by utilizing the Lantronix WiBox™, a wireless TCP/IP bridging device (2,3-A). This device was connected to the scale head through a communication port and then housed in a water tight plastic box with line-of-sight proximity to all probable download locations.

Software was then required to associate the weights from the scales with IDs from the reader. The software, *S108363.cod - version 1.11*, was a custom application put together under a joint effort among the programming staff at Rice Lake Weighing Systems, I.D.ology and the Iowa Beef Center.

A Rice Lake Weighing Systems software tool, *Interchange*, was acquired to simplify data download from the scale indicator to a PC. This program placed the logged data into spreadsheet form. The data was parsed into a record giving the animal's electronic tag identification number, the bunk number, the weight of the feed when entering the bunk, the weight of the feed when exiting the bunk and the date and time the record was generated.

The data itself was then compiled using another custom application, *Feed Intake Interface*, developed at the Iowa Beef Center to summarize the individual feed records generated from the logged data. This piece of software was necessary to tally intake and convert the value to a dry matter basis since each animal using the system generated over 100 records per day per animal. This software

application also evaluated each record by comparing the initial bunk weight to the ending bunk weight at each feeding event. If the situation existed where the ending weight was higher than the initial weight, which can occur for a number of reasons, the application would compare initial intakes of subsequent records to arrive at the feed consumed.

Special Design Considerations

Set up of the initial system is somewhat demanding in terms of skill, but once in place works well and is fairly simple to operate on a daily basis. Daily operation entails stopping the reader system which can also be done remotely with the *Interchange* software, accessing the WiBox with a PC running the *Interchange* software, and initiating the download from the scale indicator. This data can then be stored in its raw form in a spreadsheet as well as processed with the *Feed Intake Interface* software.

A number of additional points deserve mentioning in terms of equipment design and software setup. This system requires limited animal access to a given feed bunk to prevent two RF tags from being simultaneously read by a given reader. Because of this fact, an adjustable feeding opening was required. It can be widened for larger animals or narrowed for smaller animals to limit entry of one tag into the reader's field at any given time.

Electromagnetic interference (EMI), often referred to a "RF noise" is always a concern when implementing any device that uses RF receivers. EMI is stray RF that can be caused by poorly grounded or shielded transformers, fluorescent lights, variable speed motors, etc. RFID readers are typically designed to eliminate any unwanted "noise" received through the antenna. However, a source of EMI that has a frequency on or very near 134.2 KHz will adversely affect all ISO11784/ISO11785 RFID compliant systems to some degree. The effect on the RFID reader is increased as strength of the EMI is increased, the proximity between the RF reader and EMI source is decreased, or if the size (square area) of the receiving antenna is increased. Due to the nature of their operation, half-duplex RFID readers are much more sensitive to the affects of EMI than are full-duplex readers. Proper cable shielding and equipment grounding of existing electrical farm equipment and their power cables can reduce or eliminate the sources of EMI. The presence and "strength" of EMI at a given installation will vary with each location.

Another necessary consideration regarding the feed bunk RFID antennas is the physical proximity of steel to the antennas. Steel (such as pen rails/posts, head locks, etc.) that is physically too close to the read field of the antenna will "ground out" the power of the electromagnetic field of the antenna. This will reduce the power of the antenna and thereby reduce the distance at which the reader will detect a transponder.

Tests can be performed that can assess the amount and strength of potential EMI sources before system installation. However, the actual performance of a stationary RFID system with large antennas cannot be fully gauged until the system is placed into the environment in which it will operate.

The RS232 "point-to-point" serial communications somewhat restricts the current system. RS232 is limited to less than 75 feet lengths for communications cable to the central processor. Also, due to the "point-to-point" communication of RS232, a communications port (PC card) had to be installed in the central processor for each RFID reader (for a total of 8). The use of a RS485 "multi-drop" serial communications between the central processor and the RFID readers would result in lower PC card cost and lower communications cabling costs. It would also extend the communication cable lengths to 300 feet.

Feed spillage from an animal throwing feed out of the sides of the bunk is a problem that required a taller sidewall to correct. The removal of feed by throwing it out of the bunk generated a less desired feed conversion. Feed which ended up under the scale also presented a problem and requires some management to maintain unrestricted scale movement and eliminate nesting places for rodents.

The opening through which the animal enters the bunk also requires special consideration since it is necessary to limit one animal access to the bunk at a given time. The designed opening has adjustable widths regulated with iron bars. Once cattle were accustomed to using the bunk, a process that took about one day, the bars were set in place. The smallest opening width used was nine inches. This occurred at the start of the trials feeding using 600 pound cattle. This opening needed to be increased to eleven inches by the end of the trials. This was done by removing one bar.

Water tight connections are necessary to maintain component integrity and ensure accurate data collection. This system was set inside a naturally ventilated steel building. This protected the system from direct contact with outside weather, but did not guarantee a moisture free, warm environment. Moisture did get into the scale platform connections and caused scales to not record weights properly. These connections were replaced with more environmentally protected connectors and the system returned to operation. Extreme cold weather (below 0 deg. F) could be a problem as could extremely warm weather (above 140 deg. F), but in this system where a power feed was maintained throughout the time of winter operation, an operating temperature was maintained within the enclosures during winter months that prevented system failure. If the system must be operated in extreme cold or heat, heating or cooling devices can be added to the electronics enclosures (at extra cost) to compensate for extreme weather environments and guarantee proper system operation regardless of atmospheric temperature.

All items are sealed in water-tight enclosures and are not opened unless absolutely necessary to prevent unwanted

dust or moisture from accumulating within the electronic enclosures.

The wireless bridge has been a very good addition to the system since it is no longer necessary to physically open the indicator and connect a communication cable to download data. This feature facilitates remote downloading which in turn allows the PC to be kept in a dust free area up to 300 feet away from the scale indicator-bridge assembly. This wireless bridge distance can be increased to 1000 feet or more for additional costs.

Data records can quickly become unmanageable if not considered in software design. This system logs records in a way that greatly reduces memory requirements of the database by utilizing either duration of presentation or the presence of a different ear tag in logging a record. One potential problem this system can have is removing remaining feed in the bunk after an animal has eaten since this untagged subtraction of feed would be attributed to the last animal/tag presented to the feeding system in the event that the scale did not stabilize thus logging an end bunk weight greater than the starting weight which then references the next record's starting weight.

Table 1 shows an example of how the raw data appears when down loaded from the 920i indicator to an Excel spreadsheet. Each row shown indicates one record. The first column displays the animal's electronic ear tag number. The second column gives the date and time that the animal left the bunk. The third column gives the bunk number that the animal visited. The forth column gives the weight of the feed in the bunk prior to eating and the fifth column gives the weight of the feed after the animal left the bunk's RF field.

The number of records generated by a given animal in a pen of 8 to 10 head generally totals over 100 for a single day with this system. Since this system generally monitored 64 to 80 head, about 7,000 records would be collected each day. A one megabyte memory card added to the indicator's existing ½ megabyte of memory allowed for three days of storage in the scale indicator memory bank. This raw data was then compiled into a single consumption record per animal to ease management of data. This compiled data record tallies as-fed and dry matter consumption for each animal along with recording the time interval of the day the animal consumed the feed. The intervals were broken down as 6:00 to 9:00 AM, 9:00 to Noon, Noon to 3:00 PM, 3:00 to 6:00 PM, 6:00 to 9:00 PM, 9:00 to Midnight, Midnight to 6:00 AM.

Table 2 shows an example of reported, compiled data. The animal's electronic ID tag appears in the first column. The pounds of dry matter consumed each day of the test appear in the columns that follow.

Acknowledgements

The Iowa Beef Center would like to formally acknowledge Warden Farms, Perry "Bud" Beedle, I.D.ology Inc., Rice Lake Weighing Systems, Miraco Livestock Water Systems (Ahren Agricultural Industries Inc.), Darrell Busby, Shawn Shouse, and Dallas Maxwell for their assistance in aiding in the completion of this project.

Figure 1. System Components.

Key to labels: A=stock Miraco feed bunk, B=Rice Lake bench scale, C=Rice Lake scale indicator, D=embedded RF antenna, E=shielded cable runs, F=RF reader

Figure 2. Latronix Wi-box.

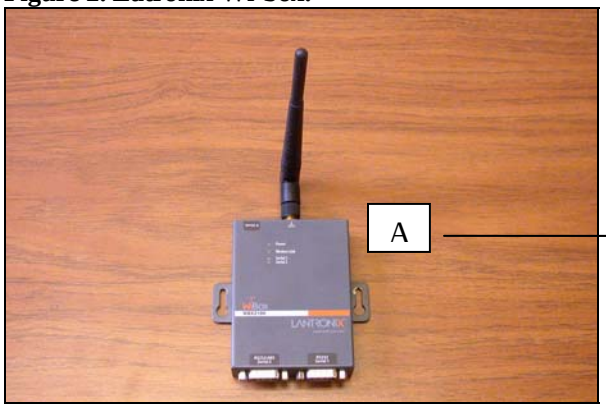


Figure 3. Wi-box Enclosure.

Key to labels: A=enclosure and location of wireless data transmitter (Wi-box)

Figure 4. Indicator Face – Refers to item C from Figure 1.

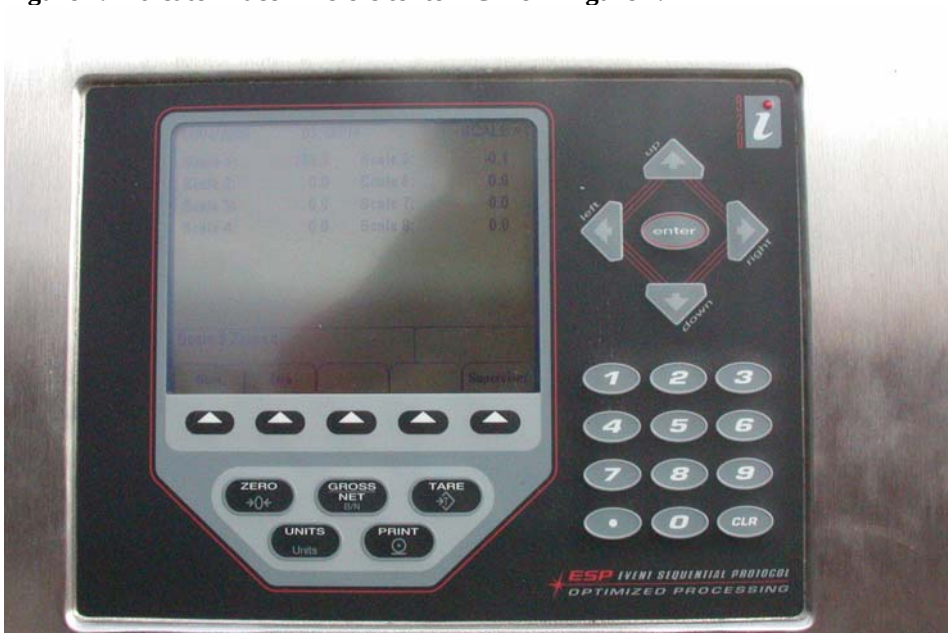
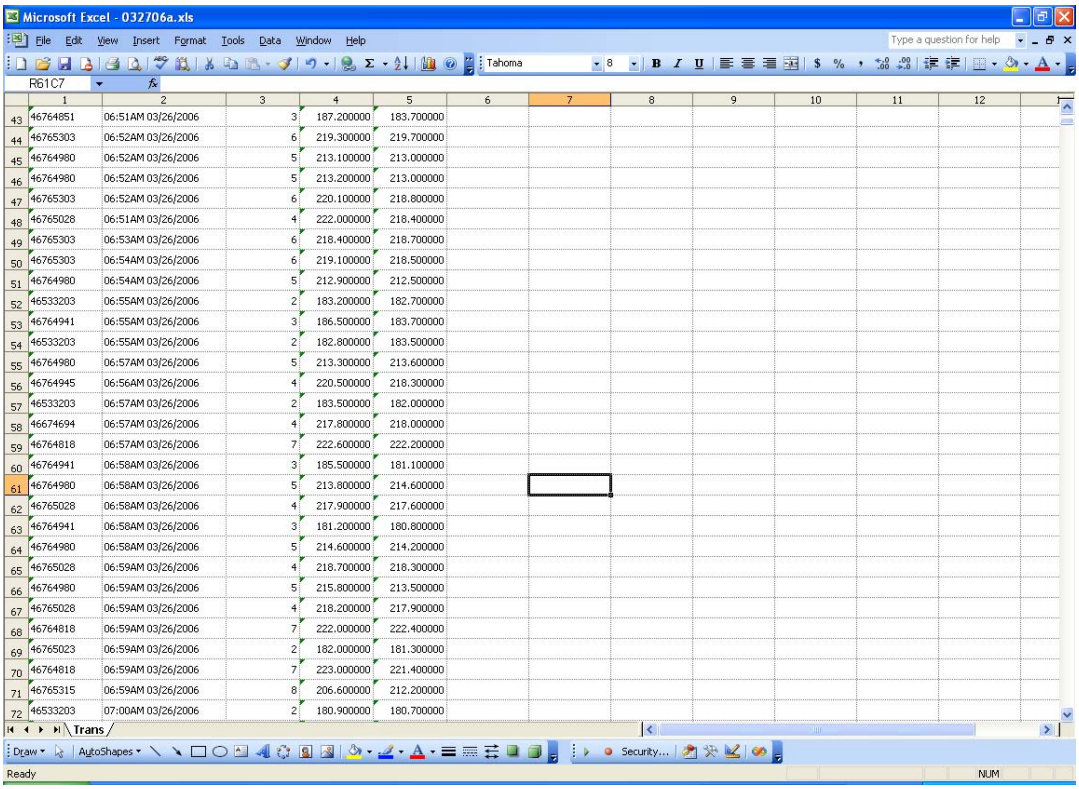


Figure 5. System Operation.

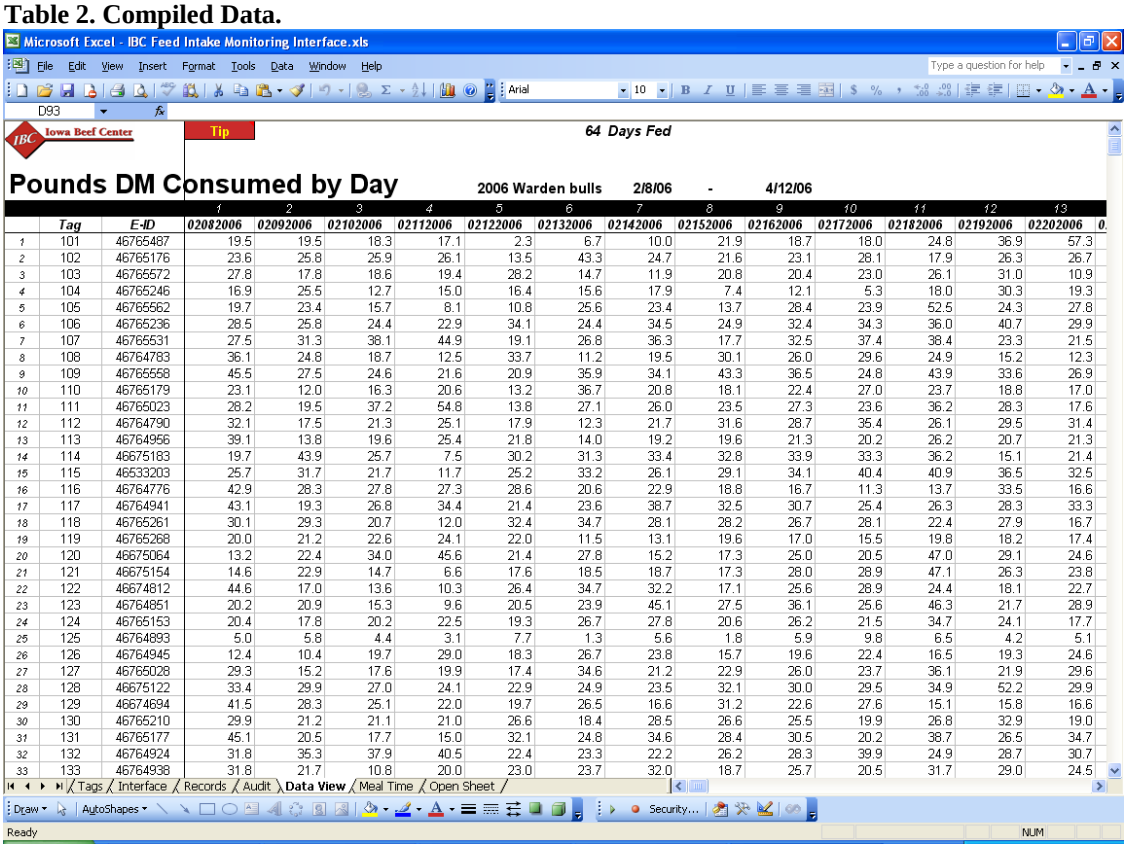
Table1. Raw Data.



Microsoft Excel - 032706a.xls

	1	2	3	4	5
43	46764851	06:51AM 03/26/2006	3	187.200000	183.700000
44	46765303	06:52AM 03/26/2006	6	219.300000	219.700000
45	46764980	06:52AM 03/26/2006	5	213.100000	213.000000
46	46764980	06:52AM 03/26/2006	5	213.200000	213.000000
47	46765303	06:52AM 03/26/2006	6	220.100000	218.800000
48	46765028	06:51AM 03/26/2006	4	222.000000	218.400000
49	46765303	06:53AM 03/26/2006	6	218.400000	218.700000
50	46765303	06:54AM 03/26/2006	6	219.100000	218.500000
51	46764980	06:54AM 03/26/2006	5	212.900000	212.500000
52	46533203	06:55AM 03/26/2006	2	183.200000	182.700000
53	46764941	06:55AM 03/26/2006	3	186.500000	183.700000
54	46533203	06:55AM 03/26/2006	2	182.800000	183.500000
55	46764980	06:57AM 03/26/2006	5	213.300000	213.600000
56	46764945	06:56AM 03/26/2006	4	220.500000	218.300000
57	46533203	06:57AM 03/26/2006	2	183.500000	182.000000
58	46674694	06:57AM 03/26/2006	4	217.800000	218.000000
59	46764818	06:57AM 03/26/2006	7	222.600000	222.200000
60	46764941	06:58AM 03/26/2006	3	185.500000	181.100000
61	46764980	06:58AM 03/26/2006	5	213.800000	214.600000
62	46765028	06:58AM 03/26/2006	4	217.900000	217.600000
63	46764941	06:58AM 03/26/2006	3	181.200000	180.800000
64	46764980	06:58AM 03/26/2006	5	214.600000	214.200000
65	46765028	06:59AM 03/26/2006	4	218.700000	218.300000
66	46764980	06:59AM 03/26/2006	5	215.800000	213.500000
67	46765028	06:59AM 03/26/2006	4	218.200000	217.900000
68	46764818	06:59AM 03/26/2006	7	222.000000	222.400000
69	46765023	06:59AM 03/26/2006	2	182.000000	181.300000
70	46764818	06:59AM 03/26/2006	7	223.000000	221.400000
71	46765315	06:59AM 03/26/2006	8	206.600000	212.200000
72	46533203	07:00AM 03/26/2006	2	180.900000	180.700000

Table 2. Compiled Data.



Microsoft Excel - IBC Feed Intake Monitoring Interface.xls

Iowa Beef Center — Tip — *64 Days Fed*

Pounds DM Consumed by Day — 2006 Warden bulls — 2/8/06 - 4/12/06

	Tag	E-ID	1 02082006	2 02092006	3 02102006	4 02112006	5 02122006	6 02132006	7 02142006	8 02152006	9 02162006	10 02172006	11 02182006	12 02192006	13 02202006	0
1	101	46765487	19.5	19.5	18.3	17.1	2.3	6.7	10.0	21.9	18.7	18.0	24.8	36.9	57.3	
2	102	46765176	23.6	25.8	25.9	26.1	13.5	43.3	24.7	21.6	23.1	28.1	17.9	26.3	26.7	
3	103	46765572	27.8	17.8	18.6	19.4	28.2	14.7	11.9	20.8	20.4	23.0	26.1	31.0	10.9	
4	104	46765246	16.9	25.5	12.7	15.0	16.4	15.6	17.9	7.4	12.1	5.3	18.0	30.3	19.3	
5	105	46765562	19.7	23.4	15.7	8.1	10.8	25.6	23.4	13.7	28.4	23.9	52.5	24.3	27.8	
6	106	46765236	28.5	25.8	24.4	22.9	34.1	24.4	34.5	24.9	32.4	34.3	36.0	40.7	29.9	
7	107	46765531	27.5	31.3	38.1	44.9	19.1	26.8	36.3	17.7	32.5	37.4	38.4	23.3	21.5	
8	108	46764783	36.1	24.8	18.7	12.5	33.7	11.2	19.5	30.1	26.0	29.6	24.9	15.2	12.3	
9	109	46765558	45.5	27.5	24.6	21.6	20.9	35.9	34.1	43.3	36.5	24.8	43.9	33.6	26.9	
10	110	46765179	23.1	12.0	16.3	20.6	13.2	36.7	20.8	18.1	22.4	27.0	23.7	18.8	17.0	
11	111	46765023	28.2	19.5	37.2	54.8	13.8	27.1	26.0	23.5	27.3	23.6	36.2	28.3	17.6	
12	112	46764790	32.1	17.5	21.3	25.1	17.9	12.3	21.7	31.6	28.7	35.4	26.1	29.5	31.4	
13	113	46764956	39.1	13.8	19.6	25.4	21.8	14.0	19.2	19.6	21.3	20.2	26.2	20.7	21.3	
14	114	46675183	19.7	43.9	25.7	7.5	30.2	31.3	33.4	32.8	33.9	33.3	36.2	15.1	21.4	
15	115	46533203	25.7	31.7	21.7	11.7	25.2	33.2	26.1	29.1	34.1	40.4	40.9	36.5	32.5	
16	116	46764776	42.9	28.3	27.8	27.3	28.6	20.6	22.9	18.8	16.7	11.3	13.7	33.5	16.6	
17	117	46764941	43.1	19.3	26.8	34.4	21.4	23.6	38.7	32.5	30.7	25.4	26.3	28.3	33.3	
18	118	46765261	30.1	29.3	20.7	12.0	32.4	34.7	28.1	28.2	26.7	28.1	22.4	27.9	16.7	
19	119	46765268	20.0	21.2	22.6	24.1	22.0	11.5	13.1	19.6	17.0	15.5	19.8	18.2	17.4	
20	120	46675064	13.2	22.4	34.0	45.6	21.4	27.8	15.2	17.3	25.0	20.5	47.0	29.1	24.6	
21	121	46675154	14.6	22.9	14.7	6.6	17.6	18.5	18.7	17.3	28.0	28.9	47.1	26.3	23.8	
22	122	46674812	44.6	17.0	13.6	10.3	26.4	34.7	32.2	17.1	25.6	28.9	24.4	18.1	22.7	
23	123	46764851	20.2	20.9	15.3	9.6	20.5	23.9	45.1	27.5	36.1	25.6	46.3	21.7	28.9	
24	124	46765153	20.4	17.8	20.2	22.5	19.3	26.7	27.8	20.6	26.2	21.5	34.7	24.1	17.7	
25	125	46764893	5.0	5.8	4.4	3.1	7.7	1.3	5.6	1.8	5.9	9.8	6.5	4.2	5.1	
26	126	46764945	12.4	10.4	19.7	29.0	18.3	26.7	23.8	15.7	19.6	22.4	16.5	19.3	24.6	
27	127	46765028	29.3	15.2	17.6	19.9	17.4	34.6	21.2	22.9	26.0	23.7	36.1	21.9	29.6	
28	128	46675122	33.4	29.9	27.0	24.1	22.9	24.9	23.5	32.1	30.0	29.5	34.9	52.2	29.9	
29	129	46674694	41.5	28.3	25.1	22.0	19.7	26.5	16.6	31.2	22.6	27.6	15.1	15.8	16.6	
30	130	46765210	29.9	21.2	21.1	21.0	26.6	18.4	28.5	26.6	25.5	19.9	26.8	32.9	19.0	
31	131	46765177	45.1	20.5	17.7	15.0	32.1	24.8	34.6	28.4	30.5	20.2	38.7	26.5	34.7	
32	132	46764924	31.8	35.3	37.9	40.5	22.4	23.3	22.2	26.2	28.3	39.9	24.9	28.7	30.7	
33	133	46764938	31.8	21.7	10.8	20.0	23.0	23.7	32.0	18.7	25.7	20.5	31.7	29.0	24.5	

Table 3. A Summary of Components for an 8 Station Feed intake Monitoring System.

Item	Count	Notes
Adjustable Width Feeding Panels	8	Home-made
Floor Scales	8	500 pound capacity
Polyurethane Feed Bunks	4 (8 foot)	Each bunk cut to make 8, 4 foot bunks.
RF Readers	8	
RF Antenna	8	
Scale Indicator	1	Expanded to handle 8 scales and 8 communication lines.
Wireless Transmitter	1	
Personal Computer	1	Does not need to be only dedicated for this task.
Conduit, Cable, Fittings	variable	
Power Supply	1 (readers) 1 (scale indicator)	
Battery Backup	1 (readers) 1 (scale indicator)	Prevent system reset during power inconsistencies.
Surge Protector	1 (readers) 1 (scale indicator)	Protect system during power inconsistencies
Software – Data Collection	1	Custom application
Software – Data Download from System	1	Rice Lake – Interchange Program
Software – System Configuration	1	Rice Lake – I Rev Program
Software – Data Compilation	1	Iowa Beef Center - Custom appl.