Appendix 2: Assumptions for Simulations Other than the Base Case

1 Background for Other Scenarios

1.1 Number of Cattle Oral ID_{50}s Imported from the UK Before the Import Ban

Of the 334 head of cattle imported in the United States from the U.K. before such imports were banned in 1989, USDA has determined that 161 did not enter either the cattle feed supply or the human food supply. This appendix describes how we estimated the potential number of ID_{50}s from the 173 cattle that may have been recycled into feed administered to cattle during this period.

For each animal introduced into the feed supply, the number of ID_{50}s to which other cattle are exposed is the product of the number of ID_{50}s in the infected animal and the fraction of ID_{50}s in that animal that end up in feed administered to healthy cattle. We used the simulation software (with parameter values corresponding to the USA scenario) to determine the distribution of values for this fraction. In particular, we repeatedly simulated the slaughter of an animal with a single ID_{50} and recorded the number of ID_{50}s that reached cattle following that event. Table 1.1-1 summarizes the key percentile values for this distribution.

Table 1.1-1
Distribution of Values for the Proportion of ID_{50}s in a Slaughtered Animal Eventually Administered to Other Cattle

Percentile	Value
5th	0
25th	0
50th	1.0%
75th	9.8%
95th	10.0%
Average	**5.0%**

The number of ID_{50}s in the animal depends on whether the animal is infected, when (if ever) it was infected, and when (if it was infected) the animal would have developed clinical signs. We assume that if the animal became infected, it became infected some time between birth and the age at which it was exported to the United States (E). We assume further that even if the animal had become infected before export to the United States, it had not developed clinical signs by the time it was last seen (age L). That is, the age at which clinical signs would have become manifest (C) exceeds L.

We first present an expression quantifying the probability that the age at which the animal became infected (I) is equal to i, where i ranges from 1 to E. The probability that the animal became infected at age i is proportional to the product of three probabilities. In particular, $p(I = i) \propto p(AI)\, p(I = i \mid AI)\, p(C > L \mid I = i)$, where "*AI*" represents the event that the animal becomes infected.

We assume that *p(AI)* equals the lifetime cumulative incidence of becoming infected. Schreuder et al.(1997) (Schreuder et al., 1997) reported the lifetime cumulative incidence of developing clinical signs by birth year for animals born in the UK between the years 1975/76 and 1993/94. Donnelly and Ferguson (2000) estimated that for each animal in the UK that developed clinical signs, another four animals went undetected. We therefore assume that the cumulative lifetime incidence of infection is five times the values reported by Schreuder et al.

Next, we refined these probabilities to reflect differences in the age-adjusted disease prevalence between all male and all female cattle. Because males represented 5% of animals over the age of two years in the U.K. during the BSE epidemic (based on beef herd management (Radostits et al., 1994)) but accounted for only 510 (MAFF BSE Statistics, Confirmation in Bulls) of the 178,164 (MAFF BSE Statistics, General Statistics) diagnosed BSE cases (*i.e.*, 0.28%), we assume that the cumulative lifetime incidence of clinical disease for males is only 6% as great as the cumulative lifetime incidence of infection for females (0.28% ÷ 5%). Because females represent 99.7% of animals that developed clinical signs, we treat the values reported by Schreuder et al. (1997) (Schreuder et al., 1997) as representative of the female cattle population.

Finally, the incidence of clinical BSE differs between dairy females and beef females. These differences may reflect differences in feeding practices, especially early in life. For example, female beef calves consume less bypass protein in feed than do female dairy calves because the beef calves have access to their mother's milk. In order to quantify the lifetime cumulative incidence rates of clinical disease for dairy (I_D) and beef (I_B) animals, we first develop a relationship between I_D and other parameters whose values are known. In particular, we note that fraction of BSE cases in dairy animals (BSE_D) can be computed as

$$BSE_D = \frac{I_D F_D}{I_D F_D + I_B F_B},$$

where F_D is the proportion of animals in the population that are dairy, and F_B is the corresponding proportion for beef animals. We estimate that F_D is approximately 65% and that F_B is approximately 35%[1]. BSE_D = 89% and BSE_B = 11%[2]. Solving for I_BF_B in the preceding equation yields

$$I_B F_B = \frac{BSE_B}{BSE_D} I_D F_D .$$

Because $I_DF_D + I_BF_B = I$ (the cumulative incidence rate for the entire population), it follows that

$$I_D F_D + \frac{BSE_B}{BSE_D} I_D F_D = I ,$$

and hence that

$$I_D = \frac{I}{F_D\left(1 + \frac{BSE_B}{BSE_D}\right)} .$$

After computing ID, IB can be computed from the relationship $I_B = \frac{I - I_D F_D}{F_B}$.

Table 1.1-2 summarizes the estimated probability of infection estimated here for male, dairy female, and beef female cattle by year of birth. Note that we assume the cumulative lifetime incidence rate for infection exceeds the cumulative lifetime incidence of clinical disease by a factor of 5.36. This factor is the ratio of the number of infected animals in the UK estimated by Donnelly and Ferguson (2000, Table 5.3, best fit susceptibility function (7) and incubation distribution (C) to the number of confirmed clinical cases (MAFF BSE Statistics, General Statistics)).

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[1] MAFF (Table 5.13) reported that for 1989, there were 2,866,000 dairy cows in the UK and 1,525,000 beef cows.

Table 1.1-2
Cumulative Lifetime Incidence of Infection by Year of Birth and Gender

Year of Birth	Schreuder et al. Reported Cumulative Lifetime Incidence of Developing Clinical Signs[a]	Female: Estimated Cumulative Lifetime Incidence of Developing Clinical Signs	Female: Estimated Cumulative Lifetime Incidence of Infection — Dairy	Female: Estimated Cumulative Lifetime Incidence of Infection — Beef	Male: Estimated Cumulative Lifetime Incidence of Developing Clinical Signs	Male: Estimated Cumulative Lifetime Incidence of Infection
1975	0	0	0	0	0	0
1976	3.3×10^{-5}	3.3×10^{-5}	2.4×10^{-4}	5.6×10^{-5}	1.9×10^{-6}	1.0×10^{-5}
1977	1.2×10^{-4}	1.2×10^{-4}	8.4×10^{-4}	2.0×10^{-4}	6.6×10^{-6}	3.5×10^{-5}
1978	2.0×10^{-4}	2.0×10^{-4}	1.5×10^{-3}	3.4×10^{-4}	1.2×10^{-5}	6.2×10^{-5}
1979	4.7×10^{-4}	4.7×10^{-4}	3.4×10^{-3}	7.9×10^{-4}	2.7×10^{-5}	1.4×10^{-4}
1980	8.1×10^{-4}	8.1×10^{-4}	5.9×10^{-3}	1.4×10^{-3}	4.7×10^{-5}	2.5×10^{-4}
1981	1.7×10^{-3}	1.7×10^{-3}	1.2×10^{-2}	2.9×10^{-3}	9.8×10^{-5}	5.2×10^{-4}
1982	5.0×10^{-3}	5.0×10^{-3}	3.7×10^{-2}	8.5×10^{-3}	2.9×10^{-4}	1.5×10^{-3}
1983	1.1×10^{-2}	1.1×10^{-2}	7.9×10^{-2}	1.8×10^{-2}	6.2×10^{-4}	3.3×10^{-3}
1984	1.6×10^{-2}	1.6×10^{-2}	1.2×10^{-1}	2.8×10^{-2}	9.4×10^{-4}	5.0×10^{-3}
1985	2.3×10^{-2}	2.3×10^{-2}	1.7×10^{-1}	3.9×10^{-2}	1.3×10^{-3}	7.1×10^{-3}
1986	3.8×10^{-2}	3.8×10^{-2}	2.7×10^{-1}	6.4×10^{-2}	2.2×10^{-3}	1.2×10^{-2}
1987	5.1×10^{-2}	5.1×10^{-2}	3.7×10^{-1}	8.6×10^{-2}	2.9×10^{-3}	1.6×10^{-2}
1988	3.9×10^{-2}	3.9×10^{-2}	2.8×10^{-1}	6.6×10^{-2}	2.2×10^{-3}	1.2×10^{-2}
1989	1.8×10^{-2}	1.8×10^{-2}	1.3×10^{-1}	3.0×10^{-2}	1.0×10^{-3}	5.4×10^{-3}

Notes:

a. *Schreuder* et al. *(Table 2) reported values for years running from summer to summer (*e.g.*, year 1974-75, 1975-76,* etc.*). We have computed calendar year cumulative incidence rates by taking the average of the two contributing summer-to-summer years reported by Schreuder* et al. *For example, the 1980 cumulative incidence is estimated as the average of the 1979-80 and 1980-81 years.*

We assume that $p(I=i \mid AI)$ is proportional to the product of the animal's susceptibility at age i and the animal's exposure to the transmissible agent. Exposure to the transmissible agent is assumed to be proportional to consumption of animal bypass protein. We have used the consumption rates for the U.S. herd for the purpose of this calculation (see Section 3.1.3.4). Although animal bypass protein consumption rates in U.K. differed from rates in the U.S., the U.S. rates are likely to provide a reasonable characterization of the relative pattern of animal bypass protein consumption as a function of age.

[2] The total number of clinical BSE cases in beef amounted to 20,997 (Personal Communication, Danny Matthews), while the total number of clinical BSE cases in all animals was 178,164 (MAFF, General Statistics).

Finally, the value of *p(C>L | I=i)* equals the probability that the time between infection and the development of clinical signs exceeds *L-i*. This distribution is detailed in Section 3.1.1.5.

Although the product of the quantities described thus far (*i.e.*, $p(AI)\,p(I=i \mid AI)\,p(C>L \mid I=i)$) yields an expression that is proportional to the probability that the animal becomes infected at age i, it must be divided by a normalizing factor in order to quantify that actual probability. The normalizing constant is the sum of the probabilities for events consistent with the assumption that animal did not display signs when last seen at age L. Events consistent with this observation include the possibility that the animal is not infected at all, and the possibility that the animal was infected at any time (ages 0 to *E* months) and *C > E*. The sum of the probabilities for these events is

$$K = p(not\ AI) + \sum_{j=0}^{E} p(AI)\,p(I=j \mid AI)\,p(C>L \mid I=j),$$

where *p(not AI) = 1 – p(AI).* Note that because we have assumed that infection must occur prior to age E, $\sum_{j=0}^{E} p(I=j \mid AI) = 1$. In summary,

$$p(I=i) = \frac{p(AI)\,p(I=i \mid AI)\,p(C>L \mid I=i)}{p(not\ AI) + \sum_{j=0}^{E} p(AI)\,p(I=j \mid AI)\,p(C>L \mid I=j)}).$$

Next we characterize the distribution for the number of ID_{50}s in the animal given that it was infected at age *I = i*, and that it had not yet developed signs when last seen at age *L*. The probability that the animal would have developed signs at age *C = c* can be calculated directly from the distribution of incubation period durations (see Section 3.1.1.5), conditioning on c exceeding L. Assuming that the animal would have developed signs at age *c*, at age L it has completed a portion of the incubation period equal to $\frac{L-i}{c-i}$. The distribution described in Section 3.1.2.1 quantifies the number of ID_{50}s in an animal by months since infection for an incubation period that lasts 36 months. Normalizing this function so that the end of the incubation period occurs at unity yields the relationship that can be used to quantify ID_{50}s in an animal that has completed any specified fraction of the BSE incubation period.

To characterize the distribution of ID_{50}s in all animals imported, we randomly selected 1,000 values from the ID_{50} distribution for each animal. Table 1.1-3 reports key fractile values from this distribution. As these statistics indicate, the distribution is highly skewed to the right.

Table 1.1-3
Distribution of Values for the Number of ID in Animals Imported from the UK During the 1980s

Percentile	Value
5^{th}	0
25^{th}	0
50^{th}	0
75^{th}	0
80^{th}	0
85^{th}	0.19
90^{th}	2.6
95^{th}	26
99^{th}	250
Average	**10.0**
Probability ≥ 0	**18.4%**

2 Parameter Values

2.1 Base Case

Parameter values for the base case appear in Section 3 of Appendix 1.

2.2 Alternative Assumptions

2.2.1 Maternal Transmission Probability

- Best case: birthVisitor <probTrans> = 0.
- Worst case: birthVisitor <probTrans> = 0.13.

2.2.2 Slaughter Process

2.2.2.1 Cattle Oral ID_{50}s Per Animal

- Best case: materializer <totalInfectivity> cattle oral ID_{50} values are halved relative to their base case values.

- Worst case: materializer <totalInfectivity> cattle oral ID_{50} values are doubled relative to their base case values.

2.2.2.2 *Ante Mortem* Inspection Detection Probability

Animal's Clinical Status	Age in Months	Probability of Passing AM Inspection	
		Best Case	**Worst Case**
Animal does have clinical BSE signs	All ages	0.01	0.50

2.2.2.3 Spinal Cord Removal Probabilities

- Best Case

Mis-split/AMR/Spinal Cord Removal Outcome[a]	Probability for Age:		
	0-12 Months	**13-23 Months**	**≥ 24 Months**
No-No-No	0.0095	0.003325	0.00368
No-No-Yes	0.9405	0.329175	0.36432
No-Yes-No	0	0.000618	0.000552
No-Yes-Yes	0	0.616883	0.551448
Yes-No-No	0.0005	0.000175	0.00032
Yes-No-Yes	0.0495	0.017325	0.03168
Yes-Yes-No	0	3.25×10^{-5}	0.000048
Yes-Yes-Yes	0	0.032468	0.047952

- Worst Case

Mis-split/AMR/Spinal Cord Removal Outcome[a]	Probability for Age:		
	0-12 Months	**13-23 Months**	**≥ 24 Months**
No-No-No	0.855	0.29925	0.3312
No-No-Yes	0.095	0.03325	0.0368
No-Yes-No	0	0.1235	0.1104
No-Yes-Yes	0	0.494	0.4416
Yes-No-No	0.045	0.01575	0.0288
Yes-No-Yes	0.005	0.00175	0.0032
Yes-Yes-No	0	0.0065	0.0096
Yes-Yes-Yes	0	0.026	0.0384

2.2.2.4 Proportion of Cattle Stunned Using Air-Injected Pneumatic Stunners

- Best Case – Proportion of cattle stunned using air-injected pneumatic stunning = 0% (same as Base Case).

- Worst Case – Proportion of cattle stunned using air-injected pneumatic stunning = 15%.

2.2.3 Rendering, Feed Production, and Feeding

2.2.3.1 Render Reduction Factors

Technology	Infectivity Inactivation Achieved (log base 10)	Proportion of cattle rendered	
		Best Case	Worst Case
Batch	3.1 logs	5%	5%
Continuous/fat added	2 logs	85%	20%
Continuous/ no fat added	1 log	5%	70%
Vacuum	0 logs	5%	5%

2.2.3.2 Rendering Contamination: Probability and Magnitude

	Best Case	Worst Case
Probability of contamination at mixed rendering facilities	0.05	0.25
Proportion of prohibited material involved	0.0001	0.01

2.2.3.3 Rendering: Mislabeling Probability

- Best Case – Probability of mislabeling for prohibited and mixed producers: 2%.
- Worst Case – Probability of mislabeling for prohibited and mixed producers: 10%.

2.2.3.4 Feed Production Contamination: Probability and Magnitude

	Best Case	Worst Case
Probability of contamination at mixed rendering facilities	0.05	0.25
Proportion of prohibited material involved	0.0001	0.01

2.2.3.5 Feed Production: Mislabeling Probability

- Best Case – Probability of mislabeling for prohibited and mixed producers: 2%.
- Worst Case – Probability of mislabeling for prohibited and mixed producers: 33%.

2.2.3.6 Misfeeding Probability

- Best Case – Probability that correctly labeled prohibited feed will be fed to cattle: 0.1%
- Worst Case -- Probability that correctly labeled prohibited feed will be fed to cattle: 15%

2.2.4 Human Food – Proportion of Each Tissue Available for Human Consumption

	Proportion of Tissues Recovered from Cattle for Human Consumption	
Tissue	**Best Case**	**Worst Case**
AMR Meat	0.98	0.98
Blood	0.025	0.3
Bone (in-bone cuts of meat)	0.98	0.98
Brain	0.001	0.02
Dorsal root ganglia	0	0
Eyes	0	0.002
Ileum	0.001	0.02
Heart	0.3	0.6
Kidney	0.15	0.35
Liver	0.4	0.7
Lung	0	0
Muscle	0.98	0.98
Spinal Cord	0.001	0.02
Trigeminal ganglia	0	0

2.2.5 Fraction of Animals That Die on the Farm that are Rendered

- Best Case: 60%
- Worst Case: 99%

2.2.6 BSE Infectivity in Blood

	Proportion of Infectivity	
Tissue	**0 to 18 Months**	**≥ 19 Months**
AMR Meat	0	
Blood	0.00016	0.00016
Bone (in-bone cuts of meat)	0	0
Brain	0	0.64444
Dorsal root ganglia	0	0.04
Eyes	0	0.0004
Ileum	0.99984	0.033
Heart	0	0
Kidney	0	0
Liver	0	0
Lung	0	0
Muscle	0	0
Spinal Cord	0	0.256
Trigeminal ganglia	0	0.026

2.2.7 BSE Infectivity in Trigeminal Ganglia

	Proportion of Infectivity	
Tissue	**0 to 18 Months**	**≥ 19 Months**
AMR Meat	0	
Blood	0	0
Bone (in-bone cuts of meat)	0	0
Brain	0	0.670574
Dorsal root ganglia	0	0.04
Eyes	0	0.0004
Ileum	1.0	0.033
Heart	0	0
Kidney	0	0
Liver	0	0
Lung	0	0
Muscle	0	0
Spinal Cord	0	0.256
Trigeminal ganglia	0	0.000026

The food inspector is the same as the base case, with the exception of the probability for trigeminal ganglia, which is 0.01.

2.3 Alternative Sources of Infectivity

2.3.1 Spontaneous BSE

The following table details the age-specific monthly spontaneous BSE incidence rates.

Incidence of Spontaneous BSE

Age (Months)	BSE Incidence
0 to 16	0
17 to 32	8.3×10^{-10}
33 to 48	8.3×10^{-10}
49 to 64	3.33×10^{-9}
65 to 80	6.67×10^{-9}
81 to 96	1.33×10^{-8}
97 to 112	3.75×10^{-8}
113 to 128	8.25×10^{-8}
129 to 144	1.78×10^{-7}
145 to 160	2.96×10^{-7}
161 to 176	4.19×10^{-7}
177 to 192	4.79×10^{-7}
193 to 208	4.67×10^{-7}
209 to 224	3.28×10^{-7}
225 to 240	2.02×10^{-7}
241 to 256	2.02×10^{-7}
257 to 272	2.02×10^{-7}
≥ 273	2.02×10^{-7}

2.3.2 Imported Cattle

Assumptions for these simulations were identical to the base case assumptions except for the number of infected cattle introduced. The six simulations introduced 1, 5, 20, 50, 200, and 500 infected female dairy cattle that are 12 months of age. The sick cattle are introduced at the beginning of the simulation, at which time it is assumed that they become infected.

2.3.3 Domestic Scrapie

This simulation assumes that cattle are exposed to 1.0 cattle oral ID_{50} per month in feed. The infectivity is evenly divided among 10 cattle (*i.e.*, parameter numCowsReceiving in parameter group randomInfector is set equal to 10).

2.4 Alternative Scenarios

2.4.1 Switzerland

The Switzerland scenario introduces 30 25 month-old infected female dairy cattle and 37 26 month-old infected dairy cattle at month 0. At month 1, cattle are exposed to 4000 cattle oral ID_{50}s in feed, divided among 133 cattle.

The following table details the number of cattle at the beginning of the simulation.(*i.e.*, parameter <initSize> in parameter group genesisvisitor).

Type	**Gender**	**Age (Months)**	**Initial Number of Animals**
Beef	Male	0	23700
		1	23463
		2	23416
		3	23369
		4	23323
		5	22833
		6	22353
		7	20990
		8	19290
		9	16955
		10	14904
		11	13101
		12	6537
		13	3262
		14	1628
		15	975
		16	779
		17	622
		18	497
		19	397
		20	318
		21	285
		22	257
		23	244
		24	234
		25	224
		26	215
		27	206
		28	198
		29	193
		30	189
		31	185
		32	181
		33	178
		34	174
		35	170
		36	167
		37	163
		38	160
		39	156
		40	153
		41	150

Appendix 2

Type	Gender	Age (Months)	Initial Number of Animals
		42	147
		43	144
		44	141
	Female	0	17775
		1	13313
		2	7975
		3	5574
		4	3896
		5	1944
		6	1554
		7	1241
		8	992
		9	792
		10	633
		11	569
		12	512
		13	486
		14	461
		15	437
		16	415
		17	398
		18	382
		19	366
		20	351
		21	337
		22	326
		23	316
		24	306
		25	260
		26	221
		27	187
		28	159
		29	135
		30	115
		31	97
		32	78
		33	62
		34	50
		35	40
		36	30
		37	22
		38	17
		39	12
		40	9
		41	7
		42	5
		43	4

Appendix 2

Type	Gender	Age (Months)	Initial Number of Animals
		44	3
Beef Reproductive	Male	All ages	0
	Female	All ages	0
Dairy	Male	0	4770
		1	811
		2	641
		3	608
		4	571
		5	542
		6	514
		7	488
		8	463
		9	439
		10	417
		11	396
		12	387
		13	379
		14	371
		15	364
		16	356
		17	348
		18	341
		19	334
		20	327
		21	320
		22	313
		23	307
		24	300
		25	294
		26	287
		27	281
		28	275
		29	269
		30	264
		31	258
		32	253
		33	247
		34	242
		35	236
		36	231
		37	226
		38	221
		39	216
		40	211

Type	Gender	Age (Months)	Initial Number of Animals
		41	206
		42	202
		43	197
		44	193
		45	188
		46	184
		47	180
		48	176
		49	172
		50	168
		51	164
		52	161
		53	157
		54	153
		55	150
		56	147
		57	143
		58	140
		59	137
		60	134
		61	131
		62	128
		63	125
		64	122
		65	119
		66	117
		67	114
		68	112
		69	109
		70	107
		71	104
		72	102
		73	100
		74	97
		75	95
		76	93
		77	91
		78	89
		79	87
		80	85
		81	83
		82	81
		83	79
		84	78
		85	76
		86	74
		87	72
		88	71

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Type	Gender	Age (Months)	Initial Number of Animals
		89	69
		90	68
		91	66
		92	65
		93	63
		94	62
		95	60
		96	59
		97	58
		98	56
		99	55
		100	54
		101	53
		102	51
		103	50
		104	49
		105	48
		106	47
		107	46
		108	45
		109	44
		110	43
		111	42
		112	41
		113	40
		114	39
		115	38
		116	37
		117	37
		118	36
		119	35
		120	34
		121 to 122	33
		123	32
		124	31
		125 to 126	30
		127	29
		128 to 129	28
		130 to 131	27
		132	26
		133 to 134	25
		135 to 136	24
		137 to 138	23
		139 to 140	22
		141 to 142	21
		143	20
		144 to 145	19
		146 to 147	18

Appendix 2

Type	Gender	Age (Months)	Initial Number of Animals
		148 to 149	17
		150 to 151	16
		152 to 154	15
		155 to 156	14
		157 to 159	13
		160 to 162	12
		163 to 165	11
		ge 166	10
	Female	0	25175
		1	23665
		2	22955
		3	22564
		4	22294
		5	22026
		6	21762
		7	21501
		8	21243
		9	20988
		10	20736
		11	20487
		12	20241
		13	19998
		14	19708
		15	19423
		16	19141
		17	18863
		18	18590
		19	18320
		20	18055
		21	17793
		22	17535
		23	17281
		24	17030
		25	16783
		26	16521
		27	16264
		28	16010
		29	15760
		30	15514
		31	15272
		32	15034
		33	14799
		34	14606
		35	14414
		36	14225
		37	14039
		38	13855

Appendix 2

Type	Gender	Age (Months)	Initial Number of Animals
		39	13674
		40	13494
		41	13318
		42	13143
		43	12971
		44	12801
		45	12633
		46	12468
		47	12305
		48	12143
		49	11984
		50	11827
		51	11672
		52	11520
		53	11369
		54	11220
		55	11073
		56	10928
		57	10784
		58	10643
		59	10504
		60	10366
		61	10230
		62	10096
		63	9964
		64	9834
		65	9705
		66	9578
		67	9356
		68	9140
		69	8929
		70	8723
		71	8521
		72	8325
		73	8132
		74	7944
		75	7761
		76	7582
		77	7406
		78	7235
		79	7068
		80	6905
		81	6745
		82	6590
		83	6437
		84	6289
		85	6143
		86	6002

Appendix 2

Type	Gender	Age (Months)	Initial Number of Animals
		87	5863
		88	5727
		89	5595
		90	5466
		91	5340
		92	5216
		93	5096
		94	4978
		95	4863
		96	4751
		97	4641
		98	4473
		99	4312
		100	4156
		101	4006
		102	3862
		103	3722
		104	3588
		105	3433
		106	3285
		107	3144
		108	3008
		109	2879
		110	2775
		111	2674
		112	2578
		113	2485
		114	2353
		115	2228
		116	2110
		117	1998
		118	1892
		119	1791
		120	1696
		121	1606
		122	1521
		123	1440
		124	1363
		125	1291
		126	1223
		127	1158
		128	1096
		129	1038
		130	983
		131	931
		132	881
		133	834
		134	807

Appendix 2

Type	Gender	Age (Months)	Initial Number of Animals
		135	780
		136	754
		137	729
		138	705
		139	682
		140	659
		141	637
		142	616
		143	596
		144	576
		145	557
		146	544
		147	532
		148	519
		149	507
		150	496
		151	484
		152	473
		153	463
		154	453
		155	444
		156	435
		157	421
		158	408
		159	395
		160	383
		161	371
		162	360
		163	349
		164	338
		165	327
		166	317
		167	307
		168	298
		169	274
		170	246
		171	221
		172	188
		173	159
		174	135
		175	108
		176	81
		177	61
		178	45
		179	34
		180	25
		181	19
		182	14

Appendix 2

Type	Gender	Age (Months)	Initial Number of Animals
		183	11
		184	8
		185	6
		186	5
		187 to 188	3
		189	2
		#ge 190	1

The following table details monthly slaughter rates (parameter <rateSlaughter> in parameter group rateSlaughter).

Type	Gender	Age (Months)	Monthly Slaughter Rate
Beef	Male	0	0
		1 to 3	0.001
		4 to 5	0.02
		6	0.06
		7	0.08
		8 to 10	0.12
		11 to 13	0.5
		14	0.4
		15 to 19	0.2
		20 to 21	0.1
		22	0.05
		23 to 27	0.04
		28 to 43	0.02
		44	1
	Female	0	0.25
		1	0.4
		2 to 3	0.3
		4	0.5
		5 to 9	0.2
		10 to 11	0.1
		12 to 15	0.05
		16 to 20	0.04
		21 to 23	0.03
		24 to 30	0.15
		31 to 34	0.2
		35 to 42	0.25
		43	0.3

Type	Gender	Age (Months)	Monthly Slaughter Rate
		44	1
Beef Reproductive	Male	All ages	0
	Female	All ages	0
Dairy	Male	0	0.82
		1	0.2
		2	0.05
		3	0.06
		4 to 10	0.05
		11 to 140	0.02
		141 to 157	0.0258
		158	1
	Female	0 to 1	0.05
		2	0.02
		3	0.015
		4 to 13	0.01
		14 to 33	0.0125
		34 to 66	0.01
		67 to 97	0.02
		98 to 104	0.033
		105 to 109	0.04
		110 to 113	0.033
		114 to 133	0.05
		134 to 143	0.03
		144 to 151	0.02
		152 to 163	0.03
		164	0.08
		165 to 166	0.1
		167 to 169	0.15
		170	0.2
		171 to 190	0.25
		191 to 206	0.3
		207	1

The Switzerland scenario specifies conditions for six time periods beginning in 1986.

Months 0 to 47

- No feed ban was in effect.

- Parameter group rendererer: During this period, all rendering facilities are considered to be non-prohibited and all MBM is labeled non-prohibited (there was no such thing as “prohibited” MBM). Parameter <probType> = 1.0 for non-prohibited producers, and <probMisLabel> = 1.0 for non-prohibited renderers. That is, all MBM is labeled as non-prohibited.

- Parameter group MBMTransporter: 65% of the MBM produced is sent to non-prohibited feed producers. The remaining 35% is diverted to applications that do not pose any risk of exposing cattle. All blood is sent to blood meal producers.

- Parameter group feedProducer: All sent to non-prohibited feed producers is used to produce non-prohibited feed.

- Parameter group feedTransporter: 98% of all non-prohibited feed is sent to farms with cattle. The remaining 2% is diverted to applications that do not pose any risk of exposing cattle. 15% of blood meal is sent to farms with cattle, while the remainder is diverted to applications that do not pose any risk of exposing cattle.

- Parameter group feeder: Any properly labeled prohibited feed that reaches farms has a 15% chance of being administered to cattle. This parameter has no effect at the beginning of the simulation because no prohibited feed is produced. It becomes relevant later in the simulation when the feed ban is introduced.

- Parameter group renderer: The table below details the values assigned to parameter <renderFactor>.

Technology	**Infectivity Inactivation Achieved (log base 10)**	**Proportion of cattle rendered**
Batch	3.1 logs	5%
Continuous/fat added	2 logs	85%
Continuous/ no fat added	1 log	5%
Vacuum	0 logs	5%

Months 48 to 71

- The simulation reflects the introduction of a feed ban.

  - Parameter group rendererer: All animal products not used as human food are sent to prohibited MBM producers. We assume no mislabeling and no contamination.

  - Parameter group MBMTransporter: 68% of the prohibited MBM produced by the prohibited renderers is sent to prohibited feed producers, 30% is sent to mixed feed producers, and 2% is diverted to applications that do not pose any risk of exposing cattle.

- Parameter group feedProducer: 100% of the prohibited MBM received by mixed feed producers is used to manufacture prohibited feed. The mixed feed producers mislabel 10% of the prohibited feed they produce. 20% of the prohibited feed manufactured by mixed feed producers is involved in contamination of non-prohibited feed. When contamination occurs, 0.3% of the affected prohibited feed is deposited in non-prohibited feed.

- Parameter group feedTransporter: 100% of the prohibited feed produced by prohibited feed manufacturers is diverted to applications that do not pose an y risk of exposing cattle. Of the prohibited feed produced by prohibited feed manufacturers, 98% is sent to farms with cattle, while the remaining 2% is diverted to applications that pose no risk of exposing cattle. Finally, of the blood meal produced, 15% is sent to farms with cattle, while the remaining 85% is diverted to applications that do not pose a risk of exposing cattle.

- The post mortem inspection probabilities are changed to the following values:

Age	Detectable Emboli	Organ	Probability of Passing Inspection
All Ages	No	Brain	0
		Spinal cord	0
		Dorsal root ganglia	0.9
		Blood	0.98
		Heart	0.8
		Lung	0
		Liver	0.8
		Kidney	0.8
		Ileum	0
		Eyes	0
		Muscle	0.98
		Bone	0.98
		Trigeminal Ganglia	0
	Yes	Brain	0
		Spinal cord	0
		Dorsal root ganglia	0.9
		Blood	0.98
		Heart	0.8
		Lung	0
		Liver	0.8
		Kidney	0.8

Age	Detectable Emboli	Organ	Probability of Passing Inspection
		Ileum	0.8
		Eyes	0
		Muscle	0.98
		Bone	0.98
		Trigeminal Ganglia	0

Months 72 to 119

The simulation assumes that all rendering facilities use batch processing and hence reduce infectivity by a factor of 1,259.

Months 120 to 143

- A specified risk materials ban is implemented. The ban eliminates brain, spinal cord, dorsal root ganglia, ileum, lung, eyes, AMR meat, and trigeminal ganglia.
- The proportion of correctly labeled prohibited feed sent to farms that is administered to cattle drops to 0.1% (see parameter <probfeedOK> in parameter group feeder.
- Finally, all animals that die on the farm are disposed of in a manner that eliminates possible cattle exposure or contamination of human food.

Months 144 to 155

The probabilities for mis-split, advanced meat recovery, and spinal cord removal appear in the table below: They reflect the assumption that for animals up to 23 months of age, the mis-split probability is 5% and the spinal cord removal probability is 99.9%. For animals 24 months of age and older, the mis-split probability is 8% and the spinal cord removal probability is still 99.9%. AMR is not used at any facilities.

Mis-split/AMR/Spinal Cord Removal Outcome[a]	Probability for Age:		
	0-12 Months	13-23 Months	≥ 24 Months
No-No-No	0.00095	0.00095	0.00092
No-No-Yes	0.94905	0.94905	0.91908
No-Yes-No	0	0	0
No-Yes-Yes	0	0	0
Yes-No-No	0.00005	0.00005	0.00008
Yes-No-Yes	0.04995	0.04995	0.07992
Yes-Yes-No	0	0	0
Yes-Yes-Yes	0	0	0

Notes:

a. *The first No/Yes indicates whether there is a mis-split. The second No/Yes indicates whether the facility uses AMR. The third No/Yes indicates whether the facility removes spinal cords.*

Month 156 through the end of the simulation

- Parameter group MBMTransporter: All MBM is diverted to applications that do not pose any risk to cattle of exposure.

- Parameter group feedProducer: The probabilities for mislabeling or contamination of prohibited feed are set to zero. Note that this change has no impact because of the MBMTransporter changes listed in the preceding bullet.

2.4.2 Spontaneous BSE Prior to the U.S. Feed Ban

The simulation uses the spontaneous disease incidence rates described in Section 2.3.1 of this appendix. The simulation also assumes that there is no feed ban in effect. That is:

- Parameter group rendererer: During this period, all rendering facilities are considered to be non-prohibited and all MBM is labeled non-prohibited (there was no such thing as "prohibited" MBM). Parameter <probType> = 1.0 for non-prohibited producers, and <probMisLabel> = 1.0 for non-prohibited renderers. That is, all MBM is labeled as non-prohibited.

- Parameter group MBMTransporter: 65% of the MBM produced is sent to non-prohibited feed producers. The remaining 35% is diverted to applications that do not pose any risk of exposing cattle. All blood is sent to blood meal producers.

- Parameter group feedProducer: All sent to non-prohibited feed producers is used to produce non-prohibited feed.

- Parameter group feedTransporter: 98% of all non-prohibited feed is sent to farms with cattle. The remaining 2% is diverted to applications that do not pose any risk of exposing cattle. 15% of blood meal is sent to farms with cattle, while the remainder is diverted to applications that do not pose any risk of exposing cattle.

2.4.3 Imported Cattle From the UK During the 1980s

This scenario considers the introduction of 0.1, 1.0, 5.0, 10.0, and 50.0 cattle oral ID_{50}s into cattle feed at the beginning of the simulation. The simulation is divided into four time periods.

1980 through 1992 (Months 0 to 155):

- No feed ban was in effect:
  - Parameter group rendererer: During this period, all rendering facilities are considered to be non-prohibited and all MBM is labeled non-prohibited (there was no such thing as "prohibited" MBM). Parameter <probType> = 1.0 for non-prohibited producers, and <probMisLabel> = 1.0 for non-prohibited renderers. That is, all MBM is labeled as non-prohibited.
  - Parameter group MBMTransporter: 65% of the MBM produced is sent to non-prohibited feed producers. The remaining 35% is diverted to applications that do not pose any risk of exposing cattle. All blood is sent to blood meal producers.
  - Parameter group feedProducer: All sent to non-prohibited feed producers is used to produce non-prohibited feed.
  - Parameter group feedTransporter: 98% of all non-prohibited feed is sent to farms with cattle. The remaining 2% is diverted to applications that do not pose any risk of exposing cattle. 15% of blood meal is sent to farms with cattle, while the remainder is diverted to applications that do not pose any risk of exposing cattle.
- Parameter group stunner: 15% of cattle were stunned using air-injected pneumatic devices.
- Parameter group splitter[3]: The probabilities for mis-split, advanced meat recovery, and spinal cord removal appear in the table below: They reflect the

[3] Probability values were not provided for animals below the age of 12 months. This omission has no impact on the results because the probability of an animal below the age of 12 months advancing to the stage of the disease at which infectivity appears in the spinal cord is on the order of 1 in 1 million (see discussion in Appendix 1 for parameter <clinicalDate> in parameter group sickBovine).

assumption that for animals between 12 and 23 months of age, the mis-split probability is 5%, the probability that AMR will be used is 20%, and the probability that the spinal cord will be removed is 50%, whether or not AMR is used. For animals 24 months of age and older, the mis-split probability is 8%.

	Probability for Age:		
Mis-split/AMR/Spinal Cord Removal Outcome[a]	**0-12 Months**	**13-23 Months**	**≥ 24 Months**
No-No-No	0	0.380	0.368
No-No-Yes	0	0.380	0.368
No-Yes-No	0	0.095	0.092
No-Yes-Yes	0	0.095	0.092
Yes-No-No	0	0.020	0.032
Yes-No-Yes	0	0.020	0.032
Yes-Yes-No	0	0.005	0.008
Yes-Yes-Yes	0	0.005	0.008

Notes:

a. The first No/Yes indicates whether there is a mis-split. The second No/Yes indicates whether the facility uses AMR. The third No/Yes indicates whether the facility removes spinal cords.

1993 through 1996 (Months 156 to 203)

- Parameter group splitter: The probabilities for mis-split, advanced meat recovery, and spinal cord removal appear in the table below: They reflect an increase to 40% in the probability that AMR will be used for all age groups.

	Probability for Age:		
Mis-split/AMR/Spinal Cord Removal Outcome[a]	**0-12 Months**	**13-23 Months**	**≥ 24 Months**
No-No-No	0	0.285	0.276
No-No-Yes	0	0.285	0.276
No-Yes-No	0	0.19	0.184
No-Yes-Yes	0	0.19	0.184
Yes-No-No	0	0.015	0.024
Yes-No-Yes	0	0.015	0.024
Yes-Yes-No	0	0.01	0.016
Yes-Yes-Yes	0	0.01	0.016

1997 through 1999 (Months 204 to 227)

The feed ban is introduced. Base case assumptions are adopted for parameter groups renderer, MBMTransporter, feedProducer, and feedTransporter, with the following exceptions:

- Parameter group renderer: The contamination probability for mixed producers is 28%. The mislabel probability for prohibited and mixed renderers is 10%.
- Parameter group feedProducer: The contamination probability for mixed producers is 32%. The mislabel probability for prohibited and mixed producers is 10%.

1999 through the end of the simulation (Months 228 and following)

All assumptions are set to the base case scenario.

2.4.4 SRM Ban

The specified risk materials ban eliminates the rendering of animals that die on the farm. These animals are disposed of in a manner that eliminates the possibility that cattle will be exposed to any infective agents they may carry.

The SRM eliminates the following tissues from all slaughtered cattle, ensuring their disposal in a manner that eliminates the possibility that infective agents in these tissues will contaminate human food or cattle feed: brain, spinal cord, ileum, eyes, AMR meat (for modeling purposes this is equivalent to prohibiting the vertebral column from AMR), trigeminal ganglia.

The food inspector allows tissues not eliminated by the SRM ban to be used for human food consumption with the following probabilities: dorsal root ganglia (0%), blood (5%), heart (50%), lung (0%), liver (0%), kidney (25%), muscle meat (98%), and in-bone cuts of meat (98%).

2.4.5 No Rendering of Animals that Die on the Farm

This scenario eliminates the rendering of animals that die on the farm. These animals are disposed of in a manner that eliminates the possibility that cattle will be exposed to any infective agents they may carry.