May 2015

Costs of Food Safety Investments
Contract No. AG-3A94-B-13-0003
Order No. AG-3A94-K-14-0056

Final Report

Prepared for

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1 Introduction

As a regulatory agency, the Food Safety and Inspection Service (FSIS) must assess all costs and benefits of available regulatory alternatives, as required by Executive Orders 12866 and 13563, and, if regulation is necessary, select regulatory approaches that maximize net benefits. The costs associated with regulations enacted by FSIS are often a product of food safety investments made by the meat, poultry, and egg products industries.

On September 15, 2014, FSIS initiated a task order with RTI International to collect data on the costs of food safety investments[1] for the production of meat and poultry products at the pre-harvest and slaughter and processing stages.

1.1 BACKGROUND AND OBJECTIVE

FSIS is faced with the task of estimating the cost of food safety investments, which routinely changes because of technological advancements, is often highly variable because of differences in firm size and process requirements, and is rarely publicized by suppliers. Because of these challenges, FSIS needs the assistance of industry experts to acquire better estimates of the costs of food safety investments. These estimates will allow FSIS to better assess the effects of current regulations on the industries it regulates and provide more cost-effective alternatives in future rulemaking.

The overall objective of this task order was to estimate costs of food safety investments in the production of meat and poultry products using an expert panel and other sources.

The overall objective of this task order was to estimate costs of food safety investments in the production of meat and poultry products using an expert panel and other sources. The areas of

[1] In this report, investments and interventions are used interchangeably.

food safety investment costs include pre-harvest interventions, product sampling and testing, slaughter and processing interventions, employee training, and other expenses.

1.2 ORGANIZATION OF REPORT

The remainder of this report is organized as follows:

- Section 2: Methods
- Section 3: Costs of Interventions at Pre-harvest
- Section 4: Costs of Interventions at Slaughter and Processing
- Section 5: Costs of Microbiological Tests

In Appendix A, we provide the following:

- Project description and interest form
- Agenda for expert panel on pre-harvest costs
- PowerPoint for expert panel on pre-harvest costs
- Definitions and background information for pre-harvest
- Agenda for expert panel on slaughter and processing costs
- PowerPoint for expert panel on slaughter and processing costs
- Definitions and background information for slaughter and processing

2 Methods

To collect the data requested by FSIS, RTI used a combination of primary and secondary sources. Primary data were collected from experts during two in-person meetings. We also collected secondary data through various Web searches. This section describes these methods in greater detail.

2.1 DATA NEEDS

RTI and FSIS held a series of workgroup meetings on October 30, 2014, to identify the specific interventions for which FSIS needs cost data. The data needs are grouped by the stage in which an investment would be made (i.e., investments made pre-harvest, investments made during slaughter and processing, and costs of microbiological testing). These are shown in Tables 2-1 through 2-3.

To better understand the investments in which FSIS needed data, we conducted a search for published literature in scientific journals, trade publications, and extension publications to identify background information describing each intervention. To ensure consistency and understanding between the experts, we fully defined each intervention and developed appropriate assumptions, as needed.

Table 2-1. Food Safety Costs Data Needs for Pre-harvest

Pre-harvest Investment	Species	
	Beef and Pork	Chickens and Turkeys
Animal washing, before or after shipping to slaughter	X	
Water only	X	
Water and soap (i.e., detergents)	X	
Bacteriophages	X	
Bacteriocins	X	
Antimicrobials (chemicals)	X	
Feed additives		
Antibiotics	X	X
Probiotics	X	X
Seaweed extract	X	X
Growth hormones	X	
Colicin-producing *E. coli* strains	X	X
Poultry vaccinations		X
Salmonella spp.		X
Campylobacter		X
Cattle vaccinations	X	
STEC biotypes	X	
Salmonella spp.	X	
Biosecurity on the farm		
Vermin control and eradication—plan development and implementation		X
Litter/bedding changes		X
Third-party certification		
Pork Quality Assurance (PQA) Plus	X	
Transport Quality Assurance (TQA)	X	
Beef Quality Assurance (BQA)	X	
Humane raising and handling	X	X
Restaurants, Food services, and Institutions (RFI) certifications	X	X
Farmers Assuring Responsible Management (FARM)	X	X
Roughage at end of finishing phase	X	
Feed withdrawal before shipping	X	X
Pre-conditioned animals purchased	X	

[a] Results for in-house laboratories are presented in Section 5, Costs of Microbiological Tests.

Table 2-2. Food Safety Costs Data Needs for Slaughter and Processing

Slaughter and Processing Investment	Species	
	Beef and Pork	Chickens and Turkeys
HACCP plans	X	X
Development and validation	X	X
Reassessment	X	X
SSOP plans	X	X
Development and validation	X	X
Reassessment	X	X
Training of management and production employees	X	X
HACCP	X	X
SSOPs	X	X
Humane handling	X	X
Recordkeeping	X	X
Food defense	X	X
Sampling	X	X
Sanitary dressing	X	X
Recall procedures	X	X
Biosecurity	X	X
Antimicrobial equipment	X	X
Antimicrobial solutions	X	X
Acidified sodium chlorite	X	X
Bromine	X	X
Chlorine dioxide	X	X
Cetylpyridium chloride	X	X
Organic acids	X	X
Peracetic acid	X	X
Trisodium phosphate	X	X
Monochloramine	X	X
Electrolyzed water	X	X
Hypochlorous acid	X	X
In-house laboratories[a]	X	X
Sampling plan development and verification costs	X	X
Sanitization equipment	X	X
Knife and other equipment sanitizers	X	X
Boot washing systems	X	X
Hand washing stations	X	X

(continued)

Table 2-2. Food Safety Costs Data Needs for Slaughter and Processing (continued)

Slaughter and Processing Investment	Species	
	Beef and Pork	Chickens and Turkeys
Cold storage	X	X
Records storage	X	X
Waste removal and processing	X	X
Downed animal removal	X	
Third-party auditing	X	X
Global Food Safety Initiative (GFSI)	X	X
International Organization for Standardization (ISO)	X	X
Safe Quality Food (SQF)	X	X
Water additives and treatment		
Chlorination		
Electrolyzed water		
Ozonation		
Ultraviolet		
Acidification		
RTE processing equipment	X	X
High pressure processors (HPP)	X	X
Irradiation systems	X	X
Ultrasonic	X	X
Infrared	X	X
Ultraviolet	X	X
Radiant heating	X	X
Smokers	X	X
Drying	X	X
Freezing	X	X
Removal of large lymph nodes	X	
Liability and recall insurance	X	X
Cost of a recall	X	X
Government facilities[b]	X	X
Offices	X	X
Lockers	X	X
Showers	X	X
Parking spaces	X	X
Clothing (purchasing and laundering)	X	X
Utilities (electricity, telephone, water, heating)	X	X

[a] Results for in-house laboratories are presented in Section 5, Costs of Microbiological Tests.

[b] The experts were not familiar with the costs of government facilities; thus, these costs are not included in this report.

Table 2-3. Food Safety Costs Data Needs for Microbiological Testing

Microbiological Test	Type of Test	
	Screen	Confirmation
Pathogen testing costs		
Salmonella	X	X
Campylobacter	X	X
STEC O157:H7	X	X
Non-O157 STEC	X	X
Listeria monocytogenes	X	X
Indicator testing costs		
APC	X	
Enterobacteriaceae	X	
Generic *E. coli*	X	
Coliforms	X	
TPC	X	
Additional pathogens		
Staphylococcus aureus	X	X
Clostridium perfringens	X	X
Toxoplasma gondii	X	X
Trichinae	X	X
Species determination		
Residue testing		
Antibiotics		
Pesticides		
Staphylococcal enterotoxin		

2.2 EXPERT PANELS

To conduct the expert elicitations, we identified and recruited experts, developed the meeting materials based on the data needs, and planned the logistics of the in-person meetings. To recruit the experts, we prepared a project background/ description sheet to provide potential experts with more information about the requirements of the expert panels. We also prepared a form for each expert to rank their expertise levels on various aspects of the meat and poultry industries and list any potential conflicts of interest. This document can be found in Appendix A.

We selected experts from among our network of academic and independent researchers with whom we regularly collaborate and recommendations provided by key experts. We invited a total of 19 potentially qualified experts, of which 10 expressed interest in participating and were available at the time of the meeting. Based on their self-ratings and areas of expertise, we determined if each expert should serve on the pre-harvest panel or the slaughter and processing panel, or both. Each panel contained a mix of expertise in beef, pork, and poultry. The selected experts are listed in Sections 2.2.1 and 2.2.2.

We prepared the following materials for the panel meetings in a binder for each participant:

- meeting agenda
- PowerPoint presentation to guide the discussion (e.g., purpose of the project, assumptions, definitions of interventions, and types and ranges of costs)
- worksheets for recording the experts' estimates and rationale for the estimates for each of the cost categories
- background materials, including the literature and publications identified above

We sent the binders of materials to the experts in advance of the meetings for their preparation. The agendas, PowerPoint presentations, and background materials are provided in Appendix A.

To collect the appropriate data, we focused one expert panel on pre-harvest interventions and one expert panel on slaughter and processing interventions with representation across meat and poultry for both panels. Both of the panel meetings were held at RTI's headquarters in Research Triangle Park, North Carolina. These panels are described in greater detail in Sections 2.2.1 and 2.2.2.

Each panel meeting began with a review of overall assumptions and definitions for each cost category to ensure that all experts responded from a common frame of reference. We then engaged the panelists in an open discussion of each food safety intervention followed by developing consensus on the estimated costs of each intervention. In developing the estimates, we assumed the baseline is that the intervention is not currently conducted by any method; thus, the estimates represent the

total costs of implementing an intervention. For some interventions with several different options, such as use of different types of chemical solutions, we asked the experts to first identify the lowest and highest cost methods, provide cost estimates for the lowest and highest cost methods, and then rank the remaining methods by order of costs. In addition to obtaining point estimates for costs, we asked the experts to provide input regarding a percentage range for the estimates (i.e., a margin of error for their estimates).

2.2.1 Pre-harvest Interventions

FSIS defines pre-harvest as any activity conducted prior to the animal being slaughtered, including activities at feedlots, finishing farms, and holding pens and other lairages at the slaughter establishment. Thus, the experts selected for the pre-harvest panel have extensive experience in beef, pork, or poultry production and at least moderate experience in the slaughter and processing of those products. The following experts participated in the pre-harvest panel meeting:

- Dr. Dana Hanson, North Carolina State University, Department of Food, Bioprocessing, and Nutrition Sciences[2]
- Dr. Bill Henning, Pennsylvania State University, Department of Animal Science
- Dr. Ken Macklin, Auburn University, Department of Poultry Science
- Dr. Morgan Morrow, North Carolina State University, Department of Animal Science
- Dr. Manpreet Singh, Purdue University, Department of Food Science[2]

The 1-day, in-person panel meeting was held on Friday, February 6, 2015.

2.2.2 Slaughter and Processing Interventions

The selected experts for the slaughter and processing panel have extensive experience in slaughter and processing operations, both for small and large operations, in beef, pork, or poultry. The following experts participated in the slaughter and processing panel meeting:

[2] Expert served on both panels.

- Dr. Christine Alvarado, Texas A&M University, Department of Poultry Science
- Dr. Jonathan Campbell, Pennsylvania State University, Department of Animal Science
- Dr. Catherine Cutter, Pennsylvania State University, Department of Food Science
- Dr. Alejandro Echeverry, Texas Tech University, Department of Animal and Food Sciences
- Dr. Dana Hanson, North Carolina State University, Department of Food, Bioprocessing, and Nutrition Sciences
- Dr. Kevin Keener, Purdue University, Department of Food Science and Agricultural & Biological Engineering
- Dr. Manpreet Singh, Purdue University, Department of Food Science

Because the data needs for slaughter and processing interventions were more extensive than for pre-harvest, we met in-person for 2 days, on February 24 and 25, 2015.

2.3 SECONDARY DATA SEARCHES

In addition to collecting data through expert elicitation, we also collected data through Internet searches and various contacts in academia and industry. Throughout the expert panel meetings, the experts referred us to various contacts at universities and animal nutrition and agricultural companies. We also found prices of various pieces of equipment online, such as bait stations for vermin control, garden hoses and nozzles for animal washing, filing cabinets for recordkeeping, and other minor capital equipment. Details on these estimates and sources are noted in the appropriate subsections in Sections 3 and 4.

To collect cost data on microbiological tests, RTI obtained price lists from five laboratory Web sites:

- Barrow Agee Laboratories, LLC (www.balabs.com)
- Great Lakes Scientific, Inc. (www.glslab.com)
- Medallion Labs (www.medallionlabs.com)
- Merieux NutriSciences (www.merieuxnutrisciences.com)
- Midwest Laboratories, Inc. (www.midwestlabs.com)

RTI compiled the prices of the various microbiological tests into an Excel spreadsheet and calculated the minimum, mean, and maximum prices for each test. During the expert panel meeting on slaughter and processing, we reviewed the price lists with the experts to ensure that the prices were realistic and to inquire about tests for which no data existed.

2.4 CALCULATING COST ESTIMATES

The total costs of investments for a meat or poultry establishment to respond to regulatory requirements may encompass capital equipment, labor, materials, utilities, and other costs, as described below:

- **Capital equipment costs** include new equipment as well as installation costs. These costs are estimated in dollars.
- **Labor costs** include wages for managers, food scientists, production employees, and animal handlers and are associated with each of the interventions. These costs are estimated in hours per year by type of employee and then multiplied by median hourly wages from the Bureau of Labor Statistics (BLS).
- **Materials costs** include ingredients, packaging, and cleaning supplies. These costs are estimated in dollars per year.
- **Utilities costs** include increased water use, liquid and solid waste disposal or sewer costs, and energy for operating establishment equipment or interventions during various stages of the process. These costs are estimated in dollars per year.
- **Other costs** include the cost of hiring consultants and travel between establishments for consultants.
- **Annual repairs and maintenance costs** are estimated as a percentage of capital equipment costs. The experts advised that we use 10% as a general rule.
- **Annual amortization costs** for capital equipment is calculated based on years of life or useful life of equipment and interest rate. We used an interest rate of 7%.[3]

To calculate labor costs, RTI obtained estimates of wage rates for the Animal Slaughtering & Processing industry (NAICS code

[3] The salvage value of equipment and the costs of taxes and insurance were not included in our analysis.

311600) from the BLS Web site. For the types of activities included in pre-harvest and slaughter activities, the following labor categories were identified as relevant:

- Food Scientists and Technologists
- Management Occupations
- Production Occupations
- Animal Handlers (at the farm level)
- Animal Handlers (at the slaughter establishment)

We used the median wage rate in the cost calculations. We also display the 10th and 90th percentile wage rates as provided by BLS to facilitate estimation of the range of cost estimates for each practice, if FSIS desires in the future. The current estimates do not account for benefits, although the cost spreadsheets have a placeholder if FSIS desires to incorporate a benefits rate later. The wage rates are shown in Table 2-4.

Table 2-4. Wage Rates, 2014[a] Industry: Animal Slaughtering and Processing (NAICS code 311600)

Labor Category	Dollars per Hour		
	10th Percentile	Median	90th Percentile
Food Scientists & Technologists	$13.60	$27.08	$47.01
Production Occupations	$8.98	$12.16	$17.71
Management Occupations	$24.37	$42.15	$82.86
Animal handlers (minimum wage) (Farmworkers, Farm, Ranch, and Aquacultural Animals)	$8.21	$11.02	$17.96
Animal handlers (minimum wage) (Slaughterers and Meat Packers)	$8.93	$12.29	$16.74

[a] These rates do not include benefits.

Source: Bureau of Labor Statistics

FSIS typically categorizes meat and poultry establishments into three size classes by the number of their employees. For purposes of this task order, RTI calculated costs for two establishment sizes—small and large—and excluded very small establishments because they are unlikely to use most of the interventions included in the exercise.[4] Because the FSIS size

[4] Some of the cost estimates do not apply to very small establishments, because the equipment required is too large relative to the production volume of very small establishments.

categorization by number of employees is generally not representative of how costs are delineated by size, we asked the experts for an appropriate breakpoint in slaughter volumes per shift by species. Volumes below the breakpoint are representative of a small establishment, while volumes above the breakpoint are representative of a large establishment. These breakpoint values are

- Beef: 500 head per shift
- Pork: 8,000 head per shift
- Chickens: 60,000 head per shift
- Turkeys: 12,000 head per shift

Using the breakpoint values, we estimated average slaughter volumes per year using slaughter volume data from FSIS's Public Health Information System (PHIS) for small and large establishments (excluding volume data for very small establishments).

We also asked the experts for typical operating characteristics (e.g., hours per shift, shifts per day, days per week) by establishment size and species, and we used these estimates to calculate annual costs. These standard assumptions are shown in Table 2-5. We did not account for seasonal variations, though the experts noted it occurs for some species, particularly for turkeys.

Finally, applying the margin of error obtained during the expert panels allowed RTI to estimate a low and high estimate for each intervention. Based on input from the experts, the margin of error ranged from 15% to 50%, depending on the intervention. All calculations were done in Microsoft Excel.

2.5 COST LIMITATIONS

Our study was subject to several limitations. Most of the data presented in this report are based on the knowledge and expertise of the experts chosen for the expert panels. Although we strived to find a diverse group of experts, the experts selected were not familiar with every intervention or investment made by meat and poultry slaughter and processing establishments. Further, the estimates provided by the experts are general estimates. They are not precise estimates from vendors or from industry interviews.

In addition, there are some cost categories that were not captured in our analysis. These include taxes, which are regional, and insurance premiums, which are highly variable, and salvage value of capital equipment.

Further, the wage estimates are national averages and could vary by region and establishment size.

Table 2-5. Standard Assumptions Used for Cost Calculations by Establishment Size and Species

	Beef		Pork		Chickens		Turkeys		RTE	
	Small	**Large**	**Small**	**Large**	**Small**	**Large**	**Small**	**Large**	**Small**	**Large**
Hours per Shift	8	8	8	8	8	8	8	8	8	8
Shifts per Day	1	2	1	2	1	2	1	2	1	2.5
Days per Week	4	5.5	4.5	5.5	4	5.5	4	5	4.5	5.5
Hours per Week	32	88	36	88	32	88	32	80	36	110
Weeks per Year	50	50	50	50	50	50	50	50	50	50
Hours per Year	1,600	4,400	1,800	4,400	1,600	4,400	1,600	4,000	1,800	5,500
Shifts per Year	200	550	225	550	200	550	200	500	225	687.5
Days per Year	200	275	225	275	200	275	200	250	225	275
Breakpoint Values	500		8,000		60,000		12,000		N/A	N/A
Number of head per shift	182	1,439	2,271	9,567	59,312	115,398	6,650	20,891	N/A	N/A
Number of head per year	36,400	791,450	510,975	5,261,850	11,862,400	63,468,900	1,330,000	10,445,500	N/A	N/A

3 Costs of Interventions at Pre-harvest

This section presents the specific cost estimates for each of the interventions for which FSIS requested data at the pre-harvest stage.

3.1 COSTS OF ANIMAL WASHING

FSIS requested data on the costs of washing cattle and swine prior to slaughter using five methods: antimicrobials, bacteriocins, bacteriophages, water and soap, and water only. The experts ranked these methods from lowest to highest costs as follows:

- water only
- water and soap
- antimicrobials
- bacteriocins
- bacteriophages

We calculated the cost of the lowest and highest cost methods for a small beef establishment and a small pork establishment, using prices obtained online for capital equipment, published water expenses, estimated water usage levels (as estimated by the experts), and a price quote from an animal health company (Table 3-1).

Table 3-1. Costs of Animal Washing Using Water Only or With Bacteriophage

Species: Beef and pork Units: $/operation	Small Beef Establishment			Small Pork Establishment		
	Low	**Midpoint**	**High**	**Low**	**Midpoint**	**High**
Capital equipment purchase ($)	$27.48	$54.96	$82.44	$27.48	$54.96	$82.44
Labor hours per shift	4	8	12	4	8	12
Labor costs ($/year)	$9,832	$19,664	$29,496	$11,061	$22,122	$33,183
Water (gallons/head)	15	30	45	15	30	45
Water (gallons/year)	546,000	1,092,000	1,638,000	7,664,625	15,329,250	22,993,875
Water cost ($/year)	$2,020	$4,040	$6,061	$28,359	$56,718	$85,077
Total annual costs: water only	$11,880	$23,759	$35,639	$39,448	$78,895	$118,343
Bacteriophage ($/head)	$0.42	$0.83	$1.25	no known product		
Bacteriophage ($/year)	$15,106	$30,212	$45,318			
Total annual costs: bacteriophage	$26,986	$53,971	$80,957			

Our assumptions and notes for these calculations for small establishments are as follows[5]:

- **Capital equipment** includes a commercial grade ¾" water hose and water nozzle. The prices for these were obtained from a home and garden store website (www.lowes.com). We assume they are replaced annually.
- **Labor type** for this intervention would be an animal handler at the slaughter establishment level. The experts estimated that one employee would spend an entire shift washing animals at a small establishment.
- **Water and sewer** costs of $3.70 per 1,000 gallons were based on published estimates by the North Carolina Cooperative Extension service.
- **Materials** used for animal washing would include bacteriophages (at the highest cost level), in addition to

[5] The experts were not familiar with animal washing practices at large establishments; thus, costs of animal washing at large establishments are not included in our analysis.

water. The product referenced is a pre-harvest hide wash used to aid in the reduction of *E. coli* on beef cattle. The quoted price of $2,500 per liter of concentrate allows an establishment to wash 3,000 head, resulting in a cost of $0.83 per head. There is no similar product for swine.

- **Margin of error** for this intervention was assumed to be 50%.

Thus, the annual costs of washing animals ($COST\_AW_s$) using water only in a small establishment were calculated as

$$COST\_AW_s = CAP + (LH\_AW \bullet WR\_AH) + (GPA \bullet VOL_s \bullet WAT),$$

where CAP is the cost of capital equipment, LH_AW is the estimated number of labor hours for animal washing, WR_AH is the wage rate for an animal handler, GPA is the number of gallons needed to wash each animal, VOL_s is the volume of head slaughtered of species s, and WAT is the per gallon cost of water. To add bacteriophage to the wash, the costs were calculated as

$$COST\_AW_s + (BAC \bullet VOL_s),$$

where BAC is the cost of bacteriophage for beef cattle (per head).

The experts discussed the difference between washing and misting the animals, for humane handling purposes. Misting the animals with a chemical would not be effective at reducing the pathogen load on cattle, because there would not be enough contact with the chemical.

3.2 COSTS OF FEED ADDITIVES

FSIS requested data on the costs of the following feed additives: antibiotics, colicin-producing *E. coli* strains, growth hormones, probiotics, and seaweed extract. In the panel discussion, the experts were not familiar with seaweed and growth hormones; thus, we eliminated these from our analysis. The experts ranked the remaining feed additives in terms of costs for each species, as shown in Table 3-2. Antibiotics are the most commonly used of these feed additives and also less expensive than probiotics. Colicin-producing *E. coli* strains only apply to cattle and have higher costs than either antibiotics or probiotics. The experts commented that prices are largely

dependent on volume purchased with larger volumes having lower per-unit prices due to volume discounts.

Table 3-2. Cost Ranking of Feed Additives

Species: Beef, pork, chickens, and turkeys				
Additive	**Beef**	**Pork**	**Chickens**	**Turkeys**
Antibiotics	1	1	1	1
Probiotics	2	2	2	2
Colicin-producing *E. coli* strains	3	not used		

Note: The baseline for feed is to include ionophores.

We obtained an estimate from an animal feed sales representative of an additional $5 per ton for feed with antibiotics. For example, poultry feed costs approximately $130 per ton without antibiotics and $135 per ton with antibiotics. Feed mills are licensed to add antibiotics to animal feed, so the producer receives feed with the antibiotic already included. Thus, the producer does not incur additional labor costs associated with using feed additives. The experts and the sales representative noted that antibiotics should not be given during the finishing stage because of residues and withdrawal times.

The experts also noted that all feed, with the exception of organic feed, includes ionophores. While this is considered an antibiotic in the United States, it is considered the baseline for animal feed. Ionophores increase feed efficiency by approximately 10%, offsetting any additional costs for the feed.

3.3 COSTS OF VACCINATIONS

The list of data needs from FSIS included the costs of poultry vaccinations for *Salmonella* and *Campylobacter* and cattle vaccinations for *Salmonella* and STEC. Based on the findings from the background searches we conducted, and confirmed by the experts, there are no commercially available vaccines for *Salmonella* and *Campylobacter* for broilers at this time. Current poultry vaccinations are for layers only. Vaccinations are available for cattle and swine; the costs of these are displayed in Table 3-3.

Table 3-3. Cost of Vaccinations

Species: Beef and pork
Units: $ per animal

Beef	***Salmonella***			**STEC**		
	Low	**Midpoint**	**High**	**Low**	**Midpoint**	**High**
Vaccine cost ($/dose)	$0.43	$0.50	$0.58	$2.13	$2.50	$2.88
Dosages per animal	3	3	3	3	3	3
Total vaccine cost ($/animal)	$1.28	$1.50	$1.73	$6.38	$7.50	$8.63
Labor hours per dose	0.08	0.08	0.08	0.08	0.08	0.08
Labor cost ($/dose)	$0.92	$0.92	$0.92	$0.92	$0.92	$0.92
Total cost ($/animal)	$2.19	$2.42	$2.64	$7.29	$8.42	$9.54
Pork	***Salmonella***			**STEC**		
	Low	**Midpoint**	**High**	**Low**	**Midpoint**	**High**
Vaccine cost ($/dose)	$0.81	$0.95	$1.09			
Dosages per animal	1	1	1			
Total vaccine cost ($/animal)	$0.81	$0.95	$1.09			
Labor hours per dose	0.03	0.03	0.03			
Labor cost ($/dose)	$0.37	$0.37	$0.37			
Total cost ($/animal)	$1.17	$1.32	$1.46			

Our assumptions and notes for these calculations are as follows:

- **Vaccine** prices and number of dosages were obtained from two veterinary supply websites for *Salmonella* (www.jefferspet.com and www.qcsupply.com) and from the expert panel for STEC.
- **Labor type** for this intervention would be an animal handler at the farm level. The experts estimated that 12 head of cattle can be vaccinated per hour, and 30 head of swine can be vaccinated per hour.
- **Margin of error** for this intervention was assumed to be 15%.

Thus, the costs per animal of administering vaccinations ($COST\_AV_{s,p}$) were calculated as

$$COST\_AV_{s,p} = (VAC_{s,p} \bullet DOS_{s,p}) + (LH\_V_s \bullet WR\_AH),$$

where $VAC_{s,p}$ is the cost of the vaccine for species s and pathogen p, $DOS_{s,p}$ is the number of dosages needed per animal for species s and pathogen p, LH_V_s is the number of labor hours per animal for vaccinating species s per dose, and WR_AH is the wage rate for an animal handler.

Operations may incur additional costs for a veterinarian to oversee the vaccination administration. However, we do not have a specific estimate on this cost.

3.4 COSTS OF VERMIN CONTROL AND ERADICATION

FSIS requested data on the costs of vermin control and eradication at poultry operations, including plan development and implementation. For poultry, vermin are typically rodents. Beetles are also a problem at poultry operations but, according to the experts, are not the focus of control efforts. The experts noted that all poultry operations already have a vermin control plan, separate from other written plans. Vermin control plans are typically required by the processor and usually developed by the company veterinarian. Using assumptions from the expert panel on the typical number of houses per operation and bait stations per house, we developed estimates for implementing vermin control at chicken and turkey operations (Table 3-4).[6]

Our assumptions and notes for these calculations are as follows:

- **Labor type** for this intervention would be a farm laborer (whose wage rate is the equivalent of an animal handler at the farm level). The experts estimated that one employee would spend 30 minutes per house per month checking the bait stations and replacing bait.
- **Capital equipment** includes bait stations. The number of bait stations needed per house is the same for small and large operations, as the size of the house does not differ (the number of houses per operation differs). The prices for bait stations were obtained from a rodent control website (www.qcsupply.com). We assumed they

[6] According to the experts, the average poultry house can accommodate 20,000 broilers, for both small and large operations. Some producers have "mega-houses" with 40,000 broilers. The square footage of an average house is 50 to 55 ft by 500 ft.

Table 3-4. Costs of Vermin Control and Eradication

Species: Chickens and turkeys
Units: $ per operation

	Small Operation			Large Operation		
Chickens	**Low**	**Midpoint**	**High**	**Low**	**Midpoint**	**High**
Typical number of stations per house	10	12	18	10	12	18
Number of houses per operation	4	4	4	8	8	8
Cost of bait stations	$414	$487	$731	$828	$974	$1,462
Labor hours per house	0.43	0.50	0.58	0.43	0.50	0.58
Labor costs ($/year)	$224.81	$264.48	$304.15	$449.62	$528.96	$608.30
Bait ($/house/month)	$20	$23	$35	$20	$23	$35
Bait ($/year)	$950	$1,117	$1,676	$1,900	$2,235	$3,352
Total annual costs	$1,589	$1,869	$2,711	$3,178	$3,738	$5,422
	Small Operation			**Large Operation**		
Turkeys	**Low**	**Midpoint**	**High**	**Low**	**Midpoint**	**High**
Typical number of stations per house	10	12	18	10	12	18
Number of houses per operation	2	2	2	6	6	6
Cost of bait stations	$207	$244	$365	$621	$731	$1,096
Labor hours per house	0.43	0.50	0.58	0.43	0.50	0.58
Labor costs ($/year)	$112.40	$132.24	$152.08	$337.21	$396.72	$456.23
Bait ($/house/month)	$20	$23	$35	$20	$23	$35
Bait ($/year)	$475	$559	$838	$1,425	$1,676	$2,514
Total annual costs	$794	$935	$1,356	$2,383	$2,804	$4,067

are replaced annually and therefore do not amortize the costs of the bait stations.

- **Materials** used for vermin control would include bait. Bait costs were obtained from a rodent control website (www.qcsupply.com). The costs of bait are the same for chicken and turkey operations.
- **Margin of error** for this intervention was assumed to be 15%.

Thus, the annual costs of vermin control (COST_ $VC_{s,j}$) per establishment were calculated as

$$COST\_VC_{s,j} = (SPH_{s,j} \bullet HPO_{s,j} \bullet STA) + (LH\_VC \bullet HPO_{s,j} \bullet WR\_AH \bullet 12) + (B \bullet HPO_{s,j} \bullet 12),$$

where $SPH_{s,j}$ is the number of stations per house for species s and operation size j, $HPO_{s,j}$ is the number of houses per operation for species s and operation size j, STA is the cost of each bait station, LH_VC is the number of labor hours per house per month, WR_AH is the wage rate for an animal handler, and B is the monthly cost of bait per house.

3.5 COSTS OF LITTER AND BEDDING CHANGES

FSIS requested the cost to poultry operations for removing litter and changing bedding materials. The general recommendation is for operations to change out their bedding materials at least once per year; however, some producers wait as long as 2 years between complete bedding changes. A few operations replace their bedding after each flock, although this is not typical. Partial clean-outs are more common after each flock. For a partial clean-out, operations remove litter that collects on top of the screen (also called “de-caking”) and spray an insecticide. According to the experts, pine shavings are used as bedding material in the North Carolina area, pine shavings and rice hulls are used in Mississippi and Arkansas, and hardwood shavings are used more in the northern United States. Generally, each chicken house has six “grow-out phases,” or cycles of birds per year, whereas turkey houses have two.

We estimated the costs of a partial and a full clean-out (Table 3-5). Costs are the same for chicken and turkey houses.

Our assumptions and notes for these calculations are as follows:

- **Labor type** for this intervention would be a farm laborer (whose wage rate is the equivalent of an animal handler at the farm level). The experts estimated that one employee would spend a full day, or 8 hours, for each clean-out.
- **Materials** used for bedding changes include the bedding materials and chemicals, such as insecticides and

Table 3-5. Costs of Litter and Bedding Changes

Species: Chickens and turkeys
Units: $ per house for a single bedding change

	Cost per Bedding Change		
Partial Clean-Out	**Low**	**Midpoint**	**High**
Labor hours per bedding change	6.8	8	9.2
Labor costs ($)	$75	$88	$101
Bedding materials ($)	$170	$200	$230
Chemicals (insecticides/acidifiers)	$255	$300	$345
Fuel costs for tractor ($)	$102	$120	$138
Total costs ($)	$602	$708	$814
	Cost per Bedding Change		
Full Clean-Out	**Low**	**Midpoint**	**High**
Labor hours per bedding change	6.8	8	9.2
Labor costs ($/year)	$75	$88	$101
Bedding materials ($)	$723	$850	$978
Chemicals (insecticides/acidifiers)	$425	$500	$575
Fuel costs for tractor ($)	$102	$120	$138
Total costs ($)	$1,324	$1,558	$1,792

acidifiers. The experts estimated the cost of both materials for full and partial clean-outs.

- **Fuel** costs for the tractor are estimated at 5 gallons per hour, for 8 hours, at $3 per gallon.
- **Margin of error** for this intervention was assumed to be 15%.

Thus, the per-house costs of litter and bedding changes (COST_BC) for each clean-out were calculated as

$$COST\_BC = (LH\_BC \bullet WR\_AH) + BM + C + F,$$

where LH_BC is the number of labor hours for each bedding change, WR_AH is the wage rate of an animal handler, BM is the cost of replacement bedding materials, C is the cost of chemicals, and F is fuel costs for the tractor.[7]

[7] Producers also incur the annualized costs of a tractor and waste disposal costs. However, the experts did not have information on these costs to include in our analysis.

Once the old bedding is removed, operators compost it onsite on a concrete pad with roofed structure and then spread it on their land, or they may sell it for fertilizer (estimated by the experts to have a price of $35 to $50 per ton).

3.6 COSTS OF THIRD-PARTY CERTIFICATIONS

FSIS requested cost data for six third-party certifications: (1) Pork Quality Assurance Plus (PQA+), (2) Transport Quality Assurance (TQA), (3) Beef Quality Assurance (BQA), (4) humane handling, (5) Farmers Assuring Responsible Management (FARM), and (6) Restaurants, Foodservice, and Institutions (RFI). We discuss each of these below, and present the costs of obtaining relevant certifications in Table 3-6.

Table 3-6. Costs of Third-Party Certification

Species: Beef, pork, chickens, and turkeys

Units: $ per employee

	Pork Quality Assurance Plus (PQA+)			Transport Quality Assurance (TQA)			Beef Quality Assurance (BQA)			Humane Handling and Raising		
	Low	Mid-point	High	Low	Mid-point	High	Low	Mid-point	High	Low	Mid-point	High
Species	**Pork**			**Pork**			**Beef**			**All**		
Certification fee	$0	$0	$0	$0	$0	$0	$0	$25	$100	$1,200	$1,500	$1,700
Labor hours per course	3	5	7	3	5	7	4	8	12	2	4	6
Labor costs ($/course)	$81	$135	$190	$81	$135	$190	$108	$217	$325	$54	$108	$162
Travel costs ($)	$0	$58	$115	$0	$58	$115	$0	$58	$115	$0	$0	$0
Total costs ($)	$81	$193	$305	$81	$193	$305	$108	$299	$540	$1,254	$1,608	$1,862

PQA+ certification is a producer-driven program to ensure that U.S. pork products are safe to consume and that animals raised to produce these products are raised in a responsible manner. The certification process involves watching a 2-hour video and then completing a 1-hour test. This must be done in-person for the first time and then can be renewed online. An operator's certification lasts for 3 years. The certification class does not

have a fee, as it is paid for through the Pork Checkoff program[8]. More information about PQA+ can be found at www.pork.org/pqa-plus-certification/.

TQA is a program for swine transporters, producers, and handlers that helps them to understand how transporting pigs affects their well-being and pork quality. TQA is also administered through the Pork Checkoff program; thus, the certification trainings are the same length, and there are no fees for the course. More information about TQA can be found at www.pork.org/tqa-certification/.

BQA is a national program with guidelines for beef cattle production, administered at the state level. Each state administers its program differently, with some states requiring training, other states requiring in-person audits, and some states requiring both training and audits. For example, in Texas, operations are certified every year through an annual in-person audit, which takes between 4 to 6 hours per operation. There is no audit fee because it is part of the state Beef Cattleman's Association membership fee. In Nebraska, feed yards are required to participate in an in-person, 3-hour training and all-day assessment. The fee for this is $50 for operations with 5 or fewer employees, or $100 for operations with 6 or more employees. Kansas is the only state that has an online certification program, for a $25 fee. More information about BQA can be found at www.bqa.org.

For the **humane handling** certification, we used the Global Animal Partnership (GAP) certification, at the suggestion of the experts. The GAP program has a 5-step animal welfare rating system that allows producers to become certified in individual steps related to environmental enrichment, outdoor access for animals, prohibiting cages, and more. The audits and certification administration are done through third-party companies, and thus the cost varies by vendor (we received three fee estimates shown in Table 3-6). The labor costs for GAP certification in Table 3-6 are for time spent with the auditor as he/she visits the operation. The experts suggested that cattle raised under GAP certification are worth between $100 and $200 more per head (not reflected in our cost

[8] The Pork Checkoff program is a producer-funded program, whereby pork producers and importers pay $0.40 per $100 of value when pigs are sold.

estimates). More information about GAP can be found at www.globalanimalpartnership.org.

FARM is a program designed for dairy animal (cattle and calves) operations. It includes a best-practices manual for dairy animals (including dairy beef animals and dairy vealers) well-being and a third-party verification program. The certification lasts for 1 year and can be renewed online with a 1-hour online course and exam. More information about FARM can be found at www.nationaldairyfarm.com/.

For the **RFI** certification, we were unable to locate a certification with this title. However, the ServSafe certification program, administered by the National Restaurant Association, certifies restaurant and food service managers and food handlers. In-person and online trainings and exams are available for managers and food handlers. The online managerial course and exam costs $161, and the online course and exam for food handlers costs $15. These costs are not included in Table 3-6 because they apply to restaurant or food service employees. More information about ServSafe can be found at www.servsafe.com.

Our assumptions and notes for the calculations shown in Table 3-6 are as follows:

- **Certification fee** represents the costs charged to attend the training. For the humane handling certification, the course fee represents the third-party auditor fee.
- **Labor type** for this intervention would have a wage rate at the equivalent of a food scientist at a processing establishment. Labor hours represent time in training, traveling to training, and/or spent with an auditor.
- **Travel** costs represent car mileage traveling to trainings at the federal reimbursement fuel rate of 57.5 cents per mile. For the low estimate, we assumed the training was held locally; for the midpoint estimate, we assumed the mileage would be 100 miles round trip; for the high estimate, we assumed the mileage would be 200 miles round trip. We assumed that overnight travel to attend a training would be unnecessary.

Thus, the per-employee costs of obtaining third-party certification (COST_TC) are calculated as follows:

$$COST\_TC_s = FEE_s + (LH\_CER_s \bullet WR\_FS) + (MI \bullet FR)$$

where FEE is the certification fee for species s, LH_CER is the number of labor hours for training needed to obtain certification for species s, WR_FS is the wage rate for a food scientist, MI is the number of miles needed to travel to the course, and FR is the fuel rate.

The experts noted that operators are constantly monitoring to be prepared for audits. However, this cost of monitoring is difficult to estimate and therefore is not built into the cost estimates.

3.7 FEEDING ROUGHAGE AT END OF FINISHING PHASE

FSIS is interested in the costs of feeding proportionately more roughage in the ration at the end (i.e., the last couple of days before slaughter) of the finishing phase for beef cattle, which could have a food safety benefit if by changing the microflora and chemistry of the animal's digestive system it has a significant lethality effect (4 to 6 log reductions) on any pathogens in the feces. Roughage is hay or low-grain/hay silage; the alternative is to continue feeding a relatively high grain ration, with relatively low proportions of grain/alfalfa/grass silage, or alfalfa/grass hay combined. According to the experts, feeding roughage results in a live weight decrease of 2.2 pounds per day. For example, at 5 days, this weight reduction would total 11 pounds. Assuming the live weight price is $1.64 per pound (approximate current price), the finisher would receive approximately $18 less per head. The experts suspect that there may also be a decrease in carcass quality by switching to roughage. If a carcass decreases in quality from choice to select, there is an approximate $50 reduction in carcass price. Some of these costs would be offset by the reduction in feed prices, estimated at approximately $3 to $5 over the 5 days.

3.8 FEED WITHDRAWAL PRIOR TO SHIPPING

We obtained limited information on withdrawing feed from livestock prior to shipping to slaughter. The idea for this intervention is that by withdrawing feed before shipment, there will be less fecal shedding of pathogens during shipment. Typical withdrawal times are 1 day for cattle, the night before for swine, and 8 to 12 hours for poultry. According to the

experts, the industry has fully adopted this practice, and there are documented food safety benefits in poultry. Operations realize cost savings associated with this practice because of reduced feed usage.

3.9 PURCHASE OF PRECONDITIONED ANIMALS

FSIS also requested information on the practice of purchasing preconditioned animals. Preconditioned beef cattle are weaned, accustomed to eating solid food from a trough, castrated, and have received normal vaccinations. Preconditioned animals have more value for the operation. If an animal is not preconditioned, it has a lower value of approximately $5 to $10 per hundredweight at the feeder stage.

4 Costs of Interventions at Slaughter and Processing

This section presents the specific cost estimates for each of the interventions for which FSIS requested data at the slaughter and processing stage.

4.1 COSTS OF DEVELOPMENT, VALIDATION, AND REASSESSMENT OF PLANS

4.1.1 HACCP Plans

We estimated the initial costs of developing a HACCP plan and the annual costs of validating and reassessing the plan. Small establishments will either develop the entire plan internally using company employees or hire a consultant to assist in plan development. Table 4-1 presents both options. Costs are presented on a per-plan and per-reassessment basis. The experts also stated that the cost to develop a second plan would be 75% of the cost to develop the first plan; the cost to develop a third plan would be 50% of the cost to develop the first plan, and so on. They also mentioned that large establishments typically reassess their plans two to three times per year, whereas small establishments typically reassess their plans once per year (as required).

The experts stated that the costs to develop a second plan would be 75% of the cost to develop the first plan; the cost to develop a third plan would be 50% of the cost to develop the first plan, and so on.

Table 4-1. Costs of HACCP Plan Development, Validation, and Reassessment per HACCP Category

Species: Beef, pork, chickens, and turkeys

Units: Hours and $s per establishment

	Costs per HACCP Category		
	Low	**Midpoint**	**High**
Small Establishment			
Initial Costs			
Option A: Develop Plan Internally			
Labor hours	250	500	750
Labor costs ($)	$6,770	$13,540	$20,310
Travel costs ($)	$0	$0	$0
Total initial costs ($)	$6,770	$13,540	$20,310
Option B: Develop Plan With Consultant			
Labor hours	125	250	375
Labor costs ($)	$3,385	$6,770	$10,155
Consultant costs ($)	$5,000	$10,000	$15,000
Travel costs ($)	$500	$1,000	$1,500
Total initial costs ($)	$8,885	$17,770	$26,655
Annual Costs			
Validate Plan			
Labor hours	200	400	600
Labor costs ($)	$5,416	$10,832	$16,248
Reassess Plan			
Labor hours	15	30	45
Labor costs ($)	$182	$365	$547
Total costs per reassessment	$5,598	$11,197	$16,795
Large Establishment			
Initial Costs			
Develop Plan			
Labor hours	500	1,000	1,500
Labor costs ($)	$13,540	$27,080	$40,620
Consultant costs ($)	$7,500	$15,000	$22,500
Travel costs ($)	$500	$1,000	$1,500
Total initial costs ($)	$21,540	$43,080	$64,620

(continued)

Table 4-1. Costs of HACCP Plan Development, Validation, and Reassessment per HACCP Category (continued)

	Costs per HACCP Category		
	Low	**Midpoint**	**High**
Annual Costs			
Validate Plan			
Labor hours	160	320	480
Labor costs ($)	$4,333	$8,666	$12,998
Reassess Plan			
Labor hours	30	60	90
Labor costs ($)	$365	$730	$1,094
Total costs per reassessment	$4,698	$9,395	$14,093

Our assumptions and notes for these calculations are as follows:

- **Labor type** required to develop and validate a HACCP plan is generally a food scientist employee, while a production employee with additional experience would reassess the plan.
- **Consultant** costs are based on the assumption that they charge $250 per hour.
- **Travel** costs are incurred by the consultant and typically paid by the establishment in addition to their fee. We estimate travel costs at $1,000 per person per trip, which is the sum of airfare ($500), lodging ($200), meals ($200), and rental car ($100).
- **Margin of error** for this intervention is assumed to be 50%.

The initial cost of developing a HACCP plan ($COST\_PD_j$) is

$$COST\_PD_j = (LH\_FS_j \bullet WR\_FS) + CON + TR,$$

where LH_FS_j is the number of labor hours for a food scientist for establishment size j, WR_FS is the wage rate of a food scientist, CON is the consultant cost, and TR is travel costs. Note that if a small establishment develops its plan using only internal labor, the internal labor hours are higher than if it also uses a consultant, and the consultant costs and travel costs are $0. According to the experts, a large establishment would generally always use a consultant in addition to internal labor.

To validate and reassess the HACCP plan, the costs ($COST\_PVR_j$) were calculated as

$$COST\_PVR_j = (LH\_FS_j \bullet WR\_FS) + (LH\_PR_j \bullet WR\_PR),$$

where LH_PR is the number of labor hours for a production employee for establishment size j, and WR_PR is the wage rate of a production employee.

For establishments that are part of a corporation, the experts mentioned that corporate costs might be approximately 25% of the establishment costs. These costs are not reflected in our calculations.

4.1.2 SSOP Plans

Table 4-2 presents the establishment-level costs of developing, validating, and reassessing a SSOP plan at small and large slaughter establishments and at large RTE processing establishments. The assumptions and formulas used were the same as for a HACCP plan, shown above.

Table 4-2. Costs of SSOP Plan Development, Validation and Reassessment

Species: Beef, pork, chickens, and turkeys

Units: Hours and $s per establishment

	Costs per SSOP Plan		
	Low	**Midpoint**	**High**
Small Establishment			
Initial Costs			
Option A: Develop Plan Internally			
Labor hours	250	500	750
Labor costs ($)	$6,770	$13,540	$20,310
Travel costs ($)	$0	$0	$0
Total initial costs ($)	$6,770	$13,540	$20,310
Option B: Develop Plan With Consultant			
Labor hours	125	250	375
Labor costs ($)	$3,385	$6,770	$10,155
Consultant costs ($)	$1,250	$2,500	$3,750
Travel costs ($)	$500	$1,000	$1,500
Total initial costs ($)	$5,135	$10,270	$15,405

(continued)

Table 4-2. Costs of SSOP Plan Development and Reassessment (continued)

	Costs per SSOP Plan		
	Low	**Midpoint**	**High**
Annual Costs			
Validate Plan			
Labor hours	200	400	600
Labor costs ($)	$5,416	$10,832	$16,248
Reassess Plan			
Labor hours	15	30	45
Labor costs ($)	$182	$365	$547
Total annual costs	$5,598	$11,197	$16,795
Large Establishment			
Initial Costs			
Develop Plan			
Labor hours	500	1,000	1,500
Labor costs ($)	$13,540	$27,080	$40,620
Consultant costs ($)	$7,500	$15,000	$22,500
Travel costs ($)	$500	$1,000	$1,500
Total initial costs ($)	$21,540	$43,080	$64,620
Annual Costs			
Validate Plan			
Labor hours	160	320	480
Labor costs ($)	$4,333	$8,666	$12,998
Reassess Plan			
Labor hours	30	60	90
Labor costs ($)	$365	$730	$1,094
Total annual costs	$4,698	$9,395	$14,093
Large RTE Establishment			
Initial Costs			
Develop Plan			
Labor hours	1,500	3,000	4,500
Labor costs ($)	$40,620	$81,240	$121,860
Travel costs ($)	$0	$0	$0
Total initial costs ($)	$40,620	$81,240	$121,860

(continued)

Table 4-2. Costs of SSOP Plan Development and Reassessment (continued)

	Costs per SSOP Plan		
	Low	**Midpoint**	**High**
Annual Costs			
Validate Plan			
Labor hours	480	960	1,440
Labor costs ($)	$12,998	$25,997	$38,995
Reassess Plan			
Labor hours	90	180	270
Labor costs ($)	$1,094	$2,189	$3,283
Total annual costs	$14,093	$28,186	$42,278

For large RTE processing establishments, the experts estimated the labor hours for developing, validating, and reassessing an SSOP plan would be three times higher than for large establishments producing raw products.

4.1.3 Microbiological Sampling Plans

The costs to develop, validate, and reassess microbiological sampling plans at small and large establishments are shown in Table 4-3. We assumed that all sizes of establishments will hire a consultant to assist in the development of a sampling plan. The assumptions and formulas used were the same as for HACCP and SSOP plans, shown above. As with the SSOP plans, there are no economies of scale with sampling plans; thus, the cost to develop a second plan would be 100% of the cost of developing the first plan.

The number of labor hours spent on validating sampling plans at small and large RTE processing establishments is estimated to be three times higher than for slaughter and processing establishments. These costs are shown in Table 4-3 as well.

Table 4-3. Costs of Sampling Plan Development, Validation, and Reassessment

Species: Beef, pork, chickens, and turkeys

Units: Hours and $s per establishment

	Costs per Sampling Plan		
	Low	**Midpoint**	**High**
Small Establishment			
Initial Costs			
Develop Plan With Consultant			
Labor hours	10	20	30
Labor costs ($)	$271	$542	$812
Consultant costs ($)	$2,500	$5,000	$7,500
Travel costs ($)	$500	$1,000	$1,500
Total initial costs ($)	$3,271	$6,542	$9,812
Annual Costs			
Validate Plan			
Labor hours	600	1,200	1,800
Labor costs ($)	$16,248	$32,496	$48,744
Reassess Plan			
Labor hours	10	20	30
Labor costs ($)	$122	$243	$365
Total annual costs ($)	$16,370	$32,739	$49,109
Large Establishment			
Initial Costs			
Develop Plan With Consultant			
Labor hours	1,500	3,000	4,500
Labor costs ($)	$40,620	$81,240	$121,860
Consultant costs ($)	$2,500	$5,000	$7,500
Travel costs ($)	$500	$1,000	$1,500
Total initial costs ($)	$43,620	$87,240	$130,860
Annual Costs			
Validate Plan			
Labor hours	480	960	1,440
Labor costs ($)	$12,998	$25,997	$38,995
Consultant costs ($)	$10,000	$20,000	$30,000
Travel costs ($)	$500	$1,000	$1,500
Reassess Plan			
Labor hours	2,000	4,000	6,000
Labor costs ($)	$24,320	$48,640	$72,960
Consultant costs ($)	$2,500	$5,000	$7,500
Travel costs ($)	$500	$1,000	$1,500
Total annual costs ($)	$50,818	$101,637	$152,455

(continued)

Table 4-3. Costs of Sampling Plan Development, Validation, and Reassessment (continued)

	Costs per Sampling Plan		
	Low	**Midpoint**	**High**
Small RTE Establishment			
Annual Costs			
Validate Plan			
Labor hours	1,800	3,600	5,400
Labor costs ($)	$48,744	$97,488	$146,232
Consultant costs ($)	$1,000	$2,000	$3,000
Travel costs ($)	$500	$1,000	$1,500
Total annual costs ($)	$50,244	$100,488	$150,732
Large RTE Establishment			
Annual Costs			
Validate Plan			
Labor hours	1,440	2,880	4,320
Labor costs ($)	$38,995	$77,990	$116,986
Consultant costs ($)	$5,000	$10,000	$15,000
Travel costs ($)	$500	$1,000	$1,500
Total annual costs ($)	$44,495	$88,990	$133,486

4.2 COSTS OF TRAINING

FSIS requested data on the costs of training on the following topics: HACCP, SSOP, humane handling, food defense, sampling, Good Manufacturing Practices (GMPs), sanitary dressing, and recall procedures. FSIS also requested the cost of training on recordkeeping; however, the experts noted that recordkeeping is a component of all training, and thus costs for recordkeeping training were not estimated separately. Biosecurity training was also included in the list of data needs. However, the experts said that biosecurity training applies to farm-level production (pre-harvest stage), and thus they did not have the expertise to provide estimates.

During the panel discussions, the experts noted that the labor hours included in their cost estimates represent the amount of time that establishments should spend on training and not the amount of time that establishments necessarily spend.

Table 4-4 shows the initial and annual costs for each type of training on a per-employee basis. The difference in costs between small and large establishments is because of differences in the number of employees trained. During the panel discussions, the experts noted that the labor hours included in their cost estimates represent the amount of time that establishments should spend on training and not the amount of time that establishments necessarily spend. They

later noted that establishments spend approximately one-third of the time on training than what the experts would recommend.

Table 4-4. Training Costs for Management and Production Employees

Species: Beef, pork, chickens, and turkeys

Units: Hours and $s per establishment employee

	HACCP Training					
	New Employee Training			Annual Refresher Training		
	Low	Midpoint	High	Low	Midpoint	High
Management Staff						
Labor hours	6	12	18	1	2	3
Labor costs ($)	$252.90	$505.80	$758.70	$42.15	$84.30	$126.45
Course fee ($)	$250	$500	$750			
Travel costs ($)	$500	$1,000	$1,500	$0	$0	$0
Total costs for management ($/employee)	$1,003	$2,006	$3,009	$42	$84	$126
Quality Assurance (QA) Staff						
Labor hours	6	12	18	1	2	3
Labor costs ($)	$162.48	$324.96	$487.44	$27.08	$54.16	$81.24
Course fee ($)	$250	$500	$750			
Travel costs ($)	$500	$1,000	$1,500	$0	$0	$0
Total costs for quality ($/employee)	$912	$1,825	$2,737	$27	$54	$81
Production Line Staff						
Labor hours	2	4	6	1	2	3
Labor costs ($)	$24.32	$48.64	$72.96	$12.16	$24.32	$36.48
Course fee ($)	$250	$500	$750			
Total costs for production ($/employee)	$274	$549	$823	$12	$24	$36

(continued)

Table 4-4. Training Costs for Management and Production Employees (continued)

	SSOP Training					
	New Employee Training			Annual Refresher Training		
	Low	Midpoint	High	Low	Midpoint	High
Management Staff						
Labor hours	6	12	18	1	2	3
Labor costs ($)	$252.90	$505.80	$758.70	$42.15	$84.30	$126.45
Course fee ($)	$250	$500	$750			
Travel costs ($)	$500	$1,000	$1,500	$0	$0	$0
Total costs ($)	$1,003	$2,006	$3,009	$42	$84	$126
Quality Assurance (QA) Staff						
Labor hours	6	12	18	1	2	3
Labor costs ($)	$162.48	$324.96	$487.44	$27.08	$54.16	$81.24
Course fee ($)	$250	$500	$750			
Travel costs ($)	$500	$1,000	$1,500	$0	$0	$0
Total costs for quality ($/employee)	$912	$1,825	$2,737	$27	$54	$81
Production Line Staff						
Labor hours	5	10	15	1	2	3
Labor costs ($)	$60.80	$121.60	$182.40	$12.16	$24.32	$36.48
Course fee ($)	$250	$500	$750			
Total costs for production ($/employee)	$311	$622	$932	$12	$24	$36
	Humane Handling Training					
	New Employee Training			Annual Refresher Training		
	Low	Midpoint	High	Low	Midpoint	High
Animal Handler Staff						
Labor hours	4	8	12	1	2	3
Labor costs ($)	$49.16	$98.32	$147.48	$12.29	$24.58	$36.87
Course fee ($)	$156	$312	$468			
Travel costs ($)	$0	$0	$0	$0	$0	$0
Total costs ($)	$205	$410	$615	$12	$25	$37

(continued)

Table 4-4. Training Costs for Management and Production Employees (continued)

	Food Defense Training					
	New Employee Training			Annual Refresher Training		
	Low	Midpoint	High	Low	Midpoint	High
Management Staff						
Labor hours	4	8	12	1	2	3
Labor costs ($)	$168.60	$337.20	$505.80	$42.15	$84.30	$126.45
Course fee ($)	$75	$150	$225			
Travel costs ($)	$500	$1,000	$1,500	$0	$0	$0
Total costs ($)	$901	$1,801	$2,702	$81	$163	$244
Quality Assurance (QA) Staff						
Labor hours	4	8	12	1	2	3
Labor costs ($)	$108.32	$216.64	$324.96	$27.08	$54.16	$81.24
Course fee ($)	$75	$150	$225			
Travel costs ($)	$500	$1,000	$1,500	$0	$0	$0
Total costs for quality ($/employee)	$683	$1,367	$2,050	$27	$54	$81
Production Line Staff						
Labor hours	4	8	12	1	2	3
Labor costs ($)	$48.64	$97.28	$145.92	$12.16	$24.32	$36.48
Course fee ($)	$75	$150	$225			
Total costs for production ($/employee)	$124	$247	$371	$12	$24	$36

	Sampling Training					
	New Employee Training			Annual Refresher Training		
	Low	Midpoint	High	Low	Midpoint	High
Quality Assurance (QA) Staff						
Labor hours	12	24	36	1	2	3
Labor costs ($)	$324.96	$649.92	$974.88	$27.08	$54.16	$81.24
Course fee ($)	$500	$1,000	$1,500			
Travel costs ($)	$0	$0	$0			
Total costs ($)	$825	$1,650	$2,475	$27	$54	$81

(continued)

Table 4-4. Training Costs for Management and Production Employees (continued)

	GMP Training					
	New Employee Training			Annual Refresher Training		
	Low	Midpoint	High	Low	Midpoint	High
Management Staff						
Labor hours	4	8	12	1	2	3
Labor costs ($)	$168.60	$337.20	$505.80	$42.15	$84.30	$126.45
Course fee ($)	$125	$250	$375			
Travel costs ($)	$0	$0	$0	$0	$0	$0
Total costs ($)	$294	$587	$881	$42	$84	$126
Quality Assurance (QA) Staff						
Labor hours	4	8	12	1	2	3
Labor costs ($)	$108.32	$216.64	$324.96	$27.08	$54.16	$81.24
Course fee ($)	$125	$250	$375			
Travel costs ($)	$0	$0	$0	$0	$0	$0
Total costs for quality ($/employee)	$233	$467	$700	$27	$54	$81
Production Line Staff						
Labor hours	4	8	12	1	2	3
Labor costs ($)	$48.64	$97.28	$145.92	$12.16	$24.32	$36.48
Course fee ($)	$125	$250	$375			
Total costs for production ($/employee)	$174	$347	$521	$12	$24	$36
	Sanitary Dressing					
	New Employee Training			Annual Refresher Training		
	Low	Midpoint	High	Low	Midpoint	High
Production Line Staff						
Labor hours	5	10	15	1	2	3
Labor costs ($)	$60.80	$121.60	$182.40	$12.16	$24.32	$36.48
Course fee ($)	$0	$0	$0	$0	$0	$0
Travel costs ($)	$0	$0	$0	$0	$0	$0
Total costs ($)	$61	$122	$182	$12	$24	$36

(continued)

Table 4-4. Training Costs for Management and Production Employees (continued)

	Recall Procedures Training					
	New Employee Training			Annual Refresher Training		
	Low	Midpoint	High	Low	Midpoint	High
Management Staff						
Labor hours	2	4	6	1	2	3
Labor costs ($)	$84.30	$168.60	$252.90	$42.15	$84.30	$126.45
Course fee ($)	$125	$250	$250			
Travel costs ($)	$500	$1,000	$1,500	$0	$0	$0
Total costs ($)	$709	$1,419	$2,003	$42	$84	$126
Quality Assurance (QA) Staff						
Labor hours	2	4	6	1	2	3
Labor costs ($)	$54.16	$108.32	$162.48	$27.08	$54.16	$81.24
Course fee ($)	$125	$250	$250			
Travel costs ($)	$500	$1,000	$1,500	$0	$0	$0
Total costs for quality ($/employee)	$679	$1,358	$1,912	$27	$54	$81

Our assumptions and notes for these calculations are as follows:

- **Labor type** for training includes employees at all levels: management, quality assurance staff (food scientists), production employees, and animal handlers.
- **Course fees** for each type of training were estimated by the experts. We assume that management and quality assurance staff will attend third-party trainings, whereas production employees and animal handlers will attend trainings conducted by employees who have received external training. The course fees shown for production employees and animal handlers are the equivalent of establishment personnel labor hours spent preparing and delivering the trainings. We did not include a course fee for refresher training, because we assume this will be done either online or at the establishment.
- **Travel** costs are incurred by establishment employees who travel to trainings. We assume that only management employees and quality assurance staff will

travel to trainings. We estimate travel costs at $1,000 per person per trip, which is the sum of airfare ($500), lodging ($200), meals ($200), and rental car ($100). We also assume that annual refresher training will take place onsite or online; thus, there are no travel fees.

- **Margin of error** for this intervention is assumed to equal 50%.

The initial per-employee cost of training ($COST\_T_{k,l}$) is estimated as

$$COST\_T_{k,l} = (LH\_EM_k \bullet WR\_EM_k) + FEE_l + TR,$$

where LH_EM_k is the number of labor hours spent by employee type k, WR_EM_k is the wage rate for employee type k, FEE is the fee for course l, and TR is travel costs.

The experts were not aware of any third-party trainings on sanitary dressing, so we assumed that these trainings are done at the establishment. Thus, we estimated labor costs but did not include travel costs for this type of training.

4.3 COSTS OF ANTIMICROBIAL EQUIPMENT

The list of data needs from FSIS included antimicrobial equipment, but FSIS left it open to the experts to identify the most common types of equipment. The experts created two lists of equipment that are used by small and large establishments, by species (shown in Tables 4-5 and 4-6, respectively).

Table 4-5. Antimicrobial Equipment Used by Small Establishments

Equipment	Beef	Pork	Chickens	Turkeys
Spray cabinet	X	X		
Hand sprayer for carcasses	X	X		
Handheld hot water sprayer for carcasses	X			
Hand sprayer for subprimals or trim	X			
Inside-outside bird washer			X	X
Chiller (water)			X	X
Dip tank			X	X
Automated or hand sprayer			X	X

Table 4-6. Antimicrobial Equipment Used by Large Establishments

Equipment	Beef	Pork	Chickens	Turkeys
Steam vacuum	X			
Steam pasteurization cabinet	X			
Spray cabinet		X		
Automated spray on subprimals/trimmings		X		
Hotbox/chilling	X			
Sprayers in coolers	X			
Blast chill		X		
Inside-outside bird washer			X	X
Pre-chill drench (CPC) or spray cabinet (PAA)			X	X
Chiller (water)			X	X
Post-chill dip tank/finishing chiller			X	X
Post-chill spray bars			X	X

The initial and annual costs for antimicrobial equipment are shown in Table 4-7 for small establishments and Table 4-8 for large establishments by species. Our assumptions and notes for the cost calculations are as follows:

- **Capital equipment** costs were estimated by the expert panelists. To amortize these costs, we assumed an interest rate of 7% over 4 to 10 years, depending on the purchase price of the equipment. Equipment over $1 million was amortized over 10 years.
- **Labor type** for operating antimicrobial equipment would be production employee. The experts estimated how much labor time is spent operating the equipment per shift.

- **Water** usage was estimated for each piece of equipment, on a per-head basis, for beef and pork establishments.[9][10]
- **Utilities** costs were estimated at $3 per 1,000 gallons of water used, to heat or chill the water being used in the process.[11]
- **Repairs and Maintenance** costs are 10% of the cost of capital equipment.
- **Margin of error** for this intervention is assumed to be 50% for small establishments and 20% for large establishments.

Thus, the annual costs of antimicrobial equipment ($COST\_AE_{i,s,j}$) was calculated as follows:

$$COST\_AE_{i,s,j} = CAP\_AM_{i,s,j}^{n} + COST\_L_{i,s,j} + COST\_W_{i,s,j} + COST\_U_{i,s,j} + COST\_M_{i}$$

where $CAP\_AM_{i,s,j}^{n}$ is the amortized cost of capital equipment i for species s at establishment size j over n years, $COST\_L_{i,s,j}$ is the cost of labor for equipment i for species s at establishment size j, $COST\_W_{i,s,j}$ is the cost of water for equipment i for species s at establishment size j, $COST\_U_{i,s,j}$ is the cost of utilities for equipment i for species s at establishment size j, and $COST\_M_{i}$ is the cost of maintenance for equipment i. Each of these cost components was calculated as follows:

$$COST\_L_{i,s,j} = (LH\_PR_{s,i} \bullet WR\_PR \bullet SPY_{s,j})$$

$$COST\_W_{i,s,j} = (GAL_{s,i} \bullet WAT \bullet HPY_{s,j})$$

$$COST\_U_{i,s,j} = (3 \bullet (GAL_{s,i}/1{,}000) \bullet HPY_{s,j})$$

$$COST\_M_{i} = (CAP_{i} \bullet 0.10)$$

where $LH\_PR_{s,i}$ is the number of labor hours per shift spent by production employees for species s and equipment i, WR_PR is

[9] Water costs were not estimated for individual equipment at poultry establishments. According to FSIS, poultry plants often recycle water throughout the production process; therefore, calculating water costs for each piece of equipment is not an accurate reflection of total water costs. The experts estimated the total water usage is 8 to 10 gallons per bird at a chicken establishment and 20 to 25 gallons per bird at a turkey establishment.

[10] The experts estimated that the total water usage is 150 to 450 gallons at a beef establishment and 43 to 129 gallons at a pork establishment (the pork estimates were calculated by dividing the beef estimate by 3.5).

[11] By utilities, we mean energy costs.

the wage rate for production employees, $SPY_{s,j}$ is the number of shifts per year for species s at establishment size j, $GAL_{s,i}$ is the number of gallons of water used per head for species s for equipment i, WAT is the cost of water per gallon, $HPY_{s,j}$ is the number of head slaughtered per year for species s at establishment size j, and CAP_i is the capital cost of equipment i.

Table 4-7. Costs of Antimicrobial Equipment Used in Small Slaughter and Processing Establishments

Species: Beef, pork, chickens, and turkeys

Units: $s per establishment

	Beef Establishments		
Spray cabinet	**Low**	**Midpoint**	**High**
Initial Cost			
Purchase and installation cost	$25,000	$50,000	$75,000
Annual Costs			
Annualized purchase and installation cost	$7,381	$14,761	$22,142
Workers per shift	0.125	0.5	0.375
Labor costs ($/year)	$2,432	$9,728	$7,296
Water usage per head (gallon)	18	35	53
Water cost ($)	$2,357	$4,714	$7,071
Utilities costs ($)	$1,911	$3,822	$5,733
Repairs and maintenance costs ($)	$2,500	$5,000	$7,500
Total annual cost	$16,581	$38,025	$49,742
Hand sprayer for carcasses (antimicrobials)	**Low**	**Midpoint**	**High**
Initial Cost			
Purchase and installation cost	$75	$150	$225
Annual Costs			
Annualized purchase and installation cost	$41	$83	$124
Workers per shift	0.5	1	1.5
Labor costs ($/year)	$9,728	$19,456	$29,184
Water usage per head (gallon)	0.1321	0.2642	0.3963
Water cost ($)	$10.58	$21.16	$31.74
Repairs and maintenance costs ($)	$8	$15	$23
Total annual cost	$9,788	$19,575	$29,363

(continued)

Table 4-7. Costs of Antimicrobial Equipment Used in Small Slaughter and Processing Establishments (continued)

	Beef Establishments		
Hand held hot water sprayer for carcasses	**Low**	**Midpoint**	**High**
Initial Cost			
Purchase and installation cost	$5	$10	$15
Annual Costs			
Workers per shift	0.5	1	1.5
Labor costs ($/year)	$9,728	$19,456	$29,184
Water usage per head (gallon)	20	40	60
Water cost ($)	$1,602	$3,203	$4,805
Utilities costs ($)	$2,184	$4,368	$6,552
Total annual cost	$13,519	$27,037	$40,556
Hand sprayer for subprimals or trim (antimicrobial)	**Low**	**Midpoint**	**High**
Initial Cost			
Purchase and installation cost	$75	$150	$225
Annual Costs			
Annualized purchase and installation cost	$22	$83	$124
Workers per shift	0.5	1	1.5
Labor costs ($/year)	$9,728	$19,456	$29,184
Water usage per head (gallon)	0.03302	0.06604	0.09906
Water cost ($)	$2.64	$5.29	$7.93
Repairs and maintenance costs ($)	$8	$15	$23
Total annual cost	$9,760	$19,559	$29,339
	Pork Establishments		
Spray cabinet	**Low**	**Midpoint**	**High**
Initial Cost			
Purchase and installation cost	$25,000	$50,000	$75,000
Annual Costs			
Annualized purchase and installation cost	$7,381	$14,761	$22,142
Workers per shift	0.5	0.5	1.5
Labor costs ($)	$10,944	$10,944	$32,832
Water usage per head (gallon)	7	14	21
Water cost ($)	$13,234	$26,469	$39,703
Utilities costs ($)	$10,730	$21,461	$32,191
Repairs and maintenance costs ($)	$2,500	$5,000	$7,500
Total annual cost	$44,789	$78,635	$134,368

(continued)

Table 4-7. Costs of Antimicrobial Equipment Used in Small Slaughter and Processing Establishments (continued)

	Pork Establishments		
Hand sprayer for carcasses (antimicrobial)	**Low**	**Midpoint**	**High**
Initial Cost			
Purchase and installation cost	$75	$150	$225
Annual Costs			
Annualized purchase and installation cost	$22	$83	$124
Workers per shift	0.5	1	1.5
Labor costs ($/year)	$10,944	$21,888	$32,832
Water usage per head (gallon)	5	10	15
Water cost ($)	$5,621	$11,241	$16,862
Utilities costs ($)	$7,665	$15,329	$22,994
Repairs and maintenance costs ($)	$8	$15	$23
Total annual cost	$24,259	$48,557	$72,835
	Chicken Establishments		
Chiller (water)	**Low**	**Midpoint**	**High**
Initial Cost			
Purchase and installation cost	$3,000	$6,000	$9,000
Annual Costs			
Annualized purchase and installation cost	$886	$1,771	$2,657
Workers per shift	1	2	3
Labor costs ($)	$21,888	$43,776	$65,664
Water usage per head (gallon)	0.25	0.5	0.75
Utilities costs ($)	$8,897	$17,794	$26,690
Repairs and maintenance costs ($)	$300	$600	$900
Total annual cost	$31,970	$63,941	$95,911
Dip tank	**Low**	**Midpoint**	**High**
Initial Cost			
Purchase and installation cost	$750	$1,500	$2,250
Annual Costs			
Annualized purchase and installation cost	$221	$443	$664
Workers per shift	0.5	1	1.5
Labor costs ($)	$9,728	$19,456	$29,184
Water usage per head (gallon)	0.125	0.25	0.375
Utilities costs ($)	$4,448	$8,897	$13,345
Repairs and maintenance costs ($)	$75	$150	$225
Total annual cost	$14,473	$28,946	$43,418

(continued)

Table 4-7. Costs of Antimicrobial Equipment Used in Small Slaughter and Processing Establishments (continued)

	Turkey Establishments		
Chiller (water)	**Low**	**Midpoint**	**High**
Initial Cost			
Purchase and installation cost	$3,000	$6,000	$9,000
Annual Costs			
Annualized purchase and installation cost	$886	$1,771	$2,657
Workers per shift	1	2	3
Labor costs ($)	$21,888	$43,776	$65,664
Water usage per head (gallon)	0.31	1.25	2.81
Utilities costs ($)	$1,247	$4,988	$11,222
Repairs and maintenance costs ($)	$300	$600	$900
Total annual cost	$24,321	$51,135	$80,443
Dip tank	**Low**	**Midpoint**	**High**
Initial Cost			
Purchase and installation cost	$750	$1,500	$2,250
Annual Costs			
Annualized purchase and installation cost	$221	$443	$664
Workers per shift	0.5	1	1.5
Labor costs ($)	$9,728	$19,456	$29,184
Water usage per head (gallon)	0.5	0.625	0.75
Utilities costs ($)	$1,995	$2,494	$2,993
Repairs and maintenance costs ($)	$75	$150	$225
Total annual cost	$12,019	$22,543	$33,066

Table 4-8. Costs of Antimicrobial Equipment Used in Large Slaughter and Processing Establishments

Species: Beef, pork, chickens, and turkeys

Units: $s per establishment

	Beef		
Steam vacuum (Capacity: 300 head/hour)	**Low**	**Midpoint**	**High**
Initial Cost			
Purchase and installation cost	$70,000	$87,500	$105,000
Annual Costs			
Annualized purchase and installation cost	$17,072	$21,340	$25,609
Workers per shift	6	7.5	9
Labor costs ($)	$321,024	$401,280	$481,536
Water usage per head (gallon)	0.11	0.13	0.16
Water cost ($)	$184	$230	$276
Utilities cost ($)	$251	$314	$376
Repairs and maintenance costs ($)	$7,000	$8,750	$10,500
Total annual cost	$345,531	$431,914	$518,297
Steam pasteurization cabinet (Capacity: 300 head/hour)	**Low**	**Midpoint**	**High**
Initial Cost			
Purchase and installation cost	$800,000	$1,000,000	$1,200,000
Annual Costs			
Annualized purchase and installation cost	$113,902	$142,378	$170,853
Workers per shift	0.4	0.5	0.6
Labor costs ($)	$21,402	$26,752	$32,102
Water usage per head (gallon)	0.07	0.13	0.20
Water cost ($)	$115	$230	$345
Utilities cost ($)	$157	$314	$470
Repairs and maintenance costs ($)	$80,000	$100,000	$120,000
Total annual cost	$215,575	$269,673	$323,771

(continued)

Table 4-8. Costs of Antimicrobial Equipment Used in Large Slaughter and Processing Establishments (continued)

	Beef		
Spray cabinet (Capacity: 300 head/hour)	**Low**	**Midpoint**	**High**
Initial Cost			
Purchase and installation cost	$80,000	$100,000	$120,000
Annual Costs			
Annualized purchase and installation cost	$19,511	$24,389	$29,267
Workers per shift	0.4	0.5	0.6
Labor costs ($)	$21,402	$26,752	$32,102
Water usage per head (gallon)	100	125	150
Water cost ($)	$174,119	$217,649	$261,179
Utilities cost ($)	$237,435	$296,794	$356,153
Repairs and maintenance costs ($)	$8,000	$10,000	$12,000
Total annual cost	$460,467	$575,584	$690,701
Automated spray on subprimals/trimmings (Capacity: 500 head/hour)	**Low**	**Midpoint**	**High**
Initial Cost			
Purchase and installation cost	$24,000	$30,000	$36,000
Annual Costs			
Annualized purchase and installation cost	$5,853	$7,317	$8,780
Workers per shift	0.4	0.5	0.6
Labor costs ($)	$15,805	$19,756	$23,707
Water usage per head (gallon)	0.2	0.25	0.3
Water cost ($)	$348	$435	$522
Utilities cost ($)	$475	$594	$712
Repairs and maintenance costs ($)	$2,400	$3,000	$3,600
Total annual cost	$24,881	$31,102	$37,322

(continued)

Table 4-8. Costs of Antimicrobial Equipment Used in Large Slaughter and Processing Establishments (continued)

	Beef		
Hotbox/chilling (Capacity: 2,000–3,000 head/8–24 hours)	**Low**	**Midpoint**	**High**
Initial Cost			
Purchase and installation cost	$5,600,000	$6,000,000	$6,400,000
Annual Costs			
Annualized purchase and installation cost	$797,314	$854,265	$911,216
Workers per shift	0.8	1	1.2
Labor costs ($)	$42,803	$53,504	$64,205
Water usage per head (gallon)	16	32	48
Water cost ($)	$46,854	$93,708	$140,562
Utilities cost ($)	$37,990	$75,979	$113,969
Repairs and maintenance costs ($)	$560,000	$600,000	$640,000
Total annual cost	$1,484,961	$1,677,456	$1,869,951
Water sprayers in coolers (sometimes antimicrobials) (Capacity: 2,000–3,000 head/8–24 hours)	**Low**	**Midpoint**	**High**
Initial Cost			
Purchase and installation cost	$40,000	$50,000	$60,000
Annual Costs			
Annualized purchase and installation cost	$9,756	$12,195	$14,633
Workers per shift	0.4	0.5	0.6
Labor costs ($)	$21,402	$26,752	$32,102
Water usage per head (gallon)	0.2	0.25	0.3
Water cost ($)	$348	$435	$522
Utilities cost ($)	$475	$594	$712
Repairs and maintenance costs ($)	$4,000	$5,000	$6,000
Total annual cost	$35,980	$44,975	$53,971

(continued)

Table 4-8. Costs of Antimicrobial Equipment Used in Large Slaughter and Processing Establishments (continued)

	Pork		
Spray cabinet (Capacity: 1,000 head/hour * 2)	**Low**	**Midpoint**	**High**
Initial Cost			
Purchase and installation cost	$80,000	$100,000	$120,000
Annual Costs			
Annualized purchase and installation cost	$19,511	$24,389	$29,267
Workers per shift	0.4	0.5	0.6
Labor costs ($)	$21,402	$26,752	$32,102
Water usage per head (gallon)	50	62.5	75
Water cost ($)	$578,804	$723,504	$868,205
Utilities cost ($)	$789,278	$986,597	$1,183,916
Repairs and maintenance costs ($)	$8,000	$10,000	$12,000
Total annual cost	$1,416,994	$1,771,242	$2,125,491
Automated spray on subprimals/trimmings (Capacity: 1,500 head/hour * 4 lines)	**Low**	**Midpoint**	**High**
Initial Cost			
Purchase and installation cost	$24,000	$30,000	$36,000
Annual Costs			
Annualized purchase and installation cost	$5,853	$7,317	$8,780
Workers per shift	0.4	0.5	0.6
Labor costs ($)	$21,402	$26,752	$32,102
Water usage per head (gallon)	0.2	0.25	0.3
Water cost ($)	$2,315	$2,894	$3,473
Utilities cost ($)	$3,157	$3,946	$4,736
Repairs and maintenance costs ($)	$2,400	$3,000	$3,600
Total annual cost	$35,127	$43,909	$52,691

(continued)

Table 4-8. Costs of Antimicrobial Equipment Used in Large Slaughter and Processing Establishments (continued)

		Pork	
Blast chill (Capacity: 1,000 head/hour)	**Low**	**Midpoint**	**High**
Initial Cost			
Purchase and installation cost	$5,600,000	$6,000,000	$6,400,000
Annual Costs			
Annualized purchase and installation cost	$797,314	$854,265	$911,216
Workers per shift	0.8	1	1.2
Labor costs ($)	$42,803	$53,504	$64,205
Water usage per head (gallon)	8	10	12
Water cost ($)	$155,751	$194,688	$233,626
Utilities cost ($)	$126,284	$157,856	$189,427
Repairs and maintenance costs ($)	$560,000	$600,000	$640,000
Total annual cost	$1,682,152	$1,860,313	$2,038,474
		Chickens	
Inside-outside bird washer (Capacity: 140/min with 2 per line and 2 lines)	**Low**	**Midpoint**	**High**
Initial Cost			
Purchase and installation cost	$60,000	$75,000	$90,000
Annual Costs			
Annualized purchase and installation cost	$14,633	$18,292	$21,950
Workers per shift	0.2	0.25	0.3
Labor costs ($)	$10,701	$13,376	$16,051
Water usage per head (gallon)	0.4	0.5	0.6
Utilities cost ($)	$76,163	$95,203	$114,244
Repairs and maintenance costs ($)	$6,000	$7,500	$9,000
Total annual cost	$107,497	$134,371	$161,245

(continued)

Table 4-8. Costs of Antimicrobial Equipment Used in Large Slaughter and Processing Establishments (continued)

	Chickens		
Pre-chill drench (CPC) or spray (PAA) cabinet (Capacity: 140/min with 2 lines)	**Low**	**Midpoint**	**High**
Initial Cost			
Purchase and installation cost	$44,000	$55,000	$66,000
Annual Costs			
Annualized purchase and installation cost	$10,731	$13,414	$16,097
Workers per shift	0.2	0.25	0.3
Labor costs ($)	$10,701	$13,376	$16,051
Water usage per head (gallon)	0.5	0.625	0.75
Utilities cost ($)	$95,203	$119,004	$142,805
Repairs and maintenance costs ($)	$4,400	$5,500	$6,600
Total annual cost	$121,035	$151,294	$181,553
Chiller (water) (Capacity: 2 * 140 birds/min)	**Low**	**Midpoint**	**High**
Initial Cost			
Purchase and installation cost	$800,000	$1,000,000	$1,200,000
Annual Costs			
Annualized purchase and installation cost	$113,902	$142,378	$170,853
Workers per shift	0.4	0.5	0.6
Labor costs ($)	$21,402	$26,752	$32,102
Water usage per head (gallon)	2	2.5	3
Utilities cost ($)	$380,813	$476,017	$571,220
Repairs and maintenance costs ($)	$80,000	$100,000	$120,000
Total annual cost	$596,117	$745,146	$894,176

(continued)

Table 4-8. Costs of Antimicrobial Equipment Used in Large Slaughter and Processing Establishments (continued)

	Chickens		
Post-chill dip tank/finishing chiller (Capacity: 280 birds for 10–12 seconds)	**Low**	**Midpoint**	**High**
Initial Cost			
Purchase and installation cost	$60,000	$75,000	$90,000
Annual Costs			
Annualized purchase and installation cost	$14,633	$18,292	$21,950
Workers per shift	0.2	0.25	0.3
Labor costs ($)	$10,701	$13,376	$16,051
Water usage per head (gallon)	0.2	0.25	0.3
Utilities cost ($)	$38,081	$47,602	$57,122
Repairs and maintenance costs ($)	$6,000	$7,500	$9,000
Total annual cost	$69,416	$86,769	$104,123
Post-chill spray bars (Capacity: 60–75 birds per minute)	**Low**	**Midpoint**	**High**
Initial Cost			
Purchase and installation cost	$12,000	$15,000	$18,000
Annual Costs			
Annualized purchase and installation cost	$2,927	$3,658	$4,390
Workers per shift	0.2	0.25	0.3
Labor costs ($)	$10,701	$13,376	$16,051
Water usage per head (gallon)	0.125	0.25	0.375
Utilities cost ($)	$23,801	$47,602	$71,403
Repairs and maintenance costs ($)	$1,200	$1,500	$1,800
Total annual cost	$38,628	$66,136	$93,644

(continued)

Table 4-8. Costs of Antimicrobial Equipment Used in Large Slaughter and Processing Establishments (continued)

	Turkeys		
Inside-outside bird washer (Capacity: 140/min with 2 per line and 2 lines)	**Low**	**Midpoint**	**High**
Initial Cost			
Purchase and installation cost	$240,000	$300,000	$360,000
Annual Costs			
Annualized purchase and installation cost	$58,534	$73,167	$87,801
Workers per shift	0.2	0.25	0.3
Labor costs ($)	$9,728	$12,160	$14,592
Water usage per head (gallon)	1	1.25	1.5
Utilities cost ($)	$31,337	$39,171	$47,005
Repairs and maintenance costs ($)	$24,000	$30,000	$36,000
Total annual cost	$123,598	$154,498	$185,397
Pre-chill drench (CPC) or spray (PAA) cabinet (Capacity: 140/min with 2 lines)	**Low**	**Midpoint**	**High**
Initial Cost			
Purchase and installation cost	$44,000	$55,000	$66,000
Annual Costs			
Annualized purchase and installation cost	$10,731	$13,414	$16,097
Workers per shift	0.2	0.25	0.3
Labor costs ($)	$9,728	$12,160	$14,592
Water usage per head (gallon)	1.3	1.6	1.9
Utilities cost ($)	$39,171	$48,963	$58,756
Repairs and maintenance costs ($)	$4,400	$5,500	$6,600
Total annual cost	$64,030	$80,037	$96,045

(continued)

Table 4-8. Costs of Antimicrobial Equipment Used in Large Slaughter and Processing Establishments (continued)

	Turkeys		
Chiller (Capacity: 2 * 140 birds/min)	**Low**	**Midpoint**	**High**
Initial Cost			
Purchase and installation cost	$800,000	$1,000,000	$1,200,000
Annual Costs			
Annualized purchase and installation cost	$113,902	$142,378	$170,853
Workers per shift	0.4	0.5	0.6
Labor costs ($)	$19,456	$24,320	$29,184
Water usage per head (gallon)	5	6.25	7.5
Utilities cost ($)	$156,683	$195,853	$235,024
Repairs and maintenance costs ($)	$80,000	$100,000	$120,000
Total annual cost	$370,041	$462,551	$555,061
Post-chill dip tank/finishing chiller (Capacity: 280 birds for 10-12 seconds)	**Low**	**Midpoint**	**High**
Initial Cost			
Purchase and installation cost	$60,000	$75,000	$90,000
Annual Costs			
Annualized purchase and installation cost	$14,633	$18,292	$21,950
Workers per shift	0.2	0.25	0.3
Labor costs ($)	$9,728	$12,160	$14,592
Water usage per head (gallon)	0.5	0.625	0.75
Utilities cost ($)	$15,668	$19,585	$23,502
Repairs and maintenance costs ($)	$6,000	$7,500	$9,000
Total annual cost	$46,030	$57,537	$69,045

(continued)

Table 4-8. Costs of Antimicrobial Equipment Used in Large Slaughter and Processing Establishments (continued)

	Turkeys		
Post-chill spray bars (Capacity: 60–75 birds / min)	**Low**	**Midpoint**	**High**
Initial Cost			
Purchase and installation cost	$12,000	$15,000	$18,000
Annual Costs			
Annualized purchase and installation cost	$2,927	$3,658	$4,390
Workers per shift	0.2	0.25	0.3
Labor costs ($)	$9,728	$12,160	$14,592
Water usage per head (gallon)	0.5	0.625	0.75
Utilities cost ($)	$15,668	$19,585	$23,502
Repairs and maintenance costs ($)	$1,200	$1,500	$1,800
Total annual cost	$29,523	$36,904	$44,284

4.4 COSTS OF ANTIMICROBIAL SOLUTIONS

FSIS requested data on the costs of antimicrobial solutions that would be used with the antimicrobial equipment described in Section 4.3. The original list of solutions provided by FSIS included the following: acidified sodium chlorite, bromine, cetylpyridium chloride (CPC), chlorine dioxide, electrolyzed water, hypochlorous acid, monochloromine, organic acids, peracitic acid (PAA), trisodium phosphate, and lauric arginate (used on RTE products).

… the experts noted that the cost of using lauric arginate on RTE products is $0.03 per pound of product produced.

The experts concluded that several of these solutions are not used by industry; thus, we eliminated the following from our analysis: bromine, electrolyzed water, monochloromine, and trisodium phosphate. Table 4-9 shows the remaining antimicrobial solutions and the types of establishments in which they are used.

The experts then ranked the solutions in terms of costs for each species and provided cost estimates for the lowest and highest cost solutions by species. We show the cost per head and annual costs for each species for small and large establishments in Table 4-10. Although it was not a focus of our data collection efforts, the experts noted that the cost of using

lauric arginate on RTE products is $0.03 per pound of product produced.

Table 4-9. Antimicrobial Solutions Used

Solutions Used	Beef	Pork	Poultry
Acidified sodium chlorite	Minimal	Minimal	Used
Cetylpyridium chloride (CPC)	Not used	Not used	Used
Chlorine dioxide	Minimal	Not used	Minimal
Hypochlorous acid	Used	Used	Used
Organic acids	Used	Used	Used
Peracetic acid (PAA)	Used	Used	Used

Table 4-10. Costs of Antimicrobial Solutions, Low and High Cost Methods

Species: Beef, pork, chickens, and turkeys

Units: $ per establishment

	Lowest Cost Method			Highest Cost Method		
	Low	**Midpoint**	**High**	**Low**	**Midpoint**	**High**
Beef—Small Est.	Hypochlorous Acid			Organic Acids		
Cost per head ($)	$0.045	$0.050	$0.055	$1.575	$1.750	$1.925
Total annual cost ($)	$1,638	$1,820	$2,002	$57,330	$63,700	$70,070
Beef—Large Est.	Organic Acids			Peracetic Acid (PAA)		
Cost per head ($)	$0.158	$0.175	$0.193	$1.656	$1.840	$2.024
Total annual cost ($)	$124,653	$138,504	$152,354	$1,310,641	$1,456,268	$1,601,895
Pork—Small Est.	Hypochlorous Acid			Organic Acids		
Cost per head ($)	$0.045	$0.050	$0.055	$1.575	$1.750	$1.925
Total annual cost ($)	$22,994	$25,549	$28,104	$804,786	$894,206	$983,627
Pork—Large Est.	Organic Acids			Peracetic Acid (PAA)		
Cost per head ($)	$0.135	$0.150	$0.165	$1.620	$1.800	$1.980
Total annual cost ($)	$710,350	$789,278	$868,205	$8,524,197	$9,471,330	$10,418,463
Chickens—Small Est.	Hypochlorous Acid			Cetylpyridium chloride (CPC)		
Cost per head ($)	$0.001	$0.001	$0.001	$0.810	$0.900	$0.990
Total annual cost ($)	$10,676	$11,862	$13,049	$9,608,544	$10,676,160	$11,743,776

(continued)

Table 4-10. Costs of Antimicrobial Solutions, Low and High Cost Methods (continued)

Species: Beef, pork, chickens, and turkeys

Units: $ per establishment

	Lowest Cost Method			Highest Cost Method		
	Low	**Midpoint**	**High**	**Low**	**Midpoint**	**High**
Chickens—Large Est.	Hypochlorous Acid			Cetylpyridium chloride (CPC)		
Cost per head ($)	$0.001	$0.001	$0.001	$0.810	$0.900	$0.990
Total annual cost ($)	$57,122	$63,469	$69,816	$51,409,809	$57,122,010	$62,834,211
Turkeys—Small Est.	Hypochlorous Acid			Cetylpyridium chloride (CPC)		
Cost per head ($)	$0.001	$0.001	$0.001	$0.810	$0.900	$0.990
Total annual cost ($)	$1,197	$1,330	$1,463	$1,077,300	$1,197,000	$1,316,700
Turkeys—Large Est.	Hypochlorous Acid			Cetylpyridium chloride (CPC)		
Cost per head ($)	$0.001	$0.001	$0.001	$0.810	$0.900	$0.990
Total annual cost ($)	$9,401	$10,446	$11,490	$8,460,855	$9,400,950	$10,341,045

Our assumptions and notes for these calculations are as follows:

- **Materials** costs are for the cost of the antimicrobial solutions. The solution costs are similar across species on a per-gallon basis but vary based on the volume of the solution needed per head or bird. For chicken and turkey establishments, the per-bird costs of the lowest cost solution are the same across all small establishments.
- **Margin of error** for this intervention is assumed to equal 10%.

Thus, the annual costs of using antimicrobial solutions ($COST\_AS_{s,j,l}$) were calculated as

$$COST\_AS_{s,j,l} = COST\_H_l \bullet HPY_{s,j}$$

where $COST\_H_l$ is the cost of antimicrobial solution per head for solution l and $HPY_{s,j}$ is the number of head slaughtered per year for species s and establishment size j.

4.5 COSTS OF SANITIZING EQUIPMENT

FSIS requested the costs of various sanitizing equipment, including knife and other equipment sanitizers, boot washing

stations, and hand washing stations. The experts recommended that we add an additional intervention: floor foamers. This technology sprays a sanitizing foam on the floors near doorways that employees walk through to sanitize their shoes.

Using assumptions from the expert panel on the typical number of equipment stations per establishment, we developed estimates for installing and operating sanitizing equipment for small and large establishments by species (Table 4-11). Capital equipment and labor costs are the same across species, but materials costs vary when slaughter volumes are applied to calculate the annual estimates. The panelists distinguished between the manual hand washing stations at slaughter and processing establishments and the more expensive automated stations at RTE establishments.[12]

Table 4-11. Sanitizing Equipment Costs

Species: Beef, pork, chickens, and turkeys

Units: $s per establishment

	Beef					
	Small Establishments			Large Establishments		
Knife and other equipment sanitizers	**Low**	**Midpoint**	**High**	**Low**	**Midpoint**	**High**
Typical number of stations	1	2	3	8	15	23
Initial Cost						
Purchase and installation cost ($/unit)	$750	$1,000	$1,250	$750	$1,000	$1,250
Total initial cost ($)	$750	$2,000	$3,750	$5,625	$15,000	$28,125
Annual Costs						
Annualized purchase and installation cost	$183	$244	$305	$183	$244	$305

(continued)

[12] The panelists also noted that manual hand washing stations are different from hand washing areas in restrooms.

Table 4-11. Sanitizing Equipment Costs (continued)

	Beef					
	Small Establishments			Large Establishments		
	Low	Midpoint	High	Low	Midpoint	High
Labor hours per shift	0.25	0.25	0.25	0.5	0.5	0.5
Labor costs ($/year)	$608	$608	$608	$3,344	$3,344	$3,344
Materials ($/shift)	$1	$1	$1	$5	$5	$5
Materials ($/year)	$200	$200	$200	$2,750	$2,750	$2,750
Maintenance costs ($/year)	$75	$200	$375	$563	$1,500	$2,813
Total annual costs	$1,066	$1,252	$1,488	$6,839	$7,838	$9,211
Boot washing systems						
Typical number of stations	0.5	1	2	1	2	3
Initial Cost						
Purchase and installation cost ($/unit)	$413	$550	$688	$9,000	$12,000	$15,000
Total initial cost ($)	$206	$550	$1,031	$9,000	$24,000	$45,000
Annual Costs						
Annualized purchase and installation cost	$101	$134	$168	$2,195	$2,927	$3,658
Labor hours per shift	0.25	0.25	0.25	0.5	0.5	0.5
Labor costs ($/year)	$608	$608	$608	$3,344	$3,344	$3,344
Materials ($/shift)	$1	$1	$1	$5	$5	$5
Materials ($/year)	$200	$200	$200	$2,750	$2,750	$2,750
Maintenance costs ($/year)	$21	$55	$103	$900	$2,400	$4,500
Total annual costs	$929	$997	$1,079	$9,189	$11,421	$14,252
	Small Establishment			Large Establishment		
Hand washing stations	Low	Midpoint	High	Low	Midpoint	High
Typical number of stations	1	2	3	3	5	8
Initial Cost						
Purchase and installation cost ($/unit)	$750	$1,000	$1,250	$750	$1,000	$1,250
Total initial cost ($)	$750	$2,000	$3,750	$1,875	$5,000	$9,375
Annual Costs						
Annualized purchase and installation cost	$183	$244	$305	$183	$244	$305

(continued)

Table 4-11. Sanitizing Equipment Costs (continued)

	Beef					
	Small Establishment			Large Establishment		
Hand washing stations	**Low**	**Midpoint**	**High**	**Low**	**Midpoint**	**High**
Labor hours per shift	0.25	0.25	0.25	0.5	0.5	0.5
Labor costs ($/year)	$608	$608	$608	$3,344	$3,344	$3,344
Materials ($/shift)	$1	$1	$1	$5	$5	$5
Materials ($/year)	$200	$200	$200	$2,750	$2,750	$2,750
Maintenance costs ($/year)	$75	$200	$375	$188	$500	$938
Total annual costs	$1,066	$1,252	$1,488	$6,464	$6,838	$7,336
	Small Establishment			**Large Establishment**		
Floor foamers	**Low**	**Midpoint**	**High**	**Low**	**Midpoint**	**High**
Typical number of stations	2	3	5	5	10	15
Initial Cost						
Purchase and installation cost ($/unit)	$1,350	$1,800	$2,250	$1,350	$1,800	$2,250
Total initial cost ($)	$2,025	$5,400	$10,125	$6,750	$18,000	$33,750
Annual Costs						
Annualized purchase and installation cost	$329	$439	$549	$329	$439	$549
Labor hours per shift	0.25	0.25	0.25	0.5	0.5	0.5
Labor costs ($/year)	$608	$608	$608	$3,344	$3,344	$3,344
Materials ($/day)	$27	$27	$27	$270	$270	$270
Materials ($/year)	$5,400	$5,400	$5,400	$74,250	$74,250	$74,250
Maintenance costs ($/year)	$203	$540	$1,013	$675	$1,800	$3,375
Total annual costs	$6,540	$6,987	$7,569	$78,598	$79,833	$81,518
	Pork					
	Small Establishment			Large Establishment		
Knife and other equipment sanitizers	**Low**	**Midpoint**	**High**	**Low**	**Midpoint**	**High**
Typical number of stations	1	2	3	8	15	23
Initial Cost						
Purchase and installation cost ($/unit)	$750	$1,000	$1,250	$750	$1,000	$1,250

(continued)

Table 4-11. Sanitizing Equipment Costs (continued)

	Pork					
	Small Establishment			Large Establishment		
Knife and other equipment sanitizers	**Low**	**Midpoint**	**High**	**Low**	**Midpoint**	**High**
Total initial cost ($)	$750	$2,000	$3,750	$5,625	$15,000	$28,125
Annual Costs						
Annualized purchase and installation cost	$183	$244	$305	$183	$244	$305
Labor hours per shift	0.25	0.25	0.25	0.5	0.5	0.5
Labor costs ($/year)	$684	$684	$684	$3,344	$3,344	$3,344
Materials ($/shift)	$1	$1	$1	$5	$5	$5
Materials ($/year)	$225	$225	$225	$2,750	$2,750	$2,750
Maintenance costs ($/year)	$75	$200	$375	$563	$1,500	$2,813
Total annual costs	$1,167	$1,353	$1,589	$6,839	$7,838	$9,211
	Small Establishment			**Large Establishment**		
Boot washing systems	**Low**	**Midpoint**	**High**	**Low**	**Midpoint**	**High**
Typical number of stations	0.5	1	2	1	2	3
Initial Cost						
Purchase and installation cost ($/unit)	$413	$550	$688	$9,000	$12,000	$15,000
Total initial cost ($)	$206	$550	$1,031	$9,000	$24,000	$45,000
Annual Costs						
Annualized purchase and installation cost	$101	$134	$168	$2,195	$2,927	$3,658
Labor hours per shift	0.25	0.25	0.25	0.5	0.5	0.5
Labor costs ($/year)	$684	$684	$684	$3,344	$3,344	$3,344
Materials ($/shift)	$1	$1	$1	$5	$5	$5
Materials ($/year)	$225	$225	$225	$2,750	$2,750	$2,750
Maintenance costs ($/year)	$21	$55	$103	$900	$2,400	$4,500
Total annual costs	$1,030	$1,098	$1,180	$9,189	$11,421	$14,252

(continued)

Table 4-11. Sanitizing Equipment Costs (continued)

	Pork					
	Small Establishment			Large Establishment		
Hand washing stations	**Low**	**Midpoint**	**High**	**Low**	**Midpoint**	**High**
Typical number of stations	1	2	3	3	5	8
Initial Cost						
Purchase and installation cost ($/unit)	$750	$1,000	$1,250	$750	$1,000	$1,250
Total initial cost ($)	$750	$2,000	$3,750	$1,875	$5,000	$9,375
Annual Costs						
Annualized purchase and installation cost	$183	$244	$305	$183	$244	$305
Labor hours per shift	0.25	0.25	0.25	0.5	0.5	0.5
Labor costs ($/year)	$684	$684	$684	$3,344	$3,344	$3,344
Materials ($/shift)	$1	$1	$1	$5	$5	$5
Materials ($/year)	$225	$225	$225	$2,750	$2,750	$2,750
Maintenance costs ($/year)	$75	$200	$375	$188	$500	$938
Total annual costs	$1,167	$1,353	$1,589	$6,464	$6,838	$7,336
	Small Establishment			**Large Establishment**		
Floor foamers	**Low**	**Midpoint**	**High**	**Low**	**Midpoint**	**High**
Typical number of stations	2	3	5	5	10	15
Initial Cost						
Purchase and installation cost ($/unit)	$1,350	$1,800	$2,250	$1,350	$1,800	$2,250
Total initial cost ($)	$2,025	$5,400	$10,125	$6,750	$18,000	$33,750
Annual Costs						
Annualized purchase and installation cost	$329	$439	$549	$329	$439	$549
Labor hours per shift	0.25	0.25	0.25	0.5	0.5	0.5
Labor costs ($/year)	$684	$684	$684	$3,344	$3,344	$3,344
Materials ($/day)	$27	$27	$27	$270	$270	$270
Materials ($/year)	$6,075	$6,075	$6,075	$74,250	$74,250	$74,250
Maintenance costs ($/year)	$203	$540	$1,013	$675	$1,800	$3,375
Total annual costs	$7,291	$7,738	$8,320	$78,598	$79,833	$81,518

(continued)

Table 4-11. Sanitizing Equipment Costs (continued)

	Chicken					
	Small Establishment			Large Establishment		
Knife and other equipment sanitizers	**Low**	**Midpoint**	**High**	**Low**	**Midpoint**	**High**
Typical number of stations	1	2	3	8	15	23
Initial Cost						
Purchase and installation cost ($/unit)	$750	$1,000	$1,250	$750	$1,000	$1,250
Total initial cost ($)	$750	$2,000	$3,750	$5,625	$15,000	$28,125
Annual Costs						
Annualized purchase and installation cost	$183	$244	$305	$183	$244	$305
Labor hours per shift	0.25	0.25	0.25	0.5	0.5	0.5
Labor costs ($/year)	$608	$608	$608	$3,344	$3,344	$3,344
Materials ($/shift)	$1	$1	$1	$5	$5	$5
Materials ($/year)	$200	$200	$200	$2,750	$2,750	$2,750
Maintenance costs ($/year)	$75	$200	$375	$563	$1,500	$2,813
Total annual costs	$1,066	$1,252	$1,488	$6,839	$7,838	$9,211
	Small Establishment			**Large Establishment**		
Boot washing systems	**Low**	**Midpoint**	**High**	**Low**	**Midpoint**	**High**
Typical number of stations	1	1	2	1	2	3
Initial Cost						
Purchase and installation cost ($/unit)	$413	$550	$688	$9,000	$12,000	$15,000
Total initial cost ($)	$206	$550	$1,031	$9,000	$24,000	$45,000
Annual Costs						
Annualized purchase and installation cost	$101	$134	$168	$2,195	$2,927	$3,658
Labor hours per shift	0.25	0.25	0.25	0.5	0.5	0.5
Labor costs ($/year)	$608	$608	$608	$3,344	$3,344	$3,344
Materials ($/shift)	$1	$1	$1	$5	$5	$5
Materials ($/year)	$200	$200	$200	$2,750	$2,750	$2,750
Maintenance costs ($/year)	$21	$55	$103	$900	$2,400	$4,500
Total annual costs	$929	$997	$1,079	$9,189	$11,421	$14,252

(continued)

Table 4-11. Sanitizing Equipment Costs (continued)

	Chicken					
	Small Establishment			Large Establishment		
Hand washing stations	**Low**	**Midpoint**	**High**	**Low**	**Midpoint**	**High**
Typical number of stations	1	2	3	3	5	8
Initial Cost						
Purchase and installation cost ($/unit)	$750	$1,000	$1,250	$750	$1,000	$1,250
Total initial cost ($)	$750	$2,000	$3,750	$1,875	$5,000	$9,375
Annual Costs						
Annualized purchase and installation cost	$183	$244	$305	$183	$244	$305
Labor hours per shift	0.25	0.25	0.25	0.5	0.5	0.5
Labor costs ($/year)	$608	$608	$608	$3,344	$3,344	$3,344
Materials ($/shift)	$1	$1	$1	$5	$5	$5
Materials ($/year)	$200	$200	$200	$2,750	$2,750	$2,750
Maintenance costs ($/year)	$75	$200	$375	$188	$500	$938
Total annual costs	$1,066	$1,252	$1,488	$6,464	$6,838	$7,336
	Small Establishment			**Large Establishment**		
Floor foamers	**Low**	**Midpoint**	**High**	**Low**	**Midpoint**	**High**
Typical number of stations	2	3	5	5	10	15
Initial Cost						
Purchase and installation cost ($/unit)	$1,350	$1,800	$2,250	$1,350	$1,800	$2,250
Total initial cost ($)	$2,025	$5,400	$10,125	$6,750	$18,000	$33,750
Annual Costs						
Annualized purchase and installation cost	$329	$439	$549	$329	$439	$549
Labor hours per shift	0.25	0.25	0.25	0.5	0.5	0.5
Labor costs ($/year)	$608	$608	$608	$3,344	$3,344	$3,344
Materials ($/day)	$27	$27	$27	$270	$270	$270
Materials ($/year)	$5,400	$5,400	$5,400	$74,250	$74,250	$74,250
Maintenance costs ($/year)	$203	$540	$1,013	$675	$1,800	$3,375
Total annual costs	$6,540	$6,987	$7,569	$78,598	$79,833	$81,518

(continued)

Table 4-11. Sanitizing Equipment Costs (continued)

	Turkey					
	Small Establishment			Large Establishment		
Knife and other equipment sanitizers	**Low**	**Midpoint**	**High**	**Low**	**Midpoint**	**High**
Typical number of stations	1	2	3	8	15	23
Initial Cost						
Purchase and installation cost ($/unit)	$750	$1,000	$1,250	$750	$1,000	$1,250
Total initial cost ($)	$750	$2,000	$3,750	$5,625	$15,000	$28,125
Annual Costs						
Annualized purchase and installation cost	$183	$244	$305	$183	$244	$305
Labor hours per shift	0.25	0.25	0.25	0.5	0.5	0.5
Labor costs ($/year)	$608	$608	$608	$3,040	$3,040	$3,040
Materials ($/shift)	$1	$1	$1	$5	$5	$5
Materials ($/year)	$200	$200	$200	$2,500	$2,500	$2,500
Maintenance costs ($/year)	$75	$200	$375	$563	$1,500	$2,813
Total annual costs	$1,066	$1,252	$1,488	$6,285	$7,284	$8,657
	Small Establishment			**Large Establishment**		
Boot washing systems	**Low**	**Midpoint**	**High**	**Low**	**Midpoint**	**High**
Typical number of stations	1	1	2	1	2	3
Initial Cost						
Purchase and installation cost ($/unit)	$413	$550	$688	$9,000	$12,000	$15,000
Total initial cost ($)	$206	$550	$1,031	$9,000	$24,000	$45,000
Annual Costs						
Annualized purchase and installation cost	$101	$134	$168	$2,195	$2,927	$3,658
Labor hours per shift	0.25	0.25	0.25	0.5	0.5	0.5
Labor costs ($/year)	$608	$608	$608	$3,040	$3,040	$3,040
Materials ($/shift)	$1	$1	$1	$5	$5	$5
Materials ($/year)	$200	$200	$200	$2,500	$2,500	$2,500
Maintenance costs ($/year)	$21	$55	$103	$900	$2,400	$4,500
Total annual costs	$929	$997	$1,079	$8,635	$10,867	$13,698

(continued)

Table 4-11. Sanitizing Equipment Costs (continued)

	Turkey					
	Small Establishment			Large Establishment		
Hand washing stations	**Low**	**Midpoint**	**High**	**Low**	**Midpoint**	**High**
Typical number of stations	1	2	3	3	5	8
Initial Cost						
Purchase and installation cost ($/unit)	$750	$1,000	$1,250	$750	$1,000	$1,250
Total initial cost ($)	$750	$2,000	$3,750	$1,875	$5,000	$9,375
Annual Costs						
Annualized purchase and installation cost	$183	$244	$305	$183	$244	$305
Labor hours per shift	0.25	0.25	0.25	0.5	0.5	0.5
Labor costs ($/year)	$608	$608	$608	$3,040	$3,040	$3,040
Materials ($/shift)	$1	$1	$1	$5	$5	$5
Materials ($/year)	$200	$200	$200	$2,500	$2,500	$2,500
Maintenance costs ($/year)	$75	$200	$375	$188	$500	$938
Total annual costs	$1,066	$1,252	$1,488	$5,910	$6,284	$6,782
	Small Establishment			**Large Establishment**		
Floor foamers	**Low**	**Midpoint**	**High**	**Low**	**Midpoint**	**High**
Typical number of stations	2	3	5	5	10	15
Initial Cost						
Purchase and installation cost ($/unit)	$1,350	$1,800	$2,250	$1,350	$1,800	$2,250
Total initial cost ($)	$2,025	$5,400	$10,125	$6,750	$18,000	$33,750
Annual Costs						
Annualized purchase and installation cost	$329	$439	$549	$329	$439	$549
Labor hours per shift	0.25	0.25	0.25	0.5	0.5	0.5
Labor costs ($/year)	$608	$608	$608	$3,040	$3,040	$3,040
Materials ($/day)	$27	$27	$27	$270	$270	$270
Materials ($/year)	$5,400	$5,400	$5,400	$67,500	$67,500	$67,500
Maintenance costs ($/year)	$203	$540	$1,013	$675	$1,800	$3,375
Total annual costs	$6,540	$6,987	$7,569	$71,544	$72,779	$74,464

(continued)

Table 4-11. Sanitizing Equipment Costs (continued)

	RTE Processing		
	Large Establishment		
Hand washing stations	**Low**	**Midpoint**	**High**
Typical number of stations	2	3	5
Initial Cost			
Purchase and installation cost ($/unit)	$22,500	$30,000	$37,500
Total initial cost ($)	$33,750	$90,000	$168,750
Annual Costs			
Annualized purchase and installation cost	$5,488	$7,317	$9,146
Labor hours per shift	0.5	0.5	0.5
Labor costs ($/year)	$4,180	$4,180	$4,180
Materials ($/shift)	$5	$5	$5
Materials ($/year)	$3,437.50	$3,437.50	$3,437.50
Maintenance costs ($/year)	$3,375	$9,000	$16,875
Total annual costs	$16,480	$23,934	$33,638

Our assumptions and notes for these calculations are as follows:

- **Capital equipment** costs were estimated by the experts. We amortized the capital equipment costs over 5 years, assuming a 7% interest rate.
- **Labor type** for this intervention would be production employees to monitor the dosage of chemicals in the equipment (not labor time spent in sanitizing hands, boots, or knives). The experts estimated that one employee would spend 0.25 labor hours per shift on this activity.
- **Materials**[13] for this intervention include quaternary ammonia for boot washing stations and soap, sanitizers, paper towels, and gloves for hand washing stations. The costs were estimated by the experts at $1 per day for

[13] Water is also used as an input for sanitizing equipment, particularly for boot and hand washing stations. However, we do not have estimates for the amount of water used by this equipment; therefore, it is not included in the cost estimates.

small establishments and $5 per shift for large establishments for knife sanitizers and hand and boot sanitizing stations. For floor foamers, we obtained an estimate of $9 per gallon from a manufacturer. Assuming that small establishments use 3 gallons per day and large establishments use 30 gallons per day, the daily cost is $27 for small establishments and $270 for large establishments.

- **Maintenance** costs are 10% of the cost of the capital equipment.
- **Margin of error** for this intervention is assumed to be 25% for equipment costs and 50% for the number of stations.

Thus, the annual costs of sanitizing equipment ($COST\_SE_{i,j,s}$) were calculated as

$$COST\_SE_{i,j,s} = CAP\_AM_{i,j}^{n} + (LH\_PR_i \bullet SPY_s \bullet WR\_PR) + MAT_{j,l} + (CAP_i \bullet 0.10),$$

where $CAP\_AM_{i,j}^{n}$ is the amortized capital cost of equipment i at establishment size j over n years, LH_PR_i is the number of labor hours for a production employee per shift for equipment i, SPY_s is the number of shifts per year for species s, WR_PR is the wage rate of a production employee, $MAT_{i,j}$ is the cost of materials for equipment i at establishment size j, and CAP_i is the capital cost of equipment i (cost per station times number of stations).

4.6 COSTS OF STORAGE

FSIS requested data on the costs of records storage and cold storage for product. There are two types of records storage (physical storage and electronic storage) and two types of cold storage (refrigerated and frozen). Table 4-12 displays the costs of each of these types of storage, which were obtained from various vendors.

Physical records storage requires dedicated space within the establishment for filing cabinets. If there is not enough space, we assume that the company will rent a portable storage locker and place it on the company property. We obtained the cost of a filing cabinet from an office supply website, www.staples.com, and the cost of a portable storage locker from a vendor's e-mail quote. The experts did not believe offsite storage of physical records is common.

For smaller establishments, electronic records storage requires the use of an external hard drive to store data, as well as Internet and backup services to store larger amounts of data. We obtained the cost of an external hard drive from an office supply website, www.staples.com, and the cost of monthly Internet service from a vendor quote by telephone. The monthly Internet service price assumes the business has between 20 and 35 employees and allows for 35 MB download/5 MB upload with unlimited wireless service. The monthly server backup service, or "cloud" storage, price was obtained from a server backup website (www.carbonite.com). The quoted price is for three application servers and a total of 250 GB of space. Larger establishments that are part of a corporation will have integrated computer systems with a dedicated IT staff person.

The main difference in cold storage prices is based on whether the product needs to be refrigerated or frozen; frozen cold storage costs are double the amount of refrigerated cold storage.

For cold storage, we assume that the cost of creating and maintaining onsite storage would be equivalent to third-party, offsite cold storage. The establishment needs to ensure that the offsite cold storage facility is certified for food-grade products by USDA. Incoming product will already be cooled, so the storage facility would only need to maintain the product temperature. The main difference in cold storage prices is based on whether the product needs to be refrigerated or frozen; frozen cold storage costs are double the amount of refrigerated cold storage.

Table 4-12. Storage Costs

Species: Beef, pork, chickens, and turkeys	
Records storage—physical	**Midpoint**
Filing cabinet	$85
Locker rental ($/month)	$139
Records storage—electronic	
External hard drive	$130
Internet service ($/month)	$189
Backup server service ($/month)	$66
Cold storage—refrigerated	
Cost of storage ($/lb/month)	$0.05
Cold storage—frozen	
Cost of storage ($/lb/month)	$0.10

4.7 COSTS OF REMOVAL OF INEDIBLES AND DOWNED ANIMALS

FSIS is interested in the costs of removing inedible materials and downed animals from slaughter facilities. Inedible materials do not include offal, which is edible. Downed animals are either dead upon arrival or die during lairage before the slaughter process begins. Estimates for these activities were obtained from the experts.

For inedibles, the experts estimated that small beef establishments spend $65 per week on a third-party service to remove them from the premises. The experts stated a large margin of error for this intervention, as establishments follow a wide range of practices. For instance, very small establishments will sometimes compost the inedibles, whereas some large establishments have their own rendering plant.

In comparison to small establishments, large establishments receive payment for inedible materials. In particular, large beef establishments receive $0.10 per pound by sending their inedibles to a renderer. Large poultry establishments are paid $0.04 per pound for feathers and other inedibles that go into pet food.

For downed animal removal, beef establishments are able to sell the hides for approximately $65 per head, which offsets the downed animal removal costs. Poultry mortality rates prior to slaughter are very low. When they occur, broiler establishments lose $3 per head in lost value.

4.8 COSTS OF THIRD-PARTY AUDITS

Although third-party audits are customer driven and not regulatory driven, FSIS needs estimates of the costs incurred by slaughter and processing establishments for third-party audits. FSIS requested the cost of having GFSI, ISO, and SQF audits. However, ISO and SQF are benchmarked to GFSI; thus the experts only calculated the cost of a GFSI audit. To learn more about GFSI, see http://www.mygfsi.com/schemes-certification/overview.html.

Costs for an audit are the same across species and are presented in Table 4-13. Audits are generally conducted twice per year, although the costs in Table 4-13 are on a per-audit basis. Small establishments may hire a consultant to help them

prepare for an audit, whereas a large establishment would usually not.

Table 4-13. Third-party Audit Costs

Species: Beef, pork, chickens, and turkeys

Units: $s per audit

	Small Establishment			Large Establishment		
	Low	**Midpoint**	**High**	**Low**	**Midpoint**	**High**
Without Consultant						
Labor hours—Food Safety Manager	30	40	50	144	192	240
Labor costs—Food Safety Manager ($)	$1,265	$1,686	$2,108	$6,070	$8,093	$10,116
Labor hours—Technician	120	160	200	0	0	0
Labor costs—Technician ($)	$3,250	$4,333	$5,416	$0	$0	$0
Total labor costs ($)	$4,514	$6,019	$7,524	$6,070	$8,093	$10,116
Auditor fee ($)	$4,875	$6,500	$8,125	$11,250	$15,000	$18,750
Travel costs ($)	$750	$1,000	$1,250	$750	$1,000	$1,250
Total costs ($/audit)	$10,139	$13,519	$16,899	$18,070	$24,093	$30,116
With Consultant						
Labor hours—Food Safety Manager	30	40	50	*Not Applicable*		
Labor costs—Food Safety Manager($)	$1,265	$1,686	$2,108			
Consultant costs ($)	$6,000	$8,000	$10,000			
Auditor fee ($)	$4,875	$6,500	$8,125			
Travel costs ($)	$1,500	$2,000	$2,500			
Total costs ($/audit)	$13,640	$18,186	$22,733			

Our assumptions and notes for the calculations are as follows:

- **Labor type** for third-party audits involve a food safety manager and a technician, which has the equivalent pay rate as a food scientist, if a consultant is not hired. Time spent for an audit requires pulling records, meeting with the auditor to answer questions, and touring the auditor around the establishment. Between 6 and 10 employees

at a large establishment will spend approximately 3 days on an audit.

- **Auditor fee** represents the fee charged by the auditor, estimated by the experts at $2,500 per day regardless of establishment size. The auditor will spend approximately 2 days at a small establishment and a week at a large establishment.
- **Consultant** costs may be incurred by small establishments and were estimated by the experts.
- **Travel** costs are incurred by the auditor and consultant, if applicable. Travel costs are estimated at $1,000 per person per trip, which is the sum of airfare ($500), lodging ($200), meals ($200), and rental car ($100), as described earlier.

Thus, the per-audit costs of having third-party audits ($COST\_TA_j$) without a consultant are calculated as

$$COST\_TA_j = (LH\_MGR_j \bullet WR\_MGR) + (LH\_FS_j \bullet WR\_FS) + FEE_j + TR$$

and with a consultant are calculated as

$$COST\_TAC_j = (LH\_FS_j \bullet WR\_FS) + CON + FEE_j + TR$$

where LH_MGR_j is the number of labor hours for a food safety manager at establishment size j, WR_MGR is the wage rate for a food safety manager, LH_FS_j is the number of labor hours for a food scientist at establishment size j, WR_FS is the wage rate for a food scientist, FEE_j is the auditor fee for establishment size j, CON is the consultant fee, and TR is the travel costs.

4.9 COSTS OF WATER ADDITIVES AND TREATMENTS

FSIS requested data on the costs of the following water additives and treatments: chlorination, electrolyzed water, ozonation, ultraviolet, and acidification. In the panel discussion, the experts concluded that electrolyzed water, ozonation, and acidification are not used by the meat or poultry slaughter industries, and therefore we eliminated these from our analysis. The experts suggested that we add reverse osmosis for ice and water softeners and filtration to the list. Table 4-14 displays the water additives and treatments used by each species.

The experts provided cost for chlorination, which is the lowest cost water treatment, and reverse osmosis for ice, which has

the highest costs due to the equipment costs, as shown in Table 4-15. Purchase and installation costs do not vary across species.

Table 4-14. Water Additives and Treatments Used

Method Used	Beef & Pork	Poultry	Processed Product
Chlorination	minimal	used	used on equipment
Ultraviolet	not used	used-non municipal waste water only	not used
Reverse osmosis	used for ice	used for ice	used for ice
Water softeners and filtration	minimal	may be used to remove minerals	used

Table 4-15. Low and High Cost Methods of Water Additives and Treatments

Species: Beef, pork, chickens, and turkeys

Units: $s and hours per piece of equipment

	Small Establishment			Large Establishment		
Type of Treatment	Purchase & Installation ($)	Labor Hours per Shift (#)	Materials Costs ($)	Purchase & Installation ($)	Labor Hours per Shift (#)	Materials Costs ($)
Lowest cost—Chlorination	$500	0.25	$5 per 1000 gallons	$2,500	0.25	$5 per 1000 gallons
Highest cost—Reverse osmosis for ice	$7,500	0.25	$5 per 1000 gallons	$10,000	0.25	$5 per 1000 gallons

More detail on these costs are outlined below:

- **Capital equipment** costs were estimated by the experts. For example, a chlorination system involves a drip system with a tank, pump, and meter that regulates the dosage.
- **Labor type** for this intervention would be production employees to monitor the chemical levels in the water. The experts estimated that one employee would spend 0.25 labor hours per shift on this activity.

- **Materials** for reverse osmosis include carbon filters. For chlorination, chlorine is added at a rate of about 50 ppm.
- **Margin of error** for this intervention is assumed to be 50%.

The length of life for this equipment is estimated to be 5 years.

4.10 READY-TO-EAT PROCESSING EQUIPMENT

FSIS is interested in estimated costs for various pieces of equipment used for RTE meat food processing, including

- high pressure processors,
- irradiation systems,
- ultrasonic,
- infrared systems,
- ultraviolet,
- radiant heating systems,
- smokers,
- drying, and
- freezing.

The experts reviewed the list and provided general comments, but they were not able to provide specific costs for most of the investments, with the exceptions below.

High pressure processing (HPP). The experts believe that meat and poultry companies would send their RTE products to a third-party service provider for HPP rather than installing equipment within the establishment. This is currently done for some deli meats, and costs range from $0.10 to 0.15 per pound (not including transport to the service provider).

Irradiation. The cost of installing irradiation equipment would be cost prohibitive for most meat and poultry companies; thus, they would send their RTE product to an irradiation service provider.[14] The costs are dependent upon the volume, with the costs ranging from $0.30 to 0.50 per pound for a low volume meat product and $0.10 per pound for a high volume meat product (not including transport to the service provider).

[14] Some processors may also send raw meat to an irradiation service provider.

Antimicrobial spray-in-the-bag for RTE meat products. An antimicrobial spray in the bag system used at a large establishment costs $15,000 for the purchase and installation of equipment and a fraction of a cent (0.25 cents) per bag for the antimicrobial solution. The capacity for this equipment is 6,000 pounds per hour. In a smaller establishment, a production employee would manually spray the solution in each bag. Because they cannot afford downtime for repairs or slow machinery, large RTE meat establishments are likely to replace equipment every 5 years as technologies improve.

Large RTE meat establishments operate 24 hours per day, with 1 day per week reserved for sanitation.

4.11 REMOVAL OF LARGE LYMPH NODES

The removal of large lymph nodes is recommended for all ages of cattle that are slaughtered, because they may harbor *Salmonella*. If lymph nodes inadvertently end up in ground beef, they are ground throughout the product. Because *Salmonella* is encapsulated in the lymph nodes, it is not killed by antimicrobials; thus, one of the interventions is the removal of the lymph nodes before grinding meat operations. This practice is required by the National School Lunch Program for beef, as there cannot be visible lymph nodes on beef carcasses parts going into ground beef production for their products. The establishments that grind beef for the National School Lunch Program inspect subprimals or smaller cuts for visible lymph nodes.

Although it requires less than 1 minute to remove the four primary lymph nodes that are the most likely to harbor *Salmonella*, it slows the line speed and adds between 10% and 50% to fabrication costs. The experts believe it is logistically impossible to remove all lymph nodes of carcass parts in a large establishment that fabricates 500 beef carcasses per hour.

4.12 LIABILITY AND RECALL INSURANCE

Liability and recall insurance protects the company in the event of a product recall and any resulting liability claims. The experts believe that 90% or more of meat and poultry establishments already have liability and recall insurance. Smaller establishments tend to think that their personal insurance will

cover these events, but it will not. Larger establishments may self-insure. Although they do not have to pay a premium, they have to set aside funds in their budget to cover the costs of a recall.

Because liability payouts are usually around $150,000 per illness and $2 to $3 million per death, the experts recommend $5 million in coverage for a small establishment. In one example given, a small establishment with a $3 million policy pays a premium of $13,000 per year.

An industry trade association, the National Meat Institute, offers discounted recall insurance plans to its members with up to $25 million in coverage (NAMI, 2015). The premium is not publically available.

4.13 COSTS OF A RECALL

Estimating a firm's costs and losses from a recall is difficult, because firm-level data are generally not available. To overcome this, Pozo and Schroeder (2015) analyzed publicly traded stock prices of firms selling beef, pork, chicken, and turkey products that had been recalled. Stock returns decreased by 0.63%, on average, within 5 days after a recall event and up to 1.15% for Class I recalls (those with the largest human health effect). This translates to a reduction in market equity by $109 million for a firm with 472 million shares of stock outstanding and a $20 per share value on the day of a recall announcement. Seriousness of human health risk, volume recalled, and extent of media exposure all affect the magnitude of the effect of the recall. Firm size, diversification, and experience managing past recalls also affect a firm's stock price.

In addition to stock market affects, commodity prices are also affected. In the 2006 Dole spinach recall, farm-level prices of spinach decreased by 58% in the 2 months following the recall. Prices recovered approximately 2 months after the problem was under control. The overall farm-level loss in U.S. spinach sales was approximately $12 million (Ribera et al., 2012).

In discussing the costs of a recall, the experts suggested that FSIS consider the cost of a mock recall, as these are typically conducted at least once per year in many establishments. Some large establishments may conduct mock recalls twice per year,

with a different product type each time (e.g., RTE, frozen, not fully cooked). While some larger establishments can conduct a mock recall in a few hours, smaller establishments tend to take longer. As mock recalls are becoming more common, personnel are becoming more efficient at conducting them. A small establishment may only use one employee to conduct a mock recall, whereas a large establishment will need up to 10 employees. Also, small establishments may hire a consultant to assist with their mock recalls.[15] The experts stated that the only difference between a mock recall and an actual recall is the lack of media exposure and product disposal.

[15] RTI, under contract with FSIS, developed a Food Defense & Recall Preparedness exercise tool that can assist processors with testing their required written recall procedures. Although using this tool does not constitute a full mock recall, it allows the establishment to become more prepared in the event of a recall. More information about this free tool can be found online at http://www.fsis.usda.gov/wps/portal/fsis/topics/food-defense-and-emergency-response.

5 Costs of Microbiological Tests

In this section, we describe estimates of the costs of microbiological tests at third-party labs and present information on how costs might differ for in-house laboratories.

Table 5-1 lists the laboratory tests that FSIS requested cost data for along with minimum, maximum, and mean prices for each test. The table includes 31 different tests, including confirmation and screening test costs for microbiological tests. As discussed in Section 2.3, we obtained pricing information from five testing laboratories that were used as the basis for the estimates.

Most test costs did not vary more than $10 between laboratories, which provides evidence that the estimates are generally reliable.

Using the estimates from the five laboratories, RTI calculated the minimum, maximum, and mean values for each test. In cases where we obtained an estimate from only one lab, we provided the value in the mean column. Most test costs did not vary more than $10 between laboratories, which provides evidence that the estimates are generally reliable. The largest variations were for *Staphylococcus Enterotoxin* and Residues–Pesticides, but these estimates were based on fewer than five responses and are thus less reliable than other estimates. The following tests were not offered by the labs we contacted: species determination test, *Toxoplasma gondii* (confirmation or screen), Trichinae (confirmation or screen), and *Vibrio*.

Table 5-1. Laboratory Testing Costs

Test	Minimum	Mean	Maximum
Aerobic Plate Count (APC) (screen)	$16	$18	$20
Campylobacter (confirm)	$38	$74	$110
Campylobacter (screen)	$35	$43	$55
Clostridium perfringens (confirm)		$50[a]	
Clostridium perfringens (screen)	$20	$29	$35
Coliforms (screen)–Petrifilm	$15	$18	$22
Coliforms (screen)–MPN	$24	$25	$27
Enterobacteriaceae (screen)	$18	$23	$27
Generic *E. coli* (screen)–Petrifilm	$15	$18	$22
Generic *E. coli* (screen)–MPN	$24	$25	$27
Listeria Monocytogenes (confirm)	$27	$36	$46
Listeria Monocytogenes (screen)	$20	$32	$45
Non-O157 STEC (confirm)[b]	$175	$266	$358
Non-O157 STEC (screen)	$17	$33	$49
STEC O157:H7 (confirm)	$150	$213	$275
STEC O157:H7 (screen)	$25	$32	$49
Salmonella (confirm)	$27	$40	$50
Salmonella (screen)	$17	$25	$32
Shigella	$32	$50	$67
Species Determination Test		Not available[c]	
Staphylococcus aureus (confirm)		$30[a]	
Staphylococcus aureus (screen)	$15	$21	$27
Staphylococcus Enterotoxin	$40	$101	$161
Toxoplasma gondii (confirm)		Not available[d]	
Toxoplasma gondii (screen)		Not available[d]	
Total Plate Count (TPC) (screen)	$16	$16	$17
Trichinae (confirm)		Not available[c]	
Vibrio		Not available[c]	
Trichinae (screen)		Not available[c]	
Residue–Antibiotics		$20[e]	
Residue–Pesticides	$150	$358	$473

Note: Prices for tests increase as sample size increases.

[a] Only a single estimate was available across the five testing laboratories.

[b] This test is for all six non-O157 STEC.

[c] None of the testing laboratories contacted have a test available.

[d] The expert panel stated that one laboratory sells a test kit for *Toxoplasma gondii* for $375.

[e] Estimate of $20 for NARMS testing was provided by the expert panel.

During the expert panel meeting for slaughter and processing, we asked the experts for information on the tests for which we could not find cost data. The experts were aware of species determination testing but were unaware of any labs that conducted it. The experts explained that Trichinae cannot be tested for because when the sample is frozen for shipment, the Trichinae is killed. They also mentioned that the only motivation to test for Trichinae would be for a customer requirement. The experts were not familiar with any establishments that test for *Toxoplasma gondii*. A test kit is sold for *Toxoplasma gondii*, but the experts stated that it is not feasible for use in an establishment setting because of the challenges of sample preparation and the high percentage of false positives.

5.1 DIFFERENCES IN TESTING COSTS FOR IN-HOUSE LABORATORIES

We asked the experts about the cost savings of conducting tests in onsite versus offsite, third-party labs. They agreed that more testing occurs in-house than through third-party labs and that it was approximately 50% less costly. However, the cost savings is offset because establishments with in-house labs conduct more tests as part of their routine operations than those without in-house labs. They generally believed that there is no establishment-size cut off for in-house testing; most establishments producing RTE meat product use both in-house and third-party labs. Establishments that are part of large corporations may send their samples to corporate labs; thus, they still have to ship the samples.

References

Bilgili, S. F. & Hess, J. B. (1997). Tensile strength of broiler intestines as influenced by age and feed withdrawal. *Journal of Applied Poultry Research, 6*, 279–283.

NAMI. (2015). NAMI Product Recall Insurance. Retrieved from https://www.meatinstitute.org/ht/d/sp/i/1273/pid/1273

National Chicken Council. (1992). Good manufacturing practices. Fresh broiler products. Retrieved from www.usapeec.org/p_documents/newsandinfo_160404101434.pdf

National Turkey Federation. (2004). Best management practices for turkey production. Retrieved from www.usapeec.org/p_documents/newsandinfo_280404094832.pdf

Pozo, V., & Schroeder, T. (2015, February). *Costs of meat and poultry recalls to food firms*. Utah State University Extension Publication. Retrieved from http://www.agmanager.info/livestock/marketing/FoodSafety/Pozo_Schroeder_FactSheet_2015.pdf

Ribera, L. A., Palma, M. A., Paggi, M., Knutson, R., Masabni, J. G., & Anciso, J. (2012, April). Economic analysis of food safety compliance costs and foodborne illness outbreaks in the United States. *HortTechnology, 22*(2), 150–156.

Appendix A: Expert Panel Materials

This section includes the following set of materials used for the expert elicitation:

- Project description and interest form
- Agenda for expert panel on pre-harvest costs
- PowerPoint for expert panel on pre-harvest costs
- Definitions and background information for pre-harvest
- Agenda for expert panel on slaughter and processing costs
- PowerPoint for expert panel on slaughter and processing costs
- Definitions and background information for slaughter and processing

PROJECT DESCRIPTION & EXPERT INFORMATION FORM
Expert Panels to Estimate the Costs of Food Safety Investments

RTI International is conducting two expert elicitations for the U.S. Department of Agriculture (USDA), Food Safety and Inspection Service (FSIS) to determine the costs of food safety investments. The first expert elicitation meeting will be a one-day meeting that focuses on interventions used pre-harvest, and the second expert elicitation meeting will be a two-day meeting that focuses on interventions used in slaughter and processing. The expert elicitation will be conducted at a high level of aggregation across meat and poultry products, and will focus on the capital equipment, labor, materials and other costs of investments such as:

- Feed & Drinking Water Additives
- Vaccinations
- Development and Validation of Written Plans
- Antimicrobial Equipment and Solutions
- Cold Storage
- Third-party Auditing and Certification
- Waste and Downed Animal Disposal
- RTE Processing Equipment
- Food Safety Training
- In-house Laboratories

If you are interested in participating in either of the expert elicitation panels, please complete the expert information form on the following two pages and return it to RTI by **Wednesday, December 10**. *Please also attach your CV or resume.*

If you are selected to participate, we will need for you to do the following:

- complete a panel participation agreement form that RTI's contracts office will send to you after we confirm the date of the panel
- travel to RTI's office in Research Triangle Park, NC for an in-person meeting on agreed-upon dates in January or February 2015, arriving the evening prior to the panel
- during the meeting, participate in open discussions with the other participants on a set of questions to address the study needs
- based on your experience and knowledge, complete worksheets in which you will provide your best estimates regarding the costs of food safety investments for the production of meat and poultry products at the pre-harvest and slaughter and processing stages

We are offering an honorarium of $1,750 per day for completion of the exercise and will reimburse you for reasonable travel expenses. If you are selected to participate, you will be identified as a participant on the panel, but your specific responses will be combined with those of the other participants in the report we prepare for USDA.

Please return the form and your CV to Jenna Brophy (919-541-8881) at jbrophy@rti.org

Technical questions regarding this project can be directed to:

FSIS Project Officer
Gary Noyes
USDA, FSIS, OPPD, Policy Analysis Staff
Patriot Plaza III, Office 8-124C
355 E St. SW, Washington, DC 20024
(301) 504-3672

RTI Technical Lead
Catherine Viator
3040 Cornwallis Road
Research Triangle Park, NC 27709
Voice: 919-597-5127
viator@rti.org

Name	
Preferred Phone	
Preferred Email	
Mailing Address	
Country of Citizenship	

1. Information on areas of expertise

Please provide an assessment of your expertise in each area and establishment size listed below. It is not necessary to demonstrate expertise in all areas.

Area	Level of Experience/Knowledge		
	Minimal / None	**Moderate**	**Extensive**
Beef or pork production	☐	☐	☐
Poultry production	☐	☐	☐
Beef or pork slaughter	☐	☐	☐
Poultry slaughter	☐	☐	☐
Beef or pork processing	☐	☐	☐
Poultry processing	☐	☐	☐
RTE processing	☐	☐	☐
Small operations	☐	☐	☐
Large operations	☐	☐	☐

2. <u>Conflict of Interest Information</u>

Please list only current or in-pipeline projects and other relationships with the following entities. Activities listed below do not necessarily disqualify you from participation. RTI will evaluate your responses for any conflict of interest. All information you provide RTI will be kept strictly confidential.

List of projects/relationship ⇩ and funding type ⇨		**Grant**	**Contract**
Meat and poultry companies that may be affected by rules and regulations on food safety investments			
1		☐	☐
2		☐	☐
3		☐	☐
4		☐	☐
5		☐	☐
Organizations or associations representing above industries			
1		☐	☐
2		☐	☐
3		☐	☐
4		☐	☐
5		☐	☐
Government agencies related to meat and poultry production and processing			
1		☐	☐
2		☐	☐
3		☐	☐
4		☐	☐
5		☐	☐

AGENDA

Expert Panel on Costs of Pre-harvest Interventions
RTI International, Hobbs Bldg., Research Triangle Park, NC
Friday, February 6, 2015

7:45 AM Meet Catherine Viator at hotel lobby (out-of-town panelists)

8:00 AM Arrive at RTI

8:15 AM Orientation

- Introductions
- Review agenda and materials in binder
- Review purpose and goals of expert panel
- Review overall cost assumptions:
    - Types of costs
    - Ranges of estimates
    - Categorization of establishment sizes for estimating costs

9:30 AM Break

9:45 AM Discuss animal washing, feed additives, and vaccinations

- For each intervention, discuss definition, assumptions, units and categories of costs
- Complete worksheets providing cost estimates by species (meat/poultry) and establishment size for each intervention

12:00 PM Catered lunch

12:45 PM Discuss biosecurity and third-party certification

- For each intervention, discuss definition, assumptions, units and categories of costs
- Complete worksheets providing cost estimates by species (meat/poultry) and establishment size for each intervention

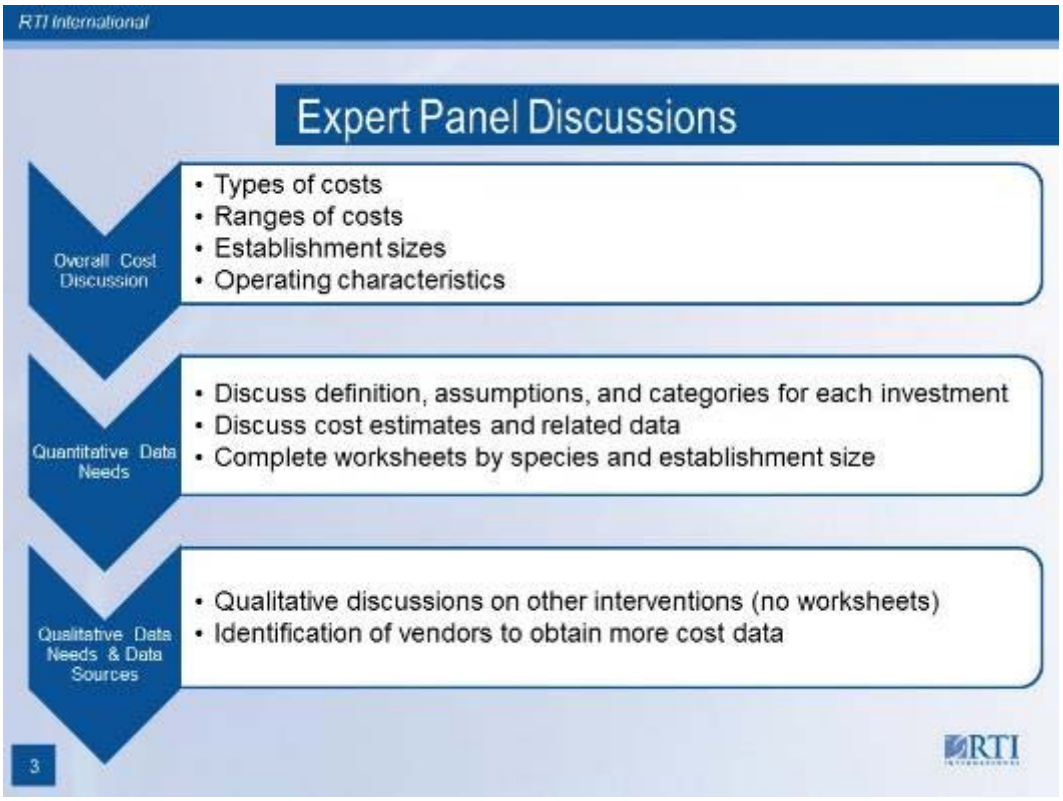
2:30 PM Break

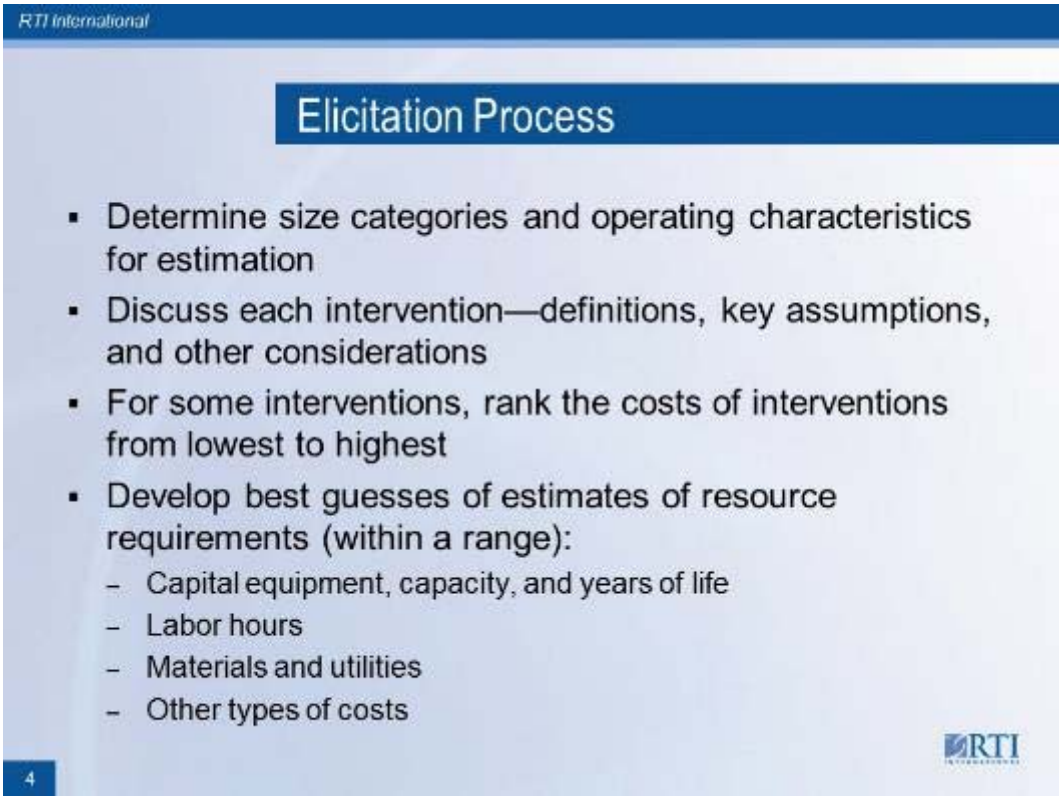
2:45 PM Discuss feeding roughages, feed withdrawal, and preconditioning animals (qualitative discussion)

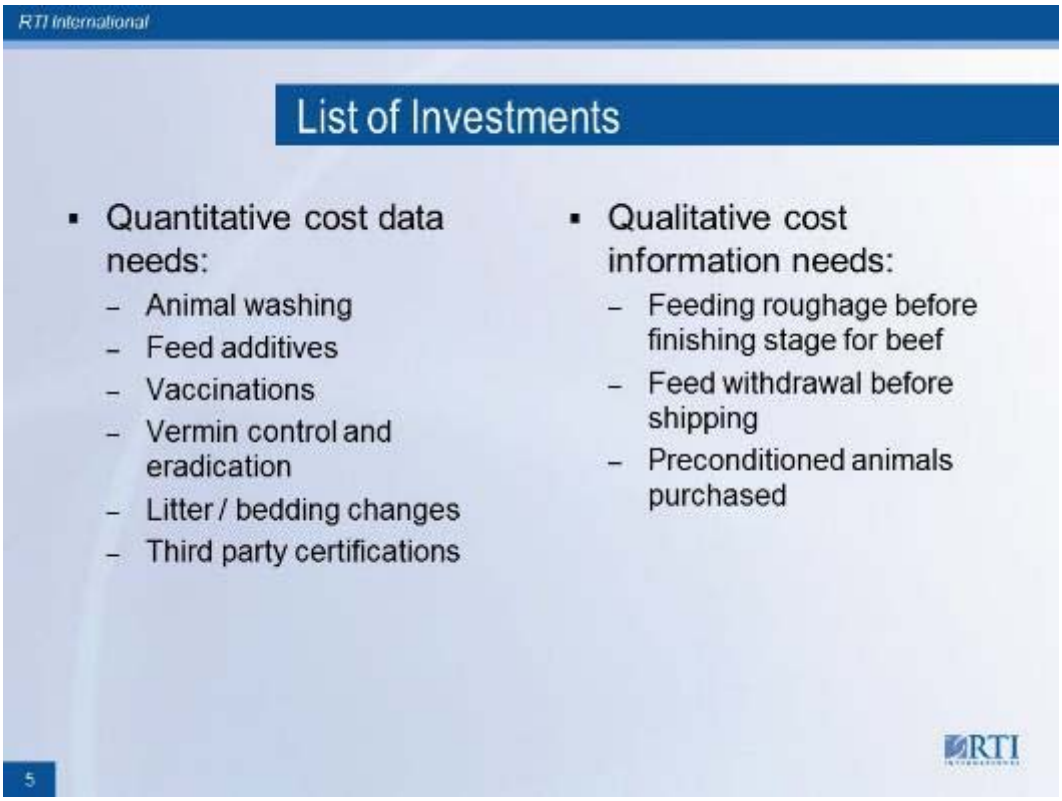
3: 15 PM Wrap-up discussion and identify possible vendors to confirm cost estimates

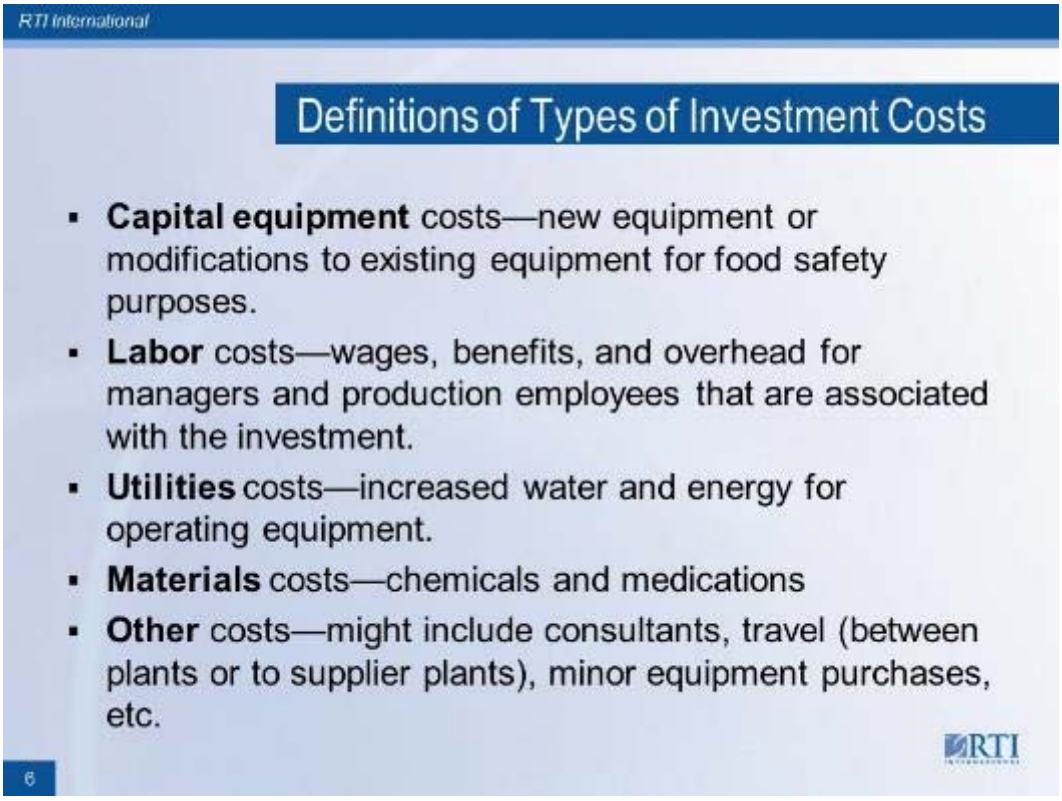
4:00 PM Adjourn

Pre-harvest Presentation


RTI International
Expert Panel Discussions
Overall Cost Discussion
• Types of costs
• Ranges of costs
• Establishment sizes
• Operating characteristics
Quantitative Data Needs
• Discuss definition, assumptions, and categories for each investment
• Discuss cost estimates and related data
• Complete worksheets by species and establishment size
Qualitative Data Needs & Data Sources
• Qualitative discussions on other interventions (no worksheets)
• Identification of vendors to obtain more cost data
3
RTI


RTI International
Elicitation Process
▪ Determine size categories and operating characteristics for estimation
▪ Discuss each intervention—definitions, key assumptions, and other considerations
▪ For some interventions, rank the costs of interventions from lowest to highest
▪ Develop best guesses of estimates of resource requirements (within a range):
– Capital equipment, capacity, and years of life
– Labor hours
– Materials and utilities
– Other types of costs
4
RTI


RTI International
List of Investments
Quantitative cost data needs:
Animal washing
Feed additives
Vaccinations
Vermin control and eradication
Litter / bedding changes
Third party certifications
Qualitative cost information needs:
Feeding roughage before finishing stage for beef
Feed withdrawal before shipping
Preconditioned animals purchased
RTI
5


RTI International
Definitions of Types of Investment Costs
Capital equipment costs—new equipment or modifications to existing equipment for food safety purposes.
Labor costs—wages, benefits, and overhead for managers and production employees that are associated with the investment.
Utilities costs—increased water and energy for operating equipment.
Materials costs—chemicals and medications
Other costs—might include consultants, travel (between plants or to supplier plants), minor equipment purchases, etc.
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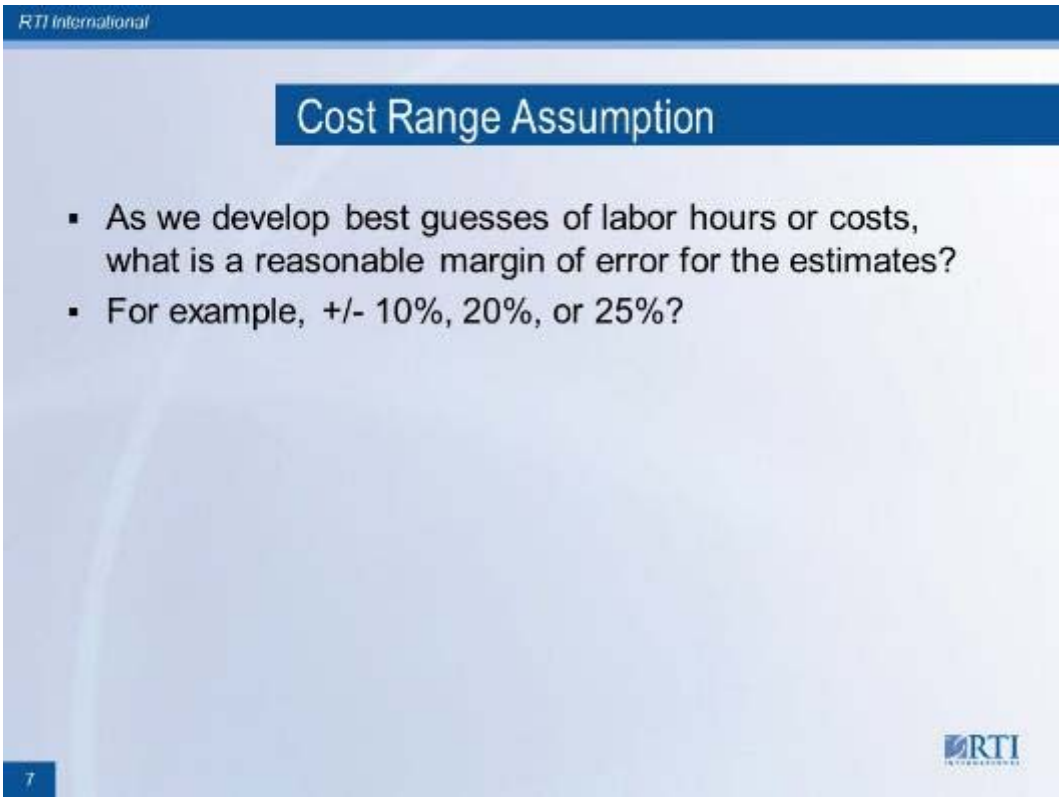
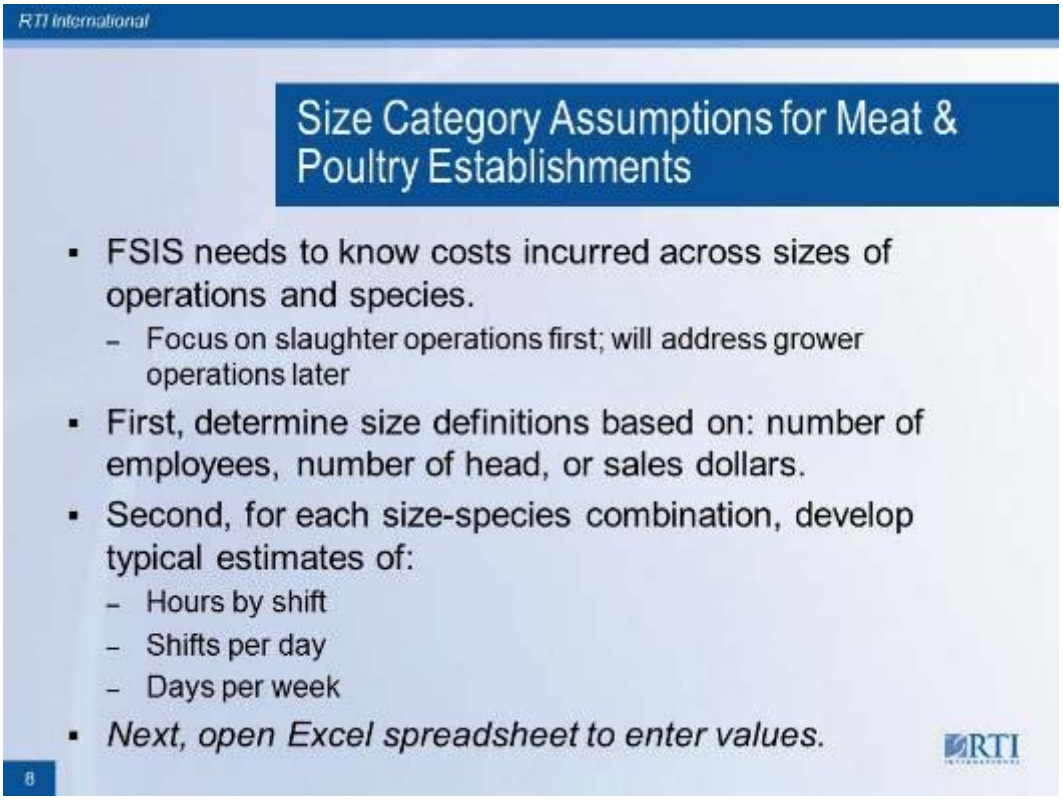
6


RTI International
Cost Range Assumption
As we develop best guesses of labor hours or costs, what is a reasonable margin of error for the estimates?
For example, +/- 10%, 20%, or 25%?
RTI
7


RTI International
Size Category Assumptions for Meat & Poultry Establishments
FSIS needs to know costs incurred across sizes of operations and species.
Focus on slaughter operations first; will address grower operations later
First, determine size definitions based on: number of employees, number of head, or sales dollars.
Second, for each size-species combination, develop typical estimates of:
Hours by shift
Shifts per day
Days per week
Next, open Excel spreadsheet to enter values.
RTI
8

RTI International

Labor Categories for Food Manufacturing

	Median Wage (2012)	Range (10th & 90th percentile)
Food Scientists & Technologists	$26.39	[$15.59, $47.75]
Office & Administrative Support	$15.11	[$9.58, $24.21]
Production Occupations	$12.47	[$8.71, $20.93]
Management Occupations	$43.66	[$24.36, $87.44]

Source: Bureau of Labor Statistics

Note: These values do not account for benefits and overhead.

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9

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Quantitative Data Needs

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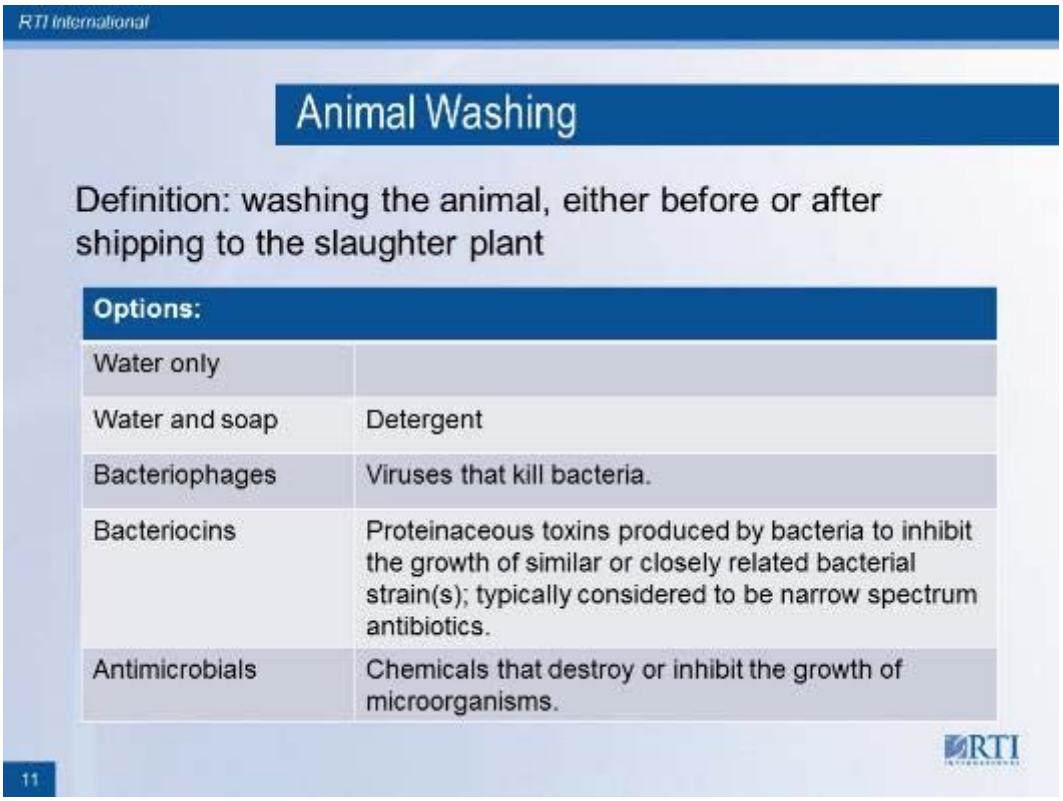
10


RTI International
Animal Washing
Definition: washing the animal, either before or after shipping to the slaughter plant
Options:
Water only
Water and soap
Detergent
Bacteriophages
Viruses that kill bacteria.
Bacteriocins
Proteinaceous toxins produced by bacteria to inhibit the growth of similar or closely related bacterial strain(s); typically considered to be narrow spectrum antibiotics.
Antimicrobials
Chemicals that destroy or inhibit the growth of microorganisms.
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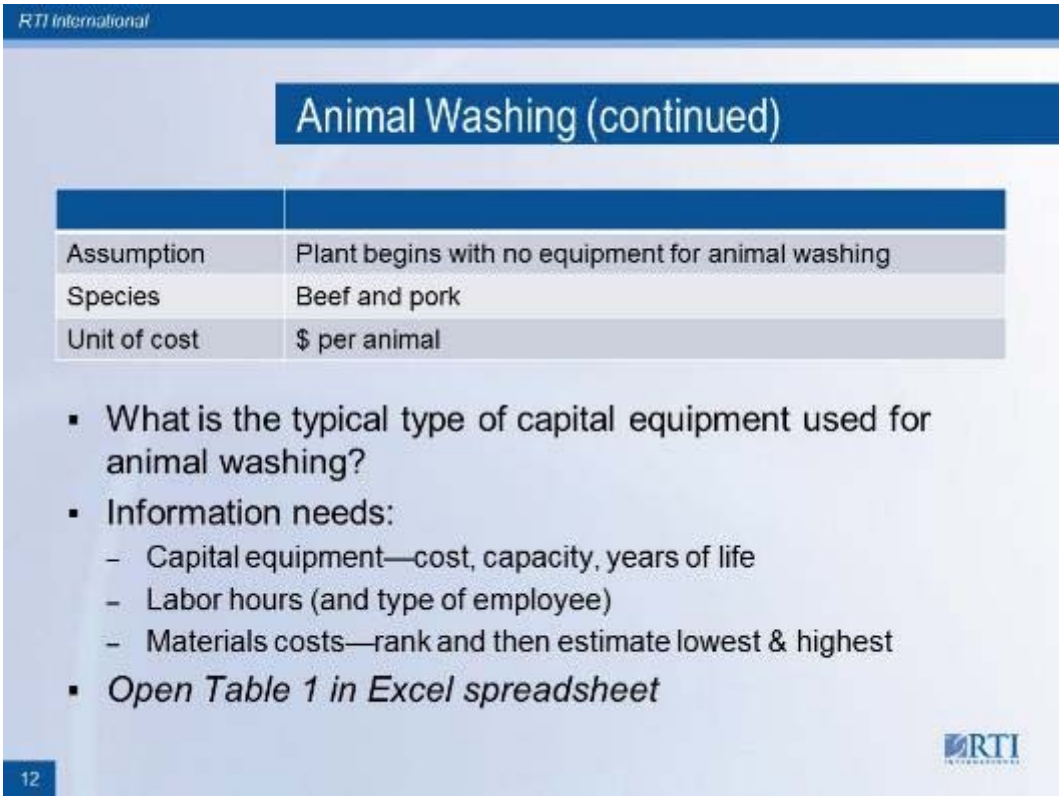
11


RTI International
Animal Washing (continued)
Assumption
Plant begins with no equipment for animal washing
Species
Beef and pork
Unit of cost
$ per animal
What is the typical type of capital equipment used for animal washing?
Information needs:
Capital equipment—cost, capacity, years of life
Labor hours (and type of employee)
Materials costs—rank and then estimate lowest & highest
Open Table 1 in Excel spreadsheet
RTI
12

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Feed Additives

Definition: Substances that are added to the already prepared feeds to improve upon their nutritive value and enhance their functionality.

Includes the following:	
Antibiotics	Used in cattle feed for disease prevention; suggested as a means to reduce *E. coli* O157:H7 shedding in cattle
Probiotics	Microorganisms or bacteria that are beneficial to the host animal.
Seaweed Extract	An extract from the seaweed Ascophyllum nodosum, a known source of cytokinins with increased antioxidant activity.
Growth Hormones	Control growth and lactation in cattle and swine
Colicin-producing *E.coli* strains	Antimicrobial proteins produced by certain strains of *E. coli* that can be effective in inhibiting the growth of *E. coli* O157:H7

RTI

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Feed Additives (continued)

Assumptions	• Baseline is feed with no additives • Frequently a contract stipulation with growers • Costs do not vary by establishment size (*verify*)
Species	Beef, pork, chickens, and turkeys
Unit of cost	$ per CWT of feed (relative to feed without additives)

- Are costs likely to vary by size of operation?
- Information needs:
  - Materials costs—rank and then estimate lowest & highest
- *Open Table 2 in Excel spreadsheet*

RTI

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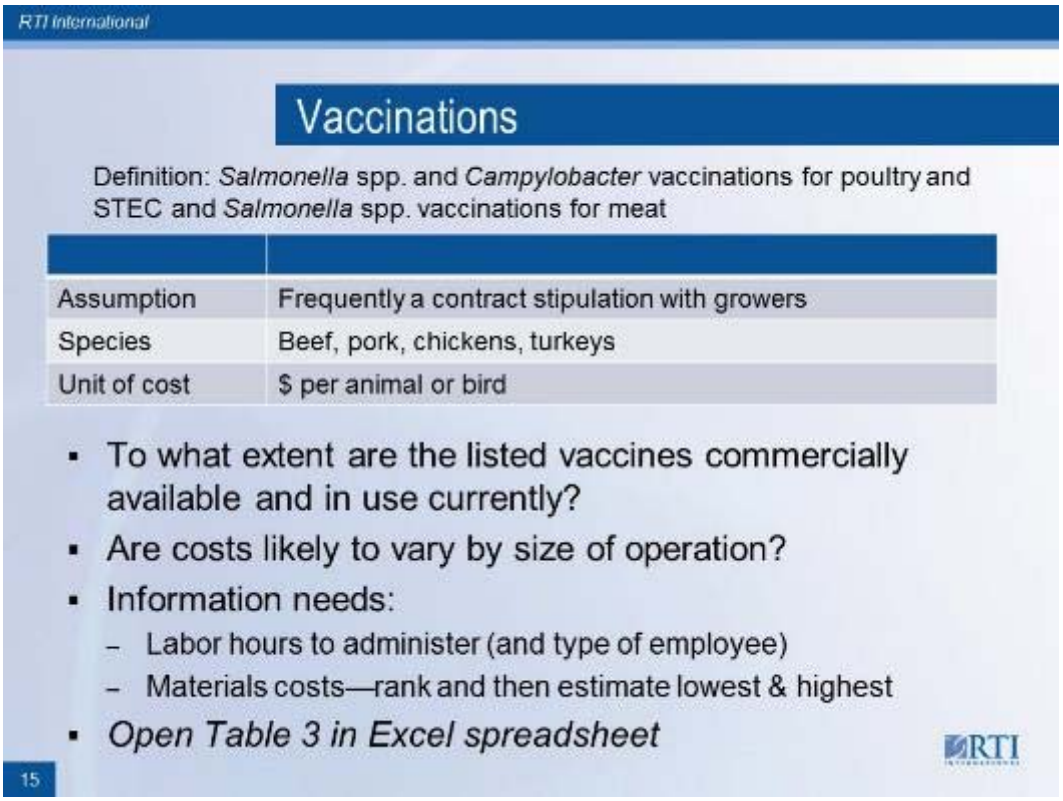
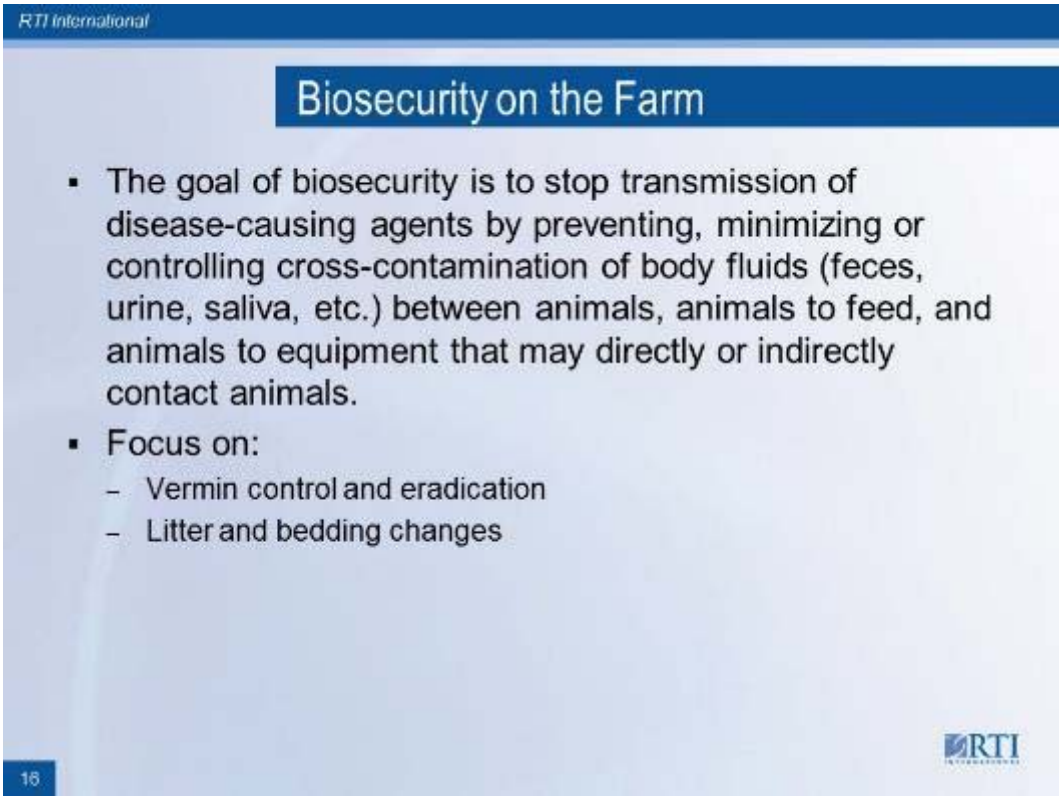

RTI International
Vaccinations
Definition: Salmonella spp. and Campylobacter vaccinations for poultry and STEC and Salmonella spp. vaccinations for meat
Assumption
Frequently a contract stipulation with growers
Species
Beef, pork, chickens, turkeys
Unit of cost
$ per animal or bird
To what extent are the listed vaccines commercially available and in use currently?
Are costs likely to vary by size of operation?
Information needs:
Labor hours to administer (and type of employee)
Materials costs—rank and then estimate lowest & highest
Open Table 3 in Excel spreadsheet
RTI
15


RTI International
Biosecurity on the Farm
The goal of biosecurity is to stop transmission of disease-causing agents by preventing, minimizing or controlling cross-contamination of body fluids (feces, urine, saliva, etc.) between animals, animals to feed, and animals to equipment that may directly or indirectly contact animals.
Focus on:
Vermin control and eradication
Litter and bedding changes
RTI
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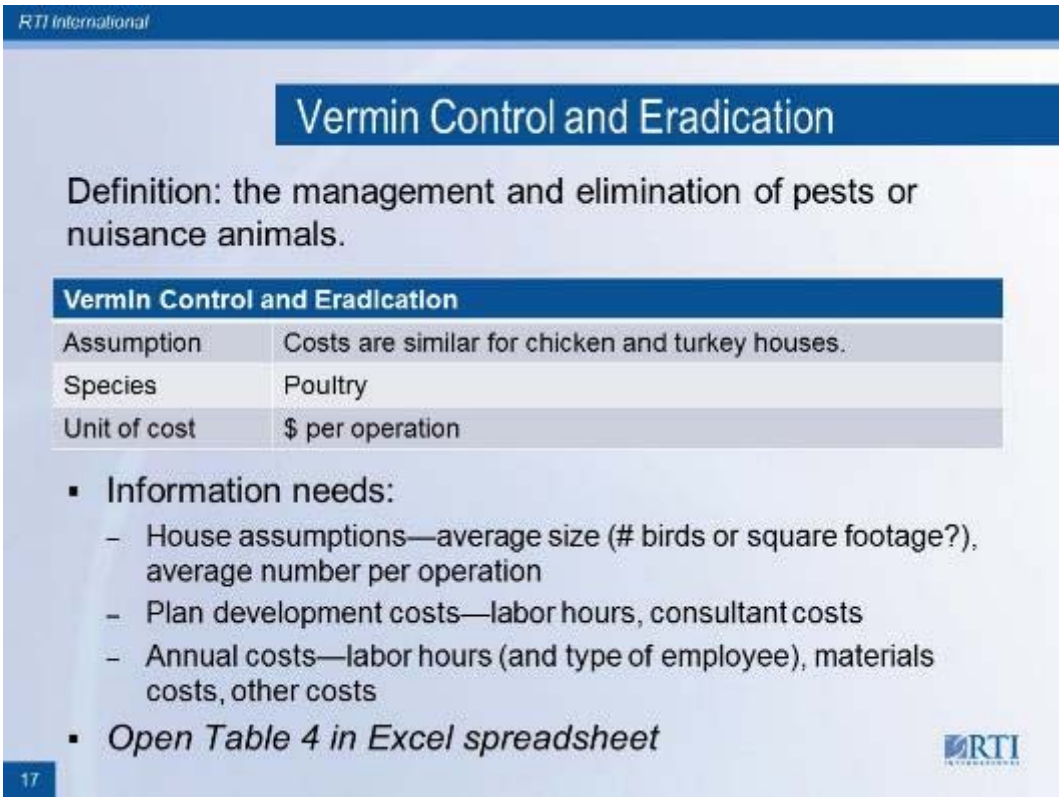
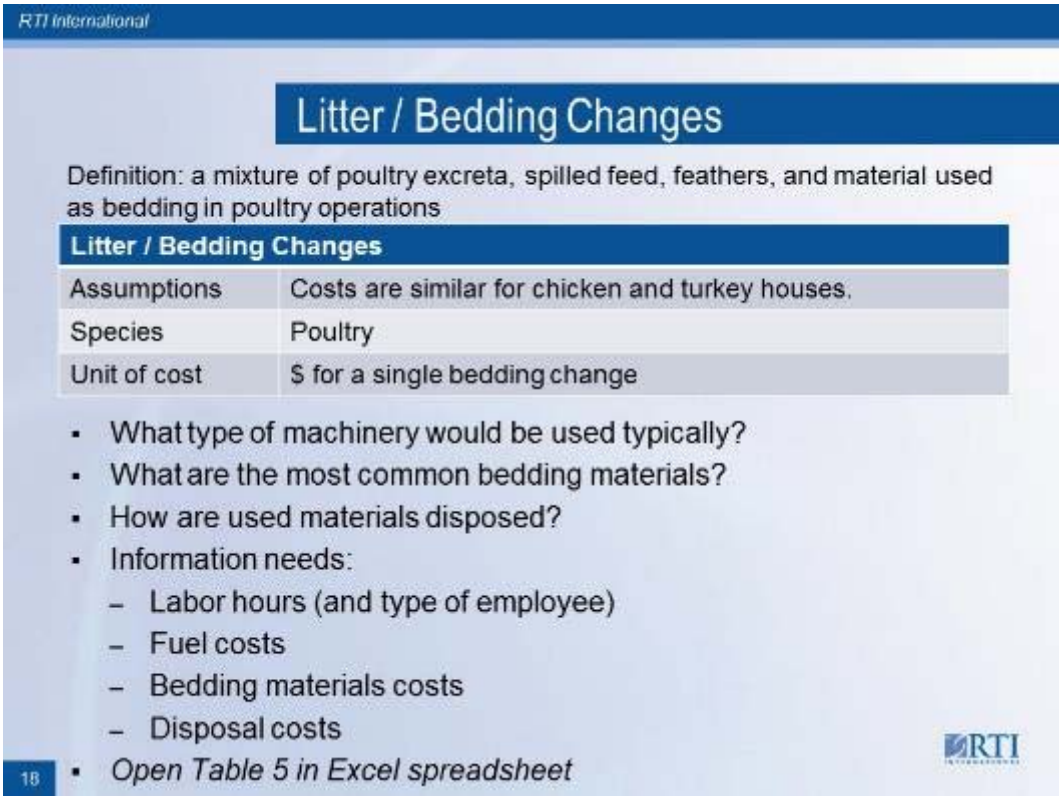

RTI International
Vermin Control and Eradication
Definition: the management and elimination of pests or nuisance animals.
Vermin Control and Eradication
Assumption
Costs are similar for chicken and turkey houses.
Species
Poultry
Unit of cost
$ per operation
Information needs:
House assumptions—average size (# birds or square footage?), average number per operation
Plan development costs—labor hours, consultant costs
Annual costs—labor hours (and type of employee), materials costs, other costs
Open Table 4 in Excel spreadsheet
RTI
17


RTI International
Litter / Bedding Changes
Definition: a mixture of poultry excreta, spilled feed, feathers, and material used as bedding in poultry operations
Litter / Bedding Changes
Assumptions
Costs are similar for chicken and turkey houses.
Species
Poultry
Unit of cost
$ for a single bedding change
What type of machinery would be used typically?
What are the most common bedding materials?
How are used materials disposed?
Information needs:
Labor hours (and type of employee)
Fuel costs
Bedding materials costs
Disposal costs
Open Table 5 in Excel spreadsheet
RTI
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RTI International
Third Party Certifications
Includes:
Pork Quality Assurance Plus (PQA+)
A producer-driven education and certification program to reduce the risk of violative animal health product residues in pork.
Transport Quality Assurance (TQA)
A program that helps swine transporters, producers and handlers understand how to handle, move and transport pigs
Beef Quality Assurance (BQA)
A national program that provides guidelines for beef cattle production.
Farmers Assuring Responsible Management (FARM)
Designed to "bring uniformity to animal care through education, on-farm evaluations, and objective third-party verification."
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Third Party Certifications (continued)
Includes:
Restaurants, food service, and institutions (RFI) certifications
Buyer certifications conducted or contracted by livestock and poultry buyers
Humane raising and handling
Practices focused on improving the lives of farm animals in food production from birth through slaughter.
RTI
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Third Party Certifications (continued)

Assumptions	Costs are incurred for initial certification and annual recertification (audits).
Species	Beef, pork, chickens, turkeys
Unit of cost	$ per operation

- Are costs likely to vary by size of operation?
- Are there costs other than the certification fee and internal labor hours?
- Information needs—initial and annual:
  - Certification fee
  - Internal labor hours (and type of employee)
- *Open Table 6 in Excel spreadsheet*

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Qualititative Data Needs

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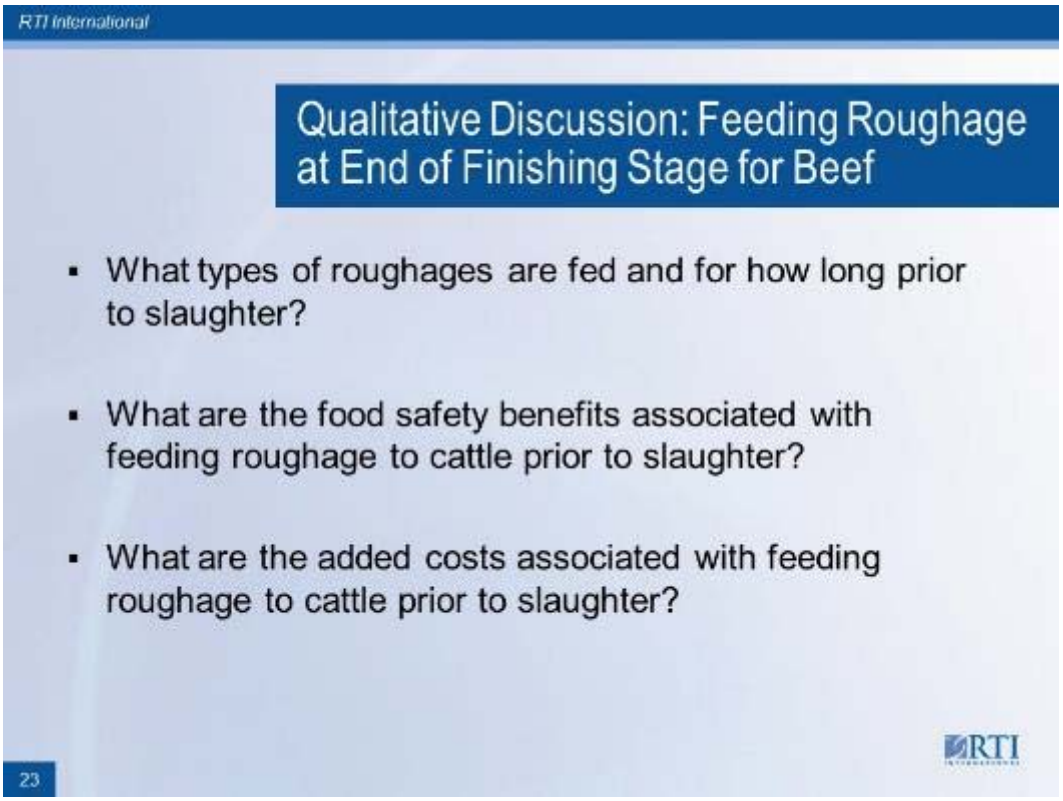
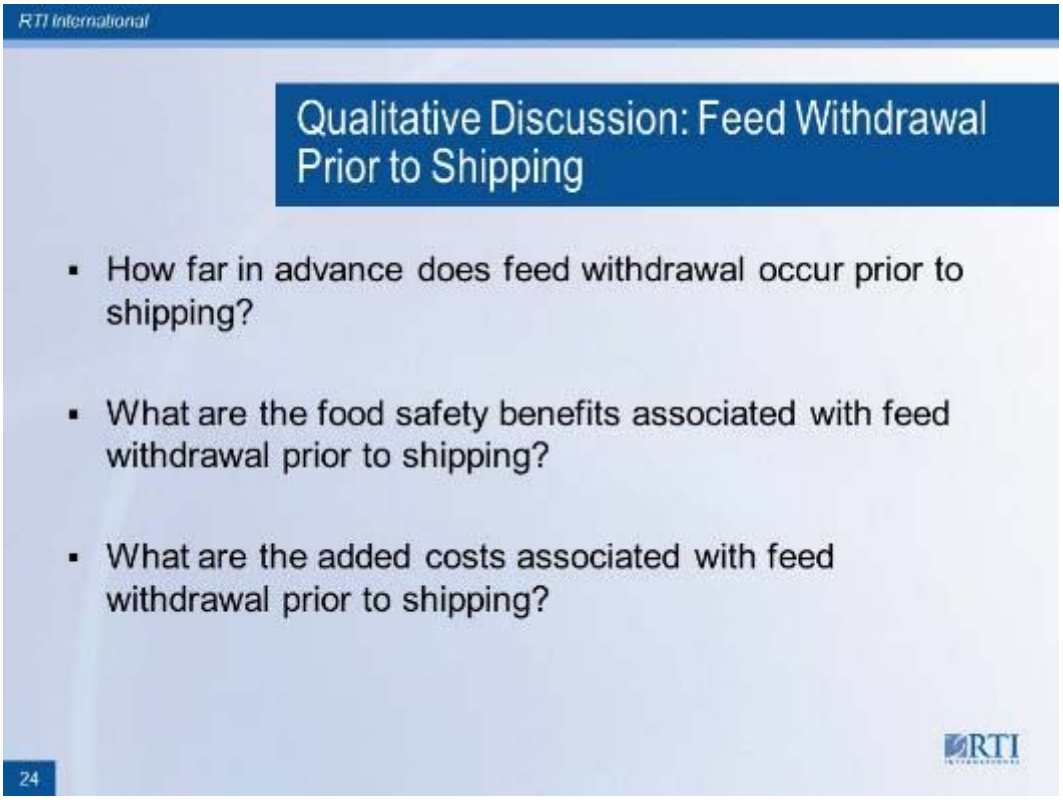
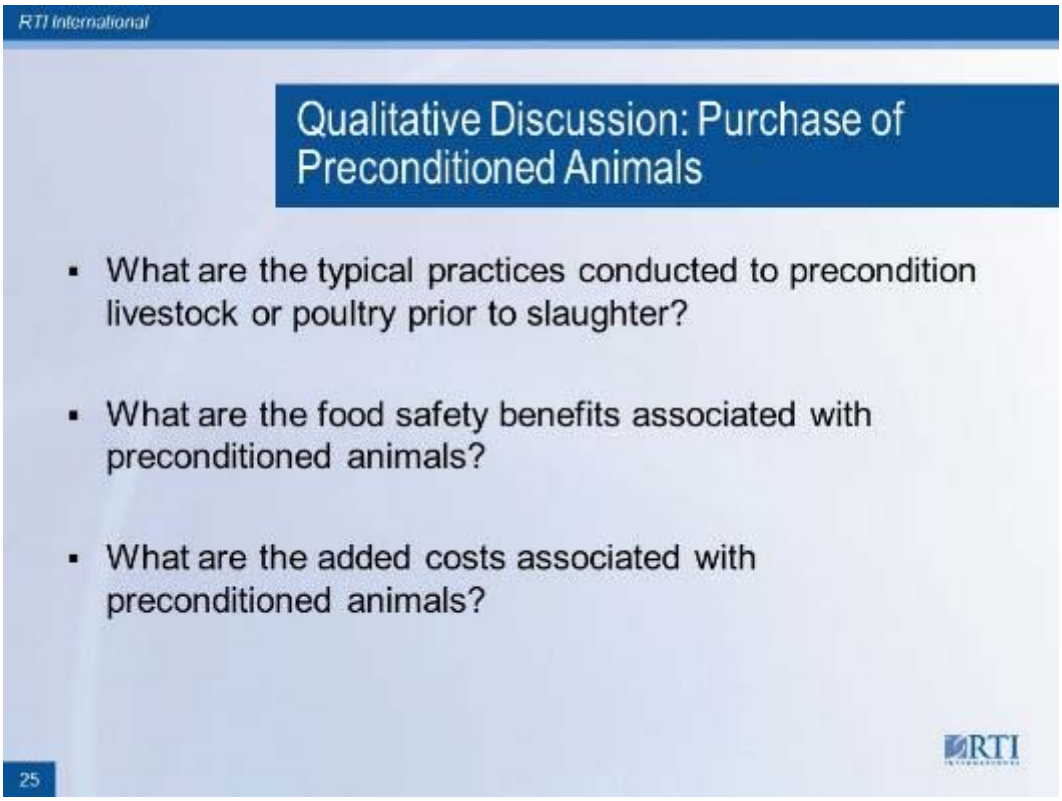

RTI International
Qualitative Discussion: Feeding Roughage at End of Finishing Stage for Beef
▪ What types of roughages are fed and for how long prior to slaughter?
▪ What are the food safety benefits associated with feeding roughage to cattle prior to slaughter?
▪ What are the added costs associated with feeding roughage to cattle prior to slaughter?
RTI
23


RTI International
Qualitative Discussion: Feed Withdrawal Prior to Shipping
▪ How far in advance does feed withdrawal occur prior to shipping?
▪ What are the food safety benefits associated with feed withdrawal prior to shipping?
▪ What are the added costs associated with feed withdrawal prior to shipping?
RTI
24


RTI International
Qualitative Discussion: Purchase of Preconditioned Animals
What are the typical practices conducted to precondition livestock or poultry prior to slaughter?
What are the food safety benefits associated with preconditioned animals?
What are the added costs associated with preconditioned animals?
RTI
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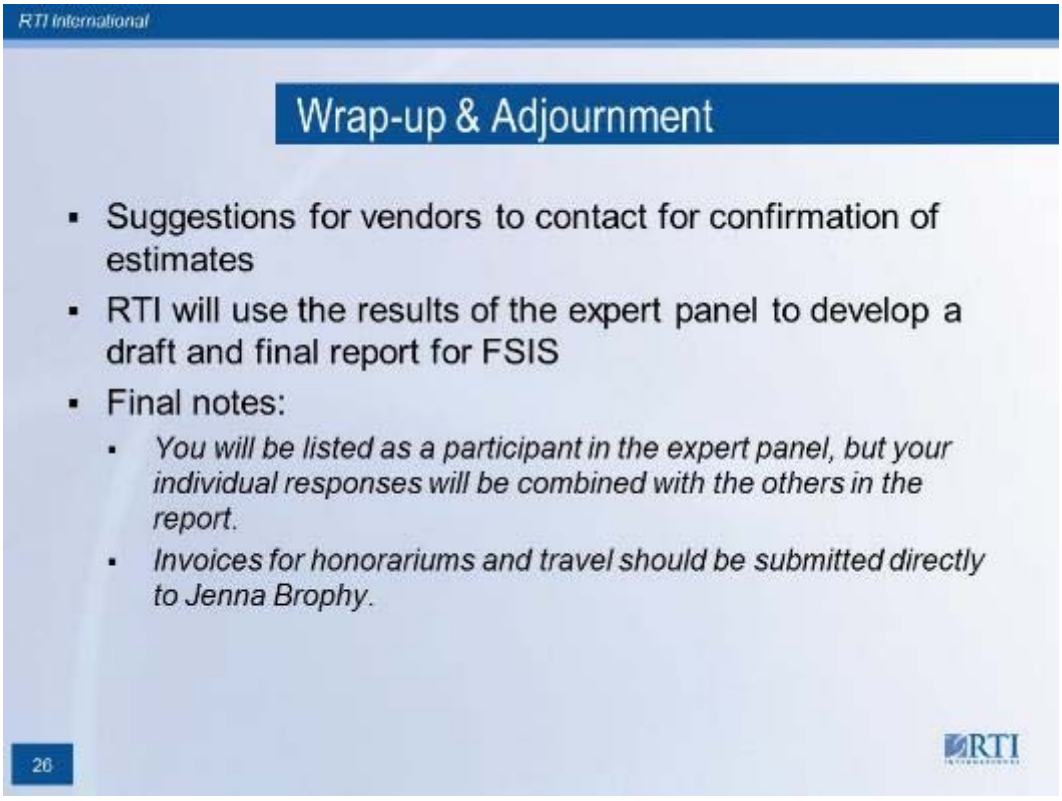
RTI International
Wrap-up & Adjournment
Suggestions for vendors to contact for confirmation of estimates
RTI will use the results of the expert panel to develop a draft and final report for FSIS
Final notes:
You will be listed as a participant in the expert panel, but your individual responses will be combined with the others in the report.
Invoices for honorariums and travel should be submitted directly to Jenna Brophy.
RTI
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RTI International
More Information
Mary Muth
Program Director
919.541.7289
muth@rti.org
Catherine Viator
Economist
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viator@rti.org
Jenna Brophy
Associate Economist
919.541.8881
jbrophy@rti.org
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Pre-harvest Definitions

Investment / Intervention	Definition	Source
Bacteriophages	Bacteriophages are FDA approved for use in or on live cattle as a treatment or for control of *E. coli* O157:H7 shedding in cattle. Bacteriophages (phages) are viruses that kill bacteria. A subset of bacteriophages can reduce bacterial loads in and on cattle and on the carcasses post-harvest.	•http://www.fsis.usda.gov/wps/wcm/connect/d5314cc7-1ef7-4586-bca2-f2ed86d9532f/Reducing-Ecoli-Shedding-in-Cattle.pdf?MOD=AJPERES p21-22
Bacteriocins	Bacteriocins are proteinaceous toxins produced by bacteria to inhibit the growth of similar or closely related bacterial strain(s). They are typically considered to be narrow spectrum antibiotics.	•http://www.princeton.edu/~achaney/tmve/wiki100k/docs/Bacteriocin.html
Feed additives (beef, poultry, swine)	Animal feed additives can be explained as those substances that are not of natural origin that are added to the already prepared feeds so as to improve upon their nutritive value and enhance their functionality. They are gaining importance because of their varied functions that include controlling infectious diseases, and promoting growth among the animals. Currently, lactic acid, acetic acid, and sodium bisulfate are considered "general purpose food additives" by the FDA.	•http://www.marketsandmarkets.com/Market-Reports/feed-additives-market-870.html •Compliance Guide for Controling Salmonella and Campylobacter in Poultry http://www.fsis.usda.gov/wps/wcm/connect/6732c082-af40-415e-9b57-90533ea4c252/Compliance_Guide_Controling_Salmonella_Campylobacter_Poultry_0510.pdf?MOD=AJPERES
Antibiotics	Antibiotics have been suggested as a means to reduce *E. coli* O157:H7 shedding in cattle. Ionophores are commercially available and routinely added to feed to increase feed efficiency in feedlot cattle.	•http://www.fsis.usda.gov/wps/wcm/connect/d5314cc7-1ef7-4586-bca2-f2ed86d9532f/Reducing-Ecoli-Shedding-in-Cattle.pdf?MOD=AJPERES p17
Probiotics	Probiotics preparations contain microorganisms or bacteria that are beneficial to the host animal	•http://www.fsis.usda.gov/wps/wcm/connect/d5314cc7-1ef7-4586-bca2-f2ed86d9532f/Reducing-Ecoli-Shedding-in-Cattle.pdf?MOD=AJPERES P18

(continued)

Investment / Intervention	Definition	Source
Seaweed extract	Tasco-14 is an extract from the seaweed Ascophyllum nodosum, a known source of cytokinins with increased antioxidant activity. Currently, some beef producers feed the extract to cattle in commercial feedlots for various reasons, such as to improve carcass quality. Research indicates that Tasco-14 may be effective in reducing *E. coli* O157:H7 shedding in cattle. Several university studies demonstrated that supplementing cattle diets with Tasco-14 for two weeks before slaughter resulted in fewer naturally occurring *E. coli* O157:H7 in the feces and on the hides of cattle.	•http://www.fsis.usda.gov/wps/wcm/connect/d5314cc7-1ef7-4586-bca2-f2ed86d9532f/Reducing-Ecoli-Shedding-in-Cattle.pdf?MOD=AJPERES p16
Growth hormones	Growth hormone (GH) and insulin-like growth factor-I (IGF-I) control growth and lactation in cattle and swine	•http://www.ncbi.nlm.nih.gov/pubmed/18638098
Colicin-producing *E. coli* strains	Colicins are antimicrobial proteins produced by certain strains of *E. coli* that can be effective in inhibiting the growth of *E. coli* O157:H7. Some strains can be effective in killing *E. coli* O157:H7 organisms. Use of colicin–producing *E. coli* strains, in feed or as direct fed products, may be effective in reducing fecal shedding of *E. coli* O157:H7.	•http://www.fsis.usda.gov/wps/wcm/connect/d5314cc7-1ef7-4586-bca2-f2ed86d9532f/Reducing-Ecoli-Shedding-in-Cattle.pdf?MOD=AJPERES p19
Roughage at end of finishing phase (beef and cattle only)	Roughage is a fibrous indigestible material in vegetable foodstuffs that aids the passage of food and waste products through the gut (wikipedia) General: 1) Although some feedlots use all-concentrate diets, usually, high-concentrate finishing diets contain small amounts (3 to 15%) of roughage. 2) On the energy basis, roughage can be one of the most expensive ingredients in finishing diets. 3) Can be an important component of feedlot diets and have a large influence on ruminal function, e.g., the low dietary roughage content has been associated with digestive upsets such as acidosis & liver abscesses.	•http://www.ag.auburn.edu/~chibale/an14beefcattlefeeding.pdf p472-3

(continued)

Investment/ Intervention	Definition	Source
	4) Common sources? Alfalfa hay, grass hays, silages (corn, wheat, and grasses), and by-product feeds (e.g., cottonseed hulls).	
Biosecurity	The goal of biosecurity is to stop transmission of disease-causing agents by preventing, minimizing or controlling cross-contamination of body fluids (feces, urine, saliva, etc.) between animals, animals to feed and animals to equipment that may directly or indirectly contact animals. Biosecurity has three major components: (1) Isolation prevents contact between animals within a controlled environment. (2) Traffic control includes traffic onto your operation and traffic patterns within your operation, including vehicles, people, and animals. (3) Sanitation addresses the disinfection of materials, people and equipment entering the operation and the cleanliness of the people and equipment on the operation.	•http://www.ianrpubs.unl.edu/pages/publicationD.jsp?publicationId=433
Vermin control and eradication	Modern dairy producers are weaving careful use of pesticides into integrated pest management (IPM) programs. IPM programs seek to maximize the effectiveness of pest control actions while conserving beneficial insects and minimizing pesticide use. The cornerstone of effective IPM is correct pest identification along with accurate and timely pest monitoring. Other components are various combinations of cultural, biological, and chemical control practices designed to keep pest populations below economically injurious levels	•dairy cattle pest management: http://pubs.cas.psu.edu/FreePubs/PDFs/XF0275.pdf

(continued)

Investment / Intervention	Definition	Source
Feed withdrawal before shipping	Feed withdrawal is recommended to reduce food and fecal contamination on the carcasses (NCC, 1992, NTF, 2004). Removing feed too late may result in carcass contamination because the gut may rupture during processing. Economically, non-digested food does not contribute to the final weight of the carcass. However, if feed is removed too early, the internal organs become more fragile. The crop and cloaca can easily tear during processing. One study reported that feed withdrawal periods greater than 14 hours made the intestine and gall bladder more fragile (Bilgili and Hess, 1997).	•Compliance Guide for Controlling Salmonella and Campylobacter in Poultry http://www.fsis.usda.gov/wps/wcm/connect/6732c082-af40-415e-9b57-90533ea4c252/Compliance_Guide_Controling_Salmonella_Campylobacter_Poultry_0510.pdf?MOD=AJPERES
3rd party certification		
PQA Plus	Pork Quality Assurance Plus is a producer education and certification program to reduce the risk of violative animal health product residues in pork. PQA Plus is a producer-driven program they can use to ensure U.S. pork products are of the highest quality and safe, and animals raised for food are cared for in a way ensuring their well-being. Modeled after the Hazard Analysis Critical Control Point (HACCP) programs used by food manufacturers to ensure the safety of food products, PQA was then customized for on-farm use. It was designed to identify practices with potential to result in a food safety hazard and minimize this potential risk through producer education of relevant on-farm practices	•http://www.pork.org/pqa-plus-certification/
TQA	Transport Quality Assurance is a program that helps swine transporters, producers and handlers understand how to handle, move and transport pigs and the potential impacts of those actions on pig well-being and/or pork quality. Anyone who handles or transports pigs, or sets protocols for handling pigs, is a potential influencer of animal well-being and pork quality.	•http://www.pork.org/tqa-certification/

(continued)

Investment/ Intervention	Definition	Source
BQA	Beef Quality Assurance is a national program that provides guidelines for beef cattle production. Nearly every state in the U.S. has an active BQA program. Funding for these efforts ranges from state-derived Beef Checkoff money to national Beef Checkoff support through the Cattlemen's Beef Board. State BQA programs are voluntary, locally led, and administered through organizations such as state beef councils, land grant universities and state cattle associations. State-based activities are often enhanced through locally derived private and public grants. BQA programming focuses on educating and training cattle producers, farm advisors, and veterinarians on the issues in cattle food safety and quality. It also provides tools for verifying and documenting animal husbandry practices.	•http://www.bqa.org/
Farmers Assuring Responsible Management (FARM)	The program was developed by the National Milk Producers Federation with support from Dairy Management Incorporated. FARM was designed to "bring uniformity to animal care through education, on-farm evaluations, and objective third-party verification."	•http://dairyline.com/wpbackend/?p=1542
Humane Farm Animal Care	Humane Farm Animal Care (HFAC) is the leading non-profit certification organization dedicated to improving the lives of farm animals in food production from birth through slaughter.	•http://certifiedhumane.org/how-we-work/overview/

AGENDA
Expert Panel on Costs of Food Safety Investments at Slaughter and Processing
RTI International
Research Triangle Park, NC

Tuesday, February 24, 2015

8:00 AM Meet Catherine Viator at hotel lobby (out-of-town panelists)

8:15 AM Arrive at RTI

8:30 AM Orientation

- Introductions
- Review agenda and materials in binder
- Review purpose and goals of expert panel
- Review overall cost assumptions:
    - Types of costs
    - Ranges of estimates
    - Categorization of establishment sizes and labor for estimating costs

9:30 AM Break

For each intervention, discuss definition, assumptions, units, and categories of costs. Complete worksheets providing cost estimates by establishment size for each intervention.

9:45 AM Development, validation, and reassessment of HACCP, SSOP, and sampling plans

Food safety and biosecurity training programs

12:00 PM Catered lunch

12:45 PM Antimicrobial equipment and solutions

Antimicrobial solutions

2:45 PM Break

3:00 PM Sanitizing equipment

4:30 PM Adjourn

Wednesday, February 25, 2015

8:00 AM Meet Catherine Viator at hotel lobby (out-of-town panelists)

8:15 AM Arrive at RTI

8:30 AM Review assumptions and estimates from first day

Cold storage and records storage

Waste removal and processing and downed animal removal

Third-party audits

10:30 AM Break

10:45 AM Drinking water additives and treatments

12:00 PM Catered lunch

12:45 PM RTE processing equipment

2:15 PM Break

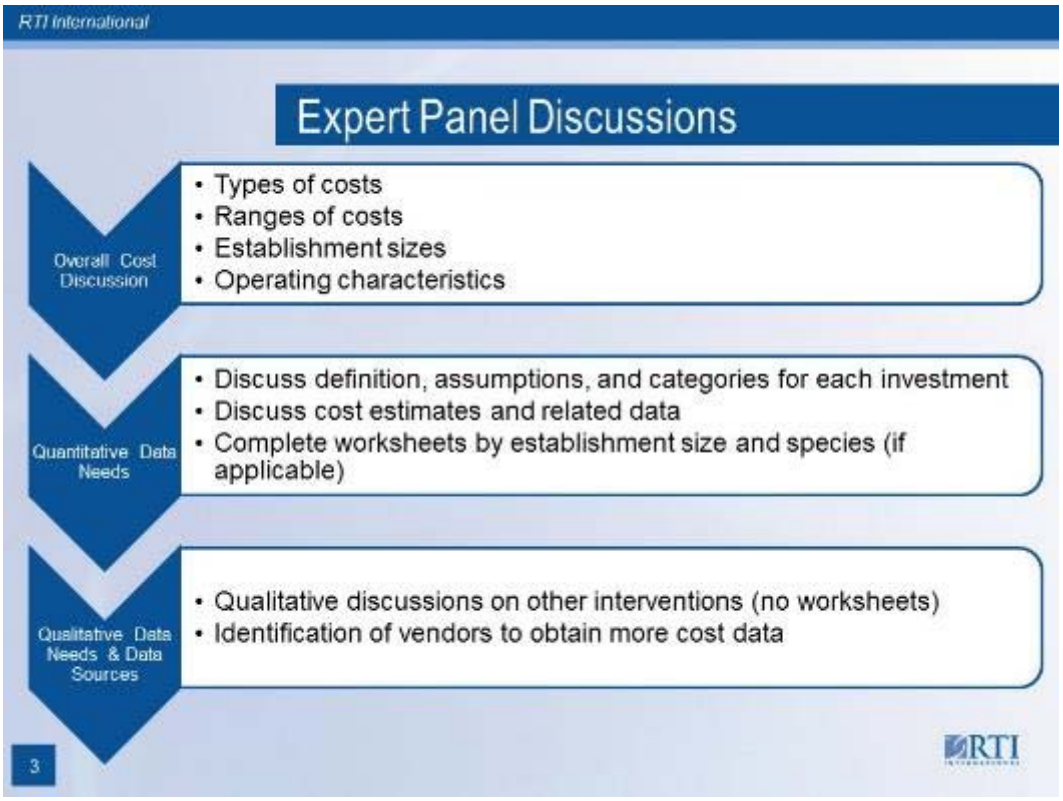
2:30 PM Qualitative discussion on remaining interventions

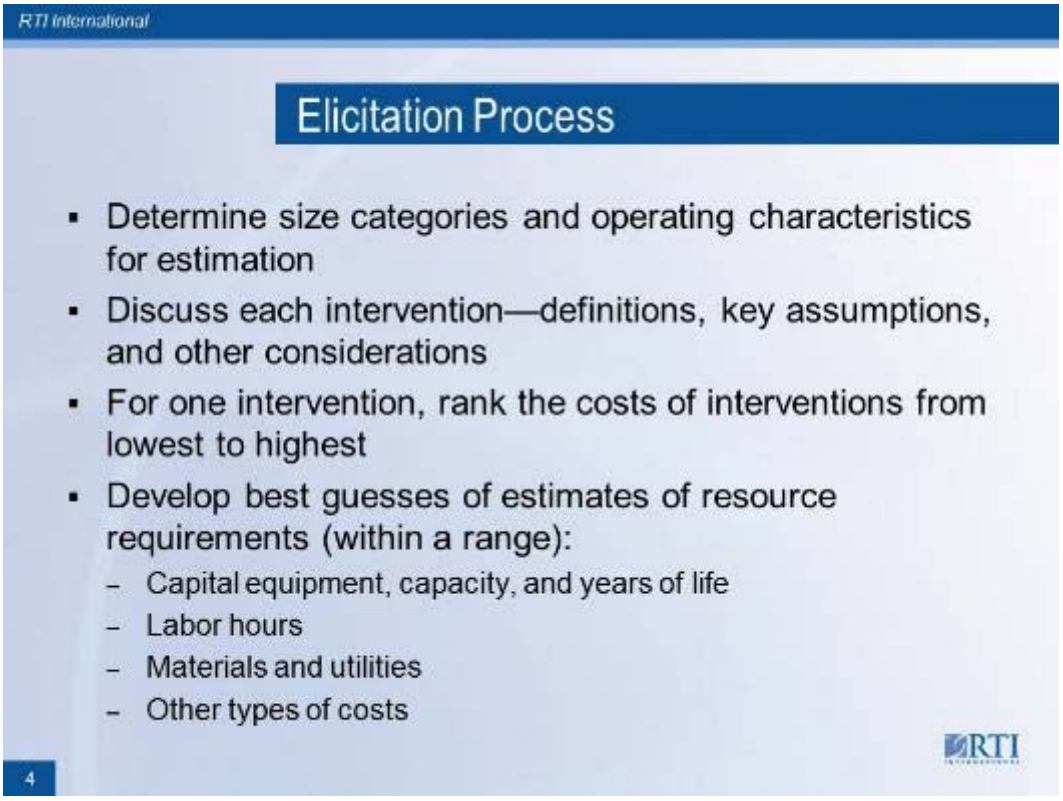
- Testing: species determination, Trichinae, Toxoplasma gondii
- In-house testing laboratories
- Removal of large lymph nodes
- Liability and recall insurance
- Product recalls
- In-plant inspector facilities

3: 45 PM Wrap-up discussion

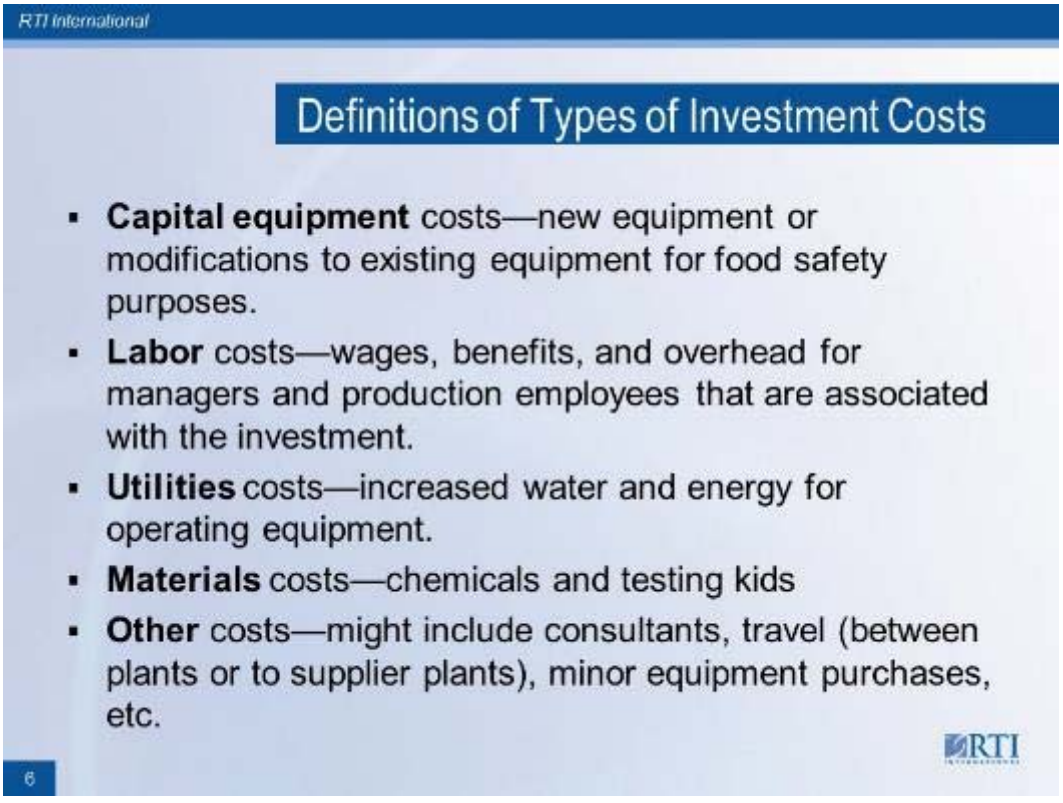
4:00 PM Adjourn

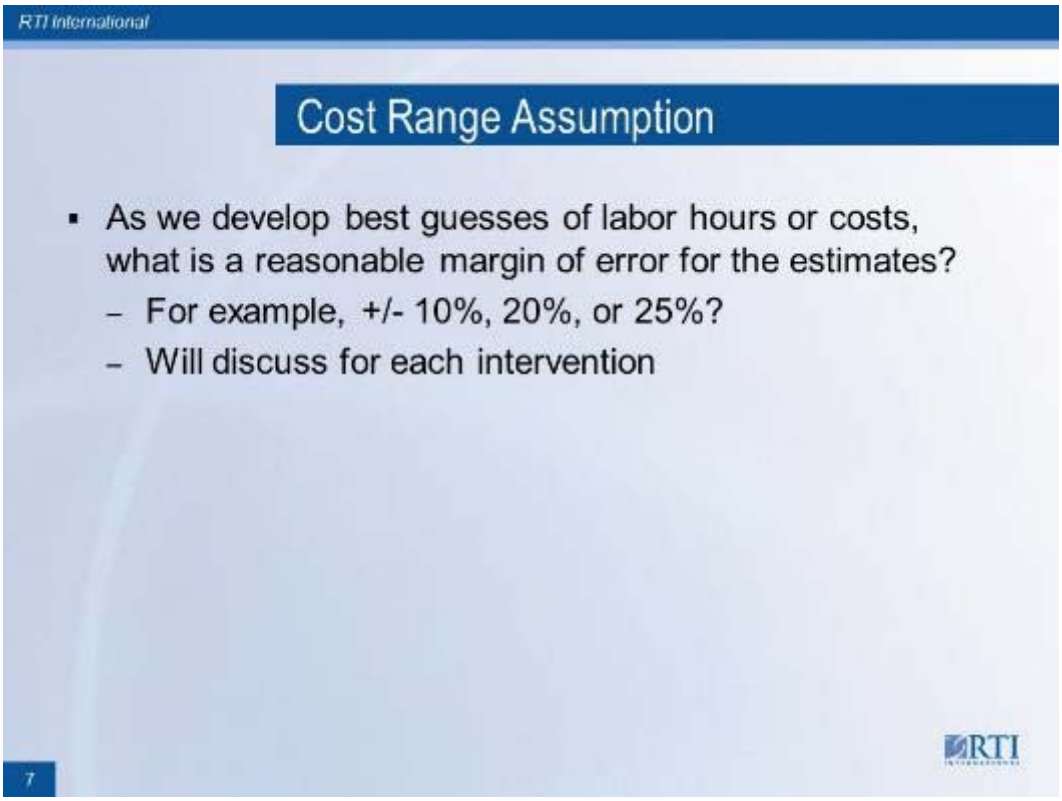
Slaughter and Processing Presentation

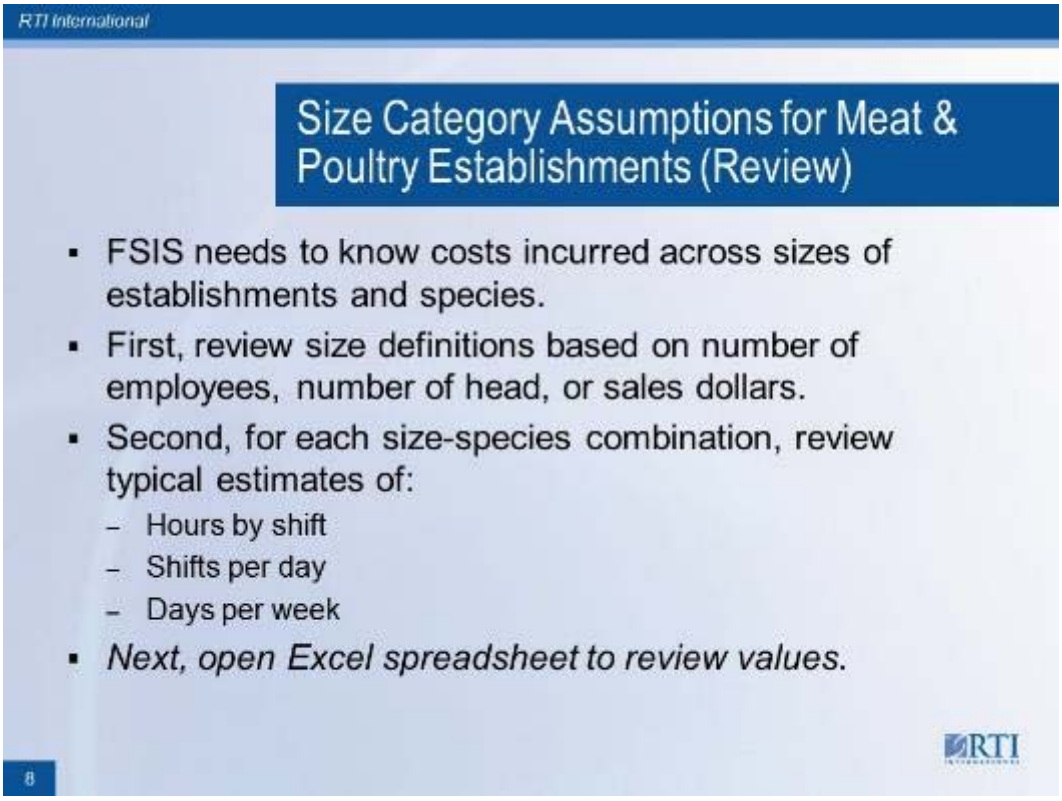

RTI International
Expert Panel Discussions
Overall Cost Discussion
• Types of costs
• Ranges of costs
• Establishment sizes
• Operating characteristics
Quantitative Data Needs
• Discuss definition, assumptions, and categories for each investment
• Discuss cost estimates and related data
• Complete worksheets by establishment size and species (if applicable)
Qualitative Data Needs & Data Sources
• Qualitative discussions on other interventions (no worksheets)
• Identification of vendors to obtain more cost data
3
RTI


RTI International
Elicitation Process
▪ Determine size categories and operating characteristics for estimation
▪ Discuss each intervention—definitions, key assumptions, and other considerations
▪ For one intervention, rank the costs of interventions from lowest to highest
▪ Develop best guesses of estimates of resource requirements (within a range):
– Capital equipment, capacity, and years of life
– Labor hours
– Materials and utilities
– Other types of costs
4
RTI


RTI International
List of Food Safety Investments
Quantitative cost data needs:
HACCP & SSOP plans
Sampling plans
Employee training
Antimicrobial equipment
Antimicrobial solutions
Sanitizing equipment
Cold storage
Records storage
Waste removal
Downed animal removal
Third party audits
Water treatment
RTE processing equipment
Qualitative cost information needs:
Testing (selected types)
In-house testing laboratories
Removal of large lymph nodes
Liability and recall insurance
Product recalls
Inspector facilities in the plant
RTI
5


RTI International
Definitions of Types of Investment Costs
Capital equipment costs—new equipment or modifications to existing equipment for food safety purposes.
Labor costs—wages, benefits, and overhead for managers and production employees that are associated with the investment.
Utilities costs—increased water and energy for operating equipment.
Materials costs—chemicals and testing kids
Other costs—might include consultants, travel (between plants or to supplier plants), minor equipment purchases, etc.
RTI
6


RTI International
Cost Range Assumption
As we develop best guesses of labor hours or costs, what is a reasonable margin of error for the estimates?
For example, +/- 10%, 20%, or 25%?
Will discuss for each intervention
RTI
7


RTI International
Size Category Assumptions for Meat & Poultry Establishments (Review)
FSIS needs to know costs incurred across sizes of establishments and species.
First, review size definitions based on number of employees, number of head, or sales dollars.
Second, for each size-species combination, review typical estimates of:
Hours by shift
Shifts per day
Days per week
Next, open Excel spreadsheet to review values.
RTI
8

RTI International

Labor Categories for Food Manufacturing

	Median Wage (2012)	Range (10th & 90th percentile)
Food Scientists & Technologists	$26.39	[$15.59, $47.75]
Office & Administrative Support	$15.11	[$9.58, $24.21]
Production Occupations	$12.47	[$8.71, $20.93]
Management Occupations	$43.66	[$24.36, $87.44]

Source: Bureau of Labor Statistics

Note: These values do not account for benefits and overhead.

RTI

9

RTI International

Quantitative Data Needs

RTI

10

RTI International

HACCP Plans

Definition: A systematic, preventive approach to food safety from biological, chemical, and physical hazards.

Phases:	
Development	To create an establishment's HACCP plan by applying the 7 principles: (1) hazard analysis, (2) critical control point identification, (3) establishment of critical limits, (4) monitoring procedures, (5) corrective actions, (6) record keeping, and (7) verification procedures.
Validation	The process of demonstrating that the HACCP system as designed can adequately control potential hazards to produce a safe, unadulterated product. Can be accomplished by conducting in-plant studies, providing literature citations, and conducting pathogen inoculation studies in controlled laboratory settings.
Reassessment	Review and update of the HACCP plan to ensure that it reflects current needs, on an annual or more frequent basis.

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RTI International

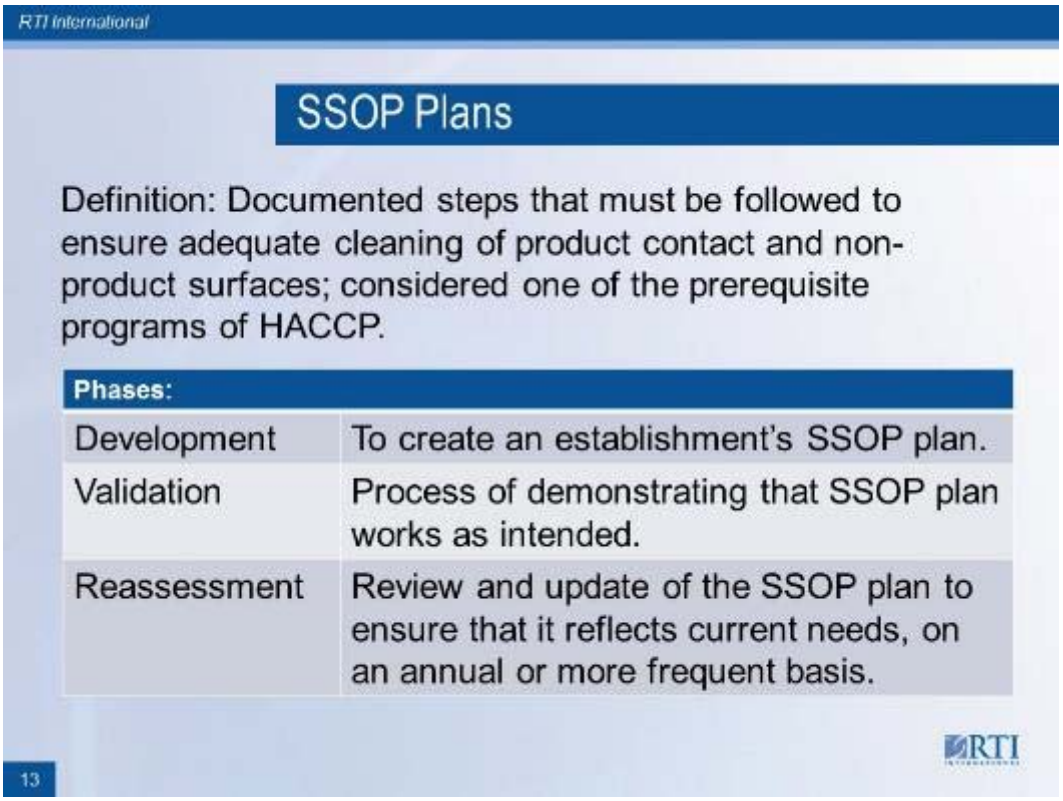
HACCP Plans (continued)

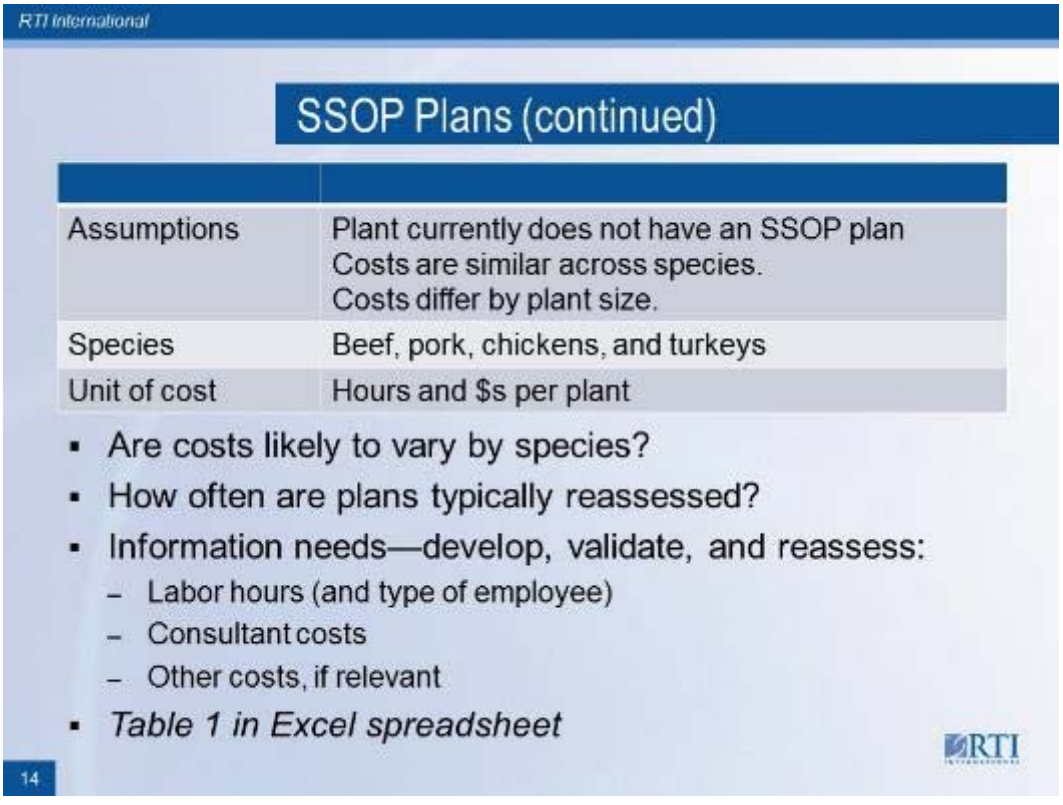
Assumptions	Plant currently does not have a HACCP plan. Costs are similar across species. Costs differ by size.
Species	Beef, pork, chickens, and turkeys
Unit of cost	Hours and $s per plant

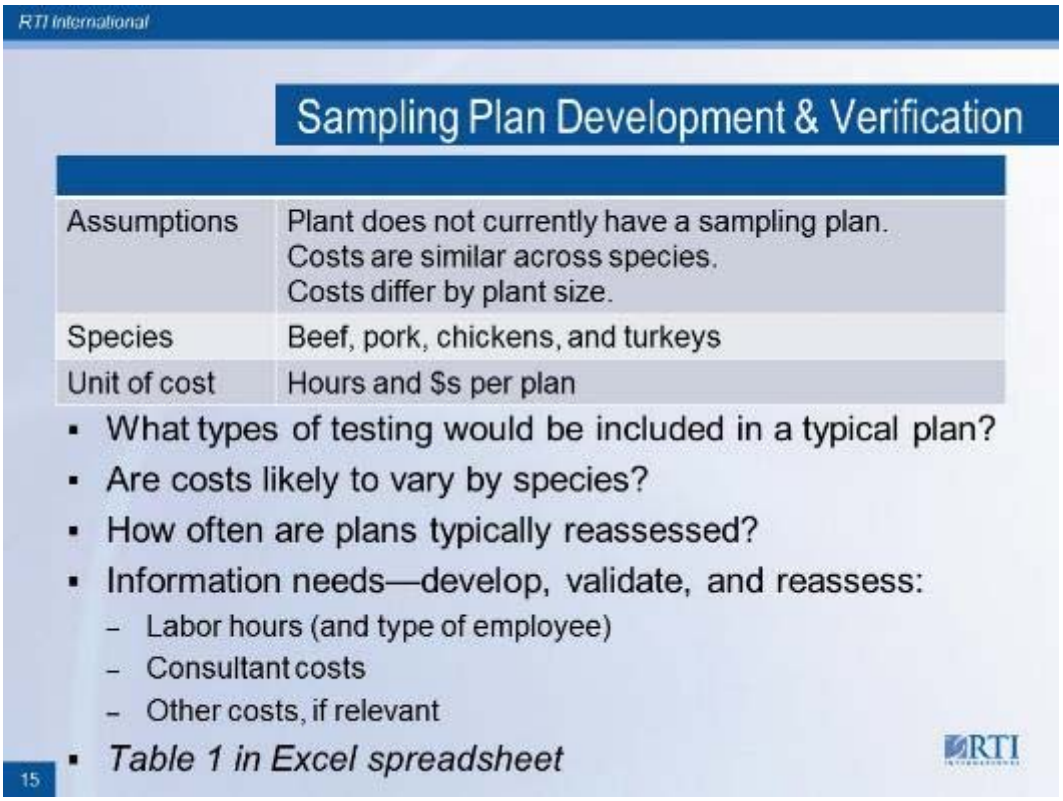
- Are costs likely to vary by species?
- How often are plans typically reassessed?
- Information needs—develop, validate, and reassess:
  - Labor hours (and type of employee)
  - Consultant costs
  - Other costs, if relevant
- *Table 1 in Excel spreadsheet*

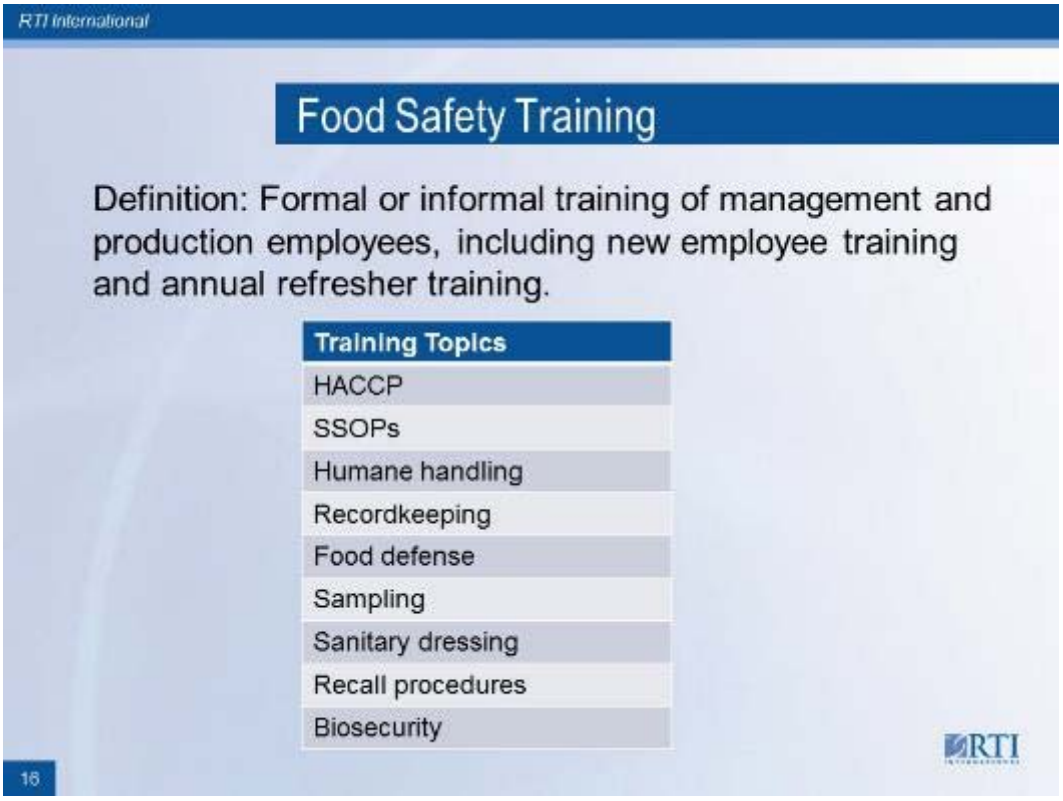
RTI

12

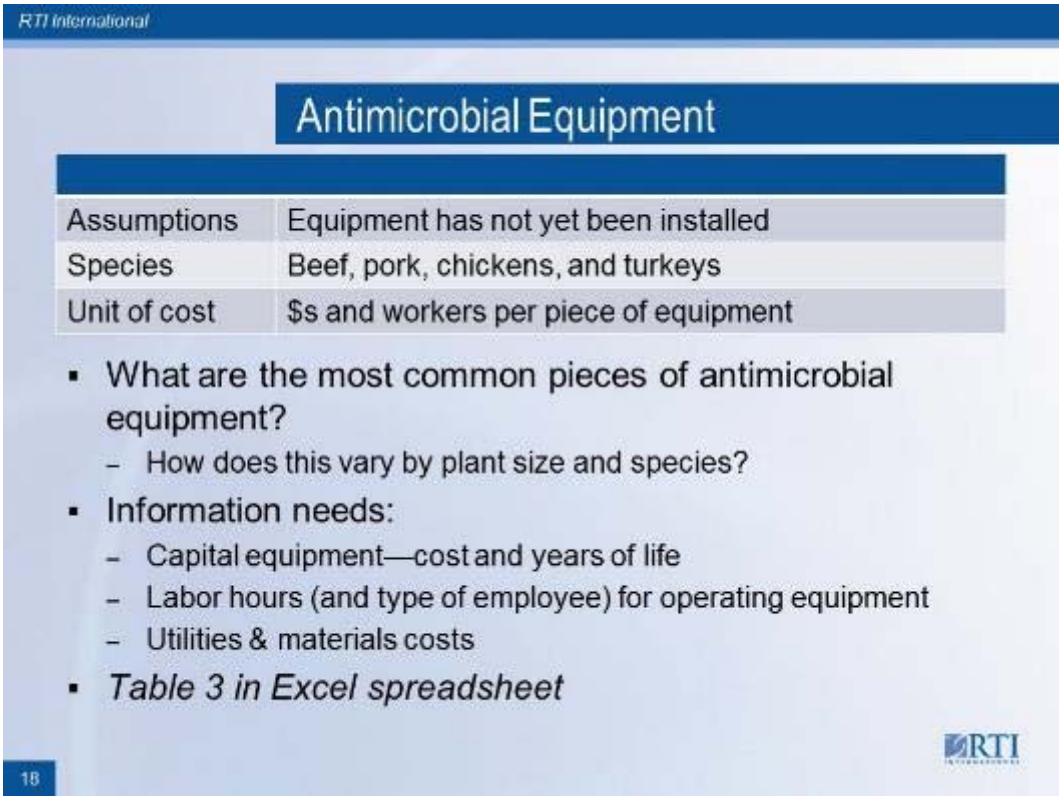

RTI International
SSOP Plans
Definition: Documented steps that must be followed to ensure adequate cleaning of product contact and non-product surfaces; considered one of the prerequisite programs of HACCP.
Phases:
Development
To create an establishment's SSOP plan.
Validation
Process of demonstrating that SSOP plan works as intended.
Reassessment
Review and update of the SSOP plan to ensure that it reflects current needs, on an annual or more frequent basis.
RTI
13

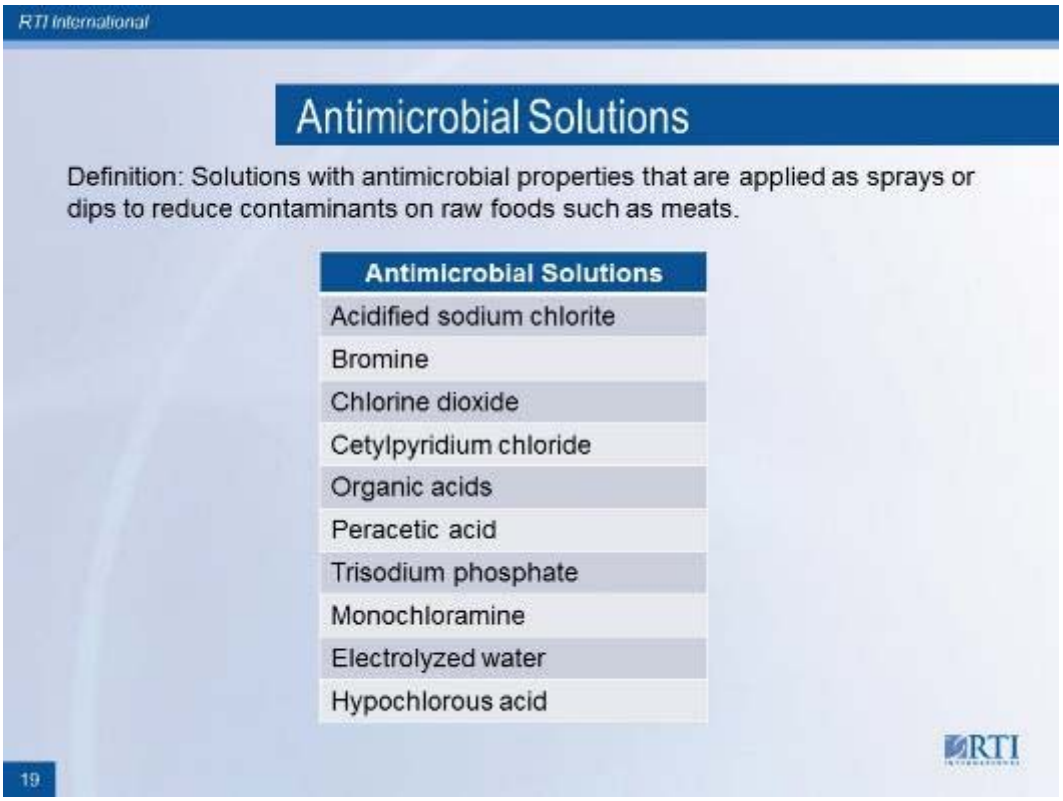

RTI International
SSOP Plans (continued)
Assumptions
Plant currently does not have an SSOP plan
Costs are similar across species.
Costs differ by plant size.
Species
Beef, pork, chickens, and turkeys
Unit of cost
Hours and $s per plant
Are costs likely to vary by species?
How often are plans typically reassessed?
Information needs—develop, validate, and reassess:
Labor hours (and type of employee)
Consultant costs
Other costs, if relevant
Table 1 in Excel spreadsheet
RTI
14

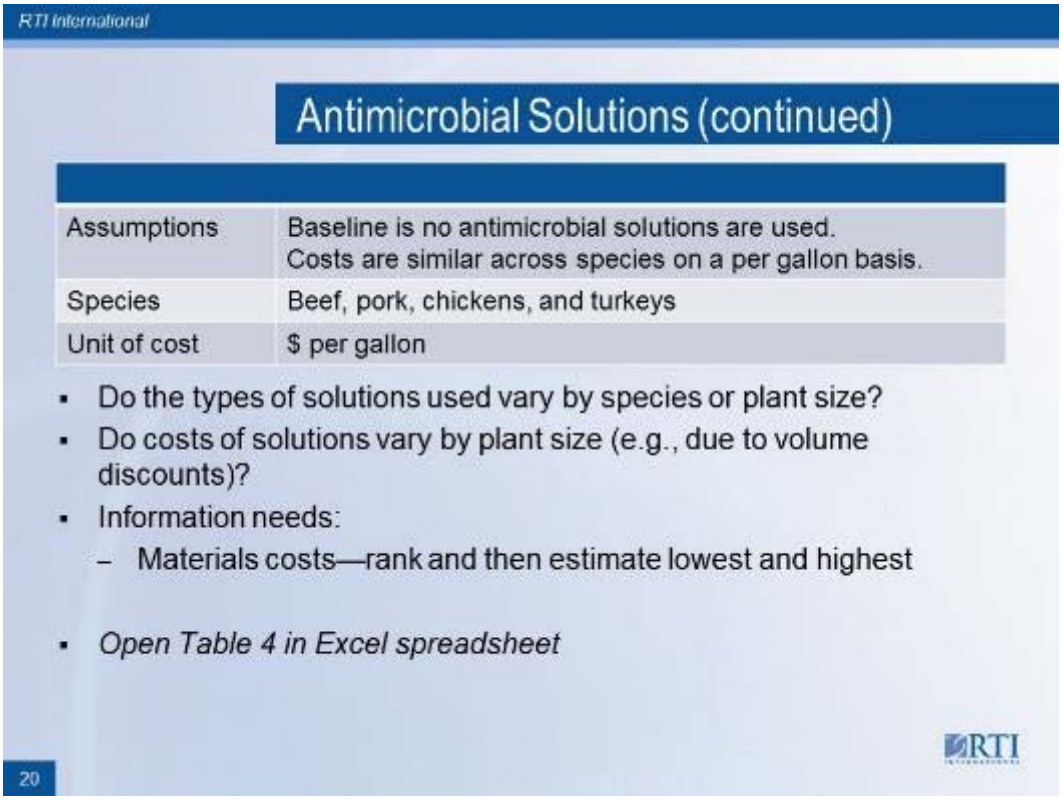

RTI International
Sampling Plan Development & Verification
Assumptions
Plant does not currently have a sampling plan.
Costs are similar across species.
Costs differ by plant size.
Species
Beef, pork, chickens, and turkeys
Unit of cost
Hours and $s per plan
What types of testing would be included in a typical plan?
Are costs likely to vary by species?
How often are plans typically reassessed?
Information needs—develop, validate, and reassess:
Labor hours (and type of employee)
Consultant costs
Other costs, if relevant
Table 1 in Excel spreadsheet
RTI
15

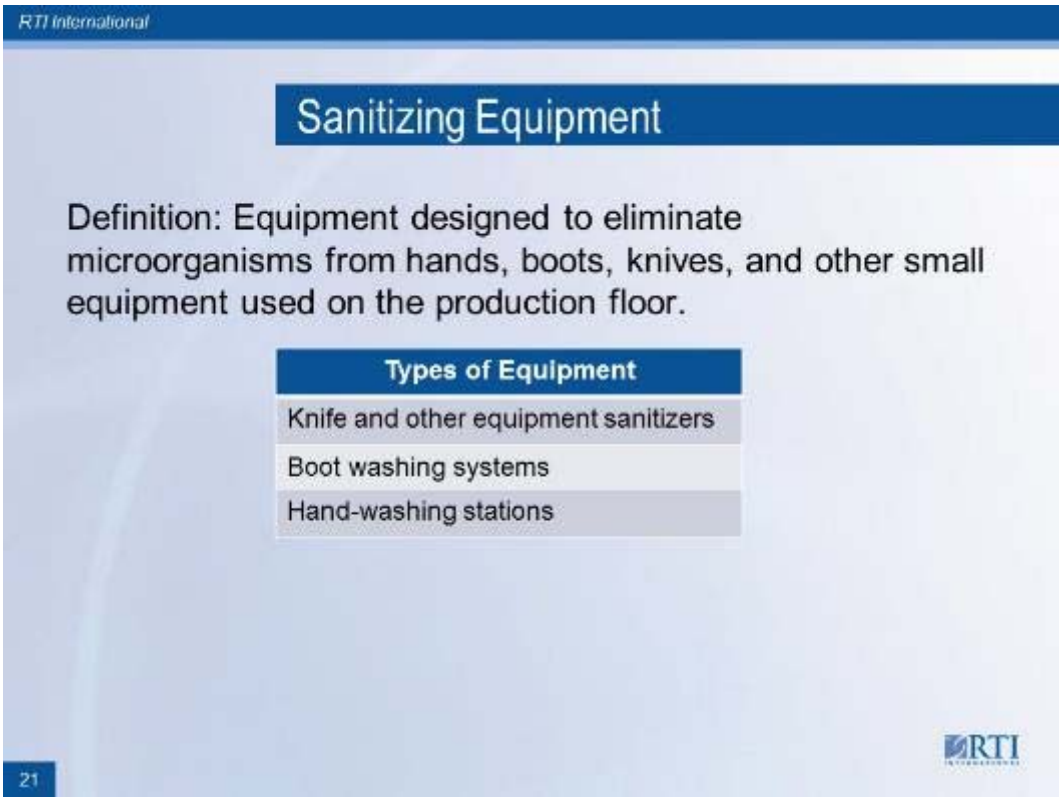

RTI International
Food Safety Training
Definition: Formal or informal training of management and production employees, including new employee training and annual refresher training.
Training Topics
HACCP
SSOPs
Humane handling
Recordkeeping
Food defense
Sampling
Sanitary dressing
Recall procedures
Biosecurity
RTI
16

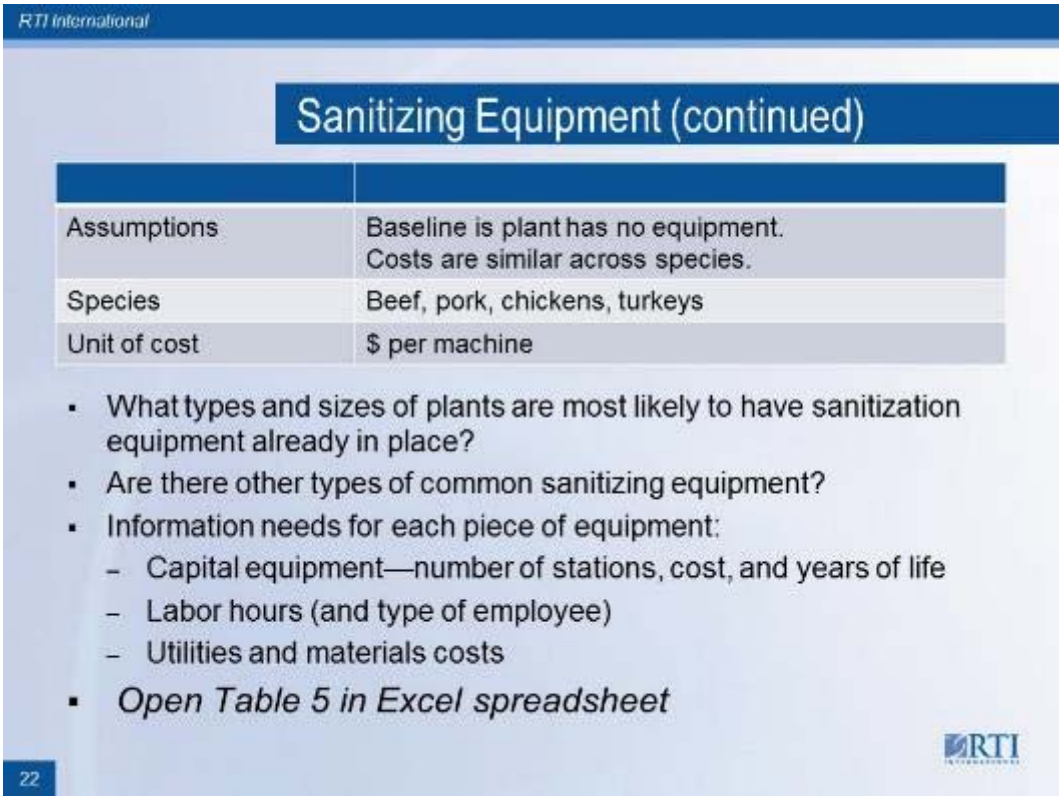

RTI International
Food Safety Training (continued)
Assumptions
Training includes new employee training and annual refresher training.
Costs vary by size of plant.
Species
Beef, pork, chickens, turkeys
Unit of cost
$ per employee
Are costs likely to vary by species?
How is training typically delivered (onsite with trainer, offsite training, web-based training)?
Information needs:
Group topics typically addressed together in training
Labor hours and course fees for new employee training and annual refresher training for production and management staff.
Table 2 in Excel spreadsheet
RTI
17

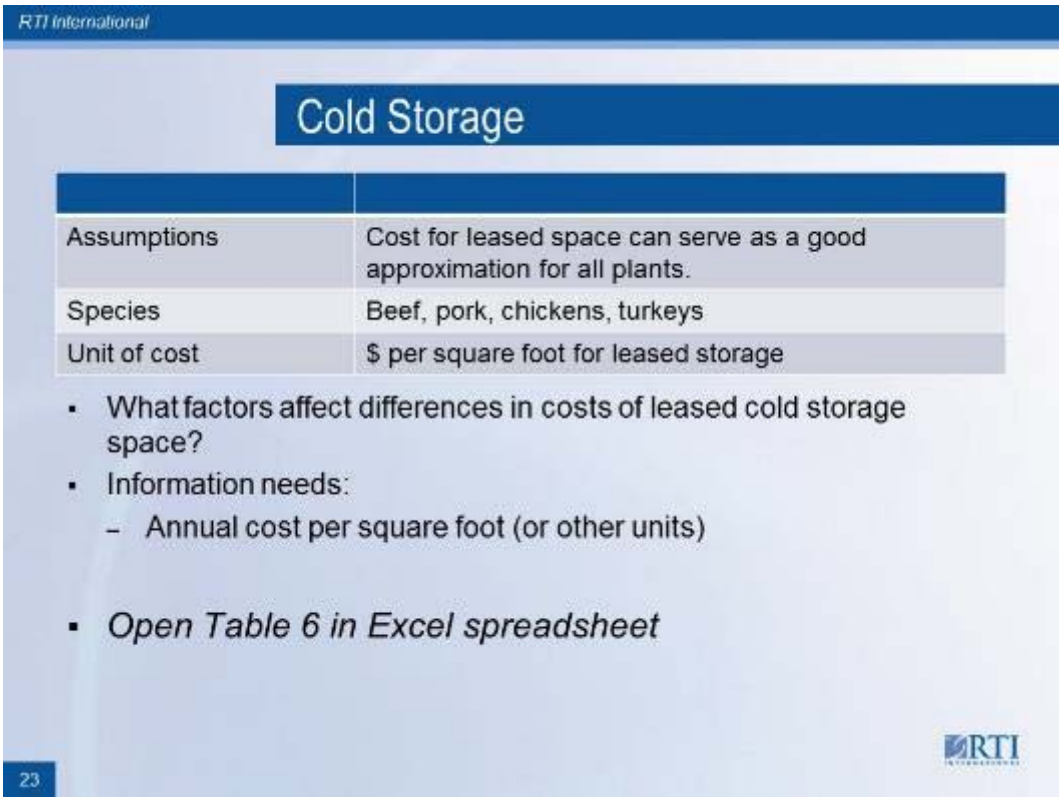

RTI International
Antimicrobial Equipment
Assumptions
Equipment has not yet been installed
Species
Beef, pork, chickens, and turkeys
Unit of cost
$s and workers per piece of equipment
What are the most common pieces of antimicrobial equipment?
How does this vary by plant size and species?
Information needs:
Capital equipment—cost and years of life
Labor hours (and type of employee) for operating equipment
Utilities & materials costs
Table 3 in Excel spreadsheet
RTI
18

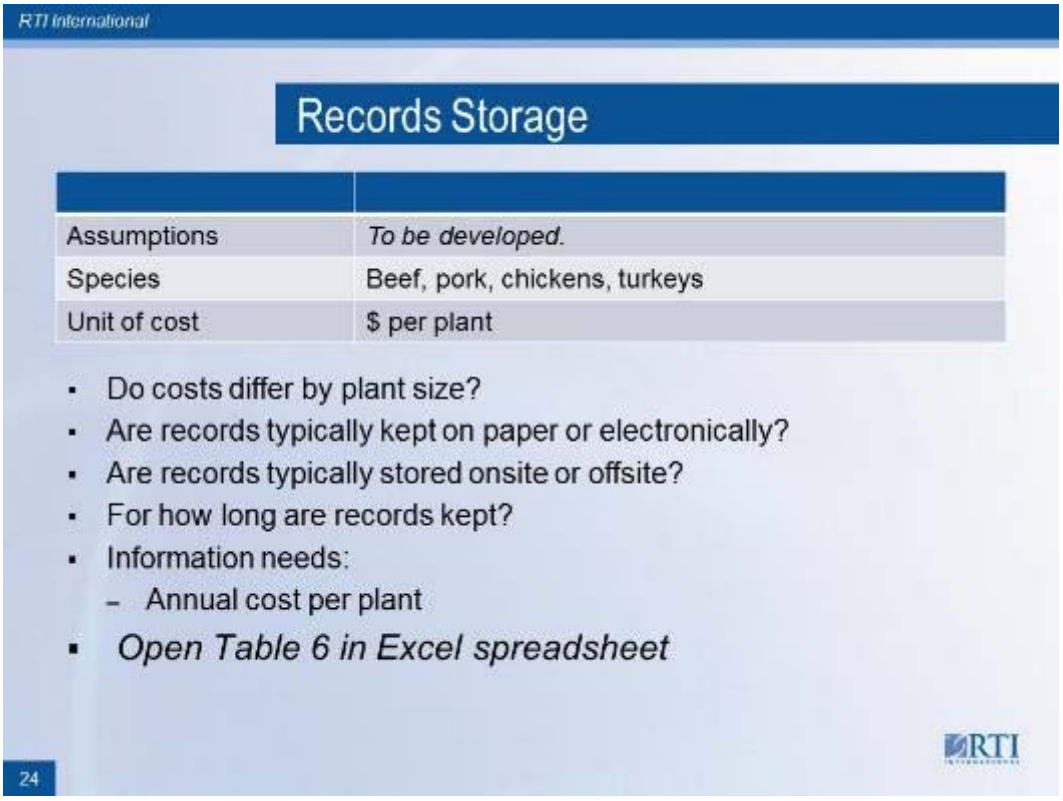

RTI International
Antimicrobial Solutions
Definition: Solutions with antimicrobial properties that are applied as sprays or dips to reduce contaminants on raw foods such as meats.
Antimicrobial Solutions
Acidified sodium chlorite
Bromine
Chlorine dioxide
Cetylpyridium chloride
Organic acids
Peracetic acid
Trisodium phosphate
Monochloramine
Electrolyzed water
Hypochlorous acid
RTI
19

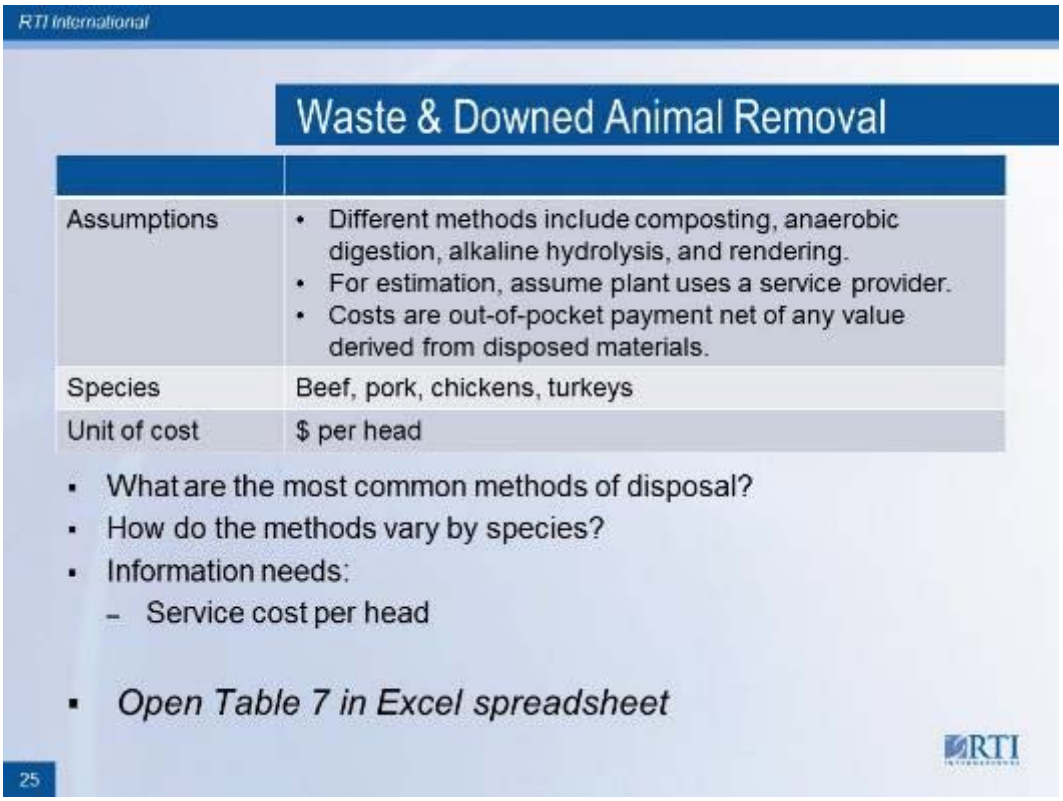

RTI International
Antimicrobial Solutions (continued)
Assumptions
Baseline is no antimicrobial solutions are used.
Costs are similar across species on a per gallon basis.
Species
Beef, pork, chickens, and turkeys
Unit of cost
$ per gallon
Do the types of solutions used vary by species or plant size?
Do costs of solutions vary by plant size (e.g., due to volume discounts)?
Information needs:
– Materials costs—rank and then estimate lowest and highest
Open Table 4 in Excel spreadsheet
RTI
20

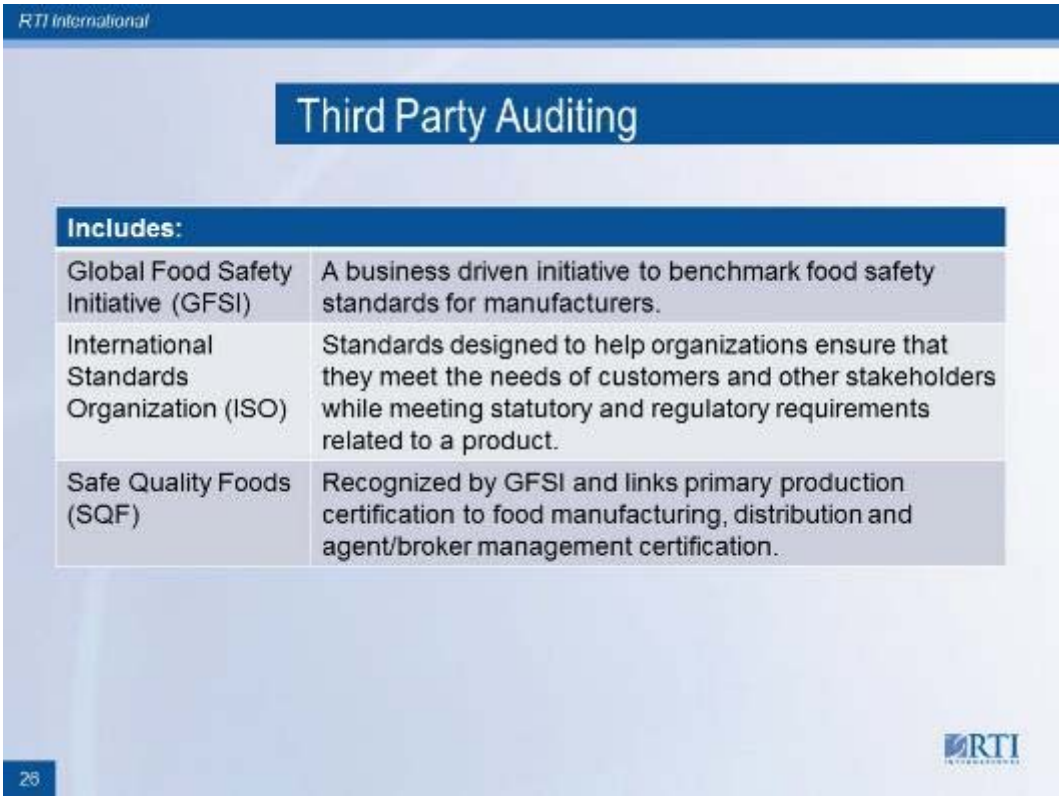

RTI International
Sanitizing Equipment
Definition: Equipment designed to eliminate microorganisms from hands, boots, knives, and other small equipment used on the production floor.
Types of Equipment
Knife and other equipment sanitizers
Boot washing systems
Hand-washing stations
RTI
21


RTI International
Sanitizing Equipment (continued)
Assumptions
Baseline is plant has no equipment.
Costs are similar across species.
Species
Beef, pork, chickens, turkeys
Unit of cost
$ per machine
What types and sizes of plants are most likely to have sanitization equipment already in place?
Are there other types of common sanitizing equipment?
Information needs for each piece of equipment:
Capital equipment—number of stations, cost, and years of life
Labor hours (and type of employee)
Utilities and materials costs
Open Table 5 in Excel spreadsheet
RTI
22


RTI International
Cold Storage
Assumptions
Cost for leased space can serve as a good approximation for all plants.
Species
Beef, pork, chickens, turkeys
Unit of cost
$ per square foot for leased storage
What factors affect differences in costs of leased cold storage space?
Information needs:
Annual cost per square foot (or other units)
Open Table 6 in Excel spreadsheet
RTI
23


RTI International
Records Storage
Assumptions
To be developed.
Species
Beef, pork, chickens, turkeys
Unit of cost
$ per plant
Do costs differ by plant size?
Are records typically kept on paper or electronically?
Are records typically stored onsite or offsite?
For how long are records kept?
Information needs:
Annual cost per plant
Open Table 6 in Excel spreadsheet
RTI
24


RTI International
Waste & Downed Animal Removal
Assumptions
• Different methods include composting, anaerobic digestion, alkaline hydrolysis, and rendering.
• For estimation, assume plant uses a service provider.
• Costs are out-of-pocket payment net of any value derived from disposed materials.
Species
Beef, pork, chickens, turkeys
Unit of cost
$ per head
▪ What are the most common methods of disposal?
▪ How do the methods vary by species?
▪ Information needs:
– Service cost per head
▪ Open Table 7 in Excel spreadsheet
RTI
25


RTI International
Third Party Auditing
Includes:
Global Food Safety Initiative (GFSI)
A business driven initiative to benchmark food safety standards for manufacturers.
International Standards Organization (ISO)
Standards designed to help organizations ensure that they meet the needs of customers and other stakeholders while meeting statutory and regulatory requirements related to a product.
Safe Quality Foods (SQF)
Recognized by GFSI and links primary production certification to food manufacturing, distribution and agent/broker management certification.
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Third Party Auditing (continued)

Assumptions	• Costs are incurred for initial certification and annual recertification (audits). • Costs vary by plant size.
Species	Beef, pork, chickens, turkeys
Unit of cost	$ per operation

- Do plants incur a separate cost for initial certification?
- What is the typical frequency of audits?
- Are there other common types of 3rd party audits for food safety purposes?
- Information needs:
  - Plant personnel hours
  - Auditor fee
- *Open Table 8 in Excel spreadsheet*

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Water Additives & Treatment

Includes the following:	
Chlorination	Can remove dissolved iron, manganese, and hydrogen sulfide if followed by mechanical or activated carbon filtration.
Electrolyzed water	Considered a type of "functional" water, whereby the water has the ability to carry nutrients and penetrate cellular structures.
Ozonation	Water is exposed to ozone gas and can then destroy microorganisms.
Ultraviolet	UV light has disinfection properties that kill bacteria, viruses and some cysts.
Acidification	Acidifiers such as sodium bisulfate, citric acid or vinegar are used by poultry producers to lower the pH of the drinking water they give their birds.

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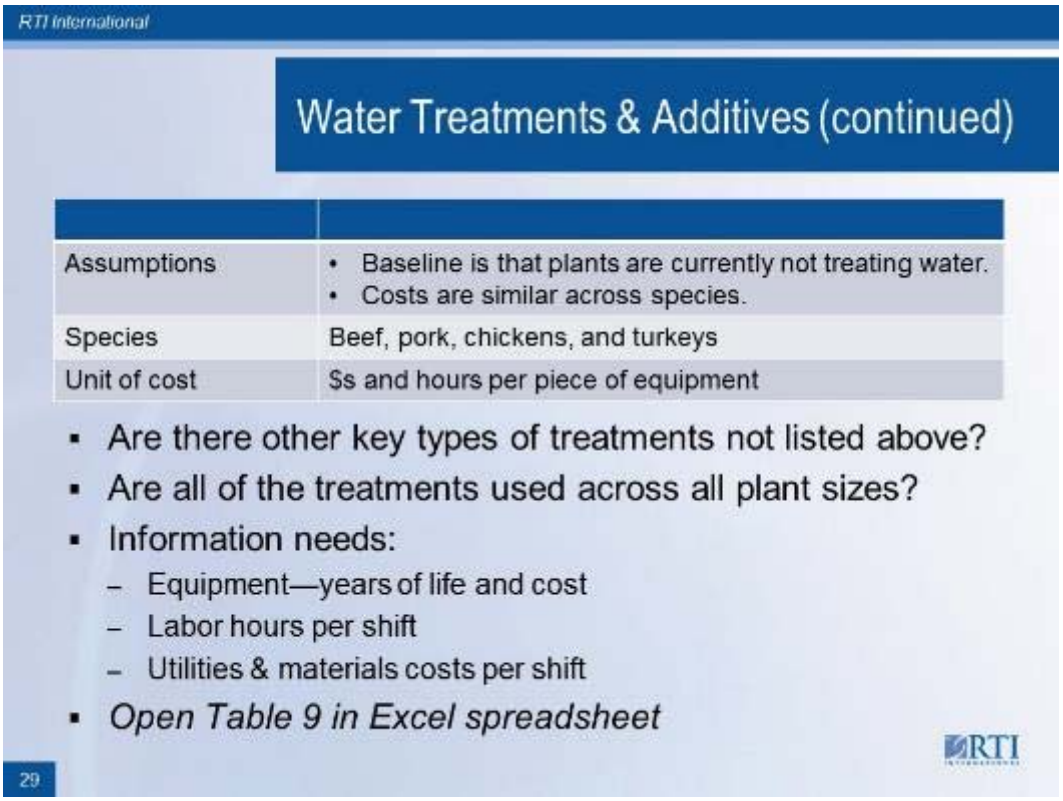
RTI International
Water Treatments & Additives (continued)
Assumptions
• Baseline is that plants are currently not treating water.
• Costs are similar across species.
Species
Beef, pork, chickens, and turkeys
Unit of cost
$s and hours per piece of equipment
▪ Are there other key types of treatments not listed above?
▪ Are all of the treatments used across all plant sizes?
▪ Information needs:
– Equipment—years of life and cost
– Labor hours per shift
– Utilities & materials costs per shift
▪ Open Table 9 in Excel spreadsheet
RTI
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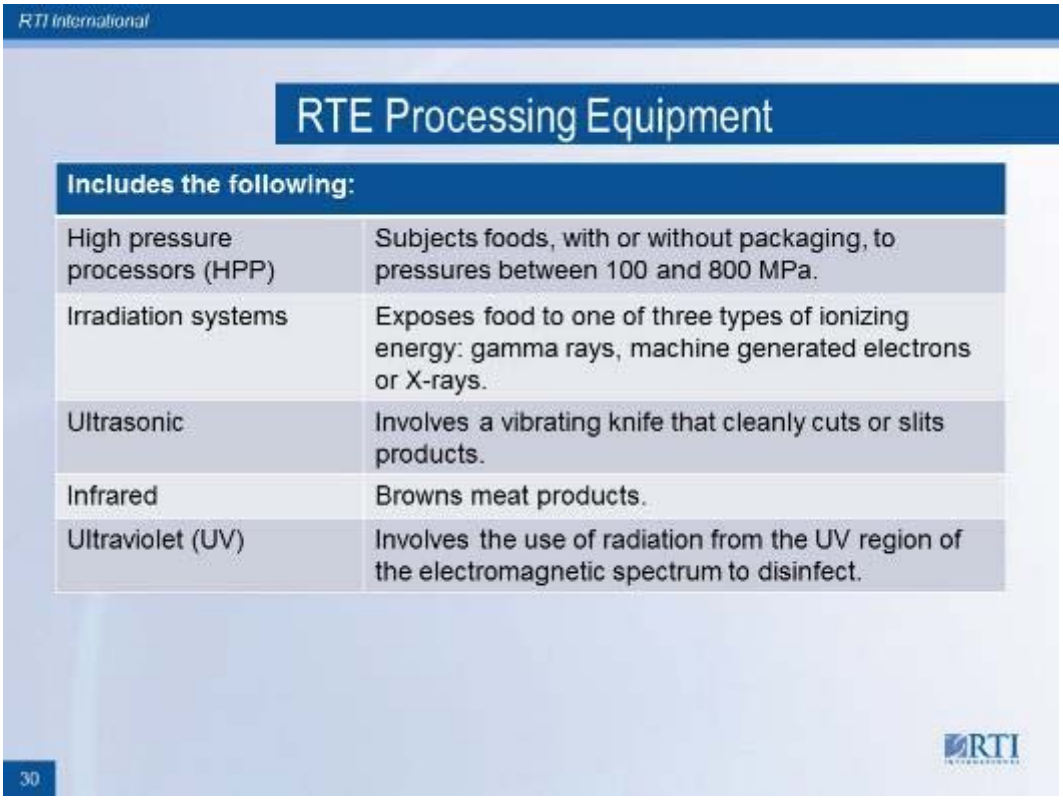
RTI International
RTE Processing Equipment
Includes the following:
High pressure processors (HPP)
Subjects foods, with or without packaging, to pressures between 100 and 800 MPa.
Irradiation systems
Exposes food to one of three types of ionizing energy: gamma rays, machine generated electrons or X-rays.
Ultrasonic
Involves a vibrating knife that cleanly cuts or slits products.
Infrared
Browns meat products.
Ultraviolet (UV)
Involves the use of radiation from the UV region of the electromagnetic spectrum to disinfect.
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RTE Processing Equipment (continued)

Includes the following (continued):	
Radiant heating	The transfer of heat energy by electromagnetic waves.
Smokers	The process of flavoring, cooking, or preserving food by exposing it to smoke from burning or smoldering material, most often wood.
Drying	Dehydrated and freeze-dried foods have a low moisture level and therefore are shelf stable at room temperature.
Freezing	Freezing and storage at 0°F kills most bacteria.

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RTE Processing Equipment (continued)

Assumptions	• Plants are not currently using RTE processing equipment. • Costs are similar across species.
Species	Beef, pork, chickens, turkeys
Unit of cost	$s and hours per piece of equipment

- Do each of these investments have a food safety purpose?
- Should some of these be estimated as a service cost instead (e.g., irradiation)?
- Information needs:
  - Equipment—years of life and cost
  - Labor hours per shift
  - Utilities and materials costs per shift
- *Open Table 10 in Excel spreadsheet*

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Qualitative Data Needs

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Qualitative Discussion: Testing feasibility

- Are the following tests commonly used in slaughter and processing plants?
  - species determination
  - Trinchinae
  - Toxoplasma gondii
- Would plants test in-house or ship samples to a laboratory?
- What are sources of cost estimates for these tests?

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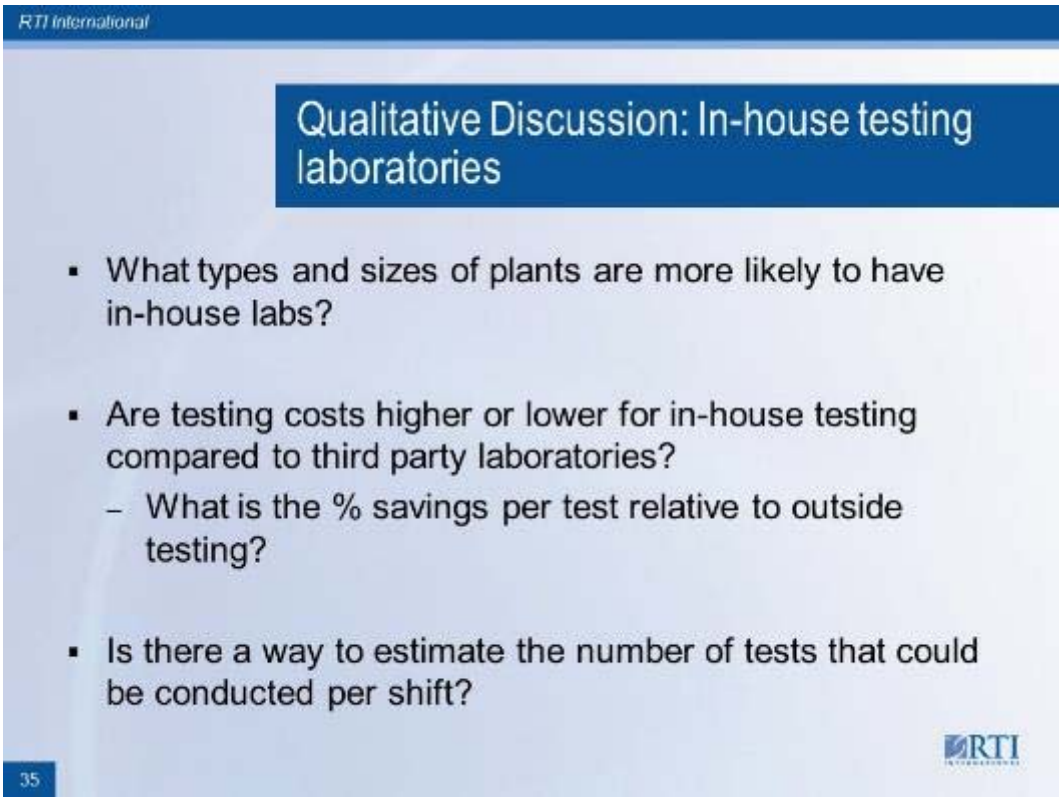
RTI International
Qualitative Discussion: In-house testing laboratories
What types and sizes of plants are more likely to have in-house labs?
Are testing costs higher or lower for in-house testing compared to third party laboratories?
What is the % savings per test relative to outside testing?
Is there a way to estimate the number of tests that could be conducted per shift?
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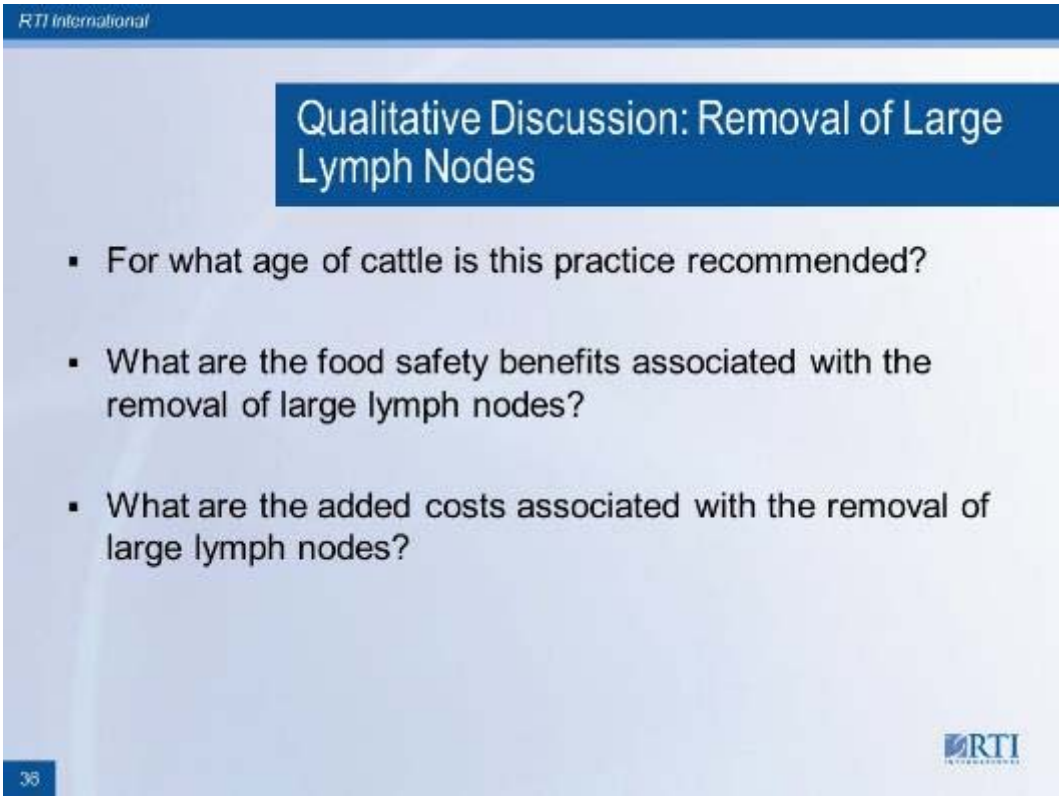
35


RTI International
Qualitative Discussion: Removal of Large Lymph Nodes
For what age of cattle is this practice recommended?
What are the food safety benefits associated with the removal of large lymph nodes?
What are the added costs associated with the removal of large lymph nodes?
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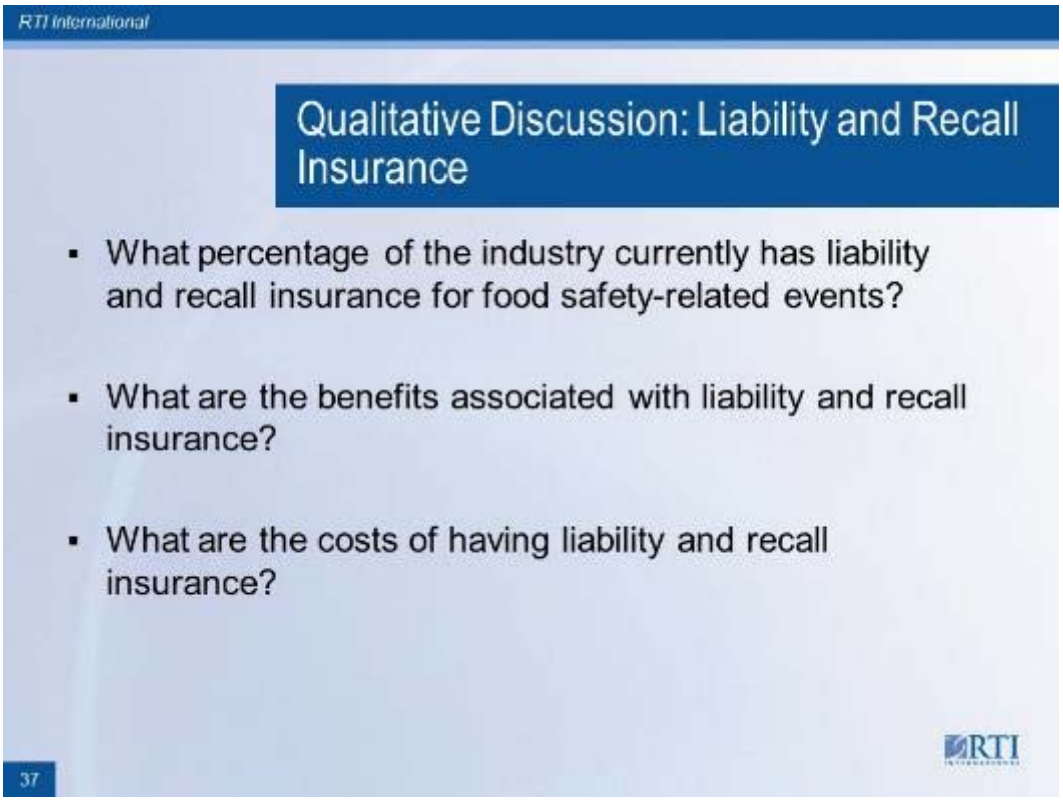
RTI International
Qualitative Discussion: Liability and Recall Insurance
What percentage of the industry currently has liability and recall insurance for food safety-related events?
What are the benefits associated with liability and recall insurance?
What are the costs of having liability and recall insurance?
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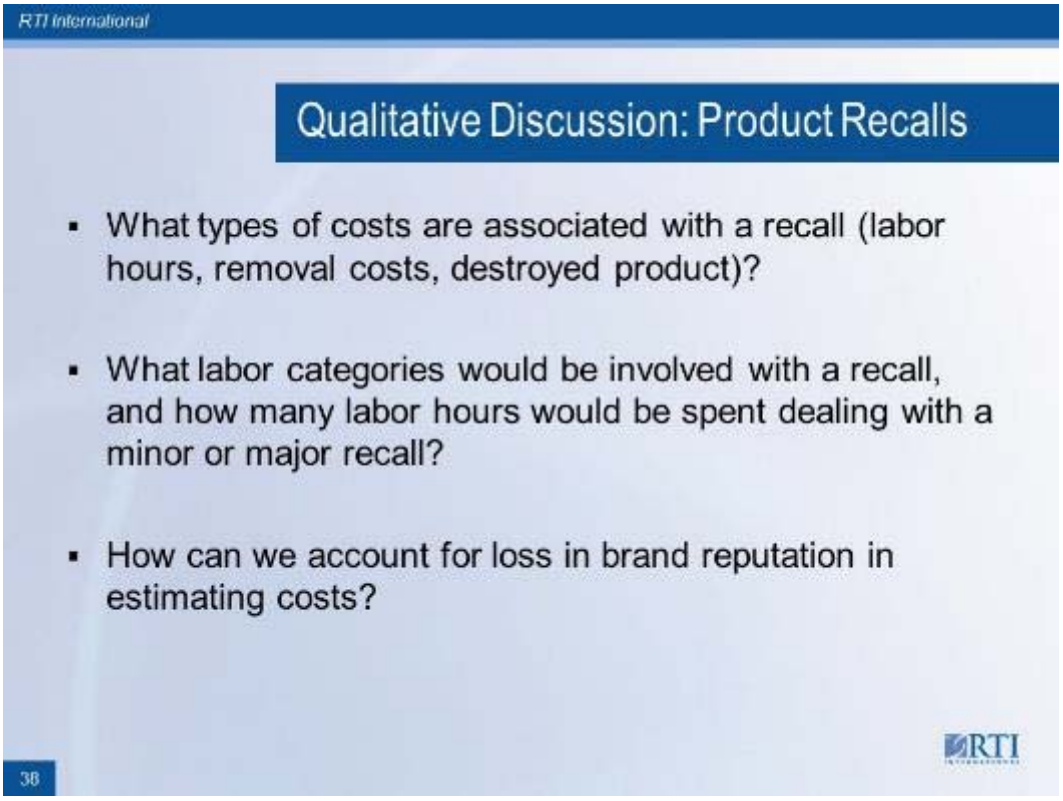
RTI International
Qualitative Discussion: Product Recalls
What types of costs are associated with a recall (labor hours, removal costs, destroyed product)?
What labor categories would be involved with a recall, and how many labor hours would be spent dealing with a minor or major recall?
How can we account for loss in brand reputation in estimating costs?
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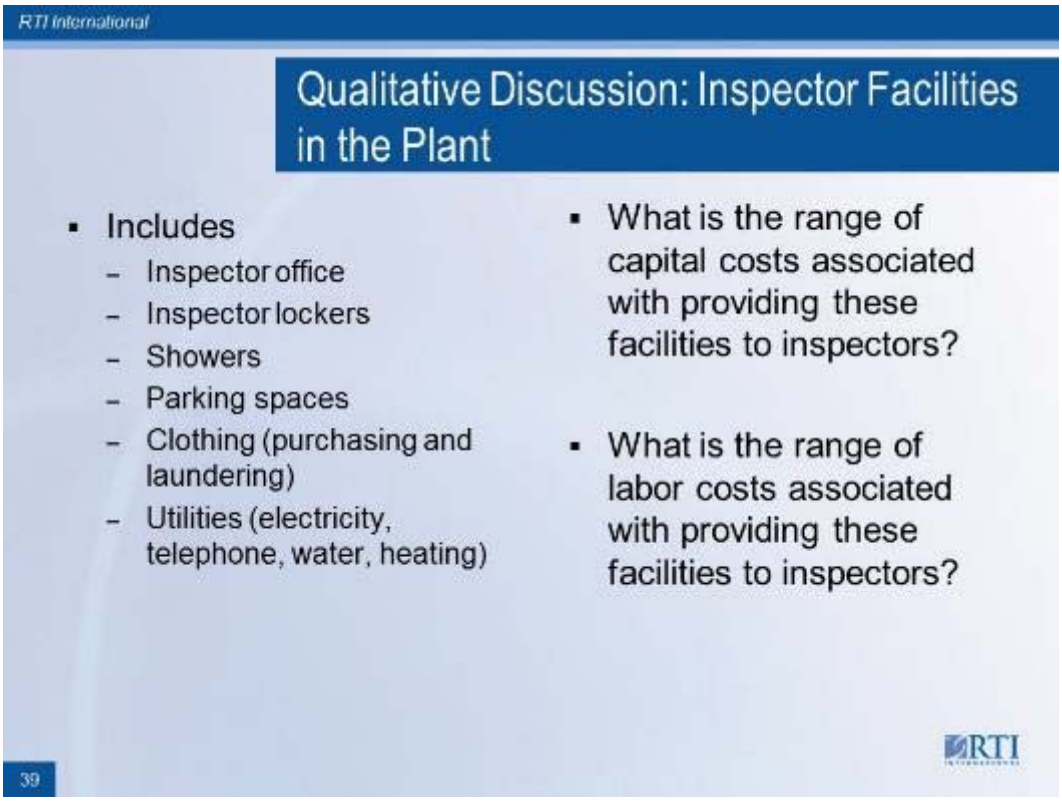
RTI International
Qualitative Discussion: Inspector Facilities in the Plant
Includes
Inspector office
Inspector lockers
Showers
Parking spaces
Clothing (purchasing and laundering)
Utilities (electricity, telephone, water, heating)
What is the range of capital costs associated with providing these facilities to inspectors?
What is the range of labor costs associated with providing these facilities to inspectors?
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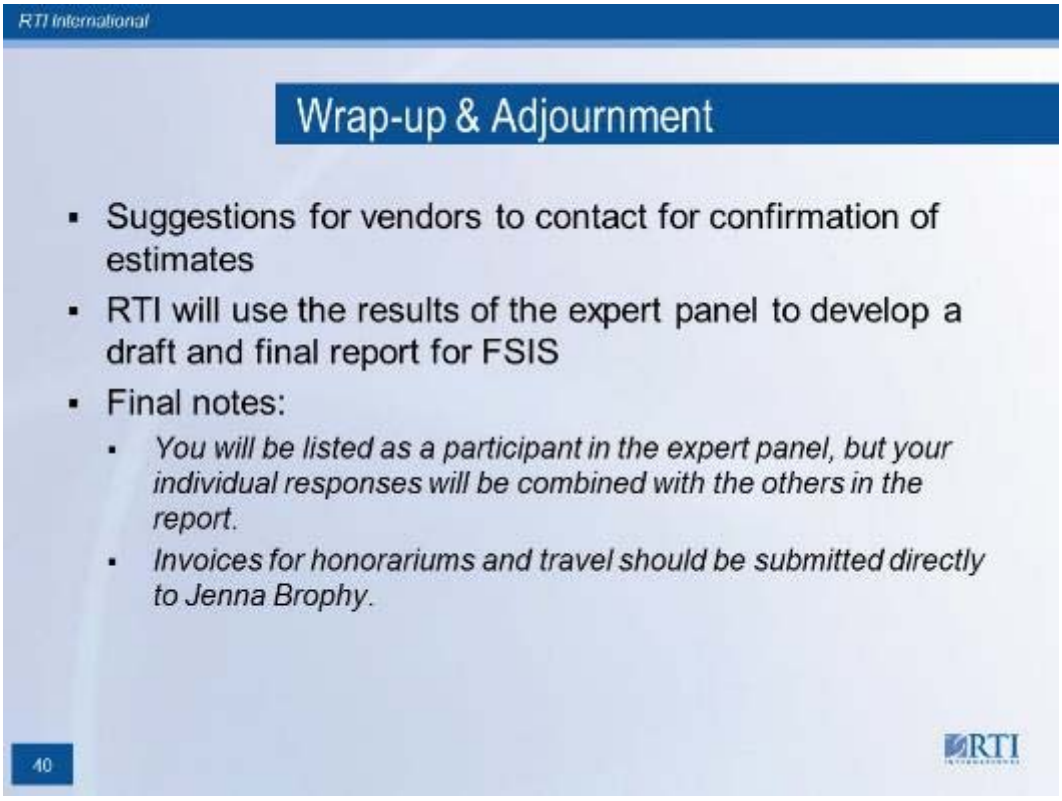
RTI International
Wrap-up & Adjournment
Suggestions for vendors to contact for confirmation of estimates
RTI will use the results of the expert panel to develop a draft and final report for FSIS
Final notes:
You will be listed as a participant in the expert panel, but your individual responses will be combined with the others in the report.
Invoices for honorariums and travel should be submitted directly to Jenna Brophy.
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Slaughter and Processing Definitions

Investment / Intervention	Definition	Source
HACCP plans	If the plant decides through its hazard analysis that *Salmonella* or *Campylobacter* is a food safety hazard likely to occur, 9 CFR 417.2 requires that the plant's Hazard Analysis and Critical Control Point (HACCP) plan address these food safety hazards. The HACCP plan must meet all parts of 9 CFR 417.2(c). In this case, the HACCP plan must have a Critical Control Point (CCP) to address *Salmonella* or *Campylobacter*. A plant should be able to support any decision that it makes during the hazard analysis. The HACCP plan must contain verification procedures that the plant will do to ensure the HACCP system is working as designed. If a critical limit is not met in the HACCP plan, the corrective actions listed in 417.3 must be met.	•http://www.fsis.usda.gov/wps/wcm/connect/6732c082-af40-415e-9b57-90533ea4c252/Compliance_Guide_Controling_Salmonella_Campylobacter_Poultry_0510.pdf?MOD=AJPERES
Sanitation Standard Operating Procedures (SSOP)	SSOP is the common name given to the sanitation procedures in food production plants which are required by FSIS. It is considered one of the prerequisite programs of HACCP. SSOP's are generally documented steps that must be followed to ensure adequate cleaning of product contact and non-product surfaces.	•http://en.wikipedia.org/wiki/Sanitation_Standard_Operating_Procedures
Antimicrobial Solutions		
Acidified sodium chlorite	ASC can be used as a surface treatment antimicrobial agent. ASC possesses antimicrobial properties and is intended for use primarily as a spray or a dipping solution for poultry, meats, vegetables, fruits and sea foods. It is also used in poultry chilling water. Cross contamination may be reduced by using chlorinated washes or immersion treatments with acidified sodium chlorite or chlorinated water.	•http://www.fao.org/fileadmin/templates/agns/pdf/jecfa/cta/68/Acidified_Sodium_Chlorite.pdf, summary •Stopforth, et al., 2007 http://www.ncbi.nlm.nih.gov/pubmed/17612069

(continued)

Investment / Intervention	Definition	Source
Bromine	Examples of use: o During the warm weather, all of the wood in work pens and partitions or walls around the killing beds must be scraped and whitewashed weekly, or more often if necessary, together with disinfection of the premises. For this, bromine and water (1 to 500) has proved efficacious. o The product will be introduced to facility process water and applied to animal hides, carcasses, heads, trim, parts, and organs to reduce the numbers of and inhibit the growth of pathogens and other bacteria	•http://books.google.com/books?id=470_AQAAMAAJ&pg=PA75&lpg=PA75&dq=bromine+in+slaughterhouses&source=bl&ots=IkuXdgaWR1&sig=vCQXb6ydJyLSlLVFUg8SCDn5bV0&hl=en&sa=X&ei=qzCHVIvQHdCqyASXj4D4Cw&ved=0CDcQ6AEwBA#v=onepage&q=bromine%20in%20slaughterhouses&f=false, p75 •http://www.fda.gov/downloads/Food/IngredientsPackagingLabeling/EnvironmentalDecisions/UCM147199.pdf, p337
Chlorine dioxide	Examples of use: o Deodorization/odor control o Chlorine Dioxide can be used as an antimicrobial agent in water used in poultry processing at an amount not to exceed 3 ppm residual chlorine dioxide. Chlorine dioxide is a highly reactive compound that rapidly reduces to chlorite and chlorate in process water. Its use leaves no detectable residues of chlorine dioxide, chlorite, chlorate, or byproducts on poultry carcasses after application.	•http://www.alibaba.com/showroom/chlorine-dioxide-slaughterhouse-disinfection-poultry.html •http://www.fsis.usda.gov/wps/wcm/connect/6732c082-af40-415e-9b57-90533ea4c252/Compliance_Guide_Controling_Salmonella_Campylobacter_Poultry_0510.pdf?MOD=AJPERES
Cetylpyridium chloride	An antiseptic that kills bacteria and other microorganisms. It has been used as an ingredient in certain pesticides. Reduces *Salmonella Typhimurium* on poultry and prevents cross contamination.	•http://en.wikipedia.org/wiki/Cetylpyridinium_chloride •http://www.ncaur.usda.gov/SP2UserFiles/Place/30400510/2000630593.pdf, abstract)
Organic acids	Carcass decontamination utilizing organic acids (such as acetic, citric, and lactic acid), is a sanitation process that is widely used in the industry, and has been studied deeply. Spraying with organic acid solutions and/or hot or cold water is increasingly applied as sequential interventions for meat decontamination.	•http://www.scielo.br/scielo.php?pid=S0101-20612013000300009&script=sci_arttext •http://www.fsis.usda.gov/wps/wcm/connect/be391870-32cc-4d03-8799-4b0b240e5593/Coop_Agree_09-2003.pdf?MOD=AJPERES, introduction

(continued)

Investment/ Intervention	Definition	Source
Peracetic acid	Chemical used in disinfectants, used against bacteria, spores, yeasts, molds and viruses	•http://www.fao.org/docrep/003/x6557e/x6557e05.htm
Trisodium phosphate	The highly alkaline compound trisodium phosphate (TSP) is used as an intervention to reduce the load of *Campylobacter* on poultry meat in U.S. poultry slaughter plants.	•http://aem.asm.org/content/78/5/1411.full
Monochloramine	An antimicrobial agent for reducing populations of bacteria on broiler chicken carcasses	•http://www.ncbi.nlm.nih.gov/pubmed/15830667
Electrolyzed water	Electrolyzed oxidative waters decontaminate hides of cattle before slaughter.	•http://webcache.googleusercontent.com/search?q=cache:KU206W4zqc4J:www.researchgate.net/publication/7732045_Efficacy_of_ozonated_and_electrolyzed_oxidative_waters_to_decontaminate_hides_of_cattle_before_slaughter/links/00b7d51e9fdbca7e97000000+&cd=3&hl=en&ct=clnk&gl=u
Hypochlorous acid	Hypochlorous acid (HOCl), a powerful oxidizer and deproteinizer produced by neutrophils, has a good microbicidal activity within these cells. It reacts with many biological molecules, especially thiol, thiolether, heme proteins, amino groups and carbohydrates, as well as overcomes pathogens and fights infection. Mild acidic HOCl solutions, developed by acidifying NaOCl with HCl or electrolyzing NaOCl solutions, have been widely used as disinfectants.	http://www.ajol.info/index.php/tjpr/article/viewFile/86198/76038
Waste removal and processing	Different methods include composting, anaerobic digestion, alkaline hydrolysis, and rendering	•http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3622235/
Drinking water additives/ treatments		
Chlorination	Chlorination can remove dissolved iron, manganese, and hydrogen sulfide if followed by mechanical or activated carbon filtration. Chlorine is pumped directly into the water in proportion to water flow and it may have some residual effects in the system	•http://www.wdmc.org/2009/Solving%20Bad%20Water%20Problems%20for%20Thirsty%20Cows.pdf, p220

(continued)

Investment / Intervention	Definition	Source
Electrolyzed water	Electrolyzed water can be considered a type of "functional" water, whereby the ability of water to apparently carry nutrients; and penetrate cellular structures with these nutrients is claimed to be considerably enhanced.	•http://www.aquatechnology.net/electrolyzed.html
Ozonation	Water is exposed to ozone gas; destroys microorganisms. The equipment typically is quite expensive, however there are no residual effects on the environment or treated water. This method also can be used to remove color, off-taste, odors, hydrogen sulfide, solubilized iron and manganese, if the water is subsequently passed through a mechanical or ACF system.	•https://www.msu.edu/~beede/dairycattlewaterandnutrition.pdf, p16
Ultraviolet	Ultraviolet (UV) light has disinfection properties that kill bacteria, viruses and some cysts. However, it will not kill giardia cysts. The concept of using light to treat water supplies has been around for over 75 years.	•http://extension.missouri.edu/publications/DisplayPub.aspx?P=WQ102
Acidification	Acidification of the drinking water has become very popular in the broiler industry as a tool for improving bird performance.	•http://www.agrolab.us/pdfs/avianadvice_sp05.pdf
RTE processing equipment		
Irradiation systems	Food irradiation is physical means of food treatment comparable to heat pasteurization, canning or freezing. The process involves exposing food to one of three types of ionizing energy: gamma rays, machine generated electrons or X-rays. This is done in a special processing room or chamber for a specified duration.	•http://ftsi.us/irradiation
Ultrasonic	Ultrasonic food processing involves a vibrating knife producing a nearly frictionless surface which does not deform food products and to which they do not stick. The surface cleanly cuts or slits products including fillers such as nuts, raisins, dried fruit or chocolate morsels without displacement or plowing.	•http://www.dukane.com/us/PFO_whatisFP.htm

(continued)

Investment/ Intervention	Definition	Source
Infrared	Browning of Meat Products. Medium wave carbon infrared lamps heat meat surfaces in a targeted fashion. Sandwich meat, hamburgers and hams are made to look even more appetizing without additional fat.	•http://www.noblelight.net/industries_using_infrared/processing/food.shtml
Ultraviolet	Methods consist of: pre-treatment disinfection and treating direct contact fluids and ingredients, CIP and bottle rinse, liquid sweeteners, meat brine, tank headspace, venting, packaging and surfaces.	•http://www.aquionics.com/main/food-beverage/
Smokers, drying and freezing technologies	Freezing is probably one of the safest forms of food preservation. Frozen food is normally held at O°F. The freezing and storage process kills most bacteria, but the spores are able to survive. Once frozen foods are thawed they should be utilized promptly. The equipment for freezing foods can be quite costly and the energy to operate it is also expensive. Small scale operations are in existence, but usually most freezing operations require a high capital investment. Foods preserved by drying- Dehydrated and freeze-dried foods have a low moisture level and therefore are shelf stable at room temperature. Moisture is removed in dehydrated foods by hot air, whereas freeze-dried products are produced under a vacuum with minimal heat involved.	•http://aggie-horticulture.tamu.edu/food-technology/food-processing-entrepreneurs/getting-started/processing/