APPENDIX C

METHODOLOGY TO ASSESS MARKET EFFECTS OF CAFO REVENUE

This appendix describes EPA's methodology for estimating changes in farm revenue based on predicted changes in market prices and quantities attributable to the final regulations. This analysis modifies a similar analysis conducted for the 2001 Proposal, in which EPA assumed a portion of the costs are passed up through the food marketing chain under assumptions of long-run market adjustment. Section C.1 presents the methodology and underlying concepts for estimating changes in farm revenues using this approach. Section C.2 describes how EPA applies this information to its discounted cash flow analysis. Section C.3 discusses how EPA uses information on alternative revenue scenarios at representative model CAFOs.

C.1 METHODOLOGY FOR ESTIMATING CHANGES IN FARM REVENUE

The impact of the ELG on farm revenues is directly derived from the market model as described above. The market model for each type of livestock contains baseline equilibrium price (P^0 in Figure C-1) and quantity, as well as equations representing estimated supply and demand responses to changes in price. From the cost annualization model, EPA estimates compliance costs per unit of production (CC/Q in Figure C-1). This measures the vertical shift in the supply curve. Given the vertical shift in the supply curve, the model solves for the post-regulatory equilibrium price (P^1 in Figure C-1). Thus, all components are baseline parameters, inputs, or outputs of the market model.

A key factor that determines how much compliance costs will increase market price is the equations that represent the responsiveness of supply and demand to changes in price. Elasticities are used to measure how responsive supply and demand quantities are to changes in price. To illustrate how elasticities affect price change, Figure C-2 compares how post-regulatory market equilibrium will differ according to the price elasticity of demand in response to a given shift in the supply curve. The steeper of the two demand curves is relatively inelastic: consumers are relatively unresponsive to an increase in price in the sense that they decrease purchases of meat by only a small amount. The flatter of the two demand curves is relatively elastic: consumers are relatively responsive to a price increase in the sense that the decrease in their meat purchases is much larger compared to the case of relatively inelastic demand. Thus, holding all other things constant (e.g., price elasticity of supply, initial market equilibrium price and quantity, and compliance costs per head), an ELG will cause a greater increase in market price if demand is relatively inelastic than if demand is relatively elastic. This can be observed in Figure C-2 in that the post-regulatory equilibrium price if demand is relatively inelastic (P^1) is higher than the post-regulatory equilibrium price if demand is relatively elastic (P^2). In a similar manner, differences in the price elasticity of supply also affect how the market price responds to a shift in supply.

For the purpose of its market analysis, EPA uses estimates of price elasticities of supply and demand obtained through an extensive search of the agricultural economics literature and consultation with leading experts in the field. The price elasticity of demand may be defined as the percentage change in quantity demanded caused by a 1-percent change in price. If demand is inelastic, the price elasticity of

demand lies between zero and minus one: a 1-percent increase in price causes a less than one percent decrease in quantity demanded; consumers are unresponsive to the price change. If demand is elastic, the price elasticity of demand lies between minus one and $-\infty$: a 1-percent increase in price causes a greater than 1-percent decrease in quantity demanded.

The price elasticity of supply may be defined as the percentage change in quantity supplied caused by a 1-percent change in price. If supply is inelastic, the price elasticity of supply is greater than zero but less than one: a 1-percent increase in price causes a less than one percent increase in quantity supplied. If supply is elastic, the price elasticity of supply is greater than one: a 1-percent increase in price causes a greater than one percent increase in quantity supplied.

The measured price elasticities used in the market model are based on econometric estimation of data. That is, the equations that represent the responsiveness of consumers and producers to price changes are based on observation and measurement of their responsiveness in the past.

Much of this research to estimate price elasticities of supply and demand for the livestock and poultry sectors is conducted by the various land grant universities and is published in the leading academic journals. Research by USDA also contributes to this body of work. For the 2001 Proposal, EPA compiled a list of published supply and demand elasticities in each sector for use in its market model. (See Appendix C of the Proposal EA; also, ERG, 1999a, 1999b.) Because the market model is designed to measure long-term market adjustment, elasticities that are specified in the long run are the most appropriate for this analysis. In particular, estimates of supply elasticities are highly dependent on time frame. Generally, the longer the time frame, the more elastic is supply because farms have an opportunity to change production in the most efficient way while these expand or contract their operations. In the short term, however, farms have less flexibility and cannot change production as efficiently. The supply elasticities identified in the literature, however, include short-, intermediate-, and long-run estimates. The demand elasticities identified usually do not specify a time period.

From its compiled studies, EPA selected elasticity values to reflect baseline market conditions. These values represent a consensus of expert opinion on a reasonable estimate of supply and demand elasticities for each sector (Vukina, 2000; Foster, 2000) and are considered to reflect long-run conditions. Appendix C of the Proposal EA contains a complete listing of studies and values found. Section 4.2.6 of the Proposal EA provides more detailed information on EPA's methodology for computing cost passthrough for this analysis.

Table C-1 presents the elasticity values EPA selected for use in its market model and also to estimate regulatory price effects as a percentage of unit compliance costs for this analysis.

Table C-1 also shows EPA's estimate of the relative impact compliance costs will have on price given the specified price elasticities of supply and demand. EPA expresses the price impact as a percent of unit compliance costs for two reasons. First, it simplifies comparing the responsiveness of price in different markets—or different specifications of the same market (see Table C-2)—to regulatory costs. In Table C-1, for example, it is readily apparent that the price of beef cattle is much more responsive to increased regulatory costs than the price of turkeys. Second, because this measure of the responsiveness of markets is essentially determined by the price elasticities of supply and demand (as well as the elasticities of imports and exports), once this measure is estimated, the percentage will remain constant as

long as the elasticities are unchanged. Therefore, the change in market price can be estimated knowing this percentage and per unit compliance costs.[1] EPA demonstrates how it uses this characteristic in its analysis of discounted cash flow in Section C.2.

EPA employs a simple method for calculating the estimated price impact as a percentage of unit compliance costs using supply and demand elasticities. This approach is consistent with that used by the Agency in past regulatory analyses (see references in the Proposal EA, USEPA, 2001a). This approach uses estimates of price elasticity of supply divided by the difference in estimated price elasticity of supply and the price elasticity of demand for each sector, as shown below:

$$\text{Percentage Price Impact} = \frac{\text{price elasticity of supply}}{\text{price elasticity of supply - price elasticity of demand}}$$

Table C-1. Selected Elasticity Estimates and Estimated Regulatory Price Impact

Animal Sector	Selected Price Elasticity of Supply [a/]	Selected Price Elasticity of Demand [a/]	Price Increase as Percent of per unit Compliance Costs
Beef	1.020	-0.621	70.7%
Dairy	1.527	-0.247	84.8%
Hogs	0.628	-0.728	69.7%
Broiler [b/]	0.200	-0.372	68.7%
Layer	0.942	-0.110	93.7%
Turkey	0.200	-0.535	49.5%

Sources: Various (ERG, 1999a, 199b); also see summary in Appendix C in Proposal EA (USEPA, 2001a).
[a/]Elasticities representing a consensus of expert opinion (Vukina, 2000; Foster, 2000a).
[b/]Includes elasticity estimates for both broilers and chickens because studies vary between the two terms when analyzing the markets for meat from chickens.

C.2 APPLICATION TO DISCOUNTED CASH FLOW ANALYSIS

Conceptually, applying the impact of the ELG on facility revenues to the DCF analysis is straightforward. In essence, the DCF analysis compares the cash flow of a model CAFO with its estimated compliance costs for each year of the project life. Although in some individual years cash flow

[1] Because EPA's CAFO market model is not a constant elasticity model, the change in price as a percentage of unit compliance costs varies as unit compliance costs change. In practice, because of the relatively small magnitude of estimated unit compliance costs used in this analysis, the change in elasticities— and therefore the variance in the measured change in price as a percentage of unit compliance costs—is so small that it can be treated as constant.

might exceed compliance costs and in other years compliance costs might exceed cash flow, over the project life the stream of discounted cash flows must exceed the stream of discounted compliance costs for the rule to be economically achievable.

In effect, EPA first calculates the post-regulatory cash flow for each year of the project life by subtracting operating expenses and compliance costs from operating revenues, discounting the result, and then summing the stream of post-regulatory discounted cash flows over the entire project life. For each year of the project life, this calculation can be represented (in simplified form) as

$$\text{post-regulatory } CF_t = P_t \times Q_t - OE_t - CC_t$$

where:

CF_t	=	cash flow in year t
$P_t \times Q_t$	=	market price times units sold in year t (i.e., operating revenues)
OE_t	=	operating expenses in year t
CC_t	=	compliance costs in year t

As a conservative estimate, EPA performs the analysis assuming that the rule will have no impact on facility level revenues. That is, EPA assumes that the equilibrium market price is unchanged by the rule (i.e., EPA essentially uses price P^0 in Figure C-1 for the analysis).

To estimate post-regulatory cash flow assuming that market price is affected by the ELG, the model CAFO's operating revenues should reflect the expected price after the effluent guideline is promulgated (i.e., price P^1 in Figure C-1). As a practical matter, however, applying this concept to the analysis of the model CAFO's DCF is more complex than plugging the estimated post-regulatory market price (P^1) into the equation above. First, pre-regulatory model CAFO revenues and market model prices are estimated from different (albeit consistent) data sources. Second, model CAFO cash flow is estimated over a 10-year period based on USDA projections of industry conditions. Revenues in each of these years are affected by the ELG. The market model, on the other hand, provides a "snapshot" of the market in two periods: the initial pre-regulatory equilibrium and the long-run, post-regulatory equilibrium after all market adjustments have occurred. The market model does not provide a time series of price estimates over a 10-year period. For detailed discussion of how EPA developed these models, see the Proposal EA. This report provides a summary overview of the DCF model assumptions (Section 2.4) and the market model (Section 2.5).

EPA estimates the increase in model CAFO revenues over the 10-year period based on the relationship between price and unit compliance costs. In Figure C-1, post-regulatory market price, P^1, is equal to the market price in the absence of the regulation, P^0, plus the change in price ($P^1 - P^0$) attributable to the effluent guideline (i.e., the vertical shift in the supply curve). This change in price is expressed as a percentage of unit compliance costs. Because it is a function of the price elasticities of demand and supply used in the market model, it will not change regardless of the size of the supply curve shift (as long as the elasticities are unchanged).

Therefore, for each time period EPA can estimate the change in market price ($P^1_t - P^0_t$)—and thus the model CAFO's change in revenues—from initial revenues ($P^0_t \times Q^0_t$) using the change in price as a percent of unit compliance costs derived from the market model ($\Delta P_{CC} = (P^1_t - P^0_t)/(CC/Q)$) and estimated per unit compliance costs (CC/Q). Using these definitions and substitutions the cash flow analysis for each year after adjusting for market-induced changes in revenues can be represented as:

$$\text{post-regulatory } CF_t = P^1_t \times Q_t - OE_t - CC_t$$

$$= (P^0_t + (P^1_t - P^0_t)) \times Q_t - OE_t - CC_t$$

$$= \left(P^0_t + \Delta P_{CC} \times \left(\frac{CC_t}{Q_t} \right) \right) \times Q_t - OE_t - CC_t$$

$$= P^0_t \times Q_t + \Delta P_{CC} \times CC_t - OE_t - CC_t$$

Discounting for the project year and summing over all years of the project life result conceptually in the DCF formula EPA uses to project impacts after modifying facility revenues to account for market price adjustments. For ease of calculation, EPA performs its DCF analysis using the equivalent calculation:

$$\text{Post-regulatory } CF_t = P^0 \times Q^0 - OE - CC \times (1 - \Delta P_{CC}).$$

In addition, EPA first estimates the discounted stream of pre-regulatory model facility cash flow over the entire 10-year period (i.e., the equivalent of estimating $P^0 \times Q^0 - OE$ for each period, discounting, then summing over all periods) and the discounted stream of compliance costs per period, and then adjusts these compliance costs by ($1 - \Delta P_{CC}$) to account for revenue changes.

C.3 USE OF ALTERNATIVE REVENUE SCENARIO IN IMPACT ESTIMATION

Because of uncertainties over how market-induced price increases will affect farm income, EPA presents its economic impact analysis under two different assumptions: (1) there will be no change in farm revenues to offset compliance costs, and (2) farm prices will increase as projected by the market model to partially offset compliance costs. Although EPA considers the results of both analyses in making its determination of economic achievability, the Agency's overall conclusions do not rely on the assumption that farm revenues will increase to offset compliance costs.

EPA uses these alternative assumptions to estimate a range of potential economic impacts. The most conservative estimate of impacts occurs under the assumption that facilities receive no additional revenues after promulgation of the rule to help offset increased costs of production. This analysis is too pessimistic because the market model clearly demonstrates that price can be expected to increase, and because the facility is assumed to make no changes to its operations to mitigate the impacts of increased costs. Smaller impacts will occur under the alternative assumption that an increased market price resulting from the ELG will increase facilities' revenues, thus partially offsetting the impacts of increased

costs. However, this analysis might be too optimistic for a number of reasons. First, it assumes that the full increase in price will affect revenues immediately; this is an unrealistic assumption in that market adjustment to the final long-run price occurs over time, not instantaneously. Second, this assumption does not account for potential decreases in facility production that may occur in response to increased production costs. Third, the unknown effects of market power and vertical integration on the relationship between processors and growers has the potential to modify these results. Therefore, performing the DCF analysis under alternative assumptions, some of which are too pessimistic, and others of which are too optimistic, provides EPA with upper and lower bounds to the impacts projected by its DCF analysis.

EPA also performs sensitivity analyses to examine how projected market level impacts vary with alternative values for price elasticities of supply and demand. These sensitivity analyses have implications for the DCF analysis because different specifications for the price elasticities affect the responsiveness of market price to unit compliance costs. EPA selected the highest and lowest (acceptable) price elasticity estimates that it found in its literature search as alternative parameter values in its market model.

Table C-2 shows the high and low elasticity estimates used in market model sensitivity analysis and estimated regulatory price impact as a percent of unit compliance costs. As shown in Table C-2, should the true market response be more consistent with the "high" values for price elasticities than with the values EPA selected for its market model, the impact of compliance costs on market price will be larger than those cited in Table C-2. The impact of the rule on facility level DCF will be further mitigated by the increased revenues. Conversely, should the true market response be more consistent with the "low" values for price elasticities than with the values EPA selected, the impact of compliance costs on market price will be smaller and the rule's impact on facility level DCF will be more severe.

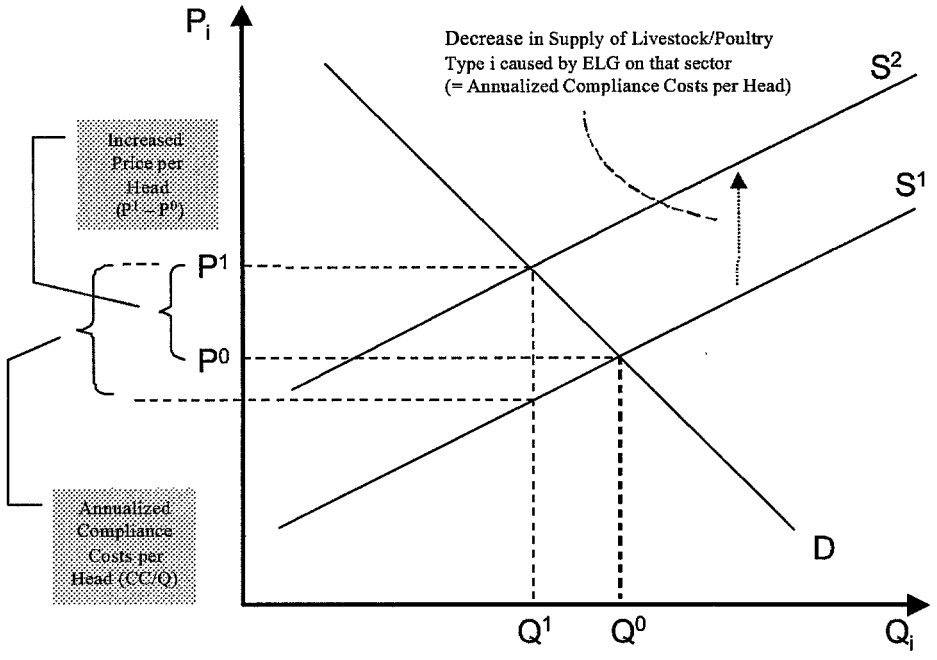
Table C-2. Selected High and Low Elasticity Estimates and Estimated Regulatory Price Effect

Animal Sector	High Value for Price Elasticities			Low Value for Price Elasticities		
	Selected Price Elasticity of Supply [a/]	Selected Price Elasticity of Demand [a/]	Price Increase as %per unit Compliance Costs	Selected Price Elasticity of Supply [a/]	Selected Price Elasticity of Demand [a/]	Price Increase as %per unit Compliance Costs
Beef	3.240	-0.450	91%	0.060	-1.270	7%
Dairy	4.000	-0.050	96%	0.070	-0.650	10%
Hogs	1.800	-0.070	96%	0.007	-1.234	2%
Broiler [b/]	0.587	-0.104	96%	0.064	-1.250	17%
Layer	0.942	-0.022	99%	0.031	-0.780	7%
Turkey	0.518	-0.372	78%	0.210	-0.680	45%

Sources: Various (ERG, 1999a, 199b); also see summary in Appendix C in Proposal EA (USEPA, 2001a).

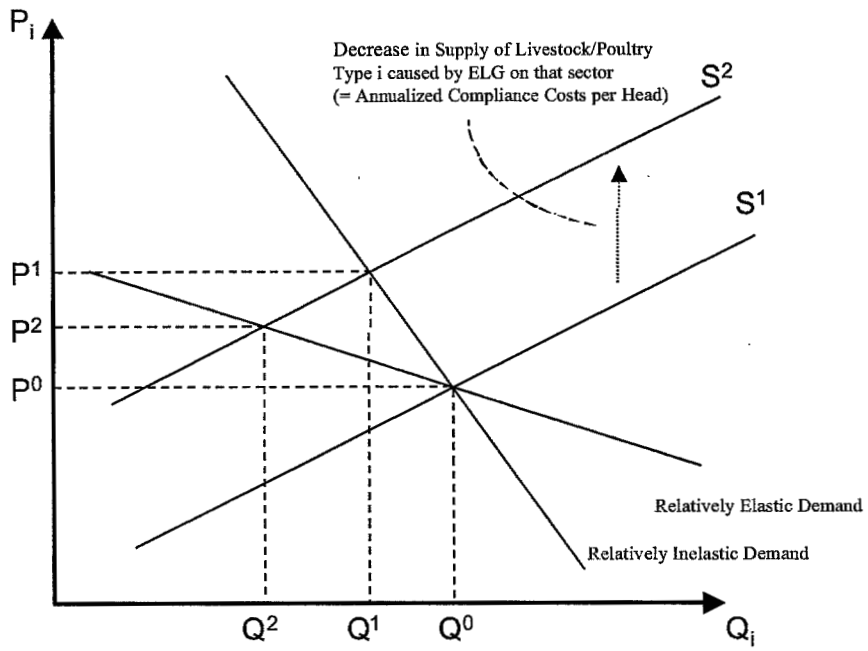
[a/] Estimated elasticities as identified in Tables C-1 through C-12, Appendix C of the Proposal EA.

[b/] Includes elasticity estimates for both broilers and chickens because studies vary between the two terms when analyzing the markets for meat from chickens.



D, S^1 = pre-regulatory market supply and demand conditions
D, S^2 = post-regulatory market supply and demand conditions
P^0, Q^0 = pre-requlatory equilibrium price and quantity
P^1, Q^1 = post-requlatory equilibrium price and quantity

Figure C-1.
Impact of the Effluent Guideline on Market for Livestock/Poultry Type i



S^1 = pre-regulatory market supply
S^2 = post-regulatory market supply
P^0, Q^0 = pre-requlatory equilibrium price and quantity
P^1, Q^1 = post-requlatory equilibrium price and quantity if demand is relatively inelastic
P^2, Q^2 = post-requlatory equilibrium price and quantity if demand is relatively elastic

Figure C-2.
Effect of Price Elasticity of Demand on Change in Market Price
Due to Impact of Effluent Guideline on Market for Livestock/Poultry