CHAPTER 11
NON-WATER QUALITY ENVIRONMENTAL IMPACTS

Sections 304(b) and 306 of the Clean Water Act require EPA to consider non-water quality environmental impacts, including energy requirements, associated with effluent limitations guidelines and standards. In accordance with these requirements, EPA has considered the potential impacts of the proposed regulation on energy consumption, solid waste generation, and air emissions. The estimates of these impacts for the concentrated aquatic animal production (CAAP) industry are summarized in Sections 11.1, 11.2, and 11.3.

11.1 ENERGY

Additional energy requirements for the proposed rule are a result of electric motors needed to operate microscreen filters (a component of Option 3 for flow-through and recirculating systems) and video monitoring equipment for active feed management at net pen facilities. EPA proposed microscreen filters as a solids polishing treatment technology to remove additional TSS from the effluent prior to discharge. EPA proposed active feed management as a means to prevent uneaten feed from leaving the net pen. To calculate incremental energy consumption increases for the CAAP industry, EPA first determined the number of facilities that potentially would need to install new equipment, which are those flow-through facilities that annually produce more than 475,000 lb and recirculating and net pen system facilities that annually produce more than 100,000 lb. EPA used AAP screener survey data (Westat, 2002) and the 1998 Census of Aquaculture (USDA, 2000) to estimate the number of existing flow-through and recirculating system facilities without solids polishing currently in place. EPA used the same procedure to estimate the number of facilities without active feed management. Then, using the cost model (described in Chapter 9 of this document), EPA estimated the total number of microscreen filters and video monitors that would need to be installed to achieve the goal of the proposed rule. Finally, EPA used manufacturers' information to calculate the energy that would be required to operate microscreen filters and video monitors at those facilities without solids polishing currently in place. EPA estimated the energy requirements for the video monitoring equipment using a personal computer as a surrogate because manufacturer information on energy use was not available.

11.1.1 Estimating Increased Energy Requirements

Option 1

Option 1 proposes that flow-through and recirculating CAAP facilities implement primary settling treatment operations and develop a BMP plan. Primary settling treatment uses gravity settling, which requires no additional energy inputs. EPA assumed all facilities would use gravity flow to move water from quiescent zones (in flow-through systems) and other solids capture processes (in recirculating systems) to settling basins. EPA based this assumption on observed gravity flows from solids capture to primary settling in all of flow-through and recirculating systems seen during the site visits. Because gravity flow is assumed, no additional energy would be required for primary settling operations.

Option 1 would require net pen facilities to develop a best management practices (BMP) plan to minimize the addition of pollutants into the environment. Net pen systems are also subject to general requirements, which include the following BMPs:

- Develop and implement practices to minimize the potential escape of nonnative aquatic animals.
- A BMP plan to address net fouling and net cleaning; control of discharges of water containing blood associated with the transport or harvesting of fish or discharges of substances associated with pressure-washing nets.
- Practices to prevent the discharge of feed bags and other solid wastes, biocides or disinfectants used to clean equipment or nets, and materials containing or treated with tributyltin compounds.

Option 1 components for net pen facilities do not require additional energy; therefore, EPA assumed that there would be no increase in the energy used under regulatory Option 1 for any of the net pen facilities.

Option 2

Regulatory Option 2 for all facilities would require the reporting of the use of certain drugs and chemicals, which would not increase the energy requirements of production facilities.

Option 3

Energy requirements for flow-through and recirculating systems would be increased under Option 3 based on the installation of microscreen filters (solids polishing) as a treatment technology to meet the requirement of this regulatory option. Flow-through facilities that annually produce more than 475,000 lb and recirculating system facilities that annually produce more than 100,000 lb would be required to meet Option 3 standards under the proposed rule. Based on the AAP screener survey data (Westat, 2002) and the 1998 Census of Aquaculture (USDA, 2000), 40 CAAP facilities meet these definitions and require implementation of solids polishing.[1]

[1] To obtain estimates of the total number of facilities in the United States affected by the proposed rule, EPA used a comparison of the AAP screener survey results (Westat, 2002) and the 1998 Census of Aquaculture (USDA, 2000). Because the 1998 Census of Aquaculture represents only commercial facilities in the United States, EPA compared the number of facilities that responded to the AAP screener survey to the number of similar facilities in the 1998 Census of Aquaculture. EPA found the ratio to be about 2.5. For noncommercial facilities, EPA assumed that the AAP screener survey reflects a good approximation of the total number of facilities in the United States. Refer to Hochheimer (2002d) for more details.

EPA assumed the electricity requirements for the microscreen filter would be 5,782 kilowatt-hours (kWh) per year (Keaton Industries, 2002, personal communication). EPA used the following equation to determine the increase in energy requirements.

Energy increase = number of facilities x per facility energy increase

Where:

Number of facilities = the number of in-scope facilities that will have an energy increase

Per facility increase = the EPA-estimated per facility energy requirement increase

Energy increase = 40 facilities * 5,782 kWh

Energy increase = 231,280 kWh

EPA also estimated the cost of underwater video monitoring at net pen facilities. The Agency was not able to find manufacturers' data on the amount of electricity used in operating underwater video monitoring equipment, so EPA assumed the electrical usage would be similar to that for a personal computer and monitor, which is about 7.8 amps at 120 volts. EPA assumed that the feeding time per net pen is about 10 min per feeding. The fish are fed once per day for 312 d/yr (6 feeding days per week). The model facility has 12 net pens. EPA used the following equations to estimate the increase in energy (Hochheimer, 2002b).

Watts = amps * volts = 7.8 amps * 120 volts = 936 watts

Daily energy use (kWh) = (watts/1,000) * (10 min/feeding * 1 h/60 min) * 1 feeding per day

Daily energy use = (936 W/1,000) * (10 min/feeding * 1 h/60 min) * 1 feeding per day = 0.156 kWh

Annual energy increase (kWh/yr) = kWh * 312 d = 0.156 kWh * 312 d = 48.7 kWh per net pen

Total energy increase per facility = number of net pens * 48.7 kWh per net pen

Total energy increase per facility = 12 net pens * 48.7 kWh per net pen = 584.4 kWh

Total industry energy increase = 12 facilities * 584.4 kWh = 7,013 kWh

11.1.2 Energy Summary

EPA estimates that implementing this rule will result in a net increase in energy consumption for some CAAP facilities. The incremental increase is based on electricity used to operate microscreen filters or video monitoring equipment at facilities that are not currently operating wastewater treatment equipment comparable to the proposed regulatory options.

EPA extrapolated the energy consumption increases to represent the entire CAAP industry using estimates of the number of facilities and frequency factors (as discussed in Chapter 9). The total incremental energy increase for microscreens and video monitoring equipment at CAAP facilities as a result of this regulation would be 238,293 kWh/yr.

Site-specific information is needed to assess the impact of additional energy required for solids polishing at flow-through and recirculating facilities and video monitoring at net pen facilities. EPA used estimates of electrical costs from published enterprise budgets to provide a comparison of the existing electrical requirements and the added electrical requirements of microscreen filters at flow-through and recirculating system facilities (Hochheimer, 2002a). Hinshaw et al. (1990) estimated annual electrical requirements at about 7,357 kWh for a 100,000-lb production facility in North Carolina. San et al. (2001) estimated electrical requirements of about 1,662 kWh for a facility of similar size in West Virginia. Dunning et al. (1998) estimated an annual electrical requirement of 2.3 kWh per pound of fish produced at recirculating system facilities. Thus, for average-size flow-through facilities (annual production of 1,841,889 lb/yr; Westat, 2002), the range of existing energy use is from 30,612 to 135,507 kWh. For recirculating systems (annual production of 681,022 lb/yr; Westat, 2002), the existing electrical usage estimate is about 1,566,351 kWh. Thus, the average flow-through facility would increase its electrical use by about 4.3% to 18.9%, and the average recirculating system would increase its use by about 0.4%.

Site-specific information is also needed to accurately assess the impact of additional energy required for active feed monitoring at net pen facilities. EPA was not able to find estimates of current energy usage at net pen facilities. The estimated increase in energy usage at a facility was about 584 kWh, which is not expected to be a significant increase with respect to the total energy requirements at these facilities.

EPA does not expect any adverse impacts to occur as a result of the small energy requirements for the proposed regulation.

11.2 SOLID WASTE

The proposed treatment technologies will generate solid wastes. Solid wastes include sludge from sedimentation basins (primary settling) and from solids polishing technologies such as microscreen filters. EPA assumed all solid wastes generated by the CAAP industry to be nonhazardous. Federal and state regulations require CAAP facilities to manage solids to prevent release to the environment.

11.2.1 Sludge Characterization

Chen et al. (1996) provide a comprehensive review of the treament and characteristics of CAAP sludge. Table 11.2-1 shows the characteristics of recirculating system sludge captured from solids filter backwash allowed to settle for 30 min. Although representing only one study, these data represent a process similar to EPA's Option 1.

Table 11.2-1. Characterization of CAAP Sludge

Parameter	CAAP Sludge		
	Range	Mean	Standard Deviation
TS (%)	1.4–2.6	1.8	0.35
TVS (% of TS)	74.6–86.6	82.2	4.1
BOD_5 (mg/L)	1,588–3,867	2,756.0	212.0
TAN (N, mg/L)	6.8–25.6	18.3	6.1
TKN (N, % of TS)	3.7–4.7	4.0	0.5
TP (P, % of TS)	0.6–2.6	1.3	0.7
pH	6.0–7.2	6.7	0.4

Source: Reported in Chen et al., 1996.

Naylor et al. (1999) compared fish manure with manure from beef, poultry, and swine. Overall, the nutrient composition of trout manure is similar to that of other animal manures (Table 11.2-2). Like livestock manure, the composition of fish manure is also highly variable due to differences in animal, age, feed, manure handling, and storage conditions.

Table 11.2-2. Rainbow Trout Manure Compared to Beef, Poultry, and Swine Manures (Presented as Ranges on a Dry Weight Basis)

Element	Fish	Beef	Poultry	Swine
Nitrogen (%)	2.04–3.94	1.90–7.8	1.3–14.5	0.6–10.0
Phosphorus (%)	0.56–4.67	0.41–2.6	0.15–4.0	0.45–6.5
Potassium (%)	0.06–0.23	0.44–4.2	0.55–5.4	0.45–6.3
Calcium (%)	3.0–11.2	0.53–5.0	0.71–14.9	0.4–6.4
Magnesium (%)	0.04–1.93	0.29–0.56	0.3–1.3	0.09–1.34

Source: Naylor et al., 1999.

11.2.2 Estimating Increased Sludge Collection

EPA estimated the incremental sludge generation from the treatment options similarly to the way the Agency estimated the incremental energy consumption. EPA assumed that sludge generation would not increase at facilities with the required technology already in place. EPA used the loadings models (see Chapter 9) to estimate the incremental sludge generation rates for facilities that do not have these technologies in place.

By using reported production values, EPA estimated the total amount of solids collected and disposed of for CAAP facilities. The total estimated amount of solids currently collected by all in-scope facilities before regulation is shown in the first column of Table 11.2-3.

EPA also estimated the incremental amounts of solids collected for disposal by CAAP facilities after implementation of the proposed regulatory options. They are shown in

Table 11.2-3. The proposed regulation requires all flow-through and recirculating CAAP facilities to meet the requirements contained in Option 1. Net pen systems do not collect solids. Under general requirements for net pen systems, however, facilities must control discharges of solid waste and prevent discharge of water used for transport, which might contain blood and other wastes. Regulatory Option 2 does not have additional solids removal for any of the facility groupings. Large flow-through and recirculating facilities collect additional solids under Option 3, and the estimated amounts are shown in Table 11.2-3.

Table 11.2-3. Estimated Solids Collection

Facility Group	*Current Solids Collection (lb/yr)*	*Option 1 Incremental Solids Collection (lb/yr)*	*Option 2 Incremental Solids Collection (lb/yr)*	*Option 3 Incremental Solids Collection (lb/yr)*
State-Federal-Other-Medium-Flow-through	2,719,134	269,270	0	0
Commercial-Medium-Flow-through	3,060,809	207,524	0	0
State-Federal-Other-Large-Flow-through	1,673,874	379,782	0	424,214
Commercial-Large-Flow-through	10,562,685	0	0	1,198,193
Large-Recirculating	5,956,215	0	0	165,787
Total	23,972,717	856,576	0	1,788,194

EPA assumed that collected solids would be land-applied as fertilizer at agronomic rates and therefore does not expect any adverse impacts due to solid waste to occur as a result of the proposed regulation.

11.3 AIR EMISSIONS

Potential sources of air emissions from CAAP facilities include primary settling operations (e.g., settling basins and lagoons) and the land application of manure.

11.3.1 Air Emissions from Primary Settling Operations

EPA assumed that the additional air emissions from primary settling operations would be minimal. Only about 10% of in-scope flow-through and recirculating CAAP facilities (estimated from the AAP screener survey data (Westat, 2002) and the 1998 Census of Aquaculture (USDA, 2000)) would require the addition of primary settling to meet Option 1 requirements. Primary settling treatment technologies store collected solids below the surface of the water, reducing their exposure to the atmosphere. Air emissions primarily result from exposure of collected solids to air (Battye et al., 1994). For ammonia that volatilizes from aquatic animal manures, the pH of the water in the sedimentation basin covering the settled solids reduces the rate of volatilization because at lower pH levels most of the ammonia in the water is in an ionized form. At pH levels from 6.5 to 7.5, which are typical of sampled sedimentation basins, and at a temperature of 86 °F (a worst-case situation), the percentage of ammonia in solution (un-ionized) ranges from 0.26% to 2.48%. At typical total ammonia levels found in the sampling of sedimentation basins (about 0.4 to 3.69 mg/L), the concentration of un-ionized ammonia ranges from 0.0010 to 0.0915 mg/L. The air-to-water interface is also relatively low in sedimentation basins (Hochheimer, 2002c)

11.3.2 Air Emissions from Land Application Activities

The CAAP sludge emits pollutants when it is spread on land for its fertilizer value. Air emissions are primarily generated from the volatilization of ammonia at the point the material is applied to land (Anderson, 2000). Additional emissions of nitrous oxide are liberated from agricultural soils when nitrogen applied to the soil undergoes nitrification and denitrification. Loss through denitrification depends on the oxygen levels of the soil to which manure is applied. Low oxygen levels, resulting from wet, compacted, or warm soil, increase the amount of nitrate-nitrogen released to the air as nitrogen gas or nitrous oxide (OSUE, 2000). A study by Sharpe and Harper (1997), which compared losses of ammonia and nitrous oxide from the sprinkler irrigation of swine effluent, concluded that ammonia emissions made a larger contribution to airborne nitrogen losses. Data for the CAAP industry are insufficient to quantify air emission impacts from the land application of manure; therefore, this analysis uses available information from similar industries and focuses on the volatilization of nitrogen as ammonia. The emission of other constituents is expected to be less significant.

11.3.2.1 Application Rate

The application rate affects the volatilization rate if the amount of manure applied causes significant buildup of material on the field surface, causing a mulching effect. For the purposes of this analysis EPA assumed that the CAAP industry applies manure at agronomic rates or lower. Applying at agronomic rates, CAAP facilities do not apply enough waste under the proposed options to cause mulching.

11.3.2.2 Application Method

Significant differences in the volatilization rate of ammonia result from the method used to apply manure (see Table 11.3-1). When manure is sprinkler-irrigated, a greater surface area from which the ammonia can volatilize is available. Manure application methods practiced by the CAAP industry include irrigation, surface application, and subsurface injection. EPA observed that applying solids as fertilizer for cropland at agronomic rates is a common industry practice. When agricultural land is adjacent to a CAAP facility, solids can be vacuumed directly from quiescent zones into a sprinkler system that land-applies the biosolids and water (IDEQ, n.d.). EPA assumed this regulation would not change the method of land application used by any CAAP facilities. Based on this assumption, no significant change in the rate at which ammonia volatilizes is expected.

Table 11.3-1. Percent of Nitrogen Volatilizing as Ammonia from Land Application

Application Method		*Percent Loss* [a]
Surface application	Broadcast (solid)	15–30
	Broadcast (liquid)	10–25
Subsurface injection	Broadcast (solid, immediate incorporation)	1–5
	Broadcast (liquid, immediate incorporation)	1–5
	Knifing (liquid)	0–2
Irrigation	Sprinkler irrigation (liquid)	15–40

Source: MWPS, 1983.
[a] Percent of nitrogen applied that is lost within 4 days of application.

11.3.2.3 Quantity of Animal Waste

The movement of waste off-site changes the location of the ammonia released but not the quantity released. Although the proposed options do not require land application of manure, the options do increase the amount of solid waste collected from CAAP facilities. Land application is a common solid waste disposal method in the CAAP industry; therefore, the amount of ammonia released as air emissions would be expected to increase as the quantity of waste applied to cropland increases.

11.3.2.4 Calculation of Emissions

EPA estimated the increase in ammonia emissions resulting from the implementation of each proposed regulatory option. The Agency assumed the ammonia content of solid waste from CAAP facilities was approximately 2.83% (Naylor et al., 1999). A factor of 30% was chosen as a conservative estimate of losses from land application activities. Table 11.3-2 indicates the current estimated ammonia volatilization resulting from land application of solids by CAAP facilities. Tables 11.3-3 and 11.3-4 indicate the estimated incremental increase in ammonia volatilization resulting from regulatory Option 1 and Option 3.

EPA calculated the ammonia content of the solid waste using the following equation:

Ammonia content = solid waste volume * 2.83%

Where:

Solid waste volume = the amount of solids collected by CAAP facilities

The following equation was used to calculate the ammonia volatilized during application:

Ammonia volatilization = ammonia content * 30.0%

Where:

Ammonia content = the amount of ammonia contained in solids from CAAP facilities

Table 11.3-2. Baseline Ammonia Volatilization

Facility Group	*Current Solids Collection (lb/yr)*	*Ammonia Content (lb/yr)*	*Ammonia Volatilization (lb/yr)*
State-Federal-Medium-Flow-through	2,719,134	76,951	23,085
Commercial-Medium-Flow-through	3,060,809	86,621	25,986
State-Federal-Large-Flow-through	1,673,874	47,371	14,211
Commercial-Large-Flow-through	10,562,685	298,924	89,677
Large-Recirculating	5,956,215	168,561	50,568

Table 11.3-3. Incremental Increases in Ammonia Volatilization Under Option 1

Facility Group	*Option 1 Solids Collection Increase (lb/yr)*	*Ammonia Applied (lb/yr)*	*Ammonia Volatilization (lb/yr)*
State-Federal-Medium-Flow-through	269,270	7,620	2,286
Commercial-Medium-Flow-through	207,524	5,873	1,762
State-Federal-Large-Flow-through	379,782	10,748	3,224
Commercial-Large-Flow-through	0	0	0
Large-Recirculating	0	0	0

Table 11.3-4. Incremental Increases in Ammonia Volatilization Under Option 3

Facility Group	*Option 3 Solids Collection Increase (lb/yr)*	*Ammonia Applied (lb/yr)*	*Ammonia Volatilization (lb/yr)*
State-Federal-Medium-Flow-through	0	0	0
Commercial-Medium-Flow-through	0	0	0
State-Federal-Large-Flow-through	424,214	12,005	3,602
Commercial-Large-Flow-through	1,198,193	33,909	10,173
Large-Recirculating	165,787	4,692	1,408

EPA does not expect any adverse air impacts to occur as a result of the proposed regulation.

11.4 REFERENCES

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