UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON D.C., 20460

OFFICE OF
PREVENTION, PESTICIDES AND
TOXIC SUBSTANCES

Chemical: Lactofen
PC Code 128888
DP Barcode: D319594
Chemical: Sodium Acifluorfen
PC Code 114402

MEMORANDUM DATE: October 13, 2006

SUBJECT: Drinking water and aquatic exposure water assessments for IR4 Tolerance petition for the new use (R17) of lactofen on the fruiting vegetable group and okra.

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The Registration Division (RD) has requested that EFED prepare a drinking water assessment for a new lactofen (Lactofen technical, EPA Reg. No. 56639-94 and Cobra Herbicide (EPA Reg. No. 59639-34) use on vegetables (Crop Group 8 - fruiting vegetables, and Okra), as part of the tolerance assessment process. In this memo, EFED presents a Tier 2 surface water assessment for drinking water and aquatic exposure assessments for the use of lactofen on these crops. Tier 1 estimates of ground-water concentrations are also provided.

Lactofen (Cobra) is formulated as an emulsifiable concentrate. Lactofen is a selective, broad spectrum herbicide for preemergence and postemergence control of susceptible broadleaf weeds. Lactofen works primarily through contact. Good coverage of actively growing weeds is necessary for maximum weed control. Adjuvants and additives are generally required. When applied as a postemergence treatment a portion of the spray may contact the soil surface. If soil moisture conditions are favorable for preemergence activity following application, the suppression of germination of small-seed broadleaf weeds may occur for 2 to 3 weeks. Excessive crop or weed foliage at the time of application will reduce the amount of herbicide spray contacting the soil surface, thus, reducing the level of soil activity. Lactofen is currently approved for use on cotton, snap bean, kenaf, peanut, soybean, and strawberry crops, and conifers and forestry nursery plantings uses (Label # 59639-34, 10/24/05).

A. PROPOSED USE

The IR-4 proposes a new use of lactofen for weed control in fruiting vegetables (Crop Group 8) and okra. The use is to be limited to nine South Eastern states; Alabama, Arkansas, Florida, Georgia, Mississippi, North Carolina, South Carolina, Tennessee, and Virginia.

The proposed lactofen use rates for the new uses are summarized in Table 1. The use is limited to two applications of lactofen per season, with the maximum rate 0.5 lb ai/acre per application (1.0 lb ai/acre/season). This use cannot be applied by air or within 30 days of harvest. The application rate for the previous water assessment was limited to two, 0.20 lb ai/acre, applications (0.40 lb ai/acre seasonal rate) on soybeans. Aerial application was also allowable for these other uses.

Table 1. Proposed lactofen (Cobra) use rates, number of applications, and period of application.

Pesticide Use:	Rate per Application to row middle		Max. Number Applications	Time of Application
	Fl oz/acre	(lb ai/ac)		
Pre-transplant	19 to 32 fl oz	0.30 to 0.50	1	Minimum 10 days before transplant to row middles
Post-transplant	19 to 32 fl oz	0.30 to 0.50	1	Minimum 16 inches high before second application; Peppers must transplanted 45 days before post transplant application
Total for Growing Season	38 to 64 fl oz	0.60 to 1.00	2	Do not apply within 30 days of harvest

The Health Effects Division (HED) has concluded that lactofen has two degradates of concern; acifluorfen and amino acifluorfen, which should be include in the drinking water assessment. Therefore this water assessment considers both parent lactofen and acifluorfen. To estimate acifluorfen (derived from lactofen) concentrations in surface and ground water, acifluorfen was simulated separately assuming acifluorfen was applied at 58.2 percent of the lactofen rate. The 58.2 percent is the average of the maximum amount of acifluorfen observed (7 days after lactofen application) from the degradation of lactofen in the two ASM studies. For surface water, the acifluorfen was "applied" seven days after the lactofen was applied and spray drift contribution was assumed to be zero.

B. BACKGROUND

The drinking water assessment for lactofen is complicated by the fact that lactofen has several degradates in common with another herbicide, sodium acifluorfen (PC 114402). Lactofen and sodium acifluorfen also have some common uses (e.g., soybeans). The major degradates of lactofen include acifluorfen, desethyl lactofen, and amino acifluorfen. Acifluorfen and amino acifluorfen are also primary degradates of the herbicide sodium acifluorfen. There are also at least two degradation pathways: lactofen to desethyl lactofen then desethyl lactofen to acifluorfen and/or lactofen to acifluorfen. Although, lactofen degrades rapidly into acifluorfen, it is not formed instantaneously from lactofen, and would not be expected to move through the soil matrix as a single "pulse". The Health Effects Division (HED) has concluded that acifluorfen and amino acifluorfen are degradates of concern (FR Vol. 68, No. 19, Wednesday, 01/29/03). Because lactofen is expected to degrade to acifluorfen in the environment, the EPA has considered the contribution of acifluorfen as an environmental degradate of lactofen and from the use of the herbicide sodium acifluorfen (USEPA, 2003b; D291747) in the aggregate assessment. Data are insufficient to estimate the amino acifluorfen concentration in water, but it is likely to be less than that of acifluorfen (less mobile and lower amounts present as radioactivity). The concern for a cancer risk has been removed by HED (D292794).

The drinking water assessments for surface water have been fairly straight forward for lactofen (USEPA, 2003b; D291747) and sodium acifluorfen (D239269; D291747). Considerable disagreement has transpired over the estimates of acifluorfen residues in ground water, from lactofen and sodium acifluorfen, using the Tier 1 ground-water screening model SCI-GROW. SCI-GROW assumes that sorption is only related to organic carbon content (Koc). Acifluorfen is anionic under normal field pH values, thus, other factors other than organic carbon also influence sorption – pH, minerals, clay content, surface area, etc (D291747). Therefore, depending upon soil conditions, acifluorfen may have more or less of a potential to sorb than suggested by Koc. Literature also suggest that there is a kinetic (time dependant component) aspect to the sorption of acifluorfen (longer contact time the greater the sorption) (Gaston and Locke, 2000).

C. MODELS AND SCENARIOS

The Tier 2 surface water EDWCs (estimated drinking water concentrations) and EECs (estimated environmental concentrations) for lactofen and acifluorfen (a degradate of lactofen) were generated with standard Florida pepper and Florida tomato cropping scenarios (Leovey, 2002) using PRZM3 (Carsel, 1997) and EXAMS (Burns, 2002). PRZM simulates pesticide fate and transport as a result of leaching, direct spray drift, runoff and erosion from an agricultural field and EXAMS estimates environmental fate and transport of pesticides in surface water body for a 30-year period (1961-1990) (Appendix 1). PRZM and EXAMS were linked by the program PE4-PL (version 01). The EDWCs and EECs assessment for surface water uses a single or multiple sites which typically represent a high-end exposure scenario from pesticide use on a particular cropped or non-cropped site. Ground-water concentrations were estimated using the Tier 1 screening model SCI-GROW (USEPA, 2003f.).

Scenarios

The Florida tomato and Florida bell pepper standard scenarios were chosen to represent Crop Group 8, Fruiting Vegetables for the Tier 2 surface water assessments. The okra crop profile also indicated that okra could be grown under similar conditions. Table 2 lists the application dates for lactofen for the Florida bell pepper and tomato scenarios. The acifluorfen is "applied" 7 days after the lactofen. For ground water, the SCI-GROW model is not scenario specific, although, it represents a site vulnerable to ground-water contamination.

Table 2. Crop stage dates and dates for preemergence and postemergence applications of lactofen used in PRZM/EXAMS modeling.

	Date: (DAY/MONTH)	
Crop Stage[1]	Preemergence Application	Postemergence Application
Florida Peppers		
Date of Crop Emergence: 01/09	22/08	17/10 (45 days after plant)
Date of Crop Maturity: 15/11		
Date of Crop Harvest: 12/01		
Florida Tomatoes		
Date of Crop Emergence: 10/01	01/01	15/02
Date of Crop Maturity: 30/03		
Date of Crop Harvest: 05/04		

[1] Defined in the scenario.

Pesticide Inputs (application rate, number, spray drift fraction, fate properties)

The maximum lactofen label seasonal rate of 1.0 lb ai/acre was split between pre-emergence and post-emergence (both at 0.5 lb ai/acre) for each crop (Table 1). The proposed application method is by ground spray. The spray drift fraction for drinking water was 0.064 and for aquatic exposure assessments 0.01. The rates of formation and decline all lactofen degradates are not been well defined. However in the two lactofen aerobic soil metabolism (ASM) study, acifluorfen accounted for 52.3 and 64.1 percent of the applied radio-labeled lactofen on day 7 (D291747). For this assessment, acifluorfen was simulated separately assuming acifluorfen was applied at 58.2 percent of the lactofen rate (0.291 lb ai/acre = 0.582 x 0.5 lb ai/acre) seven days after the lactofen application, and where the spray drift contribution assumed to be zero.

The environmental fate values used in for modeling are summarized in Tables 6 and 7 for lactofen and Table 8 for acifluorfen.

Detailed description, documentation, and direct links for running these models can be found in: http://www.epa.gov/oppefed1/models/water/index.htm. Model outputs are given in Appendix 2.

D. DRINKING WATER

Surface Water

The Tier 2 surface water EDWCs were estimated for the fruiting vegetables (tomatoes, peppers) with the proposed maximum application rate. Table 3 summarizes the estimated exposure concentrations (corrected for Percent Crop Area (PCA)) of lactofen and acifluorfen in surface water as a result of two ground spray applications at the maximum proposed lactofen rate of 0.50 lb ai/acre (Table 1). Acifluorfen was "applied" twice at a rate of 0.291 lb ai/acre (0.58 lb ai/acre maximum season rate)" seven days after the lactofen application, with no spray drift. The lactofen and acifluorfen concentrations represent, the 1-in-10-year annual exceedance probability for peak, yearly mean, and the overall mean for the Florida pepper and tomato scenarios (Table 3).

The estimated peak concentration for lactofen is 1.48 µg/L, the annual mean is 0.044 µg/L, and the long term average is 0.039 µg/L as this represents the most conservative concentrations for the peak concentration. The estimated peak concentration for acifluorfen derived from lactofen is 22.5 µg/L, the annual mean is 3.9 µg/L, and the long term average is 2.0 µg/L, for the most conservative concentrations for the peak concentration. The default PCA of 0.87 is used, rather than a crop specific PCA. It is likely that the PCA for the proposed crops could be lower for these new uses.

Table 3. Estimated drinking water concentrations (EDWC) (µg/L) in surface water for acute, chronic, and cancer exposure from lactofen and the acifluorfen derived from lactofen in µg/L for peppers and tomatoes using linked PRZM/EXAMS[1] and Index Reservoir (IR) and Percent Crop Area (PCA) for surface water. **The bold values are estimates to be used in the drinking water assessment.**

Crop	Chemical Species	1-in-10 year Maximum/mean (µg/L)	Long term average Mean (30 yrs.) (µg/L)
		(acute/chronic)	(cancer)
Pepper	Lactofen	**1.48**/0.040	0.033
	Acifluorfen	**22.5**/3.5	**2.0**
Tomato	Lactofen	1.13/**0.044**	**0.039**
	Acifluorfen	20.9/**3.9**	1.7

Ground Water

The EFED Tier 1 assessment process currently uses the SCI-GROW model to estimate ground-water concentrations. The SCI-GROW (Screening Concentration In GROund Water) is an empirical screening model based on actual ground-water monitoring data collected from small-scale prospective ground-water monitoring studies for the registration of a number of pesticides that serve as benchmarks for the model (USEPA, 2003f). The ground-water concentrations generated by SCI-GROW are based on the largest 90-day average concentration recorded during the sampling period. The model was developed so that only under exceptional circumstances would concentrations of a pesticide exceed the SCI-GROW estimates. It was thought that this exception should be rare since the SCI-GROW model is based exclusively on ground-water concentrations resulting from studies conducted at sites (shallow ground water and coarse soils) and under conditions most likely to result in ground-water contamination.

The SCI-GROW model was found to under estimate acifluorfen concentrations observed in the Wisconsin sodium acifluorfen PGW Study (acifluorfen range 1 to 46 µg/L; mean 7.33 µg/L) (USEPA, 1989; USEPA, 2003b, 2003c, 2003e). Therefore, EFED did not think that the SCI-GROW estimates were conservative for acifluorfen. Later SCI-GROW over estimated the acifluorfen concentrations in ground water (compared to a lactofen PGW) when the acifluorfen was a degradation product of lactofen (USEPA, 2003b). Thus, SCI-GROW model was not used previously to estimate the drinking water concentrations acifluorfen derived from lactofen in ground water (USEPA, 2003b). Several limitations of SCI-GROW were identified as reasons why the SCI-GROW under predicted the acifluorfen concentrations observed in ground water for the Wisconsin PGW (D291747, D278403).

More recently, the ground-water EDWCs for acifluorfen derived from lactofen were based upon observations from a PGW study. Low level concentrations of acifluorfen (as degradate of lactofen) were detected during the Michigan lactofen PGW (USEPA, 2003c) in soil-water at several depths (3- and 6-feet) (acifluorfen LOD in soil water = 0.035 µg/L. There were no ground-water detections of acifluorfen in the Michigan lactofen prospective ground-water (PGW) monitoring study, with a limit of detection (LOD) for acifluorfen of 0.035 µg/L in ground water (USEPA, 2003b, 2003c). The EDWCs for acifluorfen ground water were set at the lactofen PGW study's LOD method limit of detection (0.035 µg/L) for acifluorfen (USEPA, 2003b).

The uncertainty of this estimate increases when extrapolating the findings of the lactofen PGW where 0.40 lb ai/acre lactofen was applied, to the proposed new use rate is 1.0 lb ai/acre (an increase of 2.5 times the previous use rate). The concentrations of acifluorfen derived from lactofen measured in the Michigan lactofen PGW were much lower than in the Wisconsin sodium acifluorfen PGW study. However, the estimated maximum acifluorfen concentration "applied" under the proposed new rate is 0.58 lb ai/acre (from 1.0 lb ai/acre lactofen) more comparable in magnitude to that of the 0.75 lb ai/acre sodium acifluorfen used in the Wisconsin PGW than at the Michigan study.

Due to multiple detections, an understanding of the site's hydrology (USEPA, 1989), and known acifluorfen use, EFED is highly confident that acifluorfen residues can contaminate shallow ground water. Knowing that the sorption of acifluorfen is dependent on factors in addition to organic carbon (minerals, pH, type of organic matter, etc.), one could obtain better estimates of the acifluorfen concentration by lowering the 'Koc' value. However, it was necessary to lower the Koc values below what could be justified (based upon available information).

In addition the difference in sorption of acifluorfen based upon soil conditions, other factors have since been identified (D278403) that also could have contributed to the occurrence of the "high" levels of acifluorfen observed in ground water at the Wisconsin PGW. One is that the amount and frequency that the irrigation water applied during the Wisconsin PGW was based upon consumptive use without including the actual precipitation. This resulted in a high relative amount of water being added. Also, no acifluorfen degradates were identified, thus, acifluorfen appears to have been leached out of the soil before significant degradation (no degradation products were identified) and/or sorption had occurred.

These factors are possible reasons why the ground-water concentrations were under estimated by SCI-GROW. The acifluorfen concentrations observed at the Wisconsin PGW site, while valid, probably do not reflect the acifluorfen concentration likely from the application of lactofen (or sodium acifluorfen) under more typical conditions.

The lactofen and acifluorfen application rates for this assessment use the same rates as those used above for the surface water estimates. The SCI-GROW model to estimate ground-water concentrations for lactofen (Table 4) and acifluorfen (Table 5).

Lactofen

The high Koc (median = 10500 mL/g) and short aerobic soil half-life (< 3 days) indicates that lactofen has a low potential to leach. The estimated lactofen concentration in ground water is 6.00E-03 µg/L, the lower limit of SCI-GROW, as concentrations estimated with Koc values greater than 9995 ml/g are beyond the scope of the regression data used in SCI-GROW development. The fate data (Tables 7 and 8), prospective ground-water monitoring studies and monitoring data confirm that lactofen is not persistent or mobile. With the exception of the lactofen PGW, the Agency is not aware of any ground-water monitoring data for lactofen.

The estimated concentrations of lactofen for acute and chronic exposures in ground water using SCI-GROW are presented in Table 4. **The estimated concentrations of lactofen in ground water for the new use rate (1.0 lb ai/acre) is less than 0.006 µg/L, the lower limit (0.006 µg/L) of the algorithm used to calculate pesticide concentrations.** Although, the maximum application rate is higher than used in the previously assessment (USEPA, 2003b), EFED believes that the likelihood of lactofen contamination ground water would still be quite low.

Table 4. SCI-GROW estimates of lactofen EDWCs in ground water from two 0.5 lb ai/acre per year application of lactofen.		
Water Type	Chemical	Acute and Chronic (µg/L)
Ground Water	Lactofen	**0.006**

Acifluorfen

SCI-GROW estimates of ground-water concentrations depend upon the input values (Table 9) selected for Koc, the aerobic soil metabolism half-life, and the numbers and rate of application (USEPA, 2003b). Acifluorfen is anionic under normal field pH values, thus, other factors other than organic carbon also influence sorption – pH, minerals, clay content, surface area, etc. (Gaston and Locke, 2000). Thus, the sorption of acifluorfen is dependent upon other soil properties in addition to organic carbon (matter) content.

The SCI-GROW estimates for acifluorfen in ground water, as a lactofen degradate, in ground water using the range of Kocs, lowest (50.02 mL/g) and the highest (198.7 mL/g), are 3.17 µg/L and 0.57 µg/L, respectively. However, by assuming that the (median from Table 9) Koc reflects all the sources of sorption, the estimated acifluorfen concentration for the new use (1.0 lb ai/acre lactofen = 0.58 lb ai/acre acifluorfen) in ground water with SCI-GROW is 2.00 µg/L. **The recommended EDWC for acifluorfen acute and chronic drinking water, for the proposed new lactofen use, is 2.00 µg/L (Table 5).** The acifluorfen (from sodium acifluorfen) exposure concentration for drinking water previously used by HED was 3.67 µg/L (D291747).

Table 5. SCI-GROW estimate of acifluorfen (as a degradate of lactofen) in ground water from a 0.58 lb[1] ai/acre annual application of lactofen.		
Water Body	Chemical	Acute and Chronic
Ground Water	Acifluorfen	**2.00 µg/L**

[1] Conversion of lactofen to acifluorfen is 58 percent (average value), thus, 1 lb ai/acre yields 0.58 lb ai/acre.

Aquatic Exposure Estimates

Lactofen and acifluorfen concentrations for surface water aquatic exposure estimates are given in Table 6. The environmental fate inputs used are the same as in the drinking water assessments. The Standard Pond has a different field to water body ratio compared to the Index Reservoir and does not use a PCA. The (ground) spray drift, as a fraction, is 0.01 for the pond (EECs) compared to 0.064 used for the drinking water assessment (EDWCs).

Table 6. The 1-in-10 year estimated environmental concentrations (EECs) for lactofen and a primary degradate acifluorfen in a standard farm pond for aquatic exposure assessments. The bold values are recommended to be used in the aquatic exposure assessment.				
Scenario	Chemical Species	1-in-10 year peak, 21-day mean, and 60-day mean concentration (µg/L).		
		Peak	21-day	60-day
Pepper	Lactofen[1]	**0.48**	**0.095**	0.047
	Acifluorfen[2]	**18.0**	**17.7**	**17.0**
Tomato	Lactofen[1]	0.28	0.076	**0.051**
	Acifluorfen[2]	14.4	14.2	13.8

[1] Lactofen application = 2 applications at 0.5 lb ai/acre.
[2] Acifluorfen estimate assumes that the conversion from lactofen is 0.582 (58.2 percent) – thus 2 applications at 0.291 lbs ai/acre (0.291 = 0.50 * 0.58)

Environmental Fate Summary

<u>Lactofen:</u>

The lactofen environmental fate data is discussed in greater detail in Drinking Water Exposure Assessment for Lactofen, Updated for Prospective Ground-Water (PGW) Monitoring Study (USEPA, 2003b; D263956, D283774).

Aerobic soil metabolism and hydrolysis are the major degradation routes for lactofen. Lactofen is not persistent (half-life less than 3 days) in the environment, has a high affinity for binding (high Koc values), and low solubility (Table 7). Lactofen is not expected to leach to ground water because of its high binding potential and short half-life. A lactofen PGW study confirms this (D283774). Lactofen degrades to desethyl lactofen and acifluorfen; desethyl lactofen will also degrade to acifluorfen. Other degradates include amino acifluorfen. Desethyl lactofen appears relatively stable to photolysis and hydrolysis at least for the duration of the available studies.

Aquatic degradation information for lactofen is lacking. This increases the uncertainty of our understanding of the fate of these compounds in surface water. The fate of lactofen in an aquatic system (surface water) is less clear, but it is not persistent in soil and would have an affinity to bind to sediment rather than remain in solution. Whether soil-bound lactofen will degrade to acifluorfen is not known.

TABLE 7. LACTOFEN ENVIRONMENTAL FATE PROPERTIES AND MODEL INPUT VALUES USED IN PRZM, EXAMS, and SCI-GROW.				
LACTOFEN PROPERTY	FATE DATA	MODEL INPUT CALCULATIONS	MODEL INPUT VALUE	SOURCE
Solubility (ppm)	0.945 0.10		**0.945**	E. Tamichi, Valent EFED One-liner
Molecular Weight	461.77		461.77	EFED One-liner
Hydrolysis (days) Half-life	pH 5: 10.7 @ 40 °C pH 7: 4.6 @ 40 °C pH 9 < 1.0 @ 40 °C	all values multiple by 5 to reflect 20° C, 2.5 by slower for each 10° C1	53.51 @ 20 °C **23.01 @ 20 °C** 5.01 @ 20 °C	EFED One-liner
Henry's Constant (atm. M^3/Mol)	2.43E-08 (calculated)		2.43E-08	EFED One-liner
Photolysis half-life (days)	water: 2.75 soil: 23	converted to rate in hours	**2.75 days**	E. TAMICHI, Valent EFED One-liner
Aerobic Soil Metabolism half-life (days)2	1: 2.41 (DT_{50}) 2: 1.496 (DT_{50})	90th percent upper bound of mean = 2.82 (PRZM & SCI-GROW)	**2.82 days**	1:EFED One-liner Acc. #s 071228; 073854 2: MRID # 45722201 (D284417)
Anaerobic Soil Metabolism half-life	est. 18.5	multiply max. value by 3	55.5 days	EFED One-liner
Aerobic Aquatic Half-life	no data	estimated - multiply aerobic soil input half-life value by 2 (multiply max aerobic soil value by 2)	**5.64 days**	Est. from Aerobic soil metabolism
Anaerobic Aquatic Half-life	no data	estimated -multiply anaerobic soil input half-life value by 2 (multiply max anaerobic soil value by 6)	**111 days**	EFED One-liner
Soil Water Partition (Koc) mL/g	6600 15000	mean value (PRZM/EXAMS) (SCI-GROW)	**10800 mL/g** **10800 mL/g**	E. TAMICHI, Valent DP Barcode D242256

[1] J.C. Harris. 1981. Rate of Hydrolysis. Pages 7-1 to 7-48. *in* Lyman, W.J. *et al.*, Research and Development of Methods for Estimating Physiochemical Properties of Organic Compounds of Environmental Concern. US Army Medical Research Development Command, Frederick, MD The hydrolysis rate decrease (longer half-life) as temperature decreases. Harris suggest that the rate is 2.5 slower for each 10 °C decrease. Thus, hydrolysis at 20 °C would be five times slower than at 40 °C.
The rate constants in hours are for acid, neutral, and basic hydrolysis, KAH, KNH, and KBH, are -6.71/hr, 1.21 E-03/hr, and 4.57 E+02/hr, respectively.
[2] The decline pattern of lactofen did not follow first order kinetics. Non-linear estimate of first order equation fit the data better. Lactofen decline was very rapid.

Lactofen undergoes hydrolysis with an increasing rate with increasing pH (Table 8). As the pH increases the percent and persistence of acifluorfen and desethyl lactofen increases. The final percentages of ^{14}C lactofen and degrades acifluorfen (PPG-847) and desethyl lactofen (PPG-947) at the three pH values used in the study are given in Table 8. It should be noted that this study was determined to be invalid because lactofen residues bound to the container walls. Although this study was flawed, it indicates that lactofen can degrade via hydrolysis resulting in persistent degradates at concentrations similar to parent lactofen. The study was not long enough to understand the long term persistence of these degradates. The current scenario only considers a water with a neutral pH (pH=7), thus, only the hydrolysis rate at pH 7 is used.

Table 8. Final ^{14}C-lactofen and degradates acifluorfen and desethyl lactofen remaining in hydrolysis study at three pH values.

pH	Time of Final Sample Interval (hr)	Lactofen	Acifluorfen PPG-847	Desethyl Lactofen PPG-947
		% of recovered		
5	944	81.5	1.3	17.3
7	720	11.9	9.6	76.8
9	48	2.5	27.9	65.6

<u>Acifluorfen:</u>

Limited environmental fate data are available for acifluorfen (Table 9) and desethyl lactofen especially as degradates of lactofen. Soil samples from a prospective ground-water (PGW) monitoring study (D283774) were collected to conduct an aerobic soil metabolism (162-1) study (D284417). The decline pattern of lactofen residues did not appear to follow first-order kinetics. Lactofen is not persistent. The calculated half-life and the DT_{50} values were essentially the same (about 1.4 days). The formation and decline patterns of acifluorfen tended to follow a first-order decline curve upon reaching its maximum concentration (on day 7). The half-life (40 days) and the DT_{50} (40 days) were essentially the same. Using a degradation series (lactofen to desethyl lactofen to acifluorfen), a DT_{50} was calculated to be about 63 days. The "half-life" of the desethyl lactofen was calculated to be less than a day (<1 day).

The environmental fate of sodium acifluorfen, acifluorfen, and amino acifluorfen are discussed in greater detail in the reregistration eligibility document (RED) of sodium acifluorfen (PC Code 114402) and other uses (DP Barcode D252561, D280710, 239268). The environmental fate parameters for sodium acifluorfen used in this reassessment are listed in Table 9. The aerobic soil metabolism rate for acifluorfen ranges from 100 to 200 days (D291747) for sodium acifluorfen.

Acifluorfen is highly mobile with K_{ads} values ranging from 0.148 to 3.1 mL/g (Table 9, D232775) suggesting a potential to leach to ground water. This is confirmed by monitoring data. The Koc values range from 50.22 to 198.7 mL/g (Table 9).

The Kads values for the degradate acifluorfen amine (amino acifluorfen) were 47.01, 19.34, 12.11, and 1.25 for loamy sand, loam, clay, and sand soils, respectively (1/n values ranged from 0.802 to 0.936) (DP D253561). Koc values were 7368, 741, 652, and 431 for loamy sand, loam, clay, and sand soils, respectively. Using the relative mobility classification of McCall et al (1980), acifluorfen amine has a mobility classification of "immobile" in loamy sand, "low mobility" in loam and clay, and "medium mobility" in sand.

Acifluorfen can be quite persistent, is highly soluble, and is highly mobile. The environmental fate properties suggest that if acifluorfen reaches ground water it is quite persistent. Monitoring data from a prospective ground-water study confirms the persistence of acifluorfen in ground water (D173298). There is also evidence in that sorption of acifluorfen to different soils can be highly variable depending upon specific soil properties. This variability may explain the difference in leaching seen at different locations.

Acifluorfen will tend to remain in solution rather than being bound to sediment, therefore, acifluorfen in runoff will remain in solution. Acifluorfen and desethyl lactofen appear relatively stable to photolysis and hydrolysis at least for the duration of the available studies. Acifluorfen reduces to amino acifluorfen under anaerobic conditions. The degradate amino acifluorfen appears to be persistent but less mobile than acifluorfen in non-sandy soils. Photolysis in water may be one of the possible ways for acifluorfen to degrade in surface water as the aqueous photolysis half-life ranges from 0.9 to 15 days. However, when light penetration is restricted the rate of photolysis would be reduced.

TABLE 9. SELECTED (SODIUM) ACIFLUORFEN ENVIRONMENTAL FATE PROPERTIES AND MODEL INPUTS VALUES USED IN PRZM, EXAMS and SCI-GROW.

ACIFLUORFEN PROPERTY	FATE DATA	MODEL INPUT CALCULATIONS	MODEL INPUT VALUE	SOURCE
Solubility (ppm)	2.50E+05		**2.50E+05**[1]	EFED One-liner
Molecular Weight	383.70		**383.70**	EFED One-liner
Hydrolysis (days)	stable at pH 5,7,9		considered stable	EFED One-liner
Henry's Constant (atm.m^3 /mol)	1.51E-13 (calculated)		**1.51E-13**	EFED One-liner

TABLE 9. SELECTED (SODIUM) ACIFLUORFEN ENVIRONMENTAL FATE PROPERTIES AND MODEL INPUTS VALUES USED IN PRZM, EXAMS and SCI-GROW.				
ACIFLUORFEN PROPERTY	FATE DATA	MODEL INPUT CALCULATIONS	MODEL INPUT VALUE	SOURCE
Photolysis half-life (days)	Water: 3.8 (0.9 to 14.7)[2] Soil: 57 @pH4	 upper 90%=mean + t90 x std/√n; single tail student t, α=0.1 and n = number of samples	**3.8 days** **13.31 days**	EFED One-liner **MRID 41891208** **D232775**
Aerobic Soil Metabolism half-life (days)	30, 60 - 180, 170, 59, 6 (60 and 180 were used to cover the range 60 - 180) **(100,108,193,200 used)** **40** **Mean – 150.25 days**	- upper 90%=mean + t90 x std/√n; single tail student t, α=0.1 and n = number of samples	121 days **172.84 days** **150.25 days** (SCI-GROW)	EFED One-liner **(MRID 00143572)** **MRID 45722201**
Anaerobic Soil Metabolism half-life (days)	<28 days	multiply value by 3	**84 days**	EFED One-liner
Aerobic Aquatic half-life (days)	98%-day 0, 82%-day 35: half-life estimated to be 117 days [2 x 172.84 = 345,68 days]	multiple value by 3 2 times aerobic soil metabolism half-life	351 days 345.68 days	EFED One-liner
Anaerobic Aquatic half-life (days)	no data	estimate by multiplying anaerobic soil half-life by 6 (28 x 3 x 2)	168 days	EFED One-liner

TABLE 9. SELECTED (SODIUM) ACIFLUORFEN ENVIRONMENTAL FATE PROPERTIES AND MODEL INPUTS VALUES USED IN PRZM, EXAMS and SCI-GROW.				
ACIFLUORFEN PROPERTY	FATE DATA	MODEL INPUT CALCULATIONS	MODEL INPUT VALUE	SOURCE
Soil Water Partition (Kd)mL/g (Kads mL/g)	1.0 0.148, 0.346, 1.51, 1.87, 3.1	Mean = 1.39 upper 90%=mean + t90 x std/√n; single tail student t, α=0.1 and n = number of samples	previous 1 (assume OC=1%); Koc = 100 (50.22 to 198.7) **Mean = 1.39** K_{ads} = 2.22 [for PRZM and EXAMS]	EFED One-liner (MRID 42703501)
Soil Water Partition (Koc) mL/g (Koc)ads mL/g)	50.22, 56.96, 73.52, 164.9, 198.7	Use median (m) value m = 73.52	**m = 73.52** [for SCI-GROW]	(MRID 42703501) [D278403]

[1] Bold values used as inputs for modeling.
[2] Additional information was considered in reassessment.

OTHER CONSIDERATIONS

The potential for acifluorfen to contaminate ground water has been recognized by the Agency since the mid -1980s. Since this time a number of assessments have been made by EFED as additional information became available. With the advent of the FQPA (Food Quality Protection Act), concentrations of pesticide residues in water needed to be estimated so they could be included in the dietary exposure estimates. Until recently (2002), there was a concern for dietary exposure for acifluorfen due to a potential cancer risk (D292794), with the (ground) drinking water concentration of concern (cancer DWLOC) of 2.8 µg/L. Estimates of acifluorfen residues (from ground-water monitoring and modeling) in water occasionally exceeded this value under some conditions. A sodium acifluorfen PGW study (USEPA, 1989) conducted in Wisconsin had acifluorfen concentrations higher (max. = 46 µg/L; mean = 7.33 µg/L) than predicted by SCI-GROW or observed in other monitoring studies (D291747).

Additional information submitted to the Agency has removed the cancer concern (D292794), so the chronic exposure (non-cancer) is now the point of comparison. The chronic exposure (non-cancer) level of concern has been estimated to be about 455 µg/L (DWLOC). This value far exceeds the levels of acifluorfen found in the monitoring programs and those estimated by EFED screening models. Based on the modeled estimates and the limited monitoring it seems unlikely that acifluorfen concentrations from lactofen applied to the new uses would reach this level in either ground water or surface water.

The environmental fate input values for acifluorfen which were used with SCI-GROW are summarized in Table 9. SCI-GROW estimates of ground-water concentrations depend upon the input values selected for Koc, the aerobic soil metabolism half-life, and the numbers and rate of application (USEPA, 2003b). Acifluorfen is anionic under normal field pH values, thus, other factors other than organic carbon also influence sorption – pH, minerals, clay content, surface area, etc. (Gaston and Locke, 2000). Thus, the sorption of acifluorfen is dependent upon other soil properties in addition to organic carbon (matter) content. The "application rate" or concentration of acifluorfen derived from lactofen depends upon the degradation pathway and the assumptions used concerning the rates of formation of acifluorfen and lactofen decline. The fate data (Tables 9) and retrospective ground-water monitoring study suggests that acifluorfen is mobile and persistent enough to contaminate ground water, and the prospective ground-water study (PGW) and monitoring data confirms that acifluorfen can contaminate ground water.

A small-scale sodium acifluorfen prospective ground-water monitoring (PGW) was conducted in the Central Sands region of Wisconsin (USEPA, 1989). Acifluorfen was detected in 56 out of 283 ground-water samples (20%) with concentrations ranging from 1 to 46 µg/L. The average concentration for the last sampling was 15.2 µg/L, the overall mean for the 56 detections was 8.36 µg/L, and the average of the 10 sampling dates with detections was 7.33 µg/L. Due to multiple detections, an understanding of the site's hydrology, and known acifluorfen use, EFED is highly confident that acifluorfen residues can contaminate shallow ground water.

The SCI-GROW model was found to under estimated acifluorfen concentrations observed in the Wisconsin sodium acifluorfen PGW Study (USEPA, 1989; USEPA, 2003b, 2003c, 2003e). Thus, EFED did not think that the SCI-GROW estimates were conservative. Therefore, the SCI-GROW model was not used previously to estimate the drinking water concentrations acifluorfen derived from lactofen in ground water (USEPA, 2003b). SCI-GROW over estimated acifluorfen concentrations compared observed in Michigan PGW (USEPA, 2003c).

\ Knowing that the sorption of acifluorfen (due to its anionic nature) is dependent on factors in addition to organic carbon (minerals, pH, type of organic matter, etc.), the 'Koc' value was adjusted as a means to improve the estimated acifluorfen concentrations (to conform with those seen in the Wisconsin PGW). Better estimates could be obtained by lowering the Koc, however, it was necessary to lower the Koc values below what might be thought of as a reasonable value (based upon available information). Additional factors have since been noted (D278403) that could have contributed to the occurrence of the "high" levels of acifluorfen observed in ground water at the Wisconsin PGW. These factors include:

1. The soil at the Wisconsin site was highly vulnerable- - low organic carbon content, low water holding capacity, and perhaps minerals with low sorption potential,

2. Irrigation was applied based upon consumptive use (from study site) estimates without taking into account any actual precipitation (i.e., the plots were irrigated

whether irrigation was need or not), so with the low water holding capacity, leaching would be enhanced,

3. Sodium acifluorfen was applied in one 0.75 lb ai/acre application,

4. The primary degradates (amino acifluorfen and desnitro acifluorfen) of acifluorfen were analyzed for and not found, suggesting no degradation and that leaching was the only dissipation pathway,

5. The measured peak concentration in ground water was 46 µg/L; the average measured concentration was 7.33 µg/L. The SCI-GROW estimates are based upon the highest average concentrations for a three month period. Using the acifluorfen fate inputs (Table 8) as currently recommend by EFED guidance (USEPA, 2002a), SCI-GROW estimates an acifluorfen concentration of 2.57 µg/L for an application of sodium acifluorfen 0.75 lb ai/acre.

The high concentrations of acifluorfen in ground water at the Wisconsin site are at least partially the result of the amount and frequency that the irrigation water applied during the PGW. It appears that the "mobile" acifluorfen was leached out of the surface soil layers (the most active microbial populations) before degradation and sorption occurred. This resulted in ground-water concentrations estimated by SCI-GROW. The acifluorfen concentrations observed at the Wisconsin PGW site, while valid, probably do not reflect the acifluorfen concentration likely from the application of lactofen (or sodium acifluorfen) under more typical conditions.

Low level concentrations of acifluorfen (as degradate of lactofen) were detected during the Michigan lactofen PGW (USEPA, 2003c) in soil-water at several depths (3- and 6-feet) (acifluorfen LOD in soil water = 0.035 µg/L. There were no ground-water detections of acifluorfen in the Michigan lactofen prospective ground-water (PGW) monitoring study, with a limit of detection (LOD) for acifluorfen of 0.035 µg/L in ground water (USEPA, 2003b, 2003c). The EDWCs for acifluorfen ground water were set at the lactofen PGW study's LOD method limit of detection (0.035 µg/L) for acifluorfen (USEPA, 2003b). The uncertainty of this estimate increases when extrapolating the findings of the lactofen PGW where 0.40 lb ai/acre was applied, the proposed new use rate is 1.0 lb ai/acre (an increase of 2.5 times the previous use rate). The concentrations of acifluorfen derived from lactofen measured in the lactofen PGW were much lower than in the Wisconsin sodium acifluorfen PGW study.

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APPENDIX 1.

The surface water EDWCs (estimated drinking water concentrations) and EECs (estimated environmental concentrations) for lactofen and acifluorfen were generated with standard cropping [Table B-1, Florida peppers and tomatoes] scenarios (Leovey, 2002) using PRZM3 (version 3.12 beta, Carsel, 1997) and EXAMS (version 2.98.04, Burns, 2002). PRZM simulates pesticide fate and transport as a result of leaching, direct spray drift, runoff and erosion from an agricultural field and EXAMS estimates environmental fate and transport of pesticides in surface water body for a 30-year period (1961-1990). The EECs and EDWCs assessment for surface water uses a single or multiple sites which typically represent a high-end exposure scenario from pesticide use on a particular cropped or non-cropped site. PRZM and EXAMS were linked by the program (PE4-PL, version 01). Ground-water concentrations were estimated using the Tier I screening model SCI-GROW (version 2.3, compile 08/08/03). Detailed description, documentation, and direct links for running these models can be found in: http://www.epa.gov/oppefed1/models/water/index.htm. Model outputs are given in Appendix 2.

The standard farm pond scenario is used to estimate EECs for ecological exposure. The farm pond scenario, represents a 10-ha corn (all cropped) field that is adjacent to a 1-ha pond that is 2 meters deep standard pond (10,000-m^2 pond, that has neither hydraulic inlets nor outlets (i.e., pesticide cannot leave by outflow). The Index Reservoir (IR) is intended as a drop-in replacement for the standard pond for use in drinking water exposure assessment. It is used in a manner similar to the standard pond, except that flow rates have been modified to reflect local weather conditions. The index reservoir (IR) is approximately 82 m wide and 640 m long, with an area of 5.3 ha (USEPA, 2000). The area of the entire watershed is 172.8 ha, thus, the field to watershed ratio is different. Weather and agricultural practices are simulated for 30 years so that the 10-year exceedance probability at the site can be estimated. The simulation was generated using 30 years of meteorological data, encompassing the years from 1961 to 1990. Guidance for using the IR is located at: http://www.epa.gov/pesticides/trac/science/html. Model outputs are given in Appendix 3.

The Percent Crop Area (PCA) is a generic watershed-based adjustment factor that will be applied to pesticide concentrations estimated for the surface water component of the drinking water exposure assessment using PRZM/EXAMS with the index reservoir (IR). The output generated by the linked PRZM/EXAMS models is multiplied by the maximum percent of crop area (PCA) in any watershed (expressed as a decimal) generated for the crop or crops of interest. Currently, OPP will apply PCA adjustments for four major crops. Guidance for using PCAs and a thorough discussion of this method and comparisons of monitoring and modeling results for selected crop/site combinations is located at: http://www.epa.gov/pesticides/trac/science/. No PCA adjustment is required for SCI-GROW. Model outputs are given in Appendix 4.

Ground-Water Monitoring:

Lactofen Prospective Ground-Water (PGW) Monitoring Studies

The registrant previously conducted a small-scale PGW monitoring study, where lactofen (Cobra) was applied at the rate of 0.45 lb ai/acre, at a "hydro-geologically vulnerable" site in Ohio. Site instrumentation was standard and met minimum guideline requirements at the time or the study. Lactofen was not detected in ground water at or above the study limit of quantification (1.0 µg/L). Several detections were suspected, but not verified, and were assumed by the registrant to be the result of analytical interference. Evidence of the metabolite acifluorfen leaching was also not observed in this prospective study. The Agency concluded that there was no evidence to suggest the leaching of lactofen or formation acifluorfen. Since no tracer was used, there is no collaborative evidence to demonstrate that any leaching actually took place during the study (D203252).

A second small-scale PGW conducted for lactofen in Michigan (USEPA, 2003c). Lactofen concentrations in soil declined with no evidence of leaching. The soil and soil water concentrations of acifluorfen at the Michigan lactofen PGW were typically lower than those observed at the Wisconsin sodium acifluorfen PGW study. This most likely is due to the fact that the 0.40 lb ai/acre lactofen (Michigan site) yields about 0.23 lb ai/acre (58% conversion) compared to higher rate of sodium acifluorfen used (0.75 lb ai/acre) in the Wisconsin study (D915031). The formation of acifluorfen from lactofen is not instantaneous, and therefore will not move through the soil matrix a single “pulse”.

Low level concentrations of acifluorfen (degradate) were detected during the Michigan lactofen PGW (USEPA, 2003c) in soil-water at several depths (3- and 6-feet) (acifluorfen LOD in soil water = 0.035 µg/L), but there were no detections in the ground water (acifluorfen LOD in ground water = 0.035 µg/L). The leaching of acifluorfen is not unexpected based upon the fate data (low sorption and persistent). Leaching of acifluorfen below six feet is possible and also likely.

Sodium Acifluorfen Prospective Ground-Water (PGW) Monitoring Studies

The Wisconsin sodium acifluorfen PGW study (USEPA, 1989) reported acifluorfen concentrations ranging from > 1 µg/L to 46 µg/L. The long term average acifluorfen concentration at the prospective study site was 7.33 µg/L. Many were higher than those concentrations predicted by SCI-GROW or observed in other monitoring studies (D291747). The results of this study are valid, but they probably do not represent conditions under more typical conditions. The sodium acifluorfen was applied in a single 0.75 lb ai/acre application, the soil at the study site had a low organic carbon content, low clay content, and water holding capacity; and with predominately permanently charge surfaces. Irrigation water was applied based upon “estimated consumptive use” and irrigated whether it rained or not. Acifluorfen and the two primary degradates were analyzed for (amino acifluorfen, desnitro acifluorfen) in the study. No (sodium acifluorfen) degradates were detected, acifluorfen concentrations decreased with time in the soil samples, the suction lysimeters were effective in collecting water samples which contained acifluorfen residue, and acifluorfen residue was eventually detected ground-water monitoring well samples. The fact that no degradates were detected suggests that the acifluorfen residues were leached out of soil and into ground water (D280710).

Survey Monitoring

The Pesticides in Ground Water Data Base (PGWDB) (USEPA, 1992) summarizes the results of a number of ground-water monitoring studies. Four of 1185 wells sampled, in one study, for acifluorfen reported concentrations ranged from 0.003 to 0.025 µg/L. The studies reported in the PGWDB may reflect conditions where no lactofen or acifluorfen had been used or where there is a low susceptibility to ground-water contamination. Therefore, EFED has low confidence that the monitoring reflects the potential contamination of ground water from acifluorfen.

The maximum acifluorfen concentration was 0.19 µg/L (0.14% of 1476 samples) in the NAWQA study from wells in the mixed land use (major aquifer surveys) http://ca.water.usgs.gov/pnsp/pestgw/Pest-GW_2001_Text.html. Since the USGS NAWQA study is to assess water quality in general and not specifically lactofen and acifluorfen, there is less confidence in using these data to assess the potential for lactofen and acifluorfen to contaminate ground water than the prospective studies.

Surface Water Monitoring

For acifluorfen, there have been a small number of detections in (4.04% of 1233 samples from 48 sites with streams with agricultural land use) the surface water monitoring program (NAQWA, 2/19/03; http://ca.water.usgs.gov/pnsp/pestsw/Pest-SW_2001_Text.html).
The peak concentration was 1.10 µg/L, more than half (2.1 % ranged between 0.1 and 1.0 µg/L. In land designated as mixed by NAWQA, 3 samples of 561 samples from 25 sites contained acifluorfen residues with a maximum concentration of 0.04 µg/L. Three samples out of 503 samples had acifluorfen residues in land designated as urban use. The maximum concentration was 0.060 µg/L. The estimated values from PRZM/EXAMS tended to be higher than maximum concentration seen in NAWQA monitoring data. Because of the high mobility and long persistence of acifluorfen in water, potentially "high" concentrations of acifluorfen may exist in surface water bodies. Without specifically targeted monitoring data it is not possible to determine peak environmental concentration. The monitoring data demonstrates the potential for acifluorfen to contaminate ground water.

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