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MEMORANDUM

SUBJECT: Drinking Water Exposure Assessment for Total Aldicarb Residues (Parent, Aldicarb Sulfoxide, and Aldicarb Sulfone) Based on the N-Methyl Carbamate Cumulative Risk Assessment

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This updated assessment, based on the work for the NMC cumulative assessment, was requested by SRRD and HED. It reflects drinking water exposure estimates used for the N-Methyl Carbamate (NMC) cumulative risk assessment (CRA) and is based on typical application rates. The attached document provided estimated exposures for both ground- and surface-water sources of drinking water, characterizes the variability in the exposure estimates, compares estimated concentrations to available monitoring data, and describes the potential extent of high aldicarb exposure areas.

Private well monitoring data submitted by Bayer CropScience have not yet been fully analyzed. Such information will help in the characterization of the potential extent of aldicarb exposure in private wells.

Drinking Water Exposure Assessment for Total Aldicarb Residues (Parent, Aldicarb Sulfoxide, and Aldicarb Sulfone) Based on the N-Methyl Carbamate Cumulative Risk Assessment

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Summary

This updated drinking water assessment for aldicarb and its major degradates (aldicarb sulfoxide and aldicarb sulfone) reflects total aldicarb residue exposures used in the N-methyl carbamate (NMC) cumulative exposure assessment. While that assessment includes multiple NMC pesticides, the ground water exposure assessment focused on high aldicarb use areas and reflects the high potential exposure areas for aldicarb based on current use. The surface water assessment represents areas of highest combined NMC use and may not reflect the highest potential exposure sites for aldicarb alone. Both of the assessments represent exposures based on typical application rates and do not reflect potential exposures that can occur when aldicarb is used at maximum allowable label rates to address pest pressures. The characterization section addresses variability in exposure estimates resulting from differing application rates, depths to ground water, and setback distances between the well and the application area.

At this level of refinement, EFED focused on those areas that have the greatest potential for exposure to aldicarb. As noted in the preliminary NMC cumulative risk assessment, total aldicarb residues are not expected to occur at levels that will contribute to dietary exposures for most of the country (available at [HYPERLINK "http://www.epa.gov/scipoly/sap/meetings/2005/august/preliminarynmc.pdf"]). However, total aldicarb residues estimated for vulnerable private wells in some areas of Florida (primarily along the central ridge) and high leaching potential areas in the southeastern coastal plain approach levels that may be a concern for total dietary exposures. These areas represent a relatively small area of the country where the estimated ground water residues are reasonable estimates of drinking water exposure for residents who get their drinking water from shallow private wells.

Groundwater

The estimated distributions of total aldicarb residues (parent plus the sulfoxide and sulfone transformation products) in **ground water** reflect:

- **Shallow (30-ft) private wells**. Concentrations will vary with varying depths to ground water and well depths. Higher concentrations would be expected in more shallow wells while lower concentrations would be likely in deeper wells.
- **High leaching potential** soils (as classified by the USDA Natural Resources Conservation Service), with similarly permeable conditions extending through the vadose zone to ground water. Soil and vadose zone permeability will vary across the landscape and with depth. Where the vadose zone includes low-permeability layers, concentrations will be lower.
- Aldicarb applications to fields at **label setback distances** between the field of application and the well, as specified on the current aldicarb label. Since travel time varies with well depth, a longer setback distance would be needed for shallower wells while a shorter setback distance might be sufficient for deeper wells.

- A **high-end typical lateral flow velocity** to estimate the travel time from the field of application to the well based on well setback distance. This assumes that the ground water is flowing from the field of application toward the well.
- **Typical application rates** for aldicarb, provided by the Biological and Economic Analysis Division (BEAD). Concentrations would be greater if maximum label rates are used.
- **Acidic soil and ground water**, which favor the persistence of the sulfoxide and sulfone transformation products (both degrade rapidly under alkaline conditions; the parent aldicarb is less susceptible to alkaline hydrolysis).

Table 1 summarizes the estimated distributions of total aldicarb residues for various crop/site scenarios and label-specified well setback distances based on typical application rates. While the soils along the central ridge of Florida are typically more vulnerable to leaching in comparison to other regions, estimated total aldicarb residues used for dietary exposures are less than for the Georgia coastal plain scenario because of a greater setback distance (1000 ft for citrus in FL compared to 300 ft in GA).

Table 1: Estimated concentrations of total aldicarb residues in private, shallow (30-ft) wells in high leaching potential soils in FL and the southeastern Coastal Plain based on typical rates.

Scenario	Well setback distance	Concentrations, ug/l						
		Max-imum	99th %ile	95th %ile	90th %ile	80th %ile	75th %ile	50th %ile
FL central ridge citrus	**1000 ft**	3.0	2.8	2.6	2.4	2.1	2.0	1.7
GA Coastal Plain Peanuts/ cotton	**300 ft**	6.5	6.0	5.1	4.8	4.3	4.1	3.1
NC Coastal Plain Peanuts/ cotton	**300 ft**	1.3	1.2	1.1	1.0	0.9	0.8	0.6

The estimated ground water concentrations are not national numbers but are reasonable for people living in those vulnerable areas who get their drinking water from shallow private wells. The exposure estimates represented by these scenarios are limited to these crops and conditions:

- The **Florida central ridge citrus** scenario represents those high leaching potential soils that occur along the central ridge of Florida and are in citrus production. Outside of the central ridge, the soils are typically less permeable and/or the ground water is alkaline (pH>7) and aldicarb residues are not expected to persist.
- The **Georgia coastal plain peanuts/cotton** scenario represents high leaching potential soils in the southern coastal plain (GA, AL, SC) underlying cotton and peanuts. Although aldicarb use on pecans was not included in this assessment, it is likely that, under the same high leaching potential soils, total aldicarb residues in private wells from pecan use would be greater than estimated for peanuts because of a higher typical application rate (3.22 kg/ha for pecans compared to

1.10 kg/ha for peanuts). Pecans were not modeled because, according to BEAD estimates, only a small portion of pecan acres (1%) are treated with aldicarb.

- The **North Carolina coastal plain peanuts/cotton** represents high leaching potential soils in the northern coastal plain (NC, VA, Delmarva pensinsula) underlying peanuts or cotton.

The ground water exposure represents private drinking water wells. The Agency assumed in this assessment that, in general, public water supplies supplied by ground water will typically draw from deeper aquifers and/or aquifers that have a relatively impermeable layer between the surface and the water supply. Such supplies are expected to be much less vulnerable to pesticide contamination. Public water supplies have a higher probability of being treated, although conventional treatments processes are likely to result in little or no reduction of aldicarb residues in water. However, where lime softening, which will accelerate pH-dependent hydrolysis for aldicarb sulfoxide and sulfone, or activated carbon filtration is used, some reduction in aldicarb residues between untreated and treated water may occur.

Surface Water

The estimated surface water exposures reflect areas of high combined NMC use, but not necessarily the highest aldicarb use areas. An evaluation of the scenarios used for the NMC CRA assessment indicate that three scenarios – FL central ridge (citrus), NC coastal plain (peanuts, cotton), and LA/MS Mid-south (cotton) – coincide with high aldicarb use areas where drinking water intakes are likely to occur.

For the NMC CRA, OPP used typical application rates and acres treated because of a low likelihood that all of the NMC pesticides will be used at maximum rates on all of the crop acreage in a watershed at the same time. This assumption does not hold up for the individual pesticides because high exposures are likely where the pesticide is applied in response to pest pressures, often treating the entire crop on a local area. The typical application rates and percent acres treated are derived from state-level survey data and assume uniform use practices across the state. Indeed, an uneven distribution of application rates and percent acres treated is expected in response to differing pest pressures. This assumption will underestimate areas where pest pressures may dictate a higher percentage of acres treated in a given year. Thus, for this aldicarb assessment, OPP assumed that all of the crop acres in the watershed were treated. While reported acres treated ranged from 14% for citrus in FL to 63% for peanuts in NC, the use data do not allow for a reasonable upper bound estimate on percent treated in localized areas across the state.

The estimated surface water concentrations (Table 2) represent total aldicarb residues reservoirs located in high use areas which coincide with relatively high runoff conditions. They reflect typical application rates, but assume that the entire crop in the watershed is treated.

Table 2: Estimated concentrations of total aldicarb residues in surface water sources of drinking water in high runoff potential areas based on typical rates.

Scenario Location	Crops	Concentrations, ug/l					
		Max-imum	99th %ile	95th %ile	90th %ile	80th %ile	75th %ile
FL central ridge citrus	Orange, grapefruit	10.2	1.6	0.3	0.1	0.02	0.01
NC Coastal Plain	Peanuts, cotton	4.6	1.0	0.2	0.1	0.01	0.005
LA/MS Mid-south	Cotton	0.8	0.2	0.02	0.004	<0.001	<0.001

The variability in concentrations from year to year in the surface water distributions reflect the variability due to varying weather patterns over 30 years of actual weather data. Because these scenarios target high aldicarb use areas associated with drinking water intakes in high runoff areas, they represent high end exposure sites. Total aldicarb residues in surface water sources in the rest of the country are expected to be lower.

The sections that follow include a brief write-up of the ground water modeling approach used to estimate total aldicarb residues in ground water, a summary of the results and a comparison against recent monitoring, and a characterization of the spatial extent of the potential high exposure areas. More detail on the ground water conceptual model and the model approach can be found in the NMC cumulative risk assessment (FIFRA SAP, 2005). The surface water modeling approach is also described.

Ground Water Exposure Assessment

Ground water modeling approach

Although previous drinking water exposure assessments for aldicarb relied on a summary of available monitoring data, the vast majority of the monitoring represents unknown conditions (in particular, no information on aldicarb rates, distances between fields and wells, ground water depth, type of well, soil or hydrogeologic conditions, or ground water pH) and represented monitoring prior to label changes. Bayer CropScience has recently submitted a compilation of recent monitoring of private wells in selected areas of the US. Although EPA has not yet had time to fully evaluate the monitoring (in particular, the correlation of aldicarb detects with high leaching potential soils, distance between field and well, depth to ground water, and nature of well), a brief review of study results indicates that the estimated exposures reported below are on the same order as reported detections.

EPA used the Pesticide Root Zone Model (PRZM) to simulate transport processes through high leaching potential soils to a shallow unconfined aquifer with a water table at 30 feet (approximately 9 m) below the surface. The well screen extended an additional 1 m below the water table. While information on typical depths of private

wells is not readily available, USGS NAWQA and ground water atlases suggest that 30 feet is a reasonable depth for shallow ground water supplying private wells in the southeastern coastal plain and Florida.

The well concentration is the average pore water concentration across the length of the screen. PRZM was set up to deliver the average pore water concentration in the 'saturated' soil profile in the upper meter of the ground water zone.

The modes and rates of degradation for aldicarb residues changed through the soil profile. EPA used the pesticide aerobic soil metabolism rate for the top 25 cm, linearly decreasing the rate with depth to 1 m. Below that, EPA used hydrolysis. Table 3 summarizes the pertinent aldicarb properties used for this assessment. These properties came from an evaluation of registrant-submitted studies. Other chemical properties are required as inputs, but have negligible effect on model output; these properties can be found in the model input files as well as in the RED. Properties for aldicarb represent total residue (parent aldicarb, plus the degradates aldicarb sulfoxide and aldicarb sulfone) properties.

Table 3: Summary of aldicarb fate and transport properties for leaching.

Input Parameter	Value	Reference/Comment
Kd	Kd = 0.12 mL/g (Koc = 10 mL/g)	Value for aldicarb sulfone (MRID 43560302)
Hydrolysis	Parent degrades slowly at pH9 Sulfoxide 2-3 days @ pH9 Suflone 60-63 days @ pH7, 6 days @pH8, 1 day @ pH9	Parent hydrolyzed only at pH 9 (MRID 00102065) – degradates hydrolyze more rapidly at neutral-to-high pH
Soil Half-life	55 days for total aldicarb residues for the top 25 cm; decreased linearly from 25 to 100 cm	Revised from 2001 Aldicarb RED; Upper 90th pct bound on mean for combined parent+sulfoxide+sulfone half-life from 19 soils
Additional Notes	Modeled total aldicarb residues	Half-life values used in inputs based on combined aldicarb + sulfone + sulfoxide residues; lowest K_d of the 3 chemicals used for mobility. Assumes equal toxicity of parent, degradates

Aldicarb was modeled using a unit rate of 1 kg ai/ha for each scenario. Because the exposure concentrations are linearly related to the application rate, the resulting rates were multiplied by the typical application rates (Table 4). The maximum label application rates are also provided in contrast. If these rates are used, the concentrations would increase proportionally.

Table 4: Summary of aldicarb seasonal application rates used for ground water exposure modeling.

Location	Crop	PRZM scenario	App. Rate (kg/ha)[1]	Max. Label Rate (kg/ha)[1]	App. Date	Well setback (ft)
Southeast coastal plain/ NC	Peanut, Cotton	NC Cotton	1.10 (peanut)	5.55 (cotton); 3.66 (peanut)	10-Apr	300
Southeast coastal plain/ GA	Peanut, Cotton	GA Peanut	1.00 (peanut)	5.55 (cotton); 3.67 (peanut)	10-Apr	300
FL Central Ridge	Oranges / grapefruit	FL Citrus	4.27	5.49	1-Apr	1000
Northeast FL	Potato	FL potato	0.80	3.66	20-Jun	300
Central WA	Potato	WA potato	3.21	3.66	15-May	300

[1] Application rates, typically reported in pounds per acre (lb/A), has been converted to kg/ha for modeling purposes.

Because aldicarb labels specify well setback distances (varying with soil type and among states), EPA used a plug flow model to simulate the additional travel time for a pesticide to reach a drinking water well from point of application. This is explained in detail in the preliminary NMC cumulative assessment (USEPA/FIFRA SAP, 2005).

Well setback distances result in additional travel time for the chemical to move laterally to the well. This results in additional degradation. Reductions in concentration are calculated in these assessments by a plug flow approximation:

[EMBED Equation.3]

where C = concentration at well [mass/volume]
C_0= concentration at point of application [mass/vol]
L = well setback distance [length]
v = lateral groundwater velocity [length/time]
k = degradation rate in aquifer [$time^{-1}$]

Table 5 provides estimated travel times and concentration reduction factors for varying well setback distances. For the ground water exposure assessment, EPA used the reduction factor associated with the corresponding well-setback distance on the aldicarb label (1000 ft for citrus in FL; 300 ft for other crops in FL and in the southeastern coastal plain). The reduction factor is based on a typical high-end lateral groundwater velocity of 0.15 m/da (0.49 ft/da) for the FL central ridge as reported by Russell et al, 1987. Other studies reported velocities ranging from 0.09 to 0.27 m/da (Paramasivam et al, 1999). Based on that range in groundwater velocities, resulting concentration reduction factors for a 300-foot setback distance ranged from 43% lower (0.244) to 46% higher (0.625) than what was calculated with the 0.15 m/da velocity.

Table 5. Travel time and concentration reduction factors for varying well setback distances for aldicarb (based on 500-day half-life for hydrolysis @ pH5).

Setback distance (ft)	Travel time (da)	Reduction factor
100	203	0.754
300	610	0.429
500	1016	0.244
1000	2033	0.060

Estimated total aldicarb residues in ground water

Table 6 summarizes the distributions of total aldicarb residues for various scenarios and varying well setback distances. The distributions represent 25 years of simulations. The distributions highlighted in bold in the table represent estimated residues for the labeled setback distance between the treated field and the well. The 0-foot "setback" estimates in-field concentrations which were used to compare model estimates with in-field ground water monitoring data.

Table 6: Estimated concentrations of total aldicarb residues in private, shallow (30-ft) wells. Concentrations represent typical application rates in high leaching potential soils.

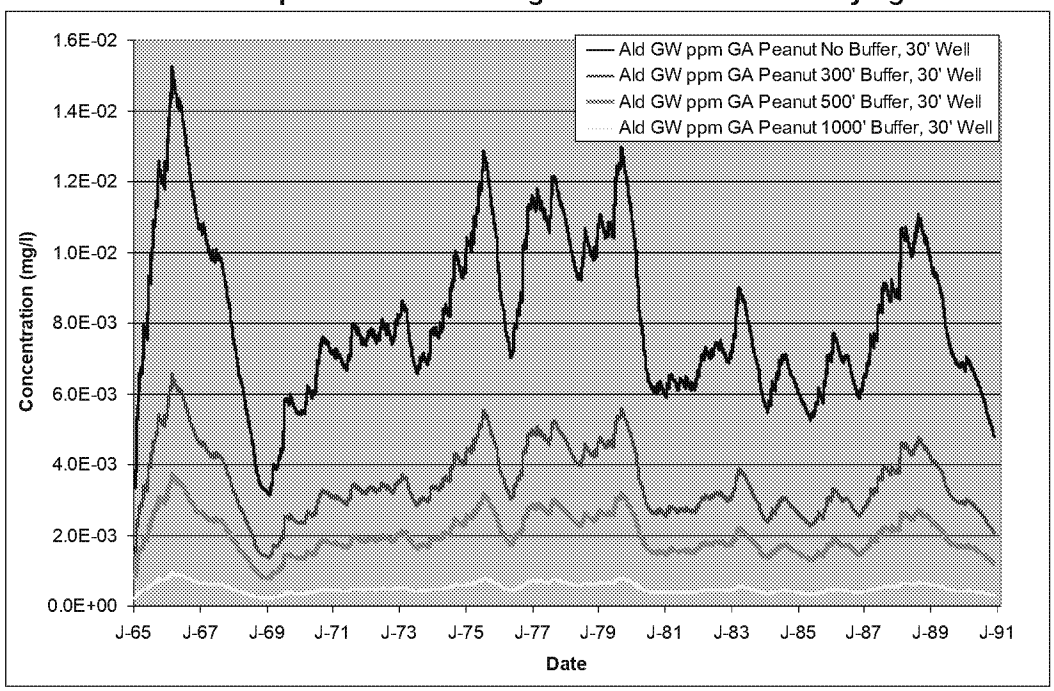
Scenario	Well setback	Concentrations, ug/l						
		Max-imum	99th %ile	95th %ile	90th %ile	80th %ile	75th %ile	50th %ile
FL Central Ridge/ Citrus	0 ft	58.5	55.5	50.9	48.5	41.8	40.3	33.8
	300 ft	24.9	23.6	21.6	20.6	17.8	17.2	14.4
	1000 ft	**3.0**	**2.8**	**2.6**	**2.4**	**2.1**	**2.0**	**1.7**
FL Potatoes (alkaline GW)	0 ft	3.9e-05	3.0e-05	1.9e-05	1.3e-05	8.1e-06	6.2e-06	2.3e-06
	300 ft	**1.7e-05**	**1.3e-05**	**8.0e-06**	**5.7e-06**	**3.5e-06**	**27.e-06**	**9.9e-07**
GA Coastal Plain Peanuts/ cotton	0 ft	15.2	14.1	12.0	11.2	10.1	9.6	7.2
	300 ft	**6.5**	**6.0**	**5.1**	**4.8**	**4.3**	**4.1**	**3.1**
	500 ft	3.7	3.4	2.9	2.7	2.5	2.4	1.8
	1000 ft	0.9	0.8	0.7	0.7	0.6	0.6	0.4
NC Coastal Plain Peanuts/ cotton	0 ft	3.1	2.9	2.5	2.3	2.0	2.0	1.5
	300 ft	**1.3**	**1.2**	**1.1**	**1.0**	**0.9**	**0.8**	**0.6**
	500 ft	0.8	0.7	0.6	0.6	0.5	0.5	0.4
	1000 ft	0.2	0.2	0.2	0.1	0.1	0.1	0.1
WA Potato (alkaline soil, GW)	300 ft, 15-ft depth	0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001

Variability due to well setback distances

The exposure estimates for total aldicarb residues assume that aldicarb is applied at the appropriate setback distances specified on the label – 300 feet between the field of application and the well for most crops; 1000 feet for citrus in Florida. Figure 1 illustrates the estimated effect of varying well setback distances on total aldicarb residues in the southern coastal plain of Georgia. Similar responses can be seen in the other regional scenarios (Table 6). The graph plots

estimated concentrations of total aldicarb residues in a 30-foot well located near treated peanut fields in high leaching potential soils in the coastal plain.

Figure [SEQ Figure * ARABIC]: Estimated concentrations of total aldicarb residues in groundwater at 30 feet under peanuts in the Georgia Coastal Plain with varying setback distances.



The Agency is not aware of studies that would quantify the effect of varying setback distances on concentrations of total aldicarb residues in ground water. Thus the relative differences in concentration magnitudes based on varying setback distances shown in the figure are more illustrative than quantitative. The net effect of the setback distances will vary depending on predominant direction and velocity of ground water flow. Other factors, such as the influence of irrigation wells on shallow ground water flow, are not easily quantifiable and are not accounted for in this assessment.

Variability due to well depth

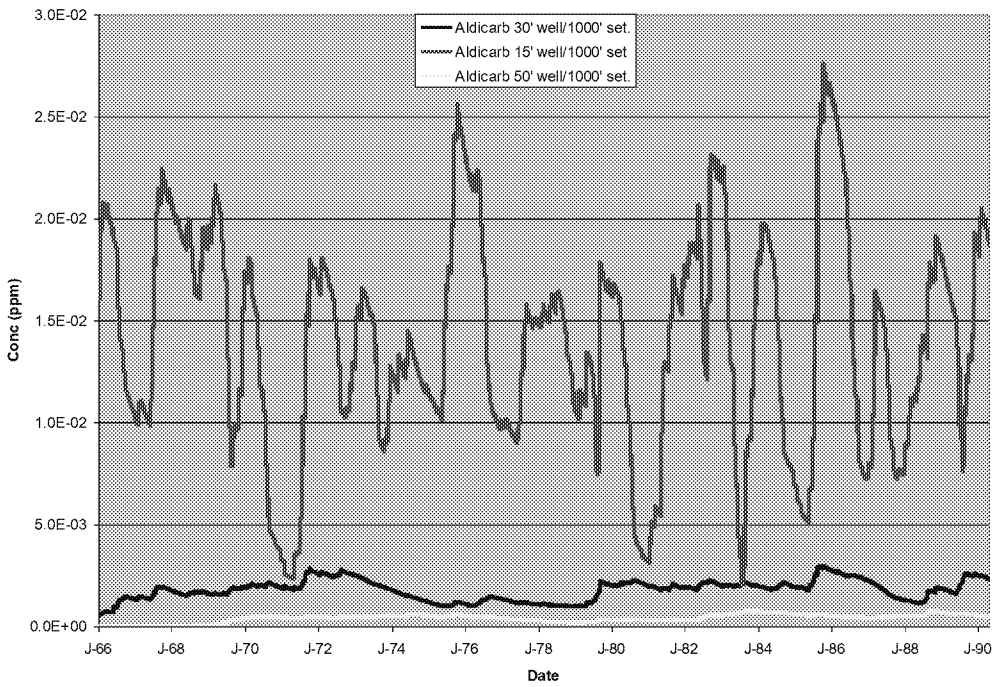
The estimated drinking water exposures for shallow private wells are based on a ground water depth of 30 feet. For comparisons, OPP used PRZM to estimate concentrations from wells drawing from 15, 30, and 50 feet (Table 7). The 30-50 foot depths are more representative of shallow private wells, while the 15-foot depth may represent shallow dug wells. With the increased travel time allowing for more degradation, estimated aldicarb residues decreased by nearly an order of magnitude between 15 and 30 feet (Table 7). Estimated concentrations at 50 feet were approximately 3 times lower than those at 30 feet.

Table 7: Estimated concentrations of total aldicarb residues in private, shallow wells of varying depths. Concentrations represent typical application rates in high leaching potential soils.

Scenario	Well Depth, ft	Concentrations, ug/l						
		Max-imum	99th %ile	95th %ile	90th %ile	80th %ile	75th %ile	50th %ile
FL Central Ridge/ Citrus (1000' setback)	15	32.6	30.3	26.2	23.7	21.7	20.7	16.6
	30	3.0	2.8	2.6	2.4	2.1	2.0	1.7
	50	0.9	0.9	0.8	0.7	0.6	0.6	0.5
GA Coastal Plain Peanuts/ cotton (300' setback)	15	36.8	32.7	28.6	25.9	23.1	21.6	14.0
	30	6.5	6.0	5.1	4.8	4.3	4.1	3.1
	50	2.0	1.9	1.8	1.7	1.5	1.4	1.1
NC Coastal Plain Peanuts/ cotton (300' setback)	15	17.2	16.5	14.0	12.5	9.5	8.7	7.4
	30	1.3	1.2	1.1	1.0	0.9	0.8	0.6
	50	0.2	0.2	0.2	0.2	0.2	0.2	0.1

Estimated concentrations at the 15-foot depth showed more variation in concentrations over time (Figure 2), reflecting the shorter time frame for movement. Seasonal and yearly variations due to weather are less pronounced with depth. This is consistent with monitoring data which show that mobile chemicals applied to the surface of highly permeable soils can reach shallow groundwater in the same season or year.

Figure [SEQ Figure * ARABIC]. Estimated concentrations of total aldicarb residues at different depths in groundwater near citrus in the Central Ridge of Florida (1000 foot setback from well).



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Variability due to application rates

For the estimated concentrations for total aldicarb residues in private wells, based on the NMC CRA, typical application rates specific to the regional scenarios (reported at the state level) were used. These typical distributions have been provided for the aldicarb aggregate exposure assessment. For ground water 30 to 50 feet or more below the surface, typical transport time for aldicarb residues is likely to span multiple seasons. While the typical rates used in the exposure assessment may reflect the integrated application of aldicarb over multiple seasons, it will underestimate the amount of aldicarb residue available for transport in high application seasons.

Table 8 contrasts estimated concentrations of total aldicarb residues for the three high exposure scenarios based on both typical and maximum label application rates. The range in concentrations between typical and maximum application rates reflects the potential variability in high-end exposures based on application. Obviously, the total aldicarb load available for transport to ground water would be lower in those years when little or no aldicarb is applied.

Table 8: Estimated concentrations of total aldicarb residues in private, shallow wells (30 ft) in high leaching potential soils contrasting typical and maximum application rates.

Scenario	App. Rate, kg/ha	Concentrations, ug/l						
		Max-imum	99th %ile	95th %ile	90th %ile	80th %ile	75th %ile	50th %ile
FL Central Ridge/ Citrus (30' depth; 1000' setback)	5.5 (max)	4.5	4.3	3.9	3.7	3.4	3.1	2.6
	4.3 (typ)	3.0	2.8	2.6	2.4	2.1	2.0	1.7
GA Coastal Plain Peanuts/ cotton (30' depth; 300' setback)	3.3 (max)	19.8	18.4	15.7	14.5	13.2	12.5	9.4
	1.0 (typ)	6.5	6.0	5.1	4.8	4.3	4.1	3.1
NC Coastal Plain Peanuts/ cotton (30' depth; 300' setback)	3.3 (max – peanut)	4.2	3.9	3.4	3.0	2.8	2.6	2.0
	1.1 (typ - peanut)	1.3	1.2	1.1	1.0	0.9	0.8	0.6
	5.5 (max – cotton)	6.9	6.4	5.6	5.0	4.7	4.3	3.3
	0.7 (typ – cotton)	0.9	0.8	0.7	0.7	0.6	0.6	0.4

Comparisons with monitoring

OPP compared estimated aldicarb concentrations from PRZM modeling to two recent groundwater monitoring datasets from Florida. The first study, conducted by the USGS and the Florida Department of Agriculture, measured aldicarb concentrations in monitoring wells located in citrus groves along the Central Ridge of Florida (Lake Wales Ridge). These monitoring wells are not drinking water wells, but reflect ambient pesticide concentrations in ground water beneath the citrus groves.

Since these wells are located within the treated fields, OPP used PRZM concentrations with no well setback adjustments (0-ft well setback) for comparisons to the monitoring data.

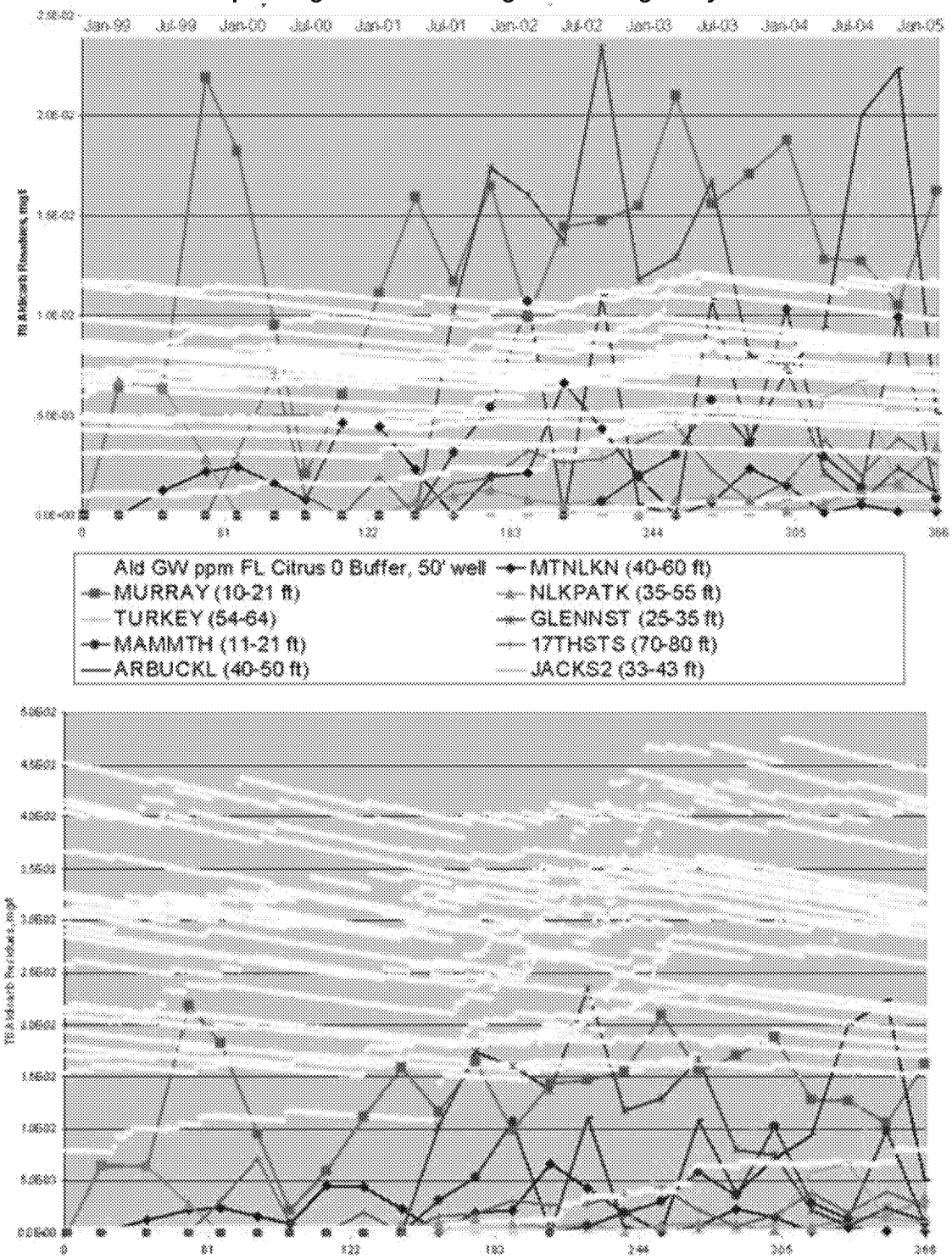
The second monitoring dataset consists of private well monitoring data collected by the FL Department of Environmental Protection across the state of Florida. While the data represent potable drinking water wells, no information is available on well depth, aldicarb use in the vicinity, or distance between the well and the treated field. A third monitoring set recently submitted by Bayer CropScience provides recent (2005) monitoring of aldicarb residues in private drinking wells in other parts of the US. These data are currently being analyzed.

Lake Wales Ridge, FL, ambient groundwater monitoring

In-field concentrations (0-ft well setback) of estimated total aldicarb residues from the FL Central Ridge Citrus scenario were compared to an on-going groundwater monitoring study on the Florida Central Ridge ([HYPERLINK "http://fisc.er.usgs.gov/Lake_Wales_Ridge/"]). The USGS and the Florida Department of Agriculture is monitoring 31 wells within and around citrus groves on the Ridge (the area of the OPP scenario). Well depths range from 4 feet to 110 feet deep (two thirds in the 20 to 60 foot range), and pH ranged from 3.9 to 6.9 (median about 5). Concentrations as high as 23 ppb have been recorded in one 26-ft well, while a 4-ft well had reported concentrations as high as 21 ppb. This study is not targeted for any specific pesticide, but rather is designed as a survey mechanism—that is, it is not known how much aldicarb was used nor is it known how far aldicarb was used from the wells.

Figure 3 compares the monitoring results from the Lake Wales Ridge study with PRZM-modeled estimated aldicarb residues at a 50-foot well depth. The PRZM estimates are shown in pale yellow and represent roughly 25 years of simulations. When compared to wells of similar depth (TURKEY, ARBUCKL, MTNLKN, NLKPATK), the estimated exposures are in the same concentration range. While the median estimated concentrations for total aldicarb residues at a 30-foot well depth were typically greater than those found in the wells at similar depths (GLENNST, JACKS2), the measured detections were still within the range of estimated concentrations.

Figure [SEQ Figure * ARABIC]: Comparison of estimated concentrations of total aldicarb residues in groundwater at 50 feet (top, yellow) and 30 feet (bottom, blue) with in-field monitoring from the USGS/FL Dept. of Ag. Lake Wales Ridge monitoring study.



Private drinking water well monitoring in FL

The Florida Department of Environmental Protection (FDEP) monitors private drinking water wells in rural areas. The monitoring is not comprehensive, but instead is instituted when there has been an indication of a problem (personal communication, FDEP). Total aldicarb residues (parent, sulfoxide and sulfone degradates) as high as 47 ppb were reported in private drinking water wells in the early 1990s in the FDEP study. The concentrations dropped off in subsequent years. The reduction in concentrations of aldicarb may have resulted from label changes which reduced application rates and applied well setback requirements. Specific reductions at home sites also were also likely the result of a Florida State program to install carbon filters or to pipe water in from treatment facilities when contamination was found. Other reasons for the decline include the possibility of discontinued use in the vicinity of the contaminated areas (personal communication FDEP) or increased method detection limit.

Method detection limits (MDL) for aldicarb residues vary over time in this monitoring study. In 1999 and earlier, the MDL for aldicarb sulfone and aldicarb sulfoxide ranged from 0.077 to 0.73 ug/L. Between 2000 and 2004, the MDL ranged from 2.1 to 3.3 ug/L for aldicarb sulfone and from 2.4 to 4.0 ug/L for aldicarb sulfoxide. Estimated concentrations for total aldicarb residues are below the high MDL for the individual degradates. This further complicates interpretations regarding the effectiveness of label changes in reducing aldicarb residues in private wells.

Private drinking water well monitoring by Bayer CropScience

Bayer CropScience recently submitted retrospective groundwater monitoring studies for aldicarb and its metabolites for the southeastern US, Mississippi Delta, Pacific Northwest, California, and Texas. The studies included 1,673 drinking water wells and collected information on groundwater depth, well depth, casing depth, well type and age, soil types, recent aldicarb use history, crops, and distance of the well from the treated field. The Agency has not completed its review of these studies. However, a preliminary evaluation of the results of the monitoring for the southeastern US indicates that roughly 16% of sampled wells had aldicarb residues above the method detection limit, with a maximum reported concentration of 2.9 ug/L. The precursory review suggests that the estimated aldicarb exposures from the PRZM simulations are in line with the reported monitoring results.

Characterization of the spatial extent of high potential exposure

Three of the scenarios – FL citrus on the Central Ridge, NC peanuts/cotton/tobacco on the coastal plain, and GA peanuts/cotton on the coastal plain – represents areas with the potential for high total aldicarb residue concentrations as a result of use,

high leaching potential, and acidic groundwater. Aldicarb residues are not expected to persist in sites represented by WA potatoes and FL potatoes because alkaline soil and/or aquifer conditions favor more rapid hydrolysis of the aldicarb residues.

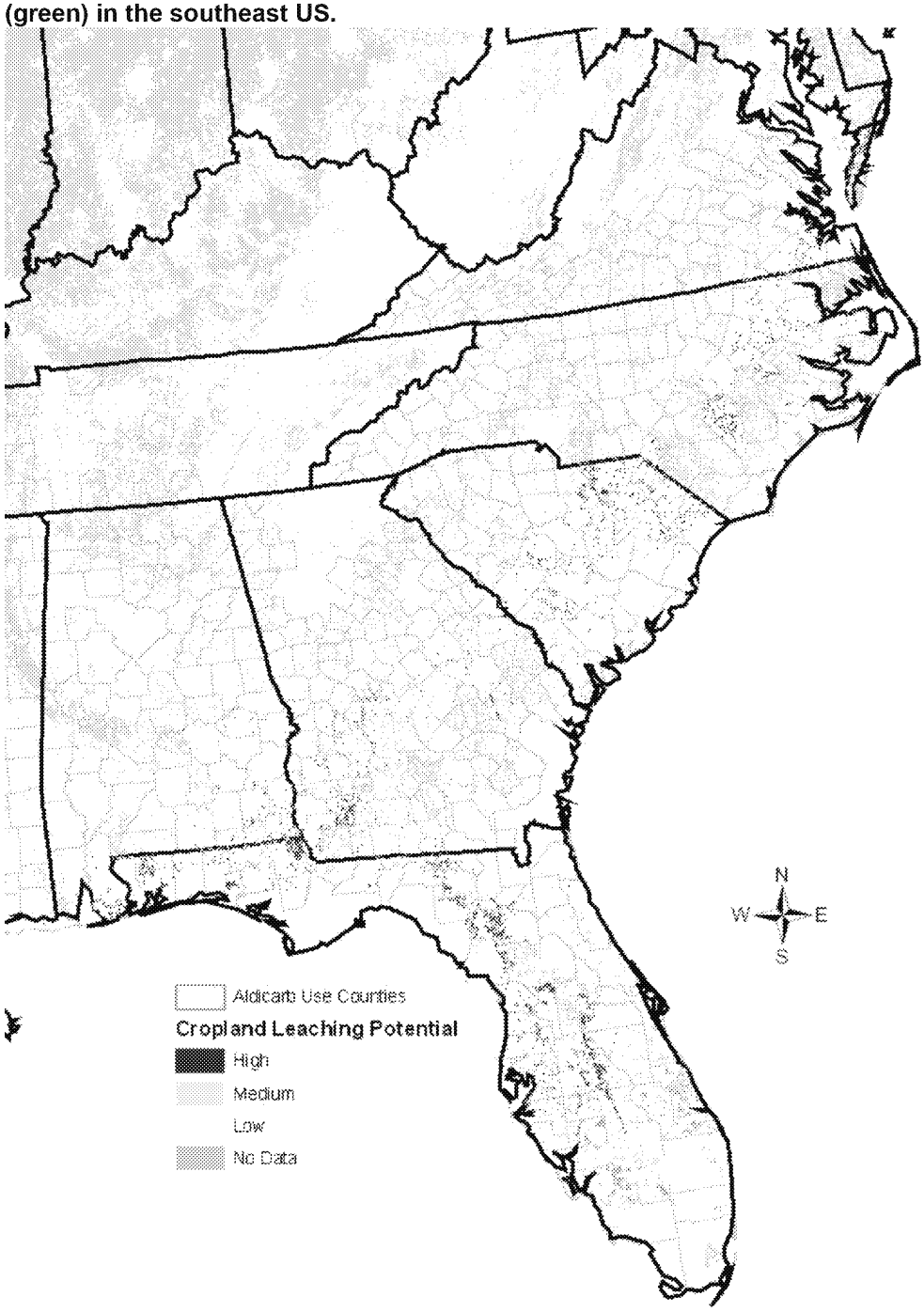
In other regions of the country, anticipated exposure to aldicarb residues in groundwater is expected to be lower than estimated in these scenarios or in surface water scenarios representing those regions. In the north and north-central, groundwater exposures are expected to be lower because of low use or because aldicarb is no longer labeled for use, particularly in northeastern states where acidic conditions and high leaching potential conditions exist. In the mid-south, drinking water is drawn predominantly from public ground water supply from deep, protected aquifers and aldicarb contamination not expected. In the Great Plains and lower Midwest, anticipated exposure is expected to be lower because of low rainfall and deeper aquifers than in the southeast and Florida. In many parts of the west, alkaline soils and/or ground water will also facilitate the rapid breakdown of aldicarb residues into non-toxic degradation products.

Figure 3 illustrates the spatial extent of high leaching potential soils (shown in red) in the aldicarb use areas (shown in green) in the southeastern US. Although county-level soil information is not available for the entire region, such soils can be identified and included on the aldicarb label. While the map includes acidic, high leaching potential soils, it does not reflect depth or pH of the ground water, or the relative permeability of the underlying vadose zone and aquifer. Neither is information on the location or depth of private drinking water wells available.

The scenarios represent potential high exposure areas for private wells:

- High leaching potential soils (as classified by the USDA NRCS)
- Shallow depth to ground water (roughly 30 feet, though the depth may vary, depending on the permeability of the overlying soil and vadose zone)
- Acidic soils and ground water

Figure [SEQ Figure * ARABIC]: Areas of high leaching potential (red) soils in aldicarb use areas (green) in the southeast US.



Comparison of high leaching potential areas with current aldicarb label setbacks

The current label for aldicarb specifies setback distances between the field of application and drinking water wells based on soil properties, water table depth, and well condition. Depending on the state, soils for which restrictions apply are identified as having either

- Loamy sand or sand surface soils and subsoils with an average organic matter in the upper 12 inches of less than 2% by weight (primarily in the south and southeast), or
- Sandy loam, loamy sand, or sand surface soils, and loamy sand or sand subsoils, with an average organic matter in the upper 12 inches of less than 2% by weight (primarily in the Midwest).

Soil texture and organic matter content act as surrogates for identifying those soils that have a high potential for leaching and a low capacity for retaining the pesticide. While these properties are relatively simple to describe and can be identified with a knowledge of the soil series mapped for the treated fields, they do not fully integrate those soil properties that affect leaching potential and are imperfect indicators of the potential for aldicarb residues to move to groundwater.

For this assessment, OPP used the USDA NRCS classification for soil leaching potential for pesticides (NRCS. 2003. Florida NRCS Field Office Technical Guide. Section II. Water Quantity and Quality. Available from the electronic FOTG site at [HYPERLINK "http://efotg.nrcs.usda.gov/treemenuFS.aspx"]). Rating criteria are provided in Table 7. The predicted exposure estimates for total aldicarb residues represent properties of soils identified as having a high soil leaching potential for pesticides. The soil leaching potential rating has been derived for all soils in the SSURGO county surveys for Florida (available for download from the USDA NRCS Soil Data Mart at [HYPERLINK "http://soildatamart.nrcs.usda.gov/"]). OPP used the criteria in Table 9 to estimate the leaching potential for soils in counties in other states (for the NMC cumulative, OPP focused on coastal plain soils in VA, NC, SC, GA, and AL). The criteria could be used to identify soils that are vulnerable to pesticide leaching throughout the country. This list of soils should provide a more definitive list of vulnerable soils than the current list of soils based solely on soil texture and organic matter content.

Table 9: USDA NRCS Criteria Used for Soil Leaching Potential for Pesticides (NRCS, 2003).

Rating	Criteria
High	Hydrologic Group = A and % Surface Horizon Organic Matter Content X Depth of the First Soil Horizon <= 30 or Hydrologic Group = B and % Surface Horizon Organic Matter Content X Depth of the First Soil Horizon <= 9 and the K Factor is <= 0.48 or Hydrologic Group = B and % Surface Horizon Organic Matter Content X Depth of the First Soil Horizon <= 15 and the K Factor is <= 0.26

Rating	Criteria
Low	Hydrologic Group = B and % Surface Horizon Organic Matter Content X Depth of the First Soil Horizon >= 35 and the K Factor is >= 0.40 or Hydrologic Group = B and % Surface Horizon Organic Matter Content X Depth of the First Soil Horizon >= 45 and the K Factor is >= 0.20 or Hydrologic Group = C and % Surface Horizon Organic Matter Content X Depth of the First Soil Horizon <= 10 and the K Factor is >= 0.28 or Hydrologic Group = C and % Surface Horizon Organic Matter Content X Depth of the First Soil Horizon >= 10
Very Low	Hydrologic Group = D
Intermediate	All other conditions

The exposure estimates for total aldicarb residues in private wells were modeled at a 30-foot depth. Current label restrictions for aldicarb apply if vulnerable soils are present and the water table is less than 25 feet below the ground surface. Exposure in private wells is a function of depth to ground water/ well screen, permeability of the overlying soil and vadose zone, the amount of precipitation in excess of evapotranspiration (to leach the chemical through the soil and vadose zone) distance between the field of application and the well, and the direction and velocity of lateral ground water flow. No single ground water depth provides a bright line between vulnerable and not vulnerable. The current label restrictions do not reflect the true range in vulnerability with depth.

[SEQ CHAPTER \h \r 1]Surface Water Exposure Assessment

The revised surface water exposure assessment focused on three high aldicarb use/ exposure scenarios: Florida citrus (central FL), Mississippi cotton, and North Carolina peanuts/cotton. While these scenarios were selected based on combined NMC uses in the vicinity of drinking water intakes in relatively high runoff potential areas, they represent areas of relatively high aldicarb use. Thus, the scenarios represent drinking water intakes with relatively high potential for aldicarb exposure.

The conceptual model for surface water exposure, scenario selection, and modeling approach is well-documented in the preliminary NMC Cumulative Risk Assessment (available at [HYPERLINK "http://www.epa.gov/scipoly/sap/meetings/2005/august/preliminarynmc.pdf"]) and will not be duplicated here. Only those aspects of the aldicarb aggregate exposure assessment that differ from the NMC CRA are documented.

Surface water modeling approach

This revised surface water exposure assessment used the same chemical input parameters that have been previously documented in the revised RED for aldicarb and in previous drinking water exposure assessments. These values, which represent the combined residues of parent aldicarb and sulfoxide and sulfone degradates, are documented in Table 10.

[SEQ CHAPTER \h \r 1]Table 10: Aldicarb-specific PRZM-EXAMS Input Parameters.

Input Parameter	Value	Reference/Comment
Molecular Weight	190.2 g/mol	MRID 00152095
Henry's Law Constant	1.7 E-10 atm-m^3/mol	Acc 255979
Vapor Pressure	1 E-6 @ 25°C	MRID 00152095
Solubility	6,000 mg/L	Acc 255979
Kd	0.12	Minimum non-sand value for aldicarb sulfone (MRID 43560302)
Hydrolysis	pH 5, stable (0) pH 7, stable (0) pH 9, >30 days	Parent hydrolyzed only at pH 9 (MRID 00102065) – degradates may hydrolyze more rapidly at neutral-to-high pH
Aqueous Photolysis Half-life	4 days	MRID 42498201
Water Half-life	12 days	MRID 44592107. Single acceptable guideline study for parent / sulfoxide / sulfone (4days) x 3; corresponds w/ DT90
Benthic Half-life	24 days	No data; use 2X aerobic aquatic half-life
Soil Half-life	55 days	Revised from 2001 Aldicarb RED; Upper 90th pct bound on mean for combined parent+sulfoxide+sulfone half-life from 19 soils
FILTRA, UPTKF, PLVKRT, PLDKRT	0	Default values
FEXTRC	0.5	Default value
Additional Notes	Modeled total aldicarb residues	Half-life values used in inputs based on combined aldicarb + sulfone + sulfoxide residues; lowest Kd of the 3 chemicals used for mobility. Assumes equal toxicity of parent, degradates

The NMC CRA used region-specific typical application rates (see 2005 NMC CRA for documentation of the use information). These rates, along with the number of applications are less than the maximum label rates. While typical rates, representing an "average" of high and low pest pressures over time, might be reflective of ground water exposures, in which the length of time for transport from the surface to groundwater tends to lessen the variability in concentrations over time, they are more likely to underestimate surface water concentrations in the case of maximum use in response to high pest pressures. Likewise, they will likely overestimate surface water concentrations in the case of low pest pressures. Table 11 documents the application-related parameters used as inputs for PRZM-EXAMS in this revised surface water assessment.

[SEQ CHAPTER \h \r 1]Table 11: Application-specific PRZM-EXAMS Input Parameters.

Scenario Location	NC Coastal Plain		Central Florida		MS/LA
Crop/Use	Cotton	Peanut	Oranges	Grapefruit	Cotton
Counties in watershed area (used to collect use,	Edgecombe, Halifax, Northhampton, NC		Polk, Hillsborough, Manatee, FL		Franklin, Madison,

Scenario Location	NC Coastal Plain		Central Florida		MS/LA
Crop/Use	Cotton	Peanut	Oranges	Grapefruit	Cotton
crop data)					Tensas, LA
Typical App. Rate, lb ai/A	0.73	1.08	3.85	3.89	0.53
Typical App. Rate, kg/ha [1]	0.81 (0.12)	1.20 (0.18)	4.27 (0.64)	4.32 (0.65)	0.59 (0.09)
Max. App. Rate, kg/ha	4.5 (0.82)	3.7 (0.5)			
Most Active Range	May 1-15	Apr10-20	Apr-Nov	Apr-Nov	May1-15
App. Date	1-May	10-Apr	1-Apr	1-Apr	1-May
No. Apps.	1.0	1.0	1.5	1.5	1.0
Interval between apps. (da)	na	na	121	121	na
PCA for Region	0.61	0.61	0.19	0.19	0.20
Crop ratio [2]	0.82	0.18	0.94	0.06	1.00

[1] – Application rate was multiplied by 0.15 (shown in parentheses) to reflect 15% of granules on the surface for CAM 1 application.
[2] – Crop ratio is based on the relative ratio of crops in the scenario watershed, based on USDA 2002 AgCensus data for the counties in the scenario area. Each crop-use is run with PRZM/EXAMS. The resulting concentration distribution is multiplied by the crop ratio before summing the daily distributions to represent total aldicarb residues from all contributing uses in the watershed.

Estimated total aldicarb residues in surface water

Table 12 summarizes the distributions of total aldicarb residues for various scenarios, reflecting the relative contributions of aldicarb from multiple crop uses in the watershed.

Table 12: Estimated concentrations of total aldicarb residues in surface water sources of drinking water in high runoff potential areas based on typical rates.

Scenario Location	Crops	Concentrations, ug/l					
		Max-imum	99th %ile	95th %ile	90th %ile	80th %ile	75th %ile
FL central ridge citrus	Oranges	9.6	1.5	0.24	0.08	0.014	0.007
	Grapefruit	0.6	0.1	0.02	0.005	0.001	0.0005
	Aggregate	**10.2**	**1.6**	**0.26**	**0.85**	**0.015**	**0.007**
NC Coastal Plain	Cotton	4.5	1.0	0.14	0.04	0.004	0.001
	Peanuts	0.8	0.1	0.03	0.01	0.001	<0.001
	Aggregate	**4.6**	**1.0**	**0.19**	**0.08**	**0.01**	**0.005**
LA/MS Mid-south	**Cotton**	**0.8**	**0.2**	**0.02**	**0.004**	**<0.001**	**<0.001**

These estimates are based on the reported typical application rates for aldicarb, with an assumption that approximately 15% of the applied pesticide is available at or near the surface for runoff. The uncertainties in these assumptions are addressed in the sections that follow.

Uncertainty due to application method

For these scenarios, OPP modeled CAM 1 in PRZM (broadcast application on the surface), using 15% of the application rate to reflect the assumption that 15% of the granules remain on the surface after application. This assumes that none of the remaining application is available for runoff. To characterize uncertainties related to the type of application method used, OPP also modeled CAM 7 in PRZM, equivalent to a T-band application, assuming that 15% of the application was incorporated in the top 2 cm while the remaining 85% was incorporated in the lower 10 cm. Peak estimates were greater with the CAM 7 simulation, which more closely reflects banded applications (Table 13). However, the peaks were generally less than 20% greater than that estimated with CAM 1, which more closely reflects broadcast applications.

[SEQ CHAPTER \h \r 1]Table 13: Comparison of estimated total aldicarb residues using different application methods and assumptions on the fraction of applied aldicarb available for runoff.

Region	App Method / Rate	15% at surface				1% at surface			
		Max	99th	95th	90th	Max	99th	95th	90th
NC/ Coastal	CAM 1 / typical rate	4.6	1.0	0.19	0.08	0.30	0.07	0.01	0.005
	Cam 7 / typical rate	5.3	1.1	0.21	0.08	0.35	0.08	0.01	0.005
Central FL Citrus	CAM 1 / typical rate	10.2	1.6	0.26	0.08	0.68	0.12	0.02	0.007
	Cam 7 / typical rate	11.8	1.8	0.30	0.09	0.79	0.14	0.02	0.008
LA/ Midsouth	CAM 1 / typical rate	0.84	0.17	0.02	0.004	0.06	0.01	0.001	<0.001
	Cam 7 / typical rate	0.99	0.25	0.03	0.007	0.07	0.02	0.002	<0.001

The registrant contends that only 1% of the granules remain unincorporated. Such an assumption would result in estimated exposures that are no more than 1/15th of the estimated concentrations reported in Table 2 (Table 13).

Uncertainty due to application rate

The estimates used in the NMC cumulative drinking water exposure assessment and provided to HED for surface water exposure are based on typical application rates. While “typical” application rates may be reflective of average conditions over an extended period of time, they fail to capture the variability in application rates that may occur from one year to the next as a result of varying pest pressures. Such variations are more likely to be reflected in surface water exposures, which are subject to short-term variations in factors such as application rates, acres treated, and the timing and intensity of rainfall after application. Table 14 summarizes the estimated distributions of total aldicarb residues based on both maximum and typical application rates. It also

characterizes the variability in estimated concentrations depending on the amount of applied pesticide remaining at or near the surface (and, thus, vulnerable to runoff). While the assumption of 15% granules left on the surface after incorporation may be a high-end estimate, the assumption of only 1% of the granules left on the surface is a “best case” condition. The actual amount left on the surface is likely somewhere in between.

[SEQ CHAPTER \h \r 1]Table 14: Comparison of estimated total aldicarb residues using different application rates and assumptions on the fraction of applied aldicarb available for runoff.

Region	App Rate	15% at surface				1% at surface			
		Max	99th	95th	90th	Max	99th	95th	90th
NC/ Coastal	Typical	4.6	1.0	0.19	0.08	0.30	0.07	0.01	0.005
	Maximum	30.7	6.6	1.1	0.39	2.0	0.44	0.07	0.03
Central FL Citrus	Typical	10.2	1.6	0.26	0.08	0.68	0.12	0.02	0.007
	Maximum	13.2	2.3	0.39	0.13	0.88	0.15	0.03	0.009
LA/ Midsouth	Typical	0.84	0.17	0.02	0.004	0.06	0.01	0.001	<0.001
	Maximum	6.4	1.3	0.14	0.03	0.43	0.08	0.01	0.002

Comparisons with monitoring

Aldicarb residues have not been detected frequently or in high amounts in surface water in the USGS NAWQA monitoring studies – 0.2% detections with a maximum concentration of 0.5 ug/L based on the 2001 national summary by Martin et al (2003; see [HYPERLINK "http://ca.water.usgs.gov/pnsp/pestsw/Pest-SW_2001_Text.html"]). While the NAWQA monitoring sites are not targeted to aldicarb use areas and the frequency of sampling is not designed to capture peak concentrations in surface water, the results suggest that actual concentrations of aldicarb residues in surface water are likely to be closer to the single or sub-parts per billion range than to 10-30 ppb.