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Managing Pesticides for Golf Course Maintenance and Water Quality Protection[1]

T.M. Buttler, A.G. Hornsby, P.W.M. Augustijn-Beckers, L.B. McCarty, D.E. Short, R.A. Dunn, G.W. Simone[2]

WATER QUALITY CONSIDERATIONS IN GOLF COURSE MAINTENANCE

Concern about the harmful effects of pesticides on surface water and groundwater quality should motivate turf-golf course operators to select pesticides with the least potential to cause water quality problems. Many operators live in rural areas near where they and other operators grow turf, therefore, their personal water supply is susceptible to contamination. Unfortunately, information that allows operators to select pesticides less likely to affect water quality has not previously been readily available.

Our purpose is to provide information that can help operators select pesticides that will have a minimum adverse impact on water quality. The procedure considers the soil properties of the application site, the mobility of pesticides in these soils, and the toxicity of the pesticides in water to humans and aquatic species. A proper selection will decrease chances of adversely affecting surface water and groundwater quality. Certain combinations of soil and pesticide properties (along with weather conditions) can pose a significant potential hazard to water quality. Our goal is to identify and avoid these circumstances. Information contained in this report can help turf-golf course operators make better decisions about the pesticides that they use. **This document in no way endorses any particular pest control product. All products must be used in accordance with the label.**

MATERIALS NEEDED TO USE THIS PROCEDURE

To effectively use this procedure you will need the following source materials: 1. A copy of the current IFAS Pest Control Guides or other appropriate information sources that identify pesticides that control specific pests.

2. A copy of your county soil survey report to identify the soil types found in your fields.

3. A copy of the Soil Science Fact Sheet entitled "[**Name of your county**]:Soil Ratings for Selecting Pesticides" for your county, available from your county Cooperative Extension Office. The basis of these ratings are given in the IFAS Extension Circular 959 entitled "Soil Ratings for Selecting

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2. T.M. Buttler, A.G. Hornsby, and P.W.M. Augustijn-Beckers, Soil and Water Science Department; L.B. McCarty, Environmental Horticulture Department; D.E. Short and R.A. Dunn, Entomology and Nematology Department; and G.W. Simone, Plant Pathology Department, Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida, Gainesville.

Pesticides for Water Quality Goals," which is also available from your county Cooperative Extension Office.

Note: If your county has not yet been mapped by the Soil Conservation Service, you will need to contact the local SCS office for a site evaluation and determination of soil types and ratings for leaching and runoff of pesticides.

IMPORTANT FACTORS THAT AFFECT PESTICIDE SELECTION

How pesticides behave in the soil is determined by many factors including properties of the pesticides and of the soil at the application site. Some of the factors that should be considered when selecting pesticides with minimal potential for water quality impacts are:

Pesticide Properties

1) The organic carbon adsorption coefficient, K_{oc}, describes the relative affinity or attraction of the pesticide to soil materials and therefore its mobility in the soil. 2) The biological degradation half-life, $T_{1/2}$, is a measure of persistence of the pesticide in soil. 3) The lifetime health advisory level or equivalent, HALEQ, is a measure of health risk to humans of pesticide contaminated drinking water. 4) Aquatic toxicity, LC_{50}, is a measure of the ability of the pesticide to cause 50% mortality in aquatic test species.

Soil Properties

1) Hydraulic permeability is a measure of the soils ability to allow water to percolate through it. 2) Organic matter is important for providing binding sites for pesticides, thus reducing their mobility and increasing their opportunity to be degraded by soil microorganisms. 3) Slope affects the potential for water to run off the land surface.

Management Practices

1) Pesticide application frequencies and rates determine the total amount applied. Lower frequencies and rates reduce the potential for contamination. 2) Application methods affect the amount of pesticide subject to transport by water. For example, if applied directly to the soil, there is a greater probability that more of the product will be available for leaching or runoff than if applied to the foliage. If the product is incorporated into the soil, leaching may be the most important loss pathway. Pesticides applied to the foliage may be lost to the atmosphere, decomposed by sunlight, or absorbed by the foliage, thereby reducing the amount available for wash-off and transport to water bodies. Irrigation practices can also determine the loss pathways of pesticides. Pesticides often move with water, so the less excess water that is applied, the less potential there is for a pesticide to move past the crop root zone or to run off in surface water. Rainfall or overhead irrigation can wash off significant quantities of pesticides from foliage immediately after application.

INDICES USED TO SELECT PESTICIDES

Table 1 contains two important indices, the pesticide leaching potential (RLPI) and the pesticide runoff potential (RRPI). Both indices are relative. For a given soil, these indices rank the pesticides by their potential to move from the application site by the indicated pathway (leaching or runoff). The indices are based on the organic carbon sorption coefficient and degradation half-life values of each pesticide. Values for these parameters have been taken from scientific literature, technical manuals, and company product literature.

Relative Leaching Potential Index

The Relative Leaching Potential Index (**RLPI**) defines the relative **attenuation** (reduction in mass as it moves through the soil) of each pesticide in soil, and therefore its potential to leach to groundwater. Pesticides that are very mobile, for example, those that have K_{oc} values less than 100 in sandy soils, or 50 or less in fine-textured soils should be used with caution. There is some uncertainty in the data used to calculate this index. However, since the values are relative they can still be used. **It is important to realize that the smaller the RLPI value of a pesticide, the greater is its potential to leach.**

Relative Runoff Potential Index

The Relative Runoff Potential Index (**RRPI**) defines the relative **immobility** and availability of each pesticide in soil, and therefore its potential to remain near the soil surface and be subject to loss in the aqueous phase or sediment phase of runoff. There is some uncertainty in the data used to calculate this index. However, since the values are relative they can still be used. **The smaller the RRPI value of a pesticide, the greater is its potential to be lost in runoff.** Table 1 also contains information on the toxicity of pesticides to humans and aquatic species. This information can be used as a secondary consideration in the pesticide selection procedure.

Lifetime Health Advisory Level or Equivalent

The Lifetime Health Advisory Level or Equivalent (**HALEQ**) provides a measure of pesticide toxicity to humans. The lifetime health advisory level as defined by the USEPA is the concentration of a chemical in drinking water that is not expected to cause any adverse health effects over a lifetime of exposure (70 years), with a margin of safety. The values in Table 1 are the USEPA lifetime health advisory level, HAL, or an equivalent value, HALEQ (denoted by a superscripted asterisk), calculated using the same formula used by the USEPA (HALEQ = RfD x 7000), where RfD is the reference dose determined by the USEPA. For non-carcinogenic pesticides the calculated HALEQ should not differ by more than a factor of 10 from the values forthcoming from the USEPA. The HAL or HALEQ has units of micrograms per liter (g/l, or ppb). **The smaller the value the greater is the toxicity to humans.**

Aquatic Toxicity

The Aquatic Toxicity provides a measure of pesticide toxicity to aquatic species. The values given in Table 1 are the lethal concentrations at which 50% of the test species die (LC_{50}). Unless otherwise noted by a lower case letter following the value, the test species was rainbow trout. **The smaller the value the greater is the toxicity to aquatic species.** Data for K_{oc}, RLPI, RRPI, HALEQ, and aquatic toxicity are given for the active ingredient (common name) of a product. When using a product that is a mixture of two or more active ingredients use the RLPI, RRPI, HALEQ, and Aquatic Toxicity value for the most restrictive active ingredient in the mixture.

Important Note: The information presented in Table 1 **DOES NOT** supersede or replace the information on the pesticide container label or product literature.

PROCEDURE FOR SELECTING PESTICIDES TO REDUCE ADVERSE WATER QUALITY IMPACTS

A "Pesticide Selection Worksheet" is provided as a convenient way to organize the information needed to select pesticides to avoid water pollution by pesticides in a particular production or management unit. Instructions for using the worksheet are outlined below. The function of the worksheet is to match the soil leach and runoff ratings at the application site with the pesticide RLPI (leaching) and RRPI (runoff) indices and toxicity values given in Table 1.

This will indicate the relative potential for pesticides to leach or run off from a particular site and consider the toxicity of the pesticides to humans or aquatic life if the pesticides leach into groundwater or if runoff enters surface impoundments or streams. The last two columns are for recording the turf-golf course operator's choices and reasons for selecting particular products.

Our intent is to provide a decision support tool for the turf-golf course operator. The operator is responsible for making the final choice. The completed worksheet can serve as a permanent record of the selection process used and decision made by the operator.

USING THE WORKSHEET

1. **TARGET PEST:** Correct identification of the pests that need to be controlled is essential! Check with knowledgeable experts and utilize competent diagnostic laboratories so that a proper diagnosis can

be made. Misdiagnosis results in the wasteful use of unnecessary pesticides and needless increases in production costs. List confirmed pests in column 1 of the Pesticide Selection Worksheet**.**

2. **RECOMMENDED PESTICIDES:** Use the current IFAS Pest Control Guides, or other appropriate information sources to identify the pesticides that control the pests of concern. List these pesticides in column 2 of the Pesticide Selection Worksheet.

3. **PESTICIDE PROPERTIES:** For each pesticide listed in column 2 on the Pesticide Selection Worksheet, copy the numeric value for K_{oc}, RLPI, RRPI, HALEQ, and Aquatic Toxicity from Table 1 into columns 3, 4, 5, 6, and 7 of the Pesticide Selection Worksheet.

4. **SOIL PROPERTIES:** Consult the County Soil Survey Report soil map sheets to locate your production fields and to identify the soils that occur in these fields. Use the Soil Science Fact Sheet entitled "[Your County]:Soil Ratings for Selecting Pesticides" (available from your county Cooperative Extension Office) to determine the leaching and surface runoff rating of the soils in your fields. As you determine the soil leach rating and the soil runoff rating for each soil in each field, list the soil name, soil leach rating, and soil runoff rating in columns 8, 9, and 10, respectively, of the Pesticide Selection Worksheet.

5. **SELECTION OF PESTICIDES:** Using infor- mation that you have compiled on the Pesticide Selection Worksheet, select appropriate pesticides using the selection criteria on page 4 to match soil and pesticide properties. The selection made can be recorded in column 11 and notes relating to the selection can be recorded in column 12.

Notes: 1. If the pesticide product selected is a formulated mixture or a tank mix, each active ingredient must be considered. **The most restrictive pesticide in the mixture will determine the choice.** Trade names in Table 1 followed by (M) are formulated mixtures.

2. Sometimes there may not be a clear choice from among the alternative chemicals available to control a particular pest. In these cases, first order screening using the RLPI or RRPI only can suffice.

3. Depth to groundwater and local geohydrology may influence your final selection. Shallow groundwater is more vulnerable to contamination.

Deep water tables with intervening impermeable geologic layers are much less vulnerable.

4. Distance to surface water bodies may also influence your final selection. Surface waters adjacent to or near the pesticide application site are more vulnerable to contamination than those further away. If surface runoff from the application site usually infiltrates into the soil off site before reaching a surface water body, then the HALEQ should be considered as the secondary screening index.

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Table 1. Golf Course Maintenance- Pesticide Parameters for Selelcting Pesticides to Minimize Water Quality Problems.

						Relative Losses		Toxicity		
		Application Type[2]		Sorption Coefficient[3]		Leaching	Runoff	MCL,HAL or HALEQ[6]	Aquatic LC_{50}[7]	
Trade Name[1]	**Common Name**	**Soil**	**Foliar**	**Koc (ml/g)**		**RLPI**[4]	**RRPI**[5]	**(ppm)**		**(ppm)**
Fumigants										
Basimid G	dazomet	INC		10	E	14	14	nd		toxic
Brom-O-Gas	methyl bromide	INJ		22		4	4	7	*	2.5
Terr-O-Gas (M)	chloropicrin	INJ		62		620	620	nd		nd
Terr-O-Gas (M)	methyl bromide	INJ		22		4	4	7	*	2.5
Vapam	metham sodium	INJ, INC		10	E	14	14	nd		0.079
Fungicide										
ATO Maneb	maneb		x	2000	E	285	7	40	*	1.9
Aliette	fosetyl-aluminium	x	x	20		2000	>1,000	20000	*	428
Apron	metalaxyl	x		50		7	7	400	*	>100
Banner	propiconazole		x	650	E	59	13	100	*	1.3b
Banol	propamocarb	x		27		nd	nd	nd		410

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Trade Name[1]	Common Name	Soil	Foliar	Koc (ml/g)		RLPI[4]	RRPI[5]	(ppm)		(ppm)
Bayleton	triadimefon	x		300		115	115	200	*	14
Chipco	iprodione		x	700		500	102	300	*	6.7
Clean Crop Evade	chlorothalonil		x	1380		460	24	2		0.049
Clean Crop Mancozeb	mancozeb		x	2000	E	285	7	20	*	1b
Clean Crop PCNB	PCNB		x	5000	E	>2,000	9	20	*	low tox
Clearys 3336	thiophanate-methyl		x	nd		nd	nd	nd		20d
Clearys PCNB	PCNB		x	5000	E	>2,000	9	20	*	low tox
ConSyst (M)	thiophanate-methyl		SPR	1830	E	1830	54	600	*	11d
ConSyst (M)	chlorothalonil		SPR	1380		460	24	2		0.049
Curalin	vinclozolin		SPR	100	E	50	50	200	*	52.5
Daconil	chlorothalonil		x	1380		460	24	2		0.049
Dow Elanco Broadway (M)	fenarimol		x	600		16	4	500	*	1.8
Dow Elanco Broadway (M)	chlorothalonil		x	1380		460	24	2		0.049
Duosan (M)	thiophanate-methyl		x	1830	E	1830	54	600	*	11d
Duosan (M)	mancozeb		x	2000	E	285	7	20	*	1b
Echo	chlorothalonil		x	1380		460	24	2		0.049

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Trade Name[1]	Common Name	Soil	Foliar	Koc (ml/g)		RLPI[4]	RRPI[5]	(ppm)		(ppm)
Engage	PCNB	DRENCH		5000	E	>2,000	9	20	*	low tox
Fore WP	mancozeb		x	2000	E	285	7	20	*	1b
Formec 80	mancozeb		x	2000	E	285	7	20	*	1b
Fungo	thiophanate-methyl	x	x	1830	E	1830	54	600	*	11d
Koban	etridiazole	x	x	1000	E	97	9	nd		4
Lesco Granular Turf Fcide	triadimefon		x	300		115	115	200	*	14
Lesco Mancozeb	mancozeb		x	2000	E	285	7	20	*	1b
Lesco Revere	PCNB		x	5000	E	>2,000	9	20	*	low
Lesco Twosome (M)	chlorothalonil		x	1380		460	24	2	0	0.049
Lesco Twosome (M)	fenarimol		x	600		16	4	500	*	1.8
Manex(M)	zinc		x	nd		nd	nd	nd		nd
Manex(M)	maneb		x	2000	E	285	7	40	*	1.9
Manicure	chlorothalonil		x	1380		460	24	2		0.049
Pace (M)	mancozeb		x	2000	E	285	7	20	*	1b
Pace (M)	metalaxyl		x	50		7	7	400	*	>100
Penstar	PCNB	DRENCH		5000	E	>2,000	9	20	*	low tox

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		Application Type[2]		Sorption Coefficient[3]		Relative Losses		Toxicity		
						Leaching	Runoff	MCL,HAL or HALEQ[6]		Aquatic LC_{50}[7]
Trade Name[1]	Common Name	Soil	Foliar	Koc (ml/g)		RLPI[4]	RRPI[5]	(ppm)		(ppm)
Prodigy	fosetyl-aluminum	DRENCH	SPR	20		2000	>1,000	20000	*	428
Protar	flutolanil	DRENCH		nd		nd	nd	nd		5.4
Protect T/O	mancozeb		SPR	2000	E	285	7	20	*	1b
Regal Consyst (M)	chlorothalonil		x	1380		460	24	2		0.049
Regal Consyst (M)	thiophanate		x	nd		nd	nd	nd		20d
Revere	PCNB	DRENCH		5000	E	>2,000	9	20	*	low tox
Rubigan	fenarimol		x	600		16	4	500	*	1.8
Scott's Fcide II	triadimefon		x	300		115	115	200	*	14
Scott's Fcide III	triadimefon		x	300		115	115	200	*	14
Scott's Proturf	chloroneb		x	1650		126	4	90	*	>4200b
Scott's Proturf Fluid	iprodione		x	1650		126	4	90	*	>4200b
Scott's Pythium	metalaxyl		x	50		7	7	400	*	>100
Sentinel	Cyproconazole		x	66		nd	nd	nd		19
Spotrete	thiram		x	670		446	99	40	*	0.13
Subdue	metalaxyl	x	x	50		7	7	400	*	>100

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Trade Name[1]	**Common Name**	**Soil**	**Foliar**	**Koc (ml/g)**		**RLPI**[4]	**RRPI**[5]	**(ppm)**		**(ppm)**
Sys Tec 1998	thiophanate-methyl		SPR	1830	E	1830	54	600	*	11d
Terraclor	PCNB	x	x	5000	E	>2,000	9	20	*	low tox
Terramec	chloroneb		x	1650		126	4	90	*	>4200b
Terraneb	chloroneb		x	1650		126	4	90	*	>4200b
Terrazole	etridiazole	x	x	1000	E	97	9	nd		4
Thalonil	chlorothalonil		x	1380		460	24	2		0.049
Touche'	vinclozolin		SPR	100	E	50	50	200	*	52.5
Turfco Accost	triadimefon		x	300		115	115	200	*	14
Turfside	PCNB	x		5000	E	>2,000	9	20	*	low tox
Vorlan	vinclozolin		x	100	E	50	50	200	*	52.5
Vorlan Flo	vinclozolin		x	100	E	50	50	200	*	52.5
Herbicide										
2 Plus 2(M)	mecoprop amine salt		x	20	EpH7	9	9	7	*	low tox
2 Plus 2(M)	2,4-D dimethylamine salt		x	20	E	20	20	70		100

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Trade Name[1]	Common Name	Soil	Foliar	Koc (ml/g)		RLPI[4]	RRPI[5]	(ppm)		(ppm)
AAtrex	atrazine	x	x	100		16	16	3		4.5
Ace Lawn Weed Kill(M)	2,4-D dimethylamine salt		x	20	E	20	20	70		100
Ace Lawn Weed Kill(M)	dicamba salt		x	2		1	1	200		28
Ace Lawn Weed Kill(M)	mecoprop amine salt		x	20	EpH7	9	9	7	*	low tox
Asulox	asulam sodium salt		x	40		57	57	350	*	>5000
Avail	glyphosate amine salt		x	24000	E	>2,000	1	700		8.3
Balan	benefin	x		9000		>2,000	2	2100	*	0.37b
Banvel	dicamba salt		x	2		1	1	200		28
Basagran	bentazon		x	34		nd	nd	nd		510
Basamid	dazomet		x	10	E	14	14	nd		toxic
Benefin Granular	benefin	x		9000		>2,000	2	2100	*	0.37b
Betamec	bensulide	x		1000	E	83	8	50	*	0.7
Betasan	bensulide	x		1000	E	83	8	50	*	0.7
Brom_O_Gas	methyl bromide	x		22		4	4	7	*	2.5
Brominal (M)	bromoxynil octanoate ester			10000	E	>2,000	14	140	*	0.1
Brominal (M)	bromoxynil butyrate		x	1079		1540	132	90		0.05

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Trade Name[1]	Common Name	Soil	Foliar	Koc (ml/g)		RLPI[4]	RRPI[5]	(ppm)		(ppm)
Buctril	bromoxynil octanoate ester			10000	E	>2,000	14	140	*	0.1
Bueno	MSMA sodium salt		x	7000	E	388	1	nd		12b
Calar	CAMA		x	nd		nd	nd	nd		nd
Chickweed Spurge(M)	dicamba salt		x	2		1	1	200		28
Chickweed Spurge(M)	2,4-D acid		x	20		20	20	70		1.1
Chickweed Spurge(M)	dichlorprop ester		x	1000	E	1000	100	40	*	1.3
Chipco Turf Herbicide	2,4-D dimethylamine salt		x	20	E	20	20	70		100
Clout	MSMA sodium salt		x	7000	E	388	1	nd		12b
Confront(M)	triclopyr amine salt		x	20	E	4	4	200	*	148b
Confront(M)	clopyralid amine salt		x	6		1	1	4000	*	1035
Crabgrass Preventer	benefin	x		9000		>2,000	2	2100	*	0.37b
DMA	2,4-D dimethylamine salt		x	20	E	20	20	70		100
DSMA Liquid	DSMA		x	7000	E	388	1	nd		>1000jb
Dacamine	2,4-D dimethylamine salt		x	20	E	20	20	70		100
Daconate	MSMA sodium salt		x	7000	E	388	1	nd		12b

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Trade Name[1]	Common Name	Soil	Foliar	Koc (ml/g)		RLPI[4]	RRPI[5]	(ppm)		(ppm)
Dacthal	DCPA	x		5000		500	2	4000		100a
Devrinol	napropamide	x		700		100	20	700	*	16.6
Dimension	dithiopyr	x		nd		nd	nd	nd		0.5
Dissolve(M)	2,4-D acid		x	20		20	20	70		1.1
Dissolve(M)	MCPA acid		x	nd	f(pH)	nd	nd	11		117
Dissolve(M)	dicamba salt		x	2		1	1	200		28
Dowfume	methyl bromide	x		22		4	4	7	*	2.5
Finale	glufosinate-ammonium		x	100	E	142	142	3		320
Formula	2,4-D dimethylamine salt		x	20	E	20	20	70		100
Gallery	isoxaben	x		1400		140	7	400	*	not tox
Gramoxone Super	paraquat dichloride salt		x	1000000	E	>2,000	1	30		15
Halt	pendimethalin	x		5000		555	2	300	*	0.199b
Halts	bensulide	x		1000	E	83	8	50	*	0.7
Horizon	fenoxaprop-ethyl		x	9490		>2,000	11	20	*	0.48
Horizon 2000	fluazifop-butyl		x	3000	E	1430	15	70	*	1.6
Illoxan	diclofop-methyl		x	16000		>2,000	2	10	*	0.35

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Trade Name[1]	Common Name	Soil	Foliar	Koc (ml/g)		RLPI[4]	RRPI[5]	(ppm)		(ppm)
Image	imazaquin ammonium salt		x	20	E pH7	3	3	2000	*	>100
Kerb	pronamide	x	x	800		133	20	50		72
Kleenup	glyphosate amine salt		x	24000	E	>2,000	1	700		8.3
Lesco Eight-One(M)	2,4-D dimethylamine salt		x	20	E	20	20	70		100
Lesco	2,4-D dimethylamine salt		x	20	E	20	20	70		100
Lesco Eight-One(M)	dicamba salt		x	2		1	1	200		28
Lesco TFC	chlorsulfuron		x	40	pH7	10	10	350	*	>250
Lesco Three-Way(M)	mecoprop amine salt		x	20	EpH7	9	9	7	*	low tox
Lesco Three-Way(M)	dicamba salt		x	2		1	1	200		28
Lesco Three-Way(M)	2,4-D acid		x	20		20	20	70		1.1
Lescogran	bentazon		x	34		nd	nd	nd		510
Lescopar(M)	2,4-D dimethylamine salt		x	20	E	20	20	70		100
Lescopar(M)	mecoprop amine salt		x	20	EpH7	9	9	7	*	low tox
Lescopex	mecoprop amine salt		x	20	EpH7	9	9	7	*	low tox
Lescosan	bensulide	x		1000	E	83	8	50	*	0.7

Table 1. Golf Course Maintenance- Pesticide Parameters for Selelcting Pesticides to Minimize Water Quality Problems.

						Relative Losses		Toxicity		
		Application Type[2]		Sorption Coefficient[3]		Leaching	Runoff	MCL,HAL or HALEQ[6]	Aquatic LC_{50}[7]	
Trade Name[1]	Common Name	Soil	Foliar	Koc (ml/g)		RLPI[4]	RRPI[5]	(ppm)		(ppm)
MSMA	MSMA sodium salt		x	7000	E	388	1	nd		12b
Manage	halosulfuron-methyl		x	nd		nd	nd	nd		
Mecomec	mecoprop amine salt		x	20	EpH7	9	9	7	*	low tox
Mecoprop	mecoprop amine salt		x	20	EpH7	9	9	7	*	low tox
Pennant	metolachlor	x		200		22	22	100		2
Phenaban(M)	dicamba salt		x	2		1	1	200		28
Phenaban(M)	2,4-D dimethylamine salt		x	20	E	20	20	70		100
Pre-M	pendimethalin	x		5000		555	2	300	*	0.199b
Prefar	bensulide	x		1000	E	83	8	50	*	0.7
Presan	bensulide	x		1000	E	83	8	50	*	0.7
Princep	simazine	x	x	130		21	21	1		2.8
Profume	methyl bromide	INJ		22		4	4	7	*	2.5
Prograss	ethofumesate		x	340		113	98	nd		>180
Prompt(M)	bentazon		x	34		nd	nd	nd		510
Prompt(M)	atrazine		x	100		16	16	3		4.5
Proturf Goosegrass(M)	oxadiazon	x		3200		533	5	40	*	>320

Table 1. Golf Course Maintenance- Pesticide Parameters for Selelcting Pesticides to Minimize Water Quality Problems.

						Relative Losses		Toxicity		
		Application Type[2]		Sorption Coefficient[3]		Leaching	Runoff	MCL,HAL or HALEQ[6]		Aquatic LC_{50}[7]
Trade Name[1]	Common Name	Soil	Foliar	Koc (ml/g)		RLPI[4]	RRPI[5]	(ppm)		(ppm)
Proturf Goosegrass(M)	bensulide	x		1000	E	83	8	50	*	0.7
Purge	atrazine	x	x	100		16	16	3		4.5
Quadmec(M)	dicamba salt		x	2		1	1	200		28
Quadmec(M)	mecoprop amine salt		x	20	EpH7	9	9	7	*	low tox
Quadmec(M)	2,4-D dimethylamine salt		x	20	E	20	20	70		100
Ronstar	oxadiazon	x		3200		533	5	40	*	>320
Round-Up	glyphosate amine salt		x	24000	E	>2,000	1	700		8.3
Rubigan	fenarimol	x		600		16	4	500	*	1.8
Sencor	metribuzin	x	x	60		15	15	200		76
South Wdgrss Wdgrss	pendimethalin		x	5000		555	2	300	*	0.199b
Super D II Weedone(M)	dicamba salt		x	2		1	1	200		28
Super D II Weedone(M)	2,4-D dimethylamine salt		x	20	E	20	20	70		100
Super Trimec(M)	dichlorprop ester		x	1000	E	1000	100	40	*	1.3
Super Trimec(M)	2,4-D acid		x	20		20	20	70		1.1
Super Trimec(M)	dicamba salt		x	2		1	1	200		28
Surflan	oryzalin	x		600		300	83	400	*	3.26

Table 1. Golf Course Maintenance- Pesticide Parameters for Selelcting Pesticides to Minimize Water Quality Problems.

						Relative Losses		Toxicity		
		Application Type[2]		Sorption Coefficient[3]		Leaching	Runoff	MCL,HAL or HALEQ[6]		Aquatic LC_{50}[7]
Trade Name[1]	Common Name	Soil	Foliar	Koc (ml/g)		RLPI[4]	RRPI[5]	(ppm)		(ppm)
Team(M)	oryzalin	x		600		300	83	400	*	3.26
Team(M)	trifluralin	x		8000		1330	2	5		0.041
Team(M)	benefin	x		9000		>2,000	2	2100	*	0.37b
Terrogas	methyl bromide	PRE, INC		22		4	4	7	*	2.5
Three-Way Selective(M)	2,4-D acid		x	20		20	20	70		1.1
Three-Way Selective(M)	MCPA acid		x	nd	f(pH)	nd	nd	11		117
Three-Way Selective(M)	dicamba salt		x	2		1	1	200		28
Trex-San(M)	2,4-D dimethylamine salt		x	20	E	20	20	70		100
Trex-San(M)	MCPA acid		x	nd	f(pH)	nd	nd	11		117
Trex-San(M)	dicamba salt		x	2		1	1	200		28
Trex-San(M)	mecoprop amine salt		x	20	EpH7	9	9	7	*	low tox
Trex-San(M)	2,4-D acid		x	20		20	20	70		1.1
Trimec Encore(M)	MCPA dimethylamine salt		x	20	EpH7	8	8	11		nd
Trimec Encore(M)	mecoprop amine salt		x	20	EpH7	9	9	7	*	low tox
Trimec Encore(M)	dicamba salt		x	2		1	1	200		28

Table 1. Golf Course Maintenance- Pesticide Parameters for Selelcting Pesticides to Minimize Water Quality Problems.

						Relative Losses		Toxicity		
		Application Type[2]		Sorption Coefficient[3]		Leaching	Runoff	MCL,HAL or HALEQ[6]		Aquatic LC_{50}[7]
Trade Name[1]	Common Name	Soil	Foliar	Koc (ml/g)		RLPI[4]	RRPI[5]	(ppm)		(ppm)
Trimec Southern(M)	MCPA acid		x	nd	f(pH)	nd	nd	11		117
Trimec Southern(M)	dicamba salt		x	2		1	1	200		28
Trimec Southern(M)	2,4-D acid		x	20		20	20	70		1.1
Trimec(M)	mecoprop amine salt		x	20	EpH7	9	9	7	*	low tox
Trimec(M)	2,4-D dimethylamine salt		x	20	E	20	20	70		100
Trimec(M)	dicamba salt		x	2		1	1	200		28
Turf Kleen(M)	mecoprop amine salt		x	20	EpH7	9	9	7	*	low tox
Turf Kleen(M)	2,4-D dimethylamine salt		x	20	E	20	20	70		100
Turflon	triclopyr amine salt		x	20	E	4	4	200	*	148b
Turflon II Amine(M)	2,4-D dimethylamine salt		x	20	E	20	20	70		100
Turflon II Amine(M)	triclopyr amine salt		x	20	E	4	4	200	*	148b
Turflon(M)	2,4-D acid		x	20		20	20	70		1.1
Turflon(M)	triclopyr amine salt		x	20	E	4	4	200	*	148b
VPC	metam sodium	INC		10	E	14	14	nd		0.079
Vantage	sethoxydim		x	100	EpH7	200	200	600	*	170

Table 1. Golf Course Maintenance- Pesticide Parameters for Selelcting Pesticides to Minimize Water Quality Problems.

						Relative Losses		Toxicity		
		Application Type[2]		Sorption Coefficient[3]		Leaching	Runoff	MCL,HAL or HALEQ[6]		Aquatic LC_{50}[7]
Trade Name[1]	Common Name	Soil	Foliar	Koc (ml/g)		RLPI[4]	RRPI[5]	(ppm)		(ppm)
Vapam	metam sodium	INC		10	E	14	14	nd		0.079
Versar	MSMA sodium salt		x	7000	E	388	1	nd		12b
Weed-B-Gon(M)	2,4-D dimethylamine salt		x	20	E	20	20	70		100
Weed-B-Gon(M)	mecoprop amine salt		x	20	EpH7	9	9	7	*	low tox
Weedar	2,4-D dimethylamine salt		x	20	E	20	20	70		100
Weedar MCPA	MCPA acid		x	nd	f(pH)	nd	nd	11		117
Weedestroy Tri-ester(M)	2,4-D esters/oil sol amines		x	100	E	100	100	70		2
Weedestroy Tri-ester(M)	mecoprop amine salt		x	20	EpH7	9	9	7	*	low tox
Weedestroy Triamine(M)	dicamba salt		x	2	1	1	200	28		
Weedestroy Triamine(M)	MCPA dimethylamine salt		x	20	EpH7	8	8	11		nd
Weedestroy Triamine(M)	mecoprop amine salt		x	20	EpH7	9	9	7	*	low tox
Weedmaster(M)	dicamba salt		x	2	1	1	200	28		
Weedmaster(M)	2,4-D dimethylamine salt		x	20	E	20	20	70		100
Weedone	2,4-D dimethylamine salt		x	20	E	20	20	70		100

Table 1. Golf Course Maintenance- Pesticide Parameters for Selelcting Pesticides to Minimize Water Quality Problems.

						Relative Losses		Toxicity		
		Application Type[2]		Sorption Coefficient[3]		Leaching	Runoff	MCL,HAL or HALEQ[6]		Aquatic LC_{50}[7]
Trade Name[1]	**Common Name**	**Soil**	**Foliar**	**Koc (ml/g)**		**RLPI[4]**	**RRPI[5]**	**(ppm)**		**(ppm)**
Weedone DCP Herbicide(M)	2,4-D acid		x	20		20	20	70		1.1
Weedone DCP Herbicide(M)	dichlorprop ester		x	1000	E	1000	100	40	*	1.3
Weedstroy	mecoprop amine salt		x	20	EpH7	9	9	7	*	low tox
XL(M)	oryzalin	x		600		300	83	400	*	3.26
XL(M)	benefin	x		9000		>2,000	2	2100	*	0.37b
Insecticide/Miticide										
Amdro Bait	hydramethylnon	x		730000		>2,000	1	2	*	0.16
Crusade	fonofos		x	870		217	28	10		0.02
Cythion	malathion		x	1800		>2,000	555	200		0.2
Diazinon	diazinon		x	1000	E	250	25	1		0.09
Dipel	bacillus thuringiensis		x	nd		nd	nd	nd		95b
Dursban	chlorpyrifos		x	6070		>2,000	5	20		0.0071
Dylox	trichlorfon		x	10		10	10	900	*	0.4
Ethion	ethion		x	10000		666	1	4	*	0.5
Gramma-Mean	lindane		x	1100		27	2	0		0.027

Table 1. Golf Course Maintenance- Pesticide Parameters for Selelcting Pesticides to Minimize Water Quality Problems.

						Relative Losses		Toxicity		
		Application Type[2]		Sorption Coefficient[3]		Leaching	Runoff	MCL,HAL or HALEQ[6]	Aquatic LC_{50}[7]	
Trade Name[1]	Common Name	Soil	Foliar	Koc (ml/g)		RLPI[4]	RRPI[5]	(ppm)		(ppm)
Lannate	methomyl		x	72		24	24	200		3.4
Logic Bait	fenoxycarb	x		1000	E	>2,000	1000	nd		1.6
Mavirik Aquaflow	fluvalinate		x	1000000	E	>2,000	1	70	*	0.0029
Mocap	ethoprop	x		70		28	28	0	*	13.8
Nudrin	methomyl		x	72		24	24	200		3.4
Oftanol	isofenphos		x	600		40	11	7	*	2d
Orthene	acephate		x	2		6	6	30	*	730
Pounce	permethrin		x	100000		>2,000	1	350	*	0.0041
Primicid	pirimiphos-ethyl	x		300	E	66	66	nd		0.22c
Proxol	trichlorfon	x		10		10	10	900	*	0.4
Pydrin	fenvalerate		x	5300		1510	5	200	*	0.0006
Sevimol	carbaryl		x	300		300	300	700		114
Sevin	carbaryl		x	300		300	300	700		114
Talstar	bifenthrin		x	240000		>2,000	1	100	*	0.00015
Trithion	carbophenothion		x	50000		>2,000	1	1		nd
Triumph	isazofos	x	x	100		29	29	0	*	0.008
Turcam	bendiocarb		x	570		1140	350	40	*	1.55

Table 1. Golf Course Maintenance- Pesticide Parameters for Selelcting Pesticides to Minimize Water Quality Problems.

						Relative Losses		Toxicity		
		Application Type[2]		Sorption Coefficient[3]		Leaching	Runoff	MCL,HAL or HALEQ[6]		Aquatic LC_{50}[7]
Trade Name[1]	Common Name	Soil	Foliar	Koc (ml/g)		RLPI[4]	RRPI[5]	(ppm)		(ppm)
Nematicide										
Mocap	ethoprop	INC		70		28	28	0	*	13.8
Nemacur	fenamiphos	INC		100		20	20	2		0.11

Footnotes							
1 Trade Name	(M) indicates that the product is a mixture of two or more active ingredients						
2 Application Type	INC: incorporated	INJ: injected	PRE: preemergence		x: applied to soil surface or foliage		
3 Sorption Coefficient	E: estimated	G: educated guess					
4 Relative Leaching	Potential Index:	(RLPI): Smaller number indicates greater leaching hazard					
5 Relative Runoff	Potential Index:	(RRPI): Smaller number indicates greater runoff hazard					
6 MCL, HAL or HALEQ	Maximum Contaminant Level (MCL), Lifetime Health Advisory Level (HAL); * =Lifetime Health Advisory Level Equivalent (HALEQ);						
7 Aquatic Toxicity	LC50: value is for rainbow trout 48 or 96 hour exposure time unless otherwize specified						
	a=channel catfish b=bluegill d=goldfish j=fat head minnow						

Table 1. Golf Course Maintenance- Pesticide Parameters for Selelcting Pesticides to Minimize Water Quality Problems.

						Relative Losses		Toxicity	
		Application Type[2]		Sorption Coefficient[3]		Leaching	Runoff	MCL,HAL or HALEQ[6]	Aquatic LC_{50}[7]
Trade Name[1]	Common Name	Soil	Foliar	Koc (ml/g)		RLPI[4]	RRPI[5]	(ppm)	(ppm)
nd	no data available								

Table 2. Pesticide Selection Worksheet

Landowner/Operator
Name:_____County:_____Date:_____
_____

Crop:_____Farm ID:_____Field
ID_____Sheet____of_____

Target Pest (1)	IFAS Recommended Pesticides (2)	K_{oc} Value (3)	Relative Losses				Soil Type (8)	Soil Leaching Rating (9)	Soil Runoff Rating (10)	Selected Pesticide (11)	Comments (12)
			Leaching RLPI (4)	Runoff RRPI (5)	MCL/HAL HALEQ (6)	Aquatic Toxicity (7)					

If the K_{oc} value is 100 or less or if the RLPI value is 10 or less and the soil leach rating is high, then the pesticide has a high potential for leaching and should be used with extreme caution. Alternative pesticides and reduced rates should be considered if possible. Apply pesticide during periods with low potential for rainfall if possible.