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SUBJECT: DEVELOPMENT OF METHYL ISOTHIOCYANATE BUFFER ZONES USING THE PROBABILISTIC EXPOSURE AND RISK MODEL FOR FUMIGANTS VERSION 2 (PERFUM2)

Background

The Department of Pesticide Regulation (DPR) is drafting a risk management strategy to meet its regulatory goal of ensuring no exposures causing recognizable eye or respiratory irritation result from the use of metam sodium (MS) and other methyl isothiocyanate (MITC) generating pesticides (MITC Risk Management Directive, December 2002). Buffer zones restricting where and under what circumstances MS applications can be made are an integral part of any risk management strategy. This memorandum documents the development of MTIC buffer zones.

The MITC mitigation strategy combines adequate separation between sensitive areas and applications (buffer zones) with application rate restrictions and intermittent watering regimes following application. A buffer zone is defined as "an area that surrounds a pesticide application block in which certain activities are restricted for a specified period of time to protect human health and safety from existing or potential adverse effects associated with a pesticide application" (Title 3, California Code of Regulations section 6000). A pesticide application block is defined as "a field or portion of a field, treated in a 24-hour period that typically is identified by visible indicators, maps, or other tangible means" (Title 3, California Code of Regulations section 6000).

The required restrictions are to be generally applicable statewide. The buffer zones described in this memorandum were developed utilizing methods appropriate for the nature of MITC-generating products but also consistent with method used by DPR to develop buffer zones for acute exposure to methyl bromide (MeBr). Methods consistent with MeBr buffer zone development include the back-calculation of flux and choice of standard source geometry. Because these are statewide conditions there is little or no site specificity in the development of these buffer zones.

Supporting Data

On April 9, 2002, the Metam Sodium Task Force (MSTF) submitted a series of documents containing results from various field studies conducted under the MSTF 1997–2001 Field Program (Sullivan and Holdsworth, 2001a, 2001b, 2001c, 2001d, and Merricks 1999, 2001, and 2002) in addition to a document presenting the MSTF proposal for buffer zone development (Sullivan, 2002). The objective of the field studies was to characterize the air concentrations of MITC associated with MS applications made by various methods and, in some cases, employing new watering-in mitigation measures. Analysis of results from these studies provides MITC flux estimates, which are integral to the development of required use mitigation measures for MITC-generating product applications in order to meet the DPR risk management goals for MITC. For details of these studies, consult the reports.

The earliest field studies conducted under the MSTF 1997–2001 Field Program monitored MITC air concentrations associated with standard sprinkler and shank applications (Merricks, 1999). These field studies were reviewed and found to be of generally acceptable quality for use to estimate MITC flux from these types of applications (Barry, 2003a).

MSTF field studies include a series of pilot studies conducted in Orange, Los Angeles, Santa Barbara, and Kern Counties, California, in June 2000 (Sullivan and Holdsworth, 2001a, 2001b, 2001c, and 2001d). These studies examined various proposed mitigation measures. The study results were reviewed and found to be unacceptable for use to estimate flux (Barry, 2003b). Therefore, these studies were not used in the development of buffer zones.

Also, in June 2000, MSTF conducted a field study monitoring air concentrations associated with the shank application method employing new intermittent watering-in mitigation measures aimed at suppressing MITC air concentrations (Merricks, 2001). This study was reviewed and found to be acceptable for use in estimating MITC flux for shank applications where intermittent watering-in is used to suppress MITC air concentrations (Barry, 2003c).

In August 2001, MSTF conducted a field study monitoring air concentrations associated with the sprinkler irrigation application method employing new intermittent watering-in mitigation measures aimed at suppressing MITC air concentrations (Merricks, 2002). This study was reviewed and found to be acceptable for use in estimating MITC flux for sprinkler irrigation applications where intermittent watering-in is used to suppress MITC air concentrations (Barry, 2003d).

Buffer Zone Development

A. Target Value

A target value must be specified before buffer zone lengths can be determined. The target value employed in buffer zone determination for MS applications is based upon air concentrations of the breakdown product MITC. A risk management directive issued by DPR on December 2, 2002 (Gosselin, 2002) sets the MITC air concentration threshold at 220 ppb as an 8-hour Time Weighted Average (TWA). Since MITC is an irritant that has effects at time scales much shorter than 8 hours, the MITC risk management directive also states that "…minimizing the likelihood of short-term peak concentrations above 220 ppb will be factored into the use restrictions." Factors associated with threshold averaging time choice are discussed in Barry and Segawa (2003) and Barry (2002).

B. Air Dispersion Modeling

Buffer zones presented in this memorandum were developed by simulating MITC air concentrations using the Probabilistic Exposure and Risk Model for Fumigants Version 2 (PERFUM2) modeling system (Reiss and Griffin, 2005). The PERFUM2 modeling system employs the Industrial Source Complex Short Term Version 3 (ISCST3) air dispersion model (U.S. EPA, 1995) as the central component together with front end and back end processing code that allows the construction of buffer zone distributions generated using historical weather data and the flux profile for a given application method. The flux profile is the pattern of flux observed from the application for typically 96 hours or less. It has been verified by DPR scientists that PERFUM2 modeling system correctly calculates air concentrations and buffer zones for averaging times of 24 hrs or less (Barry and Johnson, 2005; Johnson, 2006).

C. Flux Estimates

In order to develop buffer zones for any fumigant it is necessary to obtain appropriate flux estimates. Flux estimates may be obtained either through detailed flux studies (e.g. aerodynamic method) or through site-specific dispersion modeling using data collected from individual field studies in order to estimate the MITC flux by the back-calculation method (Johnson, et al., 1999). Back-calculation modeling requires the following inputs: (1) source geometry and location relative to surrounding sensitive areas and (2) on-site weather data, including wind speed and direction and the atmospheric stability conditions. DPR has successfully used dispersion modeling coupled with the back calculation technique for MeBr to estimate flux. The back calculation procedure has been published in a peer-reviewed journal (Ross et al, 1996). In addition, standard procedures for employing the back calculation method have been developed by DPR (Johnson et al., 1999).

MITC flux profiles were obtained from the U. S. Environmental Protection Agency (U.S. EPA) Office of Pesticide Programs for four MS application methods: (1) standard sprinkler, (2) standard shank, (3) Intermittent watering-in sprinkler, and (4) intermittent watering-in shank MS application methods. The flux profiles are shown in Appendix A. These flux profiles were developed using the back-calculation method. DPR has previously estimated MITC flux only for critical sampling periods, identified as those sampling periods resulting in the longest required buffer zone following application. U.S. EPA flux profiles have been reviewed and found to contain flux estimates for the critical periods are either of similar magnitude or larger relative to those previously developed at DPR (Barry et al., 2004). U.S. EPA flux estimates for the remainder of the sampling periods are reasonable. Therefore, to maintain efficiency of efforts and consistency, the U.S. EPA flux profiles were used to develop the buffer zones presented in this memorandum.

U. S. EPA flux profiles are two-day profiles (48 hours following the start of application). In order to estimate the required duration of the buffer zones the flux profiles were extended out from 48 hours to 96 hours following application with flux estimates calculated by MSTF based upon data in the registration volumes discussed in the supporting data section of this memorandum. MSTF flux estimates are reasonable. Inserting MSTF flux estimates to fill the last two days of the four day flux profile will not alter the required buffer zones because in all cases the longest buffer zones are required in the first 48 hours following the beginning of the application.

D. Source Geometry

The back calculation procedure requires the use of the exact source geometry of the specific application block in the field study under analysis. However, a more generic field geometry must be used for statewide buffer zone development. MeBr buffer zones were developed using square fields of each acreage size. Square fields are also used for the development of these MS buffer zones. Although in practice MS applications are often rectangular, use of square fields provides a more consistent buffer zone determination because the same centerline air concentrations will be obtained regardless of which side of the field the wind is blowing perpendicular over. This would not be the case if rectangular fields were used.

E. Meteorological Data

The PERFUM2 modeling system includes five years of historical weather data for each of five locations: (1) Bakersfield, California, (2), Flint, Michigan, (3) Tallahassee, Florida, (4) Ventura, California, and (5) Yakima, Washington. Only the California stations were used for buffer zone development. These stations are the Bakersfield Automated Surface Observing System (ASOS) station and the Ventura California Irrigation Management Information System (CIMIS) station.

F. Buffer Zone Determination

For each of the four application methods PERFUM2 model was run using the five years of historical weather data from each of the two California meteorological stations (Bakersfield ASOS and Ventura CIMIS). The PERFUM2 model summarizes the buffer zone distributions by day and period. Thus, for a four-day flux profile and an 8-hr TWA there will be 12 summary distributions to examine to determine the required buffer zone at the desired percentile. The required buffer zone is the longest 95 percentile buffer zone among the 12 periods. The final buffer zone tables cover application sizes ranging from 1 acre to 40 acres (the upper limit on field size in PERFUM2) and application rates from 80 lbs MS/acre to 320 lbs MS/acre broadcast rate. Tables 1 through 4 show the 95th percentile buffer zones using meteorological data from Bakersfield ASOS and Ventura CIMIS.

G. Buffer Zone Duration

The buffer zone duration is determined by how long after the beginning of an application the flux remains high enough to generate air concentrations requiring a buffer zone of greater than 10 m. Determination of the buffer zone duration is made only for the maximum application rate of 320 lb/acres broadcast and 40-acre field. For simplicity, all applications, regardless of size or application rate, will have the same buffer zone duration. For ease of implementation, the initial buffer zone required for a particular application rate and field size on day one remains in force for the entire required duration. Results from PERFUM2 modeling are shown in Table 5. Depending upon the application method, buffer zone duration ranges from one day (24 hours) to three days (72 hours) from the beginning of an application.

MITC Regulatory Recommendations

A. Regulatory Recommendations Associated with the MITC Buffer Zones

In addition to the buffer zone distances and duration, other regulatory requirements should be implemented to ensure that the buffer zones provide adequate protection.

Daylight Applications. All of the monitored applications occurred during daylight hours. Air concentrations associated with night applications may be higher due to more stable atmospheric conditions. Therefore, MS applications should only occur during daylight hours. Daylight hours are defined as one hour after sunrise to one hour before sunset.

Irrigation Requirements. All of the standard and intermittent watering-in applications monitored followed specified irrigation practices. While the irrigation amounts and schedules may have some flexibility, the greater the deviations from the irrigation practices monitored, the greater the probability that the buffer zones may not provide adequate protection. The monitoring studies used the irrigation regimes as shown in Tables 6 and 7.

B. Uncertainties in the Data and Recommendations

In addition to the uncertainties discussed earlier, the following may have significant impacts on the regulatory recommendations.

The flux estimates for each of the application methods are based on single studies. None of the application methods have replicated data and the variability in the flux is unknown. The coefficient of variation associated with 24-hour flux of MeBr was approximately 50 percent (Barry 1999), but this may or may not be indicative of the variability associated with MITC flux. The buffer zones will provide more or less protection than desired if the true flux is significantly lower or higher than the flux determined from the monitoring studies. DPR management should consider additional adjustment or rounding of flux estimates to account for unmeasured variability in the flux.

The application rates monitored were 160 lb/broadcast rate per acre and 320 lb/broadcast rate per acre for shank and sprinkler, respectively. Ideally, these should be the maximum application rates allowed. The buffer zone distances assume that the flux is a constant proportion of the application rate. It is likely that due to the same or greater soil adsorption and degradation, the flux proportion is the same or less for application rates lower than those monitored. However, the shank injection buffer zone tables contain buffer zones for application rates of 320 lb/acre and 240 lb/acre broadcast rates even though the maximum observed application rate is 160 lb/acre broadcast. It is not known whether the flux increases proportionally with application rate for rates beyond those monitored. Thus, it is likely that the buffer zones for application rates lower than those monitored provide equivalent or greater protection, all other factors being equal. However, this may not be true for application rates greater than those monitored. In addition, higher application rates may require greater buffer zone duration.

In MSTF studies, for standard shank and sprinkler, the largest area treated each day was 80 acres. Buffer zones for 40 acres are as large as at least 1440m (4723 feet). In fact, PERFUM2 model results for 40 acre applications for standard sprinkler method and standard shank method show required buffer zones beyond the model maximum buffer zone of 1440m (4723 feet). How much larger than the model maximum buffer zone the require buffer zones are for these scenarios is unknown but will be addressed with additional analysis. Enforcing buffer zones this large may be problematic. A more manageable maximum buffer zone distance, and corresponding smaller acreage limits should be considered.

There are other application methods described on labels, but not fully evaluated. Thus, application methods such as flood chemigation, drip chemigation, and rotary tiller are not covered by the buffer zones in this memorandum. It is likely, but not certain, that standard sprinkler applications represent the chemigation method with the highest flux. Standard shank applications may or may not represent the soil injection method with the highest flux.

The modeling results indicate that some application method/acreage/application rate combinations do not require a buffer zone. However, a minimum buffer zone should also be set by policy in order to guard against unusual or unforeseen conditions.

References

Barry, T. 1999. Methyl Bromide Emission Ratio Groupings. Memorandum to Randy Segawa dated December 2, 1999. California Environmental Protection Agency. Department of Pesticide Regulation. Environmental Monitoring Branch. Sacramento, California 95812-4015.

Barry, T. 2002. Potential Methyl Isothiocyanate Peak Concentrations Given a Proposed Regulatory Threshold Air Concentration of 220 parts per billion as an 8-hour Time Weighted Average. California Environmental Protection Agency. Department of Pesticide Regulation. Environmental Monitoring Branch. Sacramento, California 95812-40150. EM02-19.

Barry, T. 2003a. Review of the Metam Sodium Task Force document entitled: “Determination of Methyl Isothiocyanate off-site air movement from application of Metam Sodium through shank injection and sprinkler irrigation.” Memorandum to Kean S. Goh dated April 1, 2003. California Environmental Protection Agency. Department of Pesticide Regulation. Environmental Monitoring Branch. Sacramento, California 95812-4015. EM03-11.

Barry, T. 2003b. Review of Metam Sodium Task Force document entitled “Volume 3 Pilot Field Studies.” Memorandum to Kean S. Goh dated April 2, 2003. California Environmental Protection Agency. Department of Pesticide Regulation. Environmental Monitoring Branch. Sacramento, California 95812-4015. EM03-12

Barry, T. 2003c. Review of Metam Sodium Task Force document entitled “Determination of the Metam Isothiocyanate off-site air movement from the application of Metam Sodium through shank injection.” Memorandum to Kean S. Goh dated March 3, 2003. California Environmental Protection Agency. Department of Pesticide Regulation. Environmental Monitoring Branch. Sacramento, California 95812-4015. EM03-05.

Barry, T. 2003d. Review of Metam Sodium Task Force document entitled “Determination of Methyl Isothiocyanate off-site air movement from the chemigation of Metam Sodium through sprinkler irrigation.” Memorandum to Kean S. Goh dated March 3, 2003. California Environmental Protection Agency. Department of Pesticide Regulation. Environmental Monitoring Branch. Sacramento, California 95812-4015. EM03-01.

Barry, T. and B. Johnson. 2005. Verification of probabilistic exposure and risk model for fumigants 24-hour period maximum concentration calculations. Memorandum to Randy Segawa dated September 19, 2005. EM05-11.

Barry, T. and R. Segawa. 2003. Evaluation of Regulatory Goals for Methyl Isothiocyanate (MITC). Memorandum to Kean S. Goh datedAugust 6, 2003. California Environmental Protection Agency. Department of Pesticide Regulation. Environmental Monitoring Branch. Sacramento, California 95812-4015. EM03-31.

Barry, T., R. Segawa, and P. Wofford. 2004. Development of Methyl Isothiocyanate Buffer Zones. Memorandum to John S. Sanders dated February 24, 2004. California Environmental Protection Agency. Department of Pesticide Regulation. Environmental Monitoring Branch. Sacramento, California 95812-4015. EM04-09.

Gosselin, P. 2002. Risk Management Directive. Memorandum to Interested Parties dated December 2, 2002. California Environmental Protection Agency. Department of Pesticide Regulation. Sacramento, California 95812-4015.

Johnson, B. 2006. How PERFUM2 matches flux with meteorology and verification of some period averages for eight-hour periods. Memorandum to Terrell Barry, Ph.D., dated January 20, 2006.

Johnson, B., T. Barry, and P. Wofford. 1999. Workbook for Gaussian modeling analysis of air concentration measurements. California Environmental Protection Agency. Department of Pesticide Regulation. Environmental Monitoring and Pest Management Branch. Sacramento, California 95814. EH99-03.

Merricks, D.L. 1999. Determination of Methyl Isothiocyanate off-site air movement from application of Metam Sodium through shank injection and sprinkler irrigation. Agrisearch Incorporated, 5734 Industry Land, Fredrick, Maryland 21704-7293. December 14, 1999.

Merricks, D.L. 2001. Determiniation of Methyl Isothiocyanate off-site air movement from the application of Metam Sodium through shank injection. Agrisearch Incorporated, 5734 Industry Land, Fredrick, Maryland 21704-7293. March 1, 2001.

Merricks, D.L. 2002. Determiniation of Methyl Isothiocyanate off-site air movement from the application of Metam Sodium through sprinkler irrigation. Agrisearch Incorporated, 5734 Industry Land, Fredrick, Maryland 21704-7293. January 10, 2002.

Reiss, R. and J. Griffin. 2005. User's guide for the Probabilistic Exposure and Risk model for FUMigants (PERFUM), Version 2. October 17, 2005. Sciences International.

Ross, L.J., B. Johnson, K.D. Kim, and J. Hsu. 1996. Prediction of methyl bromide flux from area sources using the ISCST model. Journal Environmental Quality 25(4):855-891.

Sullivan, D.A. 2002. Dispersion modeling of exposures to MITC associated with Metam Sodium applications. Sullivan Environmental Consulting, Inc. 1900 Elkin Street, Suite 240, Alexandria, Virginia 22308. March 15, 2002.

Sullivan, D.A. and M.T. Holdsworth. 2001a. Orange County drip application study modeling results prepared for the Metam Sodium Task Force. Sullivan Environmental Consulting, Inc. 1900 Elkin Street, Suite 240, Alexandria, Virginia 22308. December 18, 2001.

Sullivan, D.A. and M.T. Holdsworth. 2001b. Lancaster pilot study of intermittent sealing for a sprinkler irrigation application. Sullivan Environmental Consulting, Inc. 1900 Elkin Street, Suite 240, Alexandria, Virginia 22308. December 18, 2001.

Sullivan, D.A. and M.T. Holdsworth. 2001c. Santa Barbara County pilot study of intermittent sealing for a shank injection application. Sullivan Environmental Consulting, Inc. 1900 Elkin Street, Suite 240, Alexandria, Virginia 22308. December 18, 2001.

Sullivan, D.A. and M.T. Holdsworth. 2001d. Panama Lane pilot study of intermittent sealing for a chemigation application. Sullivan Environmental Consulting, Inc. 1900 Elkin Street, Suite 240, Alexandria, Virginia 22308. December 18, 2001.

U.S. EPA. 1995. User's guide for the Industrial Source Complex (ISC3) dispersion models. Volume I – User Instructions. U.S. Environmental Protection Agency. Office of Air Quality Planning and Standards. Emissions, Monitoring, and Analysis Division. Research Triangle Park, North Carolina 27711. EPA-454/B-95-003a.

Table 1. Chemigation (Sprinkler). PERFUM2 95 percentile single maximum direction buffer zones in meters (feet). Five years Bakersfield ASOS meteorological data. 8-hr 220ppb target.

App Type		App Rate (lb/acre)			
	Acres	320	240	160	80
Intermittent Sprinkler Kern	1	0	0	0	0
	5	5 (16)	5 (16)	0	0
	10	5 (16)	5 (16)	0	0
	20	50 (164)	5 (16)	5 (16)	0
	40	95 (312)	30 (98)	5 (16)	0
		App Rate (lb/acre)			
	Acres	320	240	160	80
Standard Sprinkler Bakersfield	1	115 (377)	80 (262)	5 (16)	0
	5	345 (1132)	250 (820)	150 (492)	20 (66)
	10	540 (1771)	390 (1279)	240 (787)	75 (246)
	20	855 (2804)	610 (2001)	385 (1263)	135 (443)
	40	>1400 (4592)	1010 (3313)	605 (1984)	225 (738)

Table 2. Chemigation (Sprinkler). PERFUM2 95 percentile single maximum direction buffer zones in meters (feet). Five years Ventura CIMIS meteorological data. 8-hr 220ppb target.

App Type		App Rate (lb/acre)			
	Acres	320	240	160	80
Intermittent Sprinkler Kern	1	0	0	0	0
	5	5 (16)	5 (16)	0	0
	10	45 (148)	5 (16)	0	0
	20	90 (295)	30 (98)	5 (16)	0
	40	165 (541)	80 (263)	5 (16)	0
		App Rate (lb/acre)			
	Acres	320	240	160	80
Standard Sprinkler Bakersfield	1	195 (640)	145 (476)	80 (262)	0
	5	545 (1788)	410 (1345)	265 (869)	90 (295)
	10	855 (2804)	635 (2083)	415 (1361)	160 (525)
	20	1370 (4494)	1035 (3395)	655 (2148)	265 (869)
	40	>1440(4723)	>1440 (4723)	1070 (3520)	430 (1410)

Table 3. Shank injection. PERFUM2 95 percentile single maximum direction buffer zones in meters (feet). Five years Bakersfield ASOS meteorological data. 8-hr 220ppb target.

App Type		App Rate (lb/acre)			
	Acres	320	240	160	80
Intermittent Shank Lost Hills	1	0	0	0	0
	5	5 (16)	5 (16)	0	0
	10	25 (82)	5 (16)	5 (16)	0
	20	65 (213)	15 (49)	5 (16)	0
	40	120 (394)	55 (180)	5 (16)	0
		App Rate (lb/acre)			
	Acres	320	240	160	80
Standard Shank Bakersfield	1	80 (262)	40 (131)	5 (16)	0
	5	250 (820)	180 (590)	100 (328)	5 (16)
	10	395 (1296)	290 (951)	170 (558)	30 (98)
	20	620 (2034)	450 (1476)	275 (902)	80 (262)
	40	1005 (3296)	715 (2345)	440 (1445)	145 (475)

Table 4. Shank Injection. PERFUM2 95 percentile single maximum direction buffer zones in meters (feet). Five years Ventura CIMIS meteorological data. 8-hr 220ppb target.

App Type		App Rate (lb/acre)			
	Acres	320	240	160	80
Intermittent Shank Lost Hills	1	0	0	0	0
	5	5 (16)	5 (16)	0	0
	10	45 (148)	5 (16)	5 (16)	0
	20	95 (312)	35 (115)	5 (16)	0
	40	165 (541)	80 (262)	5 (16)	0
		App Rate (lb/acre)			
	Acres	320	240	160	80
Standard Shank Bakersfield	1	145 (476)	100 (328)	5 (16)	0
	5	405 (1328)	305 (1000)	190 (623)	40 (131)
	10	625 (2050)	470 (1546)	305 (1000)	95 (312)
	20	995 (3264)	740 (2427)	480 (1574)	170 (558)
	40	>1440 (4723)	1190 (3903)	770 (2526)	285 (935)

Table 5. Buffer zones required on each day for 4 days (96 hours) following beginning of an application. Buffers are shown in meters (feet). Buffer zone duration is determined as the required period of time after the beginning of an application. For example, if the minimum buffer required is 10 m, then the for a Standard Sprinkler application made beginning at 0700 hrs, the buffer zone duration is 72 hours or three full days. The buffer zone would no longer be required beginning at 0700 hrs on the fourth day.

Application Method/Study Location	Weather Station	Day 1 Buffer Meters (feet)	Day 2 Buffer Meters (feet)	Day 3 Buffer Meters (feet)	Day 4 Buffer Meters (feet)
Intermittent Sprinkler Kern	Bakersfield ASOS	165 (543)	5 (16)	0	0
	Ventura CIMIS	95 (312)	0	0	0
Standard Sprinkler Bakersfield	Bakersfield ASOS	>1440 (4737)	280 (921)	80 (263)	5 (16)
	Ventura CIMIS	>1440 (4737)	170 (559)	45 (148)	5 (16)
Intermittent Shank Lost Hills	Bakersfield ASOS	165 (543)	0	0	0
	Ventura CIMIS	120 (395)	0	0	0
Standard Shank Bakersfield	Bakersfield ASOS	1240 (4079)	>1440 (4737)	450 (1480)	5 (16)
	Ventura CIMIS	785 (2582)	1005 (3306)	265 (872)	0

Table 6. Application and watering-in sequence for the intermittent watering-in sprinkler method (Merricks, 2002).

Event	Date	Time (hrs, PDT)	Description
Application	8/21/01	0500 – 1130	17.63 acres
Watering-In (½ inch) Post Application	8/21/01	1103 – 1330	
Watering-In (¼ inch) Evening of Application	8/21/01	1852 – 1950 2301 – 2403	
Watering-In (¼ inch) Day 1	8/22/01	1930 – 2028 2248 – 2355	

Table 7. Application and watering-in sequence for the intermittent watering-in shank method (Merricks, 2001).

Event	Date	Time (hrs, PDT)	Description
Application	6/13/00	0650 – 1400	40-acres
Watering-In (½ inch) Post Application	6/13/00	0940 – 1213	East 1/3
		1252 – 1527	Center 1/3
		1545 – 1815	West 1/3
Watering-In (¼ inch) Evening of Application	6/13/00	1815 – 1930	East 1/3
		1930 – 2045	Center 1/3
		2045 – 2200	West 1/3
		2200 – 2315	East 1/3
		2315 – 2430	Center 1/3
		2430 – 0145	West 1/3
Watering-In (¼ inch) Day 1	6/14/00	1600 – 1715	East 1/3
		1715 – 1830	Center 1/3
		1830 – 1945	West 1/3
		1945 – 2100	East 1/3
		2100 – 2215	Center 1/3
		2215 – 2330	West 1/3