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STUDY GW15: GROUNDWATER PROTECTION LIST MONITORING FOR BENTAZON

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ABSTRACT

The Department of Pesticide Regulation's (DPR) Environmental Monitoring Branch (EM) Groundwater Protection Program (GWPP) staff sampled 32 wells between October 2015 and October 2017 to determine if current agricultural uses of bentazon were resulting in contamination of groundwater. For this study, wells were sampled in high-use sections of Modoc, Monterey, San Luis Obispo, Santa Barbara, and Siskiyou counties. Bentazon was detected in four wells in Modoc County; two of the wells had quantifiable detections of 0.139 and 0.199 parts per billion (ppb) and two had trace detections below the reporting limit. All bentazon concentrations are well below human health levels for drinking water. Based on these detections, it is recommended that DPR establish sections 25M47N05E10 and 25M47N05E15 as Ground Water Protection Areas.

BACKGROUND

The Pesticide Contamination Prevention Act (PCPA) of 1985 (Food and Agricultural Code sections 13149-13152, amended 1996, 2014) requires DPR to identify pesticides or degradates that have the potential to pollute groundwater based on their physical and chemical data. These pesticides are placed on the Groundwater Protection List (GWPL) (Title 3 California Code of Regulations 6800) and DPR conducts monitoring to determine if they have migrated to groundwater due to agricultural use.

In 1989, the first groundwater detections of the herbicide bentazon were found in ten California rice-growing counties. As a result, the California Department of Food and Agriculture's Director suspended the use of bentazon statewide (CDFA, 1989). Bentazon was then entered into the Pesticide Detection Response Process as required by the PCPA. Based on the findings of a subcommittee of the Pesticide Registration and Evaluation Committee, new regulations were adopted and bentazon was reinstated for limited use in 1992 (Nordmark,

2007). DPR adopted regulations that prohibited use in Del Norte and Humboldt counties and on all rice crops (Title 3 California Code of Regulations § 6457). DPR also made bentazon a restricted material statewide by adding it to section (a) of the Groundwater Protection List (Title 3 California Code of Regulations 6800[a]). These restrictions significantly reduced the amount of bentazon used statewide.

From 1992 to 2000, the GWPP conducted six groundwater monitoring studies for bentazon resulting in the collection of samples from 33 wells in nine counties. In these studies, given that bentazon had been recently prohibited from use on rice crops, no sampling was conducted within five miles of rice fields that may have historically been treated with bentazon. Bentazon was not detected in any of the samples (Nordmark, 2007). With the lack of new detections, DPR determined that suspension of the bentazon groundwater surveys was the best use of state resources. The criteria to resume sampling required: (1) significant new uses of bentazon or new irrigation methods, (2) annual bentazon use exceeding 4,000 pounds statewide or 1,000 pounds in a single county, OR (3) yearly sales of bentazon-containing products exceeding 14,000 pounds of bentazon (Nordmark, 2007).

Since 2006, there has been an increase in the reported use of bentazon statewide exceeding 4,000 pounds per year. There has also been a yearly 1,000-pound exceedance in multiple counties since 2007. Both of these criteria met DPR's threshold to conduct additional sampling and this study was initiated once an analytical method and program resources were available. As of 2015, approximately 74% of statewide applications of bentazon occurred in Modoc, Siskiyou, Monterey, and Santa Barbara counties with the highest use on peas, beans, and mint (CDPR, 2015a; Table 1; Figure 1; Figure 2). The GWPP primarily focused groundwater monitoring for bentazon on these highest use counties to determine if current agricultural uses of bentazon have resulted in contamination of groundwater (Figures 3, 4, and 5). Although the GWPP conducted monitoring in San Luis Obispo County, the use was not included in Figure 2 because the countywide use rates were low compared to the other high use counties. The GWPP chose to sample some high use sections in southern San Luis Obispo County due to their proximity to high use areas of Santa Barbara County.

Table 1. Highest use of bentazon by crop 1990-2014 (CDPR, 2015a).

Site	Bentazon Applied (lbs.)
Peas	33,180
Beans	24,064
Mint	19,856

METHODS

Sampling Methods

Samples were collected in accordance with Standard Operating Procedure (SOP) FSWA001.02 (Nordmark and Herrig, 2011) and the study protocol (CDPR, 2015b). Domestic wells were prioritized for sample collection because they are usually shallower than municipal and irrigation wells. During collection of groundwater samples, all efforts were taken to sample water directly from the aquifer as outlined in the SOP. GWPP staff sampled a total of 32 wells in Modoc, Siskiyou, Monterey, San Luis Obispo, and Santa Barbara counties between October 2015 and October 2017. The GWPP chose most sampling locations based on reported bentazon use with every effort made to sample within high use sections. Due to variations in well location and well owner participation, acquiring samples within a given section was sometimes problematic. In these cases, GWPP staff attempted to collect samples in sections as close to high use sections as possible. To conserve state resources, part of this study occurred concurrently with Study 300 (CDPR, 2017). Some sampling locations were further from high use bentazon sections because samples for the other study's active ingredient were prioritized. Each well was sampled for bentazon and 35 additional pesticides or degradation products (Table 2). Two of the 32 wells were resampled, one in Modoc County (Location Code 25-01 = 25-12) and one in Monterey County (Location Code 27-02 = 27-11).

Table 2. Pesticides and degradates included in CDFA laboratory screens.

LCMS Multi-Analyte Screen		GCMS Multi-Analyte Screen	Triazine Screen	Bentazon Screen
EMON-SM-05-032		EMON-SM-05-032	EMON-62.9	EM-5.5
Atrazine	Linuron	Clomazone	ACET [1]	Bentazon
Azinphos-methyl	Mefenoxam/Metalaxyl	Dichloran	Atrazine	
Azoxystrobin	Methiocarb	Dichlobenil	Bromacil	
Bensulide	Metolachlor	Disulfoton	DACT [2]	
Bromacil	Metribuzin	Ethoprophos	DEA [3]	
Carbaryl	Napropamide	Ethyl parathion	Diuron	
Carbofuran	Norflurazon	Fonofos	DSMN [4]	
Diazinon	Oryzalin	Malathion	Hexazinone	
Dimethenamide	Prometon	Methyl parathion	Norflurazon	
Dimethoate	Simazine	Phorate	Prometon	
Diuron	Tebuthiuron	Piperonyl butoxide	Simazine	
Ethofumesate	Thiamethoxam	Prometryn	Tebuthiuron	
Fenamiphos	Thiobencarb	Propanil	Propazine	
Fludioxonil	Uniconizole	Triallate		
Imidacloprid				

[1] ACET: deisopropyl atrazine; degradate of atrazine and simazine

[2] DACT: diaminochlortriazine; degradate of simazine

[3] DEA: deethyl atrazine; degradate of atrazine

[4] DSMN: desmethyl norflurazon; degradate of norflurazon

Analytical Methods

The California Department of Food and Agriculture (CDFA) Center for Analytical Chemistry performed the chemical analysis. CDFA analyzed samples for bentazon using method EM-5.5 (CDFA, 2015). Samples were also analyzed using Triazine Screen method EMON-SM-62.9 (CDFA, 2009) and Multi-Analyte Screen method EMON-SM-05-032 (CDFA, 2013) (Table 2). The current version of the PCPA no longer requires confirmation of pesticide detections in at least two discrete well samples or verification of a pesticide detection by a second analytical method or analytical laboratory. The PCPA allows a finding of an active ingredient or its degradates in groundwater by a single analytical laboratory using a single analytical method if the method is approved by DPR and provides unequivocal identification of those chemicals. The method for bentazon, EM-5.5, was determined by DPR to provide unequivocal identification of bentazon in groundwater (Aggarwal, 2017). The other analytical methods used in this study have also been determined by DPR to be unequivocal (Fattah, 2008; Aggarwal, 2016). The updates to the PCPA and the unequivocal determinations supersede the information in SOP QAQC001.00 (Segawa, 1995) regarding verification requirements. The SOP was recently updated to reflect the changes in the PCPA verification requirements that were followed but were not documented in the SOP at the time of the study (SOP QAQC001.01 [Peoples, 2019]).

Quality Assurance and Quality Control

CDFA Center for Analytical Chemistry (CAC) analyzed continuing quality control samples with every set of samples to assess lab precision. Procedures for continuing quality control (QC) measures are specified in SOP QAQC001.01 (Peoples, 2019). During sample analysis for each extraction set (a group of samples extracted and processed at the same time), the laboratory simultaneously analyzed a lab matrix-blank and a continuing QC matrix-spike. The lab matrix-blank is a sample of analyte-free groundwater collected from Auburn, California. The continuing QC matrix-spike consists of the same source of analyte-free groundwater that is fortified (spiked) with all analytes on each screen. The continuing QC matrix-spikes were evaluated by laboratory chemists, the CDFA CAC Quality Assurance Program, and by the EM QC Officer to ensure analytical integrity. The evaluation includes comparing the continuing QC matrix-spike recoveries to control limits set at 2-times and 3-times the standard deviation of the method validation data for each analyte fortified. Recoveries from the continuing QC were used to assess and monitor ongoing sample analysis and random variation was expected. Blind spikes were also submitted to the lab disguised as a field samples; a blind spike consists of the analyte-free groundwater (matrix-blank sample) fortified with the chosen analytes.

RESULTS

Quality Assurance and Quality Control

For this study, the lab matrix-blanks were all non-detects, and the continuing QC and blind spikes were all within control limits. A summary of QC results is shown in Table 3. Results for continuing QC of bentazon are shown in Table 4. Continuing QC for the Triazine and Multi-Analyte Screens are available upon request. Blind spike results for all spiked analytes are shown in Table 5.

Table 3. Laboratory quality control (QC) summary for 27 extraction sets.

QC Type	Total Number	Number Out of Control Limits
Lab matrix-blanks	27	All ND
Continuing QC matrix-spikes	27	0
Blind spikes	16	0

ND = No detection found above the method detection limit and below the reporting limit

Table 4. Continuing quality control (QC) results for bentazon from CDFA laboratory. One continuing QC matrix-spike was analyzed with each extraction set.

Extraction Date	Extraction Set [Blind Spikes in Brackets]	Spiked Level (ppb)	Results (ppb)	% Recovery
11/02/2015	[083], 090, 097, 118, 125 139, 146, 153	0.150	0.125	83.3
01/21/2016	102	0.150	0.162	108
10/11/2016	191, 170, 132, 226	0.150	0.122	81.3
11/04/2016	196, 175, 137, 194, 173, 135, 226	0.150	0.140	93.3
01/19/2017	300, 307, 314, 321, [342], 370, 384, 405	0.150	0.118	78.7
05/31/2017	328, 335, 356, 363, 412, 440	0.150	0.155	103
06/21/2017	337, [447]	0.150	0.146	97.0
10/19/2017	450, 457, 464, 471, 478, 485, 492, 449, 506, [520]	0.150	0.127	85.0
			Average Recovery	**91.2%**
			Deviation	**10.8%**
			Upper Control Limit	**141%**
			Lower Control Limit	**64.8%**

Table 5. Blind spike levels and recoveries.

Sample #	Extraction Date	Analysis Screen	Analyte	Spike Level (ppb)	Result (ppb)	% Recovery	Control Limit Exceeded?
83	11/2/2015	Bentazon	Bentazon	0.150	0.125	83.3%	No
226	10/20/2016	Bentazon	Bentazon	0.150	0.122	81.3%	No
227	10/12/2016	Triazine	Bromacil	0.150	0.157	105%	No
			Diuron	0.200	0.200	100%	No
			Norflurazon	0.250	0.250	96.0%	No
342	1/19/2017	Bentazon	Bentazon	0.150	0.127	84.7%	No
344	1/24/2017	Multi-Analyte	Imidacloprid	0.200	0.194	97.0%	No
351	5/30/2017	Multi-Analyte	Prometryn	0.250	0.273	109%	No
			Dichlobenil	0.150	0.114	76.0%	No
357-A	5/30/2017	Multi-Analyte	Carbaryl	0.200	0.152	76.0%	No
			Imidacloprid	0.250	0.211	84.4%	No
			Methiocarb	0.150	0.117	78.0%	No
449	6/20/2017	Multi-Analyte	Diuron	0.150	0.175	116%	No
			Linuron	0.200	0.197	98.5%	No
			Tebuthiuron	0.100	0.109	109 %	No
447	6/21/2017	Bentazon	Bentazon	0.250	0.213	85.2%	No
522	10/16/2017	Multi-Analyte	Bromacil	0.250	0.270	108 %	No
			Imidacloprid	0.300	0.280	93.3%	No
			Oryzalin	0.200	0.148	74.0%	No
			Malathion	0.250	0.162	64.8%	No
520	10/19/2017	Bentazon	Bentazon	0.250	0.180	72.0%	No

Sample Analysis

Complete sample analysis results for the Bentazon and Triazine Screens are shown in Appendix 1, Tables A1-1 and A1-2, respectively. Complete sample analysis results for the LCMS and GCMS Multi-Analyte Screen are shown in Appendix 1, Tables A1-3 and A1-4, respectively. A summary of the sample analysis results for detections above the reporting limit is shown in Table 6.

Table 6. Summary of pesticide or degradate detections above the reporting limit.

County	Number of Wells Sampled	Detections	Active Ingredient Detected
Modoc	9	3	Bentazon, Bromacil
Monterey	14	1	DACT
San Luis Obispo	2	0	None
Santa Barbara	7	1	Diuron
Siskiyou	1	0	None

Detections above the Reporting Limit

The locations and concentrations of all pesticides detected above the reporting limit are shown in Table 7.

There were two detections of bentazon above the reporting limit (0.1 ppb) in Modoc County. The concentrations of bentazon in these wells were 0.139 and 0.199 ppb (Figure 3). These detections occurred in two neighboring sections that were not previously Ground Water Protection Areas (GWPAs) nor adjacent to current GWPAs. Under the groundwater pesticide detection response process, to establish new GWPAs in sections not adjacent to current GPWAs, two or more wells within a four-section area (within a single section, two diagonally touching sections, or two adjacent sections) must have 6800(a) or degradate detections (Ross et al., 2011). Bentazon is a 6800(a)-listed chemical, thus, it is recommended that DPR establish sections 25M47N05E10 and 25M47N05E15 as GWPAs.

There was one detection of bromacil (a 6800[a]-listed chemical) in Modoc County, one detection of DACT (a degradate of atrazine or simazine, both 6800[a]-listed chemicals) in Monterey County, and one detection of diuron (a 6800[a]-listed chemical) in Santa Barbara County. The locations and concentrations of all pesticides detected are shown in Table 7. All of these detections were below the human health levels outlined in Table 8. None of these detections occurred in current GWPAs or in sections adjacent to current GWPAs. Based on the criteria for establishing new GWPAs outlined above, it is recommended that follow-up sampling be conducted to determine if the detections meet the criteria to establish new GWPAs.

Table 7. Locations and concentrations of pesticides detected above the reporting limit in the study.

Pesticide	COMTRS	Location Code	Concentration (ppb)
Bentazon	25M47N05E10	25-02	0.139
Bentazon	25M47N05E15	25-10	0.199
Bromacil	25M48N05E28	25-05	0.072
DACT	27M19S06E01	27-06	0.068
Diuron	42S10N34W17	42-05	0.082

Table 8. Human health levels for detected pesticides.

Pesticide	Primary Agricultural Uses	Drinking Water Limits (ppb)			
		MCL*	Chronic HHBP†	PHG‡	DWEL HA[1]
Bentazon	Herbicide: Peas, Beans, and Mint	18	-	200	1000
Bromacil	Herbicide: Rights-of-way (roadside)	-	-	-	3500
DACT	Degradate of Atrazine	-	12	-	-
Diuron	Herbicide	-	-	-	100

*MCL: Maximum Contaminant Level: The highest level of a contaminant allowed in drinking water. This is an enforceable standard set by the California State Water Resources Control Board (SWRCB, 2019).

†Chronic HHBP: Chronic Human Health Benchmarks for Pesticides: Levels of certain pesticides in water at or below which adverse health effects are not anticipated from lifetime exposure (non-cancer). These levels are set by the U.S. EPA (USEPA, 2020).

‡PHG: Public Health Goal: At this concentration, drinking water contaminants pose no significant health risk if consumed for a lifetime. These levels are set by the California Office of Environmental Health Hazard Assessment (OEHHA, 2020).

[1] DWEL HA: A Drinking Water Equivalent Level (DWEL) is a lifetime exposure level, assuming 100% exposure from drinking water, at or below which adverse, non-carcinogenic health effects would not be expected to occur. (USEPA, 2018).

Trace Detections

Trace detections are detections below the reporting limit but above the method detection limit. Trace detections do not trigger any regulatory processes or response but can serve as a good indicator of areas that may need follow-up or future groundwater monitoring. Table 9 lists the locations and concentrations of all chemicals detected above the method detection limit but below the reporting limit.

There were two trace detections of bentazon in Modoc County. One of these detections is located in the same section as a detection above the reporting limit (this section is already recommended to become a GWPA). The other trace detection of bentazon is located in a section adjacent to a detection above the reporting limit, but, as a trace detection, it does not meet the criteria to establish a GWPA. However, since this trace detection is situated near a quantifiable detection, follow-up monitoring in the area should be conducted to determine if further regulatory action is required.

There were also trace detections of imidacloprid (Santa Barbara), norflurazon (Santa Barbara), mefenoxam/metalaxyl (Monterey), and simazine (Monterey) (Table 9). These chemicals, except for mefenoxam/metalaxyl, have previously been detected in California groundwater. None of these detections are located in GWPAs. Follow-up or future monitoring in these areas may be warranted to determine if further regulatory action is required.

Table 9. Locations and concentrations of trace detections (TR).

Pesticide	COMTRS	Location Code	Concentration (ppb)
Imidacloprid	42S10N34W17	42-05	TR
Norflurazon	42S10N34W17	42-05	TR
Mefenoxam/Metalaxyl	27M19S07E05	27-11	TR
Simazine	27M19S06E01	27-06	TR
Simazine	27M15S04E22	27-01	TR
Bentazon	25M47N05E04	25-11	TR (0.06)
Bentazon	25M47N05E10	25-12	TR (0.059)

CONCLUSIONS

After sampling 32 wells in four counties with high bentazon use, two detections of bentazon met the criteria to establish two new GWPAs. Given the new detections of bentazon in groundwater in non-rice growing areas and the continued rise of bentazon use, the GWPP will continue to monitor for bentazon. The GWPP requested that the CDFA laboratory modify and validate the Multi-Analyte Screen to add bentazon to facilitate continued statewide monitoring.

The detection each of diuron, DACT, and bromacil and the trace detections of imidacloprid, norflurazon, mefenoxam/metalaxyl, and simazine indicate that follow-up sampling may be needed to determine if further regulatory action is required.

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FIGURES

Figure 1. Statewide use of bentazon per year (CDPR, 2015a).

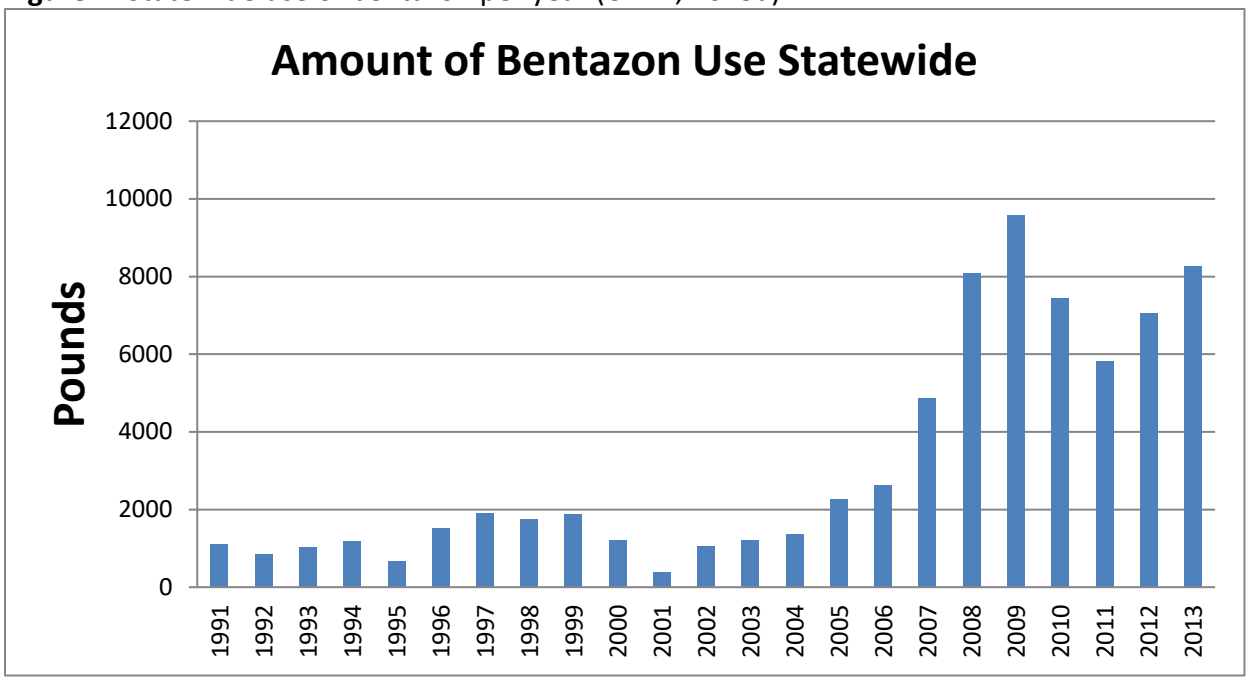


Figure 2. Amount of bentazon applied by county per year (CDPR, 2015a).

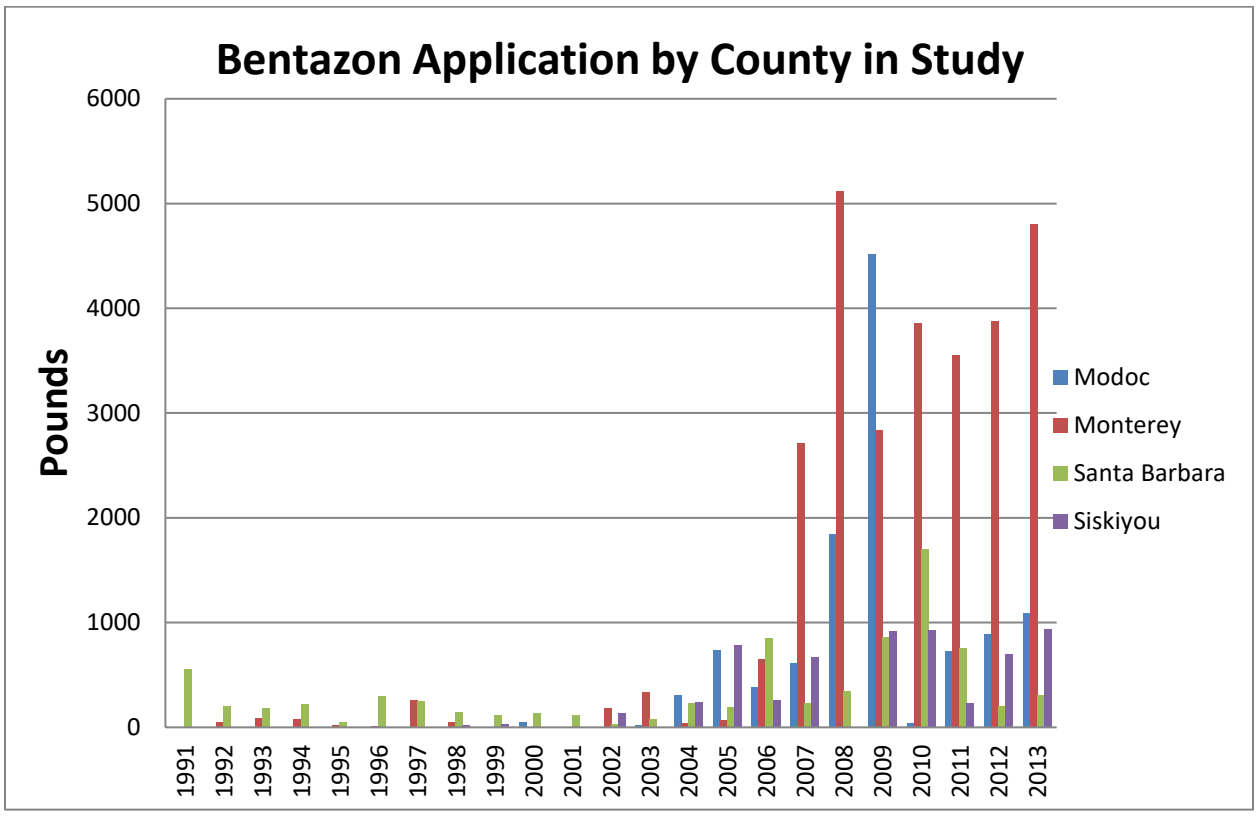


Figure 3. Bentazon use per section in Modoc and Siskiyou counties (CDPR, 2015a).

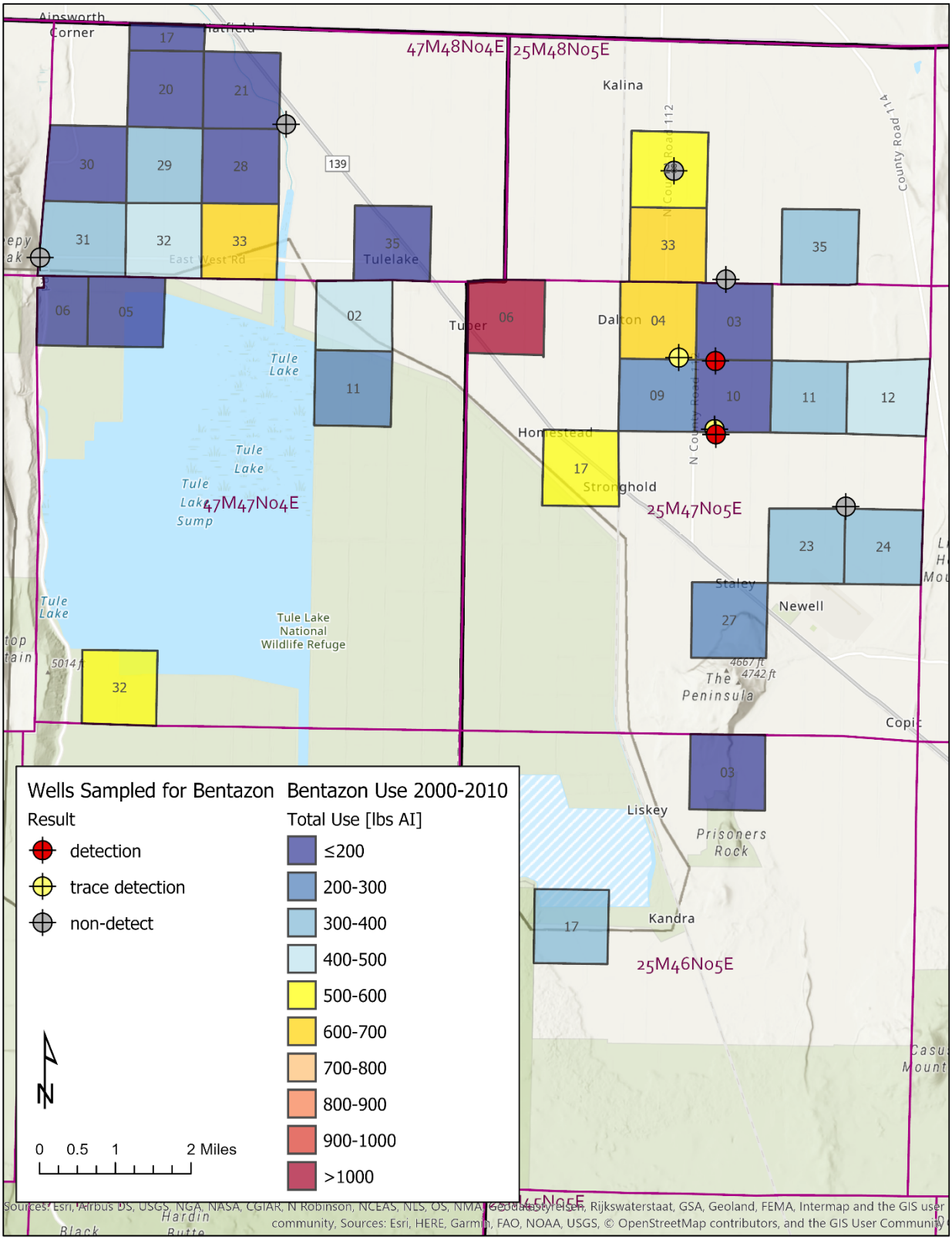


Figure 3. Bentazon use per section in Modoc and Siskiyou counties (CDPR, 2015a).
Accommodated for visual impairment.

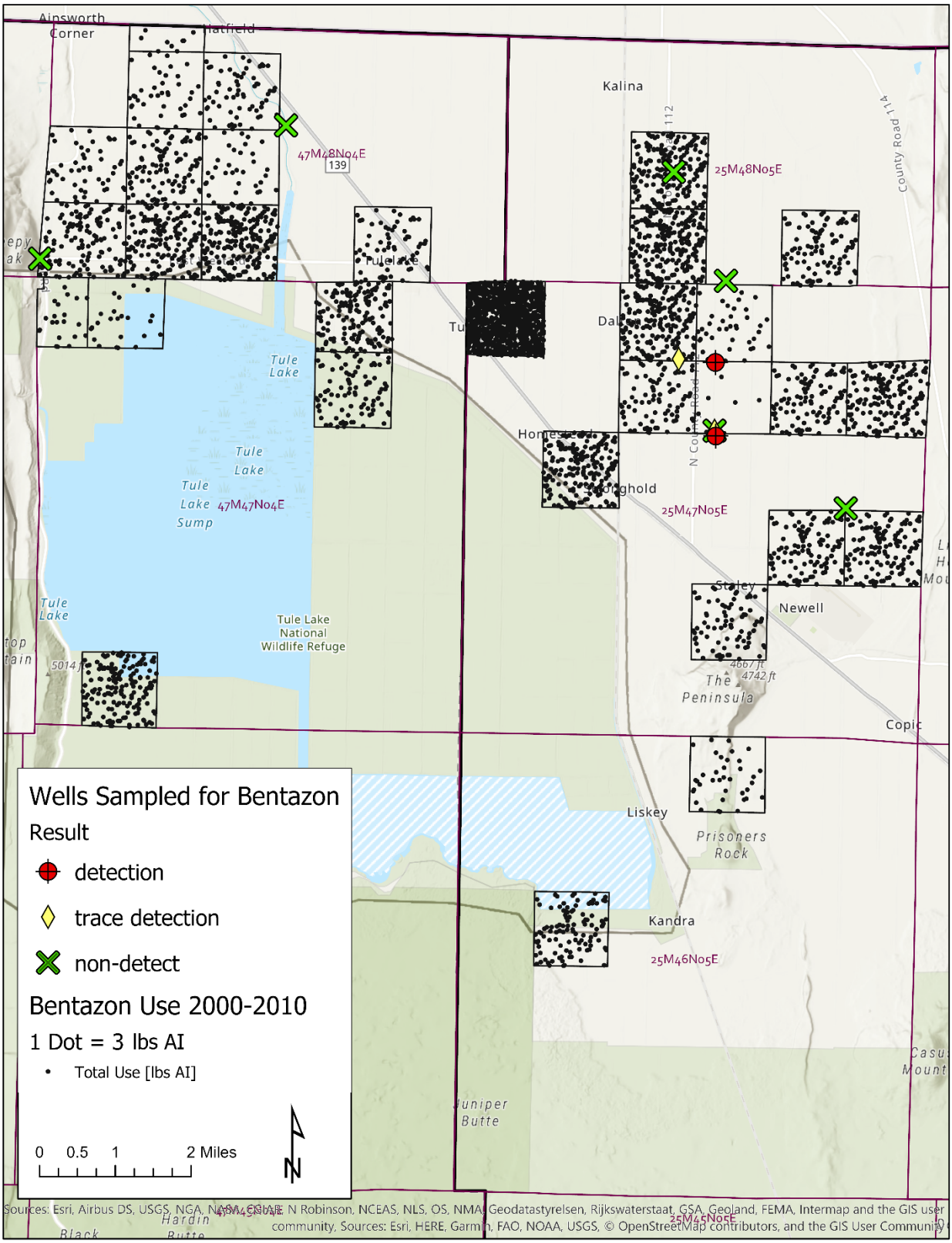


Figure 4. Bentazon use per section in Monterey County (CDPR, 2015a).

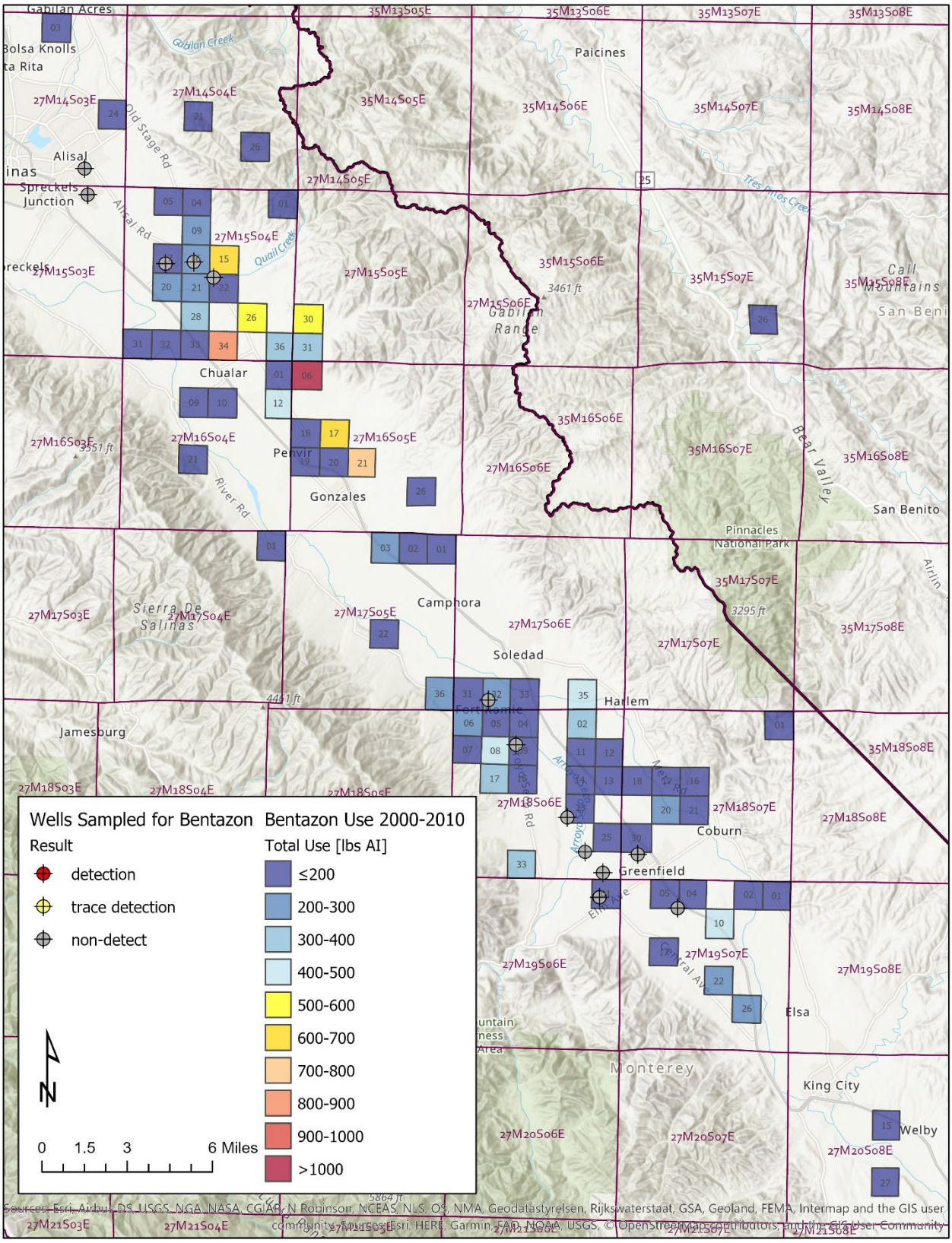


Figure 4. Bentazon use per section in Monterey County (CDPR, 2015a).
Accommodated for visual impairment.

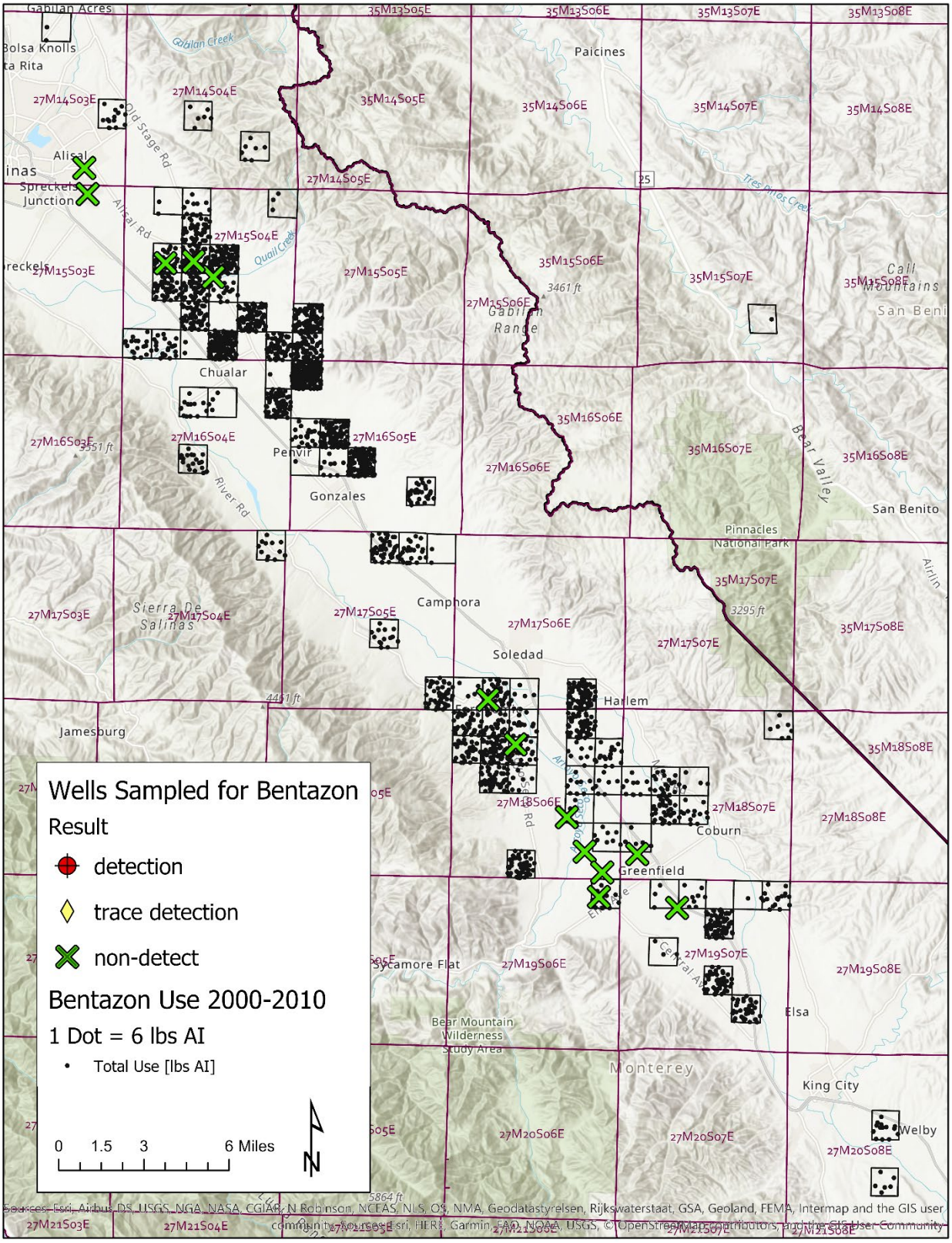


Figure 5. Bentazon use per section in San Luis Obispo and Santa Barbara counties (CDPR, 2015a).

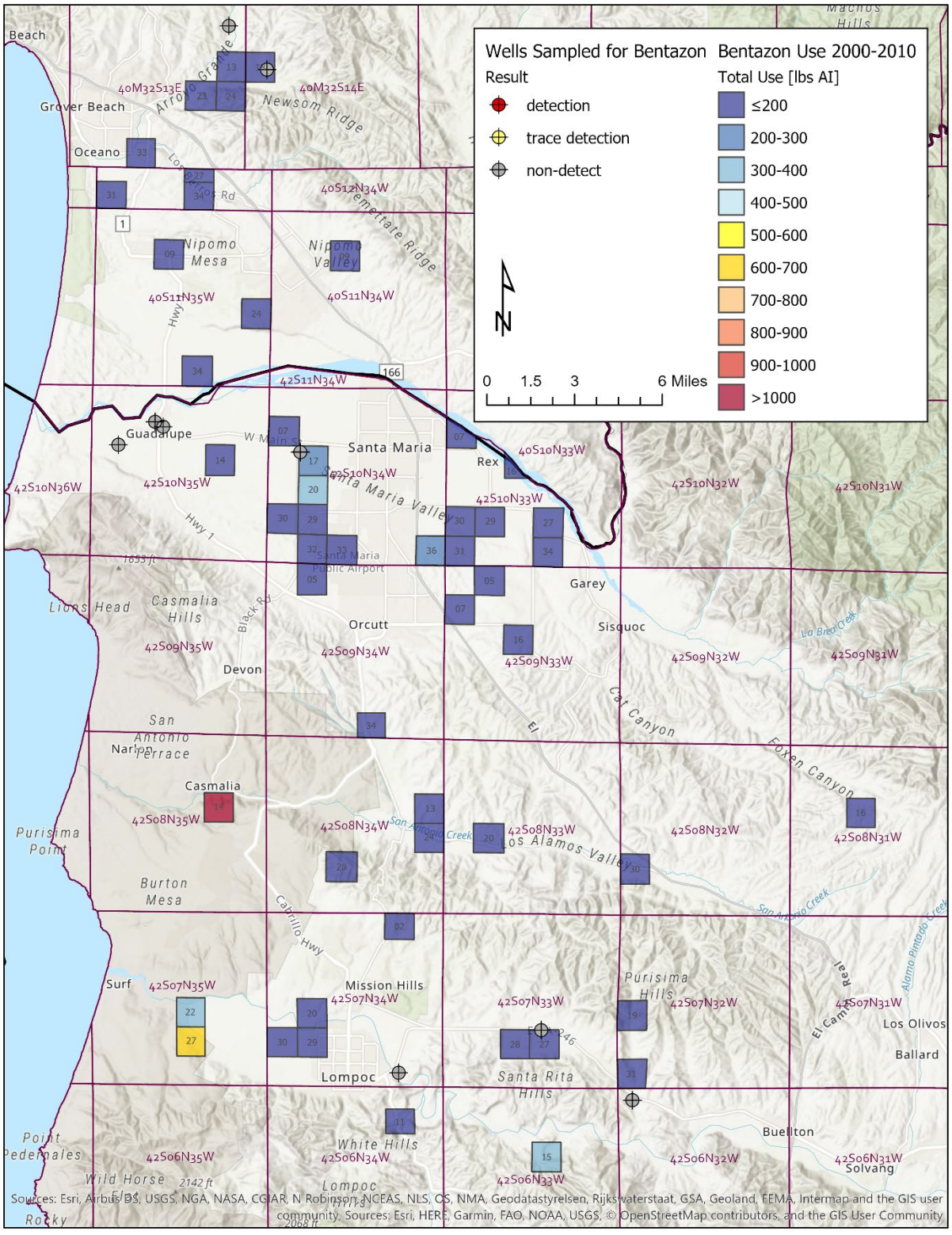
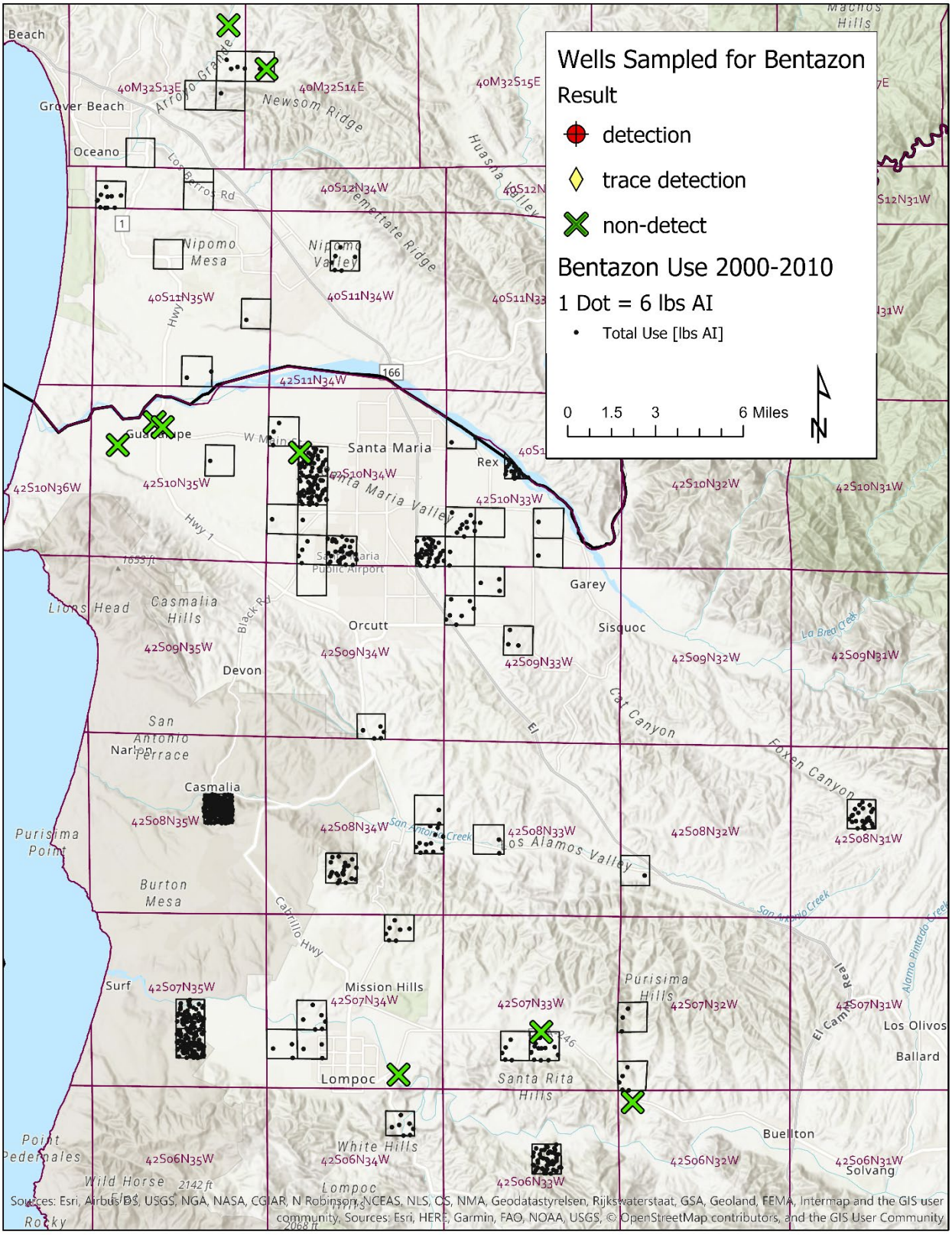


Figure 5. Bentazon use per section in San Luis Obispo and Santa Barbara counties (CDPR, 2015a). *Accommodated for visual impairment.*



APPENDIX 1: SAMPLE ANALYSIS RESULTS

Table A1-1. Bentazon Screen sample analysis results. TR refers to trace detections that are below the reporting limit of 0.1 ppb for bentazon.

Sample Number	Sample Code	County	Township/Range/Section	Location Code	Sample Date	Analysis Date	Bentazon
90	P1	47	48N04E31	25-07	10/28/2015	11/4/2015	ND
153	P1	25	47N05E13	25-03	10/27/2015	11/4/2015	ND
97	P1	25	47N05E10	25-02	10/27/2015	11/4/2015	0.139
146	P1	25	47N05E10	25-01	10/27/2015	11/4/2015	ND
139	P1	25	48N05E34	25-04	10/27/2015	11/4/2015	ND
125	P1	25	48N05E28	25-05	10/27/2015	11/4/2015	ND
118	P1	25	48N04E22	25-06	10/27/2015	11/4/2015	ND
102	FB1	25	47N05E10	25-02	10/27/2015	1/25/2016	ND
191	P1	25	47N05E15	25-10	10/5/2016	10/20/2016	0.199
170	P1	25	47N05E04	25-11	10/5/2016	10/20/2016	TR (0.06)
194	BuBTR	25	47N05E04	25-10	10/5/2016	11/15/2016	TR (0.056)
173	BuBTR	25	47N05E04	25-11	10/5/2016	11/15/2016	TR (0.066)
196	FB1	25	47N05E15	25-10	10/5/2016	11/5/2016	ND
175	FB1	25	47N05E04	25-11	10/5/2016	11/15/2016	ND
132	P1	25	47N05E10	25-12	10/6/2016	10/20/2016	TR (0.059)
137	FB1	25	47N05E10	25-12	10/6/2016	11/15/2016	ND
135	BuBTR	25	47N05E10	25-12	10/16/2016	11/15/2016	ND
314	P1	27	15S04E22	27-01	1/9/2017	1/31/2017	ND
370	P1	27	19S07E05	27-02	1/10/2017	1/31/2017	ND
405	P1	27	16S05E18	27-03	1/11/2017	1/31/2017	ND
321	P1	27	18S06E09	27-04	1/12/2017	1/31/2017	ND
307	P1	27	17S06E32	27-05	1/12/2017	1/31/2017	ND
300	P1	27	19S06E01	27-06	1/12/2017	1/31/2017	ND
384	P1	27	18S06E23	27-07	1/12/2017	1/31/2017	ND
440	P1	27	14S03E35	27-08	5/22/2017	6/1/2017	ND
335	P1	27	18S07E31	27-10	5/23/2017	6/1/2017	ND
356	P1	27	18S06E36	27-09	5/23/2017	6/1/2017	ND
328	P1	27	19S07E05	27-11	5/24/2017	6/1/2017	ND
363	P1	27	15S04E16	27-13	5/24/2017	6/1/2017	ND
412	P1	27	15S04E17	27-14	5/25/2017	6/1/2017	ND
377	P1	27	15S03E02	27-15	6/15/2017	6/22/2017	ND
478	P1	42	07N34W35	42-03	10/9/2017	10/30/2017	ND
485	P1	42	07N33W27	42-02	10/9/2017	10/30/2017	ND
492	P1	42	06N32W06	42-01	10/9/2017	10/30/2017	ND
464	P1	42	10N34W18	42-04	10/10/2017	10/30/2017	ND
471	P1	42	10N34W14	42-05	10/10/2017	10/30/2017	ND
450	P1	40	32S13E01	40-01	10/11/2017	10/30/2017	ND
506	P1	40	32S14E18	40-02	10/11/2017	10/30/2017	ND
457	P1	42	10N35W09	42-07	10/12/2017	10/30/2017	ND
499	P1	42	10N35W09	42-06	10/12/2017	10/30/2017	ND

ND = No detection found above the method detection limit and below the reporting limit of 0.1 ppb

Table A1-2. Triazine Screen sample analysis results. TR refers to trace detections that are below the reporting limit of 0.05 ppb for each analyte.

Sample Number	Sample Code	County	Township/Range /Section	Location Code	Sample Date	Analysis Date	ACET	Atrazine	Bromacil	DACT	DEA	Diuron	DSMN	Hexazinone	Norflurazon	Prometon	Simazine	Tebuthiuron	Propazine %
98	P2	25	47N05E10	25-02	10/27/2015	11/3/2015	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	91
119	P2	47	48N04E22	25-06	10/27/2015	11/3/2015	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	79
126	P2	25	48N05E28	25-05	10/27/2015	11/3/2015	ND	ND	0.072	ND	ND	ND	ND	ND	ND	ND	ND	ND	84
140	P2	25	48N05E34	25-04	10/27/2015	11/3/2015	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	84.5
147	P2	25	47N05E10	25-01	10/27/2015	11/3/2015	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	90
154	P2	25	47N05E13	25-03	10/27/2015	11/3/2015	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	82.5
84	P2	47	48N04E33	25-08	10/28/2015	11/3/2015	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	90
91	P2	47	48N04E31	25-07	10/28/2015	11/3/2015	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	87.5
192	P2	25	47N05E15	25-10	10/5/2016	11/12/2016	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	75
171	P2	25	47N05E04	25-11	10/5/2016	10/12/2016	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	81
133	P2	25	47N05E10	25-12	10/6/2016	10/12/2016	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	93.5
315	P2	27	15S04E22	27-01	1/9/2017	1/19/2017	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	TR	ND	105
371	P2	27	19S07E05	27-02	1/10/2017	1/19/2017	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	100
406	P2	27	16S05E18	27-03	1/11/2017	1/19/2017	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	95.5
301	P2	27	19S06E01	27-06	1/12/2017	1/19/2017	ND	ND	ND	0.068	ND	ND	ND	ND	ND	ND	TR	ND	95
308	P2	27	17S06E32	27-05	1/12/2017	1/19/2017	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	91.5
322	P2	27	18S06E09	27-04	1/12/2017	1/19/2017	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	96.5
385	P2	27	18S1623	27-07	1/12/2017	1/19/2017	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	101
336	P2	27	18S07E31	27-10	5/23/2017	7/12/2017	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	72
357	P2	27	18S06E36	27-09	5/23/2017	7/12/2017	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	73
329	P2	27	19S07E05	27-11	5/24/2017	7/12/2017	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	71.5
364	P2	27	15S04E16	27-13	5/24/2017	7/12/2017	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	91
413	P2	27	15S04E17	27-14	5/25/2017	7/12/2017	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	78
441	P2	27	14S03E35	27-08	5/25/2017	7/12/2017	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	76
378	P2	27	15S03E02	27-15	6/15/2017	7/14/2017	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	94
479	P2	42	07N34W35	42-03	10/9/2017	10/16/2017	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	73.5
486	P2	42	07N33W27	42-02	10/9/2017	10/16/2017	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	84.5
493	P2	42	06N32W06	42-01	10/9/2017	10/16/2017	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	79.5
465	P2	42	10N34W18	42-04	10/10/2017	10/16/2018	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	71
472	P2	42	10N34W17	42-05	10/10/2017	10/16/2017	ND	ND	ND	ND	ND	0.082	ND	ND	ND	ND	ND	ND	69.5
476	FB1	42	10N34W14	42-05	10/10/2017	11/15/2017	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	82
451	P2	40	32S13E01	40-01	10/11/2017	10/16/2017	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	77
458	P2	42	10N35W09	42-07	10/12/2017	10/16/2017	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	78.5
500	P2	42	10N35W09	42-06	10/12/2017	10/16/2017	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	89.5
507	P2	40	32S14E18	40-02	10/12/2017	10/16/2017	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	67

ND = No detection found above the method detection limit and below the reporting limit of 0.05 ppb for each analyte

Table A1-3. LCMS Multi-Analyte Screen sample analysis results. TR refers to trace detections that are below the reporting limit of 0.05 ppb for each analyte.

Sample Number	Sample Code	County	Township/Range/ Section	Location Code	Sample Date	Analysis Date	Atrazine	Azinphos-Methyl	Azoxystrobin	Bensulide	Bromacil	Carbaryl	Carbofuran	Diazinon	Dimethenamide	Dimethoate	Diuron	Ethofumesate	Fenamiphos	Fludioxonil	Imidacloprid	Linuron	Mefenoxam/Metalaxyl	Methiocarb	Metolachlor	Metribuzin	Napropamide	Norflurazon	Oryzalin	Prometon	Simazine	Tebuthiuron	Thiamethoxam	Thiobencarb	Uniconizole
193	P3	25	47N05E15	25-10	10/5/2016	10/13/2016	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
172	P3	25	47N05E04	25-11	10/5/2016	10/13/2016	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
134	P3	25	47N05E10	25-12	10/6/2016	10/13/2016	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
92	P3	47	47N04E31	25-07	10/28/2015	11/3/2015	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
99	P3	25	47N05E10	25-02	10/27/2015	11/3/2015	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
120	P3	25	48N04E22	25-06	10/27/2015	11/3/2015	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
127	P3	25	48N05E28	25-05	10/27/2015	11/3/2015	ND	ND	ND	ND	**0.133**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
141	P3	25	48N05E34	25-04	10/27/2015	11/3/2015	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
148	P3	25	47N05E10	25-01	10/27/2015	11/3/2015	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
155	P3	25	47N05E13	25-03	10/27/2015	11/3/2015	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
452	P3	40	32S13E01	40-01	10/11/2017	10/16/2017	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
459	P3	42	10N35W09	42-07	10/12/2017	10/16/2017	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
466	P3	42	10N34W18	42-04	10/10/2017	10/16/2017	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
473	P3	42	10N34W17	42-05	10/10/2017	10/16/2017	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	**0.189**	ND	ND	ND	**TR**	ND	ND	ND	ND	ND	ND	**TR**	ND	ND	ND	ND	ND	ND	ND
480	P3	42	07N34W35	42-03	10/9/2017	10/16/2017	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
487	P3	42	07N33W27	42-02	10/9/2017	10/16/2017	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
494	P3	42	06N32W06	42-01	10/9/2017	10/16/2017	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
501	P3	42	10N35W09	42-06	10/12/2017	10/16/2017	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
508	P3	40	32S14E18	40-02	10/11/2017	10/16/2017	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
379	P3	27	15S03E02	27-15	6/15/2017	6/20/2017	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
330	P3	27	19S07E05	27-11	5/24/2017	5/30/2017	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	**TR**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
337	P3	27	18S07E31	27-10	5/23/2017	5/30/2017	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
358	P3	27	18S06E36	27-09	5/23/2017	5/30/2017	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
365	P3	27	15S04E16	27-13	5/24/2017	5/30/2017	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
414	P3	27	15S04E17	27-14	5/25/2017	5/30/2017	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
442	P3	27	14S03E35	27-08	5/22/2017	5/30/2017	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
302	P3	27	19S06E01	27-06	1/12/2017	1/24/2017	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	**TR**	ND	ND	ND	ND
309	P3	27	17S06E32	27-05	1/12/2017	1/24/2017	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
316	P3	27	15S04E22	27-01	1/9/2017	1/24/2017	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
323	P3	27	18S06E09	27-04	1/12/2017	1/24/2017	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
372	P3	27	19S07E05	27-02	1/10/2017	1/24/2017	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	**TR**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
386	P3	27	18S06E23	27-07	1/12/2017	1/24/2017	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
407	P3	27	16S05E18	27-03	1/11/2017	1/24/2017	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
305/ 306	FB1/ FB2	27	19S06E01	27-06	1/12/2017	3/22/2017	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
131	FB2	25	48N05E28	25-05	10/27/2015	12/30/2015	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
477	FB2	42	10N34W14	42-05	10/10/2017	11/28/2017	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

ND = No detection found above the method detection limit and below the reporting limit of 0.05 ppb for each analyte

Table A1-4. GCMS Multi-Analyte Screen sample analysis results.

Sample Number	Sample Code	County	Township/Range/ Section	Location Code	Sample Date	Analysis Date	Clomazone	Dichloran	Dichlobenil	Disulfoton	Ethoprophos	Ethyl Parathion	Fonofos	Malathion	Methyl Parathion	Phorate	Piperonyl Butoxide	Prometryn	Propanil	Triallate
442	P3	27	14S03E35	27-08	5/22/2017	5/30/2017	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
337	P3	27	18S07E31	27-10	5/23/2017	5/30/2017	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
358	P3	27	18S06E36	27-09	5/23/2017	5/30/2017	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
330	P3	27	19S07E05	27-11	5/24/2017	5/30/2017	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
365	P3	27	15S04E16	27-13	5/24/2017	5/30/2017	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
379	P3	27	15S03E02	27-15	6/15/2017	6/20/2017	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
480	P3	42	07N34W35	42-03	10/9/2017	10/16/2017	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
487	P3	42	07N33W27	42-02	10/9/2017	10/16/2017	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
494	P3	42	06N32W06	42-01	10/9/2017	10/16/2017	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
466	P3	42	10N34W18	42-04	10/10/2017	10/16/2017	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
473	P3	42	10N34W14	42-05	10/10/2017	10/16/2017	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
477	FB2	42	10N34W14	42-05	10/10/2017	11/28/2017	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
452	P3	40	32S13E01	40-01	10/11/2017	10/16/2017	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
508	P3	40	32S14E18	40-02	10/11/2017	10/16/2017	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
459	P3	42	10N35W09	42-07	10/12/2017	10/16/2017	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
501	P3	42	10N35W09	42-06	10/12/2017	10/16/2017	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

ND = No detection found above the method detection limit and below the reporting limit of 0.05 ppb for each analyte