2016 Monitoring Report Executive Summary

Sampling Logistics

The Agricultural Chemicals & Groundwater Protection Program (Program) sampled groundwater in the following networks in 2016: Front Range Urban (FRU), Lower South Platte (LSP), Arkansas River Basin (ARB), San Luis Valley (SLV), and Weld County (WC). Sample numbers for the networks were: 63 FRU, 23 LSP, 18 ARB, 39 SLV, and 33 WC. Additionally, the Program assisted the City of Burlington, CO with collection of groundwater samples to help determine the cause of elevated nitrate levels impacting several of the city's public supply wells. The Program also continued its investigation into the feasibility of using the HydraSleeve™ as an alternative sampling method for the collection of groundwater samples from monitoring wells (MW). While 36 sites from the FRU, LSP, and ARB networks were sampled to compare the HydraSleeve to the ACGPP's traditional sampling methods, only data from the traditional sampling methods at those sites are considered in this summary and have been uploaded to the online database.

Laboratory Logistics

The CDA's Biochemistry Lab analyzed for a suite of seven anions and 101 pesticide compounds. All samples were analyzed for these constituents except for the WC irrigation wells (anions only), and the WC domestic wells (no glyphosate or AMPA). Split samples collected as part of the City of Burlington study were sent to the *Stable Isotope Lab* at the University of California at Davis for ^{15}N and ^{18}O determination; and to the *ICPMS Laboratory* at the University of Utah for analysis of the isotopes ^{11}B and ^{87}Sr along with 27 other elemental constituents.

Sampling Results (Tables 1-3)

WC: Historical nitrate-nitrogen (NO_3-N) values in the MW network since 1992 have a median of 19.8 mg L^{-1} or parts-per-million (ppm) with a range of 0.6-111.3 ppm. Sampling of the MW network (23 sites) in 2016 was conducted exclusively with the HydraSleeve™ and the resulting median NO_3-N of 21.2 ppm falls within a 95% confidence interval around the historical median of 19.2-21.5 ppm. Most wells did not deviate significantly from their long-term record. However, three wells that typically have elevated NO_3-N had less than 2.0 ppm NO_3-N. These results were determined to be reasonable and the deviation seen in 2016 was likely a result of natural variability rather than being due to use of the HydraSleeve™. Nitrate results for the seven domestic and three irrigation wells that were sampled, are consistent with past results for those wells.

Since 2012, the Program has analyzed for dissolved orthophosphate (*d*Ort-PO_4) as elevated *d*Ort-PO_4 concentrations have potential to cause water quality issues. It is uncharacteristic for *d*Ort-PO_4 to leach into groundwater and therefore unusual that it is consistently showing up in some wells at concentrations upwards of 1.0 ppm as P; often located near seeping canals or ditches conveying South Platte River water for irrigation. The Program plans to take a closer look into the fate and transport of *d*Ort-PO_4 in the shallow groundwater system.

A total of 95 detections of 17 different pesticide active ingredients were reported in 2016 using the HydraSleeve™. This is comparable to results seen in Weld County MWs since the pesticide screening list was expanded to around 100 compounds in 2009. Metolachlor ESA (MESA) and metolachlor OA (MOA) (breakdown products of metolachlor) accounted for about 41% of all detections and MESA's 96% detection frequency has been the norm since analysis for the compound began in 2009. No pesticide active ingredients were detected in the domestic wells that were sampled.

FRU: This year was the fourth sampling effort in this network since it was expanded in 2008, and is the seventh overall effort by the Program concentrated in urban areas. The majority of the anion results are comparable to historical results. One notable observation is that the median NO_3-N of 11.8 ppm from the ten wells sampled in Colorado Springs was the highest median seen for that portion of the network since sampling began back in 2008. A total of 42 detections of 12 different pesticide active ingredients were reported in 2016, with imazapyr as the most frequently detected pesticide compound.

LSP: This network's median NO_3-N of 8.8 ppm in 2016 is consistent with the long-term median of 8.3 ppm. Nine sites had measurable *d*Ort-PO_4 which is similar to the detection frequency seen in Weld County MWs. A total of 58 detections of 14 different pesticide active ingredients were reported and the most frequently detected was MESA. While most of the wells average two to three pesticide detections, a well near Ovid, CO, detected ten of the fourteen different pesticide compounds discovered in the LSP in 2016.

ARB: While being distributed throughout irrigated agriculture, this network has consistently seen low nitrate concentrations and few pesticide detections. For the most part this trend continued in 2016. The most notable observation was of three wells, previously never seeing NO_3-N above 8 ppm, ranging in concentration from 11.2-18.2 ppm. The network did see its largest ever number of pesticide active ingredient detections at 25, and the most variety of detected compounds at 11.

SLV: The median NO_3-N of 2.4 ppm seen in 2016 is higher than the all-time median (1.5 ppm) for this network of domestic wells that was first established and sampled in 2009. There was a detection rate of 74% for *d*Ort-PO4 in 2016 with concentrations ranging from 0.02-0.32 ppm as P. Only 15 detections of three different pesticide active ingredients were seen with the vast majority (93%) of those being of MESA and MOA. Since 2011, these two compounds have essentially been the only two pesticide compounds discovered in the SLV.

The results of the Town of Burlington assessment are summarized in a report by Martin & Wood Water Consultants, Inc. that can be requested from the City's Manager, Steven Rabe.

No pesticide active ingredient detected in any network in 2016 exceeded any established U.S. EPA Drinking Water Standards and three-quarters of detections across all networks were below 0.5 $\mu g\ L^{-1}$ or parts-per-billion. All data seen and/or discussed in the full report can be queried and downloaded from the Program's online water quality database which can be accessed at the following URL: http://www.erams.com/co_groundwater. Program personnel contact information and other program information can be found at http://www.co.gov/ag/gw.

TABLE 1	Inorganic Nutrient Analysis Results from Various Networks Sampled in 2016							
NETWORK	**Statistic**	**Fluoride**	**Chloride**	**Nitrite-N**	**Bromide**	**Nitrate-N**	**Orthophosphate**	**Sulfate**
Front Range Urban (63)	Average	0.73	131	No Detection	0.43	6.36	0.14	675
	Minimum	0.24	8		0.09	0.12	0.06	24
	Median	0.66	104		0.26	4.56	0.12	217
	Maximum	1.63	569		2.65	32.05	0.33	7333
	# Detections	63	63		60	61	8	63
Weld County MWs (23)	Average	0.89	117	0.06	0.35	19.73	1.35	349
	Minimum	0.29	49	0.06	0.18	1.06	0.10	95
	Median	0.85	105	0.06	0.30	21.15	1.45	245
	Maximum	1.70	207	0.06	0.69	49.08	3.02	1585
	# Detections	23	23	1	23	23	11	23
Lower South Platte (23)	Average	0.93	104	0.04	0.58	9.20	0.22	471
	Minimum	0.14	7	0.02	0.10	0.02	0.06	14
	Median	0.97	103	0.04	0.65	8.75	0.24	408
	Maximum	1.50	222	0.05	1.22	43.30	0.46	1325
	# Detections	23	23	2	23	23	9	23
Arkansas River Basin (18)	Average	1.33	101	No Detection	0.50	5.43	No Detection	1393
	Minimum	0.66	18		0.06	0.02		172
	Median	1.05	45		0.18	2.66		668
	Maximum	2.60	458		3.79	18.20		7080
	# Detections	18	18		18	18		18
San Luis Valley (39)	Average	0.24	16	0.35	0.26	5.39	0.21	98
	Minimum	0.06	1	0.03	0.05	0.09	0.06	2
	Median	0.13	3	0.35	0.10	2.43	0.14	18
	Maximum	2.80	271	0.67	1.55	40.90	0.99	1489
	# Detections	32	39	2	17	35	29	38

Concentrations are mg/L or parts-per-million (ppm). **(#)** under each network indicates the number of samples collected. **# Detections** indicates the number of samples detecting the parameter. Orthophosphate represents only dissolved orthophosphate.

TABLE 2	Pesticide Compounds Detected in Various Networks Sampled in 2016			
Pesticide Active Ingredient	**Network**	**% Detection**	**Conc. Range (Median)**	**Note**
2,4-D	San Luis Valley	2.6%	0.22	U.S. EPA Drinking Water MCL 70 µg L^{-1}
Acetochlor ESA	Lower South Platte	17.4%	0.15 - 0.69 (0.34)	No Drinking Water Standard
Acetochlor OA	Lower South Platte	4.3%	0.12	No Drinking Water Standard
Alachlor ESA	Weld County MW	13.0%	0.16 - 0.65 (0.22)	No Drinking Water Standard
	Lower South Platte	47.8%	0.11 - 1.51 (0.29)	
Aminopyralid	Front Range Urban	3.1%	0.14 - 0.53 (0.34)	U.S. EPA HHBP Chronic 3,500 µg L^{-1}
Atrazine	Weld County MW	4.3%	0.34	U.S. EPA Drinking Water MCL 3.0 µg L^{-1}
	Lower South Platte	4.3%	0.91	
	Arkansas River Basin	5.9%	0.71	
Chlorantraniliprole	Weld County MW	8.7%	0.18 - 0.31 (0.25)	U.S. EPA HHBP Chronic 11,060 µg L^{-1}
Chlorsulfuron	Front Range Urban	1.6%	0.15	U.S. EPA HHBP Chronic 140 µg L^{-1}
	Weld County MW	4.3%	0.10	
Desethyl Atrazine	Front Range Urban	17.2%	0.10 - 0.36 (0.10)	No Drinking Water Standard
	Weld County MW	26.1%	0.10 - 0.17 (0.13)	
	Lower South Platte	17.4%	0.11 - 1.04 (0.27)	
	Arkansas River Basin	17.6%	0.10 - 0.32 (0.25)	
Deisopropyl Atrazine	Weld County MW	13.0%	0.11 - 0.24 (0.18)	No Drinking Water Standard
	Lower South Platte	4.3%	0.35	
	Arkansas River Basin	5.9%	0.18	
Dicamba	Weld County MW	4.3%	0.21	U.S. EPA Drinking Water HAL 4000 µg L^{-1}
Dimethenamid ESA	Weld County MW	8.7%	0.13 - 0.17	No Drinking Water Standard
	Lower South Platte	4.3%	0.36	
	Arkansas River Basin	5.9%	0.20	
Dinotefuran	Front Range Urban	1.6%	0.12	U.S. EPA HHBP Chronic 140 µg L^{-1}
Diuron	Arkansas River Basin	5.9%	0.11	No Drinking Water Standard
Hexazinone	Arkansas River Basin	5.9%	0.12	U.S. EPA Drinking Water HAL 400 µg L^{-1}
Hydroxy Atrazine	Front Range Urban	4.7%	0.04 - 0.06 (0.06)	U.S. EPA HHBP Chronic 70 µg L^{-1}
	Weld County MW	52.2%	0.04 - 0.18 (0.06)	
	Lower South Platte	21.7%	0.06 - 0.11 (0.08)	
	Arkansas River Basin	17.6%	0.04 - 0.06 (0.05)	
Imazamox	Front Range Urban	1.6%	0.11	No Drinking Water Standard
	Arkansas River Basin	11.8%	0.10 - 0.10	
Imazapic	Front Range Urban	6.3%	0.10 - 0.29 (0.14)	U.S. EPA HHBP Chronic 3,500 µg L^{-1}
	Weld County MW	8.7%	0.10 - 0.10	
Imazapyr	Front Range Urban	29.7%	0.10 - 0.57 (0.17)	U.S. EPA HHBP Chronic 17,500 µg L^{-1}
	Weld County MW	47.8%	0.10 - 0.19 (0.14)	
	Lower South Platte	4.3%	0.13	
	Arkansas River Basin	47.1%	0.10 - 0.22 (0.11)	
Imazathapyr	Arkansas River Basin	5.9%	0.21	U.S. EPA HHBP Chronic 17,500 µg L^{-1}
Imidocloprid	Front Range Urban	1.6%	0.31	U.S. EPA HHBP Chronic 339 µg L^{-1}
	Weld County MW	8.7%	0.13-0.37	
	Lower South Platte	8.7%	0.16 - 0.24	
Metolachlor	Weld County MW	26.1%	0.14 - 3.43 (0.59)	U.S. EPA Drinking Water HAL 700 µg L^{-1}
	Lower South Platte	4.3%	0.72	
Metolachlor ESA	Front Range Urban	3.1%	0.14 - 0.27	No Drinking Water Standard
	Weld County MW	95.7%	0.15 - 7.65 (2.64)	
	Lower South Platte	82.6%	0.18 - 9.69 (0.36)	
	Arkansas River Basin	17.6%	0.10 - 0.82 (0.13)	
	San Luis Valley	23.1%	0.10 - 2.63 (0.28)	
Metolachlor OA	Weld County MW	73.9%	0.14 - 3.95 (1.13)	No Drinking Water Standard
	Lower South Platte	26.1%	0.12 - 4.06 (0.37)	
	San Luis Valley	12.8%	0.11 - 2.05 (0.13)	
Nicosulfuron	Weld County MW	4.3%	0.14	U.S. EPA HHBP Chronic 8,750 µg L^{-1}
Picloram	Front Range Urban	3.1%	0.16 - 0.23	U.S. EPA Drinking Water MCL 500 µg L^{-1}
Tebuthiuron	Front Range Urban	3.1%	0.10 - 0.11	No Drinking Water Standard
Thiamethoxam	Weld County MW	13.0%	0.19 - 0.36 (0.19)	U.S. EPA HHBP Chronic 84 µg L^{-1}
	Lower South Platte	4.3%	0.28	

Conc Range (Median), concentration range for detected pesticides, and median in parentheses for 3+ detections; **HAL**, Health Advisory Level; **MCL**, Maximum Contaminant Level; **HHBP**, Human Health Benchmark for Pesticides (non-enforceable); Concentrations are in µg/L or parts-per-billion.

TABLE 3	2016 Analyte Reporting Limits from Biochemistry Laboratory in the Colorado Department of Agriculture's ICS Division						
Analyte Name	**Reporting Limit**	**Units**	**Laboratory**	**Analyte Name**	**Reporting Limit**	**Units**	**Laboratory**
2,4-D	0.1	ug/L	CDA Groundwater Lab	Imazamox	0.1	ug/L	CDA Groundwater Lab
2,4-DB	0.1	ug/L	CDA Groundwater Lab	Imazapic	0.1	ug/L	CDA Groundwater Lab
2,4-DP	0.1	ug/L	CDA Groundwater Lab	Imazapyr	0.1	ug/L	CDA Groundwater Lab
3-Hydroxycarbofuran	0.1	ug/L	CDA Groundwater Lab	Imazethapyr	0.1	ug/L	CDA Groundwater Lab
Acetochlor	0.1	ug/L	CDA Groundwater Lab	Imidacloprid	0.1	ug/L	CDA Groundwater Lab
Acetochlor ESA	0.1	ug/L	CDA Groundwater Lab	Isoxaflutole	0.1	ug/L	CDA Groundwater Lab
Acetochlor OA	0.1	ug/L	CDA Groundwater Lab	Kresoxim methyl	0.1	ug/L	CDA Groundwater Lab
Acifluorfen	0.1	ug/L	CDA Groundwater Lab	Linuron	0.5	ug/L	CDA Groundwater Lab
Alachlor	0.1	ug/L	CDA Groundwater Lab	Malathion	0.1	ug/L	CDA Groundwater Lab
Alachlor ESA	0.1	ug/L	CDA Groundwater Lab	MCPA	0.1	ug/L	CDA Groundwater Lab
Alachlor OA	0.1	ug/L	CDA Groundwater Lab	MCPP	0.1	ug/L	CDA Groundwater Lab
Aldicarb	0.1	ug/L	CDA Groundwater Lab	Metalaxyl	0.1	ug/L	CDA Groundwater Lab
Aldicarb sulfone	0.2	ug/L	CDA Groundwater Lab	Metconazole	0.1	ug/L	CDA Groundwater Lab
Aldicarb sulfoxide	0.1	ug/L	CDA Groundwater Lab	Methomyl	0.1	ug/L	CDA Groundwater Lab
Aminopyralid	0.2	ug/L	CDA Groundwater Lab	Metolachlor	0.1	ug/L	CDA Groundwater Lab
AMPA	2.0	ug/L	CDA Groundwater Lab	Metolachlor ESA	0.1	ug/L	CDA Groundwater Lab
Atrazine	0.1	ug/L	CDA Groundwater Lab	Metolachlor OA	0.1	ug/L	CDA Groundwater Lab
Azoxystrobin	0.1	ug/L	CDA Groundwater Lab	Metribuzin	0.1	ug/L	CDA Groundwater Lab
Bentazon	0.25	ug/L	CDA Groundwater Lab	Metsulfuron methyl	0.1	ug/L	CDA Groundwater Lab
Bromacil	0.2	ug/L	CDA Groundwater Lab	Nicosulfuron	0.1	ug/L	CDA Groundwater Lab
Carbaryl	0.2	ug/L	CDA Groundwater Lab	Norflurazon	0.2	ug/L	CDA Groundwater Lab
Carbofuran	0.1	ug/L	CDA Groundwater Lab	Norflurazon desmethyl	0.5	ug/L	CDA Groundwater Lab
Chlorantraniliprole	0.1	ug/L	CDA Groundwater Lab	Oxamyl	0.2	ug/L	CDA Groundwater Lab
Chlorimuron ethyl	0.1	ug/L	CDA Groundwater Lab	Oxydemeton methyl	0.1	ug/L	CDA Groundwater Lab
Chlorsulfuron	0.1	ug/L	CDA Groundwater Lab	Picloram	0.1	ug/L	CDA Groundwater Lab
Clopyralid	0.1	ug/L	CDA Groundwater Lab	Prometon	0.1	ug/L	CDA Groundwater Lab
Cyanazine	0.1	ug/L	CDA Groundwater Lab	Propazine	0.1	ug/L	CDA Groundwater Lab
Cyproconazole	0.1	ug/L	CDA Groundwater Lab	Propoxur	0.1	ug/L	CDA Groundwater Lab
Cyromazine	0.1	ug/L	CDA Groundwater Lab	Prosulfuron	0.1	ug/L	CDA Groundwater Lab
Desethyl Atrazine	0.1	ug/L	CDA Groundwater Lab	Pyrimethanil	0.1	ug/L	CDA Groundwater Lab
Desisopropyl Atrazine	0.1	ug/L	CDA Groundwater Lab	Quinclorac	0.1	ug/L	CDA Groundwater Lab
Dicamba	0.1	ug/L	CDA Groundwater Lab	Simazine	0.1	ug/L	CDA Groundwater Lab
Diflufenzopyr	0.25	ug/L	CDA Groundwater Lab	Sulfentrazone	0.2	ug/L	CDA Groundwater Lab
Dimethenamid	0.1	ug/L	CDA Groundwater Lab	Sulfometuron methyl	0.1	ug/L	CDA Groundwater Lab
Dimethenamid ESA	0.1	ug/L	CDA Groundwater Lab	Sulfosulfuron	0.1	ug/L	CDA Groundwater Lab
Dimethenamid OA	0.1	ug/L	CDA Groundwater Lab	Tebuconazole	0.1	ug/L	CDA Groundwater Lab
Dimethoate	0.1	ug/L	CDA Groundwater Lab	Tebufenozide	0.1	ug/L	CDA Groundwater Lab
Dinotefuran	0.1	ug/L	CDA Groundwater Lab	Tebuthiuron	0.1	ug/L	CDA Groundwater Lab
Disulfoton sulfone	0.1	ug/L	CDA Groundwater Lab	Terbacil	0.1	ug/L	CDA Groundwater Lab
Disulfoton sulfoxide	0.1	ug/L	CDA Groundwater Lab	Thiamethoxam	0.1	ug/L	CDA Groundwater Lab
Diuron	0.1	ug/L	CDA Groundwater Lab	Triadimefon	0.1	ug/L	CDA Groundwater Lab
Ethofumesate	0.2	ug/L	CDA Groundwater Lab	Triallate	0.1	ug/L	CDA Groundwater Lab
Ethoprop	0.1	ug/L	CDA Groundwater Lab	Triasulfuron	0.1	ug/L	CDA Groundwater Lab
Fenamiphos	0.1	ug/L	CDA Groundwater Lab	Trichlorfon	0.2	ug/L	CDA Groundwater Lab
Fenamiphos sulfone	0.1	ug/L	CDA Groundwater Lab	Triclopyr	0.2	ug/L	CDA Groundwater Lab
Florasulam	0.1	ug/L	CDA Groundwater Lab	Triticonazole	0.1	ug/L	CDA Groundwater Lab
Flufenacet	0.1	ug/L	CDA Groundwater Lab	Bromide	0.05	mg/L	CDA Groundwater Lab
Flumetsulam	0.1	ug/L	CDA Groundwater Lab	Chloride	0.05	mg/L	CDA Groundwater Lab
Glyphosate	1.0	ug/L	CDA Groundwater Lab	Fluoride	0.05	mg/L	CDA Groundwater Lab
Halofenozide	0.1	ug/L	CDA Groundwater Lab	Nitrate as N	0.011	mg/L	CDA Groundwater Lab
Halosulfuron methyl	0.1	ug/L	CDA Groundwater Lab	Nitrite as N	0.015	mg/L	CDA Groundwater Lab
Hydroxy Atrazine	0.04	ug/L	CDA Groundwater Lab	Ortho-phosphate (Dissolved)	0.05	mg/L	CDA Groundwater Lab
Imazamethabenz ester	0.1	ug/L	CDA Groundwater Lab	Sulfate	0.05	mg/L	CDA Groundwater Lab