

# Review and Analysis of Chemical Data for the Maize Ground-Water Pit/Detention Pond for Stormwater Runoff Storage

A report for  
Equus Beds Groundwater Management District No. 2

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Aerial photograph of Maize detention pond. The inflow drainage channel  
is located at the southwest corner of the pond.

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## **INTRODUCTION**

Equus Beds Groundwater Management District No. 2 (GMD2) requested that the Kansas Geological Survey (KGS) review and provide an analysis of the data collected for the monitoring plan for a retention pond/ground-water pit used by the City of Maize for storage of stormwater runoff. The pond is also referred to as a ground-water pit because the pond is dug into the unconsolidated sediment that comprises the shallow aquifer in the area such that the bottom of the pond is below the water level in the aquifer. The detention pond is located in the NW/4 of the NW/4 of Sec. 20, T. 26 S., R. 1 W. at the northeast corner of Maize. Information on the detention pond sent by GMD2 indicates that the watershed area from which water drains to the pond is 109 acres and is located in the northern part of the city. Aerial photographs show that this watershed includes residential and commercial areas, a school with an athletic track and field, and a railroad. The pond drainage area does not appear to include agricultural land use.

Water samples were collected from the pond on March 5, 2007 by Continental Analytical Services, Inc. (CAS), and on October 25, 2007 by the City of Maize for organic analysis, and by the City of Maize on October 31, 2006 and October 30, 2007 for inorganic analysis. Samples of stormwater runoff were collected from a concrete drainage channel leading to the pond at two different times during March 20 and June 27, 2007, for inorganic and organic analyses. The first runoff sample was obtained within 30 minutes after water began entering the pond and the second between one and two hours after the runoff began. A bottom sediment sample was collected from the pond in March 2007 by CAS. The City of Wichita chemical laboratory analyzed the water samples for inorganic constituents and CAS analyzed the water samples for organic compounds and the sediment sample for both inorganic and organic constituents. GMD2 provided to the KGS the data sheets that had been sent to them by the laboratories analyzing the water and sediment samples.

The data were reviewed for characterization of accuracy and relevancy to assessment of the chemical quality of the water and sediment relative to standards for public drinking water and toxicity to aquatic wildlife. The data analysis included a comparison to the analytical data and findings of the recently completed study of water-quality effects of stormwater runoff into sand pits on ground water in the Wichita area (Whittemore 2007, 2008). Photocopies of the analytical data and data control information are in Appendix A.

## **REVIEW OF ANALYTICAL DATA**

### **Inorganic Constituents in Water Samples**

The City of Wichita laboratory is accredited by the Kansas Department of Health and Environment (KDHE) and the National Environmental Laboratory Accreditation Program (NELAP). The analysis of the water samples for inorganic constituents included all of the major constituents, which allowed a determination of the charge balance error. The charge balance error was calculated using the difference between the sum of the equivalent concentrations of the major and minor dissolved cations (calcium, magnesium, sodium, and potassium) and anions (bicarbonate, chloride, sulfate, nitrate, and fluoride) divided by the total cation and anion

equivalent concentrations times 100. The charge balance errors in the analyses for the two pond samples were -3.1% and -4.2%, which indicate very good analyses for the total dissolved solids (TDS) contents of 433 and 327 mg/L for these samples. These TDS values compare well with those based on the sum of the major and minor dissolved inorganic constituents (437 and 314 mg/L, respectively), for which the bicarbonate concentration is multiplied by 0.4917 to represent the loss of about half of the constituent as carbon dioxide in an analytical procedure involving evaporating the water sample to dryness by heating. The charge balance errors for the runoff samples ranged from 3.3% to -10.4%, with three of the values below 6%. These are good to very good analyses considering that the TDS is low for the samples, meaning that the error in individual constituent concentrations is relatively greater than for the higher TDS pond samples. The reported TDS values for the runoff samples were 49, 76, 111, and 93 mg/L compared to the computed TDS concentrations of 46, 63, 82, and 67, respectively.

The inorganic analysis included a determination of most of the major constituents and trace elements for which primary (maximum contaminant levels, MCLs) and secondary drinking water standards exist (Table 1). Mercury, thallium, and uranium concentrations, for which MCLs exist, were not measured. Most of the method detection limits (MDLs) of the Wichita laboratory were below the MCLs for trace elements. However, the MDLs for antimony, arsenic, and lead, 0.02, 0.02, and 0.033 mg/L, respectively, were greater than the MCLs of 0.006, 0.01, and 0.015 mg/L, respectively, for these elements. Values less than the MDLs for these elements do not conclusively indicate that the concentrations are less than the drinking water standard.

### **Organic Compounds in Water Samples**

The CAS laboratory analyzed the water samples for a wide variety of organic chemicals (210 compounds for the first three samples and 211 for the last three samples). The compounds comprised primarily both substituted and unsubstituted hydrocarbons in many classes, including volatile organic compounds (VOCs), herbicides and insecticides, and chlorinated aromatic hydrocarbons. The compounds included 65 chemicals listed as TCL/HSL extractables, where TCL and HSL refer to the target compound list and hazardous substance list, respectively. The TCL was developed by the U.S. Environmental Protection Agency (EPA) for Superfund site sample analyses and includes VOCs, semivolatile organic chemicals, pesticides, and polychlorinated biphenyls (PCBs) (<http://epa.gov/superfund/programs/clp/target.htm>). The HSL was developed as a part of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and includes compounds that are most commonly found at hazardous waste facilities and which are determined to pose the most significant potential threat to human health due to their known or suspected toxicity and potential for human exposure (<http://www.atsdr.cdc.gov/cercla/>). The CAS laboratory is accredited by the State of Kansas through NELAP. The data sheets included the quality control information for the compounds determined in the analyses and the chain-of-custody forms.

KDHE regulates 21 VOCs, 33 synthetic organic compounds (SOCs), and disinfection byproducts from chlorination in public water supplies (KDHE, <http://www.kdheks.gov/pws/dmccu.html>). The names of and MCLs for the VOCs and SOCs are listed in Tables 2 and 3, respectively. The CAS laboratory determined all of the regulated VOCs, 27 out of the 33 SOCs, and many of the disinfection byproducts of chlorination. Many of

Table 1. Information summary for inorganic compounds in water samples from the Maize pond and Wichita area sand pits (Whittemore 2006, 2007) for which there are drinking-water standards in Kansas. Maize values in brackets are for runoff water. Values in parentheses are Kansas surface water criteria (which also address ground water in alluvial aquifers under a recharge provision) if different from U.S. EPA standards (U.S. EPA, 2006a).

| Chemical property or dissolved constituent | Highest concentration detected in Maize pit [or runoff] water, mg/L | Highest concentration detected in Wichita pit water, mg/L | Drinking water MCL, mg/L | Drinking water secondary standard, mg/L |
|--|---|---|--------------------------|---|
| Total dissolved solids                     | 437   | 1,130   |                          | 500                                     |
| Chloride                                   | 79.5  | 462   |                          | 250                                     |
| Fluoride                                   | 0.77  | 0.7   | 4                        | 2                                       |
| Sulfate                                    | 77.3  | 227   |                          | 250                                     |
| Ammonia as N                               | [0.52]  | 0.525   |                          |   |
| Nitrite & nitrate, as N                    | [0.86]  | 0.08  | 10                       |   |
| Nitrate, as N                              | [0.77]  | 0.007   | 10                       |   |
| Aluminum                                   | [0.498]   | 0.0044  |                          | 0.05-0.2                                |
| Antimony                                   | <0.02   | 0.00034   | 0.006                    |   |
| Arsenic                                    | <0.02   | 0.0025  | 0.01                     |   |
| Barium                                     | 0.172   | 0.148   | 2 (1)                    |   |
| Beryllium                                  | <0.001  | <0.00006  | 0.004                    |   |
| Cadmium                                    | 0.002   | 0.00004   | 0.005                    |   |
| Chromium (total)                           | <0.01   | 0.00008   | 0.1                      |   |
| Copper                                     | <0.005  | 0.0038  | 1.3*                     |   |
| Cyanide (as free CN)                       | <0.005  | <0.00001  | 0.2                      |   |
| Iron                                       | [0.331]   | 0.0025  |                          | 0.3                                     |
| Lead                                       | <0.033  | 0.00021   | 0.015*                   |   |
| Manganese                                  | [0.009]   | 0.300   |                          | 0.05                                    |
| Mercury (inorganic)                        | Not determined  | 0.00001   | 0.002                    |   |
| Nickel                                     | <0.01   | 0.00425   | 0.1 (0.61)               |   |
| Selenium                                   | <0.03   | 0.0029  | 0.05 (0.17)              |   |
| Silver                                     | <0.01   | <0.0001   |                          | 0.1 (0.05)                              |
| Uranium                                    | Not determined  | 0.0104  | 0.03                     |   |
| Zinc                                       | [0.030]   | 0.003   |                          | 5 (7.4)                                 |

\* Action level (violation if >10 % of values exceed level)

Table 2. Volatile organic compounds regulated by the Kansas Department of Health and Environment, Continental Analytical Services reporting limits, and drinking water MCLs. Uses and MCLs are from the KDHE web page <http://www.kdheks.gov/pws/dmccu.html>.

| Compound name                        | Lab reporting limit, µg/L | Drinking water MCL, µg/L | Uses  |
|--------------------------------------|---------------------------|--------------------------|---|
| Benzene                              | 0.5                       | 5                        | fuels, pesticides, paints, pharmaceutical   |
| Carbon tetrachloride                 | 0.5                       | 5                        | degreasing agents, fumigants                |
| p-Dichlorobenzene                    | 5                         | 75                       | insecticides, moth balls                    |
| o-Dichlorobenzene                    | 5                         | 600                      | insecticides, industrial solvents           |
| 1,2 Dichloroethane                   | 0.5                       | 5                        | gasoline, insecticides                      |
| 1,1 Dichloroethylene                 | 0.5                       | 7                        | paints, dyes, plastics                      |
| cis-1,2 Dichloroethylene             | 0.5                       | 70                       | industrial solvents, chemical manufacturing |
| trans-1,2 Dichloroethylene           | 0.5                       | 100                      | industrial solvents, chemical manufacturing |
| Dichloromethane (methylene chloride) | 0.5                       | 5                        | paint strippers, refrigerants, fumigants    |
| 1,2 Dichloropropane                  | 0.5                       | 5                        | soil fumigants, industrial solvents         |
| Ethylbenzene                         | 0.5                       | 700                      | gasoline, insecticides                      |
| Monochlorobenzene                    | 0.5                       | 100                      | industrial solvents, pesticides             |
| Styrene                              | 0.5                       | 100                      | plastics, synthetic rubber, resins          |
| Tetrachloroethylene                  | 0.5                       | 5                        | dry cleaning/industrial solvents            |
| Toluene                              | 0.5                       | 1,000                    | gasoline, industrial solvents               |
| 1,2,4 Trichlorobenzene               | 1                         | 70                       | industrial solvents                         |
| 1,1,1 Trichloroethane                | 0.5                       | 200                      | metal cleaning/degreasing agent             |
| 1,1,2 Trichloroethane                | 1                         | 5                        | industrial degreasing solvents              |
| Trichloroethylene                    | 0.5                       | 5                        | paint strippers, dry cleaning, degreasers   |
| Vinyl chloride                       | 0.5                       | 2                        | plastics/synthetic rubber, solvents         |
| Xylenes                              | 0.5                       | 10,000                   | paints/inks solvent, synthetic fibers, dyes |



Table 3. Synthetic organic compounds regulated by the Kansas Department of Health and Environment, Continental Analytical Services reporting limits, and drinking water MCLs. Laboratory reporting values in bold are greater than the MCL. Uses and MCLs are from the KDHE web page <http://www.kdheks.gov/pws/dmcu.html>.

| Compound name  | Lab reporting limit, µmg/L | Drinking water MCL, µg/L | Uses                                     |
|--|----------------------------|--------------------------|--|
| Alachlor (Lasso)   | 0.2                        | 2                        | pesticide                                |
| Aldicarb   | 1                          | 3                        | insecticide                              |
| Aldicarb sulfoxide   | 2                          | 3                        | insecticide                              |
| Aldicarb sulfone   | 2                          | 3                        | insecticide                              |
| Atrazine (Atranex, Crisazina)                                      | 0.1                        | 3                        | weed control                             |
| Benzo(a)pyrene   | <b>5</b>                   | 0.2                      | coal tar lining & sealants               |
| Carbofuran (Furadan 4F)  | 1.5                        | 40                       | rootworm, weevil control                 |
| Chlordane  | 0.1                        | 2                        | termite control                          |
| Dalapon  | 1                          | 200                      | herbicide                                |
| Dibromochloropropane(DBCP, Nemaflume, 1,2-dibromo-3-chloropropane) | <b>10</b>                  | 0.2                      | pesticide, nematocide, soil fumigant     |
| 2,4-D (2,4-dichlorophenoxyacetic acid)                             | 1                          | 70                       | weed control, defoliant                  |
| 2,4,5-TP (Silvex)  | 1                          | 50                       | herbicide, defoliant                     |
| Di(diethylhexyl)adipate  | ND <sup>a</sup>            | 400                      | plasticizer                              |
| Di(diethylhexyl)phthalate  | 5                          | 6                        | plasticizer                              |
| Dinoseb (2,4-dinitro-6-sec-butylphenol)                            | 1                          | 7                        | insecticide, herbicide                   |
| Diquat   | ND                         | 20                       | herbicide                                |
| Endothall  | ND                         | 100                      | herbicide, defoliant                     |
| Endrin   | 0.02                       | 2                        | insecticide                              |
| Ethylene Dibromide (EDB, Bromofume, 1,2-dibromoethane)             | <b>1</b>                   | 0.05                     | gasoline additive, fumigants, & solvents |
| Glyphosate   | ND                         | 700                      | herbicide                                |
| Heptachlor (H-34, Heptox)  | 0.02                       | 0.4                      | termite control                          |
| Heptachlor epoxide   | 0.02                       | 0.2                      | insecticide                              |
| Hexachlorobenzene  | <b>5</b>                   | 1                        | by-product of solvents & pesticides      |
| Hexachlorocyclopentadiene  | 5                          | 50                       | pesticide, fungicide                     |
| Lindane (G-BHC)  | 0.05                       | 0.2                      | pesticide                                |
| Methoxychlor (DMDT, Marlata)                                       | 0.1                        | 40                       | insecticide                              |
| Oxamyl (Vydate)  | 2                          | 200                      | insecticide                              |
| Pentachlorophenol (PCP)  | <b>20</b>                  | 1                        | herbicide, fungicide, wood preservative  |
| Picloram (Tordon)  | ND                         | 500                      | herbicide, defoliant                     |
| Polychlorinated Biphenyls (PCB, Aroclors)                          | 0.2 <sup>b</sup>           | 0.5                      | herbicide                                |
| Simazine   | 0.1                        | 4                        | herbicide                                |
| 2,3,7,8 TCDD (chlorinated dibenzo dioxin)                          | ND                         | 3 x 10 <sup>-5</sup>     | pesticide & combustion byproduct         |
| Toxaphene  | 0.5                        | 3                        | pesticide                                |

<sup>a</sup> ND = Not determined

<sup>b</sup> Range of 0.1-0.5 µg/L depending on the particular PCB

the additional compounds measured have lifetime health advisories for drinking water listed by the EPA.

The SOCs for which Kansas has MCLs for drinking waters that were not determined by the CAS laboratory are di(diethylhexyl)adipate, diquat, endothall, glyphosate, picloram, and 2,3,7,8 TCDD (2,3,7,8-tetrachlorodibenzo-p-dioxin). The first of these compounds is a plasticizer, the next four are herbicides, and the last, commonly known as a dioxin, is a byproduct of waste incineration and the manufacture of certain chlorinated organic chemicals (<http://www.epa.gov/ttn/atw/hlthef/dioxin.html>). The dioxin 2,3,7,8 TCDD has a very low MCL and is difficult and expensive to analytically measure at these low levels. For the Wichita sand pit study (Whittemore 2007, 2008), only one of the six compounds not determined by CAS was included in the analyses – picloram.

The reporting limits of CAS for one VOC (1,1,2 trichloroethane) and five SOCs (benzo(a)pyrene, dibromochloropropane or 1,2-dibromo-3-chloropropane, ethylene dibromide or 1,2-dibromoethane, hexachlorobenzene, and pentachlorophenol) were greater than the drinking-water MCLs for these compounds (Table 3). Thus, values less than the MDLs for these compounds do not conclusively indicate that the concentrations are less than the drinking water standard.

The KDHE rules for disinfection byproducts include MCLs for the organic compounds known as trihalomethanes (0.08 mg/L) and haloacetic acids (0.06 mg/L). CAS determined the trihalomethanes bromoform, chloroform, and dibromochloromethane at reporting levels of 0.001, 0.005, and 0.001 mg/L, respectively, values all less than the MCL. CAS did not analyze the water samples for any haloacetic acids.

### **Bacteria in Water Samples**

The City of Wichita laboratory determined the concentrations of total coliform and fecal coliform bacteria in all the pond and runoff samples. Although no method detection limits were listed, the low concentrations of 1 and 2 colonies/100 mL in one of the samples suggest that the detection limit is 1 colony/100 mL.

### **Inorganic and Organic Constituents in Sediment Sample**

The bottom sediment sample that was analyzed was a laboratory composite of four separate samples collected from 11:25 to 11:40 am on March 5, 2007. The CAS laboratory analyzed the sediment sample for bulk density, grain-size distribution, total solids, total phosphorus, Kjeldahl nitrogen, total carbon and organic carbon, and the total concentrations of 25 metals and semi-metals. CAS also analyzed the sediment for the content of 27 organochlorine pesticides and PCBs and 65 organic compounds listed as TCL/HSL extractables.

## **ANALYSIS OF CHEMICAL DATA**

### **Inorganic Constituents in Water Samples**

Table 1 compares the highest concentration of inorganic constituents in the Maize pond and runoff samples with those for the ponds in the study of water-quality effects of stormwater runoff into sand pits on ground water in the Wichita area (Whittemore 2007, 2008). All of the Maize runoff and pond water samples were fresh (TDS <1,000 mg/L). The chloride concentration of the Maize waters was much lower than reported for the Wichita ponds. The Maize pond-water samples appear to be mainly influenced by fresh stormwater runoff and not affected substantially by naturally saline ground water in the Arkansas River and the alluvial aquifer near the river. The sulfate content of the Maize pond water was also lower than in the Wichita pits. None of the inorganic constituents determined in the Maize runoff and pond samples was found to occur at a concentration greater than drinking water MCLs.

The concentrations of ammonia and nitrate were higher in the runoff samples entering the Maize pond than in the pond water. Ammonia was below the method detection limit in both pond water samples and nitrate and nitrite were not detectable in the 2007 sample from the pond. Ammonia probably was lost by volatilization from the pond and the lower nitrate and nitrite in the pond could have resulted from use by organisms or plants in the water.

The metals aluminum and iron were present at either very low or undetectable concentrations in the pond water, whereas they were usually measurable in the runoff and occurred at a higher concentration in the first than in the second sample of runoff taken during March and June 2007. Aluminum was measured at a concentration somewhat greater than the range for recommended secondary standards for drinking water in the runoff samples. Iron occurred at a concentration slightly greater than the recommended standard in the initial runoff of March 20, 2007. Manganese was measurable in the two March runoff samples but was not detected in the pond and the June runoff samples. The results suggest that some colloidal particulates, which would be expected to include clays and oxyhydroxides, were small enough to pass through the filter membranes used to filter the samples after collection. This could be expected in the turbid waters occurring during runoff events.

### **Organic Compounds in Water Samples**

The organic compounds detected in the runoff and pond samples were the following: atrazine and simazine at the reporting limit of 0.1 µg/L in the March 2007 pond sample, 2,4-D at 3.9 µg/L (reporting limit 1.0 µg/L) and bis(2-ethylhexyl)phthalate at 5.3 µg/L (reporting limit 5.0 µg/L) in the first March 2007 runoff sample, 2,4-D at 1.1 µg/L (reporting limit 1.0 µg/L) in the second March 2007 runoff sample, and alachlor at 3.8 µg/L (reporting limit 0.2 µg/L) in the first June 2007 runoff sample, alachlor at 3.0 µg/L (reporting limit 0.2 µg/L) in the second June 2007 runoff sample, and bis(2-ethylhexyl)phthalate at 5.6 µg/L (reporting limit 5.0 µg/L) in the October 2007 pond sample.

The pesticides atrazine and simazine are herbicides usually used for weed control for agricultural crops. However, they are also sometimes used for control of weeds along roads and in selected lawn grasses. For example, a Kansas State University (KSU) publication “Turfgrass pesticide selection guide for professional applicators” (Fagerness et al., 2001) lists atrazine for pre-emergent control of annual bluegrass and winter annual broadleaf weeds in dormant bermuda grass, and simazine for pre-emergent control of annual bluegrass and winter annual broadleaf weeds in bermuda and zoysia lawns. The guide also lists atrazine in a mixture with the pesticide bentazon for post-emergent control of winter and summer annual broadleaf weeds in bermuda and zoysia lawns. The MCLs for atrazine and simazine in drinking water are 3 µg/L and 4 µg/L, respectively (Table 3). The maximum contaminant level goals (MCLGs) for these compounds are the same as the MCLs. The concentrations of these herbicides detected in the 2006 sample from the Maize detention pond were more than an order of magnitude lower than the MCL. Atrazine and simazine levels were below the reporting limits in the runoff samples and the 2007 pond sample.

The chemical 2,4-D is a herbicide used for the control of broad-leaf weeds in agriculture (on crops such as wheat and corn and on pasture and rangelands), and for control of woody plants along roadsides, railways, and utilities rights of way. The presence of this herbicide in runoff from Maize suggests that the source was likely for the latter, non-agricultural uses. A variety of microorganisms in soil and freshwater ecosystems are capable of degrading 2,4-D. If released to water, the compound will be lost primarily due to biodegradation (typical half-lives 10 to >50 days). Degradation is rapid in sediments (half-life <1 day). Leaching to groundwater can be a significant process in coarse-grained sandy soils with low organic content (U.S. EPA, <http://www.epa.gov/safewater/dwh/t-soc/24-d.html>). The MCL for 2,4-D is 70 µg/L in drinking water (Table 3) and the MCLG is zero. The concentrations of this chemical measured in the two runoff samples collected in March 2007 from Maize were both more than an order of magnitude lower than the MCL. The concentration of 2,4-D was greater in the first than in the second of these runoff samples. The compound was not detected in either of the pond samples.

Alachlor is a herbicide used for control of annual grasses and broadleaf weeds in crops, primarily on corn, sorghum, and soybeans. It is the second most widely used herbicide in the United States. If released to soil, alachlor can be broken down by bacteria and sunlight, usually within two months. However, alachlor does not bind to most soils very well and can leach into ground water. Sunlight and bacterial action are important for degrading alachlor in surface water, but evaporation generally does not occur. Once alachlor enters ground water, its degradation is very slow (U.S. EPA, <http://www.epa.gov/safewater/dwh/c-soc/alachlor.html>). The drinking-water MCL for alachlor is 2 µg/L (Table 3) and the MCLG is zero. Both June runoff samples contained an alachlor concentration greater than the MCL, and the first sample had a greater content than the later runoff. The presence of alachlor at these concentrations is not expected in urban runoff due to the agricultural use for this herbicide. No agricultural land use appears to occur within the pond watershed, thus, either some drainage from agricultural land can enter the watershed or alachlor was used on residential gardens or to control grass and weeds along roads, the railroad, or utility rights of way.

The compound bis(2-ethylhexyl)phthalate (DEHP) is used as a plasticizer in a range of plastics to make them flexible. DEHP is common in the environment due to the prevalence of

plastics. It attaches strongly to soil particles and can be broken down by microorganisms to harmless chemicals in soil and water (ATSDR, 2002). The EPA has set an MCL of 6 µg/L for drinking water. DEHP was measured in the first March 2007 sample of runoff and in the 2007 pond sample at concentrations just above the reporting limit and just below the MCL. The presence of DEHP in the two Maize water samples probably reflects a source from plastics used in the commercial and residential areas of the pond watershed.

Table 4 compares the highest concentration of pesticides and other organic compounds measured or detected in the water samples from the Wichita area sand pits (Whittemore 2007, 2008) to the measured value or laboratory reporting limit of CAS for the Maize pond samples and also to health-related values for drinking water. Atrazine was found at a higher concentration in the surface water from two of the six sand pits studied in Wichita than in the Maize detention pond sample in which this herbicide was detected. Simazine was determined at a higher concentration in the 2006 Maize pond sample than in any of the Wichita pit waters. The herbicide 2,4-D in both of the March 2007 runoff samples and alachlor in both of the June 2007 runoff samples in Maize occurred at higher levels than in any of the Wichita sand-pit waters. The USGS analysis of surface waters for the Wichita sand-pit study did not detect DEHP; the detection limits ranged from 1 to 4 µg/L. The following organic compounds were detected in the Wichita sand-pit study but not in the Maize samples: metolachlor, carbon disulfide, isophorone, 2,4-dimethylphenol, 2-nitrophenol, 4-nitrophenol, cis-1,2 dichloroethene, and pentachlorophenol. However, the detection limits of the USGS laboratory were substantially smaller than those of the CAS laboratory. Thus, the analyzed presence in the Wichita pit waters and not in the Maize samples does not indicate that these compounds were not present in the Maize water but that they could not be detected, if present, at the reporting limits of the CAS laboratory. Table 3 shows that 13 additional contaminant chemicals that the USGS laboratory detected in the Wichita pit samples were not determined by the CAS laboratory in the Maize samples. All except one of these chemicals were found at concentrations less than 0.1 µg/L; hydroxyatrazine, a degradation product of atrazine, was measured at just above the 0.1 µg/L level (Table 4).

### **Bacteria in Water Samples**

In the 2006 and 2007 pond samples, the concentrations of total coliform bacteria were 2 and 30 colonies/100 mL, respectively, and the contents of fecal coliform bacteria were 1 and 10 colonies/100 mL, respectively. The concentrations of total coliform bacteria in the runoff samples were substantially greater than in the pond samples. The first and second runoff samples of March 2007 contained 3,100 and 21,000 colonies/100 mL, respectively, and the first and second runoff samples of June 2007 contained 14,000 and 13,000 colonies/100, respectively. The contents of fecal coliform bacteria were also appreciably larger in the runoff than in the pond samples; 1,160 and 5,800 colonies/100 mL were measured in the first and second samples of March 2007, respectively, and 40 colonies/100 mL were found in each of the two samples of June 2007. The ratio of the fecal to total coliform bacteria in the runoff was greater for the March than for the June 2007 sampling.

The much smaller concentration of bacteria in the pond than in the runoff samples indicates that the bacteria were removed from the pond water by either physical or biochemical

Table 4. The highest concentration of pesticides and other organic compounds measured or detected in water samples from Wichita area sand pits (Whittemore 2006, 2007) compared to the measured value or laboratory reporting limit of Continental Analytical Services for the Maize pond and runoff samples and also to health-related values for drinking water. The letter E next to a value indicates estimated. The letter M in a cell indicates that the compound presence was verified but not quantified; the detection limit is in parentheses. See Whittemore (2006, 2007) for references for the EPA health-related values.

| Chemical compound   | Highest concentration detected in Wichita pit water, µg/L | Highest concentration detected in Maize pond/runoff, (or laboratory reporting limit), µg/L | U.S. EPA drinking water MCL, µg/L | U.S. EPA drinking water lifetime health advisory, µg/L |
|---|---|--|-----------------------------------|--|
| <i>Pesticides</i>   |   |  |                                   |  |
| Atrazine  | 0.467   | 0.1  | 3                                 |  |
| Deethylatrazine<br>(2-Chloro-4-isopropylamino-6-amino-s-triazine) | E 0.054   | ND <sup>a</sup>  |                                   |  |
| Hydroxyatrazine<br>(2-Hydroxyamino-6-ethylamino-s-triazine)       | E 0.131   | ND   |                                   |  |
| Deisopropyl s-triazine  | E 0.03  | ND   |                                   |  |
| Metolachlor   | 0.036   | (0.2)  |                                   | 700  |
| Simazine  | E 0.028   | 0.1  | 4                                 |  |
| Diuron  | 0.02  | ND   |                                   |  |
| Hexazinone  | 0.029   | ND   |                                   | 400  |
| Prometon  | 0.03  | ND   |                                   | 100  |
| 2,4-D methyl ester  | E 0.065   | ND   |                                   |  |
| 2,4-D (2,4-dichlorophenoxyacetic acid)                            | 0.95  | 3.9  | 70                                | 200  |
| Acetochlor  | E 0.015   | ND   |                                   |  |
| Alachlor  | 0.009   | 3.8  | 2                                 |  |
| Benomyl   | E 0.004   | ND   |                                   |  |
| Desulfinyl fipronil   | E 0.005   | ND   |                                   |  |
| Desulfinylfipronil amide  | E 0.005   | ND   |                                   |  |
| Myclobutanil  | E 0.009   | ND   |                                   |  |
| Siduron   | M (0.02)  | ND   |                                   |  |
| Carbon disulfide  | 0.36  | (5)  |                                   |  |
| <i>Other organic compounds</i>                                    |   |  |                                   |  |
| Isophorone  | M (0.6)   | (5)  |                                   | 100  |
| 2,4-Dimethylphenol  | M (0.4)   | (10)   |                                   |  |
| 2-Nitrophenol   | M (0.3)   | (5)  |                                   |  |
| 4-Nitrophenol   | M (0.5)   | (25)   |                                   | 60   |
| cis-1,2 Dichloroethene  | 0.69  | (0.5)  | 70                                | 70   |
| Pentachlorophenol   | M (0.87)  | (20)   | 1                                 |  |

<sup>a</sup> ND = Not determined

processes. A possible physical process could have been the flow of the runoff that entered the pond into the subsurface (due to the higher water level expected in the pond after a precipitation event than in the underlying and adjacent aquifer), followed by replacement of pond water by later ground-water discharge during dry periods. Much of the bacteria could possibly have been removed from the water by fine-grained sediments in the pond bottom during the flow from the pond into the aquifer. Another process that can affect bacteria is their inactivation by sunlight. Sinton et al. (2002) found that the inactivation of fecal coliform bacteria was about an order of magnitude greater in sunlight than in the dark, and that the inactivation rate was far more rapid in the summer than in the winter. They also found that sunlight inactivation of the bacteria increased with increasing water salinity.

The concentration ranges for coliform and fecal coliform bacteria in the sand pits recently studied in Wichita were 37-15,000 colonies/100 mL and <2-270 colonies/100 mL, respectively (Whittemore 2007, 2008). In general, the total coliform bacteria content was greater in the two sand pits (Ridge Port and Barefoot Bay) in northwest Wichita, which receive runoff from the Big Slough, than in the other pits. The watershed of the Big Slough includes the City of Maize; the Big Slough waterway is located just to the east of Kansas Highway 96, which is close to the northeast side of the Maize detention pond. One of the reasons for the higher total coliform count found in the surface waters from the Wichita sand pits than in the Maize pond might be that the Wichita pit samples were collected during April to June whereas the Maize pond was sampled at the end of October. The smaller runoff that usually occurs during the fall than in the spring could have resulted in a smaller bacteria source, and the sampling after the summer would have provided a longer period for bacteria inactivation by sunlight during hot weather for the Maize in comparison to the Wichita pond waters.

Kansas regulations require that public water supply systems disinfect drinking water provided to the public (<http://www.kdheks.gov/pws/dmcsu.html>). Systems can incur a violation if water samples test positive for total or fecal coliform or *E. coli* bacteria, although the procedure for determining a violation requires multiple samples. The KDHE also has water-quality standards for surface waters that are used for recreation and are classified stream segments; the bacteria standard is based on *E. coli* content ([http://www.kdheks.gov/water/download/swqs\\_numeric\\_criteria.pdf](http://www.kdheks.gov/water/download/swqs_numeric_criteria.pdf)). Analyses of the Maize runoff and pond samples did not include determination of *E. coli* presence. The concentration of *E. coli* in the Wichita sand-pit samples was generally in the same range as for the fecal coliform content (Whittemore 2007, 2008). The Big Slough is considered a classified stream segment downstream of the NPDES (National Pollutant Discharge Elimination System) permitted discharge of treated wastewater from City of Maize. The KDHE online document for the TMDL (Total Maximum Daily Load) for fecal coliform bacteria in the Lower Arkansas River basin, Middle Arkansas-Slate subbasin, Cowskin Creek (<http://www.kdheks.gov/tmdl/la/cowskinFCB.pdf>) includes a map of the Big Slough watershed within the TMDL area along with information on the Maize NPDES discharge. The water-quality standard in this document is listed as 2,000 colonies/100 mL of fecal coliform bacteria for secondary contact recreation. However, the Maize detention pond is not used for recreation. The drainage channel that existed before construction of the detention pond would have carried stormwater runoff from its watershed in Maize into Big Slough downstream of the NPDES

discharge. If the past runoff also had high bacteria concentration, it could have added to the bacteria count in the Ridge Port and Barefoot Bay pit waters after precipitation events.

### **Constituents in Sediment Sample**

The grain-size analysis of the sediment sample from the Maize detention pond indicated that the bottom material was primarily clay and silt (69%) mixed with about 10% fine sand, 6% medium sand, and 15% coarse sand and larger particles. The total carbon and total organic carbon contents were 0.83% and 0.62%, respectively, by weight. Of the total metals determined in the sediment, iron, calcium, magnesium, and potassium, in order of decreasing concentration from 13,000 mg/L to 1,820 mg/L, occurred at concentrations greater than 1,000 mg/kg (0.1% by weight). None of the trace metals (arsenic, cadmium, chromium, copper, lead, mercury, nickel, silver, and zinc) for which effects levels exist for toxicity to aquatic organisms in freshwater ecosystems exceeded the consensus-based threshold effects concentration for toxicity (MacDonald et al., 2000). None of the organochlorine pesticides and PCBs and organic compounds listed as TCL/HSL extractables was detected at levels above the laboratory reporting limits.

### **CONCLUSIONS**

The inorganic analysis of the Maize pond and runoff samples included a determination of most of the major constituents and trace elements for which maximum contaminant levels (MCLs) and secondary standards exist for drinking water. All of the samples were fresh based on total dissolved solids concentration. None of the inorganic constituents determined was found at concentrations greater than drinking water MCLs. The metals aluminum, iron, and manganese were usually measurable in the runoff and occurred at a higher concentration in the first than in the second sample of runoff. The expected source of these metals is colloidal particulates, which were small enough to pass through the filter membrane used to prepare the sample, occurring with sediment washed from surfaces by the runoff. Ammonia and nitrate were also higher in the runoff than in the pond samples. Most of the method detection limits (MDLs) were below the MCLs for trace elements. However, the MDLs for antimony, arsenic, and lead were greater than the MCLs for these elements. Values less than the MDLs for these elements do not conclusively indicate that the concentrations are less than the drinking water standard. Mercury, thallium, and uranium concentrations, for which MCLs exist, were not measured.

All of the volatile organic compounds (VOCs), 27 of the 33 synthetic organic compounds (SOCs), and many of the disinfection byproducts of chlorination that the KDHE regulates and for which it has drinking water MCLs were determined in the pond and runoff samples. The reporting limits of the laboratory that analyzed the water samples were greater than the drinking-water MCLs for one of these VOCs and five of these SOCs. Thus, values less than the MDLs for these compounds do not conclusively indicate that the concentrations were less than the drinking-water standard. Thirteen additional contaminant chemicals, which were detected in surface waters in sand pits recently studied in Wichita by a group of federal, state, and local agencies, were not determined in the Maize samples. However, the detection limits of the U.S. Geological Survey laboratory that analyzed the Wichita waters were substantially lower than



those of the laboratory that analyzed the Maize samples; all of the 13 chemicals found in the Wichita sand pits but not determined in the Maize samples occurred at concentrations less than 0.2 µg/L.

Four herbicide compounds and one other organic contaminant chemical were found in the Maize runoff or pond samples. The herbicides atrazine and simazine were detected at the reporting limit of 0.1 µg/L in the March 2007 pond sample, and below the MCLs of 3 µg/L and 4 µg/L, respectively, for these compounds. Atrazine and simazine are sometimes used for weed control along roads and pre-emergent control in selected lawn grasses, as well as for controlling weeds in agricultural crops. The herbicide 2,4-D was measured at levels substantially below the MCL of 70 µg/L in both of the March 2007 runoff samples. This chemical is used for control of woody plants along roadsides, railways, and utilities rights of way as well as in agriculture. The herbicide alachlor was found at a concentration greater than the MCL of 2 µg/L in both of the June 2007 runoff samples. The presence of alachlor at a concentration above the MCL is not expected in the runoff because this herbicide is used to control grasses and weeds in agricultural crops and no agricultural land use appears to occur within the detention pond watershed. The plasticizer bis(2-ethylhexyl)phthalate (DEHP) was measured at concentrations just below the MCL of 6 µg/L in the first runoff sample of March 2007 and in the pond sample collected in October 2007. The presence of DEHP probably reflects a source from plastics used in the commercial and residential areas of the pond watershed.

The Maize detention pond appears to be an effective means of removing stormwater runoff with high bacteria content from the Big Slough waterway. The runoff water samples contained substantially greater concentrations of bacteria than the pond samples, indicating that physical or biochemical processes remove most of the bacteria from the runoff entering the pond. Some sand pits in northwest Wichita, such as Ridge Port and Barefoot Bay, receive stormwater inflow from Big Slough. These pits are used for recreation and Big Slough is a classified stream segment downstream of Maize, thus, KDHE surface-water quality standards for bacteria are applicable to these pit waters.

The bottom sediment sample collected from the detention pond was primarily clay and silt (69%) mixed with fine, medium, and coarse sand and a small amount of organic matter (0.62% by weight). The metal in largest concentration in the sediment was iron (1.3% by weight), which could be expected in iron oxyhydroxide particulates and coatings in typical pond sediment. No trace metals for which effects levels exist for toxicity in freshwater ecosystems exceeded the consensus-based threshold effects concentrations. None of the organochlorine pesticides and PCBs and organic compounds listed as TCL/HSL extractables was detected at levels above the laboratory reporting limits.

The sampling plan, which included both runoff and pond samples, was designed well in that the results showed differences between the types of samples. Pond-only samples would not have discovered the presence of some organic compounds that were detected only in the runoff. The presence of several organic contaminants in the runoff or detention pond samples, especially alachlor above and DEHP close to the MCLs for drinking water, suggest that it would be useful to determine whether these contaminants have entered the ground water downgradient of the pond. The online database for water-well logs of the Kansas Geological Survey

<http://www.kgs.ku.edu/Magellan/WaterWell/index.html>) indicates that some domestic and lawn and garden wells lie in the general direction of downgradient ground-water flow from the detention pond expected in the west half of Sec. 20, T. 26 S., R. 1 W. In addition, the well records show that the City of Maize had several wells constructed for dewatering in this downgradient area, although whether all of these have been plugged is not known. Sampling of a couple of these wells or of a monitoring well installed just downgradient of the detention pond could be used for answering the question of ground-water quality impact.

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**Appendix: Scans of Analytical Data Sheets**