Austin Lawn and Garden Chemical Education Campaign

Final Report

City of Austin, Texas
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Austin, TX 78704

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Kathy Shay
Environmental Conservation
Program Manager
(512) 974-2446
Kathy.Shay@ci.austin.tx.us

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EXECUTIVE SUMMARY

The City of Austin participated in a 319(h) nonpoint source pollution prevention grant with the Texas Commission on Environmental Quality (TCEQ). The grant focus was educational outreach regarding the relationship between individual homeowner landscape practices and water quality degradation. The goal of the education effort was to reduce the use of lawn and garden chemicals by promotion of earth-wise landscaping methods. Television and radio public service announcements were created and aired in the Austin area, and printed materials were created and mailed to targeted neighborhoods. Educational outreach success was measured in the pilot neighborhoods with before-and-after education surveys, and pollution reduction was assessed with direct monitoring of groundwater springs and stormwater runoff. Monitoring included nutrients, the herbicide Atrazine and the pesticide Carbaryl near targeted neighborhoods.

Visits to the City's Grow Green education website were recorded across the United States, and increased in the months when the ads were broadcast. More than 432,000 printed fact sheets were distributed from 2009 to 2011 at area retail stores. Survey results indicate improvement in landscape practices as a result of education. Approximately 9,700 surveys were mailed, and 1,872 responses were returned. The majority of neighborhoods surveyed exhibited a positive behavioral response to education and indicated a decrease in chemical fertilizer use, a decrease in the use of weed-and-feed combined fertilizer and herbicide products and an increase in the use of organic fertilizers.

Based on monitoring data, Carbaryl was not detected in any sample and is not a good indicator of landscape chemical runoff at current detection limits. Changes in water quality after education were not consistently observed, and stormwater assessment was complicated by a lack of qualifying runoff events in year 2011. Some decreasing temporal trends in Atrazine were observed in groundwater. Stormwater runoff concentrations of Atrazine increased in spring months correlating with expected peak landscape chemical use.

INTRODUCTION

City of Austin (COA) and United States Geological Survey (USGS) scientists, as well as the Texas Groundwater Protection Committee, the Department of Agriculture, the Texas Structural Pest Control Board, U.S. Fish and Wildlife Service and the Barton Springs/Edwards Aquifer Conservation District, are concerned about the rising number of pesticide detections in Austin's surface and groundwater. Of particular interest is the increasingly frequent detection of the herbicide Atrazine, which is commonly used in many of the popular and highly advertised weed-and-feed products. Products from the Scotts Company, one of the largest fertilizer producers in the nation, are used by 37% of Austin homeowners. Scotts estimates that 1.2 million pounds of Bonus S weed-and-feed product, representing 23,000 pounds of Atrazine active ingredient, are sold in the Austin area annually. While levels of the herbicide detected in surface water and groundwater are relatively low and detection capabilities continue to improve, debate continues about the environmental impacts.

The City of Austin has developed a Watershed Protection Master Plan to help address water quality issues in the Austin area. To help support the Watershed Protection Master Plan, the City implements the Grow Green program to provide education and outreach, and conducts water quality monitoring in Austin's springs, creeks and the Colorado River. The City received a §319(h) grant and used local funds to develop a multimedia advertising campaign to educate the public on the proper use of lawn and garden chemicals. Television and radio commercials were produced and were broadcast in the Austin area beginning in spring 2009. Education materials were posted on the City's website, targeted mailings were sent to pilot neighborhoods, fact sheets were distributed, prizes were created like tattoos and T-shirts and outreach was conducted through local nurseries. Monitoring activities were used to gauge the effectiveness of public education to address individual residential sources of nutrient and pesticide contamination also through this §319(h) grant funded project.

Preventing pollution is the preferred strategy for water quality protection. Prevention is not only more cost effective than remediation, but also can avert any water resource impacts that are irreversible, such as the loss of sensitive species. The City's nationally recognized Water Quality Education program develops outreach campaigns based on local data. Comprehensive annual meetings and regular contact with scientists help to identify the issues that become the targets of outreach campaigns. Though the City continues to dedicate increased resources to education programs, grant funding allows new outreach opportunities that had previously been unaffordable.

This report details the development and execution of the education campaign, and attempts to measure the effectiveness of outreach through public opinion surveys and monitoring of groundwater and stormwater quality.

PROJECT SIGNIFICANCE AND BACKGROUND

The increased urbanization in the Austin area brings concerns for the overuse or misapplication of lawn and garden chemicals. Pesticides like Atrazine have been frequently detected in creek surface water and groundwater spring monitoring sites in the Austin area. Atrazine has been detected at the majority of sites tested in the majority of samples across Austin. Atrazine concentrations do not correlate with agricultural land uses; rather, it is detected in completely urban watersheds (with no commercial agricultural land use), and monthly average concentrations strongly correlate to months with higher expected fertilizer use. Average nitrogen concentrations increase in groundwater springs in Austin's urban areas relative to springs in rural areas. Nitrogen concentrations increase over time in groundwater springs as surface development in the contributing zones increase. The average phosphorus concentration in stormwater runoff from small watersheds in residential areas is higher than average phosphorus concentrations in stormwater runoff from undeveloped watersheds. Nutrients are increasing over time in Austin's primary receiving waters, including the iconic Barton Springs (the primary discharge point of the Barton Springs segment of the Edwards Aquifer), and the full synergistic impacts of pesticide chemicals under varying environmental stressors are not known. Increasing concentrations of nutrients and pesticides may lead to concerns in Austin's surface water and groundwater, and individual use of lawn and garden chemicals on residential property appears to be a primary source. Public education campaigns can reduce the misuse of lawn and garden chemicals and thus reduce the nutrient and pesticide loading to surface water and groundwater.

In addition to the area-wide education campaign in Austin, specific neighborhoods located in the Edwards Aquifer recharge zone were targeted with education materials. The area of the recharge and contributing zones are particularly sensitive to contamination due to rapid groundwater transport in the karst aquifer and the presence of sensitive species. Groundwater wells were not sampled for this project as the direct groundwater influences on surface waters were of primary importance, and flow paths influencing groundwater wells can be more difficult to estimate than spring-contributing drainage areas. Water quality monitoring was conducted where springs surface adjacent to creek beds.

Stormwater runoff was also collected from two different small residential drainage areas. The samples were collected during runoff events from the neighborhood stormwater outfalls. The samples were collected prior to runoff entering stormwater treatment structural controls. By measuring both stormwater runoff and spring discharge, a more complete representation of the potential success of the education campaign may be generated. The water quality monitoring was conducted to collect information on current concentrations of nutrients and pesticides. The data collected in 2009 and 2010 may also serve as a baseline for evaluation of future water quality data. The water quality data collected were used in part to determine if the targeted education campaign was successful in reducing concentrations of nutrients and pesticides. Monitoring and important education campaign dates varied (Table 1). Monitoring was initiated before education efforts began to establish a baseline for comparison, although monitoring start dates predate approval of the project Quality Assurance Project Plan (QAPP) by TCEQ. Data collected by the same methods outlined in the QAPP were used by COA for evaluation of education campaign effectiveness, but were not submitted to TCEQ Surface Water Quality Monitoring Information System (SWQMIS) under the project QAPP.

Table 1. Monitoring and education start dates

Site Name	Education Start Date	"Historic" monitoring start date by same procedures outlined in this QAPP	Monitoring under TCEQ approved QAPP, estimated start date	Monitoring End Date
Stillhouse Spring	ongoing since 2002, March 2009 under this grant program	October 2006	June 2009	August 2010
Tubb Spring	March 2009	October 2006	June 2009	August 2010
Tanglewood Spring	March 2009	October 2006	June 2009	August 2010
Backdoor Spring	March 2007	October 2006	June 2009	August 2010
Spicewood Spring	March 2008	October 2006	June 2009	August 2010
Legend Oaks Pond	February 2010	March 2008	June 2009	June 2011
Park Place Pond	February 2010	March 2009	June 2009	June 2011

Historic Groundwater Data

Water quality data have been collected prior to this education campaign. Groundwater springs that were sampled for this project were selected on the basis of historical data, indicating high detected values of Atrazine or nitrogen in previous sampling. These springs are believed to be influenced by adjacent residential land use. For sampling conducted under this project plan, spring samples were collected during routine (ambient) monitoring events with sampling clustered in spring and fall during peak lawn and garden chemical application time periods. Based on frequency of detection citywide in historical data, Atrazine and Carbaryl were selected as surrogate pesticide parameters since monitoring a full suite of pesticides would not be cost-effective and would reduce the number of samples possible. Monitoring started before education efforts began to allow establishment of a baseline for comparison.

Pre-education campaign groundwater springs monitoring began in October 2006, and continued to the beginning of the education campaign. Various education efforts have been ongoing at Stillhouse Springs since 2002. All existing groundwater data (collected after October 2006 but before the acceptance of the project QAPP) were collected under the same methods and quality guidelines as described in the project QAPP. Existing groundwater data (collected prior to October 2006) and historical groundwater data (collected prior to October 2006) are available (Table 2). Historical data (collected prior to October 2006) may or may not have been collected and analyzed under the same procedures and are thus presented for informative purposes only and not included in the final assessment (also not to be submitted as an acquired dataset).

Table 2. Existing groundwater data collected under sample procedures as described in the project QAPP that may be used for COA assessment and historic groundwater spring data summary. ND = non-detect, DT = detected value, Obs = number of measurements, Avg = arithmetic average.

			Existing (Data since Oct 2006)				Historic (Data before Oct 2006)			
Site Name	**Parameter**	**Unit**	# Obs	% ND	Max DT	Avg	# Obs	% ND	Max DT	Avg
Backdoor Spring	AMMONIA AS N	mg/L	15	66.7	0.094	0.025	49	63.3	0.11	0.026
Backdoor Spring	ATRAZINE (AATREX)	ug/L	18	77.8	0.163	0.040	6	66.7	0.061	0.032
Backdoor Spring	CARBARYL (SEVIN)	ug/L	2	100.0	n/a	<0.06	4	100.0	n/a	n/a
Backdoor Spring	NITRATE/NITRITE AS N	mg/L	14	0.0	2.8	2.318	47	0.0	5.72	1.897
Backdoor Spring	ORTHOPHOSPHORUS-P	mg/L	13	7.7	0.023	0.016	49	20.4	1.08	0.050
Canyon Creek Spring 1	AMMONIA AS N	mg/L	9	55.6	0.062	0.018	22	90.9	0.06	0.009
Canyon Creek Spring 1	ATRAZINE (AATREX)	ug/L	17	58.8	0.36	0.093	0	n/a	n/a	
Canyon Creek Spring 1	CARBARYL (SEVIN)	ug/L	0	n/a	n/a	n/a	n/a	n/a	n/a	
Canyon Creek Spring 1	NITRATE/NITRITE AS N	mg/L	10	0.0	2.38	2.056	22	0.0	1.97	1.440
Canyon Creek Spring 1	ORTHOPHOSPHORUS-P	mg/L	9	66.7	0.015	0.009	22	90.9	0.05	0.021
Spicewood Spring	AMMONIA AS N	mg/L	5	60.0	0.011	0.010	36	44.4	0.36	0.055
Spicewood Spring	ATRAZINE (AATREX)	ug/L	17	47.1	0.36	0.092	4	25.0	2.43	0.968
Spicewood Spring	CARBARYL (SEVIN)	ug/L	0	n/a	n/a	n/a	2	100.0	n/a	n/a
Spicewood Spring	NITRATE/NITRITE AS N	mg/L	5	0.0	3.91	3.098	37	0.0	5.9	4.328
Spicewood Spring	ORTHOPHOSPHORUS-P	mg/L	5	20.0	0.025	0.020	32	46.9	0.232	0.044
Stillhouse Hollow	AMMONIA AS N	mg/L	21	52.4	0.12	0.015	142	48.6	0.27	0.031
Stillhouse Hollow	ATRAZINE (AATREX)	ug/L	18	88.9	0.29	0.129	7	42.9	0.028	0.025
Stillhouse Hollow	CARBARYL (SEVIN)	ug/L	0	n/a	n/a	n/a	10	100.0	n/a	n/a
Stillhouse Hollow	NITRATE/NITRITE AS N	mg/L	24	0.0	8.23	6.745	143	0.0	10.8	6.393
Stillhouse Hollow	ORTHOPHOSPHORUS-P	mg/L	20	30.0	0.227	0.050	120	18.3	1.1	0.056
Tanglewood Spring	AMMONIA AS N	mg/L	7	71.4	0.015	0.008	61	50.8	0.27	0.037
Tanglewood Spring	ATRAZINE (AATREX)	ug/L	17	94.1	0.03	0.030	5	0.0	0.192	0.072
Tanglewood Spring	CARBARYL (SEVIN)	ug/L	0	n/a	n/a	n/a	10	100.0	n/a	n/a
Tanglewood Spring	NITRATE/NITRITE AS N	mg/L	6	0.0	2.21	1.683	62	0.0	3.6	2.120
Tanglewood Spring	ORTHOPHOSPHORUS-P	mg/L	6	66.7	0.012	0.008	46	82.6	0.05	0.008

Historical Stormwater Monitoring

All existing stormwater data (collected after March 2008 but before the acceptance of this QAPP) intended to be assessed under this QAPP (as an acquired dataset) have been collected under the same methods and quality guidelines as described in this QAPP. Existing stormwater data are available (Table 3). These data were collected under the City of Austin stormwater monitoring QAPP not approved by TCEQ.

Table 3. Existing stormwater data summary. DP = dissolved phosphorus. NH3 = Ammonia as N. NO23 = Nitrate plus nitrate as N. TKN = total Kjeldahl nitrogen as N. TN = total nitrogen. TP = total phosphorus. EMC = event mean concentration.

Event ID	Parameter	StartOfFlow	EndOfFlow	EMC	Load (mg)
20080318A	ATRAZINE (ug/l)	18-Mar-2008 12:23	19-Mar-2008 03:41	4.000	2856.8
20080318A	DP (mg/l)	18-Mar-2008 12:23	19-Mar-2008 03:41	0.262	187413.5
20080318A	NH3 (mg/l)	18-Mar-2008 12:23	19-Mar-2008 03:41	0.066	47248.1
20080318A	NO23 (mg/l)	18-Mar-2008 12:23	19-Mar-2008 03:41	0.320	228705.8
20080318A	TKN (mg/l)	18-Mar-2008 12:23	19-Mar-2008 03:41	1.236	882489.2
20080318A	TN (mg/l)	18-Mar-2008 12:23	19-Mar-2008 03:41	1.556	1111195.0
20080318A	TP (mg/l)	18-Mar-2008 12:23	19-Mar-2008 03:41	0.350	249805.4
20080410A	ATRAZINE (ug/l)	10-Apr-2008 05:40	10-Apr-2008 12:39	3.190	627.8
20080410A	DP (mg/l)	10-Apr-2008 05:40	10-Apr-2008 12:39	0.320	62992.8
20080410A	NH3 (mg/l)	10-Apr-2008 05:40	10-Apr-2008 12:39	0.690	135817.7
20080410A	NO23 (mg/l)	10-Apr-2008 05:40	10-Apr-2008 12:39	0.397	78042.7
20080410A	TKN (mg/l)	10-Apr-2008 05:40	10-Apr-2008 12:39	5.145	1012550.7
20080410A	TN (mg/l)	10-Apr-2008 05:40	10-Apr-2008 12:39	5.541	1090593.4
20080410A	TP (mg/l)	10-Apr-2008 05:40	10-Apr-2008 12:39	0.915	180178.7
20080417A	ATRAZINE (ug/l)	17-Apr-2008 23:47	18-Apr-2008 06:47	0.390	75.8
20080417A	DP (mg/l)	17-Apr-2008 23:47	18-Apr-2008 06:47	0.188	36629.9
20080417A	NH3 (mg/l)	17-Apr-2008 23:47	18-Apr-2008 06:47	0.362	70390.0
20080417A	NO23 (mg/l)	17-Apr-2008 23:47	18-Apr-2008 06:47	0.470	91442.8
20080417A	TKN (mg/l)	17-Apr-2008 23:47	18-Apr-2008 06:47	3.074	597691.1
20080417A	TN (mg/l)	17-Apr-2008 23:47	18-Apr-2008 06:47	3.544	689133.9
20080417A	TP (mg/l)	17-Apr-2008 23:47	18-Apr-2008 06:47	0.480	93258.5
20080425A	ATRAZINE (ug/l)	25-Apr-2008 21:56	26-Apr-2008 01:38	6.440	1436.2
20080425A	DP (mg/l)	25-Apr-2008 21:56	26-Apr-2008 01:38	0.230	51321.6
20080425A	NH3 (mg/l)	25-Apr-2008 21:56	26-Apr-2008 01:38	0.555	123876.8
20080425A	NO23 (mg/l)	25-Apr-2008 21:56	26-Apr-2008 01:38	0.408	91010.3
20080425A	TKN (mg/l)	25-Apr-2008 21:56	26-Apr-2008 01:38	4.462	994975.1
20080425A	TN (mg/l)	25-Apr-2008 21:56	26-Apr-2008 01:38	4.870	1085985.4
20080425A	TP (mg/l)	25-Apr-2008 21:56	26-Apr-2008 01:38	0.427	95256.8

Education Campaign Development

The City's Grow Green program, subtitled "An Earthwise Guide to Landscaping," was launched in 2000 to reduce landscaping chemicals in Austin's creeks, lakes and aquifer. Consisting of 22 fact sheets, the program emphasizes cultural and biological controls for yard care problems. It also provides toxicity ratings for products found most frequently in local nurseries. The ratings are based on a system developed by the Northwest Toxic Coalitions and now implemented through Texas AgriLife Extension.

In order to enhance the program and incorporate the most effective outreach planning and implementation tools, the grant funded a trip for City staff to a U.S. Environmental Protection Agency (EPA) "Getting in Step" program in Dallas, Texas. The sessions emphasized market research and a thorough identification of the target audience, as well as behavior change methods, developing partnerships, tips for cultivating media interest, and effective material design and distribution. Using these techniques as the building blocks for the three-year grant strategy, the City refined the goals to include the reduction of nutrients and pesticides in Austin's water resources. Additionally, the performance measures were based on the use of monitoring data to assess improvements in water quality directly, and surveys to measure behavior change before and after education in targeted neighborhoods. Television and radio advertising as well as informational websites were used in public outreach efforts.

The City identified the target audience as homeowners in the middle to high socio-economic category as they are most likely to have discretionary funds for the purchase of landscape chemicals. The Center for Watershed Protection's (1999) research shows that more highly educated audiences are usually more apt to change their behavior when presented with compelling data. Based in part on information provided by the fertilizer company Scotts/MiracleGro, the target audience was expanded to include:

- Older men (55+) who have been identified as highly valuing a green, well-manicured lawn
- 30-somethings who may be new homeowners searching for first-time advice on landscaping techniques and who have not yet developed less earth-wise habits
- Women, who are now purchasing or influencing more than 50% of fertilizer purchases

Educational messages were developed that follow the City's Grow Green program recommendations. Grow Green is based on Integrated Pest Management (IPM) principles that encourage problem prevention and identification, followed by least toxic control options. Chemicals are recommended only as a last resort. Strategies were developed that would overcome obstacles for homeowners in adopting earth-wise landscaping practices. One such strategy was to help negate the higher cost of organic fertilizer. We consistently promoted results from a greenhouse study conducted by Texas A&M and funded by the City of Austin that found that using half as much fertilizer, half as often as recommended on the bag, could offset the higher cost of naturally slow-release organic products. The City worked with existing partners including the Texas AgriLife Extension, which is associated with Texas A& M University, and also sought advice from additional sources, including the Texas Structural Pest Control Board and the Texas Department of Agriculture.

Although radio spots were also developed and aired in Austin, the City identified television as a primary outreach component and designed outreach materials that were attractive, attention getting and, in a light-hearted way, carried a serious message. The City simplified the existing Grow Green guidelines into three main messages for the educational campaign, known as The Big 3:

- Don't over-fertilize.
- Just kill the bad guys
- Accept a few weeds

The messages encourage homeowners to use landscaping chemicals responsibly. The "Don't over-fertilize" message describes the water quality impacts from excess nutrients in streams and then gives specific information on the amount of the product that should be applied ($^1/_2$ lb/ft^2) while encouraging the use of organic or natural products that are inherently slow release. Additionally, the fertilizer message gives practical reasons why reduced fertilizer use translates to less mowing, less watering, fewer turf diseases and reduced costs for homeowners.

The message "Just kill the bad guys" teaches that 95% of bugs are not pests and that broad-spectrum pesticides kill not only the nuisance bugs, but also the innocent bystanders. The recommendation is to first correctly identify the problem, then find an option or product that kills only the problem pests. It then encourages problem prevention through the use of native and adapted plants.

The message "Accept a Few Weeds" describes how weed killers, or herbicides, are frequently detected in Austin's creeks and groundwater. Combined products, such as weed-and-feed, are not recommended because most weed problems are localized and not severe enough to require a weed killer application over the entire yard. The most common weed killer for turf is Atrazine, a pre-emergent herbicide best applied before the lawn starts growing. Fertilizer, however, should be applied after the grass has been actively growing, normally after it has been mowed two times in the spring. The recommended solution is to avoid weed-and-feed products and hand pull or spot treat weeds.

Watershed Protection Department staff partnered with the Austin Water Utility water conservation program. For the last two years of the project, Austin Water Utility provided an additional $100,000 in funding for a fourth 30-second PSA called “Meet the Natives.” The goal was to encourage the planting of native and adapted plants as they require less water and fewer pesticides. The spot is a companion to the Big 3 and effectively drives people to the Grow Green website. The “Meet the Natives” spot features an animated “girl band” brought to life in the form of flowers and covers not only the benefits of plants, but also highlights the requirements of additional chemicals to maintain turf that “end up in your drain.” The “Meet the Natives” spot promotes reduced turf and describes the hydrologic functions of a watershed where stormwater runoff is transported into Austin’s creeks and aquifers.

The City additionally produced various types of printed materials and created specialized displays to distribute fact sheets at area nurseries. Prizes including T-shirts and temporary tattoos were distributed at public events.

METHODS

The goal of all the varied outreach components was to produce a cumulative impact from the exposure to the branding and the messages of the campaign and to be attractive and unique enough to foster discussion and behavior change that will improve water quality.

<u>Education Campaign Media Development</u>

A survey conducted by the Center for Watershed Protection on Residential Nutrient Behavior in the Chesapeake Bay found that most people prefer to receive their environmental information via the television, whether from newscasts, public service announcements (PSAs), or cable television. A major goal of the grant campaign was to reach people through television. Television also allows the three messages to be broadcast not only citywide, but also to cover the smaller, outlying Phase 2 Stormwater MS4 TPDES communities in the greater Austin area as well.

Grant funding allowed the City to hire a high-quality television production company, Shiny Object, to develop a style and content that would appeal to multiple audiences. Rather than take a traditional approach, the City developed three fifteen-second television spots using animation. The characters are all bugs and weeds, including both beneficial insects and pests, and the spots were intended to feel fun rather than preachy.

Professor Dung (Beetle) with his pedantic accent points to messages on a chalk board that encourage homeowners to “mow high, water deep and fertilize sparingly” to maintain “balance.” He then topples over and the tagline to visit www.growgreen.org shakes on the screen as the ad concludes. The video is viewable at You Tube under Big 3 Professor or http://www.youtube.com/user/austintexasgov?blend=23&ob=5#p/u/19/GYLbtXonvPc.

Just Kill the Bad Guys features beneficial insects led by Praying Mantis, Johnny Mantis, singing a catchy tune declaring “most of us critters are friends, not foe.” The final message is to avoid those “kill ’em all” pesticides. Well-known and recognizable local singer Dale Watson is the vocalist for the spot. The spot can be found on You Tube under Big 3 Johnny Mantis or at http://www.youtube.com/user/austintexasgov?blend=23&ob=5#p/u/21/vLEtMcwMM4o.

The third television spot features Dan D. Lion, the obnoxious #1 weed, challenging homeowners about whether or not they need to spread an herbicide over the entire lawn just to take out one ugly weed. A small child then comes along with a giggle and hand-pulls the weed in a single swoop. This spot won the EPA award for best PSA at the national Non-Point Source Pollution Prevention Conference in Portland in 2009. The PSA can be found on You Tube under Big 3 Dan D. Lion or at http://www.youtube.com/user/austintexasgov?blend=23&ob=5#p/u/22/eIbwqYEJaeU.

In the spring of 2010 we added an online survey on the Grow Green site to test recall on seeing the television spots. Out of the 44 respondents, 29.5% remembered Professor Dung, 31.8% remembered the Johnny Mantis band, but the overall favorite was Dan D. Lion with recall of 36.4%

Before choosing television stations appropriate for airing the PSAs, viewer information was requested from local stations to match demographics of the education campaign's target audiences. Socio-economic information was a driving factor for the selection process as wealthier and better-educated viewers were targeted. Working with the television sales representatives, the City chose a wide variety of stations and programs to reach the diverse audiences.

The City's Grow Green website is an invaluable source for inexpensive and effective outreach. The site has been updated consistently to provide visitors with a comprehensive guide for earth-wise gardening. Throughout the grant period, a Big 3 icon was featured on the home page to direct viewers to all of the campaign materials and landscaping recommendations. The site address was featured prominently in each of the television spots as the source of further information.

Education Campaign Media Deployment

A high percentage of television spots ran during prime time news, and were consistently rated as a good source of contact with men age 55+. Stations KVUE and KXAN were most frequently used over the three years, and were the two top-rated newscasts in the City of Austin.

Time Warner Cable provided a wide variety of shows reaching homeowners, including the Home Improvement Channel and the Food Show. The History Channel was a good choice for older men and those with higher education. News 8 offered the benefits of the news/weather programs. Several programs with high local viewer statistics, including University of Texas games in the Big 12 Basketball Tournament, were also selected.

The bulk of ads ran from mid-March though April, which is the peak gardening season when people are inspired to be outdoors following winter. Another round ran in the early fall each year as different pest problems dominated and homeowners considered fall fertilizing. Fall 2010 and spring 2011 were typical of the number and range of airings that were placed over the last three years (Table 4), in which a total of 1,737 spots were aired for the fiscal year.

Table 4. Summary of number of television spots aired by season and station for the 2010-2011 fiscal year as an example.

Season	Station	# of Spots Aired
Fall 2010	Time Warner	328
	KVUE	54
	KXAN	45
	Total	*427*
Spring 2011	Time Warner	840
	KVUE	195
	KXAN	156
	KEYE	119
	Total	*1310*

An additional benefit of using Time Warner was the number of complimentary airings because Time Warner has a large number of channels running 24 hours a day. For example, in fall 2010 Time Warner billed the City for 328 spots, but actually aired 1,712 spots. The City typically placed $10,000 to $12,000 of television advertising with each station. Each of the television (and radio) stations used said that viewers must see each spot three times before it actually makes a strong impression. The designated funding levels allowed the City to reach that goal.

To provide more variety to media outreach, the City included additional radio advertising in the campaign. In 2009, the City contracted again with Dale Watson to put all three messages into one song to promote the three simple messages that could help protect Austin's waterways and provide an attractive yard. The radio spot was titled "It's as Easy as 1-2-3" and can be found at http://www.ci.austin.tx.us/growgreen/big3_radio.htm. The "It's as Easy as 1-2-3" radio messages were aired on multiple stations (Table 5), and approximately 175 spots were aired per year.

Table 5. Summary of number of radio spots aired by station for the summer of 2011, as an example.

Station	# of Spots	Type of Station
KLBJ	104	News radio
KBPA-FM (BobFM)	72	Talk-free radio

Printed Education Materials

Various materials were created and updated over the period of the grant to reflect program evaluations and varying needs. A cornerstone of the printed campaign was The Big Three, a die-cut, tri-fold brochure that succinctly covered the major messages. The distinctive television spot characters peeking through the jagged grass were featured on the campaign summary piece and in a reminder mail out in 2010. The reminder was sent to all previous pilot neighborhoods including those reached before the inception of the grant. Distinctive envelopes helped set the stage for the content of the mail out. In 2010, the City mailed out 6,000 of these brochures in the Barton Springs Zone and the Northern Edwards Aquifer.

Figure 1. Campaign brochure

In the first year of the grant, an insert was also included in Austin utility bills to launch the campaign and as a component of the citywide promotion. The insert was mailed as the television spots were airing so that people could have more detailed information about the messages contained in the shorter TV spots.

COA and AgriLife Extension continued to expand and provide citywide pesticide prevention education through the Grow Green program, originally launched in 2000. The program includes a series of fact sheets based on Integrated Pest Management principles. Fact sheets cover information on proper landscape design, installation and maintenance techniques, as well as pest and lawn care problems and solutions. The four-color pest fact sheets provide photos and text on problem identification, prevention and least-toxic solutions. The backside of the handouts includes product toxicity ratings so that homeowners can see the impact products have on the environment, humans, pets and aquatic life. The very popular Native and Adapted Plant Guide recommends plants that require less water and fewer pesticides.

Figure 2. Utility bill insert

Figure 3. In-store display with grant topper. Plant Guide is inset

Based on the premise that people need landscaping solutions when purchasing landscaping products, the fact sheets and plant guides were placed in most local nurseries and home improvement centers throughout the city. The materials and in-store trainings are available to help nursery staff make earth-wise recommendations to their customers.

COA produced ten landscape design templates (www.ci.austin.tx.us/growgreen/landscape_templates.htm) so that homeowners had examples of landscape designs they could plant at their homes. Templates included Child Friendly, Classic, Contemporary, Deer Resistant, Drainage Solutions, Low Maintenance Shade, Pool Friendly, Sun and Color, Wildlife Habitat and Creekside designs. Seven of the ten have companion demonstration gardens throughout the downtown area so that people can view designs *in situ* and learn which plants they like and which ones work well together.

Education Campaign Pilot Neighborhoods

Because of the environmental sensitivity of the Edwards Aquifer Recharge Zone and significant baseline data, the grant proposal listed two evaluation, or pilot, neighborhoods for specialized comprehensive education. Nine pilot neighborhoods were actually targeted for specialized education: six in the Barton Springs Zone and three in the Northern Edwards. For the Northern Edwards, each neighborhood was chosen based on relatively high nutrient and Atrazine concentrations in the local springs based on existing monitoring data, by evaluation of socio-economic demographic information, average lot size and visual inspections of turf maintenance and landscaping practices. Demographics played a strong factor in the Barton Springs Zone where the data were less neighborhood-specific and most relied primarily on a sole source – Barton Springs. Stormwater monitoring considerations were more dependent on the ability to effectively monitor stormwater control effluent, which led to the selection of specific "pond-sheds" contributing drainage areas to controls at Park Place and Legend Oaks subdivisions. The grant is as an opportunity to evaluate the effectiveness of various educational techniques including incentives, website drivers, and varying formats of the mail out.

Customized materials were created for each of the pilot neighborhoods. Neighborhood-specific maps and data were incorporated to show the connections between water quality data and individual homeowner actions in the contributing drainage area. To reinforce the message, temporary tattoos were printed for three of the cartoon characters: Johnny Mantis, the Pirate Snail and the Ladybug Chorus. The tattoos were used as giveaways for children at fairs and events, although adults liked them, too. A favorite anecdotal comment came from one of the City staff members who said that his daughter came running into the room very excited to say, "Daddy, Daddy, my tattoos are on TV!!" Children teaching their parents was one of the goals for the handout.

From 2007 to 2011, public education surveys were mailed before and after the campaign to nine distinct neighborhoods corresponding to individual water quality monitoring sites. Approximately 9,700 surveys were mailed.

Figure 4. The Big 3 tattoos

2009 Pilot Neighborhood Campaign

In 2009, the first year of the grant, pilot neighborhood outreach concentrated on the Northern Edwards in the contributing drainage areas for Spicewood, Tanglewood and Tubbs springs. Each neighborhood received a different type of educational mail out to compare alternative forms of education. The cover artwork for each was similar, and contained a photo of a girl and her dogs relaxing on the lawn and asked the question, "Do you really need to use a pesticide?" Pre- and post surveys were sent to the three 2009 pilot neighborhoods.

The 469 households in Tanglewood each received a postcard inviting neighbors to attend a free workshop on earth-wise lawn care. As an added incentive, a free electric lawn mower was raffled to the attendees. Only five people representing four families attended the workshop. However, in order to not waste an educational opportunity, the postcard also offered a very limited, but essential list of issues relating to weed-and-feed products. The mail out also listed the customized website, www.AVOIDweedandfeednow.org for additional information, but had no visits to the site.

Figure 5. Cover art, 2009 educational mail out

A second approach was employed in the Tubbs Spring neighborhood in 2009 to test another incentive and the possibility of driving people to our website, again with minimal effect. A postcard was sent to 103 households with limited educational information on reducing pesticides from weed-and-feed products in the spring. Anyone visiting the neighborhood-specific web address, www.AVOIDweedandfeed.org, was offered a free weeding tool.

The third and largest pilot neighborhood for 2009 was Spicewood Springs. A more traditional approach was employed. An informative, neighborhood-specific mail out was sent to 774 homeowners that became the basis of future outreach. The information elaborated on the problem pesticides being detected in area springs, and the mailer included a neighborhood map and a photo of the spring to personalize and connect the homeowners to the source of the problem. The educational piece provided specific fertilizer and weed control recommendations and included a section labeled, "What You've Told Us," which related several of their select responses from the pre-survey questionnaire.

<u>2010 Pilot Neighborhood Education Campaign</u>

Two neighborhoods in the Barton Springs Zone, Legend Oaks and Park Place, were chosen as pilot neighborhoods in 2010, the second year of the campaign. Both neighborhoods drained to stormwater detention ponds that were monitored. Pre-surveys were sent to the designated 2010 pilot areas.

Both Park Place and Legend Oaks received the same type of personalized educational mail out that was sent to Spicewood Springs in 2009. The cover artwork on the mailer was changed from the child and dogs photo to tie more specifically to The Big 3 television campaign characters. Neighborhood maps and specific Slaughter Creek monitoring data were included in the mailer along with some discussion of the 2009 pre-survey results. Park Place was our smallest neighborhood with only 74 homeowners. In 2010, the "Grass Brochure" was mailed out to 6,000 homeowners in the pilot neighborhoods including those reached before the grant began.

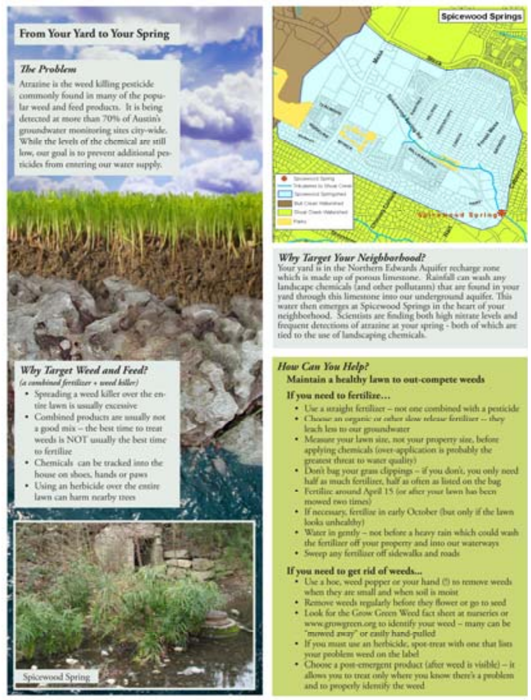

Figure 6. Spicewood Springs educational mail out content

2011 Pilot Neighborhood Education Campaign

COA defined a 2011 pilot neighborhood in the Barton Springs Zone, selecting Sendera with 813 homeowners. A pre-survey was distributed in 2010 prior to the educational mail out.

Figure 7. Cover art, 2010-2011 educational mail out

In 2011, the established outreach and mail out pattern was used to reach Sendera. Additionally, mailers were sent to La

Crosse, Alta Mira and Bauerle Ranch neighborhoods to assess homeowner awareness of COA ordinances requiring all new neighborhoods in the Barton Springs Zone, including La Crosse, Alta Mira and Bauerle Ranch, to abide by Integrated Pest Management principles. The ordinance applies to all homes built after 1992 and should have been included with the closing papers when each home was sold. Since the Grow Green and grant recommendations are based on IPM, this served as a means for reinforcing commitment to the program and grant-sponsored messages.

Environmental Monitoring

The environmental monitoring component of the project was used as one of a set of performance measures to evaluate the effectiveness of the public education campaign to promote environmentally appropriate use of lawn and garden chemicals. Nutrients (nitrogen and phosphorus) in available forms and surrogate pesticides (Atrazine and Carbaryl) were monitored in groundwater spring discharge and surface water runoff at multiple locations in Austin (Table 6, Figure 7). Monitoring was initiated before education efforts began in order to establish a baseline for comparison. Data were used to determine if nutrient and pesticide concentrations changed following education. The sample design is based on the comparison of mean nutrient and pesticide concentrations in ambient groundwater springs and surface water runoff before and after education efforts.

Table 6. Monitoring Sites. Note start dates shown include existing historical data collected under similar procedures that will be used to assess project effectiveness but not submitted to SWQMIS under the project QAPP.

TCEQ Station ID	**Site Description**	**Latitude/ Longitude**	**Start Date (including historical data)**	**End Date**	**Sample Matrix**
AU0505*	Tubb Spring	30.43159 / -97.81685	10/2006	08/2010	groundwater
16313	Spicewood Spring	30.356112 / -97.751389	10/2006	08/2010	groundwater
16318	Tanglewood Spring	30.428281 / -97.787247	10/2006	08/2010	groundwater
AU0160*	Backdoor Spring	30.25951 / -97.82371	10/2006	08/2010	groundwater
16308	Stillhouse Spring	30.371389 / -97.763054	10/2006	08/2010	groundwater
AULOA1*	Legend Oaks sand-filter inlet	30.22600 / -97.86510	03/2008	06/2011	stormwater
AUPPI1*	Park Place retention pond inlet 1	30.20140 / -97.87500	03/2009	06/2011	stormwater
AUPPI2*	Park Place retention pond inlet 2	30.20120 / -97.87430	03/2009	06/2011	stormwater
AUPPI3*	Park Place retention pond inlet 3	30.20090 / -97.87330	03/2009	06/2011	stormwater

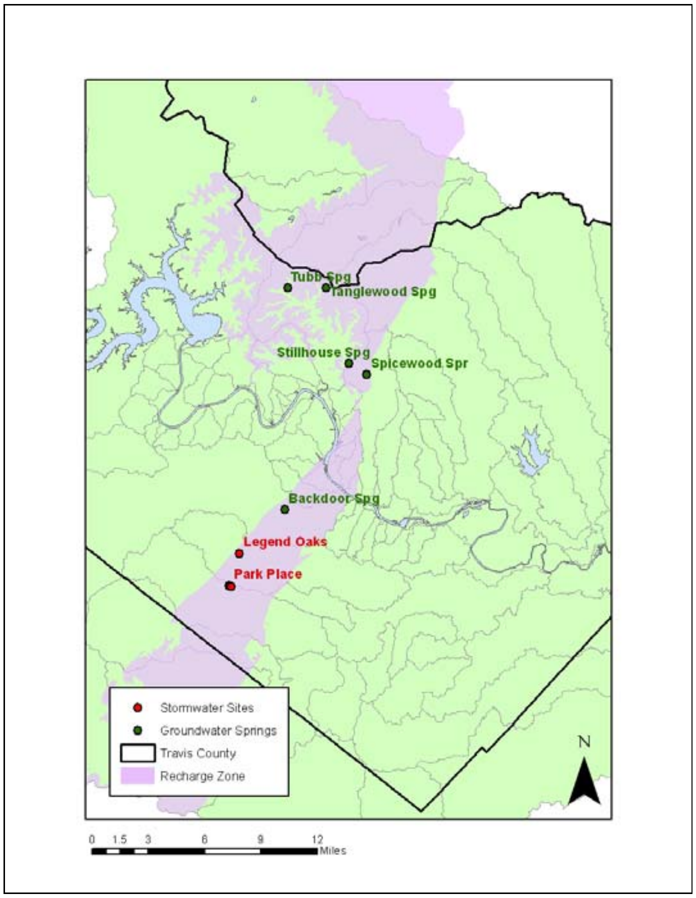

Figure 7. Sampling site location map.

Groundwater Spring Monitoring

Ambient grab samples were collected from five groundwater springs (Table 6, Figure 7) at the point of discharge to the surface on a routine schedule with 10 to 12 sample events per site, per year. Sample events were clustered during months with peak expected use of lawn and garden chemicals. Five to seven events occurred during the months of March to May (spring) and three to five events occurred during the months of June to August (summer/fall) annually. Monitoring began in June 2009 and continued through August 2010 (the end of the original contract) under the TCEQ-approved project QAPP. Instantaneous field measurements for dissolved oxygen, pH, conductivity and temperature were collected with a Hydrolab field datasonde (Table 7). Nitrate/nitrite, ammonia, orthophosphorus, Atrazine and Carbaryl were analyzed at the contract laboratory (Table 8). Sample collection and field measurements were conducted according to the current version of TCEQ's *Surface Water Quality Monitoring Procedures Manual*. Sample bottles were acidified as appropriate, iced and transported to the laboratory where they will be stored at 4ºC prior to analysis within required holding time.

For summary statistics with groundwater parameters containing censored (less than reporting limit) observations, the Kaplan-Meier (K-M) survival analysis technique (Kaplan and Meier 1958) was used because it is the preferred non-parametric method for estimating summary statistics when less than 50% of the observations are censored (Allison 1995, Helsel 2005). The non-parametric Wilcoxon rank-sum test was used for groundwater mean comparisons for datasets without censored observations. For groundwater parameters with censored observations, the modified Peto and Peto test (Prentice 1978), generally found to be the score test yielding the best overall performance for datasets with unequal sample sizes between groups (Latta 1981), was used for comparison testing. For datasets with censored observations, Cox's non-parametric proportional hazards regression procedure was used for groundwater temporal trends (Allison 1995).

Table 7. Measurement performance specifications for groundwater field parameters.

PARAMETER	UNITS	MATRIX	METHOD	PARAMETER CODE
pH	pH/ units	water	EPA 150.1 and TCEQ SOP, V1	00400
DO	mg/L	water	EPA 360.1, TCEQ SOP, V1 and ASTM D888-05	00300
Conductivity	µS/cm	water	EPA 120.1 and TCEQ SOP, V1	00094
Temperature	° C	water	SM 2550B	00010

Table 8. Measurement performance specifications for groundwater laboratory analytical data.

PARAMETER	UNITS	MATRIX	METHOD	PARAMETER CODE	AWRL	Limit of Quantitation (LOQ)	LAB
Ammonia-N, total	mg/L	water	EPA 350.1	00610	0.1	0.02	ELS
Nitrate/nitrite-N, total	mg/L	water	SM 4500-NO3-H	00630	0.05	0.02	ELS
Nitrate/nitrite-N, total (backup)	mg/L	water	EPA 300.0	00630	0.05	0.02	ELS
O-phosphate-P * Filter >15 min.	mg/L	water	EPA 300.0 Rev. 2.1 (1993)	70507	0.04	0.04	ELS
Atrazine	µg/L	water	EPA 525.2	39630	1.5	1.0	ELS
Carbaryl	µg/L	water	EPA 625	39750	1.0	50	ELS

Stormwater Monitoring

Stormwater runoff samples were collected from the inlets of two water quality structural controls in southern Austin. A weir on the inlet to a sand filter draining the Legend Oaks subdivision was sampled (Figure 8). Flumes on the three inlets to a retention/irrigation pond in the Park Place subdivision were sampled individually (Figure 9). While the hope was to conduct differential education campaigns targeted to the separate drainage areas of the control, it was determined that the areas had too few homeowners to provide adequate data. Monitoring stations were equipped with automatic stage recorders (bubbler meter) and data loggers operating on 1-minute time increments. Meter data were downloaded on a regular basis and stored in the City of Austin Hydstra/TS Time-Series Data Management System. Measurements from the flow meters were used to pace the automatic samplers and generate the total flow volume for each storm event.

Typically, three nutrients samples were collected per storm event. Some small storm events had less than three samples collected due to an insufficient volume of runoff, and for some larger storms more than three samples were collected in order to accurately characterize the hydrograph. Samples were analyzed for ammonia, nitrate+nitrite, Kjeldahl nitrogen, total phosphorus and dissolved phosphorus (filtered in the laboratory) (Table 9). Pollutant loads were determined by multiplying the event mean concentration by total flow volume to determine total load per storm event. One pesticide composite sample was generated from a separate ISCO to characterize the entire runoff event. Laboratory analytical parameters were the same as in groundwater spring monitoring. Additionally, rainfall data were collected using a 0.01-inch tipping bucket rain gauge. Runoff events to be sampled had a minimum of 0.04 inch of rainfall preceded by a six-hour dry period of no rainfall. Pre-education campaign monitoring following the exact procedures described in the project QAPP at Legend Oaks began in March 2008, and data collected prior to the acceptance of this QAPP were included in the analysis. The education campaign was initiated at Legend Oaks in February 2009, with post-education monitoring immediately following and continuing through December 2010. Pre-education campaign monitoring at Park Place began in the spring of 2009 when equipment was fully operational. The education campaign at Park Place began in February 2010 with post-education monitoring immediately following and continuing through December 2010.

Table 9. Measurement performance specifications for stormwater laboratory analytical data.

PARAMETER	UNITS	MATRIX	METHOD	PARAMETER CODE	AWRL	Limit of Quantitation (LOQ)
Ammonia-N, total	mg/L	water	EPA 350.1	00610	0.1	0.02
Nitrate/nitrite-N, total	mg/L	water	SM 4500-NO3-H	00630	0.05	0.02
Nitrate/nitrite-N, total (backup)	mg/L	water	EPA 300.0	00630	0.05	0.02
Total phosphorus *	mg/L	water	EPA 365.4	00665	0.06	0.06
Dissolved phosphorus *	mg/L	water	EPA 365.4	00666	0.06	0.06
Total Kjeldahl Nitrogen *	mg/L	water	EPA 351.2	00625	0.2	0.2
Atrazine	µg/L	water	EPA 525.2	39630	1.5	1.0
Carbaryl	µg/L	water	EPA 625	39750	1.0	50

Figure 8. Park Place targeted education neighborhood with drainage area and sampling locations prior to discharging to BMPs.

Figure 9. Legend Oaks targeted education neighborhood with drainage area and sampling locations prior to discharging to BMPs.

RESULTS AND OBSERVATIONS

Education Campaign Media Coverage

Television

Between year one and year three of the campaign, there was a marked difference between the number of people who viewed the television spots vs. those who reported seeing the mailings.

Table 10. Percent pilot neighbors seeing the television spots and mailings: 2009

Neighborhood	Television Spots	Mailings
Spicewood	23	60
Tanglewood	28	29*
Tubbs	30	30*
Average	**27**	**40**

*The number of those viewing the mailings for Tanglewood and Tubbs is somewhat deceiving since they received a very abbreviated version of the mail out compared to mail outs sent later to neighborhoods that received a version similar to the one that the Spicewood neighborhood received.

Table 11. Percent pilot neighbor respondees seeing television spots and mailings: 2011

Neighborhood	Television Spots	Mailings
Alta Mira	42	21
Bauerle Ranch	41	28
LaCrosse	27	21
Sendera	42	21
Average	**38**	**23**

Deleted:

Deleted:

As hoped, the number of people seeing the television spots increased over the additional two years the spots ran. Thirty-eight percent recalled seeing the spot in the last year of the grant, whereas only 27% recalled seeing one in year one. While 60% recalled seeing the mail out in the Spicewood neighborhood, only 23%, on average, recalled receiving them in year three. The only significant difference between the Spicewood neighborhood brochure and brochures sent to Alta Mira, Bauerle, LaCrosse and Sendera was the cover art. Spicewood featured the girl and dogs lying in the grass and the phrase, “Do you really need pesticides?” while the other four neighborhoods received the cartoon characters, and the header, “Want a pretty yard and clean water?” The child and pet photo generated more recall from the pilot responses than the cartoon characters. According to Water Words that Work (2011) some of the most effective words (in this case, ideas) that people respond to are: Future Generations, Healthy, Family and Children and Safe. We would add the concept of including pets, something else that people care about.

Website

Hits to the Grow Green website increased during the months when the television spots aired (Figure 10). The spring season is prime gardening season, and web hits dramatically increased then, suggesting that the advertising is a major factor in driving web traffic.

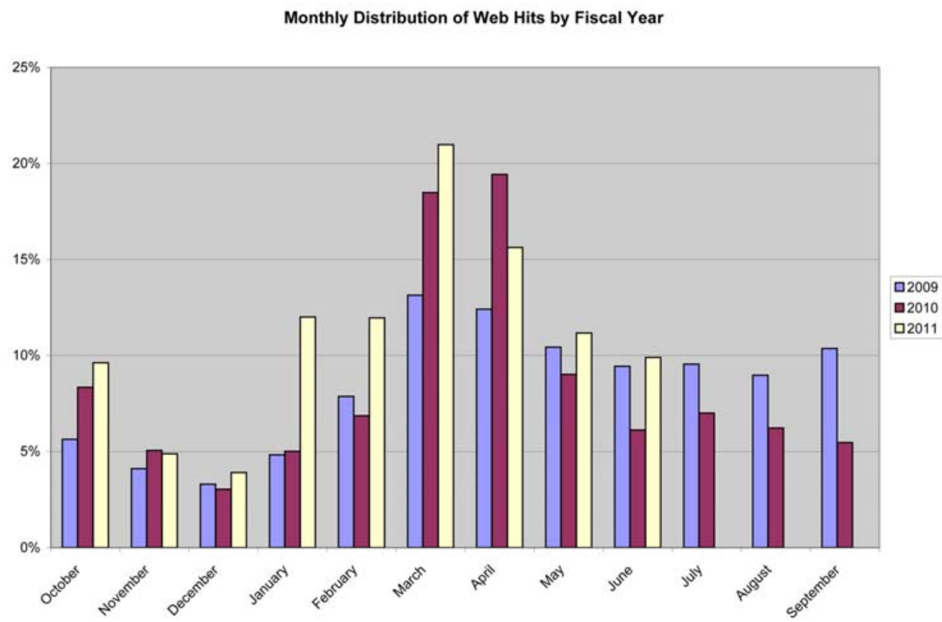

Figure 10. Monthly distribution (% of annual total) of website hits by year.

In late 2009, the City changed the way it calculates web hits so baseline total number of web hit data for pre-campaign activity is not available. There are major increases in percentage of hits for the spring season. In 2010, there were 56,451 hits in March and 59,359 in April. The following year the numbers dropped to 38,149 and 28,403, respectively, for the same months although they were still substantially higher over other months. The television spot coverage was compounded during the spring months in 2010 by the airing of the "Meet the Natives" spot in addition to The Big 3 spots.

Each of the television station websites also featured clickable promotions for the Grow Green website in conjunction with the advertising. Click rates above 0.07 are generally considered good by television stations. In spring 2011, click rates exceeded 0.07 (Table 12). A major benefit with the paired web/TV advertising is program branding, creating familiarity with the Grow Green icon so that when the logo comes up in other settings it is recognizable to the viewer.

Table 12. Website click rates for spring 2011 by station.

Station	Impressions Delivered	Clicks Recorded	Click Rate
Time Warner	150 429	119	0.0975
KXAN	424,492	332	0.09

Further analysis of the City's Grow Green website with Google Analytics yields a substantial number of hits throughout the state (Figure 11). The grant program education message value is increased by the expanded spatial coverage via the Internet. Because of the global nature of the Internet, other EPA jurisdictions are exposed to our materials as well (Figure 12).

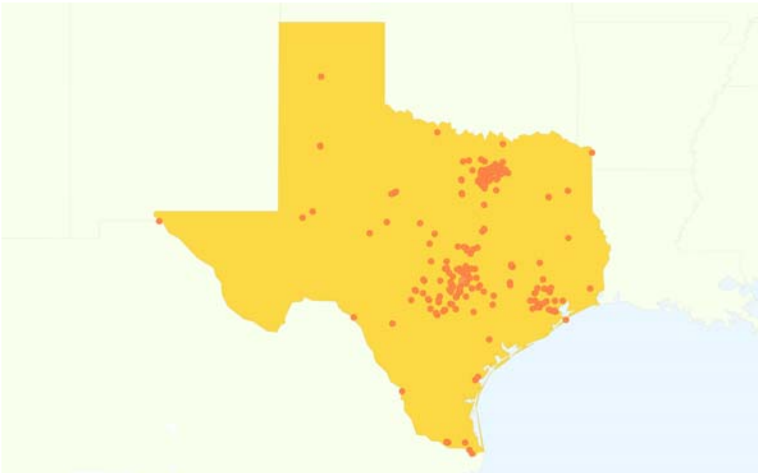

Figure 11. Grow Green program web hits in Texas (2009-2011).

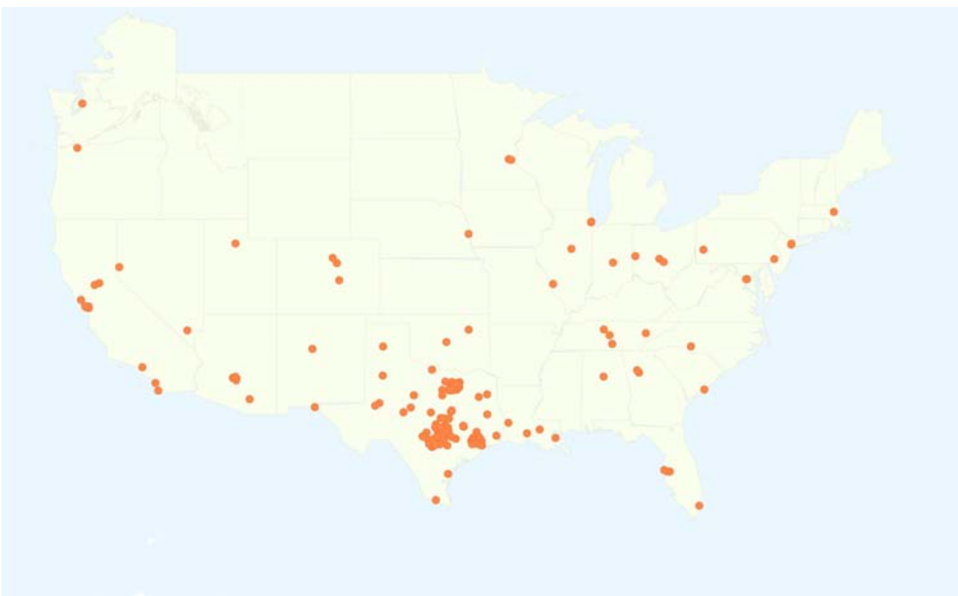

Figure 12. Grow Green program web hits nationwide (2009-2011).

An estimated 48% of the visitors to the Grow Green website are new to the site. The 52% of repeat visitors suggests users are finding the information valuable enough to return. The average time on the website is two minutes, again allowing time for several clicks/navigations to diverse information.

Education Surveys

Pre- and post-public education surveys were mailed to nine distinct neighborhoods from 2007 to 2011 corresponding to individual water quality monitoring sites (Table 13). Approximately 9,700 surveys were mailed, and 1,872 responses were returned. There was an average response return rate of 17.2% for before-education surveys and 12% for after-education surveys.

Table 13. Survey years by neighborhood with corresponding monitoring sites and percent successful return rate.

Year	Neighborhood	Monitoring Site	% Response	
			Before	After
2007	Tanglewood	Tanglewood Spring	13.9	18.1
2007	Tubb	Tubb Spring	12.6	12.6
2008	Spicewood Spring	Spicewood Spring	23.1	18.1
2009	Legend Oaks	Legend Oaks pond	27.8	13.3
2010	Park Place	Park Place pond	13.5	8.1
2010	Sendera		32.8	9.2
2011	Alta Mira		10.8	8.2
2011	Bauerle Ranch		4.7	8.5
2011	LaCrosse		11.8	5.9

Some survey questions varied by neighborhood but all neighborhoods were consistently asked two basic questions, with a third question asked at five of the nine assessment neighborhoods (Table 14). Answer options were not mutually exclusive for all questions, and answers were not recorded for all responses on all surveys.

Table 14. Basic survey questions used consistently for each neighborhood. Asterisk (*) indicates question was asked in five of nine neighborhoods for assessment.

Question	Answer Options
What type of fertilizer is used on your lawn?	Organic, chemical, weed-and-feed, slow-release
How do you treat weeds?	Hand pull, weed-and-feed, don't treat
Have you seen the Grow Green fact sheets?*	Yes, no, unsure

The majority of neighborhoods surveyed exhibited a positive response to education based on the type of fertilizer used. Out of nine neighborhoods, seven neighborhoods showed a decrease in the percentage of respondents using chemical fertilizers, eight neighborhoods yielded a decrease in percentage of respondents using weed-and-feed, eight neighborhoods yielded an increase in percentage of respondents using organic fertilizers and five neighborhoods yielded an increase in percentage of respondents using slow-release fertilizers after education. A non-parametric Wilcoxon signed-rank test was used to evaluate the statistical significance of change in response percentages before and after education, with significance defined by a type 1 error rate of 0.10 based on the low number of neighborhoods surveyed. This method controls for demographic variability by pairing before and after responses, but equally weights neighborhoods despite variation in the total number of respondents by neighborhoods (Table 15). While positive improvement was noted in all four types of fertilizer use, only the increase in organic fertilizer use was significant following education.

Table 15. Change in mean percentage of respondents before and after education for type of fertilizer used, with Wilcoxon signed-rank test results. Pr>|S| values less than 0.10 are significantly different, highlighted in green.

Type of Fertilizer	% Before	% After	Pr>|S|
Chemical	16	11	0.1328
Weed-n-Feed	34	24	0.1094
Organic	24	37	0.0508
Slow Release	16	20	0.3711

An improvement was noted in the overall average percentage of respondents who increased hand-pulling of weeds and decreased used of weed-and-feed products to treat weeds following education (Table 16). By a non-parametric Wilcoxon signed-rank test to test for differences before and after education when paired by neighborhood, the improvement in response is not statistically significant. Eight of nine neighborhoods yielded a decrease in percentage of respondents using weed-and-feed after education, and six of nine neighborhoods yielded an increase in percentage of respondents hand-pulling weeds after education.

Table 16. Change in mean percentage of respondents before and after education by type of weed removal method used, with Wilcoxon signed-rank test results.

Weed Treatment Method	% Before	% After	Pr>|S|
hand pull	67	75	0.1289
Weed-and-feed	30	22	0.2696

Four of five neighborhoods surveyed yielded an increase in the percentage of respondents who had seen the Grow Green fact sheets following education efforts. The overall average percentage of respondents who had seen Grow Green fact sheets increased from 31% to 40% following education although the difference was not statistically significant by Wilcoxon signed-rank test (Pr>|S|=0.62).

In the 2009 pilot neighborhood surveys, a substantial behavior change was noted. The percentage of respondents who used weed-and-feed decreased from 26% in the pre-education survey results to only 5% in the post-education survey. Education materials affected landscaping practices. In the post-education survey, 28% of respondents indicated they stopped using weed-and-feed after viewing the educational materials while only 8% indicated they would continue using weed-and-feed.

In the 2010 pilot neighborhood surveys, there were only six post-education survey responses from 74 homeowners, which was the smallest percentage of responses from a neighborhood during the grant. Only 13% of the homeowners in Legend Oaks responded to surveys, and the response to education was mixed, with 18% of respondents indicating reduced landscape chemical use while 3% indicated they would use more landscape chemicals.

There was very low general awareness by homeowners of the City's IPM requirements prior to education. Educational materials did increase awareness of the IPM ordinance (Table 17).

Table 17. Percentage of survey respondents aware of Austin IPM requirements before and after education.

Neighborhood	Before Education	After Education
Alta Mira	0%	44%
Bauerle Ranch	17%	37%
LaCrosse	27%	40%

Homeowners in the 2011 pilot neighborhoods were asked if they had changed behavior as a result of the educational information. Improvement in use of earth-wise landscape practices was noted in all four areas (Table 18). Both Bauerle Ranch and Sendera homeowners indicated more than a 50% increase in use of earth-wise practices and improvements were indicated in both Alta Mira and LaCrosse.

Table 18. Percentage of 2011 respondents by neighborhood adopting earth-wise landscaping practices.

Have you adopted new earth-wise practices?	Alta Mira	Bauerle Ranch	La Crosse	Sendera
Yes, many	7%	21%	14%	23%
Yes, a few	28%	34%	21%	35%
No	7%	6%	0%	10%
No, already practiced earth-wise	57%	38%	64%	32%

Demand for Grow Green printed fact sheets, distributed at area plant stores, remained elevated throughout the grant (Table 19).

Table 19. Grow Green printed fact sheet program summary by fiscal year. Year 2011 statistics only include the first nine months of the fiscal year.

Source	2009	2010	2011
Local nurseries/City sites	53	53	56
Nursery staff trained	165	170	166
Plant Guides distributed	63, 600	61,000	47,000
Fact Sheets distributed	157, 700	162,000	113,820

Groundwater (Spring) Monitoring

There were no detected values of Carbaryl for any spring site before or after education. Because all data for Carbaryl are below detection limits and cannot be used to determine effectiveness of education efforts, Carbaryl is excluded from other data analyses. Start and end dates of groundwater monitoring and number of samples collected is summarized (Table 20).

Table 20. Summary of groundwater data regarding number of observations, number of observations less than detection limit (ND) and start/end dates of monitoring included in the assessment.

site	Before Education				After Education			
	#	nd	first	last	#	nd	first	last
AMMONIA AS N								
Backdoor	46	29	05/1991	02/2007	41	28	03/2007	04/2011
Tubb	25	21	04/1996	12/2007	24	15	05/2008	07/2010
Spicewood	35	15	01/1990	06/2001	24	17	05/2008	07/2010
Stillhouse	64	20	06/1987	12/2001	109	72	01/2002	07/2010
Tanglewood	60	30	06/1987	03/2007	26	20	03/2008	07/2010
ATRAZINE (AATREX)								
Backdoor	5	3	04/2003	04/2006	37	33	03/2007	07/2010
Tubb	7	6	03/2007	02/2008	29	17	03/2008	07/2010
Spicewood	12	6	06/2001	02/2008	28	16	03/2008	07/2010
Stillhouse	.	.	.	.	44	38	05/2002	07/2010
Tanglewood	13	7	06/2001	02/2008	28	27	03/2008	07/2010
CONDUCTIVITY								
Backdoor	37	0	04/1995	02/2007	46	0	03/2007	04/2011
Tubb	27	0	04/1996	02/2008	29	0	03/2008	04/2011
Spicewood	25	0	01/1997	02/2008	30	0	03/2008	08/2010
Stillhouse	48	0	08/1995	10/2001	76	0	02/2004	07/2010
Tanglewood	29	0	04/1996	02/2008	31	0	03/2008	08/2010
DISSOLVED OXYGEN								
Backdoor	21	0	01/1996	02/2007	46	0	03/2007	04/2011
Tubb	23	0	12/2002	02/2008	29	0	03/2008	04/2011
Spicewood	32	0	04/1994	02/2008	30	0	03/2008	08/2010
Stillhouse	47	0	04/1994	10/2001	85	0	05/2002	07/2010
Tanglewood	38	0	04/1994	02/2008	33	0	03/2008	08/2010
NITRATE/NITRITE AS N								
Backdoor	44	0	01/1995	02/2007	39	0	03/2007	04/2011
Tubb	25	0	04/1996	12/2007	26	0	05/2008	04/2011
Spicewood	35	0	01/1990	06/2001	25	0	05/2008	08/2010
Stillhouse	63	0	06/1987	12/2001	108	0	01/2002	07/2010
Tanglewood	58	0	06/1987	03/2007	27	0	03/2008	08/2010
ORTHOPHOSPHORUS AS P								
Backdoor	46	10	01/1995	02/2007	39	2	03/2007	04/2011
Tubb	25	22	04/1996	12/2007	24	19	05/2008	07/2010
Spicewood	31	15	03/1991	06/2001	24	2	05/2008	07/2010
Stillhouse	48	19	03/1991	12/2001	108	9	01/2002	07/2010
Tanglewood	43	36	03/1991	03/2007	26	15	03/2008	07/2010
PH								
Backdoor	40	0	05/1994	02/2007	47	0	03/2007	04/2011
Tubb	27	0	04/1996	02/2008	29	0	03/2008	04/2011
Spicewood	40	0	01/1990	02/2008	30	0	03/2008	08/2010
Stillhouse	71	0	06/1987	10/2001	86	0	05/2002	07/2010
Tanglewood	60	0	06/1987	02/2008	33	0	03/2008	08/2010
WATER TEMPERATURE								
Backdoor	43	0	09/1990	02/2007	47	0	03/2007	04/2011

Tubb	28	0	02/1995	02/2008	29	0	03/2008	04/2011
Spicewood	40	0	01/1990	02/2008	30	0	03/2008	08/2010
Stillhouse	76	0	06/1987	10/2001	86	0	05/2002	07/2010
Tanglewood	65	0	06/1987	02/2008	33	0	03/2008	08/2010

Means by site and parameter were compared before and after education (Table 21). Potential changes from education as observed in monitoring data are mixed. Ammonia decreased at four of five sites in the post-education time period. Nitrate concentrations increased at Backdoor and Tubb springs and decreased at Spicewood Springs. Orthophosphorus concentrations decreased at Backdoor Springs after education and may have decreased after education at Tanglewood although the statistically significant change at Tanglewood was non-significant (p=0.06). Statistically significant changes in Atrazine concentration following education were observed only at Tanglewood Spring, where Atrazine concentrations increased, although there was only one detected value for the post-education time period, making the statistical output highly questionable. Conductivity increased at Backdoor and Tubb springs during the post-education period and decreased at Spicewood Spring. Dissolved oxygen decreased at Spicewood and Stillhouse springs. pH increased at four of the five sites after education, and no changes in temperature were observed over the study.

Table 21. Mean, standard deviation (STD), and results of comparison testing (Prob) for before and after education periods. Comparison testing was done by Wilcoxon rank-sum test (Pr>|Z|) for uncensored datasets and by modified Peto and Peto test for censored datasets as indicated by an asterisk (*). Green shading indicates significant improvement while pink shading indicates significant degradation.

Site	Before Education		After Education		Prob Test Result
	mean	std	mean	std	
AMMONIA AS N*					
Backdoor	0.026	0.017	0.011	0.015	0.0115
Tubb	0.011	0.013	0.010	0.013	0.7709
Spicewood	0.056	0.072	0.012	0.004	0.0001
Stillhouse	0.047	0.053	0.014	0.024	<0.0001
Tanglewood	0.036	0.047	0.009	0.011	<0.0001
ATRAZINE (AATREX)*					
Backdoor	0.032	0.037	0.035	0.025	0.1289
Tubb	0.140	0.044	0.075	0.075	0.2695
Spicewood	0.088	0.134	0.105	0.180	0.9410
Stillhouse	.	.	0.028	0.048	n/a
Tanglewood	0.044	0.048	0.048	0.005	0.0002
CONDUCTIVITY					
Backdoor	762	55	794	55	0.0012
Tubb	794	71	852	24	0.0018
Spicewood	1018	90	875	123	<0.0001
Stillhouse	888	226	1007	65	0.1505
Tanglewood	897	124	878	99	0.1741
DISSOLVED OXYGEN					
Backdoor	7.87	0.78	7.61	1.36	0.9196
Tubb	6.71	0.97	6.74	1.04	0.7623
Spicewood	6.80	1.11	6.19	1.30	0.0181
Stillhouse	8.81	1.55	7.61	0.88	<0.0001
Tanglewood	7.05	0.86	7.15	1.31	0.3807
NITRATE/NITRITE AS N					

Backdoor	1.89	0.39	2.37	0.29	<0.0001
Tubb	1.56	0.37	2.33	0.30	<0.0001
Spicewood	4.36	0.70	3.66	0.86	0.0040
Stillhouse	6.67	1.45	6.85	0.66	0.9008
Tanglewood	2.13	0.54	1.93	0.91	0.3850
ORTHOPHOSPHORUS AS P*					
Backdoor	0.023	0.018	0.015	0.006	<0.0001
Tubb	0.010	0.013	0.004	0.005	0.3121
Spicewood	0.043	0.052	0.037	0.039	0.3961
Stillhouse	0.053	0.065	0.049	0.048	0.2019
Tanglewood	0.020	0.007	0.000	0.002	0.0660
PH					
Backdoor	7.15	0.30	7.16	0.24	0.8785
Tubb	7.00	0.22	7.10	0.14	0.0264
Spicewood	6.86	0.36	7.02	0.18	0.0431
Stillhouse	7.13	0.27	7.40	0.24	<0.0001
Tanglewood	7.08	0.25	7.29	0.19	<0.0001
WATER TEMPERATURE					
Backdoor	20.6	0.8	20.5	0.3	0.6289
Tubb	20.6	1.0	20.7	0.7	0.5894
Spicewood	21.3	1.0	21.5	1.3	0.5391
Stillhouse	20.5	0.7	20.3	0.6	0.0580
Tanglewood	21.3	2.6	20.9	2.5	0.4540

Although pre- and post-education period means were not significantly different at Backdoor Spring and Stillhouse Spring, the last detection of Atrazine at these sites was in the spring of 2008. Proportional hazard regression of Atrazine concentrations over time yield statistically significant decreasing concentrations over time for Backdoor Spring ($Pr>\chi^2 = 0.0351$), Stillhouse Spring ($Pr>\chi^2 = 0.0017$) and Tanglewood Spring ($Pr>\chi^2 = 0.0001$) but no change over time at Tubb ($Pr>\chi^2 = 0.5089$) or Spicewood springs ($Pr>\chi^2 = 0.2609$). Increases in conductivity means at Backdoor and Tubb Spring were driven by earlier changes resulting from development and were most likely not a result of a change within the post-education time period. Nitrate concentrations at Backdoor and Tubb springs continue to increase over time. Orthophosphorus concentrations continue to decrease over time at Backdoor Spring.

Stormwater Monitoring

The LOA monitoring station is located in the Legend Oaks subdivision. The 13.37-acre watershed has 42.2% impervious cover and is high-density, single-family residential. Monitoring started in the spring of 2008 and continued through the spring of 2011. A lack of rainfall in 2011 resulted in no samples being collected in 2011. Event mean concentrations (EMCs) from the 37 sampled events are presented in Table 22.

Three monitoring stations were established in the Park Place section of the Circle C Ranch subdivision: PP1, PP2 and PP3. These correspond to the east, middle and west influents, respectively, of a retention-irrigation water quality pond. PP1 is 4.84 acres with 49.7% impervious cover. PP2 is 4.36 acres with 51% impervious cover. PP3 is 2.19 acres with 49.4% impervious cover. Monitoring at these sites started in the spring of 2009 and continued through the spring of 2011. As with LOA, no samples were collected in the spring of 2011 due to a lack of rainfall. EMCs from the sampled events for these stations are presented in Tables 23-25. Twenty-six events were sampled at PP1, 23 at PP2 and 24 at PP3.

The trends for the EMCs for the Atrazine and nutrients were similar for all sites. Atrazine was typically not detected in the summer and winter months but was detected at fairly high levels in the spring and fall, which would correspond with times of the year that lawn fertilizers and chemicals would be applied (Figure 13, Figure 14). Slight trends were seen in nitrogen concentrations similar to those seen in Atrazine. However, meaningful trends were not detected in phosphorus concentrations. Carbaryl was not detected at any monitoring location.

Atrazine concentrations were much higher in the Park Place runoff compared to runoff from the Legend Oaks watershed. Total nitrogen, nitrate+nitrite, total and dissolved phosphorus concentrations are also higher at Park Place but the difference is not as pronounced (Figure 14). This could indicate higher fertilizer use at Park Place or the use of different products. This may be due to slightly different demographics or the age of the neighborhood, Legend Oaks being older and more established. The average nutrient concentrations observed at the pilot neighborhood does not differ greatly for the long-term average stormwater concentrations observed elsewhere in Austin.

There are no differences in the peak concentrations of Atrazine pre- or post-education but this may be confounded by the different weather conditions. The post-education period appears to have had more rainfall, which may have resulted in additional lawn care activities, education notwithstanding.

Table 22: Stormwater monitoring results from Legend Oaks (LOA).

Start of Flow	End of Flow	Atrazine (AATREX) (ug/l)		NH_3 (mg/l)		NO_3+NO_2 (mg/l)	TKN (mg/l)	Total N (mg/l)	Total P (mg/l)	Diss. P (mg/l)
18-Mar-2008 12:23	19-Mar-2008 03:41		4.000	J(<)	0.066	0.320	1.24	1.56	0.350	0.262
25-Apr-2008 21:56	26-Apr-2008 01:38		6.440		0.555	0.408	4.46	4.87	0.427	0.230
24-Jul-2008 13:29	25-Jul-2008 02:26	U(<)	0.010	J(<)	0.022	0.176	0.76	0.94	0.260	0.156
17-Aug-2008 22:49	18-Aug-2008 02:01	U(<)	0.010		0.041	0.387	0.66	1.04	0.172	0.091
18-Aug-2008 14:11	18-Aug-2008 16:35	U(<)	0.015		0.052	0.144	0.77	0.91	0.151	0.007
19-Aug-2008 05:32	19-Aug-2008 08:15	U(<)	0.010		0.042	0.173	0.38	0.56	0.106	0.032
14-Oct-2008 16:24	14-Oct-2008 18:52	U(<)	0.012	J(<)	0.011	0.256	1.54	1.79	0.355	0.055
15-Oct-2008 03:14	15-Oct-2008 20:42	U(<)	0.012	J(<)	0.010	0.190	0.68	0.86	0.160	0.055
05-Jan-2009 12:15	06-Jan-2009 09:30		0.142		2.586	0.703	5.99	6.69	0.180	0.138
12-Mar-2009 00:08	12-Mar-2009 11:06		8.960		0.193	0.308	1.22	1.53	0.265	0.135
26-Mar-2009 13:07	26-Mar-2009 15:33		2.140	J(<)	0.004	0.162	1.12	1.29	0.184	0.077
12-Apr-2009 06:26	12-Apr-2009 12:33		2.960		0.170	0.306	1.41	1.71	0.200	0.096
17-Apr-2009 08:02	17-Apr-2009 16:16		1.096		0.206	0.222	1.27	1.49	0.257	0.109
27-Apr-2009 12:12	27-Apr-2009 18:10		1.460		0.157	0.220	0.72	0.94	0.138	0.064
16-May-2009 11:48	16-May-2009 16:40	U(<)	0.012		0.299	0.253	1.62	1.87	0.211	0.142
01-Jul-2009 11:57	01-Jul-2009 14:22	U(<)	0.012		0.158	0.402	0.87	1.27	0.163	0.081
22-Jul-2009 19:04	23-Jul-2009 03:06	U(<)	0.012		0.148	0.626	1.38	2.00	0.224	0.113
10-Sep-2009 10:30	10-Sep-2009 17:33	U(<)	0.012		---	---	---	---	---	---
11-Sep-2009 17:05	11-Sep-2009 19:44	U(<)	0.012	J(<)	0.004	0.146	0.44	0.59	0.150	0.096
22-Sep-2009 03:01	22-Sep-2009 15:38	U(<)	0.011		0.138	0.158	0.67	0.83	0.148	0.094
23-Sep-2009 15:13	23-Sep-2009 20:57	U(<)	0.012		0.038	0.234	0.31	0.55	0.069	0.047
03-Oct-2009 15:53	03-Oct-2009 23:10		1.910	J(<)	0.003	0.092	0.25	0.34	0.071	0.040
09-Oct-2009 05:42	09-Oct-2009 15:13		0.156		0.049	0.201	0.41	0.61	0.164	0.114
20-Nov-2009 04:18	21-Nov-2009 05:40	U(<)	0.011	J(<)	0.022	0.286	0.54	0.83	0.251	0.214
01-Dec-2009 11:39	02-Dec-2009 00:45	U(<)	0.012	J(<)	0.005	0.328	0.42	0.75	0.264	0.236
28-Jan-2010 22:09	29-Jan-2010 13:08		---		0.093	0.486	0.86	1.35	0.323	0.218
03-Feb-2010 04:56	04-Feb-2010 19:27		---		0.082	0.506	0.54	1.05	0.236	0.198
15-Mar-2010 23:03	16-Mar-2010 14:47		---		0.354	0.768	1.59	2.36	0.324	0.241
24-Mar-2010 20:42	25-Mar-2010 02:55		2.950		0.224	0.299	2.54	2.84	0.342	0.206
15-Apr-2010 14:44	16-Apr-2010 02:01		7.110		0.306	0.134	4.29	4.42	0.719	0.185
14-May-2010 07:19	14-May-2010 16:08	U(<)	0.011		0.927	0.563	---	---	---	---
15-May-2010 01:16	15-May-2010 07:39		1.050		0.143	0.182	0.92	1.11	0.153	0.090
02-Jun-2010 19:13	02-Jun-2010 23:17		0.754		0.201	0.292	1.60	1.89	0.292	0.110
08-Jul-2010 06:13	09-Jul-2010 03:33	U(<)	0.011		0.067	0.180	0.57	0.75	0.074	0.032
02-Sep-2010 19:56	03-Sep-2010 09:13	U(<)	0.011		0.006	0.120	1.61	1.73	0.207	0.032
02-Nov-2010 02:12	02-Nov-2010 06:40	U(<)	0.049		0.490	0.668	2.89	3.56	0.524	0.432
28-Dec-2010 21:51	29-Dec-2010 02:54	U(<)	0.052		0.162	0.543	0.81	1.36	0.119	0.060

--- no sample collected or EMC not computed

U(<) result below detection limit, ½ detection limit reported

J(<) one or more sample above detection limit, ½ detection limit used to compute EMCs if > detection limit.

Table 23: Storm water monitoring results from Park Place, east influent (PP1).

Start of Flow	End of Flow	Atrazine (AATREX) (ug/l)	NH_3 (mg/l)	NO_3+NO_2 (mg/l)	TKN (mg/l)	Total N (mg/l)	Total P (mg/l)	Diss. P (mg/l)
11-Mar-2009 06:24	12-Mar-2009 14:51	16.50	0.281	0.609	1.00	1.61	0.281	0.224
26-Mar-2009 12:50	27-Mar-2009 02:13	7.090	J(<) 0.032	0.322	0.64	0.97	0.125	0.091
17-Apr-2009 07:58	18-Apr-2009 02:17	2.310	0.210	0.383	0.95	1.34	0.281	0.227
27-May-2009 08:44	27-May-2009 15:01	0.956	0.325	0.396	1.53	1.92	0.202	0.147
22-Jul-2009 18:36	23-Jul-2009 13:17	U(<) 0.012	0.287	0.502	1.18	1.68	0.349	0.284
10-Sep-2009 13:27	11-Sep-2009 01:30	U(<) 0.012	0.054	0.276	0.71	0.98	0.335	0.246
11-Sep-2009 17:01	12-Sep-2009 22:56	0.136	0.126	0.221	1.73	1.95	0.714	0.318
22-Sep-2009 03:07	22-Sep-2009 23:15	U(<) 0.012	0.073	0.209	0.76	0.97	0.318	0.287
03-Oct-2009 15:49	04-Oct-2009 07:12	10.20	0.040	0.160	0.41	0.57	0.164	0.117
09-Oct-2009 05:45	09-Oct-2009 17:10	17.10	0.066	0.190	0.60	0.79	0.239	0.213
21-Oct-2009 18:46	22-Oct-2009 14:44	0.054	0.187	0.213	0.70	0.91	0.248	0.217
20-Nov-2009 04:16	21-Nov-2009 06:15	0.113	0.048	0.127	0.39	0.51	0.195	0.182
01-Dec-2009 11:37	02-Dec-2009 00:43	U(<) 0.011	J(<) 0.027	0.123	0.38	0.50	0.186	0.142
29-Jan-2010 00:53	29-Jan-2010 16:08	---	0.121	0.244	0.73	0.98	0.276	0.177
15-Mar-2010 22:43	17-Mar-2010 02:00	76.50	---	---	---	---	---	---
24-Mar-2010 20:57	25-Mar-2010 13:13	83.10	0.741	0.589	4.78	5.37	0.348	0.196
15-Apr-2010 17:12	16-Apr-2010 11:09	8.600	---	---	---	---	---	---
14-May-2010 11:49	15-May-2010 12:39	7.030	0.144	0.688	0.87	1.56	0.162	0.130
02-Jun-2010 19:17	03-Jun-2010 10:30	6.270	0.300	0.346	7.07	7.42	1.060	0.126
09-Jun-2010 02:50	09-Jun-2010 18:15	2.330	0.091	0.299	0.87	1.17	0.282	0.205
29-Jun-2010 14:27	30-Jun-2010 06:32	0.635	0.208	0.450	0.95	1.40	0.238	0.268
02-Sep-2010 18:18	03-Sep-2010 14:59	U(<) 0.011	0.085	0.519	0.73	1.25	0.119	0.078
07-Sep-2010 03:25	08-Sep-2010 12:38	2.760	---	---	---	---	---	---
08-Sep-2010 18:40	09-Sep-2010 03:05	0.241	0.016	0.148	0.97	1.11	0.143	0.040
02-Nov-2010 02:02	02-Nov-2010 13:07	U(<) 0.053	---	---	---	---	---	---
28-Dec-2010 22:38	29-Dec-2010 12:22	---	0.190	0.742	0.86	1.61	0.058	0.020

Table 24: Stormwater monitoring results from Park Place, middle influent (PP2).

Start of Flow	End of Flow	Atrazine (AATREX) (ug/l)		NH_3 (mg/l)	NO_3+NO_2 (mg/l)	TKN (mg/l)	Total N (mg/l)	Total P (mg/l)	Diss. P (mg/l)
12-Mar-2009 00:08	12-Mar-2009 12:39		42.40	0.327	0.913	1.91	2.82	0.635	0.506
26-Mar-2009 12:51	26-Mar-2009 18:03		6.130	0.157	0.333	0.71	1.04	0.210	0.177
17-Apr-2009 07:18	17-Apr-2009 21:04		30.90	0.315	1.058	1.55	2.61	0.681	0.606
27-Apr-2009 11:04	28-Apr-2009 12:20		31.10	0.339	0.867	1.89	2.76	0.423	0.360
16-May-2009 11:41	16-May-2009 20:55		1.100	0.406	0.612	1.93	2.55	0.437	0.331
27-May-2009 08:32	27-May-2009 13:35	U(<)	0.012	0.284	0.372	1.08	1.45	0.305	0.244
22-Jul-2009 18:33	23-Jul-2009 10:32	U(<)	0.012	0.339	0.843	1.91	2.76	1.024	0.899
10-Sep-2009 13:28	10-Sep-2009 21:21	U(<)	0.012	0.074	0.445	1.13	1.57	0.575	0.443
22-Sep-2009 03:04	22-Sep-2009 17:01	U(<)	0.012	0.151	0.568	1.42	1.98	0.558	0.443
03-Oct-2009 15:41	04-Oct-2009 08:45		17.10	0.057	0.143	0.31	0.45	0.120	0.086
09-Oct-2009 05:41	09-Oct-2009 14:32		8.560	0.312	0.870	1.28	2.15	0.628	0.589
21-Oct-2009 18:36	22-Oct-2009 13:34		0.641	0.097	0.409	0.71	1.12	0.426	0.405
20-Nov-2009 04:07	20-Nov-2009 17:45	U(<)	0.011	0.076	0.346	0.69	1.03	0.391	0.348
01-Dec-2009 11:30	02-Dec-2009 01:14	U(<)	0.012	0.075	0.590	0.80	1.39	0.510	0.431
29-Jan-2010 00:46	29-Jan-2010 13:44	---		0.275	0.672	1.11	1.78	0.420	0.356
15-Mar-2010 22:21	16-Mar-2010 18:24	---		1.240	1.150	5.30	6.45	0.337	0.201
24-Mar-2010 17:05	25-Mar-2010 22:16		81.90	0.322	0.821	5.75	6.57	0.451	0.212
14-May-2010 07:02	15-May-2010 12:43		16.30	0.362	1.060	1.21	2.27	0.452	0.390
02-Jun-2010 19:15	03-Jun-2010 01:22	U(<)	0.012	0.224	0.276	2.99	3.27	0.538	0.136
08-Jun-2010 19:44	09-Jun-2010 17:15		2.470	0.072	0.480	1.11	1.59	0.459	0.382
29-Jun-2010 14:26	29-Jun-2010 22:03		0.779	0.150	0.362	0.86	1.22	0.274	0.276
08-Jul-2010 11:51	09-Jul-2010 08:20		0.291	---	---	---	---	---	---
28-Dec-2010 20:14	29-Dec-2010 13:13		0.631	0.197	0.779	0.58	1.35	0.065	0.036

Table 25: Stormwater monitoring results from Park Place, west influent (PP3).

Start of Flow	End of Flow	Atrazine (AATREX) (ug/l)		NH_3 (mg/l)		NO_3+NO_2 (mg/l)	TKN (mg/l)	Total N (mg/l)	Total P (mg/l)	Diss. P (mg/l)
17-Apr-2009 07:59	17-Apr-2009 17:42		12.80		0.188	0.328	1.03	1.36	0.339	0.291
27-Apr-2009 12:25	27-Apr-2009 17:26		4.300		0.191	0.382	0.91	1.29	0.276	0.214
16-May-2009 11:43	16-May-2009 18:03		15.40		0.351	0.386	1.34	1.72	0.161	0.095
22-Jul-2009 18:34	22-Jul-2009 22:50	U(<)	0.012		0.167	0.454	0.76	1.22	0.282	0.210
10-Sep-2009 13:28	10-Sep-2009 19:00	U(<)	0.011		0.037	0.183	0.58	0.77	0.450	0.419
22-Sep-2009 03:05	22-Sep-2009 15:11	U(<)	0.012		0.078	0.202	0.57	0.77	0.191	0.166
03-Oct-2009 15:49	03-Oct-2009 20:46		7.920	J(<)	0.019	0.103	0.28	0.39	0.100	0.057
09-Oct-2009 05:44	09-Oct-2009 12:01		9.550		0.040	0.119	0.47	0.59	0.245	0.209
20-Nov-2009 04:10	20-Nov-2009 14:55	U(<)	0.011		0.051	0.134	0.37	0.51	0.194	0.168
01-Dec-2009 11:34	01-Dec-2009 22:46	U(<)	0.012	J(<)	0.022	0.124	0.28	0.41	0.178	0.155
14-Jan-2010 23:15	15-Jan-2010 23:44	---		J(<)	0.007	0.137	0.31	0.45	0.369	0.324
29-Jan-2010 00:52	29-Jan-2010 10:29	---			0.113	0.220	0.63	0.85	0.240	0.180
15-Mar-2010 22:37	16-Mar-2010 17:14	---			0.241	0.458	1.27	1.73	0.170	0.121
24-Mar-2010 20:49	25-Mar-2010 06:57		78.50		0.212	0.936	2.86	3.80	0.284	0.167
15-Apr-2010 17:12	16-Apr-2010 00:09		3.290	---		---	---	---	---	---
15-May-2010 01:22	15-May-2010 08:26		2.360		0.253	1.070	1.17	2.24	0.263	0.147
02-Jun-2010 19:15	03-Jun-2010 02:00		1.530		0.259	0.334	1.05	1.38	0.190	0.127
29-Jun-2010 14:26	29-Jun-2010 23:27	U(<)	0.012		0.131	0.221	0.78	1.00	0.223	0.202
08-Jul-2010 15:26	09-Jul-2010 01:08		0.053		0.105	0.159	0.47	0.63	0.122	0.084
02-Sep-2010 18:16	03-Sep-2010 08:20	U(<)	0.011		0.052	0.405	1.28	1.69	0.174	0.073
07-Sep-2010 03:25	08-Sep-2010 08:20		2.330	---		---	---	---	---	---
13-Sep-2010 17:00	13-Sep-2010 21:36	U(<)	0.011		0.943	0.283	3.54	3.82	0.340	0.069
02-Nov-2010 02:09	02-Nov-2010 06:16	U(<)	0.050		0.268	1.000	1.95	2.95	0.278	0.195
29-Dec-2010 02:41	29-Dec-2010 10:40	U(<)	0.054		0.140	1.080	0.66	1.74	0.061	0.028

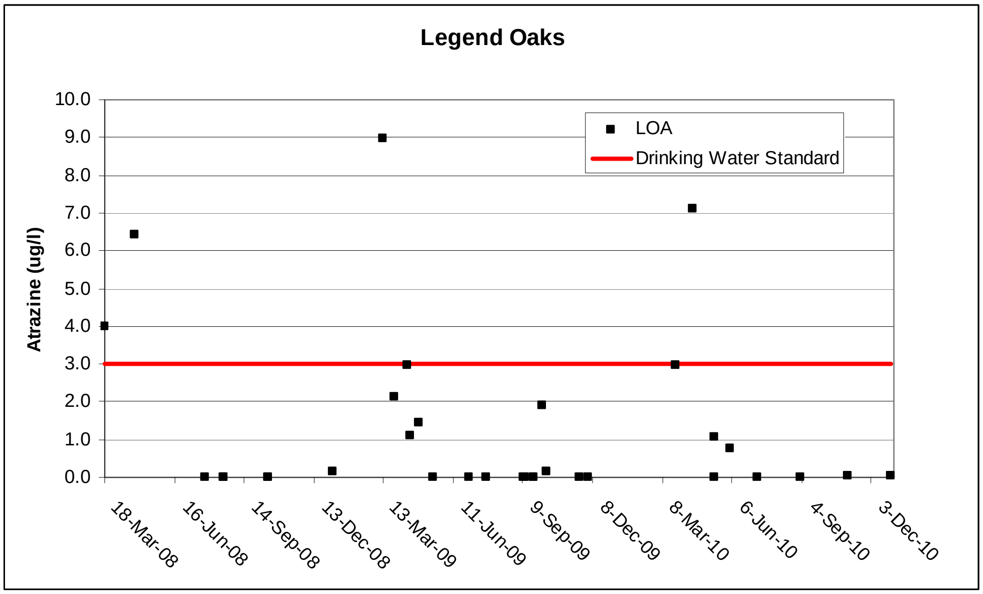

Figure 13: Atrazine concentrations at Legend Oaks compared to drinking water standards.

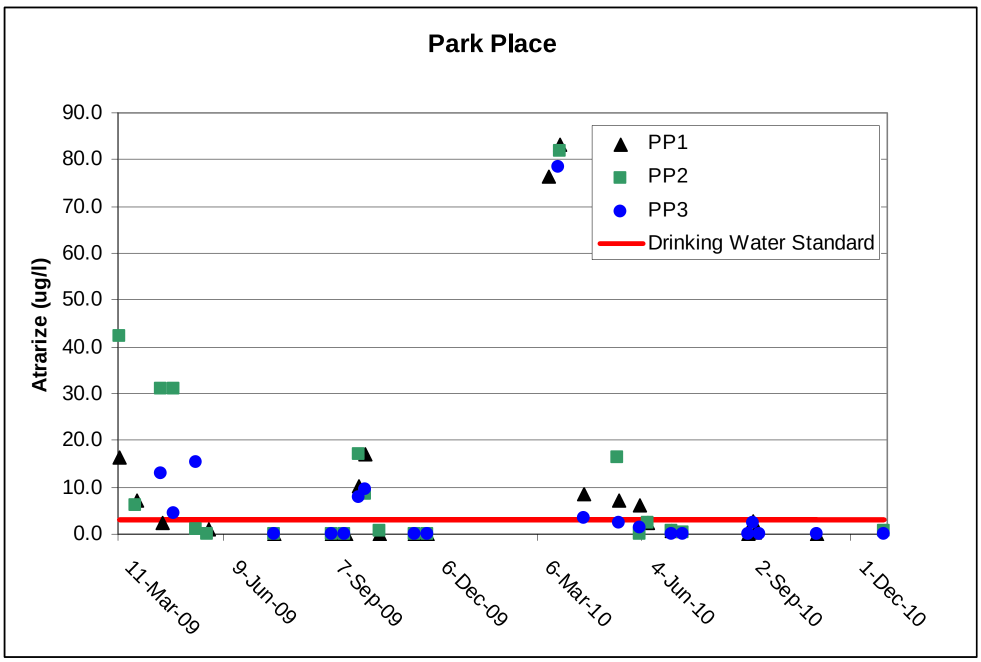

Figure 14: Atrazine concentrations at Park Place compared to drinking water standards.

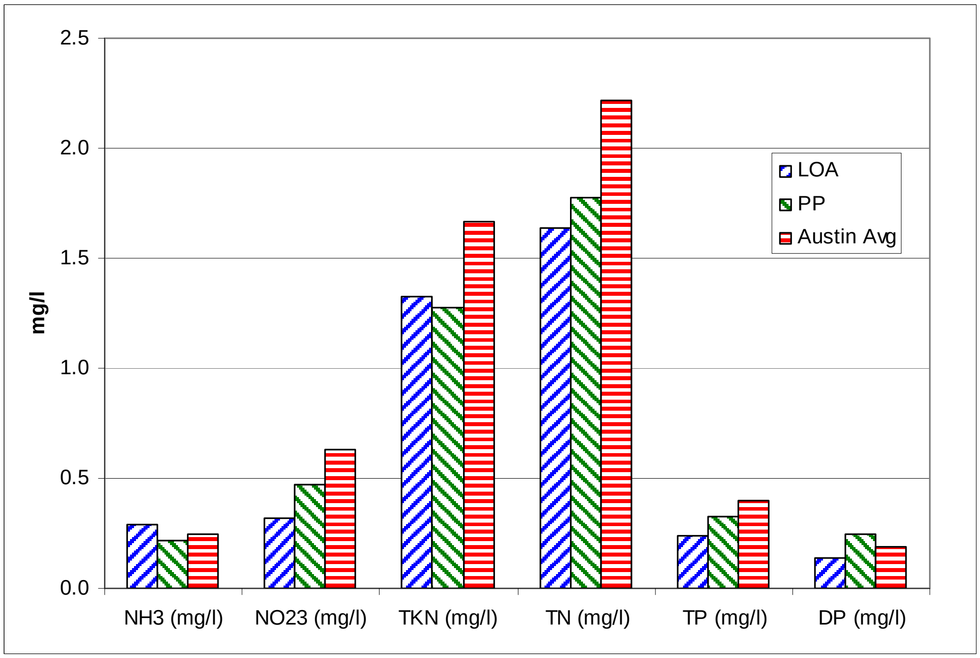

Figure 15: Nutrient concentrations at Legend Oaks and Park Place compared to long-term stormwater average concentrations in the City of Austin.

DISCUSSION

Education

There were many lessons learned throughout the course of the grant. Most notably, we were able to develop a format for neighborhood mail outs that brought results – customized maps, data and succinct, practical recommendations for earth-wise landscaping. Customized neighborhood mail outs positively affected behavior change and were deemed an effective approach to targeted outreach. In general, we saw an increase in the use of organic fertilizers and a decrease in weed-and-feed applications. Scotts MiracleGro company has confirmed to us that there has been an increase in the purchase of organic fertilizers.

We also noted increased viewership in the television spots over the three-year campaign and learned through an EPA award and online survey results that our most “obnoxious” television character, Dan D. Lion, was also the most memorable. Another successful strategy proved to be the use of cable television, which offered a significant increase in the number of airings for each of our spots above those actually purchased.

We learned from our nursery partners that our outreach materials were helpful and that they attracted in-store customer questions and comments. There was also a consistent demand for yearly trainings on earth-wise practices.

On the other hand, we have to acknowledge that survey results suggest more education on the Integrated Pest Management program, particularly the requirements of the COA Ordinance requiring homeowner IPM plans, is needed to fulfill the City's commitment to protecting Barton Springs. Through the grant we learned that neighborhood mail outs can be used in future plans to communicate ordinance requirements.. The post-education survey results reinforce the value of the grant as the average number of people aware of the ordinance improved from 18% to 40%.

Groundwater Monitoring

The lack of Carbaryl detections in any groundwater sample suggests it is of limited usability at current detection limits as an indicator of non-point source pollution from landscape chemical runoff. Monitoring was clustered in the spring and fall months when landscape chemical application is most likely to occur, but monitoring may need to be more frequent or more specifically related to runoff-generating events to more accurately quantify impacts of landscape chemical usage on groundwater quality versus the baseflow (non-storm influenced) sampling method used in the grant. A specific program to collect composite samples during or immediately after rainfall may be more effective in estimating transport of landscape chemicals like Atrazine to groundwater resources.

Stormwater Monitoring

A lack of consistent rainfall hampered the stormwater monitoring portion of this project. While the target number of storms was collected, inconsistent rainfall in the spring and fall of 2010 may have skewed the results, masking any impact of the education program. A lack of monitorable runoff events in the spring of 2011 resulted in only one year of post-education monitoring of those sites.

This study did demonstrate the seasonality of Atrazine in stormwater runoff from single-family residential areas. This would indicate a potential for Atrazine to reach the groundwater but the travel may be such that it was not seen in the spring monitoring. Monitoring the Atrazine concentration in creek runoff rather than from a single land-use site may give a better understanding of the concentrations that may be reaching the groundwater through runoff recharge.

SUMMARY

Education

The EPA 319 grant served as a valuable resource for the City of Austin. It provided an opportunity to test and refine new educational outreach methods and to determine how to best address some of Austin's most significant water quality concerns – nutrients and pesticides. It allowed for the creation of television spots that can be used over time and also, with the mere change of a tagline, can be shared with other jurisdictions throughout the country.

It provided an opportunity for the analysis of behavior change and behavior change techniques, as well as an expansion of our website and website hits.

In return, the City plans to maintain and enhance the Grow Green program, incorporating the lessons learned from the grant. The goal is to continue to air the television spots, and to again select pilot neighborhoods over Austin's sensitive aquifer that can have the greatest impact, either positive or negative, on our water resources.

Groundwater Monitoring

Potential changes from education as observed in groundwater monitoring data are mixed. Ammonia decreased at four of five sites in the post-education time period. Nitrate concentrations increased at two springs and decreased at Spicewood Springs. Orthophosphorus concentrations decreased at Backdoor Springs after education and may have decreased after education at Tanglewood, although the statistically significant change at Tanglewood was non-significant (p=0.06).

Carbaryl was not detected at any groundwater monitoring site, and no valid, statistically significant changes in Atrazine concentrations were observed between the pre- and post-education periods. Although pre- and post-education period means were not significantly different at Backdoor Spring and Stillhouse Spring, the last detection of Atrazine at these sites was in the spring of 2008. Proportional hazard regression of Atrazine concentrations over time yield statistically significant decreasing concentrations for three sites but no change was observed at the other two springs. Nitrate concentrations at Backdoor and Tubb springs continue to increase over time, and the observed increases in the post-education period are most likely the result of ongoing urbanization and not caused by the education program. Orthophosphorus concentrations continue to decrease over time at Backdoor Spring.

Stormwater Monitoring

Event mean concentrations from 110 qualifying stormwater runoff events were calculated from monitoring results. There was no stormwater sampling in 2011 due to a lack of sufficient rainfall.

The trends for average concentrations of Atrazine and nutrients were similar for all sites. Atrazine was typically not detected in the summer and winter months but was detected at fairly high levels in the spring and fall, which would correspond with periods when lawn fertilizers and chemicals would be applied. Slight trends were seen in nitrogen concentrations similar to those seen in Atrazine. Trends were not detected in phosphorus concentrations, and Carbaryl was not detected at any monitoring location.

Atrazine concentrations were much higher in the Park Place runoff compared to runoff from the Legend Oaks watershed. Total nitrogen, nitrate+nitrite, total and dissolved phosphorus concentrations are also higher at Park Place but the difference is not as pronounced (see Figure 16). This could indicate higher fertilizer use at Park Place or the use of different products. This may be due to slightly different demographics or the age of the neighborhood, Legend Oaks being older and more established. The average nutrient concentrations observed at the pilot neighborhood does not differ greatly for the long-term average stormwater concentrations observed elsewhere in Austin.

There are no differences in the peak concentrations of Atrazine pre- or post-education but this may be confounded by the different weather conditions. The post-education period appears to have had more rainfall, which may have resulted in additional lawn care activities, education not withstanding.

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APPENDIX

Educational Materials

- Television Spots
- Sendera Pre Survey
- Reminder Postcard
- Grant Brochure and Mailing Envelope
- Alta Mira Neighborhood Educational Mailout
- Sample Post Survey

Survey Results

- Alta Mira Pre Survey
- Alta Mira Post Survey
- Bauerle Ranch Pre Survey
- Bauerle Ranch Post Survey
- LaCrosse Pre Survey
- LaCrosse Post Survey
- Legend Oaks Pre Survey
- Legend Oaks Post Survey
- Sendera Pre Survey
- Sendera Post Survey
- Spicewood Pre Survey
- Spicewood Post Survey
- Tanglewood Pre Survey
- Tanglewood Post Survey