Emissions from Portable Gasoline Containers In Texas

FINAL REPORT

ERG, Inc.

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Table of Contents

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Executive Summary

Hydrocarbon emissions from portable gasoline containers were estimated using a method developed by the California Air Resources Board (CARB). This methodology adds a new subcategory of emissions, transport spillage, which was previously not included in the air emissions inventory. In Texas, statewide emissions from portable gasoline containers were approximately 78 tons per day, and were comparable and slightly lower than those found in California. Table 1 shows the results in terms of tons per day of volatile organic compounds (VOC) by emission type.

Table 1: Portable Gasoline Container Emissions, Uncontrolled, 2007

Emission Type	Residential	Commercial	Total
Permeation	5.97	0.13	6.10
Diurnal	51.57	0.98	52.55
Transport-Spillage	2.86	2.89	5.75
Spillage	3.96	5.94	9.89
Vapor Displacement	1.20	2.19	3.40
total	**65.56**	**12.13**	**77.69**

A regulation that would reduce spillage and other emissions by approximately one-half through the adoption of a no-spill portable gasoline container requirement could achieve significant reductions of VOC in Texas, as is shown in Table 2.

Table 2: Potential Portable Gasoline Container Reductions, 2007

Emission Type	Residential	Commercial	Total
Permeation	3.02	0.07	3.08
Diurnal	24.47	0.47	24.94
Transport-Spillage*	0.00	0.00	0.00
Spillage	2.68	4.02	6.71
Vapor Displacement*	0.00	0.00	0.00
total	**30.17**	**4.56**	**34.72**

*These emissions are independent of container design.

The number of gas cans used in residential and commercial applications found through surveys is as follows:

- Residential: 7,139,895
- Commercial: 92,231

The sheer number of gas cans and amount of hydrocarbon emissions indicate that residential gas can emissions predominate, although commercial gas can use rates are much higher.

Introduction

Portable gasoline containers, usually called "gas cans," can be a significant source of urban air emissions. The emissions arise from escaping gasoline vapor and spilled gasoline which then evaporates, and are measured as volatile organic compounds (VOC). While we have a fairly good grasp of emissions from refueling motor vehicles, gas can emissions are highly uncertain at this time. The California Air Resources Board (CARB) was instrumental in developing a methodology to quantify emissions from gas cans, and now several states including Texas are considering using the CARB method to help determine the need for a "no-spill" gas can regulation.

Historically, gas can emissions were part of the emissions inventory for non-road equipment such as lawn mowers, chainsaws, trimmers ("weed whackers"), and other portable power equipment. The 1992 Non-Road Equipment and Vehicle Emissions Study (NEVES)[1] considered refueling emissions as a function of gasoline consumption, and included algorithms for spillage and vapor displacement. The draft NONROAD model[2] has the same algorithms, which are used to estimate this part of the VOC emissions inventory. A major improvement in the NONROAD model over the NEVES was to separate commercial and residential equipment, as commercial equipment tend to be used during the week and residential equipment, which are more numerous in terms of numbers of engines, tend to be used fewer hours, mainly on the weekends. Therefore, we have adapted our surveys and methods to include commercial and residential gas can emissions separately.

The main emphasis of this research is on lawn and garden uses of gas cans. Lawn and garden is the largest category in the NONROAD model that is refueled entirely by gas cans. Recreational vehicles (e.g., all-terrain vehicles and off-road motorcycles) are also refueled by gas cans, but their usage is not nearly as high as that for lawn and garden equipment; this topic is revisited in the Quality Assurance section. Recreational marine engines (e.g., outboard motorboats and personal watercraft) can be refueled by portable gasoline containers, but pressurized marine gas tanks are much more common than the ubiquitous "gas can." Finally, some construction, commercial, agricultural and logging

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1 U.S. EPA. 1991. Nonroad Engine and Vehicle Emission Study – Report. EPA-460/3-91-02.

2 http://www.epa.gov/otaq/nonrdmdl.htm

equipment may be refueled with gas cans, but NONROAD assumes that these types of equipment are all refueled at the gas pump.[3]

Future updates to this analysis could include a small expansion factor to account for gasoline container emissions from these other source categories.

Methodology Overview

The emissions estimation methods are based upon a 1999 CARB document that was updated in October, 2001.[4] Emissions are estimated for the following five categories along with parenthetical estimates of their contribution to total gas can emissions in California:

- **Permeation** occurs when the gasoline has saturated the fuel container and fittings (7%)
- **Diurnal** emissions result from fuel expansion and vapor production due to rising temperatures during the day (64%)
- **Transport spillage** occurs when the gas can is refueled at the gas pump, and is a "new" emission category not previously estimated (13%)
- **Refueling spillage** occurs when the fuel is poured from the gas can into the engine fuel tank (12%)
- **Vapor displacement** occurs when gas tank on the equipment is filled and saturated vapors are forced out into the air (4%)

The first three emission types are discussed in detail below. Refueling spillage and vapor displacement are estimated from the NONROAD model (*see* NONROAD Procedure section below). The main equation to estimate emissions for permeation, diurnal, and transport spillage emissions follows the general formula:

$$E = EF * A$$

Equation 1

Where,

E = emissions
EF = VOC emission factor
A = activity level, which may have several components

[3] U.S. EPA. 1998. Refueling Emissions for Nonroad Engine Modeling. Report No. NR-013
[4] CARB. 2001. Note of Public Meeting to Consider the Approval of California's Portable Gasoline-Container Emissions Inventory. " Mobile Source Control Division.

Usage level is dependent upon the population of gas cans and their storage condition. Storage condition, such as whether or not the can is kept with its nozzle and vent open or closed, is very important for measuring permeation, diurnal, and transport spillage emissions. The gas can is considered to be "closed" if the spout is capped and the vent is closed; it is an "open" container if the spout or vent allows any vapors or liquids to escape. Consequently, open gas cans have a much higher emission factor than closed ones.

The CARB survey included questions about the status of the gas cans and found that between one third and one half of the gas cans were in the "open" condition where the vent or spout was not capped. Our surveys asked for similar information regarding Texas storage patterns, but the results are suspect since almost all responders said they had "closed" gas cans.[5] Lacking more dependable data about storage condition, we assumed CARB defaults:

- 66 percent of the gas cans are closed
- 34 percent of the gas cans are open

Residential Sector

Residential gas cans are dominated by red plastic containers in one- and two-gallon sizes, typically found in garages and sheds of single-family and duplex houses. The CARB method is based on a survey to evaluate the number of gas cans per household. The survey involved 1,500 mail solicitations, of which 324 were returned (26%). Approximately one-half of the households did not own gas cans (46%). Of the responders that had gas cans, the average was 1.8 per household.

According to the CARB methodology, the population of gas cans in a state is estimated as:

$$POP = N * A * COUNT \quad \text{Equation 2}$$

Where

POP = population of gas cans
N = number of household units
A = percentage of households with gas cans
COUNT = average number of gas cans per household

[5] We suspect that respondents may have been concerned about their perceived culpability when providing information to a State agency, and therefore may not have provided accurate information regarding storage.

The number of Texas households was obtained from the Texas State Data Center.[6] There were 7,392,054 households in the year 2000. Note that we are using the year 2000 for the baseline because that is the source of our household data; other years are projected from this baseline (e.g., 2002 and 2007).

An independent company, NuStats, Inc. was contracted to survey residential gas can ownership and usage in Texas to identify the percentage of households with gas cans and gas can counts. The NuStats data covered 297 responders that could choose between zero and six gas cans per household, using an internet-based "Web TV" approach. Initial recruitment is done by using a random dialing directory. Survey responders have a high interest in participating in the surveys because they obtain free internet television services contingent upon participation. The benefit of using this approach was that the survey response rate is often very high, in the range of 60 to 70 percent, with over 99 percent valid responses once recruited. According to their chief statistician, the web TV approach works very well but may under-represent the elderly population or those households not having telephones.[7] A separate company, Knowledge Networks,[8] actually maintains the web TV survey system but has a long experience working with NuStats. Results showed that more Texas households tend to own gas cans than those in California, although the average number of cans per household was somewhat lower:

- 72% of the households had a gas can (CARB = 54%)
- Average number per household was 1.35 gas cans (CARB = 1.80)

The NuStats residential survey report and summary data are included in Appendix B.

In the following sections we will clarify each of the steps in the CARB methodology for residential gas can emissions.

Permeation

Permeation emissions are only estimated for closed gas cans. CARB developed the following emission factors based on controlled laboratory testing using ambient conditions typical for Southern California[9]:

- Plastic cans: 1.57 grams per gallons per day
- Metal cans: 0.06 grams per gallon per day

6 Http://txsdc.tamu.edu/data/census/2000/sf1/desctab/county/cntab-03.txt
7 Email from Karol Krotky, NuStats, dated April 25, 2002.

8 See http://www.knowledgenetworks.com/index2.html

9 Closed SHED laboratory tests were meant to approximate California temperature regimes.

Permeation emissions are then estimated by Equation 3.

$$PER = POP * S * EF * SIZE * LEVEL$$

Equation 3

Where

PER = permeation emissions, VOC
POP = population of gas cans, stratified by kind (metal/plastic)
S = percentage of gas cans actually containing fuel (70%)
EF = emission factor
SIZE = average capacity of residential gas cans (2.34 gallons)
LEVEL = average amount of fuel in the container (29%)

Note that CARB default data were used to estimate how high the gas cans are filled, while Texas-specific information was substituted for the other key equation parameters. (In order to encourage high response rates, survey respondents were only asked questions they could respond to while at their computers.) Using these figures we estimated 5.97 tons of permeation VOC emissions statewide.

Diurnal

CARB developed the following emission factors for diurnal emissions in terms of grams per gallon stored per day, based on lab testing:

- Plastic, closed system: 1.38
- Metal, closed system: 0.44
- Plastic, open system: 21.8
- Metal, open system: 21.8

The following equation is used to estimate total diurnal emissions:

$$DIU = POP * S * EF * SIZE * LEVEL$$

Equation 4

Where

DIU = diurnal emissions, VOC
POP = population of gas cans stratified by kind (metal/plastic)
S = percentage of gas cans containing fuel (70%)
EF = emission factor
SIZE = average capacity of residential gas cans (2.34 gallons)
LEVEL = average amount of fuel in the container (29%)

When Texas-specific information was substituted into the equation, again using CARB defaults where noted, we found 51.57 tons of diurnal VOC emissions, the highest of any of the gas can emission levels.

Transport Spillage

Transport spillage is a slight misnomer - while some fuel is spilled during transport, the greatest spillage occurs when the gas can is filled from the gas pump. However, we keep the term in order to be consistent with the CARB classifications.

CARB developed the following emission factors using a U.S. EPA methodology[10]:

- Closed system: 23 grams per refill
- Open system: 32.5 grams per refill

Since emission rates are dependent upon the frequency of gas can refills, CARB estimated an average of 6.4 gas-can refill events per year (0.0174 per day). The following equation is then used to estimate total transport spillage emissions:

$$TRANS = POP * S * EF * REFILL$$

Equation 5

Where

TRANS = transport spillage emissions, VOC
POP = population of gas cans stratified by kind (metal/plastic)
S = percentage of gas cans containing fuel (70%)
EF = emission factor
REFILL = frequency of daily refilling (0.0174)

When Texas-specific information was substituted into the equation, we found 2.86 tons of transport spillage VOC emissions. To reiterate, these emissions are for the year 2000, even though we used a survey done in 2002, as household population data was recently made available through the U.S. Census.

At this time we will shift over to discussion of the commercial sector of permeation, diurnal, and transport spillage emissions. Refueling spillage and vapor displacement will be discussed together in a later section, as they use a combined technique.

[10] U.S. EPA, 1993, Appendix C, "OPEI/CAAC Spillage and Evaporative Losses for Lawn and Garden Applications."

Commercial Sector

Commercial lawn care and maintenance companies were surveyed and the largest ones were interviewed. While many were members of trade associations such as the Texas Nursery and Landscape Association (TNLA), it was estimated that in terms of workers, the small "mom and pop" companies outnumbered the lawn care corporations by a factor of 10:1. However, in terms of revenue, the larger corporations (the ones paying State revenue and franchise taxes) control approximately 60 percent of the revenue.[11] These industry statistics do not include nursery sales (plant and tree growers), fertilizer application, or turf installation, which were deemed to have negligible use of gas cans compared to lawn care activities, according to industry experts.[12]

Two surveys were conducted in the April-May, 2002 time period. One was posted on the TNRCC website, and was intended for all commercial companies that might have gas cans.[13] Another effort was conducted using TNLA-listed landscape companies that generated over one million dollars of revenue per year; both surveys resulted in 13 companies responding.

- 6 were from the TNLA list
- 8 were from the TNRCC responses

A third survey was conducted by NuStats towards the end of the project (August), so as to increase our confidence in the commercial survey sample. NuStats surveyed 125 lawn and garden companies by telephone, excluding those companies already surveyed earlier. (Please see Appendix C for the NuStats Commercial Survey report and data summary.) The ultimate impact of this study was to decrease commercial landscape gas-can emissions, by including relatively more data from smaller businesses. (This in turn decreased the estimate of average numbers of gas cans per business, reducing estimated emissions accordingly.)

A typical gas can used by the larger companies is a 5-gallon metal safety container equipped with "low-spill" pour spouts (46%), although plastic cans are still widely used in many of the surveyed companies (54%), probably because of lower unit cost. The "preferred lawn care" industry uses industrial safety containers not for environmental reasons but rather because of insurance and workplace liability issues.

The population of commercial gas cans in a state is estimated as:

$$POP = (N * COUNT)$$

Equation 6

[11] Personal communication with Tom Mikulastic, TruGreen, Inc. on April 15, 2002.
[12] Personal communication with Marilyn Good, Texas Nursery and Landscape Association, March, 2002.
[13] http://www.tnrcc.state.tx.us/air/aqp/gascan.html

Where

POP = population of gas cans
N = lawn & garden businesses
COUNT = average number of gas cans per businesses

A list of lawn and garden businesses was obtained from the Texas State Comptroller of Public Accounts.[14] The number of lawn & garden service businesses (SIC Code 0782) listed in Texas is 7,797. This list includes businesses that pay taxes (franchise, property, and other). We have assumed that many self-employed businesses in the lawn and garden industry do not report state taxes. We did not have any industry-wide statistics to upscale or increase the number of commercial landscaping companies, so therefore they were left the same. Based upon the survey, the average count of gas cans per business was approximately 10.5.

As was done in the residential sector, we used CARB defaults for storage condition (open versus closed), and fill level (as are noted in the equations below).

The equations for permeation, diurnal, and transport-spillage emissions are repeated below, and are very similar to the residential gas can emission calculations, except as noted.

Permeation

Permeation emissions are only estimated for closed gas cans. CARB developed the following emission factors, being the same ones from the residential emission factors:

- Plastic cans: 1.57 grams per gallons per day
- Metal cans: 0.06 grams per gallon per day

Permeation emissions are then estimated by Equation 3.

$$PER = POP * S * EF * SIZE * LEVEL$$

Equation 7

Where

PER = permeation emissions, VOC
POP = population of gas cans stratified by kind (metal/plastic)
S = percentage of gas cans containing fuel (70%)

[14] Texas State Comptroller of Public Accounts. 2002. Open Records Request No. 1128-921-501 (April 30, 2002) filed by Sam Wells.

EF = emission factor
SIZE = average capacity of residential gas cans (3.52 gallons)
LEVEL = average amount of fuel in the container (29%)

When Texas-specific information was substituted into the equation, we found 0.13 tons of permeation VOC emissions.

Diurnal

The CARB developed the following emission factors for diurnal emissions in terms of grams per gallon per day:

- Plastic, closed system: 1.38
- Metal, closed system: 0.44
- Plastic, open system: 21.8
- Metal, open system: 21.8

The following equation is used:

$$DIU = POP * S * EF * SIZE * LEVEL$$

Equation 8

Where

DIU = diurnal emissions, VOC
POP = population of gas cans stratified by type (metal/plastic)
S = percentage of gas cans containing fuel (70%)
EF = emission factor
SIZE = average capacity of residential gas cans (3.52 gallons)
LEVEL = average amount of fuel in the container (29%)

When Texas-specific information was substituted into the equation, we found 0.98 tons of diurnal VOC emissions.

Transport Spillage

The CARB developed the following emission factors from U.S. EPA[15]:

- Closed system: 23 grams per refill
- Open system: 32.5 grams per refill

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[15] U.S. EPA, 1993, Appendix C, "OPEI/CAAC Spillage and Evaporative Losses for Lawn and Garden Applications."

Since emission rates are dependant upon the frequency of gas can refills, CARB estimated an average of 0.96 refills per day. The following equation is then employed:

$$TRANS = POP * S * EF * REFILL$$

Equation 9

Where

TRANS = transport spillage emissions, VOC
POP = population of gas cans stratified by kind (metal/plastic)
S = percentage of gas cans containing fuel (70%)
EF = emission factor
REFILL = frequency of daily refilling (0.9636)

When Texas-specific information was substituted into the equation, we found 2.89 tons of transport spillage VOC emissions, being the highest category of any of the commercial gas can emission levels.

Refueling Spillage and Vapor Displacement -- NONROAD Procedure

The draft NONROAD model version 1.2 was used to estimate refueling spillage and vapor displacement VOC emissions. CARB used their OFFROAD model, which is similar in design to NONROAD, but spillage emissions appear to be much lower (see the Findings Section below). These numbers are based upon default equipment populations. However, we did update the NONROAD model to include the latest estimates of fuel quality (Reid Vapor Pressure, or RVP) and ambient temperature, both of which greatly affect evaporative emission rates.

Spillage and vapor displacement are output by the NONROAD model and no calculations were required. Technical specifications include:

- An average statewide Reid Vapor Pressure (RVP) of 7.8. This tends to inflate emission levels because some areas have low RVP (e.g., El Paso, 6.6) and reformulated gasoline (e.g., Dallas and Houston, 6.8).[16] Additionally, in the year 2000, the TNRCC implemented a rule to require a cap of 7.8 RVP in certain counties in Eastern Texas.[17]

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[16] Email from Karla Smith, TNRCC, to Sam Wells dated April 30, 2002. "County RVP and Temps."
[17] 30 TAC §114.301, "Low Emission Fuels – Gasoline Volatility."

- Ambient temperatures were based on 1999 data provided by the TNRCC Monitoring Operations Division. The averaging methods assumed that June, July, and August were summer-time months:
  - 96.8 degrees for daily average maximum temperature
  - 76.1 degrees for daily average minimum temperature
- Default lawn and garden equipment populations were assumed. In order to account for commercial activity, which mainly occurs during the work-week, and residential activity, which mainly occurs during the weekend, we ran a period total for the entire June-August period. Then, emissions were divided by 91.2, the number of days during this three-month period.

Spillage and vapor displacement emissions done in this manner were approximately 20 percent higher than those done by the CARB, perhaps reflecting influences from increased temperatures and the default NONROAD equipment populations.

Findings

Year 2000 emissions are summarized in Table 3 in terms of tons of VOC per ozone season day.

Table 3: Portable Gasoline Container Emissions, 2000 Baseline

Emission Type	Residential	Commercial	Total
Permeation	5.31	0.12	5.42
Diurnal	45.82	0.87	46.69
Transport-Spillage	2.54	2.57	5.11
Spillage	3.51	5.27	8.79
Vapor Displacement	1.07	1.95	3.02
total	**58.24**	**10.78**	**69.02**

Future Growth

These baseline emissions were then adjusted to 2002 and 2007 using growth factors. Residential gas can usage was adjusted by analyzing the number of single duplex housing units obtained from the Texas State Data Center. Based on the number of households in Texas, a compounded growth factor of 2.0% growth was assumed, using 1990-2000 census data. The 2000-2002 growth factor was 1.040, which was directly applied to emissions. The 2000-2007 growth factor was 1.126.

Table 4: Uncontrolled Portable Gasoline Container Emissions, 2002

Emission Type	Residential	Commercial	Total
Permeation	5.52	0.12	5.64
Diurnal	47.66	0.91	48.56
Transport-Spillage	2.64	2.67	5.31
Spillage	3.66	5.49	9.14
Vapor Displacement	1.11	2.03	3.14
total	**60.59**	**11.21**	**71.80**

Table 5: Uncontrolled Portable Gasoline Container Emissions, 2007

Emission Type	Residential	Commercial	Total
Permeation	5.97	0.13	6.10
Diurnal	51.57	0.98	52.55
Transport-Spillage	2.86	2.89	5.75
Spillage	3.96	5.94	9.89
Vapor Displacement	1.20	2.19	3.40
total	**65.56**	**12.13**	**77.69**

Effect of a Gas Can Regulation

The TNRCC is considering a rule that would phase-in new gas cans by effectively eliminating most of the gas cans in the "open" condition, eliminating refueling (but not transport) spillage, and reducing many of the remaining categories such as permeation because of new gas can design parameters. Presumably, such a gas can rule would apply to sales of new containers. Therefore, we estimated the useful life of a gas can to be four years, using the CARB default. If a rule is implemented in 2003, it would take until 2008 for the existing gas cans to be replaced by gas cans of the new design.

Using the NONROAD age distribution curve, we estimated that approximately 94 percent of the gas cans would be replaced by the 2007 ozone season. This estimate is consistent with the Commercial survey finding that 40% of businesses plan to replace some or all of their current containers in the next year. In addition, the residential survey found that 14% of these cans had been replaced during the previous year. Assuming

[18] We will update this estimate based upon sales data and survey responses regarding new gas can purchases, accounting for population growth, in the subsequent analysis.

linear attrition rates, this translates to a 7 year turnover cycle for these cans as well (e.g., 2003 through 2009). However, to the extent that residential gas can attrition is non-linear (as is the case with most dynamic populations), potential benefits from a gas can rule would be diminished somewhat.[19]

The next step is to apply reduction estimates to the uncontrolled 2007 emissions. Any reductions would be "negative emissions" that could be attributed to the effect of the TNRCC rule – and ultimately applied as potential State Implementation Plan credits. CARB estimated percentage reductions for all five categories of gas can emissions.[20] Although we do not know the content of a new gas can rule to be adopted in Texas, if approved, we can make some educated guesses about the efficiency of such as "Gas Can Rule." After careful consideration, we applied rule penetration (RP) and rule effectiveness (RE) to the CARB reduction estimates, expressed as control efficiency (CE), as follows:

$$\text{Reduction (\%)} = \text{CARB (CE)} * \text{RE} * \text{RP}$$

Equation 9

The RP adjusts reductions slightly lower because the rule may not apply to 100 percent of the new gas can sales, and is probably more like **90 percent**. The RE is an adjustment that says that the rule might only be followed **80 percent** of the time. The product of RP and RE is **72 percent**; this factor was then applied to the CARB reduction estimates where deemed to be appropriate. These kinds of adjustments are typical when dealing with the U.S. Environmental Protection Agency. Table 6 includes the assumptions that include the default, stated CARB reductions, which were then modified by applying rule effectiveness and rule penetration.

Table 6: 2007 Emission Reductions

Emission Type	Total Emissions	Percent Reductions - California	Percent Reductions - Texas	Reductions (Tons per day of VOC)
Permeation	6.10	74.5%	53.6%	3.08
Diurnal	52.55	70.0%	50.4%	24.94
Transport Spillage	5.75	100.0%	0.0%	0.00
Refueling Spillage	9.89	100.0%	72.0%	6.71
Displacement	3.40	40.0%	0.0%	0.00
total	**77.69**			**34.72**

[19] It would require multiple years of retirement data to generate a more realistic scrappage curve, however.
[20] CARB, 1999. "Initial Statement of Reasons for Proposed Rule Making: Public Hearing to Consider the Adoption of Portable Fuel Container Spillage Control Regulations."

Note that potential reductions were not applied to two sources: transport spillage and valor displacement. This decision was not based on actual testing but rather because common sense dictates that a no-spill gas can would still have emissions during refueling operations (the effect on vehicles in transit is not clear, either). It is quite possible that CARB also over-predicted diurnal emission reduction percentages, but there is no evidence to dispute these claims at this time.

Based on a total of 77.69 tons, the potential reductions add up to 34.72 tons per day (52%). There may be more (or less) reductions depending on how the envisioned gas can rule is written and implemented.

Houston Gas Can Emissions Inventory

We have also estimated emissions and potential reductions for the Houston-Galveston area only. The planning area includes the counties of:

- Harris
- Brazoria
- Galveston
- Chambers
- Fort Bend
- Liberty
- Montgomery
- Waller

These counties were analyzed separately because they are in a severe ozone area and because the affected industry in this area will be subject to a rule in the year 2005 requiring commercial lawn and garden companies to avoid summertime operations prior to noon.[21] There is a possibility that the TNRCC would consider repealing this rule in favor of the new gas can requirements, depending upon the new science resulting from the Texas Air Quality Study.[22]

In order to allocate gas can emissions to the eight counties, household data for residential gas cans and the NONROAD model for commercial gas cans were utilized. Household data by county was available from the Texas State Data Center. Commercial landscaping activity by county was estimated from the number of employees in the lawn and garden industry in 1996 (source: NONROAD model defaults). We performed these county-specific allocations for all 254 Texas counties and then selected only the eight Houston-Galveston nonattainment area counties. Estimated emissions for the Houston area are reported in Table 7, and potential reductions are provided in Table 8.

[21] 30 TAC §114.452, "Lawn Service Equipment Operating Restrictions," 26 TexReg 403
[22] *See* http://www.tnrcc.state.tx.us/air/aqp/airquality_science.html

Table 7: Portable Gasoline Container Emissions, Uncontrolled
Houston-Galveston Planning Area, 2007

Emission Type	Residential	Commercial	Total
Permeation	1.32	0.04	1.37
Diurnal	11.44	0.33	11.77
Transport-Spillage	0.63	0.99	1.62
Spillage	0.88	2.02	2.90
Vapor Displacement	0.27	0.75	1.01
total	**14.54**	**4.14**	**18.68**

Table 8: Portable Gasoline Container Reductions,
Houston-Galveston Planning Area, 2007

Emission Type	Residential	Commercial	Total
Permeation	0.67	0.02	0.69
Diurnal	5.43	0.16	5.59
Transport-Spillage	0.00	0.00	0.00
Spillage	0.59	1.37	1.97
Vapor Displacement	0.00	0.00	0.00
total	**6.69**	**1.55**	**8.24**

Quality Assurance

Aside from routine QA/QC, we have performed additional quality assurance tasks, as are discussed below.

Comparison to CARB Gas Can Inventory

A main quality assurance measure, called external validation, was to compare our findings to what was done in California. All other things being equal, gas can emissions in Texas should be about 80 percent of the estimate for California, based strictly on the larger population of households. As is indicated in Table 9, transport spillage and use of the NONROAD model could indicate potential out-of-control conditions.

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Table 9: California and Texas Gas Can Emissions Compared

Emission Type	California 1998	Texas 2000	Difference TX/CA
Permeation	7.2	5.42	75%
Diurnal	64.3	46.69	73%
Transport-Spillage	5.8	5.11	88%
Spillage	7.3	8.79	120%
Displacement	2.5	3.02	121%
Total	**87.3**	**69.02**	**79%**

Data Completeness for Refueling Spillage and Vapor Displacement

The U.S. EPA assumes that portable containers are used for lawn & garden, recreational vehicle, and recreational marine engines. Recreational marine engines have been addressed in a separate emissions inventory effort (Task 4). This leaves recreational vehicles such as all-terrain vehicles, off-road motorcycles, and gasoline-powered golf carts. While it may be possible to refine the recreational vehicle category in the future to account for these additional emissions, the draft NONROAD model indicates very low refueling spillage and vapor displacement emissions for this category, as compared to lawn & garden equipment:

- 0.13 tons per day of spillage VOC
- 0.24 tons per day of vapor displacement VOC

These numbers are fairly insignificant, given Texas as a whole. In addition, one could argue that the residential population statistics already included gas cans that should be used for recreational vehicles (since many gas cans would be used interchangeably used between lawnmowers and recreational equipment).

Gasoline Refueling Adopt-A-Factor Project

As a final Q/A measure, we looked at the sensitivity of the gas can emissions inventory to a "what if" scenario based on other research. In 1998 the University of Texas published a report prepared for the TNRCC regarding gasoline refueling emission rates and resulting emissions for on-road vehicles.[24] The study recommended that vehicle refueling rates should be increased by a factor of 30 percent (1.30), based on an analysis using a unique nozzle sensing device that detected gasoline vapors when the fuel tank was being refilled.

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23 Email to Archana Agrawal, CARB, dated April 28, 2002.

24 Corsi, R, Quigley, C., and Allen, D. 1998. *Gasoline Refueling Operation Adopt-A-Factor Project*. University of Texas. Contract # 620000067. Final Report submitted to the TNRCC.

There is reason to believe that gasoline being poured into a gas can or lawn and garden equipment gas tank would cause emissions in a similar manner as when poured into a motor vehicle's gasoline tank, although this is conjectural (the last studies by EPA, conducted in the 1985-1988 period, with an update for outdoor power equipment in 1993, did not measure vapor displacement explicitly). In spite of these unknowns, we can test the robustness of the gas can emissions inventory to changes in two of the constituents:

- Transport spillage
- Vapor displacement.

To reiterate, transport spillage includes not only vapor losses when filling a gas can at the pump but also spillage during transport. We have not been able to document the vapor fraction of transport spillage and therefore will apply the 30 percent increase from the University of Texas report, acknowledging that this is likely to be an overestimate. Also, vapor displacement was calculated by the NONROAD model; the algorithm is similar to that in AP-42 and the MOBILE model. Table 10 reports the impact of increasing both of these components by 30 percent.

Table 10. Sensitivity to Increases in Gasoline Refueling Vapor Losses, 2007 Uncontrolled Base Case, Statewide

Emission Type	Residential	Commercial	Total
Permeation	5.97	0.13	6.10
Diurnal	51.57	0.98	52.55
Transport-Spillage *	3.72	3.76	7.48
Spillage	5.14	7.72	12.86
Displacement *	1.20	2.19	3.40
Total	**67.60**	**14.78**	**82.38**

* Increased by 30%.

The sensitivity test shows increases of approximately two tons for residential emissions and 4 tons of commercial emissions. Taken together, the six additional tons (statewide) reflect a VOC increase of seven percent. This is significant, although the impact on local regions such as Houston would be much less in terms of mass (approximately 1-2 tons).

However, note that transport spillage and vapor displacement are not considered to have any reductions as a function of a proposed gas can regulations that would require no-spill spouts and lower permeation rates.

Conclusion

As with any emission inventory, especially non-permitted area sources, there is a high degree of uncertainty about the exact mass of emissions, especially for sources such as portable gasoline containers. Indeed, some of the emission factors have not been updated in almost twenty years (especially EPA factors for transport spillage, equipment refueling spillage, and vapor displacement). The benefit of the CARB study was to quantify gas can emissions that previously were not recorded – but probably are being emitted into the lower atmosphere, containing significant quantities of toxics such as benzene and toluene. The "new" CARB categories are permeation and diurnal emissions. All categories are shown with percentages in Table 11.

Table 11. Contribution to the Emission Inventory
2007 Tons per Day, Statewide

Emission Type	Emissions *	Percentage **	Reductions
Permeation	6.10	8%	3.08
Diurnal	52.55	68%	24.94
Transport-Spillage	5.75	7%	0.00
Spillage	9.89	13%	6.71
Displacement *	3.40	4%	0.00
Total	**77.69**	**100%**	**34.72**

* Pre-controlled, no gas-can regulation
** Based upon 2000 uncontrolled emission levels

It is evident that diurnal emissions are the largest category of emissions and emission reductions. To reiterate, diurnal emissions are caused when ambient temperatures rise during the morning and early afternoon, causing the gasoline to expand and volatize. Because most portable gasoline containers have a plastic safety release vent to keep the container from bursting during extreme conditions (e.g., temperatures over 100 degrees), additional "safety venting" emissions may occur with some frequency, especially in Texas during the summer months. Future research is needed to evaluate how these emission rates may vary between existing and new no-spill containers under safety venting conditions.

[25] http://www.tnrcc.state.tx.us/air/aqp/gascan.html

Appendix A

VOC Speciation* of Uncontrolled Portable Gasoline Container Emission
Tons Per Day, 2007

Compound	Texas	Houston-Galveston
Iso-Butane	1.27	0.32
Butane	7.87	1.96
Iso-Pentane	25.14	6.25
Pentene	1.35	0.34
Pentane	11.01	2.74
trans-2-Pentene	2.71	0.67
cis-2-Pentene	1.52	0.38
2,2, Dimethylbutane	0.76	0.19
Cyclopentane	0.25	0.06
3-Methylpentane	2.46	0.61
2-Methylpentane	4.91	1.22
Hexane	1.44	0.36
Methycyclopentane	1.02	0.25
Benzene	0.93	0.23
2,2,4-TMP	0.85	0.21
Heptane	0.17	0.04
Toluene	0.85	0.21
Ethylbenzene	0.08	0.02
m,p-Xylene	0.25	0.06
o-Xylene	0.08	0.02
Unknown	19.73	4.90
Total	**84.66**	**21.05**

* Speciation profile from Corsi et al. 1998, Table B-16

Appendix B – NuStats Findings for Residential Gas Can Survey

Residential Gas Can Survey

Final Report

Methodology and Results

Dr. Karol P. Krotki

NuStats

10 June, 2002

1. Methodology

The data collection was carried out by Knowledge Networks (www.knowledgenetworks.com), the only research organization in the country that maintains an Web-enabled panel of households recruited through a probability-based random-digit-dialing process.

Field Start Date:	5/1/02
Field End Date:	5/13/02

Number Completed:	297
Number Fielded:	415
Completion Rate:	71.57%

Respondents qualified if they had at least one portable gas can in their household.

The post stratification weights are based on The Current Population Survey (CPS) population estimates for adults in the state of Texas.

2. Results

Fully 72% of the population own portable gas cans with an average of just under two cans per household.

The proportion of the population that bought gas cans in the last year is 14%.

Of gas can owners, 40% did not know whether the gas cans are used for storing 2-stroke or 4-stroke gasoline. Of those who know about just under 50% used their cans for storing 2-stroke gasoline.

The last two questions ask about the type of gas can owned and whether it is open or closed. Here are the results:

Plastic	166	81%
Square metal	21	76%
No-spill	14	64%
Industrial Type 2	20	100%
Jerry Can	8	88%

Questionnaire

NuStats Texas Gas Can Survey

250 Completes/1 per HH/Texas Only/Adults

Sample Criteria	**1 per HH, Texas only, Adults**
Multi-Media	5 picture images

[ALL]
<u>SINGLE PUNCH ANSWER</u>

Q1. How many portable gas cans does anybody have in your household? (Please include all portable gas cans kept in a car or truck.)

1 1
2 2
3 3
4 4
5 5
6 or more 6

None 7

[ALL]
<u>SINGLE PUNCH ANSWER</u>

Q2. Did you purchase one or more gas cans in the last year?

Yes..1
No 2

[IF Q1=NONE AND Q2=NO, THEN GO TO END]

[IF Q1 NOT EQUAL "NONE"]
<u>SINGLE PUNCH ANSWER</u>

Q3. Do you use the gas can(s) for storing 2-stroke or 4-stroke gasoline?

2-stroke..................................1
4-stroke..................................2
Don't know 3

[IF Q1 NOT EQUAL "NONE"]
<u>SINGLE PUNCH ANSWER</u>

Q4. What type and size of gas can(s) do you have in your household (see next page)? On the next few screens we will show you five different types of gas cans. Please indicate if you have that type or do not have that type.

[SHOW JPEG "TYPE 1" THROUGH "TYPE 5"]

Have this one 1
Do not have this one..2

[FOR EACH IMAGE: IF Q4 = "HAVE THIS ONE"]
<u>SINGLE PUNCH ANSWER</u>

Q5. Are the gas cans closed (vent shut, spout closed) or open?

Closed..1
Open 2

[Note – images available on request.]

Results

Q1. How many portable gas cans are there in your household? (Please include all portable gas cans kept in a car or truck.)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	84	28.2	28.2	28.2
	1	101	33.9	33.9	62.2
	2	66	22.4	22.4	84.5
	3	31	10.3	10.3	94.8
	4	5	1.8	1.8	96.6
	5	6	2.1	2.1	98.8
	6	4	1.2	1.2	100.0
	Total	297	100.0	100.0	

Q2. Did you purchase one or more gas cans in the last year?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	41	13.9	13.9	13.9
	No	256	86.1	86.1	100.0
	Total	297	100.0	100.0	

Q3.Do you use the gas can(s) for storing 2-stroke (with lubricating oil) or 4-stroke gasoline?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not asked	84	28.2	28.2	28.2
	2-stroke	58	19.4	19.4	47.6
	4-stroke	71	23.8	23.8	71.4
	Don't know	85	28.6	28.6	100.0
	Total	297	100.0	100.0	

Q4_Type1. Plastic or metal pour spout - most commonly used today * Q4_Type1A. Are the gas cans currently closed (vent shut, spout closed) or open? Crosstabulation

Count

		Q4_Type1A. Are the gas cans currently closed (vent shut, spout closed) or open?				Total
		Not asked	REFUSED	Closed	Open	
Q4_Type1. Plastic or metal pour spout - most commonly used today	Not asked	84				84
	REFUSED	3				3
	Have this one		1	135	30	166
	Don't have this one	43				43
Total		130	1	135	30	296

Q4_Type2. Square metal can - more common several years ago * Q4_Type2A. Are the gas cans currently closed (vent shut, spout closed) or open? Crosstabulation

Count

		Q4_Type2A. Are the gas cans currently closed (vent shut, spout closed) or open?			Total
		Not asked	Closed	Open	
Q4_Type2. Square metal can - more common several years ago	Not asked	84			84
	REFUSED	1			1
	Have this one		16	5	21
	Don't have this one	191			191
Total		276	16	5	297

Q4_Type3. No-spill gas can * Q4_Type3A. Are the gas cans currently closed (vent shut, spout closed) or open? Crosstabulation

Count

		Q4_Type3A. Are the gas cans currently closed (vent shut, spout closed) or open?			Total
		Not asked	Closed	Open	
Q4_Type 3. No-spill gas can	Not asked	84			84
	Have this one		9	5	14
	Don't have this one	199			199
Total		283	9	5	297

Q4_Type4. Industrial Type 2 safety gas can * Q4_Type4A. Are the gas cans currently closed (vent shut, spout closed) or open? Crosstabulation

Count

		Q4_Type4A. Are the gas cans currently closed (vent shut, spout closed) or open?		Total
		Not asked	Closed	
Q4_Type4. Industrial Type 2 safety gas can	Not asked	84		84
	REFUSED	2		2
	Have this one		20	20
	Don't have this one	191		191
Total		277	20	297

Q4_Type5. Military-style jerry can * Q4_Type5A. Are the gas cans currently closed (vent shut, spout closed) or open? Crosstabulation

Count

		Q4_Type5A. Are the gas cans currently closed (vent shut, spout closed) or open?			Total
		Not asked	Closed	Open	
Q4_Type5. Military-style jerry can	Not asked	84			84
	REFUSED	1			1
	Have this one		7	1	8
	Don't have this one	204			204
Total		289	7	1	297

Gender

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	143	48.2	48.2	48.2
	Female	154	51.8	51.8	100.0
	Total	297	100.0	100.0	

Age, combined - 4 categories

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	18-29	68	23.0	23.0	23.0
	30-44	100	33.7	33.7	56.7
	45-59	74	24.9	24.9	81.5
	60+	55	18.5	18.5	100.0
	Total	297	100.0	100.0	

Race/Ethnicity -- member level

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	White, Non-hispanic	170	57.2	57.2	57.2
	Black, Non-hispanic	32	10.6	10.6	67.9
	Other, Non-hispanic	6	2.1	2.1	70.0
	Hispanic	89	30.0	30.0	100.0
	Total	297	100.0	100.0	

Education - categorical

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Less than HS	69	23.3	23.3	23.3
	HS	82	27.6	27.6	50.9
	Some college	79	26.4	26.4	77.3
	Bachelor or higher	67	22.7	22.7	100.0
	Total	297	100.0	100.0	

Appendix C – NuStats Commercial Lawn and Garden Company Survey

Gas Can Survey - Businesses

Final Report

Methodology and Results

Dr. Karol P. Krotki

NuStats

August 30, 2002

1. Methodology

The data collection was carried out by DataSource, a telephone calling center affiliated with NuStats and specializing in RDD surveys.

The sample was drawn from all Texas business listings in the Acxiom data base with an appropriate SIC code indicating that the enterprise is likely to use portable gas containers. Businesses already called by ERG were eliminated from the sample.

Number Completed: 125

Given the expected number of completes and the size of the budget, it was decided to implement this survey via telephone from hardcopy questionnaires. Data were then keyed into an SPSS file.

2. Results

- On average, businesses have just under eight (8) portable gas containers on a regular basis.
- Just over 75% of businesses have primarily plastic containers.
- Excluding a few businesses that reported gas containers that are clearly not portable, the average size of each container is just under five (5) gallons.
- Only 6% of businesses store diesel in the containers. The remaining store mainly gasoline and sometimes both gasoline and diesel.
- 40% of businesses plan to replace containers in the next year.
- 90% of businesses normally keep containers closed.
- Average number of:
    - Lawn mowers 5
    - Rear engine riding mowers 2
    - Front mowers 1
    - Rotary tillers 0.5
    - Chain saws 4
    - Trimmers 4
    - Leaf blowers 3
    - Other equipment 3
- Total number of gallons consumed per month:
    - Gas 2-stroke 100
    - Gas 4-stroke 780
    - Diesel 1,015
    - Gas 455
- Gross annual revenues of businesses in sample
    - $300,000 or less 46%
    - $300,000 - $500,000 9%
    - $500,000 - $1,000,000 15%

- Over $1,000,000 30%

Questionnaire

Portable Gasoline Container and Equipment Use Survey

Hello, my name is ____________________________________. I'm calling from NuStats. Let me assure you right away that I am not calling to sell you anything. We are conducting a study sponsored by the TNRCC (Texas Natural Resources Conservation Commission), and we are talking to people about the usage of fuel containers and equipment in businesses, and would really like to include your opinions. Let me assure you that all your answers will be held strictly confidential.

1. In what city and county is your business mainly conducted? If more than one please approximate the percent in each county.
City: _________________
County: _______________

2. How many portable gas containers are kept in your business on a regular basis?
____________ *containers*

IF Q3=00, TERMINATE

FUEL CONTAINER DESCRIPTION

3. What material are most of the containers in your business made of?
01 PLASTIC
02 METAL
97 OTHER (PLEASE SPECIFY ___________)
98 DK
99 RF

4. What is the average size in gallons of most of the containers in your business?
______ gallons.

5. What type of fuel is stored in these containers?
1.001 GASOLINE
02 DIESEL
03 BOTH
97 OTHER (PLEASE SPECIFY______)
98 DK
99 RF

6. Do you plan to replace any fuel containers in the next 12 months?

01 YES
02 NO
98 DK
99 RF

IF Q6= 01 THEN CONTINUE WITH Q7 ANYTHING ELSE CONTINUE WITH Q8

7. How many fuel containers do you plan to change in the next 12 months?

____

8. Are your fuel containers normally stored with both the nozzle and the vent closed?

01 YES
02 NO
98 DK
99 RF

FUEL USAGE

9. How many [INSERT EQUIPMENT FROM TABLE 1.] **are there in your business?** [FILL IN "#" COLUMN IN TABLE 1 WITH RESPONSE]

10. What type of fuel do most of your [INSERT EQUIPMENT FROM TABLE 1.] **use?** [FILL IN "TYPE OF FUEL" COLUMN IN TABLE 1 WITH RESPONSE]
[01- GAS 2-STROKE, 02- GAS 4-STROKE, 03- DIESEL, 97- OTHER/SPECIFY, 98- DK, 99- RF]

TABLE 1. TYPES OF FUEL USED BY MACHINERY

EQUIPMENT	#	TYPE OF FUEL
01. Lawn Mowers		
02. Rear Engine Riding Mowers		
03. Front Mowers		
04. Rotary Tillers		
05. Chain Saws (if less than 6HP)		
06. Trimmers/Edgers/Bush Cutters		

07. Leaf Blowers/Vacuums less than 25 HP		
08. Shredders less than 6 HP		
09. Wood Splitters		
10. Chippers/Strump Grinders/Mulchers less than 25 HP		
11. Commercial Turf Equipment/Sod Cutters less than 25 HP		
12. Other Lawn and Garden Equipment less than 25 HP		
97. Other (Please Specify ________)		

11. What was the total amount of fuel consumed by your business?
__ gallons of GAS 2-STROKE per _________ [LEAVE OPTION FOR TIMEPERIOD OPEN].
__ gallons of GAS 4-STROKE per _________ [LEAVE OPTION FOR TIMEPERIOD OPEN].
__ gallons of DIESEL per _________ [LEAVE OPTION FOR TIMEPERIOD OPEN].
__ gallons of OTHER(SPECIFY________) per _________ [LEAVE OPTION FOR TIMEPERIOD OPEN].

12.What is the gross annual income for this business?
01 $300,000 OR LESS
02 $300,00 - $500,000
03 $500,000- $1 MILLION
2.004 MORE THAN $1 MILLION (PLEASE APPROXIMATE __________)
3.098 DK
4.099 RF

THANK YOU FOR PARTICIPATING.

Detailed Results

Q1-In what...county is your business mainly conducted?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid		5	4.0	4.0	4.0
	Aransas	1	.8	.8	4.8
	Austin	1	.8	.8	5.6
	Bail	1	.8	.8	6.4
	Bastrop	1	.8	.8	7.2
	Bexar	4	3.2	3.2	10.4
	Blanco	1	.8	.8	11.2
	Bowie	1	.8	.8	12.0
	Brazoria	2	1.6	1.6	13.6
	Brazos	2	1.6	1.6	15.2
	Burnet	1	.8	.8	16.0
	Cameron	1	.8	.8	16.8
	Collin	2	1.6	1.6	18.4
	Collins	1	.8	.8	19.2
	Colorado	1	.8	.8	20.0
	Comal	3	2.4	2.4	22.4
	Cook	1	.8	.8	23.2
	Dallas	8	6.4	6.4	29.6
	Dawson	1	.8	.8	30.4
	Denton	2	1.6	1.6	32.0
	Ector	1	.8	.8	32.8
	El Paso	1	.8	.8	33.6
	Fort Bend	2	1.6	1.6	35.2
	Fort Bent	1	.8	.8	36.0
	Franklin	1	.8	.8	36.8
	Galveston	1	.8	.8	37.6
	Gillespie	2	1.6	1.6	39.2
	Gregg	1	.8	.8	40.0
	Grimes	2	1.6	1.6	41.6
	Hardin	1	.8	.8	42.4
	Harris	19	15.2	15.2	57.6
	Hays	1	.8	.8	58.4
	Henderson	1	.8	.8	59.2
	Hidalgo	1	.8	.8	60.0
	Houston	1	.8	.8	60.8
	Howard	1	.8	.8	61.6
	Jim Wells	1	.8	.8	62.4
	Johnson	1	.8	.8	63.2
	Lubbock	4	3.2	3.2	66.4
	McLennan	1	.8	.8	67.2
	Midland	2	1.6	1.6	68.8
	Montgomery	2	1.6	1.6	70.4
	Nueces	2	1.6	1.6	72.0
	Oak	1	.8	.8	72.8
	Parker	2	1.6	1.6	74.4
	Polk	1	.8	.8	75.2
	Porter & Randall	1	.8	.8	76.0
	Randall	1	.8	.8	76.8
	Smith	3	2.4	2.4	79.2

Q2-How many portable gas containers are kept in your business on a regular basis?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	24	19.2	19.2	19.2
	2	18	14.4	14.4	33.6
	3	28	22.4	22.4	56.0
	4	11	8.8	8.8	64.8
	5	1	.8	.8	65.6
	5	6	4.8	4.8	70.4
	6	5	4.0	4.0	74.4
	7	2	1.6	1.6	76.0
	8	4	3.2	3.2	79.2
	9	1	.8	.8	80.0
	10	7	5.6	5.6	85.6
	12	5	4.0	4.0	89.6
	15	2	1.6	1.6	91.2
	20	3	2.4	2.4	93.6
	25	2	1.6	1.6	95.2
	30	2	1.6	1.6	96.8
	40	1	.8	.8	97.6
	60	1	.8	.8	98.4
	70	1	.8	.8	99.2
	150	1	.8	.8	100.0
	Total	125	100.0	100.0	

Q3-What material are most of the containers in your business made of?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Plastic	97	77.6	77.6	77.6
	Metal	27	21.6	21.6	99.2
	DK	1	.8	.8	100.0
	Total	125	100.0	100.0	

Q4-What is the average size in gallons of most of the containers in your business?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1.00	6	4.8	4.8	4.8
	1.50	2	1.6	1.6	6.4
	2.00	19	15.2	15.2	21.6
	2.50	18	14.4	14.4	36.0
	2.67	1	.8	.8	36.8
	3.00	8	6.4	6.4	43.2
	3.33	1	.8	.8	44.0
	3.50	1	.8	.8	44.8
	4.00	6	4.8	4.8	49.6
	5.00	52	41.6	41.6	91.2
	6.00	2	1.6	1.6	92.8
	8.00	1	.8	.8	93.6
	10.00	1	.8	.8	94.4
	50.00	1	.8	.8	95.2
	70.00	1	.8	.8	96.0
	110.00	1	.8	.8	96.8
	500.00	2	1.6	1.6	98.4
	1000.00	1	.8	.8	99.2
	1166.00	1	.8	.8	100.0
	Total	125	100.0	100.0	

Q5-What type of fuel is stored in these containers?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Gasoline	86	68.8	68.8	68.8
	Diesel	8	6.4	6.4	75.2
	Both	30	24.0	24.0	99.2
	Other	1	.8	.8	100.0
	Total	125	100.0	100.0	

Q6-Do you plan to replace any fuel containers in the next 12 months?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	47	37.6	37.6	37.6
	No	66	52.8	52.8	90.4
	DK	12	9.6	9.6	100.0
	Total	125	100.0	100.0	

Q7-How many fuel containers do you plan to change in the next 12 months?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	8	6.4	19.5	19.5
	2	7	5.6	17.1	36.6
	3	10	8.0	24.4	61.0
	4	3	2.4	7.3	68.3
	5	3	2.4	7.3	75.6
	6	2	1.6	4.9	80.5
	8	1	.8	2.4	82.9
	10	2	1.6	4.9	87.8
	12	2	1.6	4.9	92.7
	15	1	.8	2.4	95.1
	30	1	.8	2.4	97.6
	98	1	.8	2.4	100.0
	Total	41	32.8	100.0	
Missing	System	84	67.2		
Total		125	100.0		

Q8-Are your fuel containers normally stored with both the nozzle and the vent closed?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	89	71.2	71.2	71.2
	No	21	16.8	16.8	88.0
	DK	15	12.0	12.0	100.0
	Total	125	100.0	100.0	

Q10-Number of lawn mowers

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	50	40.0	40.0	40.0
	1	20	16.0	16.0	56.0
	2	12	9.6	9.6	65.6
	3	5	4.0	4.0	69.6
	4	7	5.6	5.6	75.2
	5	2	1.6	1.6	76.8
	6	6	4.8	4.8	81.6
	8	6	4.8	4.8	86.4
	10	5	4.0	4.0	90.4
	12	2	1.6	1.6	92.0
	14	1	.8	.8	92.8
	15	2	1.6	1.6	94.4
	16	1	.8	.8	95.2
	20	1	.8	.8	96.0
	24	1	.8	.8	96.8
	25	2	1.6	1.6	98.4
	40	1	.8	.8	99.2
	100	1	.8	.8	100.0
	Total	125	100.0	100.0	

Q10-Number of rear engine riding mowers

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	82	65.6	65.6	65.6
	1	15	12.0	12.0	77.6
	2	10	8.0	8.0	85.6
	3	3	2.4	2.4	88.0
	4	7	5.6	5.6	93.6
	5	2	1.6	1.6	95.2
	6	1	.8	.8	96.0
	7	2	1.6	1.6	97.6
	11	1	.8	.8	98.4
	26	1	.8	.8	99.2
	60	1	.8	.8	100.0
	Total	125	100.0	100.0	

Q10-Number of front mowers

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	101	80.8	80.8	80.8
	1	10	8.0	8.0	88.8
	2	3	2.4	2.4	91.2
	3	2	1.6	1.6	92.8
	4	3	2.4	2.4	95.2
	6	2	1.6	1.6	96.8
	8	2	1.6	1.6	98.4
	12	1	.8	.8	99.2
	14	1	.8	.8	100.0
	Total	125	100.0	100.0	

Q10-Number of rotary tillers

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	88	70.4	70.4	70.4
	1	18	14.4	14.4	84.8
	2	10	8.0	8.0	92.8
	3	6	4.8	4.8	97.6
	4	2	1.6	1.6	99.2
	6	1	.8	.8	100.0
	Total	125	100.0	100.0	

Q10-Number of chain saws

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	38	30.4	30.4	30.4
	1	25	20.0	20.0	50.4
	2	20	16.0	16.0	66.4
	3	15	12.0	12.0	78.4
	4	8	6.4	6.4	84.8
	5	3	2.4	2.4	87.2
	6	4	3.2	3.2	90.4
	7	3	2.4	2.4	92.8
	8	2	1.6	1.6	94.4
	9	1	.8	.8	95.2
	12	1	.8	.8	96.0
	13	1	.8	.8	96.8
	15	1	.8	.8	97.6
	20	2	1.6	1.6	99.2
	200	1	.8	.8	100.0
	Total	125	100.0	100.0	

Q10-Number of trimmers

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	53	42.4	42.4	42.4
	1	23	18.4	18.4	60.8
	2	6	4.8	4.8	65.6
	3	7	5.6	5.6	71.2
	4	9	7.2	7.2	78.4
	5	1	.8	.8	79.2
	6	7	5.6	5.6	84.8
	8	3	2.4	2.4	87.2
	10	1	.8	.8	88.0
	12	2	1.6	1.6	89.6
	13	2	1.6	1.6	91.2
	15	3	2.4	2.4	93.6
	20	3	2.4	2.4	96.0
	24	1	.8	.8	96.8
	25	1	.8	.8	97.6
	30	1	.8	.8	98.4
	60	1	.8	.8	99.2
	80	1	.8	.8	100.0
	Total	125	100.0	100.0	

Q10-Number of leaf blowers

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	51	40.8	40.8	40.8
	1	26	20.8	20.8	61.6
	2	13	10.4	10.4	72.0
	3	6	4.8	4.8	76.8
	4	8	6.4	6.4	83.2
	5	2	1.6	1.6	84.8
	6	2	1.6	1.6	86.4
	7	2	1.6	1.6	88.0
	10	5	4.0	4.0	92.0
	12	2	1.6	1.6	93.6
	15	1	.8	.8	94.4
	16	1	.8	.8	95.2
	20	2	1.6	1.6	96.8
	21	1	.8	.8	97.6
	30	1	.8	.8	98.4
	40	1	.8	.8	99.2
	50	1	.8	.8	100.0
	Total	125	100.0	100.0	

Q10-Number of shredders

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	118	94.4	94.4	94.4
	1	5	4.0	4.0	98.4
	2	2	1.6	1.6	100.0
	Total	125	100.0	100.0	

Q10-Number of wood splitters

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	115	92.0	92.0	92.0
	1	8	6.4	6.4	98.4
	2	2	1.6	1.6	100.0
	Total	125	100.0	100.0	

Q10-Number of chippers

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	108	86.4	86.4	86.4
	1	8	6.4	6.4	92.8
	2	8	6.4	6.4	99.2
	30	1	.8	.8	100.0
	Total	125	100.0	100.0	

Q10-Number of sod cutters

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	120	96.0	96.0	96.0
	1	4	3.2	3.2	99.2
	4	1	.8	.8	100.0
	Total	125	100.0	100.0	

Q10-Number of other lawn equipment

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	121	96.8	96.8	96.8
	1	1	.8	.8	97.6
	4	2	1.6	1.6	99.2
	5	1	.8	.8	100.0
	Total	125	100.0	100.0	

Q10-Number of other equipment

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	55	44.0	73.3	73.3
	1	10	8.0	13.3	86.7
	2	6	4.8	8.0	94.7
	3	2	1.6	2.7	97.3
	10	1	.8	1.3	98.7
	100	1	.8	1.3	100.0
	Total	75	60.0	100.0	
Missing	System	50	40.0		
Total		125	100.0		

Q12-What is the gross annual income for this business?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	$300,000 or less	41	32.8	33.3	33.3
	$300,000-500,000	8	6.4	6.5	39.8
	$500,000-1 million	13	10.4	10.6	50.4
	Over $1 million	26	20.8	21.1	71.5
	DK	21	16.8	17.1	88.6
	Refused	14	11.2	11.4	100.0
	Total	123	98.4	100.0	
Missing	System	2	1.6		
Total		125	100.0		

Q11-Total number of gallons of gas 2-stroke consumed per month

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	.08	1	.8	3.4	3.4
	.42	1	.8	3.4	6.9
	.50	1	.8	3.4	10.3
	1.00	2	1.6	6.9	17.2
	1.25	1	.8	3.4	20.7
	2.00	2	1.6	6.9	27.6
	2.50	1	.8	3.4	31.0
	4.00	1	.8	3.4	34.5
	10.00	2	1.6	6.9	41.4
	12.00	1	.8	3.4	44.8
	15.00	1	.8	3.4	48.3
	16.00	1	.8	3.4	51.7
	20.00	1	.8	3.4	55.2
	30.00	1	.8	3.4	58.6
	40.00	1	.8	3.4	62.1
	45.00	1	.8	3.4	65.5
	50.00	1	.8	3.4	69.0
	60.00	1	.8	3.4	72.4
	66.67	2	1.6	6.9	79.3
	133.33	1	.8	3.4	82.8
	220.00	1	.8	3.4	86.2
	333.33	2	1.6	6.9	93.1
	583.33	1	.8	3.4	96.6
	833.33	1	.8	3.4	100.0
	Total	29	23.2	100.0	
Missing	System	96	76.8		
Total		125	100.0		

Q11-Total number of gallons of gas 4-stroke consumed per month

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1.00	1	.8	4.5	4.5
	2.08	1	.8	4.5	9.1
	3.33	1	.8	4.5	13.6
	11.00	1	.8	4.5	18.2
	12.00	2	1.6	9.1	27.3
	20.00	1	.8	4.5	31.8
	60.00	2	1.6	9.1	40.9
	80.00	1	.8	4.5	45.5
	100.00	1	.8	4.5	50.0
	120.00	1	.8	4.5	54.5
	320.00	1	.8	4.5	59.1
	333.33	1	.8	4.5	63.6
	372.00	1	.8	4.5	68.2
	416.67	1	.8	4.5	72.7
	583.33	1	.8	4.5	77.3
	750.00	1	.8	4.5	81.8
	1000.00	1	.8	4.5	86.4
	2000.00	1	.8	4.5	90.9
	2666.67	1	.8	4.5	95.5
	8333.33	1	.8	4.5	100.0
	Total	22	17.6	100.0	
Missing	System	103	82.4		
Total		125	100.0		

Q11-Total number of gallons of diesel consumed per month

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	5.00	1	.8	4.0	4.0
	8.33	1	.8	4.0	8.0
	10.00	1	.8	4.0	12.0
	20.00	1	.8	4.0	16.0
	40.00	2	1.6	8.0	24.0
	83.33	1	.8	4.0	28.0
	100.00	1	.8	4.0	32.0
	160.00	1	.8	4.0	36.0
	166.67	1	.8	4.0	40.0
	175.00	1	.8	4.0	44.0
	200.00	1	.8	4.0	48.0
	250.00	1	.8	4.0	52.0
	300.00	2	1.6	8.0	60.0
	372.00	1	.8	4.0	64.0
	400.00	1	.8	4.0	68.0
	500.00	1	.8	4.0	72.0
	666.67	1	.8	4.0	76.0
	1200.00	1	.8	4.0	80.0
	1800.00	1	.8	4.0	84.0
	3333.33	1	.8	4.0	88.0
	4000.00	1	.8	4.0	92.0
	5000.00	1	.8	4.0	96.0
	6250.00	1	.8	4.0	100.0
	Total	25	20.0	100.0	
Missing	System	100	80.0		
Total		125	100.0		

Q11-Total number of gallons of gas consumed per month

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1.00	3	2.4	5.2	5.2
	5.00	2	1.6	3.4	8.6
	6.00	1	.8	1.7	10.3
	10.00	5	4.0	8.6	19.0
	15.00	2	1.6	3.4	22.4
	16.00	2	1.6	3.4	25.9
	20.00	2	1.6	3.4	29.3
	30.00	2	1.6	3.4	32.8
	40.00	2	1.6	3.4	36.2
	75.00	1	.8	1.7	37.9
	80.00	1	.8	1.7	39.7
	100.00	4	3.2	6.9	46.6
	110.00	1	.8	1.7	48.3
	200.00	3	2.4	5.2	53.4
	300.00	2	1.6	3.4	56.9
	350.00	1	.8	1.7	58.6
	370.00	1	.8	1.7	60.3
	400.00	2	1.6	3.4	63.8
	500.00	7	5.6	12.1	75.9
	600.00	1	.8	1.7	77.6
	800.00	2	1.6	3.4	81.0
	925.00	1	.8	1.7	82.8
	1000.00	2	1.6	3.4	86.2
	1200.00	1	.8	1.7	87.9
	1300.00	1	.8	1.7	89.7
	1500.00	1	.8	1.7	91.4
	2000.00	4	3.2	6.9	98.3
	2083.33	1	.8	1.7	100.0
	Total	58	46.4	100.0	
Missing	System	67	53.6		
Total		125	100.0		