WATER USE IN THE PROFESSIONAL CAR WASH INDUSTRY

A Report for the International Carwash Association

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Executive Summary

The International Carwash Association has dedicated much of its effort to evaluating the impact of our industry on the environment. To better educate individuals on the influence of professional car washing, we have conducted a series of studies as part of our strategic plan to provide industry leadership.

In an effort to clarify water consumption and water conservation measures in professional car washes, the International Carwash Association commissioned a study of techniques used to conserve and reclaim water in the car wash industry and to define those techniques in a standardized manner. In 1999, the "Water Conservation in the Professional Car Wash Industry" report was published. It described the water use and conservation techniques for self-service, in-bay automatic, and conveyor car washes. The results of that examination were designed to advance the discussion of water usage, conservation and reclaim in the professional car wash industry.

This year the International Carwash Association has completed a two-year study that is designed to assess both water usage including the impact of evaporation and carryout, and wastewater quality including solid waste. The principal objective of this study is to determine the volume difference between fresh water consumed and the wastewater discharged while quantifying the average water consumption per vehicle by professional car washes.

Data collected from in-bay automatic car washes, self-service car washes and conveyor car washes in three different climatic locations were chosen to determine if regional differences in climate had a significant impact on water use or water losses due to differences in evaporation and carryout.

It is imperative that our businesses take proactive measures in both quantity and quality of water usage. Water regulators can use the data to determine relative water savings that can be successfully implemented by commercial car washes utilizing water reclaim systems. This data also can assist in calculations for sewage rates based upon a percentage of fresh water consumed.

This study is made available to all of those in our industry who can benefit from its conclusions. The International Carwash Association is an 'industry driven, membership organization' whose goals include providing for the continued success of all participants in the car care community. If you have any questions about the contents of this report, please contact the International Carwash Association via the Website, www.carcarecentral.com.

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INTRODUCTION

This report was produced for the International Carwash Association (ICA) as part of a consulting agreement to implement a study of car wash water use and wastewater quality. The first section examines water use and losses due to evaporation and carryout. A second section presents findings on wastewater quality and solid waste.

The main goals of this study were to quantify the average water consumption per vehicle washed, as well as to determine the volume difference between the fresh water consumed and the wastewater discharged by professional in-bay automatic car washes, self serve car washes, and conveyor car washes. The use of reclaim systems to conserve water is also considered. This study is based upon data gathered in the field as recommended in the International Carwash Association's Water Conservation Study[1] which examined water use and conservation techniques in the professional car wash industry. The previous study found water use data available primarily from manufacturers' specifications and little or no data from field studies. This report serves to compile information gathered from the work performed at individual sites in Boston, Massachusetts, Orlando, Florida, and Phoenix, Arizona for comparison and comment[2]. Three different geographic locations were chosen to determine if regional differences in climate had a significant impact upon water use or water losses due to differences in evaporation and carryout.

Facing the need to implement water conservation or drought restrictions, regulators can use the data presented to determine the contribution to water use cutbacks that can be successfully implemented by professional car washes. It can also assist in water rate calculations for sewage rates based upon a percentage of fresh water consumed. The information presented can be used to determine the relative water savings found in the study from installing and operating a water reclaim system.

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1 Brown, C., Water Conservation in the Professional Car Wash Industry, International Carwash Association, 2000.

2 Data collection was performed by Oak Engineers, Newburyport, Massachusetts for the Boston and Orlando regions in 2001. Black and Veatch, Phoenix, Arizona collected data on In-bay and Self-serve sites in the Phoenix area in 2000. Data regarding conveyor washes in the Phoenix area was collected in 1996, and reported by Jane Ploesser of Phoenix Water Department.

STUDY GOALS

The study collected data related to three basic questions: the amount of water consumed per vehicle, the water loss to evaporation and carryout, and potential water saving measures including reclaim. The second section of this report summarizes the results of waste water quality and solid waste data.

Water consumption. Each one of the study sites was audited for water use by cycle and for the total gallons used per vehicle for each of the wash types. Numerous previous studies, including the *Water Use Conservation in Carwashes* study (Brown, 1999), have used consumption estimates based upon manufacturers' specifications. This study compares water use by carwash type and region based upon fieldwork. An earlier study of conveyor carwashes in Phoenix, AZ was performed by Black and Veatch (Kobrick, 1997).

Evaporation and Carryout. Data was also collected to determine the amount of water lost through evaporation and carryout. Carryout includes water that leaves the car wash adhering to the surface of the car, or is blown from the car wash bay by wind. The location, local climate, orientation to wind, size of bay, water pressure and nozzle size and orientation will all effect evaporation and carryout losses. Water loss that occurs from evaporation and carryout reduces sewer flows from the facility. This is important in locales where sewer rates are based upon a factor representing the percentage return of freshwater to the sewer system for treatment. This study measured actual return flows versus freshwater inflows over a week at each of the study sites and compared them to determine evaporation and carryout losses.

Conservation and Reclaim. The water audits performed at each site identified potential conservation measures. Car wash operators have reduced their water use per vehicle washed by adjusting nozzle size, water pressure, and leak detection and repair. The audits identified potential conservation measures at each site, and provided economic data for operators considering installing such measures. The conservation potential of water reclaim was evaluated by measuring water use in those sites where reclaim systems were installed and operating as compared to those which were freshwater use only.

CAR WASH CLASSIFICATION AND WATER PROCESSES

The International Carwash Association characterizes the Professional Car Wash industry as those commercial services providing automotive vehicle washing service to the general public. Car washes types are divided into three broad categories: conveyor, in-bay automatic and self-service. Numerous manufacturers provide equipment to the professional car wash industry, bringing a certain variation to water use, since there are no industry-wide standards for water flow.

There are two types of Conveyor Car Washes: Full-service and Exterior only. The professional full-service wash cleans the exterior and interior and the customer waits outside the car while the wash proceeds. During the professional exterior only wash, the driver stays in the car while it is being washed and no interior cleaning services are performed. The car moves on a conveyor belt through a tunnel during both types of washes. In addition to the division based on level of service, there are two basic technologies for the wash cycle, friction or frictionless. The friction conveyor uses equipment that makes contact with the vehicle, while the frictionless conveyor uses high-pressure nozzles for a touch-free wash. The various cycles of the wash, from wash to rinse and application of various finish products, are accomplished by a series of automatic arches with spray nozzles or cleaning equipment which are activated as the car passes through.

In-Bay Automatic Car Washes are mostly found at gas stations and coin-operated car washes. The driver pulls into the bay and parks the vehicle, which remains stationary while a machine moves back and forth over the vehicle to clean it. Professional in-bay car washes use soft cloth or similar material, or friction-less automatic washers. The current generation of in-bay car washes have moved to mostly friction-less, using spray nozzles mounted on an arm to perform all aspects of the wash. Each cycle uses either fresh or reclaim water, and may use different cleaning solutions or finish products.

The Self-Service Car Wash allows the consumers to wash the car themselves. The customer purchases an initial amount of wash time for a minimum price. A device dispenses water and cleanser at varying amounts and pressures. Often a low-pressure brush is offered to assist in the wash cycle.

This section will briefly describe the stages of a professional car wash process, and some of the different services available based upon the type of car wash.

Steps in a Professional Car Wash Process:

Pre-soak - An automated nozzle or hand held spray. Not found in all car washes.

Wash - High-pressure spray or cloth material with detergent solution.

Rocker panel/undercarriage - Cloth material or high pressure sprays on sides and bottom of vehicle. In a conveyor these may be operated on independent arms or carriages that spray upward from below or beside the vehicle.

First Rinse - High-pressure water rinse.

Wax/Sealers/Polishes - An optional surface finish is sprayed on the vehicle.

Final Rinse - Low-pressure rinse with fresh or membrane-filtered/deionized water –is sprayed on the vehicle.

Air Blowers - Air is blown over the vehicle to remove water and assist in drying.

Hand Drying - The vehicle is wiped down with towels or chamois cloths. In full-service and exterior washes these are then laundered in washing machines on-site.

In a conveyor car wash, separate spray arches and/or cloth material equipment perform these steps. In the in-bay automatic, there is a set of nozzles though which all processes are performed, except in some cases where cloth material may be used for the wash cycle.

In self-service car washes there may be a brush for the wash cycle, but most functions are performed through a hand-held wand.

Spot free rinses are offered in many car washes due to the presence of dissolved materials in the water supply. Minerals and other ions, which have been dissolved, are removed by de-ionization or reverse osmosis. De-ionization (DI) is performed by running the water through beds of cations and anions, which bind the dissolved ions, and produce filtered water. Reverse Osmosis

(RO) works by using pressure to force water containing solutes through a semi-permeable membrane. Pure water results on the side of the membrane supplying the spot free rinse, while the reject side is disposed as brine or “reject” water. Reject water from the RO unit may be put back through the wash reclaim system in a closed loop system or used in landscaping or other non-potable uses in the professional car wash. Spot free rinses are more common in In-Bay and Self Service car washes, as full service conveyor washes offer towel drying, which precludes the need for spot free water.

METHODOLOGY

At each car wash site an audit was performed, and a minimum of one week's cumulative flows of freshwater and effluent were collected. The same general methodology was followed for all car washes. Specific additional measurements were taken when applicable. For example with conveyor carwashes, washing machine loads' contribution to both inflow and effluent were measured and accounted for in the calculations of water use per vehicle, evaporation and carryout. The following sections detail the methods used to collect and analyze the data.

Water Audits.

Sites were selected with the goal of accurately measuring both inflow and outflow. All plumbing that shared the water source meter with the car wash was identified and if possible, operation was discontinued during the time of measurement. If shut off was not possible, water uses were also measured as part of the audit. All ancillary processes were audited, such as towel washing, and domestic uses on site. In several instances, where the plumbing for the car wash was clearly separate from all other uses at a site and easily accessible, a dedicated meter was installed on the freshwater source line to the car wash. In some cases the central supply plumbing for the car wash was routed under a floor or through a wall in such a way that dedicated meters were not possible for all sites.

Flow rates and duration were measured for each cycle of a car wash. For conveyers this required identifying water use on separate components throughout the wash. For In Bay automatics this required measuring flow rates from the same set of nozzles, but operating in different cycles. The water pressure for each cycle was also measured. In addition to measuring flow rates for each cycle, overall water use for each car was also measured by turning off all water uses within a car wash, and running several cars through the wash, measuring total flow through the master meter or dedicated meter for each vehicle. In those car washes with Reclaim systems the audit identified flow rates and durations for all cycles using reclaim water.

In Self-service operations, water use flow rates per cycle can be determined, but duration is controlled by individual customers' decisions to change from one cycle to another, for example from a soap cycle to a rinse cycle. The audit included measuring the flow rates for each cycle. An additional obstacle to accurate flow rate monitoring was the scrub brush present at most sites.

The fibers diffused the flow through the brush, and the air bubbles entrained in the soapy water increased the apparent volume of the flow. The flow rates for soap cycles through the brush were determined by allowing the soapy water to collect in a bucket over a known period of time, and then waiting until the air bubbles burst to measure the quantity. To determine average flow rate over time, all processes other than the wash were shut off, and the total flow measured through the meter was compared to the time purchased by the customers to provide a flow rate in gallons per minute (gpm).

To determine an average use per vehicle in Self Service operations, two sites were selected and a team of observers timed with stop watches the actual duration that customers spent using the equipment. From this an average time per self-serve wash was calculated and this was multiplied by the gpm flow rate to determine water use per wash. This method was used rather than traffic counters since the researchers noted during an audit of one site that some traffic entered the car wash and drove through the bays without stopping to use the equipment.

Where the car wash used reverse osmosis equipment, the amount of water lost to reject water was measured and the total amount was added back to the water used during the wash process. Reverse osmosis works by forcing water through a membrane so that only pure water ends up on the filtered side of membrane while the remaining water, with increased salinity, flows to the sanitary sewer. The filtered water is referred to as “product,” while the more saline water is referred to as “reject” or “brine.” The Product/reject ratio and its impact on water use was evaluated as part of the study.

Evaporation and Carryout

Evaporation and carryout was calculated by comparing the freshwater inflows to car wash with the discharge flows to the sanitary sewer system. All identified water uses within a facility were accounted for in the calculation. For example, domestic water uses on some sites were on the same meter with the car wash, but sewer flows from the car wash were discrete from sanitary flows from the toilet.

Measuring sewer return flows is difficult and expensive on a permanent basis. In car washes the potential for suspended solids provides additional difficulty. While a permanent flume may be

possible, the expense of a retrofit to existing plumbing is usually not justified by the benefit. To measure water lost to evaporation and carryout it was necessary to install meters on a temporary basis in car washes in which there was adequate room to install the meter assembly.

In the Boston and Orlando studies, wastewater metering was accomplished by using positive displacement meters for car washes with low flows and paddle wheel meters for car washes with higher flow rates. Table 1 shows the type of meter used and the number of sites where it was used. Meters were installed in the final manhole for discharge to the sanitary sewer. Meter assemblies were plumbed into a straight-line pipe to minimize flow turbulence. A 45-degree fitting was installed at the end of each assembly to ensure the meter was receiving full pipe flow at all times. This configuration was used in order to accommodate traffic flow while the metering was being done. In the study performed in Phoenix, the outfall to the sewer was blocked and effluent was pumped through a meter to the sewer clean out. All Phoenix sites were metered with a one-inch disc meter. This method was not used in Boston and Orlando due to the fact that the manholes were typically located in the path of vehicles leaving the car wash bays, and metering equipment would have been at risk.

TABLE 1.1
DISCHARGE METERS BY SITE

Meter Type	Meter Size	Sites
Disc	¾”	BS1, BS3, BI4, OS1, OS2, OS4, OI1, OI2, OI3, OC3
Disc	1”	OI4
Paddle Wheel	1”	BS4, OC2
Paddle Wheel	1 1/2”	BI1, BI2, BI3, BC1, BC2, BC3, BC4, OS3

Periodic meter readings were taken for at least one week at each site. Vehicle wash counts were obtained from the car wash owner for each site. In-bay and conveyor car washes kept car wash counts on programmable logic controllers (PLCs).

Car wash counts, water consumption and wastewater discharge were monitored periodically throughout the week-long metering period at each site. These counts were compared to

freshwater use during the metering period and the average water use per vehicle was compared to the values determined through the audit.

Self-serve car washes provided a unique challenge. Since controllers count the number of minutes used, not the number of cars which are washed, another method of counting cars and establishing a relationship between time spent washing cars and water used per vehicle washed was necessary. In Phoenix, traffic counters were used, but in Boston a visual survey was performed. In a preliminary audit of a self serve facility in Boston, customers were observed using the change machine, or other vending services on site, and driving through the bays without purchasing a car wash. It was determined that a visual survey with stopwatch would be a more accurate method of determining the average time and gallons per vehicle washed. Two technicians sat at a distance from the bays and unannounced to the customers recorded the start and finish times for each wash over 5.25 hours on a Saturday at two of the more busy sites. Water meter readings were taken before and after the survey. The average time per wash was calculated from the data collected, and divided into the total minutes that the car wash operated over the monitoring period to determine the number of cars washed at each of the Boston and Orlando sites.

An analysis of variance was performed on several of the factors that affect water use. Regional differences in water use, differences in evaporation and carryout rates by type of professional car wash, and the variance in freshwater water use between car washes with reclaim versus non-reclaim car washes were all analyzed[3].

[3] Minitab for Windows, Version 10 software was used for statistical analysis.

SITES

For the purpose of this report, the various sites which were studied, are designated by location, type and number. For example a site located in the Boston area will be designated B, Orlando with an O and Phoenix with a P. The second designator is the site type, with a C for Conveyor, I for In-Bay and S for Self-serve. The separate sites in each location and type were then randomly designated with a number, so that the final designation follows the format, BC1 to BC4, OI1 to OI4, and PS1 to PS3, and so on for all 32 sites studied. This section contains a brief description of each site studied.

BC1: Car Wash BC1 was a full-service conveyor car wash with a tunnel 120 ft in length. The car wash operates from 8:00 am to 6:00 pm, Monday though Saturday, weather permitting, and stays open until 7:00 pm two nights per week. The facility is staffed during the day with approximately 25 employees. The facility has a gasoline station and a convenience store on site. The facility was constructed in the 1950's and car wash components have been upgraded and replaced as needed since.

The BC1 facility is supplied fresh water from both a private well and a municipal water supply. During the study, the well was turned off and all water to the car wash came through the municipal meter. Other water uses on the municipal meter included two restrooms for employees, washing machines for towels, and a water fountain. The convenience store was on a separate meter.

Car wash customers of BC1 have several options, including wash packages (the Works, Super Wash and Protector Package) or can purchase a basic wash package with add-on options such as clear coat sealant, undercarriage wash and rust inhibitor, triple foam protectant, and polish protectant. The conveyor uses magnetic sensors to determine overall car length and timing of car wash arches and fixtures. The employees prepare cars for the tunnel with prep wash using handheld equipment and spray guns. Water use volumes ranged from 23.2 gallons on a basic wash for a small car to 42.8 gallons for the works on a full size car. Total fresh water consumed was 43,295 gallons to wash 1607 cars for an average water use of 26.9 gpv.

The tunnel had 15 different wash elements including five different cloth equipment or "mitter"

components. Three undercarriage components, four soap and finish products applications, along with a pre-rinse arch, a side panel spray and a final rinse Rain Arch made up the components of the wash. The largest single water use of components measured was the Rain Arch for the final rinse, which used approximately 6 gpv in 20 seconds. The high-pressure undercarriage "Gatling-gun" assembly in this facility was operated at 700 psi, approximately 400-500 psi below manufacturers recommended operating pressure, thus it used approximately 1 gpm per nozzle.

BC2: Car Wash BC2 was a conveyor car wash with a tunnel 100 ft in length and a 5-bay Self-serve car wash. The Self-serve was also evaluated and is addressed later as site BS4. The BC2 facility car wash operates from 7:30 am to 7:00 pm, Monday though Saturday and 8:00 am to 6:00 pm on Sundays, weather permitting. The facility is staffed during with approximately 1 to 3 employees per shift. The facility was constructed in 1990.

The BC2 facility is supplied fresh water from a municipal water supply. Water for the car wash was supplied through a municipal meter. Other water uses on the municipal meter included an employee restroom, a pressure washer for bay wash down and a garden hose. The same municipal water meter served all ancillary uses. Reclaim water was used in the chassis bath, an undercarriage wash phase.

Car wash customers of BC2 had several options, including wash packages (Ultra Wash, The Works, Super Wash No. 2 and Super Wash No. 1) or could purchase a basic wash package with add-on options such as hand preparation, 'wheel brite', chassis bath, poly clean conditioner, poly sealant and undercarriage rust inhibitor. The conveyor uses magnetic sensors to determine overall car length and timing of car wash arches and fixtures. Water use volumes ranged from 33.6 gallons on a basic wash for a mid-size sedan to 37.4 gallons for an Ultra wash on a mid-size sedan. Total fresh water consumed was 24,826 gallons to wash 782 vehicles for an average water use of 31.7 gpv.

The tunnel had 16 different wash elements including four different cloth equipment or "mitter" components. Eight different components apply detergents or finish products, four of which were optional applications that could be selected by the customer.
The remaining four components included two high-pressure rinse cycles, a chassis bath and a spot free rinse, with de-ionized water. The largest single water use of components measured was

the High-pressure rinse, which used approximately 9 gpv in 30 seconds.

BC3: Car Wash BC3 was a full-service conveyor car wash with a tunnel 130 ft in length. The BC3 facility car wash operates from 7:00am to 9:00pm, Monday though Saturday and 7:00 am to 5:00 pm on Sundays, weather permitting. The facility is staffed during with approximately three employees per shift. The facility was constructed in the mid-1960s, current management purchased the facility in 1984 and the facility was upgraded and components replaced as needed. Sites BC3 and BC4 were owned by the same company, differences in equipment and water use were noted.

The BC3 facility is supplied fresh water from a municipal water supply. Wastewater is collected in a central trench drain and discharges to a sedimentation tank which in turn discharges to a reclaim tank system. The reclaim/sedimentation tanks are baffled and have submerged discharge orifices to permit oil/water separation. Reclaim tanks are treated periodically with chlorine by employees for odor. No other filtration or treatment is performed. Fresh water for the car wash was supplied through a municipal meter. Other water uses on the municipal meter included two restrooms for employees, which were separately metered from the car wash.

Car wash customers of BC3 had several options, including wash packages (Supershiner, Superwash, or The Works) or could purchase an exterior wash package with add-on options such as clear coat protect, sealer wax, blue polish wax, red polish wax, whitewall and wheel cleaner, rust inhibitor and undercarriage wash. The conveyor uses magnetic sensors to determine overall car length and timing of car wash arches and fixtures. The employees prepare cars for the tunnel with prep wash using handheld brushes and spray guns. Two of the components, which used reclaim water, Mitter No 1 and the Wrap Brush were on from the time a vehicle entered the tunnel until a car wash employee manually turned them off. This added an estimated 16 to 25 gallons per wash of reclaim usage per vehicle. Fresh water use volumes on individually observed washes ranged from 10.5 gallons for a Supershiner wash on a compact to 13.5 gallons on an exterior wash on a truck. Reclaim water usage ranged from 24 gallons on the Supershiner to 33 gallons on the exterior wash with all options chosen. Total fresh water consumed over the one-week period was 13,853 gallons to wash 848 vehicles for an average freshwater use of 16.3 gpv. The average freshwater use over the period of measurement was approximately 20% higher than the largest amount measured during the audit. Some explanations include the possibility of a

leak, the refilling of system holding tanks and/or prep tubs, and bay washdowns. No visible leaks were observed.

The tunnel had 19 different wash elements including eight which used reclaim water. Of the total there were five different cloth equipment or "mitter" components. Seven different components applied detergents or finish products, five of which were optional applications based upon the package selected by the customer, and one of which, the Tire Cleaner, used reclaim water. A spot free rinse, with de-ionized water, and a hand-prep Wheel Cleaner were the additional components to use fresh water. Reclaim water supplied the Hand-Prep spray gun and the following eight components: Rocker Panel, Mitter No 1, Tire Cleaner, Wrap Brush No. 1, Window Brush, Undercarriage, Flex Wraps, and Mitter Rinse No 2. Five of the components, specifically the prep arch, side brush, Mitter Rinse No 1, Mitter No 3 and Final Rinse were shut down and did not operate during the audit period. Had they been operating, water usage at BC3 would have been anticipated to be higher than measured. The cloth curtain strips in Mitter No. 3 appeared to be wetted by the passage of already wet vehicles through the tunnel.

The largest single water use of components measured in BC3 were the two components that used reclaim water, Mitter No 1 and the Wrap Brush, which were on continuously throughout each wash as mentioned above for an estimated 16 to 25 gallons per wash of reclaim usage. The largest freshwater use measured was the spot-free rinse at approximately 3.2 gpv.

BC4: Car Wash BC4 was a full-service conveyor car wash with a tunnel 120 ft in length. The BC4 facility car wash operates from 7:00 am to 7:00 pm, Monday though Friday, 7:00 am to 6:00 pm Saturday, and 7:00 am to 5:00 pm on Sunday, weather permitting. The facility is staffed during these times with approximately two to three employees per shift. The facility was constructed in the mid-1970s, current management purchased the facility in 1984 and the facility was upgraded and components replaced as needed.

The BC4 facility is supplied fresh water from a municipal water supply. Wastewater is collected in a central trench drain an discharges to a sedimentation tank which in turn discharges to a reclaim tank system. The reclaim/sedimentation tanks are baffled and have submerged discharge orifices to permit oil/water separation. Reclaim tanks are treated periodically with chlorine by

employees for odor. No other filtration or treatment is performed. Fresh water for the car wash was supplied through a municipal meter. Other water uses on the municipal meter included two restrooms for employees, which were separately metered from the car wash.

Car wash customers of BC4 had several options, including wash packages (Supershiner, Superwash, or The Works) or could purchase an exterior wash package with add-on options such as clear coat protect, sealer wax, blue polish wax, red polish wax, whitewall and wheel cleaner, rust inhibitor and undercarriage wash. The conveyor uses magnetic sensors to determine overall car length and timing of car wash arches and fixtures. The employees prepare cars for the tunnel with prep wash using handheld brushes and spray guns. Two of the components that used reclaim water, Mitter No 1 and the Wrap Brush were on from the time a vehicle entered the tunnel until a car wash employee manually turned them off. This added an estimated 16 to 24 gallons per wash of reclaim usage per vehicle. Fresh water use volumes on individually observed washes ranged from 7.1 gallons for a Regular wash to 23.2 gallons on Supershiner wash. Reclaim water usage ranged from 16.8 gallons on the exterior wash to 19.3 gallons on the Supershiner. Total fresh water consumed over the one week period was 25,154 gallons to wash 955 vehicles for an average freshwater use of 26.3 gpv. The average freshwater use over the period of measurement was approximately 12% higher than the largest amount measured during the audit. Some explanations include the possibility of a leak, the refilling of system holding tanks and/or prep tubs, and bay washdowns. No visible leaks were observed.

The tunnel had 21 different wash elements, seven of which used reclaim water. Of the total there were four different cloth equipment or “mitter” components. Eight different components applied detergents or finish products, six of which were optional applications based upon the package selected by the customer. These components all used freshwater. A spot free rinse, with de-ionized water, a final rinse, and a hand-prep Wheel Cleaner, were the additional components to use fresh water. Reclaim water supplied the Hand-Prep spray gun and the following seven components: Rocker Panel, Mitter No 2 and 3, Wrap Brush, Undercarriage, Mitter Rinse and Side Brush Rinse. Three of the components, specifically the prep arch, side brush, and Mitter No 1 were shut down and did not operate during the audit period. Had they been operating, water usage at BC4 would have been anticipated to be higher than measured. The cloth curtain strips in Mitter No. 1 appeared to be wetted by the passage of already wet vehicles through the tunnel.

The largest single water use of components measured in BC4 were the two components that used reclaim water, Mitter No 1 and the Wrap Brush, which were on continuously throughout each wash as mentioned above for an estimated 16 to 24 gallons per wash of reclaim usage. The largest freshwater use measured was the Wax Clear Coat finish at approximately 5.8 gpv. This component was available as a part of the Supershine Package, or as an option with the Regular Wash. The DI spot free rinse, was used on all vehicles, and used approximately 2.9 gpv.

BI1: Car wash facility BI1 was an In-bay automatic with one bay attached to a gasoline station. The BI1 facility car wash operates from 7:00 am to 9:00 pm, Monday though Friday, 7:00 am to 7:00 pm Saturday and Sunday. Gas station employees are on site, but not responsible for the operation and maintenance of the car wash facility. The facility is maintained by off site staff. One or two employees per shift staff the gas station. The facility was remodeled in 1995. The car wash equipment was approximately two years old at the time of the study.

The BI1 facility is supplied fresh water from a municipal water supply. The carwash equipment includes 40 nozzles placed on a moving arch with spinning arms, and an undercarriage wash system at the entrance to the bay. Fresh water for the car wash was supplied through a municipal meter. Other water uses on the municipal meter included an employee restroom, a garden hose, drinking water fountain, residential-style washing machine. All ancillary water uses were accounted for in the water audit.

Car wash customers of BI1 had three options, including wash packages, The Works, Shine & Protect, and Super Shine, which used 55, 52, and 24 gpv respectively. Total fresh water consumed over the one-week period was 22,444 gallons to wash 513 vehicles for an average freshwater use of 43.8 gpv. The average freshwater use over the period of measurement was approximately 15% higher than weighted average of washes purchased during the audit. There were 40 nozzles located on the arch and spinning arms, and seven nozzles associated with the undercarriage wash. Different wash phase used different nozzle combinations; the phases included five different options that included a detergent or finish product, and a high-pressure rinse. The high-pressure rinse, at 30 gpv was the highest amount of water used in the wash and was utilized for The Works and the Shine & Protect Packages. The Super Shine package combined an application of clear coat protectant with the high-pressure rinse phase, for a measured use of 18 gpv. A weep system exists, but was not in use due to the time of year.

BI2: Car wash facility BI2 was an In-bay automatic with two bays attached to an oil change service. The BI2 facility car wash operates 24 hours a day, seven days a week. Oil service employees are on site, but not responsible for the operation and maintenance of the car wash facility. The facility is maintained by off site staff. The oil change service is open 8:00 am to 6:00 pm Monday through Saturday, with two to six employees per shift. The facility was constructed in 2000. The car wash equipment in one bay was purchased in 1998 and previously used at another site, the equipment in the second bay was new at the time of construction, or approximately one-year old at the time of the audit.

The BI2 facility is supplied fresh water from a municipal water supply. The carwash equipment includes a mobile arm with 18 nozzles mounted on a ceiling gantry. The machine moves above the vehicle, and all wash phases are applied through the same nozzles, with a brief period in which the arm drains of soaps or finish products between wash phases. An undercarriage wash system was located at the entrance to the bay. Fresh water for the car wash was supplied through a municipal meter. Other water uses on the municipal meter included a semi-public restroom, drinking water fountain, a slop sink. All ancillary water uses were accounted for in the water audit.

Car wash customers of BI2 had three options, including wash packages, VIP, Deluxe, and Super, which used 52.4, 37.5, and 24.9 gpv respectively. Total fresh water consumed in the car wash over an 18-day period was 105,301 gallons to wash 2,885 vehicles for an average freshwater use of 36.5 gpv. The average freshwater use over the period of measurement was approximately 4% lower than the weighted average of washes purchased during the period. There were 18 nozzles located on the arm, and 11 nozzles associated with the undercarriage wash. Different wash phases used all nozzles, and the arm was drained of excess product at the end of each application phase. The phases included four different options that included a detergent or finish product, and a high-pressure rinse. The Under Carriage Wash, at 12.6 gpv used the largest amount of water of any phase in the wash.

BI3: Car wash facility BI3 was an In-bay automatic with one bay attached to a service station and convenience store. The BI3 facility car wash operates 24 hours a day, seven days a week. Convenience store employees are on site, but not responsible for the operation and maintenance

of the car wash facility. The facility is maintained by off site staff. The service station and convenience store is open 24 hours a day, seven days a week. The facility was constructed in 1999. The equipment was new at the time of construction, or approximately two years old at the time of the audit.

The BI3 facility is supplied fresh water from a municipal water supply. The carwash equipment includes a mobile arm with 15 nozzles mounted on a ceiling gantry. The machine moves above the vehicle, and all wash phases are applied through the same nozzles, with a brief period in which the arm drains of soaps or finish products between wash phases. An undercarriage wash system was located at the entrance to the bay. Fresh water for the car wash was supplied through a municipal meter. Other water uses on the municipal meter included a garden hose. The convenience store and service station were on a separate meter.

Car wash customers of BI3 had three options, including wash packages, The Works, Deluxe, and Super, which used 60.2, 33.6, and 27.6 gpv respectively. Total fresh water consumed in the car wash over a one-week period was 41,417 gallons with an average freshwater use of 47.1 gpv. There were 15 nozzles located on the arm, and 11 nozzles associated with the undercarriage wash. Different wash phases used all nozzles, and the arm was drained of excess product at the end of each application phase. The phases included four different options that included a detergent or finish product, and a high-pressure rinse. The Clear Coat Protectant, applied at high pressure in The Works package, at 21.0 gpv used the largest amount of water of any phase in the wash.

BI4: Car wash facility BI4 was an In-bay automatic with one bay attached to a gasoline station, a donut shop and a convenience store. The BI4 facility car wash operates 24 hours a day, seven days a week. Gas station employees are on site, but not responsible for the operation and maintenance of the car wash facility. One or two employees per shift staff the gas station. The facility was constructed in 1988. The car wash equipment was approximately two years old at the time of the study.

The BI4 facility is supplied fresh water from a well. The water is re-used through an on-site closed loop reclaim system. The carwash equipment includes 40 nozzles placed on a moving arch with spinning arms, and an undercarriage wash system at the entrance to the bay.

A dedicated meter was placed upon the freshwater inflow to determine fresh water use in the car wash. All water uses at the donut shop, convenience store and service station were on a municipal meter. No other water uses other than the car wash were on the well.

Car wash customers of BI4 had three options, including wash packages, The Works, Shine & Protect, and Super Shine, which used 35.4, 28.0, and 23.6 gpv of freshwater respectively. Total fresh water consumed over the one-week period was 5,283 gallons to wash 170 vehicles for an average freshwater use of 31.1 gpv. The average freshwater use over the period of measurement was approximately 1% lower than weighted average of washes purchased during the audit. There were 40 nozzles located on the arch and spinning arms, and 17 nozzles associated with the undercarriage wash. Different wash phases used different nozzle combinations; the phases included five different options that included a detergent or finish product, and a high-pressure rinse. The clear coat protectant, at 23.5 gpv was the highest amount of water used in the wash for The Works and the Shine & Protect Packages. The Super Shine package clear coat protectant application was also the single largest water use, but at half the duration of the longer wash packages, it used 18 gpv. The car wash used RO for the spot free rinse, the product to waste ratio for the RO system was 6:1.

BS1: Car wash facility BS1 was a self-serve facility with eight bays. The BS1 facility car wash is open 24 hours a day, seven days a week. An attendant is on site from 10:00 am to 3:00 pm seven days a week. The facility was constructed in 1978. The BS1 facility is supplied fresh water from a municipal water supply through a municipal meter. Other water uses on the municipal meter included an employee restroom, and a garden hose. All ancillary water uses were accounted for in the water audit.

Car wash customers of BS1 had two options, use of a spray gun or a foam brush. The spray gun was measured at high and low pressure, which used 2.0, and 1.0 gpm respectively. The foam brush used 0.1 gpm. Total fresh water consumed in the car wash over a one-week period was 9,163 gallons to wash approximately 751 vehicles for an average freshwater use of 12.2 gpv. The facility offers a spot free rinse, which utilizes a DI system. A cold weather weep system was present at the site, but was not in use due to average daily temperatures at the time of the audit.

BS2: Car wash facility BS2 was a self-serve facility with five bays, and an attached conveyor.

Only the Self-serve facility was audited for this report. The BS1 facility car wash is open 24 hours a day, seven days a week. No one is specifically employed for the self-serve facility alone. However, an attendant is on site at the conveyor from 7:00 am to 6:00 pm seven days a week. The facility was constructed in 1986. The BS2 facility is supplied fresh water from a municipal water supply through a municipal meter. The Conveyor and the self-serve facilities have separate freshwater meters, but share the DI water used for spot free rinse. The process water from the DI system to the conveyor had a meter, and the difference between freshwater into the DI system and the amount going to the conveyor was determined to have been used in the self-serve facility.

Car wash customers of BS2 had two options, use of a spray gun or a foam brush. The spray gun was measured at high and low pressure, which used 3.5, and 1.0 gpm respectively. The foam brush used 0.4 gpm. Total fresh water consumed in the car wash over a four-day period was 3,130 gallons to wash approximately 198 vehicles for an average freshwater use of 15.8 gpv. A cold weather weep system which recycled water was present at the site, but was not in use due to average daily temperatures at the time of the audit.

BS3: Car wash facility BS3 was a self-serve facility with six bays, and an attached conveyor. Only the Self-serve facility was audited for this report. The BS3 facility car wash is open 24 hours a day, seven days a week. No one is specifically employed for the self-serve facility alone. However, an attendant is on site at the conveyor from 7:00 am to 6:00 pm seven days a week. The facility was constructed in 1985. The BS3 facility is supplied fresh water from a municipal water supply through a municipal meter. Other water uses on the municipal meter included an employee restroom, a slop sink, and a garden hose. All ancillary water uses were accounted for in the water audit.

Car wash customers of BS3 had two options, use of a spray gun or a foam brush. The spray gun was measured at high and low pressure, which used 3.8, and 1.5 gpm respectively. The foam brush used 1.3 gpm. Total fresh water consumed in the car wash over a 14-day period was 23,335 gallons to wash approximately 1,349 vehicles for an average freshwater use of 17.3 gpv. A cold weather weep system which recirculated water was present at the site, but was not in use due to average daily temperatures at the time of the audit.

BS4: Car wash facility BS4 was a self-serve facility with five bays, and an attached conveyor.

The conveyor facility was audited for this report and is listed above as BC2. The BS4 facility car wash is open 24 hours a day, seven days a week. No one is specifically employed for the self-serve facility alone. However, an attendant is on site at the conveyor 7:30 am to 7:00 pm Monday through Saturday, and 8:00 am to 6:00 pm Sunday. The facility was constructed in 1965. The BS4 facility is supplied fresh water from a municipal water supply through a municipal meter separate from the conveyor facility. Other water uses on the municipal meter at the self-serve included a garden hose. All ancillary water uses were accounted for in the water audit.

Car wash customers of BS4 had two options, use of a spray gun or a foam brush. The spray gun was measured at high and low pressure, which used 3.8, and 0.3 gpm respectively. The foam brush used 0.1 gpm. Total fresh water consumed in the car wash over a 14-day period was 9,897 gallons to wash approximately 655 vehicles for an average freshwater use of 15.1 gpv. A cold weather weep system which recirculated water was present at the site, but was not in use due to average daily temperatures at the time of the audit.

OC1: Car Wash OC1 was a full-service conveyor car wash with a tunnel 105 ft in length. The car wash operates from 8:00 am to 6:00 pm hours Monday though Saturday, and 10 am to 4 pm Sunday, weather permitting. The facility was constructed in the 1987 and car wash components have been upgraded and replaced as needed since. The same company owns and operates OC1 and OC2. Minor differences in equipment are noted, as is length of tunnel, and probably explain the differences in water uses between the two sites.

The OC1 facility is supplied fresh water from a municipal water supply through a municipal meter. Other water uses on the municipal meter included a residential-sized washing machine and carpet shampooers in the detail area, and one open-tub washing machine. Waste water is collected in a central trench drain and drains by gravity to a sedimentation tank, and from there to an oil/water separation tank. The facility has a reclaim system and draws water from reclaim tanks, which is filtered before being reused in the car wash.

Car wash customers of OC1 have several options, including wash packages (Ultimate Wash, Super Wash, Deluxe Wash, Full-Service Wash or Exterior Wash) or can purchase a Full-Service Wash or Exterior Wash package with add-on options such as clear coat sealant, undercarriage wash and various cleaning solutions and finish products. The conveyor uses magnetic sensors to

determine overall car length and timing of car wash arches and fixtures. The employees prepare cars for the tunnel with prep wash using handheld brushes and spray guns. Freshwater use volumes was measured at 10 gpv for all packages, and were measured at 47.7 gpv including reclaim water. The variability was not quantified for the use of hand prep spray gun, as this would change with each vehicle depending upon size of vehicle and perceived need for prep work. Total fresh water consumed over seven days was 60,132 gallons to wash 1,205 cars for an average water use of 49.9 gpv. The difference between the freshwater use as measured during the audit of components versus the seven day period of overall water use measurements suggest that either vehicle counts were significantly lower than reported, or perhaps that freshwater was used in some components that were reported as reclaim water.

The tunnel had 11 different wash elements including four different cloth equipment or "mitter" components. An undercarriage, a rocker panel & tire cleaner, three soap and finish products applications, along with a pre-rinse arch, and a final rinse made up the remaining components of the wash. The only components reported to use fresh water were the hand prep high-pressure spray, and 'wheel brite' applications and the final clear coat finishes. The final rinse, which reportedly used filtered reclaim water, was the highest single water-using component at 12.0 gpv.

OC2: Car Wash OC2 was a conveyor car wash with a tunnel 120 ft in length, convenience store, car detailer, and oil change and gasoline service station. The OC2 facility car wash operates from 7:00 am to 8:00 pm, Monday though Friday and 8:00 am to 8:00 pm on Saturdays and Sundays, weather permitting. The facility is staffed during with of 15 employees per day. The facility was constructed in 1989. The same company owns and operates OC1 and OC2. Minor differences in equipment are noted, as is length of tunnel, and probably explain the differences in water uses between the two sites.

The OC2 facility is supplied fresh water from a municipal water supply. Water for the car wash was supplied through a municipal meter. Other water uses on the municipal meter included an employee restroom, convenience store, car detailer, and oil change and gasoline service station. As part of this study a dedicated water meter was installed on the inflow to the car wash to measure all car wash water uses. Wastewater was collected in a central trench drain and drains by gravity to a sedimentation tank and from there to an oil/water separation tank. The facility has a reclaim system and draws water from reclaim tanks, which s filtered before being reused in the

car wash. Reclaim water was used in a number of the components.

Car wash customers of OC2 had several options, including wash packages (VIP Wash, Supreme Wash, Special Wash or Express Ultra Wash) or could purchase an Express Ultra Wash package with add-on options such as Brite Kote, Chassis Bath Underwash, Clear Coat Protectant, Diamond Glaze Foam & Shine. The conveyor uses magnetic sensors to determine overall car length and timing of car wash arches and fixtures. Freshwater use volumes ranged from at 11.5 to 13.2 gpv for the Express Ultra Wash and the VIP Wash respectively. Total water use including reclaim was measured from 60.3 gpv for the Express Ultra Wash to 64.6 gpv for the VIP Wash. The variability was not quantified for the use of hand prep spray gun, as this would change with each vehicle depending upon size of vehicle and perceived need for prep work. Total fresh water consumed over the week of metering was 50,850 gallons to wash 1,375 vehicles for an average freshwater use of 37.0 gpv.

The OC2 tunnel had 16 different wash elements including three different brush or "mitter" components. Nine different components apply detergents or finish products, three of which were optional applications, which could be selected by the customer. The remaining six components included three pressure rinse cycles, including one with a drying agent, a rocker panel & wheel cleaner, a chassis bath and a spot free rinse, with RO (Reverse Osmosis) water. The RO system produced a product to reject ratio of 3:1. The pre-soak arch was disabled during the study and pre-soak was accomplished by hand. The largest single water use of components measured was the high-pressure rinse, which used reclaim water at approximately 30 gpv in 35 seconds.

OC3: Car Wash OC3 was a full-service conveyor car wash with a tunnel 70 ft in length, convenience store, oil change and gasoline service station. The carwash facility is open 24 hours a day, seven days a week. The facility is maintained by off site staff. One or two employees per shift are present at the convenience store and gas station. The facility was constructed in 2001.

The OC3 facility is supplied fresh water from a municipal water supply. Wastewater is collected in a central trench drain an discharges to a reclaim tank system, with three compartments for sedimentation and have submerged discharge orifices to permit oil/water separation. Reclaim water is filtered prior to use. Fresh water for the car wash was supplied through a municipal meter. Other water uses on the municipal meter include the convenience store, oil change and

gasoline service station. A dedicated meter was installed upon the car wash portion of the facility to measure only water used in the wash.

Car wash customers of OC3 had a choice of three wash packages, Ultra Wash, Plus Wash, or Express Wash, which used 32.2, 31.1, and 17.3 gpv of freshwater respectively. The conveyor used magnetic sensors to determine overall car length and timing of car wash arches and fixtures. Reclaim water usage ranged from 34.1 gallons on the Express Wash to 43.3 gallons on the Ultra Wash. Total fresh water consumed over the ten-day metering period was 17,125 gallons to wash 1,139 vehicles for an average freshwater use of 15.9 gpv. The average freshwater use over the period of measurement was approximately 22% lower than the lowest amount of freshwater, including RO waste (20.5 gpv), which was measured during the site audit. A possible explanation could include a miscount of vehicles washed or that more of the wash phases use reclaim water than the site employees indicated

The tunnel had 12 different wash elements including five that used reclaim water. Of the total there were three different cloth equipment or "mitter" components. Six different components applied detergents or finish products, four of which were optional applications based upon the package selected by the customer, and one of which, the Under Body Wash, used reclaim water.

The spot free rinse used RO water. Reclaim water supplied the following five components: Mitter No 1 and No 2, Wrap Brush, Panel Brush, Under Body Wash.

The largest single water use of components measured in BC3 was Mitter No 1 that used 10 gpv of reclaim water. The largest freshwater uses measured were the Clear Coat sealer and the Foam Brite wash which both used approximately 9.8 gpv.

OI1: Car wash facility OI1 was an In-bay automatic with one bay attached to a convenience store and gasoline station. The OI1 facility car wash is open 24 hours a day, seven days a week. Employees of the gas station and convenience store are on site, but not responsible for the operation and maintenance of the car wash facility. The facility is maintained by off site staff. One or two employees per shift are present at the convenience store and gas station. The facility was constructed in 1997. The car wash equipment was new at the time of construction. The OI1 and OI2 facilities both use equipment from the same manufacturer and are managed by the same

company.

The OI1 facility is supplied fresh water from a municipal water supply. Fresh water for the car wash was supplied through a municipal meter. Wastewater is collected in a two trench drains at either end of the bay and discharges to a reclaim system tank. The reclaim/sedimentation tank is separated into compartments and has submerged discharge orifices to permit oil/water separation. Reclaim water is aerated by pumping across the floor of the wash bay. Other water uses on the municipal meter included the convenience store and gasoline station. A dedicated meter was installed upon the car wash portion of the facility to measure only water used in the wash.

The carwash equipment includes a mobile arm with 53 nozzles mounted on a ceiling gantry. The machine moves above the vehicle while the arm pivots, and all wash phases are applied from the moveable arm. Separate manifolds contain the rinse and soap application nozzles, which reduces resource usage. An undercarriage wash system was located at the entrance to the bay. The wash utilized an RO system for the spot free rinse phase. The RO product to brine ratio was 2:1.

Car wash customers of OI1 had three options, including wash packages, Works Wash, Deluxe, and Express Wash, which used 21.2, 16.1, and 11.0 gpv of freshwater respectively. Total fresh water consumed over the nine-day metering period was 11,253 gallons to wash 587 vehicles for an average freshwater use of 19.2 gpv. The average freshwater use over the period of measurement was approximately 6% lower than weighted average of washes purchased during the audit. There were 53 nozzles located on the pivot arm, and four of six operating nozzles associated with the undercarriage wash. Different wash phases used different nozzle combinations; the phases included five different options that included a detergent or finish product, and a high-pressure rinse phase, which used reclaim water. The Works package received an additional freshwater rinse. The high-pressure rinse, at 38.8 gpv was the largest amount of water per phase used in the wash.

OI2: Car wash facility OI2 was an In-bay automatic with one bay attached to a convenience store and gasoline station. The OI2 facility car wash is open 24 hours a day, seven days a week. Employees of the gas station and convenience store are on site, but not responsible for the operation and maintenance of the car wash facility. The facility is maintained by off site staff. One or two employees per shift are present at the convenience store and gas station. The facility

was constructed in 1999. The car wash equipment was new at the time of construction.

The OI2 facility is supplied fresh water from a municipal water supply. Fresh water for the car wash was supplied through a municipal meter. Wastewater is collected in ~~a~~ two trench drains at either end of the bay and discharges to a reclaim system tank. The reclaim/sedimentation tank is separated into compartments and has submerged discharge orifices to permit oil/water separation. Reclaim water is aerated by pumping across the floor of the wash bay. Other water uses on the municipal meter included the convenience store and gasoline station. A dedicated meter was installed upon the car wash portion of the facility to measure only water used in the wash.

The carwash equipment includes a mobile arm with 53 nozzles mounted on a ceiling gantry. The machine moves above the vehicle while the arm pivots, and all wash phases are applied from the moveable arm. Separate manifolds contain the rinse and soap application nozzles, which reduces resource usage. An undercarriage wash system was located at the entrance to the bay. The wash utilized an RO system for the spot free rinse phase. The RO product to brine ratio was 2:1.

Car wash customers of OI1 had three options, including wash packages, Works Wash, Deluxe, and Express Wash, which used 21.2, 16.1, and 11.0 gpv of freshwater respectively. The weighted average of freshwater use was 19.6 gpv. Reclaim water use ranged from 38.0 to 52.7 gpv for the Express to Works Washes respectively. Total fresh water consumed over the eight-day metering period was 19,799 gallons but an apparent failure of the vehicle count equipment prevented an accurate vehicle count. There were 53 nozzles located on the pivot arm, and six operating nozzles associated with the undercarriage wash. Different wash phases used different nozzle combinations; the phases included five different options that included a detergent or finish product, and a high-pressure rinse phase, which used reclaim water. The Works package received an additional freshwater rinse. The high-pressure rinse, at 38.0 gpv of Reclaim water, was the largest amount of water per phase used in the wash.

OI3: Car wash facility OI3 was an In-bay automatic with one bay attached to a service station and convenience store. The OI3 facility car wash operates 24 hours a day, seven days a week. Convenience store employees are on site, but not responsible for the operation and maintenance of the car wash facility. The facility is maintained by off site staff. The service station and

convenience store is open 24 hours a day, seven days a week. The facility appeared to be less than ten years old, but on-site personnel were unable to verify this information. The same manufacturer constructed the carwash equipment at sites OI3 and OI4.

The OI3 facility is supplied fresh water from a municipal water supply. The carwash equipment includes a mobile arm with 18 nozzles mounted on a ceiling gantry. The machine moves above the vehicle, and all wash phases are applied through the same nozzles, with a brief period in which the arm drains of soaps or finish products between wash phases. An undercarriage wash system was located at the entrance to the bay. Fresh water for the car wash was supplied through a municipal meter. Wastewater is collected in a rectangular drain in the center of the bay and discharges to a reclaim system tank. The reclaim/sedimentation tank is separated into compartments and has submerged discharge orifices to permit oil/water separation. Reclaim water is aerated by circulating the water from the reclaim system to the third compartment of the tank. Other fresh water uses on the municipal meter included the convenience store and gasoline station. A dedicated meter was installed upon the car wash portion of the facility to measure only water used in the wash. The wash utilized an RO system for the spot free rinse phase.
The RO product to brine ratio was 2:1.

Car wash customers of OI3 had three options, including wash packages, The Works, Deluxe, and Express, which used 26.9, 20.9, and 17.3 gpv respectively. Total fresh water consumed in the car wash over a one-week period was 4,211 gallons with an average freshwater use of 30.3 gpv. The use of Reclaim water ranged from 27.4 to 31.9 gpv for the Express to Works packages respectively. The average freshwater use over the period of measurement was approximately 28% higher than weighted average of washes purchased during the audit. One possible explanation for the discrepancy is a leak, and although no leak was noted, low evaporation and carryout percentages at this site (6.9%) suggest a leak directly into the discharge pit is possible.

There were 18 nozzles located on the arm, and 11 nozzles associated with the undercarriage and rocker panel wash. The undercarriage and rocker panel wash phase was only included in the Works package, and used reclaim water. Different wash phases used all nozzles in the arm, and the arm was drained of excess product at the end of each application phase. The phases included three different options that included a detergent or finish product, a high-pressure rinse and a spot free rinse. The high-pressure rinse, applied in the Express Package, at 20.1 gpv used the largest

amount of reclaim water of any phase in the wash. The high-pressure clear coat application used the most amount of water for any freshwater phase at 13.1 gpv; it was applied in the Works and Deluxe packages.

OI4: Car wash facility OI4 was an In-bay automatic with one bay attached to a service station and convenience store. The OI4 facility car wash operates 24 hours a day, seven days a week. Convenience store employees are on site, but not responsible for the operation and maintenance of the car wash facility. The facility is maintained by off site staff. The service station and convenience store is open 24 hours a day, seven days a week. The facility appeared to be less than ten years old, but on-site personnel were unable to verify this information.

The OI4 facility is supplied fresh water from a municipal water supply. The carwash equipment includes a mobile arm with 18 nozzles mounted on a ceiling gantry. The machine moves above the vehicle, and all wash phases are applied through the same nozzles, with a brief period in which the arm drains of soaps or finish products between wash phases. An undercarriage wash system was located at the entrance to the bay. Fresh water for the car wash was supplied through a municipal meter. Wastewater is collected in a rectangular drain in the center of the bay and discharges to a reclaim system tank. The reclaim/sedimentation tank is separated into compartments and has submerged discharge orifices to permit oil/water separation. Two other drainage trenches are present outside either end of the bay. Water that discharges to these trenches drains to the landscaped area immediately south of the facility. Other fresh water uses on the municipal meter included the convenience store and gasoline station. At the conclusion of the metering period estimated water uses from the convenience store were deducted from total water use.

Car wash customers of OI4 had three options, including wash packages, The Works, Deluxe, and Express, which used 35.1, 21.9, and 21.9 gpv respectively. The weighted average use for 269 car washes performed over the week of metering was 29.3 gpv. The use of Reclaim water ranged from 20.5 to 27.1 gpv for the Express to Works packages respectively. The average freshwater use over the period of measurement was approximately 33% higher than weighted average of washes purchased during the audit. Possible explanations for the discrepancy include a leak, although no leak was noted; incorrect information regarding water use in the attached store; or incorrect information regarding the use of the reclaim system. Evaporation and carryout

percentage at this site (17.7%) is within the expected range, so a leak is unlikely. The wash utilized an RO system for the spot free rinse phase. The RO product to brine ratio was 2:1.

There were 18 nozzles located on the arm, and 11 nozzles associated with the undercarriage and rocker panel wash. The undercarriage and rocker panel wash phase was only included in the Works package, and used reclaim water. Different wash phases used all nozzles in the arm, and the arm was drained of excess product at the end of each application phase. The phases included three different options that included a detergent or finish product, a high-pressure rinse and a spot free rinse. The high-pressure rinse, applied in The Express package, at 21.9 gpv used the largest amount of reclaim water of any phase in the wash. The high-pressure clear coat application used the most amount of water for any freshwater phase at 12.1 gpv; it was applied in the Works and Deluxe packages.

OS1: Car wash facility OS1 was a self-serve facility with six bays, and an attached In-bay automatic. Only the Self-serve facility was audited for this report. The OS3 facility car wash is open 24 hours a day, seven days a week. An attendant is periodically on site to perform maintenance, bay wash downs, money collection and customer service. The facility was constructed in 1989. The OS1 facility is supplied fresh water from a municipal water supply through a municipal meter. Other water uses on the municipal meter included a public restroom, a slop sink, a garden hose, a water softener, and a carpet shampooer, which is manually filled with approximately 5 gallons per week. All ancillary water uses were accounted for in the water audit. All Self-serve facilities included in this study in the Orlando area were owned and managed by the same company.

Car wash customers of OS1 had two options, use of a spray gun or a foam brush. The spray gun was measured at high and low pressure, which used 2.5, and 0.5 gpm respectively. The foam brush used 0.1 gpm. Total fresh water consumed in the car wash over an one week period was 6,827 gallons to wash approximately 384 vehicles for an average freshwater use of 17.8 gpv. The facility offers a spot free rinse, which utilizes a RO system. The product to reject ratio was 1:3.

OS2: Car wash facility OS2 was a self-serve facility with five bays, and an attached In-bay automatic. Only the Self-serve facility was audited for this report. The OS3 facility car wash is

open 24 hours a day, seven days a week. An attendant is periodically on site to perform maintenance, bay wash downs, money collection and customer service. The facility was constructed in 1989. The OS2 facility is supplied fresh water from a municipal water supply through a municipal meter. Other water uses on the municipal meter included an employee restroom, a slop sink, a garden hose, a water softener, and a carpet shampooer, which is manually filled with approximately 5 gallons per week. All ancillary water uses were accounted for in the water audit.

Car wash customers of OS2 had two options, use of a spray gun or a foam brush. The spray gun was measured at high and low pressure, which used 3.5, and 0.5 gpm respectively. The foam brush used 0.1 gpm. Total fresh water consumed in the car wash over an one week period was 4,410 gallons to wash approximately 245 vehicles for an average freshwater use of 18.0 gpv. The facility offers a spot free rinse, which utilizes a RO system. The product to reject ratio was 1:3.

OS3: Car wash facility OS3 was a self-serve facility with six bays, and an attached In-bay automatic. Only the Self-serve facility was audited for this report. The OS3 facility car wash is open 24 hours a day, seven days a week. An attendant is periodically on site to perform maintenance, bay wash downs, money collection and customer service. The facility was constructed in 1989. The OS3 facility is supplied fresh water from a municipal water supply through a municipal meter. Other water uses on the municipal meter included an employee restroom, a slop sink, a garden hose, a water softener, and a carpet shampooer, which is manually filled with approximately 5 gallons per week. All ancillary water uses were accounted for in the water audit.

Car wash customers of OS3 had two options, use of a spray gun or a foam brush. The spray gun was measured at high and low pressure, which used 3.3, and 0.3 gpm respectively. The foam brush used 0.1 gpm. Total fresh water consumed in the car wash over a one-week period was 3,955 gallons to wash approximately 275 vehicles for an average freshwater use of 14.4 gpv. The facility offers a spot free rinse, which utilizes a RO system. The product to reject ratio was 3:1. Due to nightly blockage of the effluent meter with landscaping material, evaporation and carryout values are not available from this site.

OS4: Car wash facility OS4 was a self-serve facility with five bays, and an attached In-bay automatic. Only the Self-service facility was audited for this report. The OS4 facility car wash is open 24 hours a day, seven days a week. An attendant is periodically on site to perform maintenance, bay wash downs, money collection and customer service. The facility was constructed in 1990. The OS4 facility is supplied fresh water from a municipal water supply through a municipal meter. Other water uses on the municipal meter included an employee restroom, a slop sink, a garden hose, a water softener, and a carpet shampooer, which is manually filled with approximately 5 gallons per week. All ancillary water uses were accounted for in the water audit.

Car wash customers of OS4 had two options, use of a spray gun or a foam brush. The spray gun was measured at high and low pressure, which used 2.0, and 0.5 gpm respectively. The foam brush used 0.2 gpm. Total fresh water consumed in the car wash over a one-week period was 7,195 gallons to wash approximately 416 vehicles for an average freshwater use of 17.3 gpv. The facility offers a spot free rinse, which utilizes a RO system. The product to reject ratio was 1.3:3.

PC1: Site PC1 was a conveyor that employed approximately 17 people on weekdays and 29 people on weekends. The facility had minimal non-car wash related water uses, including a soda fountain, two water fountains, restroom facilities for employees and customers, a garden hose, and a three bay oil and lubrication shop. All ancillary uses were accounted for in the audit.

The PC1 Facility was supplied freshwater from a municipal water supply. It had a reclaim system. Reclaim water was pumped from the final compartment of the oil/water separation tank and used in the prep arch.

Total fresh water consumed over the week of metering was 58,422 gallons to wash 2,471 vehicles for an average freshwater use of 28.4 gpv. An additional 16.7 gpv reclaim water was used in the prep arch.

PC2: Site PC2 was a conveyor that employed approximately 20 people on weekdays and 25 people on weekends. The facility had minimal non-car wash related water uses, including two water fountains, restroom facilities for employees and customers, a garden hose, and a small evaporative misting system. All ancillary uses were accounted for in the audit.

The PC2 Facility was supplied freshwater from a municipal water supply. It had plumbing for a reclaim system that was not in use. Total fresh water consumed over the week of metering was 77,105 gallons to wash 1,211 vehicles for an average freshwater use of 63.7 gpv.

PC3: Site PC3 was a conveyor that employed approximately 17 people on weekdays and 21 people on weekends. The facility had minimal non-car wash related water uses, including a soda fountain, two water fountains, restroom facilities for employees and customers, a garden hose, and a small evaporative misting system and a three bay oil and lubrication shop. All ancillary uses were accounted for in the audit.

The PC3 Facility was supplied freshwater from a municipal water supply. It had plumbing for a reclaim system that was not in use. Total fresh water consumed over the week of metering was 87,108 gallons to wash 2,317 vehicles for an average freshwater use of 39.3 gpv.

PI1: Site PI1 consists of one in-bay automatic and five self-service wash bays. The Self Serve bays are reported separately as PS1. During the one-week observation period, the in-bay automatic washed 178 vehicles. No employees are located on-site, although one person is employed throughout the week for site cleaning. The facility has minimal associated uses including a water vending machine and water fountain, which are open to the public. A restroom and sink are located in the maintenance building, which is open only to maintenance staff.

Two oil and grease separators are located on the site; one for the in-bay automatic, and one for the self serve wash bays. The In-bay facility had five cycles with two wash cycles, a finish cycle and two rinse cycles. The high-pressure rinse used the largest amount of water of any cycle at 70.4 gpv. The spot free rinse cycle used an RO system with a 3:3.5 ratio of brine to product water. The total freshwater use per vehicle was 111.5 gpv.

PI2: Site PI2 was similar to Site PI1 with both an in-bay automatic and multiple self-service wash bays. However, the in-bay automatic was the only car-washing feature studied at this site. The in-bay automatic washed 190 vehicles during the week of metering.

The car wash is attended by the owner during the day and is left unattended during the night. No

other persons are employed at this site. This site has no water uses for customer service or convenience. However, for the purposes of this report the self-service wash bay consumption was treated as an ancillary use. Two oil and grease interceptors are located on the site, one for the in-bay automatic and one for the self serve wash bays.

Eight different cycles applied water in PI2 of which four included detergents or cleaning products, one included a finish product, and three were rinse cycles. The final rinse cycle was a spot free rinse using RO with a 2:1 reject to product ratio. The high-pressure rinse cycle used the highest amount of water at 25.8 gpv, and total water use was 74.1 gpv.

PI3: Site PI3 was an in-bay automatic car wash attached to a gas station and convenience store. The in-bay automatic equipment washed 558 vehicles washed during the week of metering.

The in-bay automatic is an unattended portion of the facility located directly behind the convenience store. Two cashiers are on duty 24 hours a day in the convenience store and an additional two people are on duty between 7:00 a.m. and 7:00 p.m. in a small kitchen area. This site has an array of associated uses including convenience store (fast food restaurant, drink machines), public restrooms, and landscape irrigation. An overall audit of the water uses at this site indicates approximately 45% of the total site consumption was attributable to the associated uses.

The car wash portion of the site consists of a single in-bay automatic. Water reclamation is in operation at this site. Water is drawn from the last compartment of the interceptor and pumped back into the system for use in the high-pressure rinse cycles. Five of the wash cycles used fresh water of which two cycles included detergents or cleaning products, and one cycle included a finish product. The spot free rinse was an RO system with a 2:1 brine to product ratio, and used the largest amount of freshwater per vehicle at 16.5gpv. The average freshwater use per vehicle was 28.9gpv. Reclaim provided approximately 63 gpv, or 69 percent of water used.

PS1: Site PS1 consists of one in-bay automatic and five self-serve wash bays. The In Bay is reported separately as PI1. Customers were able to use a spray wand or foam brush in each of the bays. No employees are located on-site, although one person is employed throughout the week for site cleaning. The facility has minimal associated uses including a water vending machine

and water fountain, which are open to the public. A restroom and sink are located in the maintenance building, which is open only to maintenance staff.

During the one-week monitoring period the total number of vehicles washed in the self-serve wash bays at PS1 was 934. The estimated water use was 12.1 gpv.

PS2: Site PS2 consists of four self serve bays equipped with spray wands and foam brushes operated by the adjacent automotive shop, although a separate water meter supplies water to the car wash The number of vehicles washed during this week was 1008. The self serve wash is itself an unstaffed facility, although two people are employed throughout the week by the automotive shop for site cleaning at both facilities. This site has no associated uses for customer service or convenience. These facilities are all located in the adjacent automotive shop waiting room, which is on a separate meter. A single oil and grease interceptor is located on-site. The estimated water use was 12.8 gpv.

PS3: Site PS3 consists of five self serve bays equipped with spray wands and foam brushes. The number of vehicles washed during the week of metering was 658. The self-service wash is an unattended facility. One person is employed throughout the week for site maintenance and cleaning. This site has no associated uses for customer service or convenience. A single oil and grease interceptor is located on-site. The estimated water use was 12.0 gpv.

RESULTS AND DISCUSSION

The results of the three-region study show clear differences with respect to the amount of water consumed per vehicle, and the water lost to evaporation and carryout by car wash type. Table 2 shows average values for freshwater consumption and evaporation and carryout for the three types of professional car washes. The results and discussion begin with a comparison of water consumption and evaporation and carryout losses by car wash type. Regional comparisons and then differences within each region were also examined. A discussion of the water savings obtained by those car washes, which installed reclaim systems, follows along with the potential for additional water conservation and financial benefits.

Consumption

In all three regions the in-bay automatic car washes consumed more fresh water per average car wash at 43.3 gallons per vehicle (gpv). Phoenix showed the highest water use per vehicle wash in all categories except for self-serve. In part, that was due to the lack of car washes with reclaim systems in the Phoenix sample. The water savings and overall water use by carwashes with reclaim systems will be discussed in a subsequent section. One of the Phoenix sites, PI1, had unusually high water use per vehicle at 111.5 gpv. No visible leaks were found, and the owner/operator had made modifications to the car wash design that probably increased the gpv of the site. Orlando's low gpv average is 47.9 gpv below Phoenix and was likely the result of all of the Orlando In-Bay sites using reclaim.

TABLE 1.2
AVERAGE FRESH WATER CONSUMPTION AND LOSS BY CAR WASH TYPE

	Gallons per Vehicle			Evaporation & Carryout (%)		
	O	**B**	**P**	**O**	**B**	**P**
Self-Serve	16.0	15.2	12.3	22.9	33.2	19.8
In-Bay	24.6	40.0	72.5	29.8	28.6	32.8
Conveyor	34.3	26.7	43.8	15.1	16.1	16.7
O = Orlando; B = Boston; P = Phoenix						

Average values for fresh water consumption across all car wash types in Boston and Orlando

were 27.2 ± 12 gpv and 24.5 ± 11 gpv respectively. While average water consumption for the nine sites appears significantly higher in Phoenix at 42.5 ± 32 gpv. The greater variability in the water consumption found in Phoenix sites provided overlap in the water use data and prevented statistical separation of the three regions (n = 32, p =0.19). Evaporation and Carryout values were more closely clustered with the range of 25.3 ± 17 percent in Boston to 23.1 ± 14 percent in Phoenix (n=29, p = 0.95). Orlando sites averaged 23.3 ± 22 percent evaporation and carryout losses. Regional climate differences did not appear to be a principle factor in water use or loss in this study.

It is worth noting the large variation in the sample, represented by the standard deviations in the samples that were calculated. It may be that increasing sample sizes will increase the statistical confidence in the mean values reported for each of the car wash types and locations. However, since car wash equipment varies by manufacturer, maintenance schedules and operator preferences, the observed variation may continue to be quite high.

Type of car wash equipment used was the most significant factor in differences in water consumption analyzed for this report. Self-serves were the lowest fresh water users at 15.0 ± 3 gpv, while In Bay automatics used the greatest amount of fresh water at 42.9 ± 26 gpv. Conveyors were closer to the In-Bay automatics at 34.0 ± 15 gpv. The probability of these differences being random was less than one percent.

The customer can purchase most In-Bay automatic washes without leaving their vehicle. The customer chooses their wash option and pays. The equipment is provided by the manufacturer and is designed to run optimally at certain speeds and pressure settings. The owner/operator may make adjustments to water pressure, and nozzle size, but of the three types, changes that affect water consumption rates are most constrained by the equipment design.

Conveyor car washes give owner/operators greater flexibility in choosing the pressure settings and nozzles sizes for each cycle of the car wash. The speed at which the conveyor moves cars through the tunnel can also be adjusted. Minor adjustments may lead to large changes in water consumption per individual wash. Water use by arches or fixtures with spray nozzles may be adjusted by changing nozzle sizes or adjusting pressures. Cloth equipment, or “mitters” need less water once they are completely wet and the car wash has been running for a period of time. These

cloth features within conveyor carwashes are among the lowest water using cycles of the conveyor car washes. In some of the sites nozzles designed to wet the brushes were left off, and the water on the car was allowed to wet the cloth equipment or mitter. Car wash personnel performed prep work with handheld spray wands and/or brushes in 9 of the 10 conveyors evaluated. This also contributed to variability of water use per vehicle in the conveyor car washes.

The self-service operations were the lowest with 15.0 gpv average. The lower gpv average for Self-serves in Phoenix was likely the result of using automatic traffic counters rather than timing actual washes. Automatic traffic counters tally every vehicle that drives over them regardless of whether the vehicle is washed. Since self-service PLCs count minutes of wash time rather than number of washes, the higher vehicle counts resulted in lower gpv totals. As mentioned in the methodology section, the visual observation of vehicles driving through bays in the Boston area without purchasing wash time led to the use of visual surveys to determine average time spent per wash. Over a 5.25 hour period, 97 cars were observed being washed for approximately 7.25 ± 0.8 minutes. The total minutes of wash time was then divided by the average time per wash to produce the number of cars washed for Boston and Orlando sites. Gallons per vehicle averages were calculated by comparing total metered fresh water use to total time elapsed on the PLC during the metering period and multiplying the result by the average wash time (metered fresh water/time x 7.25 minutes/wash = freshwater use per wash).

Previous studies, based upon manufacturers estimates, have suggested that conveyor car washes will have higher average water use than this study found.[4] The kinds of adjustments in water use described in the sites studied probably explains the somewhat lower than expected water consumption rates. Despite being lower than expected, the Boxplot on page 43 shows that the previous estimates, while high, still fall within the boundary of valid estimates for conveyor water use.

Evaporation & Carryout

Unlike water use, evaporation and carryout did not vary significantly by type of car wash

[4] Brown, C., Water Conservation in the Professional Car Wash Industry, International Carwash Association, 2000.

evaluated (n=30, p=0.18). Total evaporation across all locations was 17.6 ± 5% for Conveyors, 30.2 ± 24% for In-Bays, and 25.3 ± 14% for Self-serves. While the separation in values was not statistically significant, the apparent gap between conveyor car washes, measured 12% and 8% below In-bays and Self-serves respectively, and the other two car wash types may be explained by the use of towel drying in conveyor car washes. In those conveyor car washes that offer towel drying, a greater percentage of water may be captured and returned to the sanitary sewer since wet towels are washed and wrung dry before being returned to use. All wash water from the towel washing machines is discharged through the wastewater separation tanks and to the sanitary sewer. The length of the tunnel is also a factor and if sufficient space is allowed between the end of the last water use and the end of the tunnel this will reduce the amount of windblown water that is lost as mist.

It is clear from the Boxplot on page 41 that the variation in the values found in In-bays and Self serves was not found in the Conveyors. The fact that average and median values are tightly grouped suggests that the true value of Evaporation and Carryout losses for professional car washes should lie close to 20%. Graphs on pages 44 to 46 show the relative use of freshwater and discharge normalized to one week based upon the study in the three regions.

Another factor affecting evaporation and carryout is the use of blowers to dry the vehicle at the end of the rinse cycle. Differences between equipment type, power, orientation and number apertures could help explain some of the variation in the evaporation and carryout values. Drying equipment was not evaluated as part of this study. It was visually noted, however, that blow dryers inside In-Bays were installed at the end of the bays next to the exit, while some conveyors had a stretch of tunnel beyond the dryer, in which windblown water could be captured and returned to the car wash tanks. In-Bays offer drying as an optional service, which also increases the variability of the sample, since customer choice results in the use or lack thereof the equipment.

Two of the eleven self-serve sites (OS3 and BS4) were not able to complete the effluent metering to the sewage system due to repeated blockages of the meters with debris. The meter failures here point out an ongoing problem that self-serve operators acknowledge. When the facility is open 24

hours a day without staff present, anything washed off in the bay, for example; engine components, trailers filled with landscaping material, or mud off vehicles, can become entrained in the effluent from the wash bay. In both cases, materials such as plastic bottle caps, sticks or wood chips were found suspended in the waste stream, and fouling the effluent meters.

Reclaim and Conservation Eleven sites studied had some form of reclaim system**.** Reclaim was used in different cycles in the different car washes, thus increasing the variability of the sample. Reclaim as a percentage of total water used in the wash ranged from 82.2 percent at site OI1 to 9 percent at site BC2. Site BC2, however, only used reclaim water in one of its wash phases, the least aggressive of the approaches found. Most of the sites which had reclaim used the reclaim water in three to five of the wash phases, the greater number of those being in the conveyors.

Table 1.3 shows average freshwater use per wash, total gallons of water used in maximum wash including reclaim water, and ranges of percent reclaim use across wash options. Average freshwater use for all sites using reclaim was 28.4 gpv, which represented 49.4 percent of the water used. The range of reclaim as a percent recognizes that choices in optional wash packages can increase or decrease the ratio of freshwater to reclaim used by a carwash. In those car washes with Reclaim systems, the audit identified flow rates and durations for all cycles using reclaim water as well as those utilizing freshwater. Those sites which had the highest percentage of reclaim used the reclaim water in more phases, and in high-pressure wash phases, indicating a greater level of filtration. There was no significant difference in evaporation and carryout between sites that had reclaim systems and those that did not.

TABLE 1.3
RECLAIM SYSTEMS CONTRIBUTION TO WATER USE EFFICIENCY
AT NINE SITES IN BOSTON AND ORLANDO

SITE	AVG GPV FRESHWATER	TOTAL WITH RECLAIM (GPV)	MIN RECLAIM RANGE	MAX RECLAIM RANGE
BC2	34.0	37.4	9%	10%
BC3	16.3	34.8	53%	69%
BC4	26.3	42.4	38%	46%
BI4	31.1	66.5	44%	53%
OC2	37	54.9	33%	62%
OC3	15.9	78.7	55%	74%
OI1	19.2	77.5	69%	82%
OI2	19.6	74.1	67%	71%
OI3	30.3	58.8	54%	61%
OI4	54.7	62.2	12%	44%
PI1	28.3	45.0	37%	63%

For the sites that did not have a reclaim system, potential water savings and cost/benefits of a reclaim system were analyzed. The type of reclaim system analyzed was based upon an actual system on the market in the Boston area. Equipment costs were estimated at $15,000 and installation costs were estimated at $20,000, which includes an underground holding tank and associated piping. The assumed life expectancy of the system was 10 years, and the capital costs were calculated over that time period financed at eight percent interest. The water savings estimates used in the cost/benefit analysis for each site were based configuration of each site, and the appropriateness of use of reclaim water. Water use data and associated costs were obtained from actual water use records for the facility.

Self-serve sites did not appear to be cost effective candidates for reclaim systems. High capital costs and lower potential water savings due to the initially low water consumption per vehicle resulted in negative return on investment. In-bay sites also did not appear to benefit as much as conveyor sites, with average lower annual water costs due to lower usage. Water utilities may decide that lower water usage represented by car washes using reclaim systems are worth providing economic incentives to promote the installation of reclaim systems. The economic value of a reclaim system will depend upon site-specific data including the price of water and the total water usage of the site. As the charts in the appendix show, overall usage varied widely among the car wash facilities that were studied. The cities of Seattle, Washington, and San Antonio, Texas have provided economic incentives to car washes willing to install reclaim systems in order for the city as a whole to benefit from reduced demand.

Specific conservation measures were also examined as part of the study. Again, the relatively low water usage of self-serve facilities resulted in suggestions for reducing the size of nozzles, with minor but measurable savings as a result. In-bay automatics had the highest water use in high-pressure phases indicating that pressure management may be a productive means of reducing water use with minor adjustment to the system. In-bay automatics also showed a consistent tendency to continue moving the spray arm or arch beyond the end of the compact vehicles. Adjusting equipment to measure the actual length of the vehicle being washed could result in significant savings. In some of the In-bay designs, where the same set of nozzles are used for wash, finish and rinse phases, more careful adjustment of the timing of phases and the depressurization/draining of the arm could also produce measurable savings. The multiple manifolds used in the carwash equipment in OI1 and OI2 allowed for water with soap or finish products to stay in the manifold from vehicle car wash to the next, thus saving resources.

The conveyors included in the study showed significant savings by use of lowered pressure settings on high pressure phase, and by shutting off some of the arches or nozzles within the tunnel. Additional savings could be realized by the use of positive shut-off valves in the arches, resulting in water staying in the arch when the equipment is de-pressurized between washes.

CONCLUSIONS:

This study brought to light a number of facts about the professional car wash industry, water use and losses to evaporation and carryout through the use of field data. Previous studies have cited manufacturers estimates and anecdotal evidence for water use by car wash equipment. This study is the first multi-regional study based completely upon field data. As expected, field data showed variation, but confirmed that the manufacturers' estimates cited in earlier studies were within the bound of values found in the field.

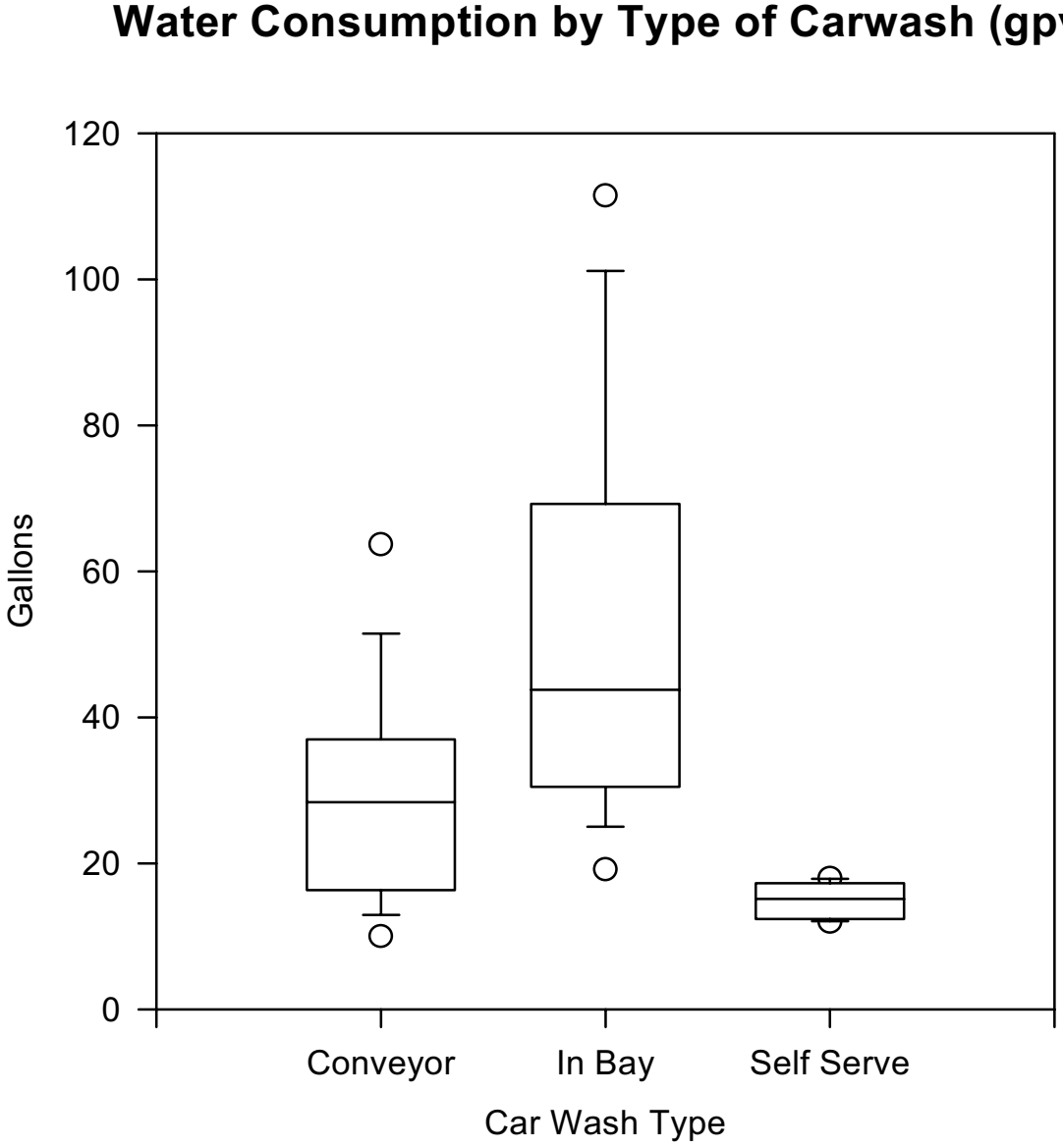
Audit techniques which focus on water consumption by individual cars washed appeared to provide more reliable information than those focused on water consumption over a period of time or water consumption by individual components within the wash. The design of some In-Bay and Conveyor equipment with spray nozzles mounted on rapidly moving arms made the collection of data on individual components difficult if not impossible in several circumstances.

Regional differences in water consumption do not appear significant based upon climate. This indicates that the water losses due to carryout appear to be a greater part of the total losses due to evaporation and carryout.

Evaporation and carryout combined appeared to be consistent across regional boundaries and differences and the mean value of the total sample was 24.0 ± 17.4%. Larger sample sizes may provide for statistical separation in water use by region, but the significant variability in the sample also indicates that individual difference in car wash equipment design, operation and maintenance are likely to be more important than differences in climate.

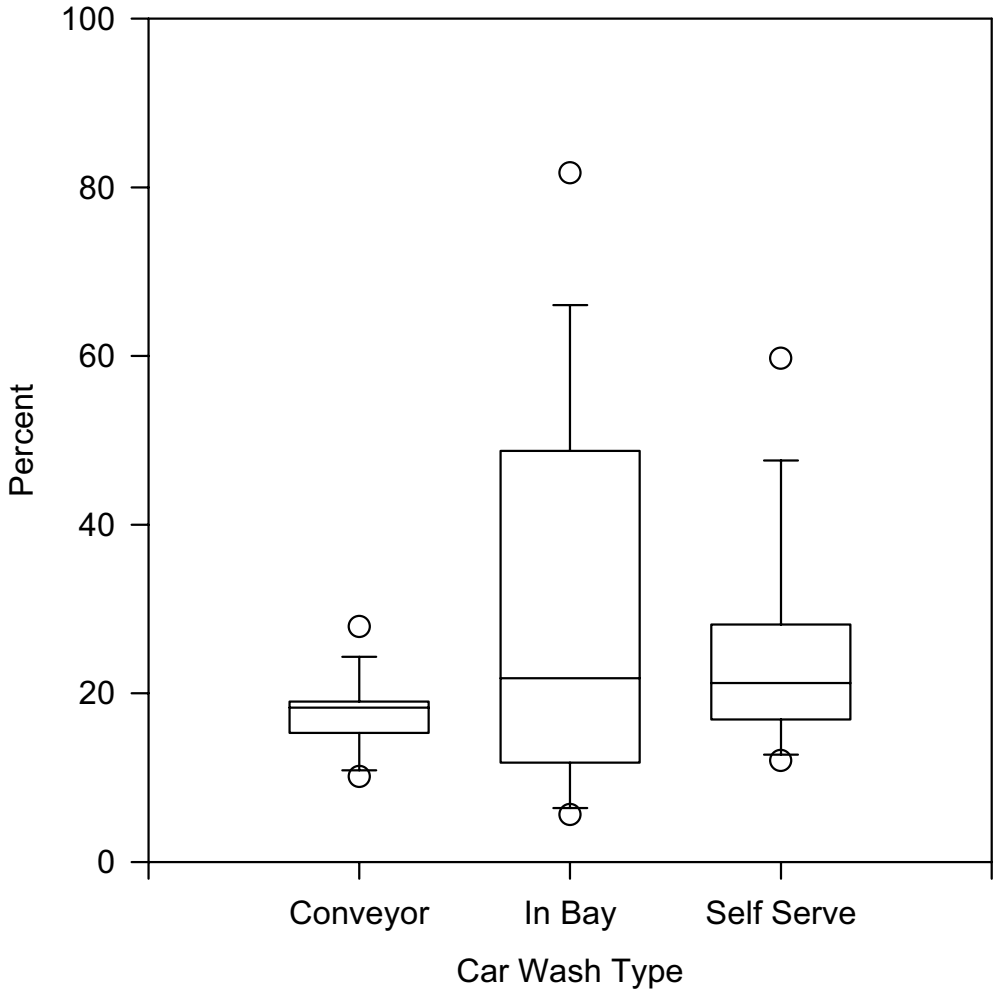
Water conservation can be promoted by encouraging the use of reclaim and by educating owner/operators to the savings that can be obtained through adjustment and maintenance of equipment. Incentive programs by local utilities facing longer term water shortages may help car wash operators make the investment in reclaim equipment. Recognition of water conserving car washes through certification program like those in Austin and San Antonio, Texas and the newly framed statewide program in Florida, can help water planning agencies and utilities to gain year-round savings in partnership with professional car wash operators.

The temporary measurement of wastewater flows from a professional car wash is hampered by the traditional plumbing design of the sewer outfall. Non-intrusive meters such as ultrasonic meters or magnetic meters are commonly used in the water industry to measure flows with entrained materials are large amounts of particulates. These types of meters require a stretch of unbroken pipe to which the meter can be attached. Most sewer outfall pipe at car washes is buried under asphalt or concrete, under the floor of the bays or the parking lot. Future design of car washes should consider leaving a stretch of outfall pipe with access through a meter box sufficiently large enough to install temporary non-invasive metering equipment. This would ease the job of a car wash owner/operator wishing to demonstrate the water losses at their facility from evaporation and carryout.



The Boxplots of water consumption data shown above show the center point of each data set, as the midline represents. The relative variability of the data can be seen by the size of the box which shows the most reasonable range of acceptable estimates for the true mean value. The outer fences show the furthest data points from the center, which could still be considered reasonable estimates of values. The circles represent outliers, which suggests that values lower than 15 gpv or higher than 60 gpv are not reasonable to expect in conveyor car washes, and values of less than 20 gpv or higher than 102 gpv are not reasonable in In-bays. The self-service data was so tightly bunched around the 15 gpv mean that it has neither fences nor outliers in the dataset.

Evaporation and Carryout by Carwash Type (%)



This Boxplot shows the mid points and variation in evaporation and carryout data. As mentioned earlier the median values of all three types of car washes are very similar. There was greater variation in the In-Bay and Self-serve datasets, than in the conveyors. The data suggests that values above 80% for In-Bays and 60% for Self serves are outliers. Reasonable estimates fall below 50% and above 15 % for in-bays, with reasonable estimates being much more closely grouped around 20 to 25% for conveyors and Self-serves. The lower circles on the plots for all three wash types and the upper circle on the conveyor are probably not outliers since they are so close to median values.