EVALUATION OF MANAGEMENT ALTERNATIVES FOR TRUCK WASH
WATER GENERATED DURING WINTER MAINTENANCE ACTIVITIES

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EVALUATION OF MANAGEMENT ALTERNATIVES FOR TRUCK WASH
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ABSTRACT

As part of routine winter maintenance activities, salt trucks are washed frequently at the Ohio Department of Transportation's (ODOT) 88 county and 136 outpost garages during the winter months. In locations where sanitary sewer is available, truck wash water is treated with an oil/water separator and discharged directly to the sanitary sewer system. However, at facilities that do not have access to sanitary sewer, truck wash water must be collected and managed, often at a significant cost. The current ODOT policy for truck wash water management, tying these facilities into the sanitary sewer system, has a high capital cost, and is not always possible.

The purpose of this research was to identify alternative strategies for managing wash water generated during routine washing of salt trucks at ODOT maintenance facilities lacking access to sanitary sewer, assess their costs, and compare the cost of alternative management strategies with the cost of tying into the sanitary sewer system. Six viable wash water management strategies were identified and the annualized costs of each option were calculated for individual maintenance facilities. The cost analysis indicated that site specific conditions, including the volume of wash water generated, the distance to the potential disposal locations, and the capital cost of tying into the sanitary sewer, directly impact the cost effectiveness of alternative management strategies. Under the conditions of the cost analysis, pursuing off-site disposal, rather than tying into the sanitary sewer, could yield an annual cost savings of approximately \$1.1 million across ODOT's 12 county and 66 outpost garages lacking access to sanitary sewer. The analysis

also showed that, for a typical county garage with 12 trucks and 30 winter events, when the capital cost of tying into the sanitary sewer is greater than \$300,000, four of the five management alternatives identified are more cost effective than tying into the sanitary sewer.

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LIST OF ACRONYMS

ATRI—American Transportation Research Institute

DNR—Department of Natural Resources

DOT—Department of Transportation

EPA—Environmental Protection Agency

FHWA—Federal Highway Maintenance Administration

GAC—Granular Activated Carbon

INDOT—Indiana Department of Transportation

MBAS—Methylene Blue Active Substance

NPDES—National Pollutant Discharge Elimination System

ODOT—Ohio Department of Transportation

PennDOT—Pennsylvania Department of Transportation

POTW—Publicly Owned Treatment Works

ppm—parts per million

RO—Reverse Osmosis

SHA—State Highway Administration

TMS—Transportation Management System

TSS—Total Suspended Solids

UF--Ultrafiltration

USEPA—United States Environmental Protection Agency

UST—Underground Storage Tank

VTRC—Virginia Transportation Research Council

WWTP—Waste Water Treatment Plant

CHAPTER I

INTRODUCTION

1.1 Background

According to the Federal Highway Maintenance Administration (FHWA), \$2.3 billion are spent by states annually for snow and ice removal (USDOT FHWA, 2012). In Ohio, approximately \$50 million are spent on snow and ice removal annually, accounting for almost half of the annual operating budget. An average of 600,000 tons of salt are used to maintain Ohio's 43,000 lane miles each year (ODOT, 2011). Due to the corrosive nature of sodium chloride, salt trucks are washed frequently at Ohio Department of Transportation's (ODOT) 88 county and 136 outpost garages during the winter months (Figure 1-1). Waste water generated during routine truck washing has elevated concentrations of suspended solids, dissolved solids, oil and grease, and heavy metals (Alleman, et al., 2004, VTRC, 2004, Miller, et al., 2012). In locations where sanitary sewer is available, truck wash water is treated with an oil/water separator and discharged directly. However, at facilities that do not have access to sanitary sewer, truck wash water must be collected and managed, often at significant cost to the DOT.

Figure 1-1: Locations of ODOT maintenance facilities and Districts

Previous research has focused on reusing truck wash water for the production of brine because of the potential savings resulting from reduced material and disposal costs (Alleman, et al., 2004, VTRC, 2008). In Ohio, it is unlikely that direct reuse of wash water would be a viable option, because heavy metals concentrations in the water exceed the allowable levels for application on Ohio's roadways (Miller, et al., 2012).

Alternative, cost effective strategies for managing truck wash water are needed. The selection of an optimal management strategy depends on site specific factors including the number of trucks, the number of winter events, and the proximity of a facility to a disposal location.

1.2 Objectives and Goals of the Study

The goal of this research project was to identify cost effective, environmentally friendly management strategies for truck wash water generated at ODOT maintenance facilities. To meet this goal, the following four project objectives were developed:

- Objective 1: Identify a range of viable management options;
- Objective 2: Determine the factors that influence their cost;
- Objective 3: Develop a preliminary process for calculating annualized costs for each management option using site specific garage information; and
- Objective 4: Evaluate the annualized costs for each alternative management option at ODOT maintenance facilities and assess the influence of site specific conditions on the overall cost.

1.3 Overview of Approach

To identify viable management strategies that could be easily implemented at ODOT maintenance facilities, the current state of the practice of truck wash water management within state DOTs outside of Ohio was evaluated using a combination of literature review and telephone interviews, with the majority of interviewees from the Midwest. The interview questions specifically addressed:

- Their current day-to-day operations,
- Specific environmental and maintenance challenges,
- What environmental strategies have they incorporated in the past,
- Operating budget,

- What applications do they use their salt brine for, and
- Long-term objectives.

The main goal from the national interview of state DOTs was to learn from their successes and failures.

In addition to evaluating current practices for wash water management within other state DOT, the current practices within the Ohio DOT were assessed using a combination of an email survey, telephone interviews with the Facilities Managers in each of ODOT's 12 districts, and site visits. The email survey was designed to collect information that could be used to estimate the volume of wash water generated at individual garages as well as to determine how wash water is currently managed at ODOT maintenance facilities and current management costs. The information collected in the survey was verified using telephone interviews and site visits.

A list of potential management strategies was developed based on the results of interviews with other state DOT, ODOT personnel, and the literature review. This list was narrowed using feedback from DOT personnel, the results of wash water volume estimation, and the results of truck wash water quality monitoring conducted during the winter of 2011.

After identifying a range of viable management strategies, the factors influencing the cost of each strategy were determined and a process for calculating their values was developed. These cost factors were then used to calculate the annualized cost of each management strategy for a typical county garage and a typical outpost garage. The impact of site specific factors on the cost of wash water management were assessed, and

the cost effectiveness of ODOT's preferred wash water management strategy, tying into sanitary sewer, was evaluated.

CHAPTER II

LITERATURE REVIEW

Several approaches for the management of truck wash water have been previously identified (Alleman, et al., 2004, VTRC, 2004, 2006, 2008).

Because disposal in the sanitary sewer after treatment with an oil/water separator is an efficient means of managing truck wash water, it is the management option of choice for many state DOT. This option is not always available in rural locations, and the capital cost, which depends on the distance to a point of access to the sanitary sewer, is high. However, this management option minimizes annual operating costs for truck wash water management and alleviates the need for ongoing collection, storage, and disposal of truck wash water.

Another potential option for managing truck wash water is to obtain a National Pollutant Discharge Elimination System (NPDES) permit for direct discharge of treated waste water (VTRC, 2004, 2006). Prior to discharge, wash water would require treatment to reduce chloride ion concentrations below the United States Environmental Protection Agency (USEPA) National Secondary Drinking Water Regulation of 250 mg/L, or further, depending on local water quality standards (U.S. CFR, 2002). Because chloride ion concentrations in truck wash water have been reported as high as 79,000 parts per million (ppm), this management approach would likely require desalination (Alleman, et al., 2004).

Desalination technologies are generally divided into two groups: thermal technologies and membrane technologies. Because of their high energy costs, thermal technologies, such as distillation, are impractical for many state DOT maintenance facilities. Based on preliminary cost estimates, the Virginia Transportation Research Council (VTRC) identified reverse osmosis (RO) as the most cost effective membrane system for use at the scale of a maintenance facility (VTRC, 2004). Pilot studies conducted to assess the ability of reverse osmosis to treat truck wash water revealed several potential issues: (1) it is difficult to treat to less than 25 mg/L chloride, which could be the discharge requirement (per Virginia groundwater standards), (2) the volume reduction of the wastewater was only 50%, and (3) pre-filtering was necessary because of the turbid water (VTRC, 2006).

One alternative to treating truck wash water to meet discharge requirements is to reuse the truck wash water for the production of brine that can be placed on the roadways as part of a winter maintenance program (Alleman, et al., 2004, VTRC, 2008). Salt brine acts as a freezing point depressant that, when applied directly to the roadway, can prevent the formation of a bond between the ice and the pavement, which makes snow removal more effective. The application of salt brine directly to the roadway is known as pre-treating or anti-icing. Research has shown that an effective anti-icing program can reduce costs in terms of salt usage, overtime labor, and accidents (USDOT FHWA, 1996). Salt brine can also be used to pre wet salt before it is applied to the roadway. Pre-wetting salt can reduce material loss due to bounce and also begins the dissolution process, making the salt effective immediately (USDOT FHWA, 1996). Because many

DOT already use brine as part of their winter maintenance program, reusing the wash water could yield cost savings in the form of reduced disposal and material costs.

Based on the concentrations of suspended solids, oil and grease, and dissolved solids in truck wash water, previous researchers have shown that truck wash water could be reused for the production of brine after a treatment process including an oil/water separator and settling tank (Alleman, et al., 2004, VTRC, 2008). Recent truck wash water quality monitoring at Ohio DOT maintenance facilities has suggested that in addition to treatment with an oil/water separator, media filtration may be required to reduce heavy metals concentrations prior to reusing the wash water. Analysis indicated that copper and zinc concentrations in the wash water exceeded the level allowable for reuse, as set by the Ohio EPA (Miller, et al., 2012). Batch and column tests indicated that media filtration would be adequate to reduce the concentrations of these metals to acceptable levels for reuse (Miller, et al., 2012).

CHAPTER III

APPROACH

3.1 Current State of the Practice of Wash Water Management (states other than Ohio)

To assess the current state of the practice of truck wash water management, thirty state DOTs were initially contacted by email on November 2, 2011 to request their participation in a survey regarding best management practices for truck wash water management. The survey specifically addressed truck wash water disposal in locations lacking sanitary sewer access, as well the benefits and limitations of reusing truck wash water. After the initial survey results were received, follow-up telephone interviews were conducted. A second request for participation in a survey of current best management practices was sent by email on January 23, 2012 and additional telephone interviews were conducted.

3.2 Current State of the Practice of Wash Water Management in Ohio

Current best management practices for truck wash water management across the state of Ohio were evaluated using a combination of an email survey and site visits. The email survey was developed and sent to the District Highway Management Administrator in each of the 12 ODOT Districts on February 7, 2012. The survey was designed to collect information regarding wash water generation and disposal, brine production, and on-site storage volumes, as this information is critical to assessing the cost of treatment,

reuse, or disposal of the truck wash water. To confirm the primary method of wash water disposal reported in the survey, the Facilities Managers in 11 of the 12 districts were contacted and interviewed. The primary method of wash water disposal for the garages in District 10 was confirmed during site visits conducted in October 2011, so it was not necessary to contact the Facilities Manager for District 10.

Based on the responses to the District Survey, a list of garages lacking access to sanitary sewer was compiled. This list was used to select 25 garages, with a minimum of one per district, for site visits. Preference for a site visit was given to county and district garages, but in districts where all county and district garages use sanitary sewer for truck wash water disposal, outpost garages were selected. Site visits were used to verify the method of truck wash water disposal and discuss truck washing protocols.

3.3 Identification of Viable Management Strategies

Using feedback from DOT personnel and the results of the literature review, a list of potential management strategies was developed. To determine the viability of these options for implementation at ODOT maintenance facilities, a preliminary evaluation of each management option was conducted. The options were assessed based the quantity and quality of wash water generated at ODOT maintenance facilities, cost, ease of implementation, and ease of maintenance.

An initial assessment of the viability of reusing wash water for the production of brine was conducted by comparing the current volumes of brine made with the estimated volumes of wash water generated at individual maintenance facilities. Information regarding salt brine usage over the past five winters was provided by ODOT personnel.

The total volume of salt brine made, volume of brine used for pre-treating, and volume of brine used for pre-wetting were reported.

Because the annual volume of wash water generated at ODOT maintenance facilities was unknown, it was estimated using the site specific number of trucks and number of winter events (based on the ODOT definition of a winter event, depending on salt use), which are recorded by ODOT (Equation 3-1).

Equation 3-1: Estimation of the annual volume of wash water generated
Annual Volume of Wash Water (gallons)

$$= \text{Number of trucks} * \text{Volume per Truck} * \text{Number of wash cycles}$$

Where:

$$\text{Volume per Truck} = 330 \text{ gallons/truck/cycle}$$

$$\text{Number of wash cycles} = \text{Number of winter events} * 1.1$$

To account for the fact that a truck may be washed more than one time during a winter event, the variable ‘wash cycle’ was defined as a cycle consisting of two quick washes (for safety purposes) and one full wash of a truck. It was assumed that during a typical winter event, each truck goes through one wash cycle, and that approximately 10% of winter events will last multiple days, yielding additional wash cycles for those events. To calculate the annual number of wash cycles, the three year average number of winter events at each facility (as provided by ODOT) was multiplied by 1.1. To estimate the volume of wash water generated per truck in one wash cycle, wash times and hose flow rates, as reported by ODOT personnel, were used. Most garages reported hose flow rates in the range of four to six gallons per minute and wash times ranging from 30 to 90 minutes. Based on these parameters, an average of 330 gallons of wash water is generated by each truck during one wash cycle.

To verify the estimate of 330 gallons of wash water per truck per cycle, the water bills for the garages in ODOT District 10 were used. Water bills were obtained for each garage for the period of July 2010 through June 2011. The annual volume of wash water generated was estimated at each of these facilities as shown in Equation 3-1. The estimated volume was then added to the actual volume of salt brine made during winter 2010-2011 and compared to the actual volume of water used from October 2010 through March 2011, as reported in the water bill. This approach assumes that truck washing and brine production account for the majority of water usage at these facilities during the winter months. The estimated volume of water used in District 10 during winter 2010 was 1,537,092 gallons (Table 3-1). The actual volume of water used during winter 2010 was 1,517,584. This suggests that the 330 gallons per truck per wash cycle estimate is reasonable.

Table 3-1: Verification of the estimate of 330 gallons of wash water generated per truck per wash cycle for garages in District 10. Analysis assumes that 10% of winter events consist of multiple wash cycles

County	Garage Name	Estimated Total Water Usage (wash water + brine made) gallons	Actual Winter Water Usage from Bill (Oct-Mar) gallons
Athens County	Athens County	175,960	206,000
	Hollister Outpost Garage**	15,246	8,270
Gallia County	Gallia County	92,899	133,000
Hocking County	Hocking County	153,352	192,000
	Laurelville Outpost Garage	7,986	
Meigs County	Meigs County**	122,748	44,000
	Tuppers Plains Outpost	17,424	18,000
Monroe County	Monroe County	156,694	165,000
	Duffy Outpost Garage **	18,876	
Morgan County	Morgan County**	183,744	129,000
Noble County	Noble County	145,915	192,063
	Belle Valley Outpost Garage**	36,300	40,109
Vinton County	Vinton County**	109,589	67,800
	Wilkesville Outpost Garage	15,246	5,000
Washington County	Washington County	189,281	218,042
	Bartlett Outpost Garage**	26,136	54,600
	Belpre Outpost Garage	43,560	29,200
	Macksburg Outpost Garage**	26,136	15,500
	District 10 Totals	1,537,092	1,517,584

** Garages without access to sanitary sewer

3.4 Cost Analysis

3.4.1 Identification of Cost Factors

To calculate the annualized costs of each management option, cost factors contributing to the total annualized cost of each management option were identified and their values assigned or calculated using site specific data, including the number of trucks at a facility and the number of winter events. Cost factors used in this analysis included storage, filtration, disposal, hauling, and monitoring. A process for calculating disposal and hauling costs on a site by site basis was developed, as these costs depend on the volume of wash water generated and the distance to a disposal or reuse location.

3.4.2 Annualized Cost Calculation

After values for each cost factor were calculated using site specific information, the annualized cost of each management option was calculated using Equations 3-2 and 3-3. A discount rate of 7% was used for the cost analysis (Veneziano, 2010). The value for n was governed by the management objective being assessed.

Equation 3-2: Calculation of annualized costs

Annualized Costs = Annualized Capital Costs + Annual Costs

Equation 3-3: Calculation of annualized capital costs

Annualized Capital Costs = Capital Costs * $\left[\frac{i}{((1+i)^n)-1} \right] + i$

Where:

i = discount rate

n = number of years

CHAPTER IV

RESULTS AND ANALYSIS

4.1 Current State of the Practice of Wash Water Management (states other than Ohio)

A total of seventeen State DOTs (57%) responded to the survey of best management practices. Table 4-1 summarizes each state's general approach to truck wash water management. Detailed information on the practice in each state is provided in separate sections below.

Table 4-1: Summary of alternative (i.e. other than sewer disposal) truck wash water management practices for each state DOT interviewed.

State	Wash Water Management Strategy	Recommend Reuse?
Indiana	Reuse wash water for brine after treatment with an oil/water separator.	Yes, for brine
Colorado	Reuse wash water for brine or truck washing after treatment with an oil/water separator and ultrafiltration system.	Yes, for brine and truck washing
Iowa	Reuse wash water for brine after treatment with an oil/water separator.	Yes, for brine
Utah	Collect wash water in retention ponds after treatment with an oil/water separator; wash water is reused for brine.	Yes, for brine
Virginia	Wash trucks at commercial facilities when possible. If not possible, trucks are washed over subsurface engineered wash pads, which filter the water before it is allowed to infiltrate.	No; don't reuse for brine because of concerns with oil/grease
Pennsylvania	Reuse wash water for truck washing after treatment with commercially available recycling system.	No; they have some reuse for truck washing, but don't recommend

State	Wash Water Management Strategy	Recommend Reuse?
Missouri	Attempting pilot study to reuse wash water for brine.	Yes, if they can meet oil/grease requirements
Tennessee	Wash trucks at commercial facilities or on a wash pad where wash water can be collected, stored, and disposed of off-site.	No
Oregon	Filter wash water with a GAC filter and discharge directly to the ground surface.	No
Washington	Route wash water to a pond or bioswale after treatment with an oil/water separator where it is allowed to infiltrate.	No; used to reuse for truck washing, but discontinued due to high cost
Maryland	Discharge directly to surface water after treatment with an oil/water separator.	No; used to reuse for truck washing, but discontinued due to high cost
Minnesota	Collect and store wash water for off-site disposal.	No; conducted pilot study to reuse for truck washing, but discontinued to corrosion issues
Vermont	Collect and store wash water for off-site disposal.	Have not tried
Michigan	Collect and store wash water for off-site disposal.	No; tried to reuse for truck washing; pilot was unsuccessful
Delaware	Route wash water to a pond after treatment with an oil/water separator where it is allowed to infiltrate.	Have not tried
Rhode Island	Wash trucks at commercial facilities.	Have not tried
Idaho	Wash trucks near the salt pile. Wash water runs back toward salt pile.	Have not tried

Indiana

Mr. Steve Mcavoy, Manager Office of Facilities Management at Indiana DOT

(INDOT) provided the following information by email and telephone:

INDOT has a formal program in place for recycling truck wash water into salt brine for winter road maintenance. All new facilities are designed and constructed with this in mind, and several older facilities have been retrofitted with this capability. The truck washing process at INDOT maintenance facilities is as follows:

1. Large debris is hand removed from the truck prior to entering the wash bay.
2. Any remaining large debris is removed during prewashing, which is conducted over a shallow pit so that the wash water can be collected and drained into the wash bay. The solids remaining in the pit are then collected and reused.
3. Trucks are washed in the wash bay. All wash water is collected and processed through an oil/water separator prior to being pumped into above ground storage tanks in the salt building until it is needed for brine production. If the volume of wash water generated exceeds the volume of storage available, wash water is routed to the sanitary sewer, rather than into the tank. The wash water is used to produce salt brine, as it is needed.

The process is similar in locations without sanitary sewer. Additional storage volume is provided at these locations to minimize the need to pump water out of the storage tanks for off-site disposal. In some cases, water is transported to a nearby maintenance facility to be converted to salt brine when the volume of wash water generated exceeds the volume of storage available.

Colorado

The following information was obtained from email and telephone correspondence with Ms. Theresa Santangelo, Hazardous Waste Management Unit Supervisor for the Colorado DOT:

In Colorado, truck wash water is reused for two purposes: brine production and truck washing. Prior to being reused, the wash water is treated to remove volatile organic chemicals, metals, bacteria, and oil and grease, and to reduce the concentration of dissolved solids. The wash water is then stored until it is needed for truck washing. Because dissolved solids are not removed during wash water processing, truck washing must be followed by a tap water rinse to ensure that the recycled wash water does not cause vehicle corrosion. In locations where the truck wash water is reused as stock for brine production, the water is treated using an ultrafiltration (UF) system to ensure that the water quality of the salt brine solution used for pretreating meets applicable standards. UF is used to remove suspended and colloidal particulate matter, but does not remove dissolved solids. After being processed through the UF unit, the treated wash water is stored until it is reused for brine production.

Iowa

The following information was obtained through telephone correspondence with Mr. James VanSickle, Supervisor at the Iowa DOT Ames Garage:

The Ames Garage installed a system to reuse wash water for brine approximately four years ago. Wash water is treated with an oil/water separator prior to being stored on-site until it is converted to brine. The facility has approximately 56,000 gallons of brine storage available on-site. Care is taken to ensure that the brine tanks are nearly empty at the end of the winter season so that all wash water generated during the summer months can be stored and used to make brine in the fall. The on-site storage capacity is such that all wash water generated can be captured. The Ames garage reportedly uses between 800,000 and 1,000,000 gallons of brine in a typical winter. They do not

generate enough wash water to produce this volume, and must also use tap water. In addition to producing brine for their own routes, they also produce brine for the City of Ames.

Prior to beginning a reuse program at the Ames Garage, Iowa DOT pilot tested a filtration system designed to treat truck wash water to an acceptable level for discharge directly to the environment. Detailed information regarding this system was not available. However, Iowa DOT no longer uses this system and is moving toward reusing truck wash water for the production of brine at facilities without access to sanitary sewer.

Utah

The following information was obtained from email and telephone correspondence with Mr. Lynn Bernhard, Methods Engineer for Utah DOT:

Utah DOT's standard practice for truck wash water management is to collect and store the wash water in retention ponds until it is reused for the production of salt brine. At the end of each season, retention ponds are sealed and allowed to evaporate. Residual solids are then disposed of as part of an approved waste stream. To address reported problems with seepage and overflow from these retention ponds, concrete liners have been replaced with membrane liners and several retention ponds have been redesigned with greater capacity. While evaporation and disposal is a viable approach to truck wash water management in Utah because of low rainfall totals and high summer temperatures, it is unlikely that this approach would be successful under Ohio's climate conditions.

Virginia

The following information was provided by email and telephone correspondence with Mr. Jim Brewbaker, Salem District Equipment Manager for the Virginia DOT:

In Virginia, truck wash water is managed in one of four ways:

1. When available, wash water is disposed of via sanitary sewer.
2. Wash water is filtered and reused for truck washing. When it can no longer be reused, wash water is disposed of using an evaporator system. Use of these systems has been discontinued in most locations due to the high cost associated with filter replacement and energy to operate the evaporator system. Because of clogging, the filters require more frequent replacement than anticipated. While the intent of these systems was to process the wash water so that it could be reused for truck washing time and time again, truck wash water was only being reused once during the winter season before being evaporated because there were concerns that the salty water would corrode the maintenance vehicles.
3. Wash water is filtered through a subsurface engineered wash pad, which is constructed of alternating layers of sand and stone. After being filtered through the wash pad, the wash water is allowed to infiltrate. Because all materials are excavated and replaced annually, the cost to maintain these wash pads is high.
4. Trucks are washed at commercial facilities when available.

Virginia DOT no longer allows truck wash water to be stored in retention ponds or reused for brine production because of elevated oil and grease concentrations.

Pennsylvania

The following information was obtained by telephone conversation with Mr. Terry Persall, Acting Division Chief—Facility Management for Pennsylvania DOT:

Pennsylvania DOT (PennDOT) does not have a formal plan for reusing truck wash water. Because the first choice for wash water disposal is via sanitary sewer,

PennDOT makes a concerted effort to locate new garages in areas with sewer access. When this is not possible, commercially available recycling systems, which process and collect the truck wash water for reuse, are utilized. These systems are known to have high maintenance costs and are ineffective when standard operating procedures for reuse are not followed. Because dissolved solids are not completely removed prior to reuse, a tap water rinse must be the final step in the truck washing process. PennDOT noted that it is difficult to ensure that all maintenance personnel comply with this requirement, but omission of this step can lead to increased costs when maintenance vehicles begin to corrode. PennDOT's final option for truck wash water disposal is to store wash water in a holding tank until it can be properly disposed. PennDOT views this as the least desirable approach, and tries to minimize the use of holding tanks at their maintenance facilities.

Missouri

The following information was obtained through email and telephone correspondence with Mr. Douglas Record, GS Facilities Manager for Missouri DOT:

Missouri DOT attempts to locate new maintenance garages in areas where sewer access is available so that truck wash water may be directed to a Publicly Owned Treatment Works (POTW). In locations where this is not possible, trucks are washed at commercial facilities. Recently, Missouri Department of Natural Resources (DNR) has instructed Missouri DOT to discontinue the practice of using leach fields for truck wash water disposal. In one of these locations, a pilot study is being conducted to evaluate the feasibility of reusing the truck wash water for brine production. The pilot system is designed to collect truck wash water in a sump where oil/water separation begins and

solids settle. Wash water is then treated using an oil/water separator prior to being stored in a 6,000 gallon above ground storage tank until it is reused. The pilot study has been unsuccessful to date due to the inability of the existing system to meet Missouri's water quality standards for oil and grease. Oil and grease concentrations in the wash water storage tank exceeded the limit of 10 mg/L during the first round of sampling. Missouri intends to continue the pilot test using a different cleaning product, which may enhance oil and grease removal, and resample the wash water.

Tennessee

The following information was obtained through email correspondence with Mr. Estel Hagewood, Transportation Manager I for the Tennessee DOT and Tennessee DOT's Standard Operating Procedure for Vehicle Wash Operations:

Tennessee DOT's standard operating procedure for truck washing specifies that trucks must be washed at commercial truck washing facilities or on a designated wash pad. In locations where wash pads are used, wash water passes through an oil/water separator prior to being discharged to the sanitary sewer or collected and stored until it can be transported to a POTW for proper disposal. Some truck wash water treatment units also include a filter paper unit for the removal of suspended solids. The filter paper is periodically changed and properly disposed. In Tennessee, wash water is not recycled.

Oregon

The following information was obtained through email and telephone correspondence with Ms. Shawna Secord, Clean Water Program Technician for the Oregon DOT:

At maintenance facilities without access to sanitary sewer, Oregon DOT's preferred approach is to filter the truck wash water with a granular activated carbon (GAC) filter and discharge the treated water directly onto the ground surface, preferably to a vegetated area. Oregon DOT has a treatment process that includes a vault separator, oil/water separator, or holding tank to remove sediment from the wash water. The wash water is then processed through a bag filter to reduce suspended solids concentrations and finally treated with the GAC filter and discharged. When the units become clogged with solids, the top six inches of media are removed and replaced. At some facilities, the media is replaced each year, while others are able to use the system for several years prior to media replacement. These systems are low maintenance and effective for Oregon DOT.

In locations where discharge to the ground surface is not possible, custom evaporator or closed loop recycling systems are used to minimize the need for wash water disposal. Because of the energy and maintenance requirements, these systems are not preferred.

Washington

The following information was obtained through email correspondence with Mr. Norm Payton, Stormwater and Environmental Policy Manager for Washington DOT:

Washington DOT has a standard operating procedure for truck washing that includes the use of prewash pads, where most of the visible dirt is removed from the trucks using high volume, low pressure washers. This water is processed through a sump, for suspended solids removal, and an oil/water separator prior to being discharged to a sanitary sewer. Additional washing is then conducted in the main wash bay. In the

past, Washington DOT installed truck wash water recycling units in approximately five wash bays. However, these are no longer used as they were deemed inefficient and expensive to operate. At facilities that lack sewer access, Washington DOT now routes the wash water to a pond or bioswale, where it infiltrates. In addition, they are considering the use of an Amended Compost Bioswale, which has just been approved by the Washington Department of Ecology for removal of suspended solids and dissolved metals. Additional research may be conducted to ensure that the Amended Compost Bioswale is adequate for oil and grease removal.

Maryland

The following information was obtained through a telephone interview with Mr. Gregory Keenan, Chief of the Environmental Compliance Division with the Maryland State Highway Administration (SHA):

Maryland SHA currently operates six maintenance facilities that do not have access to sanitary sewer for the disposal of truck wash water. With the exception of one location, wash water is treated to remove oil and grease and suspended solids and then discharged directly to surface water with an approved permit. The permit requires monitoring of total suspended solids (TSS) and oil and grease concentrations. Several facilities have had issues meeting the discharge requirements for TSS. To address this concern, treatment systems were upgraded by enlarging the grit chambers inside the wash bay and adding storage volume on-site. However, because these measures were insufficient to achieve compliance with the TSS discharge limits, these facilities have begun to store the wash water on-site until it can be pumped and hauled to a treatment facility. Maryland SHA has found that the cost for pump and haul is comparable to the

cost of monitoring and sampling required for surface water discharge. The location that does not discharge to surface water discharges to ground water with an approved permit. Maryland SHA has considered pursuing groundwater discharge permits for other facilities, but has been unable to do so.

One facility in Carroll County Maryland implemented a system for recycling wash water to use for truck washing a number of years ago, but, due to constant maintenance issues, this operation was discontinued. There is no documentation available on this system. Maryland SHA has also considered the use of an advanced filtration system to address concerns about toxicity from detergents in the wash water. However, there was concern that operation and maintenance of this system would be too difficult and time consuming during the winter season. Instead, they have discontinued the use of detergents at locations that discharge to surface water.

Minnesota

The following information was obtained through telephone interviews with Mr. Steve Lund, State Maintenance Engineer for Minnesota DOT, and Mr. Dave Morissette, Water Resource Engineer for the Minnesota DOT:

In Minnesota, the standard operating procedure for truck wash water disposal in locations without sanitary sewer is to store the wash water on-site until it can be transported to a POTW for disposal. Approximately fifteen years ago, Minnesota DOT conducted a research project to assess the possibility of treating and reusing the wash water for truck washing. Although there is no documentation available regarding this project, Minnesota DOT personnel indicated that the treatment system included filtration, ozonation, and oil and grease removal. The project was abandoned after approximately

two years due to limited employee buy-in and issues with equipment corrosion.

Minnesota does not currently recycle truck wash water for the production of salt brine.

Vermont

The following information was obtained through a telephone conversation with Mr. George McCool, District Manager for the Vermont DOT:

Truck wash water generated at facilities lacking access to sanitary sewer for disposal is treated with an oil/water separator prior to being discharged directly to a septic system and leach field. At the Central Garage, wash water is stored in an underground storage tank (UST) until it is pumped and hauled off-site for disposal. Vermont DOT has not experimented with wash water reclamation, but indicated that they are always looking for cost savings measures.

Michigan

The following information was obtained through telephone and email correspondence with Mr. Andrew Bouvy, Engineer for the Region Bridge Support Unit of the Michigan DOT:

At locations without access to sanitary sewer, Michigan DOT currently treats wash water with an oil/water separator and stores it in a 10,000 gallon UST until it is pumped and hauled off-site for disposal. Most of their facilities only require pumping of the tanks once every two to three months, although one facility reportedly requires pumping and hauling three times per month. Wash water generation is minimized by limiting truck washing activities.

In 2007, Michigan DOT installed a Rowafil wash water reclamation system through Hydro-chemical of Grand Rapids. Because the system did not remove salt from

the water, dissolved solids concentrations were elevated to a level that required its disposal as hazardous waste within several cycles. In addition, the equipment showed signs of corrosion in a short amount of time. The project was discontinued and the equipment was auctioned for one quarter of its original price. Michigan DOT does not recommend the use of reclaimed wash water for truck washing.

Delaware

The following information was obtained through a telephone interview with Mr. Alastair Probert, Maintenance Engineer for Delaware DOT:

In Delaware, it is a requirement that truck wash water be disposed of via sanitary sewer when available. In locations where sewer is unavailable, trucks must be washed on an impervious pad. Wash water is then treated using an oil/water separator and directed overland to an on-site, unlined retention pond. Because the near surface soils in Delaware are sandy, water readily infiltrates, eliminating the need to pump water out of the pond to prevent overflow.

Rhode Island

The following information was obtained by email correspondence with Mr. Joe Baker, Deputy Administrator—Division of Highways and Bridges:

Rhode Island DOT does not conduct truck washing operations at any of their maintenance facilities. Private facilities, which have been pre-approved by the state, are used for all truck washing. The cost ranges from \$8-\$125 per truck, depending on the size of the truck, and includes wash water disposal.

Idaho

The following information was obtained by telephone interview with Mr. Steve Spoor, Maintenance Services Manager for the Idaho DOT:

Formal best management practices have not been developed for the management of truck wash water in Idaho. Trucks are generally washed with a fire hydrant near the salt pile so that wash water will drain back toward the pile. The first designated truck washing facility in the state is currently under development in Coeur d'Alene, Idaho as a result of concerns regarding storm water management. When completed, the facility will be connected to sanitary sewer. As of January 2012, project specifics remain undefined.

Figure 4-1 summarizes the management options identified through the literature review and interviews with other state DOT.

Figure 4-1: Complete list of truck wash water management strategies identified through a literature review and interviews with state DOT.

In addition to providing information on current best management practices for truck wash water disposal, the interviews of other state DOTs also led to the discovery of

several potential issues with implementing a wash water treatment and reuse program. A number of states indicated that previously tested treatment systems had failed as a result of limited employee buy-in or severe equipment corrosion. Unanticipated costs associated with equipment maintenance and frequent replacement of system components was also problematic. Lastly, no one reported monitoring for heavy metals in the wash water.

4.2 Current State of the Practice of Wash Water Management in Ohio

4.2.1 Survey and Site Visits

The surveys submitted by each District are provided in Appendix A. The results are summarized below.

District 1

Survey

According to the survey submitted by District 1 personnel, District 1 currently maintains approximately 3,400 lane miles with a fleet of 123 trucks across eight counties in northwest Ohio. There are eight county garages and eight outpost garages in District 1. According to the Facilities Manager for District 1, truck washing is only conducted at the county garages, which are all tied into the sanitary sewer system. Of the eight outpost garages in District 1, the only garage with the potential to generate truck wash water that cannot be disposed of via sanitary sewer is the Carey Outpost Garage. Five of the outpost garages are tied into the sanitary sewer and the remaining two have had the floor drains in the wash bays capped (Roundhead and Paulding Outpost Garages). Figure 4-2

depicts the locations of all of the maintenance facilities in District 1. Table 4-2

summarizes key information regarding the garages in District 1.

Table 4-2: Summary of the number of trucks, lane miles, and current wash water disposal methods for maintenance facilities in District 1. Shading indicates garages without access to sanitary sewer for the disposal of truck wash water.

County	Garage Name	Total Number of Dump Trucks	Lane Miles	Current Method of Wash Water Disposal
Allen County	Allen County	8	470.0	Sanitary Sewer
	4th Street	4		Sanitary Sewer
	Delphos	3		Sanitary Sewer
	Beaverdam	4		Sanitary Sewer
	District 1 HQ			
Defiance County	Defiance County	13	340.4	Sanitary Sewer
	Hicksville	1		Sanitary Sewer
Hancock County	Hancock County	15	622.9	Sanitary Sewer
	SR 12 Outpost	6		Sanitary Sewer
Hardin County	Hardin County	9	334.0	Sanitary Sewer
	Roundhead	2		
Paulding County	Paulding County	12	392.6	Sanitary Sewer
	Paulding County OP			
Putnam County	Putnam County	15	453.5	Sanitary Sewer
VanWert County	Van Wert County	15	374.5	Sanitary Sewer
Wyandot County	Wyandot County	14	476.8	Sanitary Sewer
	Carey	2		Holding Tank
	District 1 Totals	123	3,464.7

Figure 4-2: Locations of the District, County, and Outpost Garages in District 1. Garages in red lack access to sanitary sewer for truck wash water disposal.

Site Visits

Carey Outpost

Carey Outpost, located in District 1 Wyandot County, does not have access to sanitary sewer for disposal of truck wash water. While full truck washing is not conducted at the Carey Outpost Garage, safety washes, which include washing of the truck windows and mirrors, are conducted on an as-needed basis. According to garage personnel, safety washes are conducted at least once per winter event. Wash water generated during safety washes is stored on-site in a 2,500 gallon underground storage tank (UST) until it is pumped off-site for disposal. The current disposal cost for this location is approximately \$0.15/gallon.

District 2

Survey

District 2, which is headquartered in Bowling Green, Wood County, oversees highway maintenance in Fulton, Henry, Lucas, Ottawa, Sandusky, Seneca, Williams, and Wood counties. The eight county garages and two outpost garages in District 2 maintain approximately 3,300 lane miles with a fleet of 111 trucks. The only county garage in District 2 without access to the sanitary sewer is the Henry County Garage, which collects truck wash water in a lagoon after it is processed through an oil/water separator to be reused for the production of brine. To reuse wash water in this way, the Henry County Garage is required to collect water quality samples from the lagoon annually. The Edison Outpost Garage is the only other garage in District 2 without access to sanitary sewer. According to the Facilities Manager for District 2, truck washing is rarely done at the Edison Outpost Garage. The locations of the garages in District 2 are shown in Figure 4-3 with relevant statistics summarized in Table 4-3.

Table 4-3: Summary of the number of trucks, lane miles, and current wash water disposal methods for maintenance facilities in District 2. Shading indicates garages without access to sanitary sewer for the disposal of truck wash water.

County	Garage Name	Total Number of Dump Trucks	Lane Miles	Current Method of Wash Water Disposal
Fulton County	Fulton	10	290.0	Sanitary Sewer
Henry County	Henry	10	389.0	Lagoon/Reuse
Lucas County	Lucas	16	459.0	Sanitary Sewer
	Northwood	0	307.0	Sanitary Sewer
Ottawa County	Ottawa	10	358.0	Sanitary Sewer
	Edison	4	-	Leach Field or Mound

Sandusky County	Sandusky	12	393.0	Sanitary Sewer
Seneca County	Seneca	14	410.0	Sanitary Sewer
Williams County	Williams	14	373.0	Sanitary Sewer
Wood County	Wood	21	648.0	Sanitary Sewer
	District 2 HQ			
	District 2 Totals	111	3,320

Figure 4-3: Locations of the District, County, and Outpost Garages in District 2. Garages in red lack access to sanitary sewer for truck wash water disposal.

Site Visits

The Henry County Garage in District 2 currently collects truck wash water in an on-site retention pond, where it mixes with storm water-rainfall and is reused to produce brine for winter maintenance. Annual costs associated with this system include, but are not limited to, truck wash water quality monitoring and the disposal of water in excess of the pond's storage capacity. Storm water is frequently pumped and hauled to a WWTP

20 miles away for disposal using ODOT equipment and personnel. The cost of disposal is \$0.05/gallon. During the winter of 2011, 624,800 gallons of wash water/storm water were pumped and hauled to the WWTP for disposal at a cost of \$31,240. In addition, there are fuel and labor costs associated with hauling the wash water. Using the actual number of trips made to dispose of the wash water during winter 2011 (as reported by ODOT District 2 personnel), a labor cost of \$17/hour, and a fuel cost of \$3.50/gallon, the calculated cost to haul wash water to the WWTP during winter 2011 was \$21,725. With hauling and disposal, the total cost of wash water disposal during winter 2011 was \$52,965.

District 3

Survey

ODOT District 3 currently maintains approximately 4,100 lane miles across Ashland, Crawford, Erie, Huron, Lorain, Medina, Richland, and Wayne Counties. The Huron County garage is the only county garage in District 3 without access to the sanitary sewer for truck wash water disposal. The Huron County Garage currently manages truck wash water by storing it in a holding tank on-site until it is pumped and hauled to a treatment plant. There are five outpost garages in District 3 without sanitary sewer. Truck washing is not conducted at these outposts. With the exception of the Vermillion Outpost Garage, which has a leach field, the primary means of wash water disposal at the outposts without sanitary sewer is the storm sewer. Figure 4-4 shows the locations of the garages in District 3 that do not currently have access to sanitary sewer for truck wash water disposal. Table 4-4 summarizes the relevant statistics for District 3.

Table 4-4: Summary of the number of trucks, lane miles, and current wash water disposal methods for maintenance facilities in District 3. Shading indicates garages without access to sanitary sewer for the disposal of truck wash water.

County	Garage Name	Total Number of Dump Trucks	Lane Miles	Current Method of Wash Water Disposal
Ashland County	Ashland County Garage (ASDCG)	16	544.0	Public Sanitary Sewer
	Perrysville Outpost Garage (ASDPSO)	4	139.0	Runoff / Storm Sewer
	Nova Outpost (ASDPNW)	0	-	No Plumbing
	District 3 HQ Office (New) (ASDHQ)			Public Sanitary Sewer
Crawford County	Crawford County Garage (CRACG)	14	478.6	Public Sanitary Sewer
Erie County	Erie County Garage (ERICG)	12	307.0	Public Sanitary Sewer
	Vermillion Outpost Garage (ERIPNE)	2	88.3	Class 5 Well (Septic Tank and Mound System or Leach Field)
Huron County	Huron County Garage (HURCG)	13	374.6	Holding Tank
	Plymouth Outpost Garage (HURPSE)	2	69.0	Runoff / Storm Sewer
Lorain County	Lorain County Garage (LORCG)	12	383.6	Public Sanitary Sewer
	Avon Outpost Garage (LORPNE)	6	167.2	Public Sanitary Sewer
Medina County	Medina County Garage (MEDCG)	22		Public Sanitary Sewer
	Burbank Outpost Garage (MEDPSW)	7		Runoff / Storm Sewer
Richland County	Richland County Garage (RICCG)	12	321.1	Public Sanitary Sewer
	Lexington Outpost Garage (RICPSW)	8	256.0	Runoff / Storm Sewer
Wayne County	Wayne County Garage (WAYCG)	17	585.9	Public Sanitary Sewer
	District 3 Totals	147	3,714.25

Figure 4-4: Locations of the District, County, and Outpost Garages in District 3. Garages in red lack access to sanitary sewer for truck wash water disposal.

Site Visits

Huron County Garage

The Huron County Garage is the only county garage in District 3 lacking access to sanitary sewer for truck wash water disposal. According to District 3 personnel, the truck wash water generated during routine maintenance of the 15 dump trucks at this location is stored in a 3,000 gallon UST until it is pumped and hauled off-site for disposal. The cost for wash water disposal is approximately \$0.42/gallon. Trucks from the Plymouth Outpost are also washed at the Huron County Garage. Brine is produced at the Huron County Garage using tap water.

Plymouth Outpost

The Plymouth Outpost garage is located in Huron County. There are two dump trucks stationed at the Plymouth Outpost. According to District 3 personnel, there is not a wash bay at this facility and trucks are not washed here. Instead, they are driven to the Huron County Garage for washing at the end of each winter event. Wash water is not stored on-site.

District 4

Survey

District 4, which is headquartered in Akron, Ohio, includes Ashtabula, Mahoning, Portage, Stark, Summit, and Trumbull counties. Currently, the only county garage without access to sanitary sewer for truck wash water disposal is the Summit County Garage; however, this garage was scheduled to be tied into the sanitary sewer during the summer of 2012.

Over the last two years, the Conneaut, Harpersfield, and Greensburg Outpost garages were tied into the sanitary sewer system. There are still 12 outpost garages in District 4 without access to sanitary sewer for truck wash water disposal. Four of these outpost locations use a contractor to pump and haul wash water for disposal at an average cost of \$0.51/gallon. Table 4-5 summarizes the primary method of wash water disposal for all garages in District 4 and Figure 4-5 shows their locations.

Table 4-5: Summary of the number of trucks and current wash water disposal methods for maintenance facilities in District 4. Lane miles were not reported. Shading indicates garages without access to sanitary sewer for the disposal of truck wash water.

County	Garage Name	Total Number of Dump Trucks	Current Method of Wash Water Disposal
Ashtabula County	Ashtabula County Garage	9	Public Sewer
	Conneaut Outpost	5	Public Sewer
	Harpersfield Outpost	3	Public Sewer
	Williamsfield Outpost	4	Leach Field or Mound
	Dorset Outpost	4	Holding Tank
	Rome Outpost	4	Holding Tank
Mahoning County	Mahoning County Garage	9	Public Sewer
	South Avenue Outpost		No Truck Washing.
	Sebring Outpost	2	Leach Field or Mound
	Bailey Road Outpost	4	Public Sewer
	North Lima Outpost	8	Leach Field or Mound
Portage County	Portage County Garage	11	Public Sewer
	Yale Outpost	4	Leach Field or Mound
	Drakesburg Outpost	5	Holding Tank
Stark County	Stark County Garage	17	Public Sewer
	Alliance Outpost		No Truck Washing or Storage
	Canton Outpost		No Truck Washing or Storage
	Canal Fulton Outpost		No Truck Washing
	Massillon Outpost	6	No Truck Washing
Summit County	Summit County Garage	10	Will connect to sewer--summer 2012
	Interchange Outpost	7	Package Plant
	Kelly Outpost		Public Sewer
	Twinsburg Outpost	5	Storm Sewer
	Greensburg Outpost	4	Public Sewer
	Peninsula Outpost		No Truck Washing or Storage

	Richfield Outpost		No Truck Washing or Storage
	District 4 HQ		Public Sewer
Trumbull County	Trumbull County Garage	8	Public Sewer
	Warren Outpost		No Truck Washing.
	Brookfield Outpost	7	Holding Tank
	Farmington Outpost	4	Leach Field or Mound
	Gustavus Outpost	6	Leach Field or Mound
	Trumbull Construction Office		
	District 4 Totals	146

Figure 4-5: Locations of the District, County, and Outpost Garages in District 4. Garages in red lack access to sanitary sewer for truck wash water disposal.

Site Visits

Ashtabula County Garage

Ashtabula County Garage in Ashtabula County, Ohio currently has access to the sanitary sewer for truck wash water disposal. Trucks are washed in a designated wash bay using a pressure washer and an attachment that slides under the truck to clean the undercarriage. The Ashtabula County Garage produces brine for itself and two outpost garages: Rome and Dorset.

Boston Heights Garage

The Summit County Garage in Boston Heights does not have access to sanitary sewer for truck wash water disposal. Wash water generated at this facility goes into a leach field after being processed through an oil/water separator. There are plans for this garage to be tied into the sanitary sewer line in the near future.

Greensburg Airport Outpost Garage

There are four dump trucks assigned to the Greensburg Airport Outpost Garage. Truck wash water generated at this facility is disposed of in the sanitary sewer.

Drakesburg Outpost

Drakesburg Outpost, located in Portage County, Ohio, does not currently have access to sanitary sewer for truck wash water disposal. Because of the lack of sewer access, only safety washing, which includes washing of the windows and mirrors, is conducted at this garage. Each of the four trucks receives a safety wash at the end of every 12-hour shift. At the end of a winter event, the trucks are driven to the nearest county garage for a full wash. Wash water generated during safety washing is processed through an oil/water separator and collected in a 3,000-gallon UST until it can be pumped

and hauled by a contractor to the nearest waste water treatment plant for disposal at a cost of \$0.49/gallon. During the winter of 2010/2011, the tank was pumped 13 times and 36,750 gallons of wash water were disposed of at a total cost of \$17,906.75. This volume of truck wash water was generated over the course of 51 winter events.

Rome Outpost

Rome Outpost in Ashtabula County, Ohio currently utilizes four trucks for snow and ice removal. Because sanitary sewer access is not available at this maintenance facility, wash water generated during safety washes is processed through an oil/water separator and stored in a 6,000-gallon UST until it is pumped and hauled to a nearby waste water treatment plant for disposal at a cost of \$0.53/gallon. During winter 2011, with 71 winter events reported in Ashtabula County, a total of 30,500 gallons of wash water were generated at Rome Outpost. The total cost to dispose of the wash water was \$16,332.75.

Dorset Outpost

Dorset Outpost in Ashtabula County, Ohio also has four trucks for snow and ice removal. To minimize the generation of wash water at this facility, which does not have access to sanitary sewer, safety washes are conducted at the end of each 12-hour shift during a winter event and the trucks are driven to the nearest county garage with sewer access for a full wash at the end of an event. Wash water is processed through and oil/water separator then stored in a 3,000 gallon UST until it is pumped and hauled to a nearby waste water treatment plant for disposal at a cost of \$0.53/gallon. During winter 2011, a total of 30,000 gallons of wash water was generated at Dorset Outpost Garage and disposed of at a cost of \$16,065.

District 5

Survey

District 5 maintains approximately 3,700 lane miles with a fleet of 126 trucks distributed throughout seven county and 11 outpost garages. The District 5 Garage currently uses a package plant to manage truck wash water. There are also two county garages without access to sanitary sewer: the Licking County Garage (Utica Outpost) and the Muskingum County Garage currently have leach field systems. However, full truck washing is not conducted at the Licking County Garage, and the Muskingum County Garage currently has a new wash bay under construction and was scheduled to be connected to the sanitary sewer in the summer of 2012. There are an additional seven outpost garages without access to sanitary sewer. Table 4-6 provides a summary of the lane miles and number of trucks at each maintenance facility in District 5 as well as the current approach to truck wash water management. Figure 4-6 shows the locations of the maintenance facilities in District 5.

Table 4-6: Summary of the number of trucks, lane miles, and current wash water disposal methods for maintenance facilities in District 5. Shading indicates garages without access to sanitary sewer for the disposal of truck wash water.

County	Garage Name	Total Number of Dump Trucks	Lane Miles	Current Method of Wash Water Disposal
Coshocton County	Coshocton County	16	465.9	Sanitary Sewer
	COS - New Castle	0		No water
Fairfield County	Fairfield County	15	469.3	Sanitary Sewer
	FAI -Baltimore			Sanitary Sewer
	US Rt 664			No water
Guernsey County	Guernsey County	12	315.0	Sanitary Sewer

	GUE - North Salem	5	136.0	Leach Field or Mound
	GUE -Old Washington	6	160.0	Leach Field or Mound
	GUE-Cumberland Outpost Garage			Salt Storage/No water
Knox County	Knox County	13	339.4	Sanitary Sewer
	KNO -Fredericktown	2	68.0	Sanitary Sewer
	KNO -Newcastle in with Main NO Water			No water
Licking County	Licking County--Utica	6	264.0	Leach Field or Mound
	LIC -Etna	7	228.7	Leach Field or Mound
	LIC -Brownsville	5	212.7	Leach Field or Mound
	LIC -Marne (Salt Reload Only)			No Water
	District 5 HQ and Garage			Package Plant
Muskingum County	Muskingum County	11	335.0	Leach Field or Mound (new wash bay under construction for summer 2012)
	MUS -158- Dresden	5	138.0	Leach Field or Mound
	MUS -160- Moxahala	3	64.4	Leach Field or Mound
	MUS -161- Duncan Falls	5	138.0	Leach Field or Mound
Perry County	Perry County	15	379.0	Sanitary Sewer
	Shawnee Outpost Garage			Salt Storage/No water
	District 5 Totals	126.0	3,713.4

Figure 4-6: Locations of the District, County, and Outpost Garages in District 5. Garages in red lack access to sanitary sewer for truck wash water disposal.

Site Visits

Muskingum County Garage

Truck wash water generated during the routine maintenance of the 11 dump trucks currently stationed at the Muskingum County Garage is disposed of in the sanitary sewer. In addition, the 13 other dump trucks stationed across the three outpost locations in Muskingum County are driven to the Muskingum County Garage for washing at the end of each winter event.

District 6

Survey

District 6 encompasses eight counties in central Ohio. Eight county and nine outpost garages maintain 4,882 lane miles with a fleet of 166 trucks. District 6 has one county and five outpost garages without access to sanitary sewer for truck wash water disposal. Figure 4-7 shows their locations with relevant statistics summarized in Table 4-7.

Table 4-7: Summary of the number of trucks, lane miles, and current wash water disposal methods for maintenance facilities in District 6. Shading indicates garages without access to sanitary sewer for the disposal of truck wash water.

County	Garage Name	Total Number of Dump Trucks	Lane Miles	Current Method of Wash Water Disposal
Delaware County	Delaware County	11	296.5	Sanitary Sewer
	Berkshire Outpost	9	259.2	Sanitary Sewer
	District 6 HQ			
Fayette County	Fayette County	7	213.7	Sanitary Sewer
	Jeffersonville Outpost	6	247.3	Holding Tank
Franklin County	Franklin County	13	465.8	Sanitary Sewer
	Canal Winchester Outpost Yard			
	5th Avenue Outpost	15	541.6	Sanitary Sewer
	Hilliard Outpost	13	299.9	Sanitary Sewer
	Grove City Outpost	13	205.3	Sanitary Sewer
	Worthington/Wilson Bridge Outpost Garage			
Madison County	Madison County	8	228.0	Leach Field or Mound
	Mt. Sterling Outpost	6	173.0	Storm Sewer
	West Jefferson Outpost	6	212.0	Leach Field or Mound
	Land Outpost			
Marion County	Marion County	14	434.0	Sanitary Sewer

Morrow County	Morrow County	10	323.8	Sanitary Sewer
	Chesterville Outpost	4	84.7	Sanitary Sewer
Pickaway County	Pickaway County	15	438.0	Sanitary Sewer
Union County	Union County	10	282.2	Sanitary Sewer
	Richwood Outpost	6	176.9	Leach Field or Mound
	District 6 Totals	166	4,882.0

Figure 4-7: Locations of the District, County, and Outpost Garages in District 6. Garages in red lack access to sanitary sewer for truck wash water disposal.

Site Visits

Madison County Garage

A site visit to the Madison County Garage was conducted on March 13, 2012. The visit confirmed that this garage lacks access to sanitary sewer. Wash water generated at the Madison County Garage is treated using an oil/water separator prior to being discharged to a leach field. Wash water is not being reused for brine production.

Franklin County Garage

A site visit to the Franklin County Garage was conducted on March 14, 2012. Wash water generated at the Franklin County Garage is processed through a sedimentation tank and an oil/water separator prior to being discharged to the sanitary sewer.

District 7

Survey

ODOT District 7 oversees maintenance operations in Auglaize, Champaign, Clark, Darke, Logan, Mercer, Miami, Montgomery, and Shelby Counties. All of the county garages in District 7 currently dispose of truck wash water via sanitary sewer. According to the District 7 Facilities Manager, truck washing does not occur at any of the outposts that do not have access to sanitary sewer. There are nine outpost garages in District 7 without access to sanitary sewer. Water generated at these facilities is stored in a holding tank until it can be pumped and hauled to the nearest county garage for disposal in the sanitary sewer. Figure 4-8 shows the locations of the county garages in District 7 along with all garages lacking access to sanitary sewer. Table 4-8 provides a summary

the number of trucks and lane miles assigned to each garage, as reported by District 7 personnel in the email survey.

Table 4-8: Summary of the number of trucks, lane miles, and current wash water disposal methods for maintenance facilities in District 7. Shading indicates garages without access to sanitary sewer for the disposal of truck wash water.

County	Garage Name	Total Number of Dump Trucks	Lane Miles	Current Method of Wash Water Disposal
Auglaize County	Auglaize County - Wapakoneta	17	439.0	Sanitary Sewer
	St. Mary's Outpost			Sanitary Sewer
Champaign County	Champaign County - Urbana	10	287.2	Sanitary Sewer
	CHP -Mechanicsburg	3	89.4	Holding Tank
	CHP -Saint Paris	2	55.9	Holding Tank
Clark County	Clark County- Springfield Garage	9	157.5	Sanitary Sewer
	CLA -Harmony	4	236.0	Holding Tank
	CLA -Enon	5	142.9	Holding Tank
Darke County	Darke County - Greenville Garage	14	380.4	Sanitary Sewer
	DAR - Dawn	5	159.6	Sanitary Sewer
	Fort Jefferson OP			
Logan County	Logan County - Bellefontaine	10	263.2	Sanitary Sewer
	LOG - Lakeview	3	138.3	Sanitary Sewer
	LOG - East Liberty	5	135.7	Holding Tank
	LOG-Old Northwood OP			
Mercer County	Mercer County - Celina	10	178.7	Sanitary Sewer
	MER - Mercer	3	116.0	Holding Tank
	MER -Cassella	3	134.0	Holding Tank
Miami County	Miami County - Troy	12	322.2	Sanitary Sewer
	MIA - Piqua	5	127.5	Sanitary Sewer
	MIA-Ludlow Falls OP			
Montgomery County	Montgomery County - Hoke Rd	11	242.1	Sanitary Sewer
	MOT - Lyons Road	10	191.6	Sanitary Sewer

	MOT-Shull Road OP			Sanitary Sewer
	MOT-5994 Poe Avenue			0
Shelby County	Shelby County - Sidney	14	373.7	Sanitary Sewer
	SHE - Newport	0	-	
	SHE - Dixie	0	-	
	District 7 HQ			
	District 7 Totals	155	2,644.1

Figure 4-8: Locations of the District, County, and Outpost Garages in District 7. Garages in red lack access to sanitary sewer for truck wash water disposal.

Site Visits

Darke County

The Darke County Garage disposes of truck wash water in the sanitary sewer. There are 19 dump trucks stationed at this garage. Periodically, dump trucks from the Dawn Outpost Garage are brought to the Darke County Garage for washing.

Dawn Outpost

There are five dump trucks assigned to Dawn Outpost. Wash water generated at this garage is disposed of via sanitary sewer.

District 8

Survey

ODOT District 8 oversees maintenance operations in Butler, Clermont, Clinton, Greene, Hamilton, Preble, and Warren Counties. With the exception of Preble County, the email survey was completed by District 8. According to the Facilities Manager for District 8, the only county garage without access to sanitary sewer is the Preble County Garage, which is currently using an aeration system to manage truck wash water. There are a total of five outpost garages without access to sanitary sewer; however, truck washing is not conducted at these locations. Figure 4-9 shows the locations of the garages in District 8 highlighting those that lack access to sanitary sewer. Table 4-9 summarizes the relevant information regarding District 8.

Table 4-9: Summary of the number of trucks, lane miles, and current wash water disposal methods for maintenance facilities in District 8. Shading indicates garages without access to sanitary sewer for the disposal of truck wash water.

County	Garage Name	Total Number of Dump Trucks	Lane Miles	Current Method of Wash Water Disposal
Butler County	Butler County Garage	15	346.0	Sanitary Sewer
	Middletown	3	76.0	Leach Field or Mound
Clermont County	Clermont County Garage	12	307.0	Sanitary Sewer
	Milford/Old Milford Outpost	8	260.0	Sanitary Sewer
	New Richmond Outpost	7	244.6	Sanitary Sewer
Clinton County	Clinton Main Garage	12	360.0	Sanitary Sewer
	68.O.P	5	118.0	Aeration System
Greene County	Greene County Garage (GRECG)	14	434.0	Public Sanitary Sewer
	Huffman Dam	3	80.0	Public Sanitary Sewer
Hamilton County	Hamilton County Garage (new) (HAMCG)	18	299.0	Public Sanitary Sewer
	Blue Ash Outpost Garage (HAMPNE)	9	243.0	Public Sanitary Sewer
	Miamitown Outpost Garage (HAMPWE)	8	276.0	Leach Field or Mound
	Sharonville Outpost Garage (HAMPNO)			0
Preble County	Preble County Garage (PRECG)			Aeration System
	Eaton Outpost Garage (PREPCT)			Leach Field or Mound
	Morning Sun Outpost Garage (PREPSW)			0
Warren County	Warren County Garage	14	383.0	Sanitary Sewer
	Monroe	10	183.0	Leach Field or Mound
	District 8 HQ Office (WARHQ)			Public Sanitary Sewer
	District 8 Totals	138	2,129.0

Figure 4-9: Locations of the District, County, and Outpost Garages in District 8. Garages in red lack access to sanitary sewer for truck wash water disposal.

Site Visits

Preble County

The Preble County Garage does not have access to sanitary sewer for truck wash water disposal. Truck wash water generated at this facility is treated using an aeration system. According to district personnel, the aeration system includes a 15,000 gallon tank. Treated wash water drains into a nearby ditch.

District 9

Survey

ODOT District 9 is responsible for approximately 3,900 lane miles in the counties of Adams, Brown, Highland, Jackson, Lawrence, Pike, Ross, and Scioto. According to the Facilities Manager for District 9, during the summer of 2011, the Jackson County Garage was the last county garage in District 9 to tie in to the sanitary sewer system. All county garages in District 9 now have access to sanitary sewer for the disposal of truck wash water. Neither truck washing nor maintenance is conducted at any of the outpost garages in District 9. Figure 4-10 shows the locations of the maintenance facilities in District 9, while Table 4-10 summarizes the number of trucks and lane miles for the garages in District 9, as reported by District 9 personnel in the email survey.

Table 4-10: Summary of the number of trucks, lane miles, and current wash water disposal methods for maintenance facilities in District 9. Shading indicates garages without access to sanitary sewer for the disposal of truck wash water.

County	Garage Name	Total Number of Dump Trucks	Lane Miles	Current Method of Wash Water Disposal
Adams County	Adams County Garage (ADACG)	10	480.76	Public Sanitary Sewer
	Peebles Outpost Garage (ADAPNO)	3		0
Brown County	Brown County Garage (BROCG)	10	472.82	Public Sanitary Sewer
	White Oak Outpost Garage (BROPCT)	3		0
Highland County	Highland County Garage (HIGCG)	15	522.62	Public Sanitary Sewer
Jackson County	Jackson County Garage (JACCG)	14	441.78	Public Sanitary Sewer
Lawrence County	Lawrence County Garage (LAWCG)	7	426.39	Public Sanitary Sewer
	Proctorville Outpost Garage (LAWPSE)	3		0

	Wilgus Outpost Yard (LAWPCT)	2		0
Pike County	Pike County Garage (PIKCG)	12	381.98	Public Sanitary Sewer
Ross County	Ross County Garage (ROSCG)	18	586.69	Public Sanitary Sewer
	District 9 HQ Office (ROSHQ)			Public Sanitary Sewer
Scioto County	Scioto County Garage (SCICG)	9	482.04	Public Sanitary Sewer
	Wheelersburg Outpost Garage (SCIPSE)	4		0
	District 9 Totals	110	3,795.08

Figure 4-10: Locations of the District, County, and Outpost Garages in District 9. Garages in red lack access to sanitary sewer for truck wash water disposal.

Site Visits

Ross County Garage

The Ross County Garage maintains 587 lane miles with a fleet of 18 dump trucks. According to District 9 personnel, wash water generated at the Ross County Garage is routed to a nearby prison where it is sanitized and reused.

District 10

Survey

District 10 is located in southeastern Ohio and includes Athens, Gallia, Hocking, Meigs, Monroe, Morgan, Noble, Vinton, and Washington counties. The district headquarters is located in Marietta, Washington County. There are nine county garages and nine outpost garages maintaining approximately 4,000 lane miles with a fleet of 126 trucks in District 10. There are three county garages in District 10 without access to sanitary sewer: Meigs, Morgan, and Vinton. Wash water generated at these garages is stored in a holding tank and reused to produce brine. In addition to the three county garages, there are seven outpost garages that lack access to sanitary sewer. Summary statistics for District 10 are tabulated in Table 4-11. The locations of the garages in District 10 are shown in Figure 4-11.

Table 4-11: Summary of the number of trucks, lane miles, and current wash water disposal methods for maintenance facilities in District 10. Shading indicates garages without access to sanitary sewer for the disposal of truck wash water.

County	Garage Name	Total Number of Dump Trucks	Lane Miles	Current Method of Wash Water Disposal
Athens County	Athens	10	315.90	Sanitary Sewer
	Hollister Outpost Garage (ATHPNO)	2	79.92	Leach Field or Mound
Gallia County	Gallia	13	423.80	Sanitary Sewer
Hocking County	Hocking	12	303.54	Sanitary Sewer
	Laurelville Outpost Garage (HOCPSW)	1	89.52	Sanitary Sewer
Meigs County	Meigs	12	389.58	Holding Tank/Reuse
	Tuppers Plains Outpost (MEGPNE)	3	97.04	Sanitary Sewer
Monroe County	Monroe	10	352.83	Sanitary Sewer
	Duffy Outpost Garage (MOEPSE)	2	83.26	Leach Field or Mound
Morgan County	Morgan	12	379.02	Holding Tank
Noble County	Noble	11	398.34	Sanitary Sewer
	Belle Valley Outpost Garage (NOBPWE)	4	77.20	Leach Field or Mound
Vinton County	Vinton	8	306.72	Holding Tank
	Wilkesville Outpost Garage (VINPSE)	2	45.84	Holding Tank
Washington County	Washington	13	298.36	Sanitary Sewer
	Bartlett Outpost Garage (WASPWE)	3	64.38	Leach Field or Mound
	Belpre Outpost Garage (WASPSW)	5	125.04	Leach Field or Mound
	Macksburg Outpost Garage (WASPNO)	3	136.52	Leach Field or Mound
	District 10 HQ Office			0

	District 10 Totals	126	3,966.81	
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Figure 4-11: Locations of the District, County, and Outpost Garages in District 10. Garages in red lack access to sanitary sewer for truck wash water disposal.

Site Visits

Athens County

Ten dump trucks are currently assigned to the Athens County Garage, which has access to sanitary sewer for the disposal of truck wash water.

Meigs County

The Meigs County Garage does not have access to sanitary sewer for the disposal of truck wash water. Wash water generated at this facility is filtered and collected in a 10,000 gallon storage tank until it is needed for the production of brine that is used as part of the winter maintenance program. In addition to the 10,000 wash water storage tank, the Meigs County Garage has 18,000 gallon of storage available for brine.

Morgan County

The Morgan County Garage does not have access to sanitary sewer for the disposal of truck wash water. Wash water is collected and stored on-site in a 10,000 gallon storage tank.

Vinton County

The Vinton County Garage does not have access to sanitary sewer for truck wash water disposal. Instead, wash water generated at the Vinton County Garage is collected on-site in a 10,000 gallon holding tank.

Washington County

The Washington County Garage disposes of truck wash water via the sanitary sewer.

District 11

Survey

ODOT District 11 maintains approximately 3,300 lane miles in Belmont, Carroll, Columbiana, Harrison, Holmes, Jefferson, and Tuscarawas Counties. In District 11, there are two county garages currently lacking access to sanitary sewer for truck wash water disposal: Columbiana County Garage and Tuscarawas County Garage. According to the

Facilities Manager for District 11, full truck washing is not conducted at any facility without sanitary sewer access. Only safety washes, which include cleaning of the windows and mirrors, are permitted at these locations. Holding tanks have already been designed for the Columbiana and Tuscarawas County Garages, and were scheduled for construction during the summer of 2012. With the exception of the Apples Corner and Nashville Outpost Garages, which each have 15,000 gallon holding tanks for the collection of truck wash water, trucks from outpost garages without sanitary sewer are driven to the nearest county garage for full washing. The holding tanks at Apples Corner and Nashville Outposts are pumped for disposal approximately once per month during the winter and once per quarter during the non-winter season. The locations of maintenance facilities in District 11 are shown in Figure 4-12. The number of trucks, lane miles, and current truck wash water disposal methods are summarized in Table 4-12.

Table 4-12: Summary of the number of trucks, lane miles, and current wash water disposal methods for maintenance facilities in District 11. Shading indicates garages without access to sanitary sewer for the disposal of truck wash water.

County	Garage Name	Total Number of Dump Trucks	Lane Miles	Current Method of Wash Water Disposal
Belmont County	Belmont County - Morristown Garage	12	335.0	Sanitary Sewer
	Belmont - Barnesville Outpost	4	150.0	Leach Field or Mound
	Belmont - St. Clairsville Outpost	7	200.0	Leach Field or Mound
	Belmont-Shadyside Outpost Yard			Leach Field or Mound
Carroll County	Carroll County Garage	13	305.0	Sanitary Sewer
	Carroll - Malvern Outpost	0	-	0
Columbiana County	Columbiana County Garage	14	150.0	Leach Field/Holding Tank scheduled for summer 2012

	Columbiana - Unity Outpost	4	384.2	Leach Field or Mound
	Columbiana - Apples Corner Outpost	4	150.0	Holding Tank
Harrison County	Harrison County - Cadiz Garage	8	202.0	Sanitary Sewer
	Harrison - Scio Outpost	3	108.1	Sanitary Sewer
	Harrison - Freeport Outpost	3	74.1	Leach Field or Mound
Holmes County	Holmes County - Millersburg Garage	10	293.0	Sanitary Sewer
	Holmes - Nashville Outpost	3	59.0	Sanitary Sewer
Jefferson County	Jefferson County - Wintersville Garage	12	320.0	Sanitary Sewer
	Jefferson - Toronto Outpost	3	118.0	Leach Field or Mound
	Jefferson - Bergholz Outpost	1	39.0	Leach Field or Mound
	Jefferson-Dillonvale Outpost			Sanitary Sewer
Tuscarawas County	Tuscarawas County - New Philadelphia Garage	11	252.5	Leach Field/Holding Tank scheduled for summer 2012
	Tuscarawas - Dennison Outpost	2	64.0	Sanitary Sewer
	Tuscarawas - Zoar Outpost	2	50.0	Holding Tank
	Tuscarawas - Newcomerstown Outpost	4	116.0	Sanitary Sewer
	District 11 HQ			Sanitary Sewer
	District 11 Totals	120	3,369.9

Figure 4-12: Locations of the District, County, and Outpost Garages in District 11. Garages in red lack access to sanitary sewer for truck wash water disposal.

Site Visits

Apples Corner Outpost

The Apples Corner Outpost currently collects wash water in a 10,000 holding tank until it can be pumped and disposed of off-site using ODOT personnel and equipment. According to the current facilities manager, District 11 has previously used a contractor for wash water disposal at a cost of approximately \$3,500 to \$4,000 per trip. When District 11 began using their own tanker truck and personnel, the cost was reduced to approximately \$350 to \$400 per trip, excluding labor and fuel costs.

District 12

Survey

District 12, located in northeast Ohio, includes Cuyahoga, Geauga, and Lake Counties and is headquartered in Garfield Heights, Cuyahoga County. All of the county garages in District 12 are currently tied into sanitary sewer for truck wash water disposal; however, there are five outpost locations without sanitary sewer access. According to the Facilities Manager for District 12, these locations manage truck wash water by capturing and storing it on-site in 4,000 gallon cisterns until it is pumped and hauled to a treatment facility for disposal. On average, these tanks require pumping three to four times per year. Table 4-13 summarizes survey responses and Figure 4-13 shows the locations of the garages in District 12.

Table 4-13: Summary of the number of trucks, lane miles, and current wash water disposal methods for maintenance facilities in District 12. Shading indicates garages without access to sanitary sewer for the disposal of truck wash water.

County	Garage Name	Total Number of Dump Trucks	Lane Miles	Current Method of Wash Water Disposal
Cuyahoga County	District 12 HQ			Sanitary Sewer
	611 Cleveland Garage	12	213.0	Sanitary Sewer
	612 Independence Garage	13	364.0	Sanitary Sewer
	613 Mayfield Garage	12	290.0	Sanitary Sewer
	614 Riveredge Garage	12	257.0	Sanitary Sewer
	615 Warrensville Garage	13	303.0	Sanitary Sewer
Gauga County	Gauga County Garage (GEACG)	8	86.0	Sanitary Sewer
	Montville Outpost Garage (GEAPNE)	3	93.0	Holding Tank
	Munson Outpost Garage (GEAPNO)	3	102.0	Holding Tank
	Parkman Outpost Garage	5	142.0	Holding Tank

	(GEAPSE)			
Lake County	Lake County Garage (New) (LAKCG)			Sanitary Sewer
	Unionville Outpost Garage (LAKPNE)			Holding Tank
	Vrooman Road Outpost Garage (LAKPSE)			Holding Tank
	District 12 Totals	81	1,850

Figure 4-13: Locations of the District, County, and Outpost Garages in District 12. Garages in red lack access to sanitary sewer for truck wash water disposal.

Site Visits

Geauga County Garage

Twenty trucks are currently stationed at the Geauga County Garage. Truck washing occurs in a designated wash bay with a high pressure washing system that includes an undercarriage sprayer. According to the facilities manager, wash water generated during truck washing operations is disposed of in the sanitary sewer.

Munson Outpost Garage

There are three dump trucks stationed at the Munson Outpost Garage. Truck washing activities at this facility only include safety washes. Wash water generated during safety washing is collected in a holding tank until it is pumped and hauled to a nearby waste water treatment plant (WWTP) for disposal. At the end of each event, trucks are driven to the Geauga County Garage for a full wash.

4.2.2 Summary

A total of 66 outpost garages, 12 county garages, and 1 District garage currently lack access to sanitary sewer for truck wash water disposal. Management strategies and costs vary by district. Only two garages reported reusing wash water for the production of brine (Henry and Meigs County Garages). Districts 1, 2, and 5 reduce wash water management costs by using ODOT equipment and personnel to haul wash water for disposal. While commercial disposal costs an average of \$0.51/gallon, reported disposal costs for garages using ODOT equipment and personnel to haul wash water for disposal were \$0.10/gallon (District 2) to \$0.15/gallon (District 1). The use of a retention pond for the collection of truck wash water in District 2 increases wash water disposal costs, as the pond requires frequent pumping to maintain the water level. During winter 2011, more

than 600,000 gallons were pumped from the pond and disposed of at a nearby treatment facility. Figure 4-14 summarizes the locations of ODOT maintenance facilities lacking access to sanitary sewer.

Figure 4-14: Summary of locations lacking access to sanitary sewer.

4.3 Identification of Viable Management Strategies

Based on the literature review and the current state of the practice of truck wash water management determined through interviews with other state DOT, eighteen potential management strategies were identified (Figure 4-15). The list of options was narrowed based on feedback from ODOT and other state DOT. As a result of negative

feedback from state DOT that have tried reusing truck wash water for truck washing, this option was immediately eliminated as a viable management strategy for ODOT maintenance facilities. Treatment with an RO system was also eliminated immediately. With salt concentrations at the levels found in undiluted truck wash water (Alleman, et al., 2004, Miller, et al., 2012), RO treatment would be expected to reduce the volume of waste water by one-half, meaning that half of the total volume of wash water would still require an alternative management strategy (VTRC, 2006, Asano, et al., 2007). Direct reuse of the wash water for the production of brine that could be placed back on Ohio's roadways was also eliminated as a viable management strategy because copper and zinc concentrations in the wash water generated at ODOT maintenance facilities exceed the concentrations allowable for reuse (Miller, et al., 2012). Batch and column tests conducted to assess the effectiveness of media filtration for the removal of copper and zinc from truck wash water indicated that, with filtration, reuse may be a viable management option for ODOT (Miller, et al., 2012).

Figure 4-15: Summary of management options identified through an assessment of the current state of wash water management. Based on feedback from DOT personnel, options in gray were eliminated immediately. Options in orange were included in a detailed evaluation.

4.3.1 Preliminary Assessment of Reuse of Wash Water

To maximize the cost savings that could be achieved by reusing truck wash water for the production of brine, the volume of wash water generated should be comparable to the volume of brine needed. The volume of brine made over the last five winter seasons was compared to the estimated volume of wash water generated in each of ODOT's 12 Districts.

4.3.1.1 Evaluation of Brine Usage

Many ODOT facilities are currently using salt brine as part of routine winter maintenance (ODOT, 2011). Figure 4-16 shows the volume of brine made by each of the twelve ODOT districts and the total volume of brine made in Ohio over the last five winter seasons. Table 4-14 shows the total volume of salt brine made in each ODOT District over from 2006 through 2011. As shown in Figure 4-16 and Table 4-14, District 4 consistently produces and uses the highest volume of brine. Over the past five winter seasons, the average volume of brine used per year in District 4 was 1,792,259 gallons. The total volume of brine used by all twelve ODOT districts over the last five years ranged from a minimum of 5,784,040 gallons (winter 2009/2010) to a maximum of 7,107,050 gallons (winter 2006/2007) with a median volume of 6,565,189 gallons.

Figure 4-16: Volume of Salt Brine Produced by Each ODOT District and Total Volume of Salt Brine Made by all ODOT Facilities from Winter 2006 through Winter 2011. Data Provided by ODOT Transportation Management System (TMS).

Table 4-14: Total volume of salt brine used in each of the twelve ODOT districts for winter 2006 through winter 2011. All volumes reported in gallons. Data provided by ODOT TMS.

	Winter 2006/2007	Winter 2007/2008	Winter 2008/2009	Winter 2009/2010	Winter 2010/2011
District	Total Volume of Salt Brine Used	Total Volume of Salt Brine Used	Total Volume of Salt Brine Used	Total Volume of Salt Brine Used	Total Volume of Salt Brine Used
D01 Totals	1,285,578	1,378,417	925,976	1,121,061	641,856
D02 Totals	333,105	444,718	617,110	370,858	507,938
D03 Totals	358,640	389,452	405,057	202,947	363,122
D04 Totals	2,033,541	1,603,334	1,583,099	1,816,303	1,925,023
D05 Totals	659,631	564,659	1,012,200	524,626	493,591
D06 Totals	810,814	871,676	585,419	476,065	358,301
D07 Totals	435,514	706,920	418,012	306,522	449,020
D08 Totals	309,229	425,232	30,450	135,090	44,700
D09 Totals	94,725	44,520	16,923	14,725	26,581
D10 Totals	286,078	317,121	465,371	479,379	539,931
D11 Totals	254,615	86,549	309,387	141,482	226,801
D12 Totals	245,581	248,025	196,187	194,983	386,448
ODOT Totals	7,107,050	7,080,622	6,565,190	5,784,040	5,963,312
ODOT Average	592,254	590,052	547,099	482,003	496,943
ODOT Median	345,872	434,975	441,691	338,690	417,734

4.3.1.2 Comparison of the Volume of Brine Made with the Volume of Wash Water Generated

The volume of wash water generated at each ODOT maintenance facility was estimated using Equation 3-1. The estimated volumes at each garage within a District were summed to obtain the District total estimate, and the District estimates were summed to obtain the ODOT estimated total annual volume of wash water. Estimates of the volume of truck wash water generated were incomplete in Districts 8 and 12, with two counties not participating in the survey. These volumes were then compared with the five year average volume of brine made in each District to evaluate the viability of reusing truck wash water for the production of brine.

Figure 4-17 shows the geographic distribution of the estimated volume of wash water generated and the volume of brine made by county. As expected, in the southern part of the state, where winters tend to be milder, less brine is made and less wash water is generated. In counties where the volume of wash water generated approximates the volume of brine made, reuse may be a viable option for truck wash water management.

Figure 4-17: Comparison of the volume of brine made by ODOT maintenance facilities in each of Ohio's 88 counties with the estimated volume of wash water generated.

Figure 4-18 shows a graphical comparison of the estimated annual volume of wash water generated with the five year average volume of brine made in each ODOT District. The estimated annual volume of wash water generated by all ODOT Garages for which data were available was approximately 19 million gallons, while the five year average volume of brine made by all ODOT maintenance facilities was approximately 6.5 million gallons. Based on these estimates, if all of the wash water generated at ODOT maintenance facilities were collected for reuse, at the current levels of brine use, approximately 12.5 million gallons of wash water would still require disposal. While these estimates imply that widespread reuse as a strategy for the management of truck

wash water would be impractical, the reuse of truck wash water at individual maintenance facilities may still be a viable option.

Figure 4-18: Comparison of the volume of wash water generated in each of ODOT's 12 Districts with the 5-year average volume of brine made. The totals for all of ODOT are shown in the top right.

4.3.2 Final Management Option Identification

Water quality monitoring during winter 2011 indicated that direct reuse of wash water for the production of brine would not be a viable management strategy in Ohio.

Copper and zinc concentrations in the wash water exceeded the allowable levels for direct application on Ohio's roadways (Miller, et al., 2012). Figure 4-19 shows the

additional wash water management strategies that were eliminated as a result of the truck wash water quality assessment.

Figure 4-19: Elimination of management alternatives based on the detailed analysis of water quality and costs.

After eliminating strategies that did not appear feasible for implementation at ODOT maintenance facilities, six management strategies were identified for detailed cost analysis (Figure 4-20):

1. Tie into sanitary sewer
2. Off-site Disposal
 - a. Commercial disposal using a contractor;
 - b. Disposal at a WWTP using ODOT equipment and personnel;
 - c. Disposal at a nearby ODOT garage with access to sanitary sewer using ODOT equipment and personnel;
3. Treatment
 - a. Media filtration to remove heavy metals and disposal at a nearby ODOT garage with access to sanitary sewer using ODOT equipment and personnel;
 - b. Media filtration and reuse for brine.

Figure 4-20: Final list of viable alternatives for truck wash water management at maintenance facilities lacking access to sanitary sewer.

Tie Into Sanitary Sewer

Tying into the sanitary sewer is the preferred management strategy for truck wash water generated at ODOT maintenance facilities. This option has high capital costs, which depend on the distance to the point of access, but low operating costs.

Commercial Disposal

Three off-site disposal options were identified: commercial disposal, disposal at a WWTP, and disposal at an existing ODOT garage with sanitary sewer access.

Commercial disposal refers to the use of an independent contractor for pumping, hauling, and disposing of truck wash water. In areas where this option is available, it will have low capital and maintenance costs. To implement this strategy, a holding tank system, including an oil/water separator, would be required. Hauling and disposal costs are typically assessed in the form of a unit cost in \$/gallon and depend on the total annual volume of wash water generated.

Haul to WWTP

To eliminate contractor costs, an alternative off-site disposal strategy would be to transport wash water to a WWTP using ODOT equipment and personnel. This option has the same capital costs as commercial disposal, but lower annual costs for hauling and disposal. The actual costs for hauling and disposal will depend on the distance to the WWTP and the volume of wash water generated. In addition, baseline water quality monitoring may be required to show that the wash water will not interfere with the treatment process, and volume limitations may be imposed by the treatment facility. To pursue this disposal option, the individual maintenance facilities would need to locate a treatment plant willing to accept the wash water (based on wash water quality standards

or limits) and negotiate disposal fees and volume limitations. The final cost will depend on the monitoring requirements and disposal fees, which are dictated by the individual treatment facilities.

Haul to ODOT Garage with Sewer Access

A third off-site disposal option is to haul truck wash water to a nearby ODOT maintenance facility with access to sanitary sewer. Because some sewer districts prohibit hauling waste water from outside the sewer district for disposal, the viability of this option would have to be evaluated on a site-by-site basis by working with local sewer treatment plants. Disposal fees are generally assessed based on water usage, so an agreement regarding payment for the disposal of additional water without additional water usage would need to be made. Prior to pursuing any of these disposal options, a local WWTP must be contacted for their rules and regulations regarding waste water disposal. The capital costs for this disposal option are the same as for commercial disposal and disposal at a WWTP, but the disposal costs would likely be lower than disposal at a WWTP.

Haul to ODOT Garage with Sewer Access and Filtration Unit

Although water quality analysis has shown that the quality of the truck wash water is likely to be adequate for direct disposal, individual treatment facilities have the option of setting water quality limits for specific parameters, like heavy metals. If a facility has a problem meeting their discharge permit requirements for a specific parameter, or is discharging upstream of a sensitive area, they may require that waste water being discharged into the sanitary sewer be treated to reduce contaminant concentrations prior to disposal. This option was included in the cost analysis, but its

applicability will vary by location. The capital costs associated with treatment and disposal include the filtration unit and wash water storage. The filtration unit would be installed at a garage with access to sanitary sewer, while the storage would be installed at the garage without sanitary sewer access. Annual operating costs would include hauling, monitoring, and filtration media replacement.

Haul to ODOT Garage with Filtration and Brine Production Equipment

A final option included in the cost assessment was to process truck wash water through a media filtration system to reduce heavy metals concentrations and reuse the water for the production of brine. The option of reusing wash water may not be available to all maintenance facilities. The ability to reuse the wash water will depend on site specific truck wash water quality and regional reuse standards. Initial water quality results suggest that the wash water quality is not adequate for reuse without treatment. However, because each county already has access to brine production equipment and storage, the total cost of reuse would only include hauling, monitoring, and filtration at the county garage (ODOT, 2011). To implement this option, a filtration unit would be installed at a garage with access to sanitary sewer, and a holding tank system would be installed at the garage lacking sanitary sewer access and wash water would be hauled to the location of the filtration unit for treatment and brine production. Many of the smaller satellite maintenance facilities do not produce their own brine, and do not generate enough wash water to justify the installation of filtration and reuse systems.

4.4 Cost Analysis

The cost analysis included the identification of values, or processes for calculating values, for the factors contributing to the overall cost of each management alternative as well as the calculation of annualized costs for each management alternative.

4.4.1 Cost Factors

Storage

For garages lacking access to sanitary sewer, all of the management options require that truck wash water be collected on-site using a holding tank system. Based on information provided by ODOT District 4 Garages, the approximate cost of the installation of an underground storage tank system for the collection of truck wash water is \$30,000. This includes a 3,000 gallon fiberglass UST, 500 gallon oil/water separator, and electrical components.

Filtration

Based on information provided by vendors, the capital cost for a system capable of treating ten gallons per minute would be \$30,000 and the annual cost of media replacement would be approximately \$4,600. The actual media replacement costs would depend on site specific water quality and quantity and could be determined more accurately through pilot testing.

Disposal

The annual cost of off-site disposal was calculated as the annual volume of wash water generated (Equation 3-1) multiplied by the unit cost for disposal, which was dependent on the disposal location: commercial, WWTP, or nearby ODOT garage with sanitary sewer access.

Commercial disposal costs are likely to vary across the state of Ohio and could be as low as \$0.08/gallon, or as high as \$0.54/gallon, based on estimates provided by independent contractors. Rather than using the best case scenario of \$0.08/gallon or the worst case scenario of \$0.54/gallon, an average disposal cost of \$0.30/gallon was used to calculate commercial disposal costs.

To assess the cost for ODOT to dispose of wash water at a WWTP using ODOT equipment and personnel, a unit disposal rate of \$0.05/gallon was used. This is the disposal rate currently paid by the Henry County Garage in ODOT District 2. For disposal at an existing ODOT facility with access to sanitary sewer, a disposal cost of \$0.01/gallon was used.

Hauling

Hauling costs depend on the distance to the disposal or reuse location, which varies by maintenance facility. To calculate the hauling costs, the labor cost and truck operating costs were calculated separately, based on the distance to the disposal location, and summed. To accurately determine the cost of an employee, the hourly rate was multiplied by 1.5 to account for salary and benefits (Bureau of Labor Statistics, 2012). Using an hourly wage of \$17/hour for a driver (ODOT District 2 personnel), a total hourly cost of \$26.35 was used in the labor cost calculation. The calculation assumed

that approximately one hour would be required to load and unload the truck during each trip (based on a reasonable pumping rate), and that the average truck speed would be 45 miles per hour.

The cost of operating a truck to haul the wash water to a disposal or reuse location includes fuel, depreciation, purchase, insurance, maintenance, and permits. To determine the cost of fuel per mile, a diesel fuel cost of \$4.15 per gallon (U.S. Energy Information Administration, 2013), and an average fuel efficiency of 7 miles per gallon (Barnes and Langworthy, 2003) were used. This yields a fuel cost of \$0.59/mile. An additional \$0.53/mile was added to the fuel cost to account for other truck operating costs (Barnes and Langworthy, 2003, Trego and Murray, 2009, and American Transportation Research Institute, 2011), bringing the total operating cost to \$1.12/mile (Table 4-15). To calculate the total operating costs, the roundtrip distance was multiplied by \$1.12/mile.

Table 4-15: Costs associated with the operation of a commercial vehicle

Parameter	Cost (\$/mile)	Reference
Cost of Vehicle	0.235	American Transportation Research Institute, 2011
Insurance	0.06	Trego and Murray, 2009
Repair/Maintenance	0.105	Barnes and Langworthy, 2003
Tires	0.03	Trego and Murray, 2009
Depreciation	0.08	Barnes and Langworthy, 2003
Permits/Licenses	0.023	Barnes and Langworthy, 2003, American Transportation Research Institute, 2011
Subtotal	0.53	
Fuel	0.59	US Energy Information Administration, 2013, Barnes and Langworthy, 2003
Total Cost	1.12	

To calculate the cost of hauling for each trip to the disposal location, the labor and operating costs were summed. Because multiple trips to the disposal location would be required each year, the total number of trips was calculated based on the volume of wash water generated and the volume of storage available. It was assumed that a 2,000 gallon tanker truck is available in each District for hauling wash water (District 10 personnel). The annual number of trips was calculated as the total estimated volume divided by 2,000.

Water Quality Monitoring

Water quality monitoring costs were included as a fixed cost factor for all of the management options with the exception of tying into the sanitary sewer. The annual cost of wash water quality monitoring was established using information provided by the Henry County Garage in District 2, which has an existing truck wash water quality monitoring program approved by the Ohio EPA. As part of their reuse program, the Henry County Garage is required to monitor for 17 Heavy Metals, phosphorus, cyanide, fluoride, oil and grease, methylene blue active substances (MBAS), pesticides, and herbicides. It is likely that herbicides and pesticides would be monitored on an annual basis, while all other parameters would be monitored quarterly. As shown in Table 4-16, the annual water quality monitoring cost would be \$1,385 based on cost estimates provided by TestAmerica (Canton, OH).

Table 4-16: Breakdown of laboratory costs for wash water quality monitoring (Pricing from TestAmerica). Costs assumes that samples would be analyzed for herbicides and pesticides on an annual basis and all other parameters on a quarterly basis.

Parameter	Cost/Sample	Annual Cost
Metals (excluding lithium)	\$120	\$480
Lithium	\$25	\$100
Cyanide	\$25	\$100
Phosphorus	\$30	\$120
Oil and Grease	\$35	\$140
Pesticides	\$90	\$90
Herbicides	\$135	\$135
MBAS	\$40	\$160
Fluoride	\$15	\$60
Total		\$1,385

Table 4-17 summarizes the values of cost factors used in the calculation of the annualized cost of each management option.

Table 4-17: Cost values used in the calculation of annualized wash water management costs. All variable costs are calculated based on site specific conditions.

Strategies		Capital		Annual	
1	Sanitary Sewer	Construction	Variable	Disposal	Variable
2a	Commercial Disposal	Storage	\$30,000	Hauling and Disposal	\$0.30/gallon
2b	Disposal at WWTP	Storage	\$30,000	Water Quality Monitoring	\$1,385
				Hauling	Variable
				Disposal	\$0.05/gallon
2c	Disposal at ODOT Garage with Sewer Access	Storage	\$30,000	Water Quality Monitoring	\$1,385
				Hauling	Variable
				Disposal	\$0.01/gallon
3a	Filtration and Disposal at ODOT Garage with Sewer Access	Storage	\$30,000	Water Quality Monitoring	\$1,385
		Filtration Unit	\$30,000	Hauling	Variable
				Disposal	\$0.01/gallon
				Media Replacement	\$4,600
3b	Filtration and reuse at County Garage	Storage	\$30,000	Water Quality Monitoring	\$1,385
		Filtration Unit	\$30,000	Hauling	Variable
				Media Replacement	\$4,600

4.4.2 Cost Assessment

The cost assessment of alternative management options was carried out for a typical ODOT county garage, which was defined as a facility with 12 trucks and 30 winter events and a typical ODOT outpost garage, which was defined as a facility with 3 trucks and 30 winter events. The statistical mode of the number of trucks for county and outpost garages, as reported by ODOT personnel, was used to represent the number of trucks at a typical facility. To determine the number of winter events at a typical facility, the spatial distribution of the three year average number of winter events (2008-2011) at ODOT's 88 county garages was evaluated. As shown in Figure 4-21, 52% of county garages had a three year average number of winter events between 24 and 36, with a higher number of events in the northeastern part of the state, and fewer events in the southern part of the state. Because the number of winter events at outpost garages is not recorded by ODOT, it was assumed that the number of events at an outpost location was the same as the number of events at the county garage in the same county. Under this assumption, 72 of the 136 (53%) of outposts had a three year average number of winter events between 24 and 36. Based on the results of this assessment, a value of 30 winter events was used to represent a typical facility.

Figure 4-21: Assessment of the typical number of winter events at ODOT county garages. The surface was interpolated using the Inverse Distance Weighted (IDW) method with the 3-year average number of winter events (2008-2011) for ODOT's 88 county garages.

To calculate the cost of tying a typical facility into the sanitary sewer system, it was assumed that the capital cost would be \$300,000, which was the cost estimate provided for three outpost locations in ODOT District 4 by ODOT personnel. The annualized cost of tying into the sanitary sewer was calculated over a 40 year planning horizon, while the costs of the other management options were calculated over 12 years. The analysis also assumed that storage would be added to the garage, that the roundtrip distance to a disposal or reuse location would be 55 miles, and that a 2,000 gallon tanker would be used to haul the wash water.

Tables 4-18 and 4-19 show the estimated cost of alternative wash water management strategies for a typical county and outpost garage. As shown in Table 4-18, the annual cost to tie a typical county facility into the sanitary sewer would be \$23,810, while the annual cost to dispose of wash water at a nearby county garage would be

\$14,330. By implementing off-site disposal, rather than tying into the sanitary sewer system, an annual cost savings of approximately \$9,000 could be realized. If off-site disposal were pursued at all 12 county garages currently lacking access to sanitary sewer, rather than tying these facilities into the sanitary sewer system, a cost savings of more than \$100,000 annually could be achieved.

Table 4-18: Example of cost calculation for a typical county garage with 12 trucks and 30 winter events; analysis assumes a capital cost of \$300,000 for sewer tie-in and a hauling distance of 55 miles. The cost analysis assumed that filtration costs would be assessed to a facility with sewer access, while storage, hauling, and monitoring costs would be assessed to the garage lacking sewer access.

County Garage			
Management Alternative	Annual Cost for One County Garage	Cost Savings Versus Sanitary Sewer	Annual Cost Savings for 12 County Garages
Sanitary Sewer	23,810		
Commercial Disposal	44,366	-20,556	-246,672
WWTP	19,557	4,253	51,036
Disposal at ODOT Garage	14,330	9,480	113,760
Filtration and Disposal	22,707	1,103	13,236
Filtration and Reuse	21,400	2,410	28,920

Table 4-19 shows the results of the cost analysis for a typical outpost garage. The lowest cost option for an outpost garage under the conditions of this analysis would be disposing of wash water at a nearby ODOT facility, which had an estimated annual cost of approximately \$7,500 dollars. Pursuing off-site disposal, rather than tying this facility into sanitary sewer, could yield an annual cost savings of more than \$15,000 at each outpost location. For all 66 outpost facilities lacking access to sanitary sewer, this represents a potential annual cost savings of over \$1 million.

Table 4-19: Example of cost calculation for a typical outpost garage with 3 trucks and 30 winter events; analysis assumes a capital cost of \$300,000 for sewer tie-in and a hauling distance of 55 miles. The cost analysis assumed that filtration costs would be assessed to a facility with sewer access, while storage, hauling, and monitoring costs would be assessed to the garage lacking sewer access.

Outpost			
Management Alternative	Annual Cost for One Outpost	Cost Savings Versus Sanitary Sewer	Annual Cost Savings for 66 outposts
Sanitary Sewer	22,829		
Commercial Disposal	14,963	7,866	519,156
WWTP	8,761	14,068	928,488
Disposal at ODOT Garage	7,454	15,375	1,014,750
Filtration and Disposal	15,831	6,998	461,868
Filtration and Reuse	15,504	7,325	483,450

To evaluate the impact of site specific conditions, including the volume of wash water generated and the distance to the disposal location on the cost of each wash water management alternative, annualized costs were calculated for each management option using a high, typical, and low estimated volume and a short, typical, and long distance for hauling. The results of this analysis are shown in Tables 4-20 through 4-22. For the volume analysis, the capital cost of tying into the sanitary sewer was held constant at \$300,000 and the hauling distance was held constant at 55 miles. The low volume of 4,356 gallons of wash water was calculated for a garage with two trucks and six winter events, which was the actual number of winter events reported by the Athens County Garage in District 10 for winter 2011. The typical volume of 130,680 gallons was calculated for a facility with 12 trucks and 30 winter events, and the high volume of 309,276 was calculated for a garage with 12 trucks and 71 winter events, which was the actual number of winter events at the Ashtabula County Garage during winter 2010. As shown in Table 4-20, disposal at a nearby county garage is the most cost effective option at low volumes, but tying into the sanitary sewer system becomes the most cost effective

management strategy at high wash water volumes. This analysis suggests that tying into the sanitary sewer is a cost effective management strategy for larger facilities (i.e. with more trucks), but may not be the best management approach for smaller, outpost garages generating low wash water volumes.

Table 4-20: Evaluation of the impact of the volume of wash water generated on the cost of each alternative management option. All analyses utilized a capital cost of \$300,000 to tie into the sanitary sewer. The cost savings was calculated as the annualized cost of sanitary sewer tie in minus the annualized cost of the management alternative; negative values indicate that there is no cost savings by implementing an alternative management strategy.

Management Alternative	Annualized Cost (\$)				Cost Savings		
	Volume			% Increase in Cost	Volume		
	Low	Typical	High		Low	Typical	High
Sanitary Sewer	22,546	23,810	25,596	14%			
Commercial Disposal	6,469	44,366	97,945	1414%	16,904	-20,556	-72,349
WWTP	5,642	19,557	39,231	595%	17,078	4,253	-13,635
Disposal at ODOT Garage	5,468	14,330	26,860	391%	8,701	9,480	-1,264
Filtration and Disposal	13,845	22,707	35,237	155%	8,745	1,103	-9,641
Filtration and Reuse	13,801	21,400	32,144	133%	22,546	2,410	-6,548

For the volume analysis, the low volume of 4,356 gallons was calculated using 2 trucks and 6 winter events (actual number of winter events at the Athens County Garage during winter 2011); the high volume of 309,276 was calculated using 12 trucks and 71 winter events (actual number of events at Ashtabula County Garage during winter 2010); typical volume of 130,680 was calculated using 12 trucks and 30 events; distance was held constant at 55 miles roundtrip.

For the distance analysis, distances of 25, 55, and 125 miles roundtrip to the disposal location were used. The volume was held constant at 130,680 gallons for the analysis of the costs at a county garage, and 32,670 gallons for an outpost, and the capital cost to tie into the sanitary sewer was held constant at \$300,000. Neither the cost of tying into the sanitary sewer nor the cost of commercial disposal are dependent on hauling distance. As expected, at longer hauling distances, off-site disposal and treatment become less cost effective management options (Table 4-21, 4-22). For a typical outpost garage, the lowest cost management option, disposal at a nearby county garage, has a cost

of approximately \$6,600 at a hauling distance of 25 miles, but the cost increases to \$9,400 at a hauling distance of 125 miles (Table 4-21). For a county garage, the lowest cost option, disposal at a nearby ODOT facility, has an annualized cost of approximately \$11,000 at a distance of 25 miles, but the annualized cost increases to more than \$22,000 at a hauling distance of 125 miles (Table 4-22). When compared with the cost of tying into the sanitary sewer, off-site disposal is always more cost effective than tying into the sanitary sewer for a typical outpost when the hauling distance is less than 125 miles. For a typical county garage, the potential cost savings of off-site disposal at a roundtrip hauling distance of 125 miles may not be large enough to offset the increased complexity in logistics and planning required to pursue this option.

Table 4-21: Assessment of the impact of hauling distance on the annualized cost of alternative wash water management strategies at a typical outpost with 3 trucks and 30 winter events.

	Distance				Cost Savings		
				% Increase in Cost			
	Short	Typical	Long		Short	Typical	Long
Sanitary Sewer	22,829	22,829	22,829	0%			
Commercial Disposal	14,963	14,963	14,963	0%	7,866	7,866	7,866
WWTP	7,924	8,761	10,714	35%	14,905	14,068	12,115
Disposal at ODOT Garage	6,617	7,454	9,408	42%	16,212	15,375	13,421
Filtration and Disposal	14,994	15,831	17,785	19%	7,835	6,998	5,044
Filtration and Reuse	14,667	15,504	17,458	19%	8,162	7,325	5,371

Table 4-22: Assessment of the impact of hauling distance on the annualized cost of alternative wash water management strategies at a typical county garage with 12 trucks and 30 winter events.

	Distance				Cost Savings		
				% Increase in Cost			
	Short	Typical	Long		Short	Typical	Long
Sanitary Sewer	23,810	23,810	23,810	0%			
Commercial Disposal	44,366	44,366	44,366	0%	-20,556	-20,556	-20,556
WWTP	16,208	19,557	27,371	69%	7,602	4,253	-3,561
Disposal at ODOT Garage	10,981	14,330	22,144	102%	12,829	9,480	1,666
Filtration and Disposal	19,358	22,707	30,521	58%	4,452	1,103	-6,711
Filtration and Reuse	18,051	21,400	29,214	62%	5,759	2,410	-5,404

For the distance analysis, the short distance was 15 miles roundtrip; the typical distance was 55 miles roundtrip; and the long distance was 125 miles roundtrip; the volume was held constant at 130,680 for a county garage and 32,670 for an outpost garage.

To evaluate the impact of the capital cost of tying into the sanitary sewer on the cost effectiveness of this management strategy, the annualized cost of tying into the sanitary sewer was calculated for capital cost values ranging from \$100,000 to \$800,000. The annualized cost for the sewer tie in at each value was then compared with the annualized cost of each alternative management option calculated for a typical county garage and a typical outpost garage. The hauling distance was held constant at 55 miles for this analysis. To assess the potential cost savings of implementing an alternative to tying into the sanitary sewer, the annualized cost of each management option was subtracted from the annualized cost of tying into the sanitary sewer. As shown in Figure 4-22, at a capital cost of \$100,000, tying into the sanitary sewer is the most cost effective management strategy for a typical county garage; however, at a capital cost of \$600,000, it is the least cost effective of the management options identified.

Figure 4-22: Annualized cost savings that could be achieved by implementing an alternative to tying into the sanitary sewer at a typical county garage. Savings was calculated as the annualized cost of tying into the sanitary sewer for different values of capital cost minus the annualized cost for the management option. Values above zero indicate a potential cost savings over tying into the sanitary sewer. Annualized costs for alternative management options were calculated for a typical county garage with 12 trucks and 30 winter events and a hauling distance of 55 miles.

As shown in Figure 4-23, for a typical outpost garage, off-site disposal at a nearby county garage is always more cost effective than tying into the sanitary sewer when the hauling distance is less than 55 miles. When the capital cost of tying into the sanitary sewer is \$200,000, all three of the off-site disposal strategies are more cost effective than tying into the sanitary sewer (when hauling distance is less than 55 miles), and at a capital cost of \$300,000 to tie into the sanitary sewer, all of the management options identified are more cost effective than tying into the sanitary sewer under the conditions

of this cost analysis. This suggests that for outpost garages, there may be a more cost effective strategy for managing wash water than tying into the sanitary sewer.

Figure 4-23: Annualized cost savings that could be achieved by implementing an alternative to tying into the sanitary sewer at a typical outpost garage. Savings was calculated as the annualized cost of tying into the sanitary sewer for different values of capital cost minus the annualized cost for the management option. Values above zero indicate a potential cost savings over tying into the sanitary sewer. Annualized costs for alternative management options were calculated for a typical outpost garage with 3 trucks and 30 winter events and a hauling distance of 55 miles.

CHAPTER V

CONCLUSIONS

The purpose of this research was to identify potential options for managing truck wash water generated at ODOT maintenance facilities that do not have access to sanitary sewer, to assess their costs, and to compare the costs of alternative management strategies with the cost of tying into the sanitary sewer. Based on the results of a literature review, interviews with state DOT personnel, and water quality data collected at ODOT maintenance facilities during the winter of 2011/2012, the following six viable management options were identified for detailed cost assessment: tying into the sanitary sewer, use of a contractor to pump and haul wash water to a disposal location, collection and disposal of wash water at a WWTP, collection and disposal of wash water at a nearby ODOT facility, filtration and disposal, and filtration and reuse.

A preliminary assessment of the viability of reusing truck wash water generated at ODOT maintenance facilities was conducted. Estimation of the volume of wash water generated by ODOT maintenance facilities indicated that the volume of wash water generated (approximately 19 million gallons) by all ODOT maintenance facilities greatly exceeds the volume of brine used by ODOT in a typical winter (approximately 6.5 million gallons). This suggests that even if reuse were implemented at all maintenance facilities, approximately 12.5 million gallons of wash water would still require disposal. While this option does not appear to be viable on a widespread scale, individual

maintenance facilities may be able to implement successful reuse programs depending on the volume of wash water generated and the volume of brine needed.

Cost factors were identified for each management option, and their values determined through consultation with vendors and contractors. Processes for calculating variable costs, including hauling and disposal, were developed and used to calculate the annual cost of each wash water management option for typical ODOT county and outpost garages. Results showed that an annual cost savings of approximately \$9,000 at a county garage and \$15,000 at an outpost garage could be achieved by collecting and disposing of wash water at a nearby ODOT maintenance facility, rather than tying into the sanitary sewer. Extrapolating these results to the 12 county garages and 66 outpost garages currently lacking access to sanitary sewer, an annual cost savings of \$1.1 million could be achieved by implementing an alternative to tying into sanitary sewer.

The influence of the volume of wash water generated and the hauling distance on the cost of each management option was assessed. The volume of wash water had a larger impact on the cost than hauling distance. At low volumes, all of the management options identified would yield a cost savings when compared with the cost of tying into the sanitary sewer, while at high volumes, none of the management options identified are more cost effective than tying into sanitary sewer.

The cost effectiveness of alternative management options also depends on the capital cost of tying into the sanitary sewer. Under the typical volume scenario for a county garage, at a capital cost of \$100,000, tying into the sanitary sewer is the most cost effective wash water management strategy. At a capital cost of \$300,000, disposal at a WWTP, disposal at a nearby garage, filtration and disposal, and filtration and reuse

become more cost effective than tying into the sanitary sewer. For a typical outpost garage, which generates lower volumes of wash water, , off-site disposal at a nearby county garage is always more cost effective than tying into the sanitary sewer when the hauling distance is less than 55 miles. When the capital cost of tying into the sanitary sewer system is greater than \$300,000, all of the management options identified are more cost effective than tying into the sanitary sewer under the conditions of this cost analysis.

This research suggests that tying into the sanitary sewer is not always the most cost effective management strategy and that alternative strategies should be considered based on individual garage conditions. The volume of wash water generated, distance to the disposal location, and the capital cost of sanitary sewer tie in are all factors that need to be considered in determining an ideal management strategy at individual garages.

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APPENDICES

APPENDIX A
OHIO DOT SURVEY RESULTS

District 1

	Total Number of Dump Trucks	Number of Trucks Used per Winter Event		Total Lane Miles (per garage or outpost)			
		Low End Estimate	High End Estimate	Priority	General	Urban	Total
COUNTY GARAGES							
Allen County	8	4	8	245	178	47	470
Defiance County	13	6	13	46.288	249.626	44.439	340.353
Hancock County	15	8	15	241.69	330.34	50.91	622.94
Hardin County	9	7	8	91	243	0	334
Paulding County	12	4	10	83.78	308.86	0	392.64
Putnam County	15	7	14	106.6	346.85	0	453.45
Van Wert County	15	8	15	103.92	270.6		374.52
Wyandot County	14	4	14	178.2	283.2	15.4	476.8
							0
							0
OUTPOST GARAGES							
Delphos	3	3	3	245	178	47	470
4th Street	4	4	4	245	178	47	470
Beaverdam	4	4	4	245	178	47	470
Hicksville	1	1	1				0
SR 12 Outpost	6	2	6				0
Roundhead	2	1	2				0
Carey	2	1	2				0

	Estimated Time to Conduct Full Wash of One Truck			Time to Conduct Quick Wash of one Truck minutes	Type of Hose	Flow Rate from Hose gpm	How was Flow Rate Determined?	Washwater Storage			Washwater Disposal	
	Low End Est. minutes	High End Est. minutes	Conduct Quick Wash of one Truck minutes					Total Oil Water Separator Capacity gallons	Total Sand Trap Capacity gallons	Total Other Storage Capacity gallons	Method	If not using public sewer, estimated Cost for disposal \$/gallon
COUNTY GARAGES												
Allen County	Full and Quick Wash	30	60	15	Pressure &	P=3.8gpm	estimated	2000			Sanitary Sewer	N/A
	Full and Quick Wash	20	45	20	Pressure Washer	5.5gpm		40	n/a		Sanitary Sewer	N/A
Hancock County	Full and Quick Wash	7 min.	30 min.	7 min	pressure washer @ 4						Sanitary Sewer	N/A
Hardin County	Full and Quick Wash	15	90	15	3/4" high Vol	12 gpm	Timer/Measured	2000 gal		n/a	Sanitary Sewer	N/A
Paulding County	Full and Quick Wash	15	60	15	high pressure	3	manufacturer	1,500 ga.		N/A	Storm Sewer	
Putnam County	Full and Quick Wash	30	120	30	3/8 hp 50'	4.0 gpm	tested 1/11/12	2000		0	Sanitary Sewer	N/A
Van Wert County	Full and Quick Wash	60	120	20	2000 PSI	3.9 GPM	SPECTS	2900			Sanitary Sewer	N/A
Wyandot County	Full and Quick Wash	45	90	15	1"	10	time x gal.				Sanitary Sewer	N/A
OUTPOST GARAGES												
Delphos	Full and Quick Wash	30	60	15	Pressure Wash	P=4gpm F=	estimated				Sanitary Sewer	N/A
4th Street	Full and Quick Wash	30	60	15	Pressure Wash	P=4gpm	estimated	500			Sanitary Sewer	N/A
Beaverdam	None	na	na	na	na	na		1000				
Hicksville	None											
SR 12 Outpost	Quick Wash Only	7 min.	30 min.	7 min.	fire hose	10		n/a		n/a	Sanitary Sewer	N/A
Roundhead				do not wash at this facility								
Carey	None										2500 Holding Tank	

	Is Brine Produced at this Location?	What Model of Brine Production Unit is Used?	Estimated Brine Production Rate gallons per day	Brine Storage Volume gallons	Are Liquids Other than Sodium Chloride Used for Pretreating?	Alternative Deicing Liquids	
						Type	Storage Volume gallons
COUNTY GARAGES							
Allen County	Yes	Self Made	6000	18000	No	CACL Liquid	3000
Defiance County	Yes	Homemade	5000		No	Calcium	9000
Hancock County	Yes	homemade brine maker	10,000	12,000	No		
Hardin County	Yes	ABS-1500 Brine System	2000	8000	No		
Paulding County	Yes	Homemade	375	15,500	No		
Putnam County	Yes	Homemade	12,100 gal	14,400 gal	No	Calcium Chlor	10,000 gal
Van Wert County	Yes	Homemade	9,000 TO 11,000	12000	No		
Wyandot County	Yes	made inhouse	20,000	32,700	No	Beet Heat	6100
-							
OUTPOST GARAGES							
Delphos	No			2000			
4th Street	No			3000			
Beaverdam	No			1500			
Hicksville	No						
SR 12 Outpost	No	n/a	n/a	3000	Yes	Liquid Calcium	3000
Roundhead	No						
Carey	No			9,000	No		

District 2

	Total Number of Dump Trucks	Number of Trucks Used per Winter Event		Total Lane Miles (per garage or outpost)			
		Low End Estimate	High End Estimate	Priority	General	Urban	Total
COUNTY GARAGES							
Fulton	10	8	10		290		290
Henry	10	4	10	65	324		389
Lucas	16	6	16	171	144	144	459
Ottawa	10	8	10	55	291	12	358
Sandusky	12	8	12	176	158	59	393
Seneca	14	8	14	157	85	168	410
Williams	14	12	14		373		373
Wood	21	11	19	259	389		648
							0
OUTPOST GARAGES							
Northwood	16	8	16	307			307
Edison	4	2	4				0

	What type of Truck Washing is Conducted at this facility?	Estimated Time to Conduct Full Wash of One Truck		Estimated Time to Conduct Quick Wash minutes	Type of Hose	Flow Rate from Hose gpm	How was Flow Rate Determined?	Washwater Storage			Washwater Disposal	
		Low End Est. minutes	High End Est. minutes					Total Oil Water Separator Capacity gallons	Total Sand Trap Capacity gallons	Total Other Storage Capacity gallons	Method Select one	If not using public sewer, estimated Cost for \$/gallon
COUNTY GARAGES	Select one											
Fulton	Full and Quick Wash	30	45	20	Fire & pressure	2	meter	500			Storm Sewer	
Henry	Full and Quick Wash	10	20	5	pressure	4	5 gal. bucket	500			Sanitary Sewer Leach Field or Mound	
Lucas	None	30	60	15								
Ottawa	Full and Quick Wash	45	30	20	High Pres.	5	Mnft Label	2900			Sanitary Sewer	
Sandusky	Full and Quick Wash	8	15	5	High Pres.	4	Mnft Label	n/a			Storm Sewer	
Seneca	Full and Quick Wash	8	15	5	High Pres.	4	Mnft Label	2900			Storm Sewer	
Williams	Full and Quick Wash	30	45	20	High Pres.	10	Mnft Label	2900			Other	.05 pg
Wood	Full and Quick Wash	15	30	5	High Pres.	5	5 gal. bucket	1500			Sanitary Sewer	
-												
OUTPOST GARAGES												
Northwood	Full and Quick Wash	30	60	15	High Pres.	2	Meter reading	500			Sanitary Sewer Leach Field or Mound	
Edison	None											

	Is Brine Produced at this Location?	What Model of Brine Production Unit is Used?	Estimated Brine Production Rate gallons per day	Brine Storage Volume gallons	Are Liquids Other than Sodium Chloride Used for Pretreating?	Alternative Deicing Liquids	
	Select one				Select one	Type	Storage Volume gallons
COUNTY GARAGES							
Fulton	Yes	Snow Equipment	7000	12000	No		
Henry	Yes	Cargill Accubrine	20000	6000	No	Cal. Chr.	8000
Lucas	No			6000	Yes	Cal. Chr.	6000
Ottawa	Yes	Home made	10000	16000	Yes	Calc. Chr.	8000
Sandusky	Yes	Snow Equipment	12000	10000	Yes	Calc. Chr. & Geomelt	8000 calc.
						Geomelt	6000 geo
Seneca	Yes	Snow Equipment	12000	20000	Yes	Calc. Chr. & Geomelt	8000 cal.c
						Geomelt	6000 geo
Williams	Yes	Snow Equipment	10000	6000	Yes	Cal. Chr.	8000
						Cal. Chr. & Geomelt	8000 calc.
Wood	Yes	Cargill Accubrine	24000	24400	No		9000 geomelt
-							
OUTPOST GARAGES							
Northwood	Yes	Snow Equipment		10000	Yes	Cal. Chr. & Geomelt	10000 calc.
	No						10000 geomelt
Edison							

District 3

	Total Number of Dump Trucks	Number of Trucks Used per Winter Event		Total Lane Miles (per garage or outpost)			
		Low End Estimate	High End Estimate	Priority	General	Urban	Total
COUNTY GARAGES							
Ashland Co. Garage	16	10	14	247	161	136	544
Crawford	14	9	14	89.2	389.4		478.6
Norwalk	13	7	13	136.8	231.7	6.08	374.58
Erie County	12	4	12	189.66	117.29	0	306.95
Lorain County	12	8	12	7.2	376.4		383.6
Richland County	12	9	10	120.86	200.25	0	321.11
Wayne County	17	10	14	216.96	368.92		585.88
							0
							0
OUTPOST GARAGES							0
Petrys ville	4	3	4		41	98	139
Nova	0	0	0	0	0	0	0
Plymouth	2	2	2	14	55		69
Vermilion	2	0	2	0	88.33	0	88.33
Avon	6	4	6	124.1	43.1		167.2
Lexington Outpost	8	7	8	182.87	73.13	0	256
							0

	What type of Truck Washing is Conducted at this facility?	Estimated Time to Conduct Full Wash of One Truck		Time to Conduct Quick Wash of one Truck minutes	Type of Hose	Flow Rate from Hose gpm	How was Flow Rate Determined?	Washwater Storage			Washwater Disposal		
		Low End Est. minutes	High End Est. minutes					Total Oil Water Separator Capacity gallons	Total Sand Trap Capacity gallons	Total Other Storage Capacity gallons	Method	If not using public sewer, estimated Cost for disposal \$/gallon	
COUNTY GARAGES													
Ashland Co. Garage	Full and Quick Wash	10	20	5	fire hose	5	fac. Dept	2,000	n/a	n/a	Sanitary Sewer	N/A	
Crawford	Full and Quick Wash	60	180	30	fire hose	15	flow rate test	600	0	400	Storm Sewer		
Norwalk	Full and Quick Wash	60	180	30	fire hose	20	flow rate test	1500	0	2500	Holding Tank	0.42	
Erie County	Full and Quick Wash	60	90	20	Pressure 3/8"	5	per directions	1000	NA	NA	Storm Sewer	NA	
Lorain County	Full and Quick Wash	90	120	30	1 1/4 in	15 gal/min	bucket	1000 (in the wash facility bldg)	n/a	n/a	Sanitary Sewer	n/a	
Richland County	Full and Quick Wash	15	45	10	Pressure	4	Manufacturer	1000			Storm Sewer		
Wayne County													
-													
-													
OUTPOST GARAGES													
Perryville	None								250		Leach Field or Mou	\$2.50	
Nova	None							n/a	n/a		Other	No Plumbing	
Plymouth	None												
Vermilion	Quick Wash Only			20	Garden 5/8"	1.66GPM	per directions	1000	NA	NA	Leach Field or Mou	\$345/per1000gal	
Avon	Full and Quick Wash	90	120	30	3/4 in	15 gals/min	bucket	0	n/a	n/a	Sanitary Sewer	n/a	
Lexington Outpost	Quick Wash Only			10	Pressure	4	Manufacturer	1000			Leach Field or Mou		

		Is Brine Produced at this Location?	What Model of Brine Production Unit is Used?	Estimated Brine Production Rate gallons per day	Brine Storage Volume gallons	Are Liquids Other than Sodium Chloride Used for Pretreating?	Alternative Deicing Liquids	
							Type	Storage Volume gallons
COUNTY GARAGES								
Ashland Co. Garage	Yes	Force America	n/a	9000	12,200	No		
Crawford	Yes	Van-tech		9000	9000	No	Calcium	
Norwalk	Yes	unknown		6000	6000	No	Calcium	
Erie County	Yes	VanTech Industries		14,000	12,000	No	Liquid calcium chloride	
Lorain County	Yes	Unknown		10000	14000	No	Calcium	
Richland County	Yes	Pengwyn		4000 as needed	12000	No	Chloride	
Wayne County							calcium	
-	-							
-	-							
OUTPOST GARAGES								
Perryssville	No				6,100			
Nova	No							
Plymouth	No				6000	No		
Vermilion	No	NA			6,000	No	Liquid calcium chloride	
Avon	Yes	Unknown		12200	12200	No	Calcium	
Lexington Outpost	No				12000	No	Chloride	
							calcium	
							6000	

[illegible]

	What type of Truck Washing is Conducted at this facility? Only, Full and Quick	Estimated Time to Conduct Full Wash of One Truck		Estimated Time to Conduct Quick Wash	Type of Hose	Flow Rate from Hose	How was Flow Rate Determined?	Washwater Storage			Washwater Disposal	
		Low End Est.	High End Est.					Total Oil Water Separator Capacity	Total Sand Trap Capacity	Total Other Storage Capacity	Method	If not using public sewer, estimated
COUNTY GARAGES		minutes	minutes	minutes		gpm		gallons	gallons	gallons		\$/gallon
ATB - Seven Hills	Full and quick							3000			Sanitary Sewer	N/A
MAH - Canfield	Full and quick	20		60	10" water			3000			Sanitary Sewer	N/A
POR - Ravenna	Quick and full	20		50	10" garden/Fire	10	Bucket Test	N/A			Storm Sewer	N/A
STA - Canton	Full and quick	20		50	5" garden	10	bucket test	1500	U	U	Sanitary Sewer	N/A
SUM - Boston Heights	Full and quick							1500			Leach Field	N/A
TRU - Cortland	Full and quick	20		50	10" fire	10	bucket	1500			Sanitary Sewer	N/A
-												
-												
-												
OUTPOST GARAGES												
ATB - Conneaut								500			Sanitary Sewer	N/A
ATB - Dorset								500		3000	Holding Tank	U.55
ATB - Harpersfield								500			Sanitary Sewer	N/A
ATB - Home								500		6000	Holding Tank	U.55
ATB - Williamfield								500			Leach Field	
MAH - Bailey Rd	Full and quick	20		60	1" hose			1000			Sanitary Sewer	N/A
MAH - North Lima	none							1000			Leach Field	
MAH - Sebring	none							1000			Leach Field	
POR - Drakesburg	Quick and full	20		50	10" garden	9	Bucket Test	500		3000	Holding Tank	U.55
POR - Hoodstown	Quick only	N/A		N/A	10" Garden	11	Bucket Test	1500			Sanitary Sewer	N/A
POR - Yale	Quick only	N/A		N/A	10" Garden	6	Bucket Test	500			Leach Field	N/A
STA - Massillon	Full and quick	20		50	5" garden	10	bucket test	500 (estimate)	U	U	Sanitary Sewer	N/A
SUM - Greensburg								500			Sanitary Sewer	N/A
SUM - Interchange								1000			Leach Field	
SUM - Iwinsburg								500			storm sewer	
TRU - Brookfield	quick only	10		10	fire	10	Bucket Test	500		3000	Holding Tank	0.55
TRU - Farmington	none							500			Leach Field	
TRU - Gustavus	none							500			Leach Field	
TRU - Warren	none							N/A			None	

	Is Brine Produced at this Location?	What Model of Brine Production Unit is Used?	Estimated Brine Production Rate	Brine Storage Volume	Are Liquids Other than Sodium Chloride Used for Pretreating?	Alternative Deicing Liquids	
						Type	Storage Volume
COUNTY GARAGES	Yes/No		day	gallons	Yes/No		gallons
ATB - Seven Hills	YES	Pengwyn PLC-3000SS-HYD		53000		Calcium Chloride	8000
MAH - Canfield	No			12,000 gl		Calcium Chloride	12,000 gl
POR - Ravenna	No			0			
STA - Canton	YES	Homemade	100,000 based on a 24 hour work day	100,000	no, just brine	calcium chloride	12,500
SUM - Boston Heights	YES	Pengwyn PLC-3000SS-HYD		30000		Calcium Chloride	6000
TRU - Cortland	YES	Homemade	1000 gal/hour	12,000		calcium chloride	12,000
OUTPOST GARAGES							
ATB - Conneaut	No			6000		Calcium Chloride	6000
ATB - Dorset	No			6000		Calcium Chloride	6000
ATB - Harpersfield	No			6000		Calcium Chloride	6000
ATB - Rome	No			6000		Calcium Chloride	6000
ATB - Williamsfield	No			12000		Calcium Chloride	6000
MAH - Bailey Rd	YES	Pengwyn PLC-3000SS-HYD		40,000 gl		Calcium Chl / Beet Juice	16,000/ 10,000
MAH - North Lima	No			12,000 gl		Calcium Chl.	12,000 gl.
MAH - Sebring	No			12,000 gl		Calcium Chl.	6,000 gl
POR - Drakesburg	No			6,000 gl		Calcium Chloride	12,000 gl
POR - Rootstown	YES	Homemade	30,000 gal/24 hr	63,000	just brine	Calcium Chl. or Beet	12,000 gl
POR - Yale	No			6,000		Calcium Chloride	6,000 gl
STA - Massillon	No			24000		Calcium Chloride	6000
SUM - Greensburg	YES	Homemade	2500 gal/hour	36000		Calcium Chloride	12000
SUM - Interchange	No			18000		Calcium Chloride	12000
SUM - Twinsburg	No			18000		Calcium Chloride	12000
TRU - Brookfield	No			6000		Calcium Chloride	6000
TRU - Farmington	No			0		Calcium Chloride	6000
TRU - Gustavus	No			0		Calcium Chloride	6000
TRU - Warren	No			0		Calcium Chloride	6000

District 5

	of Dump Trucks	Number of Trucks Used per Winter Event		Total Lane Miles (per garage or outpost)			
		Low End Estimate	High End Estimate	Priority	General	Urban	Total
COUNTY GARAGES							
Coshocton County	16	10	13	117.17	348.76		465.93
Fairfield County	15	12	14	107.6	294.88	66.86	469.34
Guernsey County	12	7	17	118	180	17	315
Knox County	13	8	12	155.6	183.8		339.4
Licking County							0
Muskingum County	11	6	11	109.748	195.492	29.758	334.998
Perry County	15	10	12	379.02			379.02
OUTPOST GARAGES							
COS - New Castle	0						0
FAI -Baltimore							0
GUE - North Salem	5	3	6	47	89	0	136
GUE -Old Washington	6	3	6	42	118	0	160
KNO -Fredericktown	2	1	2		68		68
KNO -Newcastle in with Main NO Water							0
MUS -158- Dresden	5	2	5	44.872	89.582	3.56	138.014
MUS -160- Moxahala	3	1	3		58.614	5.74	64.354
MUS -161- Duncan Falls	5	2	5		135.474	2.48	137.954
LIC -Etna	7	5	6	168.1	60.6		228.7
LIC -Brownsville	5	3	4	163.5	49.22		212.72
LIC -Utica	6	4	5	154.2	109.82		264.02
LIC -Marne (Salt Reload Only)							0
DISTRICT TOTAL	108			742	2,141	125	

	What type of Truck Washing is Conducted at this facility?	Estimated Time to Conduct Full Wash of One Truck		Estimated Time to Conduct Quick Wash minutes	Type of Hose	Flow Rate from Hose gpm	How was Flow Rate Determined ?	Washwater Storage				Washwater Disposal	
		Low End Est. minutes	High End Est. minutes					Total Oil Separator Capacity gallons	Total Sand Trap Capacity gallons	Total Other Storage Capacity gallons	Method	Select one	If not using public sewer, estimated \$/gallon
COUNTY GARAGES													
Coshocton County	Wash	30	60	20	Fire	6	Timed	2000	0	0	Holding Tank	N/A	0.292
Fairfield County	Full and Quick Wash	40	60	20	Power Wash	6	PW Rating	2900	655		Sanitary Sewer	N/A	
Guernsey County	Wash	25	45	15	Pressure Washer	4	Washer	2900	655	0	Sanitary Sewer	N/A	
Knox County	Full and Quick Wash	45	70	10	Fire Hose/Rinse Pressure Washer	12	Timed@ 5min	2000			Sanitary Sewer	N/A	
Licking County	Wash	5	30	30		3	On Machine	2500	1000		Other		
Muskingum County	Wash	45	75	10		4		unknown	unknown		Storm Sewer	N/A	
Perry County	Full and Quick Wash	40	60	20	1.5" Rubber	12	6 gal 30 sec	2000	500		Sanitary Sewer	N/A	
OUTPOST GARAGES													
COS - New Castle	Wash	40	60	20	Power wash	8	PW Rating	2000	500		Sanitary Sewer	N/A	
FAI - Baltimore	Quick Wash Only			10	Garden Hose	3	Timed						
GUE - North Salem	Quick Wash Only			10	Garden Hose	3	Timed						
GUE - Old Washington	Quick Wash Only			10	Pressure	5	Timed@ 5min	None	None	None			
KNO - Fredericktown	Quick Wash Only						stated on machine	none	none	none			
Water	Quick Wash Only			10	pressure washer	3	stated on machine	none	none	none			
MUS -158- Dresden	Quick Wash Only			10	pressure washer	2	stated on machine	none	none	none			
MUS -160- Moxahala	Full and Quick Wash	45	75	10	pressure washer	3	stated on machine	unknown	unknown	none	Leach Field or Mound		
MUS -161- Duncan Falls	Quick Wash Only			10	Garden or S	3	On Machine				Sanitary Sewer		
LIC -Etna	Quick Wash Only			10	Garden or Small Pressure washer	3	On Machine				Leach Field or Mound		
LIC -Brownsville	Quick Wash Only			10	Garden or Pressure washer	4	On Machine				Other		
LIC -Ulrich	Quick Wash Only			10	Garden or Pressure washer								

	Is Brine Produced at this Location?	What Model of Brine Production Unit is Used?	Estimated Brine Production Rate gallons per day	Brine Storage Volume gallons	Are Liquids Other than Sodium Chloride Used for Pretreating?	Alternative Deicing Liquids	
						Type	Storage Volume gallons
COUNTY GARAGES							
Coshocton County	Yes	Pengwyn System	455	10,000	No	Liquid calcium	5000
Fairfield County	Yes	Pengwyn	20,000	10,000	No	Calcium	5,000
Guernsey County	Yes	Pengwyn	16,000	7900	Yes	Calcium	2600
Knox County	Yes	Penguin	6000	6000	No	Calcium	1500
Licking County							
Muskingum County	Yes	Penguin	10000	16000	Yes	Calcium Chloride	5000
Perry County	Yes	Pengwyn	13,000	6,500	No	Calcium	5,100
OUTPOST GARAGES							
COS - New Castle							
FAI -Baltimore	No				No		
GUE - North Salem	Yes	Pengwyn	5000	6100	Yes	Calcium	1550
GUE -Old Washington	Yes	Pengwyn	5000	5500	Yes	Calcium	2600
KNO -Fredericktown	No			3000			
KNO -Newcastle in with Main NO Water	No			2000			
MUS -158- Dresden	Yes	Home made	5000	2500	No		
MUS -160- Moxahala	No			1800	No		
MUS -161- Durcan Falls	Yes	Penguin	6000	5000	No		

District 6

	Total Number of Dump Trucks	Number of Trucks Used per Winter Event		Total Lane Miles (per garage or outpost)			
		Low End Estimate	High End Estimate	Priority	General	Urban	Total
COUNTY GARAGES							
D6/DEL	11	2	10	85.88	210.66		296.54
D6/FAY/Wash CH	7	2	6	96.82	116.88		213.7
D6/FRA/Westerville	13	6	12	465.8			465.8
D6/MAD/London	8	4	7	95	133		228
D6/MAR	14	9	14	202	232	0	434
D6/MRW/Mt. Gilead	10	7	10	140.62	183.19		323.81
D6/PIC	15	4	11	238		200	438
D6/UNL/Marysville	10	6	10	174	108.22		282.22
							0
OUTPOST GARAGES							0
D6/DEL/Berkshire	9	2	8	163	96.2		259.2
D6/FAY/Jeffersonville	6	2	5	97.64	149.64		247.28
D6/FRA/5th Ave	15	7	12	541.6			541.6
D6/FRA/Hilliard	13	6	12	283.9	16		299.9
D6/FRA/Grove City	13	5	10	142.7	62.64		205.34
D6/MAD/Mt Sterling	6	3	6	55	118		173
D6/MAD/West Jeff	6	3	5	91	121		212
D6/MRW/Chesterville	4	2	4	80.5	4.23		84.73
D6/UNL/Richwood	6	3	6	40.24	136.66		176.9

	What type of Truck Washing is Conducted at this facility?	Low End Est. minutes	High End Est. minutes	Time to Conduct Quick Wash of one Truck minutes	Type of Hose	Flow Rate from Hose gpm	How was Flow Rate Determined?	Total Oil Water Separator Capacity gallons	Total Sand Trap Capacity gallons	Total Other Storage Capacity gallons	Method	If not using public sewer, estimated Cost for disposal \$/gallon
COUNTY GARAGES	D6/DEL	45	75	15	2" fire, 3/4"	9	5 gallon bucket	4394	0	0	Select one	N/A
	D6/FAY/Wash CH	30	60	15	high press. low		nozzle size used	500			Holding Tank	
	D6/FRA/Westerville	8	20	5	Pressure	5		1500			Storm Sewer	
	D6/MAD/London	45	60	20	High Pressure	3	5 gal bucket	1800	0	0	Leach Field or Mou	0
	D6/MAR	60	90	10	garden hose	4	on machine	2000	n/a	n/a	Sanitary Sewer	N/A
	D6/MRW/Mt. Gilead	60	90	10	pressure. Fir	4gpm. 18.5gpm measuring.		3837 ?		0	Sanitary Sewer	N/A
	D6/PTC	60	90	15	HP Fire	8.5 /20	As in example	1250	NA		Sanitary Sewer	N/A
	D6/UNI/Marysville	20	30	15	Pressure Wa	4	Measured				Storm Sewer	
OUTPOST GARAGES												
	D6/DEL/Berkshire	45	75	15	3/4" garden,	4	5 gallon bucket	500	0	0	Sanitary Sewer	N/A
	D6/FAY/Jeffersonville	30	60	15	high press. & low		nozzle size used				Storm Sewer	
	D6/FRA/5th Ave	8	20	5	Pressure	5		1500			Storm Sewer	
	D6/FRA/Hilliard	8	20	5	Pressure	5		1500			Storm Sewer	
	D6/FRA/Grove City	8	20	5	Pressure	5		1500			Storm Sewer	
	D6/MAD/Mt Sterling	45	60	20	Fire Hose	7	5 gal bucket	0	0	0	Storm Sewer	0.01
	D6/MAD/West Jeff	45	60	20	High Pressure	3	5 gal bucket	1000	0	0	Leach Field or Mou	0
	D6/MRW/Chesterville	60	90	10	pressure. Ga	4gpm 6gpm measuring.		150 ?		0	Sanitary Sewer	N/A
	D6/UNI/Richwood	20	30	15	Pressure washer		Measured				Leach Field or Mou	

	Is Brine Produced at this Location?	What Model of Brine Production Unit is Used?	Estimated Brine Production Rate gallons per day	Brine Storage Volume gallons	Are Liquids Other than Sodium Chloride Used for Pretreating?	Alternative Deicing Liquids	
						Type	Storage Volume gallons
COUNTY GARAGES							
D6/DEL	Yes	Pengyn	6000	9000	No	0	0
D6/FAY/Wash CH	Yes	ABM3000-SS	5500	5500	No	GEOMELT	5500
D6/FRA/Westerville	Yes	Pengwyn	10000	25000	Yes	Geomelt	5000
D6/MAD/London	Yes	Pengwyn	5000	8500	No	Calcium	3500
D6/MAR	Yes	ven tech	12000	12000	Yes	geo melt	6000
D6/MRW/Mt. Gilead	Yes	Pengwyn	24000	18000	No	calcium chloride	5000
D6/PIC	Yes	Pengyn	6400 Gal/Day	5500	Yes	Geo/Calcium	16500
D6/UNI/Marysville	Yes	Pengwyn	10000	14500	No	None	
-							
OUTPOST GARAGES							
D6/DEL/Berkshire	Yes	Pengyn	6000	9000	Yes	Calcium	6000
D6/FAY/Jeffersonville	Yes	ABM3000-SS	5500	5500	No	GEOMELT	5500
D6/FRA/5th Ave	Yes	Pengwyn	10000	20000	Yes	Geomelt	5000
D6/FRA/Hilliard	Yes	Pengwyn	10000	15000	Yes	Geomelt	5000
D6/FRA/Grove City	Yes	Pengwyn	10000	5000	Yes	Geomelt	5000
D6/MAD/Mt Sterling	No		0	5500	Yes	Calcium/ Geomelt	3000/5500
D6/MAD/West Jeff	Yes	Pengwyn	5000	5500	No	Calcium	3500
D6/MRW/Chesterville	No			12000	No		
D6/UNI/Richwood	No			4500	No	None	

District 7

	of Dump Trucks	Number of Trucks Used per Winter Event		Total Lane Miles (per garage or outpost)			
		Low End Estimate	High End Estimate	Priority	General	Urban	Total
COUNTY GARAGES							
Auglaize County - Wapakoneta	17	12	17	136	303		439
Champaign County - Urbana	10	4	9	18.2	269		287.2
Clark County- Springfield Garage	9	4	9	115.57	41.97		157.54
Darke County - Greenville Garage	14	9	14	116.8	263.6		380.4
Logan County - Bellefontaine	10	7	10	59.8	203.44		263.24
Mercer County - Celina	10	6	10	46	132.72		178.72
Miami County - Troy	12	8	11	87.36	234.86		322.22
Montgomery County - Hoke Rd	11	6	10	220.5	21.6		242.1
Shelby County - Sidney	14	10	14	87.96	285.72		373.68
OUTPOST GARAGES							
CHP -Mechanicsburg	3	2	3		89.42		89.42
CHP -Saint Paris	2	1	2		55.88		55.88
CLA -Harmony	4	2	4	76.38	159.62		236
CLA -Enon	5	2	5	94.26	48.6		142.86
DAR - Dawn	5	3	5	16	143.6		159.6
LOG - Lakeview	3	3	3	22	116.3		138.3
LOG - East Liberty	5	3	5	48.8	86.92		135.72
MER - Mercer	3	2	3	71.96	44		115.96
MER -Cassella	3	2	3	14	120		134
MIA - Piqua	5	3	4	77.59	49.88		127.47
MOT - Lyons Road	10	5	8	191.64	0		191.64
SHE - Newport	0	0	0	0	0		0
SHE - Dixie	0	0	0	0	0		0

	What type of Truck Washing is Conducted at this facility? Select one	Estimated Time to Conduct Full Wash of One Truck		Estimated Time to Conduct Quick Wash minutes	Type of Hose	Flow Rate from Hose gpm	How was Flow Rate Determined ?	Washwater Storage			Washwater Disposal		
		Low End Est. minutes	High End Est. minutes					Total Oil Separator Capacity gallons	Total Sand Trap Capacity gallons	Other Storage Capacity gallons	Method	Select one	If not using public sewer, estimated \$/gallon
COUNTY GARAGES													
Auglaize County - Wapakoneta	Full and Quick Wash	30	60	20	Power Wash	4	unit spec.	1500	200		Sanitary Sewer	N/A	
Champaign County - Urbana	Full and Quick Wash	30	60	20	Power Wash	5	Bucket Test	3000			Sanitary Sewer		
Clark County - Springfield Garage	Full and Quick Wash	30	50	25	Fire hose	14	Bucket Test	1200			Sanitary Sewer	N/A	
Darke County - Greenville Garage	Full and Quick Wash	45	60	30	5/8" hose	5	Bucket Test	1500			Sanitary Sewer	N/A	
Logan County - Bellefontaine	Full and Quick Wash	30	60	20	Fire hose	8	Bucket Test	1500			Sanitary Sewer	N/A	
Mercer County - Celina	Full and Quick Wash	30	60	20	Fire hose	8	Bucket Test	1500			Sanitary Sewer	N/A	
Miami County - Troy	Full and Quick Wash	30	90	10	1" copper to rubber	25 gpm	Bucket Test	3000	None	None	Sanitary Sewer	N/A	
Montgomery County - Hoke Rd	Full and Quick Wash	10	20	10	Power wash	3	Bucket Test	3000	1000	4000	Sanitary Sewer	N/A	
Shelby County - Sidney	Full and Quick Wash	90	120	60	Power wash	3	Bucket Test	3000	0	0	Holding Tank		
OUTPOST GARAGES													
CHP - Mechanicsburg	Full and Quick Wash	30	60	20	Power wash	2	Bucket Test	500		2500	Holding Tank		\$0.11
					Fire hose	10	Bucket Test	50					
CHP - Saint Paris	Full and Quick Wash	30	60	20	Power wash	2	Bucket Test	500		2500	Holding Tank		\$0.11
					Fire hose	10	Bucket Test	50					
CLA - Harmony	Full and Quick Wash	45	80		Garden hose	4	Bucket Test			1200	Holding Tank		0.38
Full and Quick Wash	Full and Quick Wash	45	80		Garden hose	4	Bucket Test			1200	Holding Tank		0.38
CLA - Enon	Full and Quick Wash	45	80	30	5/8" hose	5	Bucket Test	500		2500	Sanitary Sewer	N/A	
DAR - Dawn	Full and Quick Wash	45	60	60	Garden hose	5	Bucket Test	500			Holding Tank		
LOG - Lakeview	Quick Wash Only	60	120	60	Garden hose	5	Bucket Test	500			Holding Tank		
LOG - East Liberty	Quick Wash Only	60	120	60	Garden hose	5	Bucket Test	500			Holding Tank		
MER - Mercer	Full and Quick Wash	30	60	20	Fire hose		Bucket Test	500			Holding Tank		
MER - Cassella	Full and Quick Wash	30	60	20	Fire hose		Bucket Test	500			Holding Tank		
MIA - Piqua	Full and Quick Wash	30	90	10	3/4" garden	10 gpm	Bucket Test	None	None	None	Sanitary Sewer	N/A	
MDT - Lyons Road	Full and Quick Wash	10	20	10	Power wash	3	Bucket Test	500	600	1100	Sanitary Sewer	N/A	
				10	1 1/2" hose	10	Bucket Test						
SHE - Newport	None												
SHE - Dittie	None												

	Is Brine Produced at this Location?	What Model of Brine Production Unit is Used?	Estimated Brine Production Rate gallons per day	Brine Storage Volume gallons	than Sodium Chloride Used for Pretreating?	Alternative Deicing Liquids	
						Type	Storage Volume gallons
COUNTY GARAGES							
	Yes	Varitech Industries	3000	6500	No	Calcium	6000
Auglaize County - Wapakoneta	Yes	Varitech Industries		6000	No	Calcium	6000
Champaign County - Urbana	Yes	Varitech Industries		12000	No	Calcium	6000
Clark County- Springfield Garage	Yes	Varitech Industries	6000	6000	No	Calcium	6000
Darke County - Greenville Garage	Yes	Varitech Industries	3000	12,000	No	Calcium	6000
Logan County - Bellefontaine	Yes	Varitech Industries	3000	6000	No	Calcium	6000
Mercer County - Celina	Yes	Varitech Industries	4500	12000	No	Calcium	6000
Miami County - Troy	Yes	Varitech SB600	6000	6000	Yes	Beet Heet	6000
Montgomery County - Hoke Rd	Yes	Varitech Industries	400	6000	No	Calcium	6000
Shelby County - Sidney							
OUTPOST GARAGES							
	No			6000	No	Calcium	3000
CHP -Mechanicsburg	No			6000	No	Calcium	3000
CHP -Saint Paris	No			6000	No	Calcium	6000
CLA -Harmony	No			6000	No	Calcium	6000
CLA -Enon	No			6000	No	Calcium	6000
DAR - Dawn	No			6000	No	Calcium	3000
LOG - Lakeview	No			3,000	No		
LOG - East Liberty	No			6,000	No		
MER - Mercer	No			6000	No		
MER -Cassella	No			6000	No		
MIA - Piqua	No			6000	No	Calcium	6000
MOT - Lyons Road	Yes	Varitech SB600	6000	5800	Yes	Beet Heet	6000
SHE - Newport	No			3000	No	Calcium	3000
SHE - Dixie	No			6000	No	Calcium	3000

District 8

	Total Number of Dump Trucks	Number of Trucks Used per Winter Event		Total Lane Miles (per garage or outpost)			
		Low End Estimate	High End Estimate	Priority	General	Urban	Total
COUNTY GARAGES							
Butler	15	8	14	68	278		346
Clermont County Garage	12	5	12	79.42	135.62	91.96	307
Clinton Main Garage	12	10	12	151	209		360
Warren	14	4	14	300	83		383
Greene	14	7	14	246	188		434
Hamilton County	18	9	15	299			299
							0
							0
							0
OUTPOST GARAGES							
Middletown	3	2	3	6	70		76
Milford Outpost	8	3	8	101.2	158.76		259.96
New Richmond Outpost	7	3	7	67.42	177.22		244.64
68.O.P	5			104	14		118
Monroe	10	4	10	183			183
Huffman Dam	3	1	3	80			80
Blue Ash Outpost	9	5	9	243			243
Miamitown Outpost	8	4	8	276			276

	What type of Truck Washing is Conducted at this facility? Select one	Estimated Time to Conduct Full Wash of One Truck				Estimated Time to Conduct Quick Wash minutes	Type of Hose	Flow Rate from Hose gpm	How was Flow Rate Determined?	Washwater Storage			Washwater Disposal		
		Low End Est. minutes		High End Est. minutes						Total Oil Water Separator Capacity gallons	Total Sand Trap Capacity gallons	Total Other Storage Capacity gallons	Method	Select one	If not using public sewer, estimated Cost for \$/gallon
COUNTY GARAGES															
Butler	Full and Quick Wash	30	45	15	garden	5	5 gallon bucket	3000	n/a	n/a	Sanitary Sewer	N/A			
Clermont County Garage	Full and Quick Wash	30	60	15	3/4"	8	5 gal bucket	1500		1500	Sanitary Sewer				
Clinton Main Garage	Full and Quick Wash	30	60	15	3/4"	10	5 Gal Bucket	1,500			Sanitary Sewer				
Warren	Full and Quick Wash	15	30	5	Pr washer	5	gallons per min	500	0	0	Sanitary Sewer				
Greene	Full and Quick Wash	10	15	5	1 inch	10	bucket	1500			Sanitary Sewer	N/A			
-															
-															
-															
OUTPOST GARAGES															
Middletown	Full and Quick Wash	30	45	15	garden	5	5 gallon bucket	n/a	n/a	n/a	Leach Field or Mo	\$525			
Milford Outpost	Full and Quick Wash	30	60	15	2"	10	5 gal bucket	1000		1000	Sanitary Sewer				
New Richmond Outpost	Full and Quick Wash	30	60	15	2"	10	5 gal bucket				Sanitary Sewer				
68 O P	Full and Quick Wash	30	60	15	3/4"	10	5 Gal Bucket	1500			Storm Sewer				
Monroe	Full and Quick Wash	15	30	5	PR washer	5	gallons per min	300	0	0	Sanitary Sewer				
Huffman Dam	Full and Quick Wash	10	15	5	1 inch	12	bucket	1500			Sanitary Sewer	N/A			
Blue Ash Outpost															
Miamitown Outpost															

	Is Brine Produced at this Location?	What Model of Brine Production Unit is Used?	Estimated Brine Production Rate gallons per day	Brine Storage Volume gallons	than Sodium Chloride Used for Pretreating? Select one	Alternative Deicing Liquids	
						Type	Storage Volume gallons
COUNTY GARAGES							
Butler	Yes	Pengwyn ABM 3000	5000	5000	No	liquid calcium	5000
Clermont County Garage	Yes	Pengwyn	8000	5000	Yes	Calcium Chloride	5000
Clinton Main Garage	No				No	L.Dow	10,000
Warren	Yes	Pengwyn ABM-3000-SS	10000	6000	No	Calcium chloride	5800
Greene		Pengyun	5000	11,000	No	liquid calcium	11,600
-							
-							
-							
-							
OUTPOST GARAGES							
Middletown	No	n/a	n/a	5000	No	liquid calcium	5000
Milford Outpost	No			5000	Yes	Calcium Chloride	5000
New Richmond Outpost	No			5000	Yes	Calcium Chloride	5000
68.O.P	Yes	Snow Equipment	1,350	5000	No	L. Dow	10,000
Monroe	No	none	0	6000	No	Cacium chloride	6000
Huffman Dam						Liquid calcium	5800
Blue Ash Outpost							
Miamitown Outpost							

	Total Number of Dump Trucks	Number of Trucks Used per Winter Event		Total Lane Miles (per garage or outpost)			
		Low End Estimate	High End Estimate	Priority	General	Urban	Total
COUNTY GARAGES							
Adams	10	0	10	99.4	381.36		480.76
Brown	10	0	13	111.16	361.66		472.82
Highland	15	0	15	1.56	497.58	23.48	522.62
Jackson	14	0	14	205.68	208.52	27.58	441.78
Lawrence	7	0	12	100.78	322.57	3.04	426.39
Pike	12	0	12	160.14	221.84		381.98
Ross	18	0	18	214.02	344.73	27.94	586.69
Scioto	9	0	13	96.8	345.17	40.07	482.04
							0
OUTPOST GARAGES							
Peebles	3	0	3				0
Whiteoak	3	0	3				0
Wilgus	2	0	2				0
Proctorville	3	0	3				0
Whealersburg	4	0	4				0

	What type of Truck Washing is Conducted at this facility? Select one	Estimated Time to Conduct Full Wash of One Truck		Estimated Time to Conduct Quick Wash minutes	Type of Hose	Flow Rate from Hose gpm	How was Flow Rate Determined ?	Washwater Storage			Washwater Disposal	
		Low End Est. minutes	High End Est. minutes					Total Oil Water Separator Capacity gallons	Total Sand Trap Capacity gallons	Total Other Storage Capacity gallons	Method Select one	If not using public sewer, estimated \$/gallon
L'JUNTY GARAGES	Full and Quick Wash	30	60	30	3/4 in garden	10 gpm	Timer/Measured	600	N/A	N/A	Sanitary Sewer	N/A
Adams	Full and Quick Wash	30	60	30	Pressure	12 gpm	Estimated	1000	N/A	N/A	Sanitary Sewer	N/A
Brown	Full and Quick Wash	60	120	45	3/4 in hose & Pressure	10 gpm	Timer/Measured	1000	N/A	N/A	Sanitary Sewer	N/A
Highland	Full and Quick Wash	45	90	30	1 in fire hose	12 gpm	Estimated	2500	N/A	N/A	Sanitary Sewer	N/A
Jackson	Full and Quick Wash	45	90	30	Steam cleaner & 2 in fire hose	12 gpm	Estimated	1500	N/A	N/A	Sanitary Sewer	N/A
Lawrence	Full and Quick Wash	60	120	45	3/4 in low & Pressure	10 gpm	Timer/Measured	1000	N/A	N/A	Sanitary Sewer	N/A
Pike	Full and Quick Wash	30	60	30	5/8 garden hose & Pressure	12 gpm	Estimated	1000	N/A	N/A	Sanitary Sewer	N/A
Ross	Full and Quick Wash	45	90	30	20 pressure	10 gpm	Estimated	3000	N/A	N/A	Sanitary Sewer	N/A
Soloto	Full and Quick Wash											
OUTPOST GARAGES												
Peebles	Quick Wash Only	30	60	30	Pressure	4 gpm	Estimated	500	N/A	N/A	Sanitary Sewer Leach Field or Mound	N/A
Whiteoak	Quick Wash Only	30	60	30	Power Washer	4 gpm	Estimated	N/A	N/A	N/A	Other	N/A
Willius	Quick Wash Only	45	90	20	Power Washer	4 gpm	Estimated	500	N/A	N/A	Sanitary Sewer Leach Field or Mound	N/A
Proctorville	Quick Wash Only	30	60	20	Pressure	4 gpm	Estimated	600	N/A	N/A	Mound	N/A
Wheelerburg	Quick Wash Only											

	Is Brine Produced at this Location?	What Model of Brine Production Unit is Used?	Estimated Brine Production Rate gallons per day	Brine Storage Volume gallons	Are Liquids Other than Sodium Chloride Used for Pretreating?	Alternative Deicing Liquids	
						Type	Storage Volume gallons
COUNTY GARAGES							
Adams	Select one No	N/A	N/A	N/A	Select one Yes	Calcium Chlor	8000
Brown	No	N/A	N/A	6000	Yes	Calcium Chlor	12000
Highland	No	N/A	N/A	N/A	Yes	Calcium Chlor	8000
Jackson	Yes	Pengwyn	5000	10000	Yes	Calcium Chlor	25000
Lawrence	Yes	Pengwyn ABM-3000-SS	5000	12200	Yes	Calcium Chlor	2000
Pike	Yes	VariTech VAR SB600	5000	5500	Yes	Calcium Chlor	12000
Ross	Yes	Pengwyn ABM-3000-SS	12000	10000	Yes	Calcium Chlor	10000
Scioto	Yes	Pengwyn ABM-3000-SS	375 gal per hour	5500	Yes	Calcium Chlor	4400
-							
OUTPOST GARAGES							
Peebles	Yes	Pengwyn ABM-3000-SS	10000	12000	Yes	Calcium Chlor	4000
Whiteoak	No	N/A			Yes	Calcium Chlor	4000
Wilgus	No	N/A			Yes	Calcium Chlor	1000
Proctorville	No	N/A			Yes	Calcium Chlor	2000
Wheelerburg	No	N/A			Yes	Calcium Chlor	4400

District 10

	Total Number of Dump Trucks	Number of Trucks Used per Winter Event		Total Lane Miles (per garage or outpost)			
		Low End Estimate	High End Estimate	Priority	General	Urban	Total
COUNTY GARAGES							
ATH	10	7	10	137	191	24	352
GAL	13	7	13	71	368	0	439
HOC	12	6	12	63	257	9	329
MEG	12	9	12	67	355	0	422
MOE	10	8	10	0	401	0	401
MRG	12	4	12	0	377	0	377
NOB	11	5	11	0	380	0	380
VIN	8	5	8	0	258	0	258
WAS	13	8	13	72	235	41	348
OUTPOST GARAGES							
Hollister Outpost Garage (ATHPNO)	2	1	2	0	78	0	78
Laurelville Outpost Garage (HOCPSW)	1	1	1	0	41	0	41
Tuppers Plains Outpost (MEGPNE)	3	1	3	65	36	0	101
Duffy Outpost Garage (MOEPSE)	2	1	2	0	32	0	32
Belle Valley Outpost Garage (NOBPWE)	4	2	4	76	14	0	90
Wilkesville Outpost Garage (VINPSE)	2	2	2	31	42	0	73
Bartlett Outpost Garage (WASPWE)	3	2	3	0	97	0	97
Belpre Outpost Garage (WASPSW)	5	3	5	32	74	4	110
Macksburg Outpost Garage (WASPNNO)	3	2	3	55	34	0	89

	What type of Truck Washing is Conducted at this facility?	Estimated Time to Conduct Full Wash of One Truck		Time to Conduct Quick Wash of one Truck minutes	Type of Hose	Flow Rate from Hose gpm	How was Flow Rate Determined?	Washwater Storage			Washwater Disposal		
		Low End Est. minutes	High End Est. minutes					Total Oil Water Separator Capacity gallons	Total Sand Trap Capacity gallons	Total Other Storage Capacity gallons	Method	If not using public sewer, estimated Cost for disposal \$/gallon	
													Select one
COUNTY GARAGES													
ATH	Full and Quick Wash	15	25	5	1/2"	4	Per Your Instructions	1100	250	0	Sanitary Sewer	N/A	
GAL	Full and Quick Wash	60	180	20	1"	5	Per Your Instructions	1100	1000	0	Sanitary Sewer	N/A	
HOC	Full and Quick Wash	45	75	20	1 1/2"	65	Per Your Instructions	1500	750	0	Sanitary Sewer	N/A	
MEG	Full and Quick Wash	60	120	45	5/8"	8	Per Your Instructions	1500	1250	10000	Leach Field or Mound		
MOE	Full and Quick Wash	30	60	20	2"	15	Per Your Instructions	2000	750	0	Sanitary Sewer	N/A	
MKG	Full and Quick Wash	45	60	20	3/4"	4	Per Your Instructions	1500	1000	10000	Holding Tank		
NOB	Full and Quick Wash	30	60	10	1 1/4"	60	Per Your Instructions	1100	100	10000	Holding Tank		
VIN	Full and Quick Wash	15	30	10	3/4"	4	Per Your Instructions	3000	600	10000	Holding Tank		
WAS	Full and Quick Wash	20	60	15	1 1/2"	65	Per Your Instructions	1500	750	0	Sanitary Sewer	N/A	
OUTPOST GARAGES													
Hollister Outpost Garage (ATHPNO)	Full and Quick Wash	15	25	5	1/2"	4	Per Your Instructions	1500	100	0	Leach Field or Mound		
Laurelville Outpost Garage (HOCPSW)	Full and Quick Wash	45	75	20	1/2"	4	Per Your Instructions		0	0			
Tuppers Plains Outpost (MEGPNE)	Full and Quick Wash	15	25	5	1/2"	4	Per Your Instructions	300	0	0	Sanitary Sewer	N/A	
Duffy Outpost Garage (MOEPSE)	Full and Quick Wash	30	60	20	1/2"	5	Per Your Instructions	1500	100	0	Sanitary Sewer	N/A	
Belle Valley Outpost Garage (NOBPWE)	Full and Quick Wash	30	60	10	5/8"	8	Per Your Instructions	1500	100	0	Leach Field or Mound		
Wilkesville Outpost Garage (VINPSE)	None						Per Your Instructions			0			
Bartlett Outpost Garage (WASPSWE)	Full and Quick Wash	20	60	15	5/8"	4	Per Your Instructions	1500	100	0	Leach Field or Mound		
Belpre Outpost Garage (WASPSW)	Quick Wash Only			15	5/8"	4	Per Your Instructions	500	0	0	Sanitary Sewer	N/A	
Macksburg Outpost Garage (WASPNNO)	Full and Quick Wash	20	60	15	5/8"	4	Per Your Instructions	1500	250	0	Leach Field or Mound		

		Is Brine Produced at this Location? Select one	What Model of Brine Production Unit is Used?	Estimated Brine Production Rate gallons per day (year round)	Brine Storage Volume gallons	Are Liquids Other than Sodium Chloride Used for Pretreating? Select one	Alternative Deicing Liquids Type	Storage Volume gallons
COUNTY GARAGES								
ATH		Yes	ABS - 1500	273.23	11000	No	Liquid Calcium Chloride	2600
GAL		Yes	02 Etnyre	47.65	11000	No	Liquid Calcium Chloride	5000
HOC		Yes	02 Etnyre	157.59	5000	No	Liquid Calcium Chloride	5000
MEG		Yes	Vertitech / SB 1400	145.35	18000	No	Liquid Calcium Chloride	6000
MOE		Yes	Vertitech / HCSB-1400-	170.72	19800	No	Liquid Calcium Chloride	5000
MRG		Yes	ABS - 1500	216.98	16000	No	Liquid Calcium Chloride	5000
NOB		Yes	Vertitech / SB 600	126.27	5300	No	Liquid Calcium Chloride	5000
VIN		Yes	Vertitech / HCSB 1400 SS	133.16	12000	No	Liquid Calcium Chloride	6000
WAS		Yes	ABS - 1500	208.28	13000	No	Liquid Calcium Chloride	5000
OUTPOST GARAGES								
Hollister Outpost Garage (ATHPNO)		No	N/A	0	0	No	Liquid Calcium Chloride	2500
Laurelville Outpost Garage (HOCPSW)		No	N/A	0	5000	No	None	
Tuppers Plains Outpost (MEGPNE)		No	N/A	0	1800	No	Liquid Calcium Chloride	1500
Duffy Outpost Garage (MOEPSE)		No	N/A	0	6000	No	None	
Belle Valley Outpost Garage (NOBPWE)		No	N/A	0	0	No	Liquid Calcium Chloride	5000
Wilkesville Outpost Garage (VINPSE)		No	N/A	0	6000	No	None	
Bartlett Outpost Garage (WASPWE)		No	N/A	0	0	No	Liquid Calcium Chloride	2000
Belpre Outpost Garage (WASPSW)		No	N/A	0	0	No	Liquid Calcium Chloride	10000
Macksburg Outpost Garage (WASPNNO)		No	N/A	0	0	No	Liquid Calcium Chloride	5000

District 11

DISTRICT 11	Total Number of Dump	Number of Trucks Used per Winter Event		Total Lane Miles (per garage or outpost)			
		Low End Estimate	High End Estimate	Priority	General	Urban	Total
COUNTY GARAGES							
Belmont County - Morristown Garage	12	6	12	116	219		335
Carroll County Garage	13	4	13	0	305		305
Columbiana County Garage	14	6	11	126	223	35.2	384.2
Harrison County - Cadiz Garage	8	3	8	111.26	90.76		202.02
Holmes County - Millersburg Garage	10	8	10	131	162		293
Jefferson County - Wintersville Garage	12	6	10	320			320
Tuscarawas County - New Philadelphia Gara	11	5	8	184.5	32.5	35.5	252.5
							0
							0
OUTPOST GARAGES							0
Belmont - Barnesville Outpost	4	2	4	0	150		150
Belmont - St. Clairsville Outpost	7	5	7	94	83	23	200
Carroll - Malvern Outpost	0	0	0	0	0		0
Columbiana - Unity Outpost	4	2	3		150		150
Columbiana - Apples Corner Outpost	4	2	3		150		150
Harrison - Scio Outpost	3	1	3	0	108.06		108.06
Harrison - Freesport Outpost	3	1	3	10	64.09		74.09
Holmes - Nashville Outpost	3	2	3	0	59		59
Jefferson - Toronto Outpost	3	1	3	118			118
Jefferson - Bargholz Outpost	1	1	1	39			39
Tuscarawas - Dennison Outpost	2	1	2	24	40	0	64
Tuscarawas - Zoar Outpost	2	1	2	33	17	0	50
Tuscarawas - Newcomerstown Outpost	4	2	3	84	32	0	116

	What type of Truck Washing is Conducted at this facility?	Estimated Time to Conduct Full Wash of One Truck			Estimated Time to Conduct Quick Wash minutes	Type of Hose	Flow Rate from Hose gpm	How was Flow Rate Determined?	Washwater Storage			Washwater Disposal		
		Low End Est. minutes	High End Est. minutes						Total Oil Water Separator Capacity gallons	Total Sand Trap Capacity gallons	Total Other Storage Capacity gallons	Method	Select one	If not using public sewer, estimated Cost for \$/gallon
COUNTY GARAGES														
Belmont County - Morristown Garage	Full and Quick Wash	15 Min	30 Min	5 Min	Pressure	5gal/45sec	5 Gal Bucket	2-1500 Gal		3000 Gal		Sanitary Sewer	N/A	
Carroll County Garage	Full and Quick Wash	15 Min	30 Min	10 Min	1" Fire	20 gal/min	5 Gal Bucket	1500 Gal	0					
Columbiana County Garage	None													
Harrison County - Cadiz Garage	Full and Quick Wash	15 Min	30 Min	5 Min	Pressure	5 gal/min	5 Gal Bucket	3000 Gal	N/A	None		Sanitary Sewer	N/A	
Holmes County - Millersburg Garage	Full and Quick Wash	60 Min	90 Min	15 Min	High Pressure	3 gal/min	Pressure Washer	1000 Gal				Sanitary Sewer	N/A	
Jefferson County - Wintersville Garage	Full and Quick Wash	10 Min	30 Min	10 Min	2" Hose	12 gal/min	Bucket Fill	1000 Gal	N/A	N/A		Sanitary Sewer	N/A	
Tuscarawas County - New Philadelphia	Quick Wash Only	3 Min	5 Min	4 Min	Garden Hose	6 gal/min	Bucket x Min.	1500 Gal				Holding Tank		
-														
-														
OUTPOST GARAGES														
Belmont - Barnesville Outpost	Quick Wash Only	5 Min	10 Min	5 Min	Garden Hose	5gal/42sec	5 Gal Bucket	1000 Gal			1000 Gal			
Belmont - St. Clairsville Outpost	Quick Wash Only	5 Min	10 Min	5 Min	Garden Hose	5gal/37sec	5 Gal Bucket	1000 Gal			1000 Gal			
Carroll - Malvern Outpost	None													
Columbiana - Unity Outpost	None													
Columbiana - Apples Corner Outpost	Full and Quick Wash	5 Min	15 Min	8 Min	1"	15 gal/min	5 Gal Bucket	1500 Gal				Holding Tank	In house	
Harrison - Scio Outpost	Quick Wash Only			5 Min	Garden Hose	10 gal/min	5 Gal Bucket		N/A			Sanitary Sewer	N/A	
Harrison - Freesport Outpost	None													
Holmes - Nashville Outpost	Full and Quick Wash	60 Min	90 Min	15 Min	High Pressure	3 gal/min	Pressure Washer	500 Gal			10,000 Gal	Sanitary Sewer	0.17	
Jefferson - Toronto Outpost	Quick Wash Only			5 Min	3/4"	4 gal/min	Bucket Fill	N/A	N/A	N/A	N/A	Sanitary Sewer	N/A	
Jefferson - Bergholz Outpost	Quick Wash Only			5 Min	3/4"	4 gal/min	Bucket Fill	N/A			N/A	Other	N/A	
Tuscarawas - Dennison Outpost	Full and Quick Wash	5 Min	10 Min	10 Min	Hose	6 gal/min	Bucket x Min.					Sanitary Sewer	N/A	
Tuscarawas - Zoar Outpost	Quick Wash Only	3 Min	5 Min	5 Min	Garden Hose	6 gal/min	Bucket x Min.	1500 Gal				Holding Tank		

	Is Brine Produced at this Location?	What Model of Brine Production Unit is Used?	Estimated Brine Production Rate	Brine Storage Volume	Are Liquids Other than Sodium Chloride Used for Pretreating?	Alternative Deicing Liquids	
						Type	Storage Volume
COUNTY GARAGES	Select one		gallons per day	gallons	Select one		
Belmont County - Morristown Garage	Yes	Vanitech	12,000 Gallons	2-6000 Gal Tank	No	Calcium	5500 Gallons
Carroll County Garage	Yes	Vanitech SB600	7500 Gallons	10,500 Gal	No		
Columbiana County Garage	Yes	Vanitech SB600	7500 Gallons	10,500 Gal	No		
Harrison County - Cadiz Garage	Yes	Vanitech	Varies	5,000 Gal	No	Cal Chloride	11,000 Gallons
Holmes County - Millersburg Garage	No	N/A	N/A	N/A		Liquid Cal	5800 Gallons
Jefferson County - Wintersville Garage							
Tuscarawas County - New Philadelphia Ga	Yes		6000 Gallons	12,000 Gal	Yes	Ice Bite	3000 Gallons
-							
-							
OUTPOST GARAGES							
Belmont - Barnesville Outpost	No	No	None			Calcium	3000 Gallons
Belmont - St. Clairsville Outpost	Yes	Vanitech	12,000 Gallons	1-5500 Gal Tank		Calcium	6000 Gallons
Carroll - Malvern Outpost							
Columbiana - Unity Outpost	No						
Columbiana - Apples Corner Outpost	No						
Harrison - Scio Outpost	No						
Harrison - Freeport Outpost	No					Cal Chloride	8000 Gallons
Holmes - Nashville Outpost	No	N/A	N/A	N/A		Cal Chloride	8000 Gallons
Jefferson - Toronto Outpost						Liquid Cal	3000 Gallons

District 12

		Number of Trucks Used per Winter Event		Total Lane Miles (per garage or outpost)			
	Total Number of Dump Trucks	Low End Estimate	High End Estimate	Priority	General	Urban	Total
COUNTY GARAGES							
611 Cleveland Garage	12	5	10	213			213
612 Independence Garage	13	5	11	364			364
613 Mayfield Garage	12	5	11	290			290
614 Riveredge Garage	12	5	10	257			257
615 Warrensville Garage	13	5	11	303			303
BURTON	8	2	6	16	70		86
							0
							0
							0
							0
OUTPOST GARAGES							0
MUNSON	3	2	3	45	57		102
MONTVILLE	3	2	3		93		93
PARKMAN	5	3	5	91	51		142

	What type of Truck Washing is Conducted at this facility?	Estimated Time to Conduct Full Wash of One Truck		Estimated Time to Conduct Quick Wash minutes	Type of Hose	Flow Rate from Hose gpm	How was Flow Rate Determined?	Washwater Storage			Washwater Disposal	
		Low End minutes	High End Est. minutes					Total Oil Water Separator Capacity gallons	Total Sand Trap Capacity gallons	Total Other Storage Capacity gallons	Method	If not using public sewer, estimated Cost for \$/gallon
COUNTY GARAGES												
611 Cleveland Garage	Quick Wash Only	30	120	30	1.5" in rubber	10	15sec to fill 5gal	Unknown	Unknown	Unknown	Sanitary Sewer	N/A
612 Independence Garage	Quick Wash Only	30	120	30	1.5" in rubber	10	15sec to fill 5gal	Unknown	Unknown	Unknown	Sanitary Sewer	N/A
613 Mayfield Garage	Quick Wash Only	30	120	30	1.5" in rubber	10	15sec to fill 5gal	Unknown	Unknown	Unknown	Sanitary Sewer	N/A
614 Riveredge Garage	Quick Wash Only	30	120	30	1.5" in rubber	10	15sec to fill 5gal	Unknown	Unknown	Unknown	Sanitary Sewer	N/A
615 Warrensville Garage	Quick Wash Only	30	120	30	1.5" in rubber	10	15sec to fill 5gal	Unknown	Unknown	Unknown	Sanitary Sewer	N/A
BURTON	Full and Quick Wash	15	30	10	FIRE	30	ESTIMATED	?			Other	?
-												
-												
-												
-												
-												
-												
-												
OUTPOST GARAGES												
MUNSON	None											
MONTVILLE	None											
PARKMAN	None											

	Is Brine Produced at this Location?	What Model of Brine Production Unit is Used?	Estimated Brine Production Rate gallons per day	Brine Storage Volume gallons	Are Liquids Other than Sodium Chloride Used for Pretreating?	Alternative Deicing Liquids	
						Type	Storage Volume gallons
COUNTY GARAGES							
	No		0	0	No	Calcium	12000
611 Cleveland Garage	Yes	Pengwyn ABS-3000 SS	5600	5600	No	Calcium	11000
612 Independence Garage	Yes	Pengwyn ABS-3000 SS	5600	5600	No	Calcium	10000
613 Mayfield Garage	Yes	Pengwyn ABS-3000 SS	5600	12000	No	Calcium	10000
614 Riveredge Garage	Yes	Pengwyn ABS-3000 SS	5600	5600	No	Calcium	18000
615 Warrensville Garage	Yes	PENQWYN	500	5500	Yes	CALCIUM	11000
BURTON	Yes						
	-						
	-						
	-						
	-						
	-						
	-						
	-						
OUTPOST GARAGES							
MUNSON	No						
MONTVILLE	No						
PARKMAN	No						

APPENDIX B

EXAMPLE COST CALCULATION

For Single Garage with 12 trucks and 30 events; capital cost of sewer tie in of \$300,000; hauling distance of 55 miles roundtrip:

Parameter	Equation	Result
Annual Volume	$= \text{Number of trucks} * \text{Volume/Truck} * (\text{Number of Winter Events} * 1.1)$ <p>Where Volume/Truck = 330 gallons/truck/cycle</p>	$= 12 * 330 * 30 * 1.1$ $= 130,680 \text{ gallons}$
Annualized Sewer Tie-In Cost	$\text{Annualized Capital Costs} = \text{Capital Costs} * \left[\frac{i}{((1+i)^n) - 1} \right] + i$ <p>Where: i = discount rate n = number of years</p>	$= 300,000 * \left[\frac{0.07}{((1+0.07)^{40}) - 1} \right] + 0.07$ $= 22,502.74$
	$\text{Annual Costs} = \text{Volume} * \text{Disposal Rate}$ <p>Where disposal rate = 0.01/gallon</p>	$= 130,680 * 0.01$ $= 1,306.8$
	$\text{Annualized Costs} = \text{Annualized Capital Costs} + \text{Annual Costs}$	$= 22,502.74 + 1,306.8$ $= 23,810$

Parameter	Equation	Result
Commercial Disposal	$\text{Annualized Capital Costs} = \text{Capital Costs} * \left[\frac{i}{((1+i)^n) - 1} \right] + i$ <p>Where: i = discount rate n = number of years</p>	$= 30,000 * \left[\frac{0.07}{((1+0.07)^{12}) - 1} \right] + 0.07$ $= 3,777$
	$\text{Annual Cost} = \text{Disposal} + \text{Monitoring}$	$= (130,680 * 0.30) + 1,385$ $= 40,589$
	$\text{Annualized Costs} = \text{Annualized Capital Costs} + \text{Annual Costs}$	$= 3,777 + 40,589$ $= 44,366$

Parameter	Equation	Result
WWTP	$\text{Annualized Capital Costs} = \text{Capital Costs} * \left[\frac{i}{((1+i)^n) - 1} \right] + i$ <p>Where: i = discount rate n = number of years</p>	$= 30,000 * \left[\frac{0.07}{((1+0.07)^{12}) - 1} \right] + 0.07$ $= 3,777$
	$\text{Annual Cost} = \text{Disposal} + \text{Monitoring} + \text{Hauling}$ <p>Where: unit disposal cost = \$0.05/gallon Monitoring cost = \$1,385 Hauling cost = (labor + truck operation) * annual number of trips Labor rate = \$26.35/hour Number of hours = (roundtrip distance / 45mph) * 1 hour to load/unload Operating cost = 0.53/mile + fuel cost/fuel efficiency Fuel cost = 4.15 Fuel efficiency = 7 mpg Annual number of trips = 130,680/2,000 (assuming 2,000 gallon storage tank)</p>	$= (130,680 * 0.05) + 1,385 + (130,680/2,000) * [(26.35 * ((55/45) + 1)) + ((0.53 + 4.15/7) * 55)]$ $= 15,780$
	$\text{Annualized Costs} = \text{Annualized Capital Costs} + \text{Annual Costs}$	$= 3,777 + 15,780$ $= 19,557$

Garage-with-Sewer	$\text{Annualized Capital Costs} = \text{Capital Costs} * \left[\frac{1}{((1+i)^n)-1} \right] + i$ <p>Where: i = discount-rate n = number of years</p> $\text{Annual Cost} = \text{Disposal} + \text{Monitoring} + \text{Hauling}$ <p>Where: unit disposal cost = \$0.01/gallon Monitoring cost = \$1,385 Hauling cost = (labor + truck operation) * annual number of trips Labor rate = \$26.35/hour Number of hours = (roundtrip distance / 45mph) + 1 hour to load/unload Operating cost = 0.53/mile + fuel cost/fuel efficiency Fuel cost = 4.15 Fuel efficiency = 7 mpg Annual number of trips = 130,680/2,000 (assuming 2,000 gallon storage tank)</p> $\text{Annualized Costs} = \text{Annualized Capital Costs} + \text{Annual Costs}$	$= 30,000 * \left[\frac{0.07}{((1+0.07)^{12})-1} \right] + 0.07$ $= 3,777$ $= (130,680 * 0.01) + 1,385 + (130,680/2,000) * [(26.35 * ((55/45) + 1)) + ((0.53 + 4.15/7) * 55)]$ $= 10,553$ $= 3,777 + 10,553$ $= 14,330$
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Filtration and Disposal	$\text{Annualized Capital Costs} = \text{Capital Costs} * \left[\frac{1}{((1+i)^n)-1} \right] + i$ <p>Where: i = discount-rate n = number of years Capital Cost = Filtration Unit + Storage Filtration Unit = 30,000 Storage = 30,000</p> $\text{Annual Cost} = \text{Disposal} + \text{Monitoring} + \text{Hauling} + \text{Media Replacement}$ <p>Where: unit disposal cost = \$0.01/gallon Monitoring cost = \$1,385 Hauling cost = (labor + truck operation) * annual number of trips Labor rate = \$26.35/hour Number of hours = (roundtrip distance / 45mph) + 1 hour to load/unload Operating cost = 0.53/mile + fuel cost/fuel efficiency Fuel cost = 4.15 Fuel efficiency = 7 mpg Annual number of trips = 130,680/2,000 (assuming 2,000 gallon storage tank) Annual Media Replacement = 4,600</p> $\text{Annualized Costs} = \text{Annualized Capital Costs} + \text{Annual Costs}$	$= 60,000 * \left[\frac{0.07}{((1+0.07)^{12})-1} \right] + 0.07$ $= 7,554$ $= (130,680 * 0.01) + 1,385 + (130,680/2,000) * [(26.35 * ((55/45) + 1)) + ((0.53 + 4.15/7) * 55)] + 4,600$ $= 15,153$ $= 7,554 + 15,153$ $= 22,707$
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Filtration and Reuse	$\text{Annualized Capital Costs} = \text{Capital Costs} * \left[\frac{1}{((1+i)^n)-1} \right] + i$ $= 60,000 * \left[\frac{0.07}{((1+0.07)^{12})-1} \right] + 0.07$ $= 7,554$	
	Where: i = discount rate n = number of years $\text{Capital Cost} = \text{Filtration Unit} + \text{Storage}$ $\text{Filtration Unit} = 30,000$ $\text{Storage} = 30,000$	
	$\text{Annual Cost} = \text{Monitoring} + \text{Hauling} + \text{Media Replacement}$ $= 1,385 + (130,680/2,000) * [(26.35 * ((55/45) + 1)) + ((0.53 + 4.15/7) * 55)] + 4,600$ $= 13,846$	
	Where: $\text{Monitoring cost} = \$1,385$ $\text{Hauling cost} = (\text{labor} + \text{truck operation}) * \text{annual number of trips}$ $\text{Labor rate} = \$26.35/\text{hour}$ $\text{Number of hours} = (\text{roundtrip distance} / 45\text{mph}) + 1 \text{ hour to load/unload}$ $\text{Operating cost} = 0.53/\text{mile} + \text{fuel cost/fuel efficiency}$ $\text{Fuel cost} = 4.15$ $\text{Fuel efficiency} = 7 \text{ mpg}$ $\text{Annual number of trips} = 130,680/2,000 \text{ (assuming 2,000 gallon storage tank)}$ $\text{Annual Media Replacement} = 4,600$	
	$\text{Annualized Costs} = \text{Annualized Capital Costs} + \text{Annual Costs}$ $= 7,554 + 13,846$ $= 21,400$	