TRANSIT COOPERATIVE RESEARCH PROGRAM

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TCRP Synthesis 7

Regulatory Impacts on Design and Retrofit of Bus Maintenance Facilities

A Synthesis of Transit Practice

Transportation Research Board
National Research Council

T R A N S I T C O O P E R A T I V E R E S E A R C H P R O G R A M

Synthesis of Transit Practice 7

Regulatory Impacts on Design and Retrofit of Bus Maintenance Facilities

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TRANSIT COOPERATIVE RESEARCH PROGRAM

The nation's growth and the need to meet mobility, environmental, and energy objectives place demands on public transit systems. Current systems, some of which are old and in need of upgrading, must expand service area, increase service frequency, and improve efficiency to serve these demands. Research is necessary to solve operating problems, to adapt appropriate new technologies from other industries, and to introduce innovations into the transit industry The Transit Cooperative Research Program (TCRP) serves as one of the principal means by which the transit industry can develop innovative near-term solutions to meet demands placed on it.

The need for TCRP was originally identified in *TRB Special Report 213--Research for Public Transit: New Directions,* published in 1987 and based on a study sponsored by the Federal Transit Administration (FTA). A report by the American Public Transit Association (APTA), *Transportation 2000,* also recognized the need for local, problem-solving research. TCRP, modeled after the longstanding and successful National Cooperative Highway Research Program, undertakes research and other technical activities in response to the needs of transit service providers. The scope of vice configuration, equipment, facilities, operations, human resources, maintenance, policy, and administrative practices.

TCRP was established under FTA sponsorship in July 1992. Proposed by the U.S. Department of Transportation, TCRP was authorized as part of the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) On May 13, 1992, a memorandum agreement outlining TCRP operating procedures was executed by the three cooperating organizations: FTA, the National Academy of Sciences, acting through the Transportation Research Board (TRB), and the Transit Development Corporation, Inc (TDC), a nonprofit educational and research organization established by APTA. TDC is responsible for forming the independent governing board, designated as the TCRP Oversight and Project Selection (TOPS) Committee.

Research problem statements for TCRP are solicited periodically but may be submitted to TRB by anyone at anytime. It is the responsibility of the TOPS Committee to formulate the research program by identifying the highest priority projects. As part of the evaluation, the TOPS Committee defines funding levels and expected products.

Once selected, each project is assigned to an expert panel, appointed by the Transportation Research Board. The panels prepare project statements (requests for proposals), select contractors, and provide technical guidance and counsel throughout the life of the project. The process for developing research problem statements and selecting research agencies has been used by TRB in managing cooperative research programs since 1962. As in other TRB activities, TCRP project panels serve voluntarily without compensation.

Because research cannot have the desired impact if products fail to reach the intended audience, special emphasis is placed on disseminating TCRP results to the intended end-users of the research: transit agencies, service providers, and suppliers. TRB provides a series of research reports, syntheses of transit practice, and other supporting material developed by TCRP research. APTA will arrange for workshops, training aids, field visits, and other activities to ensure that results are implemented by urban and rural transit industry practitioners.

The TCRP provides a forum where transit agencies can cooperatively address common operational problems. TCRP results support and complement other ongoing transit research and training programs.

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Each report is reviewed and accepted for publication by the technical panel according to procedures established and monitored by the Transportation Research Board Executive Committee and the Governing Board of the National Research Council.

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PREFACE

A vast storehouse of information exists on many subjects of concern to the transit industry. This information has resulted from research and from the successful application of solutions to problems by individuals or organizations. There is a continuing need to provide a systematic means for compiling this information and making it available to the entire transit community in a usable format. The Transit Cooperative Research Program includes a synthesis series designed to search for and synthesize useful knowledge from all available sources and to prepare documented reports on current practices in subject areas of concern to the transit industry.

This synthesis series reports on various practices, making specific recommendations where appropriate but without the detailed directions usually found in handbooks or design manuals. Nonetheless, these documents can serve similar purposes, for each is a compendium of the best knowledge available on those measures found to be successful in resolving specific problems. The extent to which these reports are useful will be tempered by the user' s knowledge and experience in the particular problem area.

FOREWORD
By Staff
Transportation Research Board

This synthesis will be of interest to transit agency general managers; planning, operations, and other maintenance personnel; design, engineering, architectural, and consultant staffs; as well as environmental agency officials and others concerned with bus facility planning and design. As-built or design drawings from recently completed facilities were used to compare overall sizes of functional areas with earlier guidelines.

Administrators, practitioners, and researchers are continually faced with issues or problems on which there is much information, either in the form of reports or in terms of undocumented experience and practice. Unfortunately, this information often is scattered or not readily available in the literature, and, as a consequence, in seeking solutions, full information on what has been learned about an issue or problem is not assembled. Costly research findings may go unused, valuable experience may be overlooked, and full consideration may not be given to the available methods of solving or alleviating the issue or problem. In an effort to correct this situation, the Transit Cooperative Research Program (TCRP) Synthesis Project, carried out by the Transportation Research Board (TRB) as the research agency, has the objective of reporting on common transit issues and problems and synthesizing available information. The synthesis reports from this endeavor constitute a TCRP publication series in which various forms of relevant information are assembled into single, concise documents pertaining to a specific or closely related issue or problem.

The legal and technological environments have changed since the last systematic examination of bus maintenance facilities. The Americans with Disabilities Act (ADA) regulations may require existing facilities to make extensive modifications. Heating, ventilation, and air-conditioning systems may not meet Clean Air Act requirements. Extensive facility modifications may be required to safely accommodate buses with non-diesel fuels. Water recycling features, as well as site and floor drainage, may fall short of Clean Water Act requirements. This report describes how recently enacted legislation and implemented regulations have affected the design of bus maintenance facilities. Several case examples of changes implemented by transit agencies are included. A number of recommendations are made for transit agencies to consider in addressing these important design issues.

To develop this synthesis in a comprehensive manner and to ensure inclusion of signficiant knowledge, available information was assembled from numerous sources, including a number of public transportation agencies. A topic panel of experts in the subject area was established to guide the researchers in organizing and evaluating the collected data, and to review the final synthesis report.

This synthesis is an immediately useful document that records practices that were acceptable within the limitations of the knowledge available at the time of its preparation. As the processes of advancement continue, new knowledge can be expected to be added to that now at hand.

CONTENTS

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REGULATORY IMPACTS ON DESIGN AND RETROFIT OF BUS MAINTENANCE FACILITIES

SUMMARY

Bus operating facilities built in the 1990s must be designed under an entirely new set of guidelines. Not only must the facility be designed to efficiently perform its function as a bus maintenance facility, its design must address environmental and accessibility considerations. Because of the resulting new design considerations, transit agencies across the country are likely to spend time, money, and effort to ensure that their new or retrofit facilities are built with the appropriate accommodations.

This synthesis identifies some of the effects that recently enacted legislation and implemented regulations have had on the design of bus maintenance facilities. Also identified are some of the most recent successful practices that have been incorporated into the design of bus maintenance facilities including modifications to accommodate new technology vehicles. Recent regulations that impact on bus garage design are those relating to the Americans with Disabilities Act (ADA) *(1)*, Clean Air Act Amendments (CAAA) of 1990 (*2*), Clean Water Act (*3*), and Environmental Protection Agency (EPA) regulations regarding underground storage tanks (USTs) (*4*). Information was obtained from 16 transit agencies on practices used in the design of recently completed bus maintenance facilities. Ways in which these regulations have affected the design of relatively new bus garages are reviewed.

The ADA regulations impact a bus maintenance facility's size and functional layout in several ways. The restrooms will be larger; the employee parking area will accommodate fewer cars in the same space, because of the need for additional, larger spaces to accommodate disabled individuals; more space may be required for elevators; ramps will be required for small elevation changes; and walkways will be wider throughout the complex. A number of special features will also be required (e.g., signage, drinking fountains, special telephones and door hardware). These facility modifications and special features will add to the cost of a new or retrofit bus maintenance facility.

There are a number of facility design features that are impacted by the CAAA of 1990. The biggest impact will be on facility maintenance area modifications required to safely accommodate new technology buses using alternative fuels. These modifications include fuel handling, hazardous vapor venting, explosion-proof fixtures, special sensing devices, and other automatic controls to provide early warning of trouble. The specific requirements depend on the type of alternative fuel used. Metropolitan Transit Authority of Harris County, known as Houston Metro, estimated that the cost to retrofit a bus maintenance facility to safely accommodate new technology buses using alternative fuels will be $25.00/ft^2.

A further result of the CAAA of 1990 is that more attention is placed on providing clean air throughout the bus maintenance facility. Features such as special exhaust systems in the fuel area and repair areas are common. Further, most pits are designed with floor exhausts, many of which are also equipped with a make-up air system. New equipment items or more

stringent requirements for old ones are now found at bus maintenance facilities to perform the following functions: anti-freeze recycling, freon recovery, and containment in paint spray booths.

Several facility design features are impacted by the Clean Water Act, including the automatic bus wash system, which at most agencies includes a water recycling feature. The recycling effort is limited to about 80 percent of the water volume and can add $25,000 or more to the cost of a washer.

The Clean Water Act also impacts site and floor drainage. Site drainage requirements are closely controlled with many facilities having specific provisions to process site drainage before it drains into the municipal sanitary sewer system. A site drainage system with an oil/water separator is costly and can exceed $250,000 for a 10-acre site. The floor drainage system is also carefully controlled with most agencies having a drainage system that includes industrial waste treatment in the form of an oil/water separator.

All agencies surveyed store diesel fuel in USTs. Tank sizes vary from 4,000 gallons to 20,000 gallons. Some agencies use a number of smaller tanks rather than one or two larger ones to provide needed capacity. Many tanks are double-walled with spill prevention features including leak detectors and level monitoring. Synthesis results indicate that regulations have affected design changes to the fuel storage area of the agencies surveyed more than any other area. It should be noted that this may only have been true because the bus maintenance facilities of most of the surveyed agencies were not subject to full ADA regulations and were not accommodating new technology buses at the time redesign took place.

The new federal regulations have had and will continue to have a far-reaching impact on the design of a new or the retrofit of an old bus maintenance facility. In order for a transit agency to address these important design issues and to prevent the potential of being fined or confronted with costly design modifications resulting from noncompliance, a number of recommendations are appropriate, such as involving professionals knowledgeable in environmental regulations early and throughout the design process so that local, state, and federal regulatory requirements are addressed; using a peer review process to gain from other transit agencies' experiences; designing to full compliance with federal regulations; and preparing for additional costs that will result from compliance with federal regulations.

CHAPTER ONE

INTRODUCTION AND RESEARCH APPROACH

RESEARCH OBJECTIVE

The objective of this synthesis is twofold: 1) to identify the effects that recently enacted legislation and implemented regulations have had on the design of bus maintenance facilities; and 2) to specify some successful practices that have been incorporated into design of bus maintenance facilities, including modifications to accommodate new technology buses with alternative-fuel engines.

This synthesis is intended for use by transit managers and transit facility design consultants and engineers as well as funding agencies and officials in determining the effects of recent regulations on the size, layout, and design features for new or modified bus maintenance facilities (or other fleet maintenance facilities, as appropriate).

Information is provided on practices used at the time of the study in the design of the most recent bus maintenance facilities. Recent regulations that impact on bus garage design are those relating to ADA *(1),* the CAAA of 1990 *(2),* Clean Water Act *(3),* and EPA regulations regarding USTs (*4*). Next, the ways in which these regulations have affected the design of relatively new bus garages are reviewed. The individual practices followed in the design of a large number of relatively new bus maintenance facilities are presented, including how the systems address fuel storage, facility exhaust, site and indoor floor drainage, noise, air quality, and special concerns such as new shop equipment, bus wash areas, and repair pits.

Adequate facilities are indispensable to proper maintenance of a bus fleet. The design of new or expanded facilities should consider functional efficiency, the equipment to be maintained upon opening, and equipment that may be maintained in the future. Other factors that influence design include site-specific factors such as climate, topography, characteristics of the neighborhood, and need for security. However, recent legislation and implemented regulations have imposed an entirely new set of design considerations including those relating to accessibility, safely accommodating new technology vehicles, complying with new material handling laws, and other environmental regulations such as more stringent storm and sanitary sewer water quality. New building materials or new maintenance procedures may also influence design.

The Federal Transit Administration (FTA) sponsored two prior research projects that are relevant to this project. In 1987, *Transit Garage Planning Guidelines, a Review,* was published *(5).* This report used data from 30 bus maintenance facilities constructed after 1970 to develop statistical relationships between service variables and space allocation. Different functional areas were found to be related to different variables. For example, the size of the bus storage area depends on active bus fleet size; the size of the parts storage room depends on the number of miles of service operated, as well as the number of different bus models operated. The 1987 report updated work published in 1974, *Bus Maintenance Facilities: A Transit Management Handbook (6).* Very few modem facilities had been constructed prior to 1974 and the 1987 work was intended to reflect modern practice.

Since the 1987 examination of bus maintenance facilities, the legal and technological environment has changed. For example, accessibility in older buildings may not meet ADA regulations. Heating, ventilating, and air-conditioning systems of the facility may not meet current building codes and design guides, the CAAA of 1990 guidelines, or safely accommodate new technology buses. Yard and floor drainage systems may not meet the Clean Water Act provisions or hazardous materials handling and containment regulations.

Notwithstanding recent legislation and implementing regulations that affect design, new and rehabilitated facilities represent a valuable source of information on ideas that can lead toward successful practices. Further, many systems are experimenting with alternative-fuel vehicles as a result of the CAAA of 1990. Information on how these systems are addressing facility modifications to accommodate these vehicles is useful to other transit systems.

RESEARCH APPROACH

The first step in this project was to identify the recent regulations that influence the design of bus maintenance facilities surveyed. Next, a list of bus maintenance facilities that were built within the past seven years was compiled. This time frame was selected because it would capture the information on facilities built after 1986, which were not included in the 1987 study. Transit systems that had constructed new facilities during this period were identified through discussions with other transit professionals and review of articles in transit industry journals.

Next, a literature review was made of other work related to how regulations affect design of bus maintenance facilities. This effort did not uncover any prior research in this area. During the review, two bus maintenance facility design guideline reports were found, in addition to the two FTA projects cited above. One study was published in 1992 by the Ontario Ministry of Transportation (*7*). This Canadian study provided guidelines on facility layout as well as standard size requirements for a number of garage functional areas, including service lanes, administrative offices, bus storage space, maintenance shops, maintenance bays, and parts storage rooms.

Another study was sponsored by the FTA in 1993 that focused on assessing the transit industry's bus support facilities projected capital needs and current conditions at specific facilities *(8).* A key element of this study was to identify ways in which the overall layout and functions at a transit maintenance facility could be improved. This information was developed based on reviews at nine selected transit bus support operating garages. Neither of the reports addressed the impact of regulations on facility design. The research program currently in progress for the FTA by the Office of Technical Assistance and Safety, *Transit Facility Guidelines for Alternative Fuels,* will develop guidelines to assist transit agencies in determining a scope of modifications that are required to be made to facilities to accommodate alternative-fuel vehicles.

It was determined that the information needed for this synthesis project could be obtained through distribution of a detailed questionnaire mailed to the transit agencies that were known to have built a new bus maintenance facility since 1987.

The questionnaire contained in Appendix A. which was distributed to selected transit systems, addressed the following six categories:

- Site characteristics--Information was obtained on the overall site including prior usage, zoning, and general characteristics.
- Operations data--Data were assembled on the facility space allocation and the characteristics of the transit system as reflected in terms of fleet size, annual vehicle miles, and annual vehicle hours.
- Personnel data--Staff sizes for administration, transportation, and maintenance were obtained from the participating transit agencies.
- Design regulations--Information was obtained in this section on which regulations were considered in the design and what special design features resulted.
- Facility features--More detailed information was obtained on functional areas of the facility as well as on major facility systems such as fueling, heating, lighting, ventilating, floor drainage, and security. In this section, information was also obtained on special and innovative facility features.
- Facility description--As-built or design floor plan drawings were obtained on a number of new facilities.

CHAPTER TWO

REGULATIONS AFFECTING BUS MAINTENANCE FACILITIES

A wide variety of local, state, and federal regulations must be taken into account in the design of any structure or commercial operation. Many of these are embodied in local building codes, have been in effect for many years, and are taken into account by architects or engineers engaged to develop facility plans. Other regulations, however, implement federal legislation that has been passed or that has taken on new emphasis in recent years. The designer of new bus maintenance facilities must be cognizant of these regulations. Existing facilities may need to be modified to assure compliance with the regulations.

The newer federal legislation and regulations that affect the design and operation of bus maintenance facilities are discussed in this chapter.

AMERICANS WITH DISABILITIES ACT (ADA)

The ADA of 1990 was enacted to ensure rights for individuals with disabilities. This Act, like other legislation addressed in this synthesis, does not single out the transit industry, but imposes requirements on the broad spectrum of business. Many transit agencies are focusing on the impact of ADA on transit bus accessibility as well as the complementary paratransit service requirement. However, a major part of ADA is the requirement for transportation facilities to be accessible to persons with disabilities.

On September 6, 1991, the Architectural and Transportation Compliance Board (Access Board) and the U.S. Department of Transportation (DOT) issued the final rule that sets forth the transportation standards for ADA. The detailed federal regulations are found in 49 CFR Parts 27, 37, and 38. Accessibility requirements for transit facilities are defined in a handbook developed for the FTA (*9*). The ADA requires that all new facilities be completely accessible and that older facilities be brought into compliance as an integral part of all facility upgrades. Some of the regulations applicable to bus maintenance facilities are listed below. Table 1 summarizes the portions of a bus maintenance facility that these regulations impact. Figure 1 shows a diagram of a ramp that is in compliance with requirements listed in the FTA handbook.

Accessible Work Areas/ Pathways

- All work areas or public areas must be accessible.
- Work spaces (e.g., offices) must be designed to accommodate workers with special needs (e.g., wheelchairs).
- All accessible paths must have a stable, slip-resistant surface.
- The pathway must be at least 36 inches wide with widths of at least 32 inches at doorways.

Ramps

- Every portion of an accessible path must be equipped with a ramp when a slope is steeper than 1:20.
- The ramp must have a slope no steeper than 1:12.
- All ramps must have level landings at both the top and the bottom.
- All ramps with a rise of higher than 6 inches or a horizonal run of more than 72 inches must have handrails.

Elevators

- An elevator is required if offices are on an upper floor and may be required if second-level storage is used in the parts room.
- The elevator must be operated automatically with an independent self-leveling device to bring the car level with floor landing.
- Call buttons and indicator lights must be accessible to individuals in wheelchairs as well as those with hearing or visual impairments.
- Both raised letters and braille floor designations must be provided on both jambs of the elevator door.
- Elevator doors must remain open a minimum time, which varies based on the distance between the call button and door opening, in order to easily gain access from the lobby area, and be equipped with a device that automatically stops and reopens the doors if they are obstructed by any object.
- Space within the elevator must be large enough for a person in a wheelchair to enter the car, maneuver to reach the controls, and exit the car. The elevator floor must also be a stable and slip-resistant surface.
- Controls of an accessible elevator must meet a number of requirements related to button size and height, control indicators, panel location, and car position indicators.
- Elevators must be equipped with emergency communications systems.

Parking

- Number of accessible parking spaces depends on number of total parking spaces. For example, an area with up to 25 spaces requires one accessible space; up to 100, four are required; up to 500, nine are required; and over 1,000, 20 plus one for each 100 over 1,000.
- One in eight accessible spaces must be van-accessible.
- Accessible parking spaces must be at least 96 inches wide and have an access aisle at least 60 inches wide. An access isle can be shared between two adjacent, accessible parking spaces.
- Accessible spaces must be located on the shortest accessible route to the accessible entrance of the facility.

TABLE 1
FUNCTIONAL AREAS AFFECTED BY ADA REGULATIONS

	Administrative Areas				Vehicle Maintenance Functional Areas					
General ADA Facility Requirements	Site	Outside Parking Area	Indoor Bus Storage	Offices	Repair Bays	Machine Shop	Servicing	Parts Storage	Fluid Storage	Offices
Accessible Work Areas/Pathways				X				X		X
Ramps	X	X		X				X		X
Elevators				X				X		X
Parking		X								
Restrooms				X						X
Other				X						X

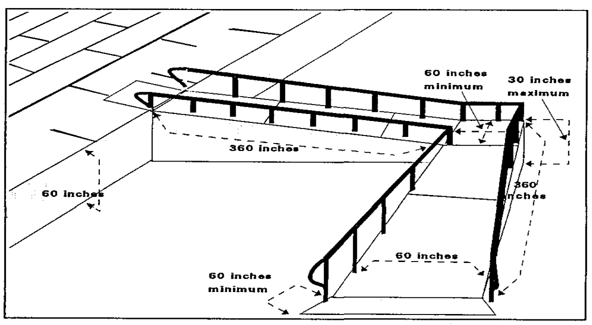

FIGURE 1 Minimum required dimensions of a ramp *(9)*.

Restrooms

- If not technically feasible to make all restrooms accessible during alterations, at least one restroom per floor must be accessible.
- Regulations in restroom design for accessibility include toilets, toilet stalls, sinks, mirrors, and maneuvering room.

Other

- If public telephones are provided, each floor must have one accessible telephone.
- In new construction, a floor must have one drinking fountain that is accessible to both individuals in wheelchairs and those who have difficulty bending or stooping.
- If a facility is upgraded, an "accessible path" to it must be provided.

CLEAN AIR ACT AMENDMENTS (CAAA) OF 1990

On November 15, 1990, President Bush signed into law the CAAA of 1990, which are designed to curb four major threats to the nation's environment and the health of Americans: acid rain, urban air pollution, ozone depletion, and toxic air emissions. The CAAA of 1990 contain eleven Titles which are listed below:

Title I:	Provisions for Attainment and Maintenance of National Air Quality Standards
Title II:	Provisions Relating to Mobile Sources
Title III:	Hazardous Air Pollutants
Title IV:	Acid Deposition Control
Title V:	Permits
Title VI:	Stratospheric Ozone Protection
Title VII:	Provisions Relating to Enforcement
Title VIII:	Miscellaneous Provisions
Title IX:	Clean Air Research
Title X:	Disadvantaged Business Concerns
Title XI:	Clean Air Act Employment Transition Assistance

The CAAA of 1990 have far-reaching impacts on the design of bus maintenance facilities as shown in Table 2. Some impacts are direct and include control and protection of workers from toxic emissions while engaged in the bus painting function (Title III); control and special handling of any substances that could be considered hazardous material, resulting in the requirement for transit agencies to recycle antifreeze (Title III); and recycling and safe disposal of CFC refrigerants that are typically used in bus air-conditioning systems (Title VI).

The other impacts of the CAAA of 1990 are not as direct but will likely have the greatest impact on bus maintenance facilities. In particular, Title II specifies a number of requirements regarding urban buses. First, the CAAA of 1990 provide for aggressive reductions in the emissions of transit buses by 1994 and throughout the remaining years of this decade. These emission restrictions are difficult to meet. However, diesel engine manufacturers have claimed that diesel engines will meet the emission standards throughout this decade *(10)*. Even with this claim, there is local pressure on transit agencies to convert their fleets to alternative-fuel buses. As a result, alternative-fuel buses may soon become a common

TABLE 2
FUNCTIONAL AREAS AFFECTED BY CAAA OF 1990

	Administrative Areas			Vehicle Maintenance Functional Areas					
General CAAA of 1990 Facility Requirements	Outside Parking Area	Indoor Bus Storage	Offices	Repair Bays	Machine Shop	Servicing	Parts Storage	Fluid Storage	Offices
Title II-Mobile Sources (New technology vehicles)									
Ventilation		X		X		X			
Eliminate ignition sources		X		X		X			
Methane detectors		X		X		X			
Explosion-proof fixtures				X		X			
Special clean area							X		
Title III-Hazardous air pollutants		X		X	X	X		X	
Title VII-Stratospheric ozone protection				X		X			

feature at all transit systems. In preparation for this occurrence, the Transit Cooperative Research Program of the Transportation Research Board published *TCRP Synthesis 2: Safe Operating Procedures for Alternative-Fuel Buses (11).* The findings from this synthesis that address bus maintenance facility design requirements are summarized in Chapter 3.

CLEAN WATER ACT

The federal Clean Water Act does not establish any specific requirements related to the design of facilities. Rather, the Act establishes standards for water quality as well as spill prevention and remediation. It is left to the states and the Environmental Protection Agency (EPA) to determine the actions necessary to achieve the required water quality and prevent spills *(12).* In summary, the Clean Water Act has the following key provisions:

- EPA or state governments issue permits to industries and municipalities that limit the amount of pollution they may discharge.
- Limits of acceptable discharge are based first on national guidelines or performance standards for entire industrial categories according to the best pollution control technology available for that industry. When guidelines are not in place for a particular industry, discharge limits are developed on a case-by-case basis.
- The above technology-based controls may not result in acceptable water quality because of many factors such as the combined effect of many point source discharges (such as factories, mills, sewage treatment plants, storm sewer outfalls) or nonpoint source discharges (such as rainwater runoff from construction sites, farming areas, suburban areas, or cities). Under these circumstances, the EPA or state may place more stringent water quality-based controls on some or all dischargers.
- The discharge is monitored to ensure that permit limits are not exceeded. If they are, then the responsible discharger must take immediate steps to stop the violations, and the states or EPA may impose stiff penalties.

In order to monitor facility discharges, EPA has published regulations contained in 40 CFR 122 and 40 CFR 125 requiring plant/facility owners, construction site owners, and other large landholders to submit a Notice of Intent (NOI) and to prepare and upgrade continuously Pollution Prevention Plans (PPP).

The elements of regulations implementing the federal Clean Water Act that affect the design and operation of bus maintenance facilities are listed in Table 3 and can be summed up relatively simply. Operations of a bus transit facility must not produce discharges that adversely affect the water quality within its surrounding area. For a transit agency to be a good neighbor, most discharges from the site to streams, wetlands, or similar drainage areas must be treated. In addition, most municipalities, wastewater authorities or similar agencies are imposing more stringent requirements on pretreatment of waste water prior to discharge into sanitary or storm sewage facilities. This has resulted in a number of transit agencies being required to retrofit their site and floor drainage systems to improve the quality of the discharge.

Another result of the Clean Water Act is that many fluids handled in a bus maintenance facility are now designated as hazardous materials.

TABLE 3
FUNCTIONAL AREAS AFFECTED BY CLEAN WATER ACT

	Administrative Areas			Vehicle Maintenance Functional Areas					
General Clean Water Act Facility Requirements	Outside Parking Area	Indoor Bus Storage	Offices	Repair Bays	Machine Shop	Servicing	Parts Storage	Fluid Storage	Offices
Site and floor drainage	X	X		X	X	X		X	
Handling of hazardous material				X	X	X		X	

EPA REGULATIONS ON ABOVE- AND UNDERGROUND STORAGE TANKS

Transit agencies have commonly stored diesel fuel and other fluids such as engine oil in underground storage tanks (USTs). Recently, regulations addressing USTs have become more stringent. One outgrowth of the Clean Water Act is the set of EPA rules (40 CFR 128) governing above- and underground storage tanks. A summary of the new regulations for USTs is contained in an EPA document entitled *Musts for USTs (13).* Leaking USTs can cause fires or explosions and can contaminate nearby groundwater, threatening human safety and groundwater resources. EPA developed regulations to protect human health and the environment by preventing leaks and spills; finding those that occur and correcting the problems they create; making sure that owners and operators of USTs can pay for corrections; and ensuring that each state has a regulatory program for USTs that is as strict as or stricter than the federal regulations.

In addition to this regulation and that under the Federal Resource Conservation and Recovery Act (RCRA) and the Clean Water Act, nationwide industry associations such as the National Fire Protection Association (NFPA) provide industry-wide codes for such things as USTs for petroleum products where refueling and maintenance occur in the same area; these codes pertain to the flammable nature of the liquids stored. The USTs are also subject to regulations under the Uniform Fire and Building Codes (UFBCs) and the National Electric Code.

As seen in later sections of this report, regulations dealing with USTs are most often cited by transit agencies as having the greatest impact on design. As a result, transit agencies are beginning to consider use of above-ground storage tanks for storing many fluids.

Design engineers who have participated in the planning of new bus maintenance facilities report that they follow state and local regulations for above- and underground storage tanks. Several examples of state and local regulations are summarized below.

Pennsylvania Storage Tank Regulations

In Pennsylvania, the law governing storage tanks is known as the Storage Tank and Spill Prevention Act *(14).* The state law addresses requirements for both underground and aboveground storage tanks. In summary, USTs meet the requirements of the Pennsylvania law if:

- The tank prevents releases due to corrosion or structural failure for the operational life of the tank,
- The tank is cathodically protected against corrosion, constructed of noncorrosive material, steel clad with a noncorrosive material, or designed in a manner to prevent release or threatened release of any stored substance,
- The material used in the construction or lining of the tank is compatible with the substance to be stored,
- The tank is equipped with spill and overfill prevention equipment, and
- The tank is installed by a certified installer.

The above regulations apply to all USTs and also require the owner to register each UST with the state and pay a required registration fee.

Similar requirements exist in Pennsylvania for regulating above-ground storage tanks. There are additional requirements for above-ground storage tanks that include inspection and testing of the tanks.

Pennsylvania regulations also apply to discontinued use of a UST and are known as closure activities. The Pennsylvania Department of Environmental Resources published a technical document that specifies good practices associated with tank closure activities *(15).* This document states that tank closure may involve three activities:

1. Tank handling activities-These activities during closure involve such tasks as hazard recognition and abatement; removal and handling of vapors, products, wastewaters, and accumulated sludges from the UST system; cleaning the UST system; leaving the UST system in the ground and filling the UST with an inert, solid, nonshrinking material; removing the UST from the ground; excavating soil from around the UST system; and initial on-site staging of excavated soil.
2. Waste management and disposal activities-Various wastes are generated during closure. It is the responsibility of the tank owner to ensure that these wastes are managed and disposed of in accordance with all applicable regulations and policy.
3. Site assessment activities-The purpose of site assessment is to determine if contamination is present around each storage tank system as a result of any leaks or spills that may

have occurred during the operation of the current or any previously existing storage tank system.

The purpose of the above activities is to restore the area in a manner that prevents any future release and to remedy any adverse impacts from any prior release.

Nassau County (New York) Storage Tank Regulations

In Nassau County, New York, the Toxic and Hazardous Materials Storage, Handling and Control Ordinance addresses requirements for both underground and above-ground storage tanks *(16).* In summary, the Nassau County ordinance defines a number of requirements for storage tanks, including:

- Acceptable materials for constructing new USTs include fiberglass-reinforced plastic, steel tanks clad with fiberglass-reinforced plastic, and double-walled tanks.
- If double-walled tanks are used, the underground piping to and from the tank must also be double-walled.
- New above-ground storage tanks must be constructed of steel.
- All new USTs must have one of the following leak monitoring systems: in-tank, observation wells, in-vault, or within annular space for double-walled tanks. A monitoring well must also be provided for USTs without double walls.
- All above-ground tanks sitting on an impermeable barrier must provide for monitoring between the tank bottom and the barrier.
- Steel tanks must be equipped with a cathodic protection system designed to provide a minimum of 30 years of protection.
- A secondary containment system must be installed with USTs consisting of a waterproof vault or an impermeable barrier. A double-walled tank will satisfy this requirement.
- A secondary containment must be installed around the above-ground tank to prevent spills or leaks from escaping into the groundwater or surface waters before a cleanup occurs.
- USTs must be tested by a certified inspector prior to acceptance for use. Above-ground storage tanks must be inspected at least monthly.

The Nassau County Ordinance also provides for detailed steps that must be followed upon abandonment of storage tanks.

OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION (OSHA) REGULATIONS

While not a recent requirement, most private facilities must be designed and operated in adherence to all applicable regulations of OSHA. These regulations do not apply to publicly owned and operated bus maintenance transit facilities. However, most new publicly owned and operated facilities comply with OSHA regulations. These regulations, found in 29 CFR 1910, address the safety aspects of the workplace from a number of standpoints, including walking and working surfaces, exits and exit signage, fire protection, machine guarding, process safety management, and many others. Some examples of transit facility features provided as a result of OSHA requirements include an eye wash near the battery charging room, chained-off areas around pits when they are not in use, shields around certain machinery such as grinders, flameproof paint cabinets, marked walkways, and safety stands underneath the bus when it is raised on a lift. In meeting OSHA safety requirements, the overall size and layout of the facility will be impacted.

CHAPTER THREE

A SUMMARY OF PRACTICE

NEW BUS MAINTENANCE FACILITIES

A key element of this synthesis study was the survey of transit agencies that had built a new transit maintenance facility within the past 7 years. A questionnaire, provided in Appendix A, was mailed to 23 transit agencies. Of the 23 questionnaires issued, 14 agencies responded with fully or partially completed information. These 14 agencies, listed in Table 4, reported information on 21 bus maintenance facilities.

Appendix B contains some further information about each reported facility including age of the prior facility, prior use and zoning of current site, and natural site characteristics.

Direct Facility Impact by Recent Federal Regulations

Elements of facility design that are directly affected by the relatively new federal legislation and implemented regulations include fuel storage systems, other fluid storage, automatic bus washers, facility exhaust systems, site drainage systems, floor drainage systems, and special shop and garage equipment. Information from the survey sample of responding transit agencies with 21 relatively new bus maintenance facilities is presented below and summarized in Table 5.

Because the ADA regulations were only recently implemented, most of the agencies indicated no impacts of this legislation on their new facilities.

Fuel Storage System

One outgrowth of the Clean Water Act is the set of EPA rules governing UST systems, 40 CFR 280 (4). These regulations, while offering a variety of procedures to ensure that UST systems are not leaking, require strict adherence to either state or local procedures. In fact, by 1998, certain fluids used in bus operating facilities are required to be in double-walled tanks. Therefore, one focus area of the survey of agencies was on fuel storage systems.

All agencies stored diesel fuel in USTs. The size of the tanks varied from 4,000 gal to 20,000 gal. All systems but one had two or more USTs. MTA New York City Transit designed its three recent facilities with a large number of smaller tanks. Two of their facilities have ten 4,000-gal USTs; one has five 8,000-gal tanks.

The total capacity of the USTs also varied widely from 18,000 gal at the York County Transportation Authority (PA) facility with 54 vehicles to 120,000 gal at the Capital Metropolitan Transportation Authority (TX) facility, which currently houses 297 vehicles and has a 400-vehicle fleet capacity. There appears to be no correlation with overall fuel storage capacity and the size of the system. For example, agencies with fleet sizes ranging from 60 to 220 buses have tanks with 40,000 gal diesel fuel capacity.

The most common underground tank, found in 10 of the 21 new garages, is a double-walled tank made of fiberglass. This type construction is found in the small 4,000-gal tank size as well as larger 20,000-gal tanks. The next most common tank type is single-walled fiberglass. Only a few agencies used tanks constructed with steel and those tanks were cathodically protected against corrosion. In fact, the survey found that three new garages were constructed with double-walled piping from the tanks to the fuel dispensing area.

In addition to constructing tanks to avoid leaks and leaking pipe connections, each new bus maintenance facility has some form of safeguard to detect a problem with the USTs. It is important to stress that fuel storage piping and connections are potentially high-risk areas. Most of the agencies have one form of additional protection: leak detection, monitoring wells, tank-level monitoring with alarms, or secondary containment. Several agencies have two of the above protection systems. One agency has three protection devices including leak detector, monitoring well, and tank-level monitoring with alarm. Figure 2 shows Houston Metro's USTs, with a trench system to achieve double-walled spill protection and a control panel to show when tanks are full. Figure 3 diagrams Houston Metro's West Bus Operating Facility UST plan.

The most common cause of soil contamination in the vicinity of fueling islands is leaking pipes. With the advent of the Clean Water Act and the emphasis to maintain and improve water quality, there is a major financial risk if contamination occurs. To reduce this risk, some agencies have designed underground pipes that carry fuel and other hazardous fluids to be double-walled, with the outside wall draining to a sump pump with a leak detector. The requirement to report and remediate even the smallest spill will make the investment in new piping, new pipe trenches, spill containment structures, or even new overhead lines (instead of inground) a better alternative than facing the high cost of spill cleanup.

Other Fluid Storage

To determine the impact of the Clean Water Act on storage of other fluids, surveyed agencies were asked to provide information on how other fluids are stored. For engine oil, of which many agencies have more than one type, USTs are primarily used. Only three relatively small agencies, 60 buses and under, used 55-gal drums for the storage of engine oil. Automatic transmission fluid (ATF) is also stored in USTs The same three relatively small agencies noted above plus another small agency store their ATF in 55-gal drums. The storage of anti-freeze varies. Thirteen agencies use USTs. One of these agencies uses 55-gal drums to store the recycled antifreeze. Four agencies use 55-gal drums. Another four located

TABLE 4
TRANSIT AGENCIES RESPONDING TO SURVEY

Transit Agency and Bus Maintenance Facility	Location	Year Built	Fleet Size
Alaska (1)			
Municipality of Anchorage	Anchorage	1991	60
Arkansas (1)			
Central Arkansas Transit	North Little Rock	1991	60
Canada (1)			
Mississauga Transit	Mississauga	1991	60
Florida (1)			
Lakeland Area Mass Transit District	Lakeland	1991	28
Hawaii (1)			
Honolulu Public Transit Authority	Honolulu	1990	280
Minnesota (1)			
Metropolitan Transit Commission	Minneapolis	1990	250
New Jersey (6)			
New Jersey Transit Corporation			
Hilton	Maplewood	1989	164
Howell	Howell	1986	159
Meadowlands	North Bergen	1993	129
Newton Avenue	Camden	1989	108
Orange	Orange	1987	159
Washington Township	Washington Township	1987	160
New York (3)			
MTA New York City Transit			
Casey Stengel	Queens	1990	175
Kingsbridge	Bronx	1993	219
Manhattanville	Manhattan	1992	216
Pennsylvania (1)			
York County Transportation Authority	York	1993	54
Texas (1)			
Capital Metropolitan Transportation Authority	Austin	1988	297
Virginia (2)			
Peninsula Transportation District Commission	Hampton	1988	110
Blacksburg	Blacksburg	1992	30
Washington (1)			
Municipality of Metropolitan Seattle	Seattle	1991	195
Wisconsin (1)			
Milwaukee County Transit System	Milwaukee	1987	(a)

(a) Central maintenance facility

in warm climates have no need for anti-freeze. Grease is most often stored in 55-gal drums. Only three agencies store grease in USTs.

At all new facilities, fluids are dispensed to the service and maintenance areas through piping leading to overhead reels (Figure 4). In most facilities, reels for dispensing fluids, such as grease, will be available within pits.

Most agencies noted that the only way they have to detect any leaks in these fluid lines is through visual observation. Most lines are mounted along the ceiling and are easily seen. A few other agencies mentioned that the lines were pressurized and that an alarm would sound if a leak occurred.

To avoid the possibility of spills and the financial risk involved, care should also be taken in the design of fluid storage areas to contain the spill. This is discussed further in the section on Floor Drainage Systems.

Automatic Bus Washers

The discharge of dirty water from an automatic bus washer is another area where the Clean Water Act and its related state and local regulations must be followed. The permit issued to an agency typically limits the amount of metal, soap, and other

TABLE 5
CURRENT PRACTICES OF TRANSIT AGENCIES-FACILITY AREAS IMPACTED BY RECENT LEGISLATION

	DIESEL FUEL STORAGE SYSTEM			FLUID STORAGE SYSTEM			AUTOMATIC	FACILITY EXHAUST SYSTEM			SITE	FLOOR DRAINAGE SYSTEM			SPECIAL
TRANSIT AGENCY	UST SIZE	TANK CONSTRUCTION	DETECTION SYSTEM	TYPES UTILIZED	DRAINAGE SYSTEM	LINE LEAK DETECTION	BUS WASHER	PRIMARY SYSTEM	SYSTEM IN PITS	MEASURE QUALITY OF AIR	DRAINAGE SYSTEM	MAINTENANCE & REPAIR AREAS	PITS	SPILL CONTAINMENT	SHOP & GARAGE EQUIPMENT
Alaska(1) Municipality of Anchorage	Three 10,000 Gal.	------	Monitoring	UST for Oil, ATF & Anti-Freeze 55 Gal. Drums for Grease	Stored in Pump Room	Meter to Detect Level Change	Recycling System	Exhaust Fans	None	None	None	Industrial Waste System Using Waste/ Oil Separator	Gravity Flow to Industrial Waste System	Absorbent Pads & Booms	Anti-Freeze Recycler
Arkansas(1) Central Arkansas Transit Authority	Two 20,000 Gal.	------	Monitoring	Tanks/Drums	Oil/Water Separator	Open Lines Overhead	Recycling System	Exhaust Fans	4 Vents in Each Pit	----	Oil/Water Separator	Industrial Waste System Using Waste/ Oil Separator	Oil/Water Separator	Catch Pit	-----
Canada(1) Mississauga Transit	Two 10,000 Gal.	Cathodically Protected	Monitoring	Tanks/Drums	None	None	Recycling System	Exhaust Fans	None	Monitoring	Storm & Sanitary Sewer System	None	None	Interceptor System & Inhouse Spill Procedure	Anti-Freeze Recycler
Florida(1) Lakeland Area Mass Transit District	Two 10,000 Gal.	Fiberglass Clad Steel	Monitoring	Above Ground	Oil/Water Separator	None	Chemical Spray Recycling System	Exhaust Fans	None	None	Retention Pond	Waste/Oil Separator	None	None	Freon Recovery & Anti-Freeze Recycler
Hawaii(1) Honolulu Public Transit Authority	Four 12,000 Gal.	Double-Walled Fiberglass	Remote Sensor	UST for Oil, ATF & Anti-Freeze 55 Gal. Drums for Grease	Oil/Water Separator	Shut-off/ Alarm	Recycling System	Exhaust Fans	Air Pump	None	Oil/Water Sump	Oil/Water Separator	Oil/Water Sump	Oil/Water Sump	Freon Recovery & Anti-Freeze Recycler
Minnesota(1) Metropolitan Transit Commission	Three 20,000 Gal.	Double-Walled Fiberglass	Monitoring	UST for Oil, AFT & Anti-Freeze 55 Gal. Drums for Grease	Oil/Water Separator	None	Recycling System	Exhaust Fans	Exhaust System	None	Storm Drains	Oil/Water Separator	Oil/Water Sump	None	None

TABLE 5 (CONTINUED)

	DIESEL FUEL STORAGE SYSTEM			FLUID STORAGE SYSTEM			AUTOMATIC	FACILITY EXHAUST SYSTEM			SITE	FLOOR DRAINAGE SYSTEM			SPECIAL
TRANSIT AGENCY	UST SIZE	TANK CONSTRUCTION	DETECTION SYSTEM	TYPES UTILIZED	DRAINAGE SYSTEM	LINE LEAK DETECTION	BUS WASHER	PRIMARY SYSTEM	SYSTEM IN PITS	MEASURE QUALITY OF AIR	DRAINAGE SYSTEM	MAINTENANCE & REPAIR AREAS	PITS	SPILL CONTAINMENT	SHOP & GARAGE EQUIPMENT
New Jersey(6)															
New Jersey Transit Corporation:															
Hilton	Two 20,000 Gal.	Single-Walled Fiberglass	Monitoring	UST for Oil & 55 Gal. Drum for Grease	Oil/Water Separator	None	Recycling System	Exhaust Fans	Supply & Return Fresh Air	None	Runs Off To Detention Basins	Industrial Waste System Using Waste/ Oil Separator	Trench & Floor Drains	None	Freon Recovery & Anti-Freeze Recycler
Howell	Three 20,000 Gal.	Single-Walled Fiberglass	Monitoring	Grease/Gear Lube in Drums, All Others in UST's	Oil/Water Separator	None	Recycling System	Exhaust Fans	Wall Ventilating Ducts	None	Runs Off To Detention Basins	Industrial Waste System Using Waste/ Oil Separator	Trench & Floor Drains	Values/ Connections in Concrete Pits	None
Meadowlands	Two 20,000 Gal.	Single-Walled Fiberglass	Monitoring	Grease/Gear Lube in Drums, All Others in UST's	Oil/Water Separator	Tank Leak Sensors	Recycling System	Exhaust Fans	None	None	Runs Off To Detention Basins	Industrial Waste System Using Waste/ Oil Separator	Sump Pump	None	Paint Booth & Freon Recovery
Newton	Two 20,000 Gal.	Single-Walled Fiberglass	Monitoring	Grease/Gear Lube in Drums, All Others in UST's	Oil/Water Separator	Tank Leak Detection	Recycling System	Exhaust Fans	Wall Ventilating Ducts	None	Runs Off To Detention Basins	Industrial Waste System Using Waste/ Oil Separator	Trench & Floor Drains	Values/ Connections in Concrete Pits	Paint Booth
Orange	Two 20,000 Gal.	Single-Walled Fiberglass	Monitoring	Light Grade Oil & Grease in Drums, All Others in UST's	Oil/Water Separator	None	Recycling System	Exhaust Fans	Supply & Return Fresh Air	None	Runs Off To Detention Basins	Industrial Waste System Using Waste/ Oil Separator	Trench & Floor Drains	None	Paint Booth & Freon Recovery
Washington Twp.	Three 20,000 Gal.	Single-Walled Fiberglass	Monitoring	Grease/Gear Lube in Drums, All Others in UST's	Oil/Water Separator	None	Recycling System	Exhaust Fans	Wall Ventilating Ducts	Monitoring	Runs Off To Detention Basins	Industrial Waste System Using Waste/ Oil Separator	Trench & Floor Drains	Values/ Connections in Concrete Pits	Paint Booth

TABLE 5 (CONTINUED)

	DIESEL FUEL STORAGE SYSTEM			FLUID STORAGE SYSTEM			AUTOMATIC	FACILITY EXHAUST SYSTEM			SITE	FLOOR DRAINAGE SYSTEM			SPECIAL
TRANSIT AGENCY	UST SIZE	TANK CONSTRUCTION	DETECTION SYSTEM	TYPES UTILIZED	DRAINAGE SYSTEM	LINE LEAK DETECTION	BUS WASHER	PRIMARY SYSTEM	SYSTEM IN PITS	MEASURE QUALITY OF AIR	DRAINAGE SYSTEM	MAINTENANCE & REPAIR AREAS	PITS	SPILL CONTAINMENT	SHOP & GARAGE EQUIPMENT
New York(3) New York City Transit Authority:															
Casey Stengel	Ten 4,000 Gal.	Double-Walled Fiberglass	Leak Detection	Fluids are Stored Above & Below Ground	Oil/Water Separator	None	Recycling System	Exhaust Fans	-----	Monitoring & Air Quality Testing	Storm/Sewer Sanitary System	Oil/Water Separator	------	Double-Walled Tanks	Oil Filter Crusher & Freon Recovery
Kingsbridge	Five 8,000 Gal.	Double-Walled Fiberglass	Leak Detection	UST for Oil & ATF, 55 Gal. Drum for Grease & Anti-Freeze	Oil/Water Separator	Leak Detection System	Recycling System	Exhaust Fans	Independent Exhaust Fans	None	Storm/Sewer Sanitary System	Oil/Water Separator	Oil/Water Separator	None	Oil Filter Crusher & Freon Recovery
Manhattanville	Ten 4,000 Gal.	Double-Walled Fiberglass	Leak Detection	Fluids are Stored Above & Below Ground	Oil/Water Separator	None	Recycling System	Exhaust Fans	Independent Exhaust Fans	Periodic Testing	Storm/Sewer Sanitary System	Oil/Water Separator	Oil/Water Separator	Double-Walled Tanks	Oil Filter Crusher & Freon Recovery
Pennsylvania(1) York County Transportation Authority	One 12,000 Gal. & One 6,000 Gal.	Double-Walled Fiberglass	Leak Detection	Tanks & Drums are Stored Above Ground	Oil/Water Separator	None	Non-Recycling System	Exhaust Fans	-----	None	Waste Separator	Oil/Water Separator	Floor Drains	None	Freon Recovery, Anti-Freeze Recycler & Waste Oil Heater
Texas(1) Capital Metropolitan Transportation Authority	Six 20,000 Gal.	Double-Walled Fiberglass	Monitoring, Tank Level Alarms & Leak Detection	UST for Oil, ATF & Anti-Freeze 55 Gal. Drum for Grease	Oil/Water Separator	Monthly PM's	Recycling System	None	Air Drains	None	Retenton Pond	Oil/Water Separator	Oil/Water Separator	Emergency Spill Station	Paint Booth, Freon Recovery & Solvent Recovery
Virginia(2) Peninsula Transportation District Commission	Two 15,000 Gal.	Fiberglass	None	ATF stored in Drums & All Others Stored Underground	Oil/Water Separator Sanitary Sewer	None	Recycling System	None	Exhaust Hose	None	Oil/Water Separator	Oil/Water Separator	Oil/Water Separator	Oil/Water Separator	Freon Recovery & Anti-Freeze Recycler

TABLE 5 (CONTINUED)

TRANSIT AGENCY	DIESEL FUEL STORAGE SYSTEM: UST SIZE	TANK CONSTRUCTION	DETECTION SYSTEM	FLUID STORAGE SYSTEM: TYPES UTILIZED	DRAINAGE SYSTEM	LINE LEAK DETECTION	AUTOMATIC BUS WASHER	FACILITY EXHAUST SYSTEM: PRIMARY SYSTEM	SYSTEM IN PITS	MEASURE QUALITY OF AIR	SITE DRAINAGE SYSTEM	FLOOR DRAINAGE SYSTEM: MAINTENANCE & REPAIR AREAS	PITS	SPILL CONTAINMENT	SPECIAL SHOP & GARAGE EQUIPMENT
Virginia (cont.)															
Blacksburg	One 20,000 Gal.	Double-Walled Fiberglass	Monitoring & Alarm	All Fluids Stored In Drums	Oil/Water Separator	None	Non-Recycler System	Exhaust Fans	Exhaust System	None	Detention Pond & Oil /Water Separator	Oil/Water Separator	Two Floor Drains Through Oil /Water Separator	Secondary Containment	Freon Recovery & Anti-Freeze Recycler
Washington(1)															
Municipality of Metropolitan Seattle	----	Double-Walled Fiberglass	Monitoring	UST for Oil, ATF & Anti-Freeze 55 Gal. Drum for Grease	Oil/Water Separator	Leak Detection System	Recycling System	Exhaust Fans	-----	None	Sediment Pond & Oil /Water Separator	Oil/Water Separator	Industrial Waste Drains	Sump Pump & Dike	Anti-Freeze Waste Stored Underground
Wisconsin(1)															
Milwaukee County Transit System	None	Double-Walled Fiberglass	-----	UST For All Fluids Stored	UST Waste Oil Tank	Leak Detection System	None	None	Forced Air Exhaust	Checked Annually By An Outside Contractor	Sewage District	Drainage to Sanitary Sewer	Drainage to Sanitary Sewer	None	Oil Filter Crusher & Anti-Freeze Recycler

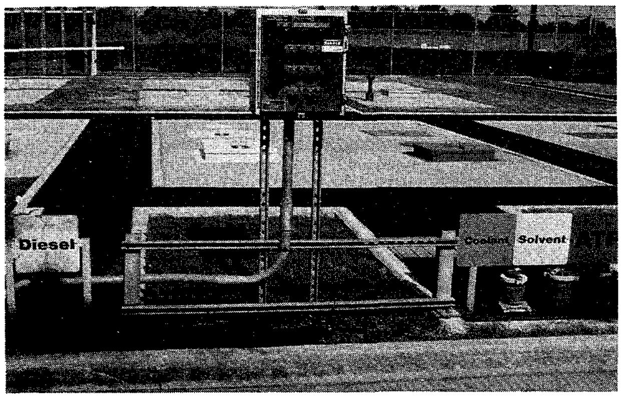

FIGURE 2 Product fill lines to underground storage tanks. Note trench system to achieve double-walled spill protection and in foreground, the control panel showing when tanks are full. (Courtesy of Houston Metro)

man-made materials that can be released into the sanitary sewer system.

All the agencies except one have at least one automatic bus washing system. All but two of the automatic bus washers are drive-thru types where a service worker drives the bus slowly through the various stages of the wash cycle. The other washer is known as the gantry type where the bus is driven into the bus wash area and parked. The washer then moves along the bus in its own floor-mounted track cleaning the front, back, sides, and roof.

Sixteen of the 20 new bus maintenance facilities have automatic bus washers with wash water recycling. A water recycling system usually recycles about 80 percent of the wash water. Typically, water used for the rinse cycle is not recycled water. The four agencies without water recycling include three relatively small agencies (under 100 buses) and one larger agency.

The high fees on wastewater discharges to the sewer system often make a water recycling system a cost savings feature. Further, the system permits more frequent vehicle washing during community water shortages.

Facility Exhaust Systems

Roof- and ceiling-mounted exhaust fans are identified as the predominant methods used to remove fumes from bus storage and servicing areas. These exhaust systems are also found in the vehicle repair bays. Design guidelines and building codes require mechanical ventilation (approximately four air changes per hour) for vehicle repair shops. In the repair bays, the central exhaust system (Figure 5) is supplemented with flexible piping that is attached to the bus tail pipe and vents the fumes into the exhaust system. Three unique facility features were identified in the questionnaire for exhausting fumes, including: 1) mounting an exhaust-catch system at the location of the tailpipe when the bus is stopped along the service island at the stages where revenue is removed and the bus is fueled (Mississauga Transit); 2) designing the bus storage area exhaust system to include provisions for opening some garage doors if sensors indicate that the fumes are above a certain level (Mississauga Transit); and 3) designing the exhaust system with a heat-recovery provision, which is incorporated in all exhaust systems of a particular facility, including that for individual bus tailpipes (Municipality of Anchorage).

A question was also asked concerning existence of any special exhaust system within the repair pits. Building codes require ventilation of all pits in the vehicle repair shop. It should be noted that two agencies did not have a pit in their new facilities. Two types of pit exhaust systems exist. The most common type is an exhaust system with vents located near the floor of the pit that remove air from near the bottom of the pit. This exhaust system operates either independently of or in conjunction with the overall exhaust system for the repair area. The pit exhaust system at one facility is designed to actuate when the lights within the pit are turned on. Another method is to provide make-up air into the pit. This is done either as the only way to provide cleaner air in the pit or in conjunction with an exhaust system. In one system, the make-up air is even heated. Four of the facilities had no special exhaust or make-up air in the pits.

The quality of air in a bus maintenance facility is of concern, especially for those who work there every day. The air in an enclosed bus storage area can be filled with exhaust fumes, especially when a large number of buses are started in the morning in preparation for their pull-out. Yet, only a few agencies reported that they measure for air quality. One agency monitors the bus storage area for carbon monoxide (CO). Two other agencies monitor for both CO and oxides of nitrogen (NOx). Two others reported that periodic testing is done of the air quality in the facility. Of note, one agency later reported that it not only monitored and measured bus storage area air quality, but that it has become practice to effect ten air exchanges per hour. No other air-quality monitoring is done at the other agencies.

Site Drainage Systems

Most of the fluids handled in a typical bus maintenance facility are considered hazardous and therefore the Clean Water Act and related state and local regulations apply. The consequences if the facility does not accommodate these materials properly can be very costly to the agency. For example, spills or wash-off into the site paving could seep through unsealed joints or cracks and contaminate the soil. This may result in a costly site cleanup problem. The spill or wash-off could also flow into nearby streams or the stormwater system and result in further fines and cleanup costs.

Three common forms of site drainage were reported. In the first, stormwater is drained directly into the municipal sanitary sewer system. Many of the 21 new facilities follow this method and have no site water pretreatment. The second most common method is where stormwater from the paved areas of the site is funneled through an oil/water separator before being discharged into the municipal sanitary sewer system. The third feeds stormwater runoff to a detention pond for ultimate release into a stream or surface water system. One agency uses a combined method where stormwater from the roof of the facility is fed into a detention pond while the runoff from the

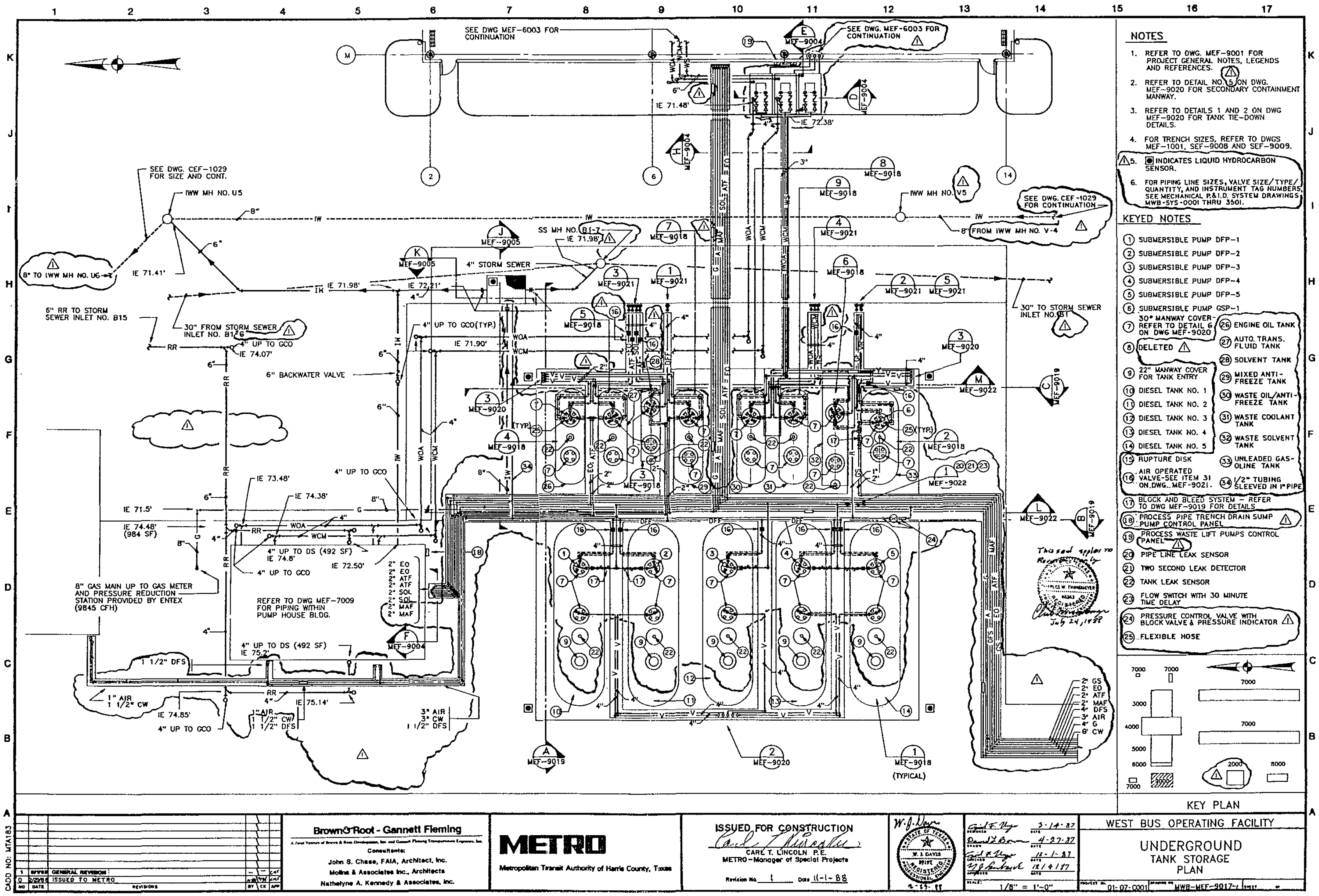

FIGURE 3 Underground tank storage plan. (Courtesy of Houston Metro)

FIGURE 4 Overhead reels.

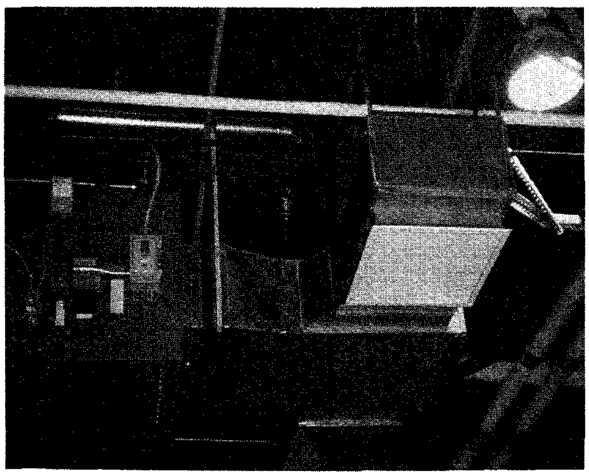

FIGURE 5 Central exhaust system.

paved, outside parking area is treated with an oil/water separator.

It should be noted that the requirements for discharge into a stream or surface water system are more stringent (e.g., maximum of 10 parts per million (ppm) of oil and no observable sheen) than discharge into a sanitary sewer system (e.g., 50 to 100 ppm of oil).

Many sewer agencies impose fines on facility owners if oil or other pollutants that exceed the limits listed in their discharge permits are discharged into their systems. One agency found that the cost of an oil/water separator system for a large complex (10 to 12 acres) can cost up to a quarter million dollars.

Floor Drainage Systems

Nearly all (18) of the new facilities have floor drainage systems throughout the maintenance areas (including fluid storage areas, steam clean bays, repair bays, and machine shop) that feed an industrial waste system or an oil/water separator before any fluid is discharged into the sanitary sewer system. This is a relatively new requirement that has occurred as a result of the Clean Water Act and implementation of state and local regulations. Several agencies enhance this treatment method by feeding the effluent into sediment basins before the oil/water separator system. Two of the remaining agencies only have a sediment basin to trap impurities. One agency has no pretreatment method.

Of the 19 systems using pits, the pits at 16 are equipped with drains that feed into the facility industrial waste or oil/water separator system. The remaining three systems with pits have no special treatment of effluent from pit drains.

Older bus maintenance facilities are typically equipped with grease traps within floor drains as the only method to capture impurities before the fluid is discharged into the sanitary sewer system. As presented above, most facilities now have industrial waste or oil/water separator systems for this purpose. Even so, five new facilities have floor drains that contain grease traps. These traps are cleaned periodically. In most cases, the effluent from the trap is then treated by the oil/water separator.

Another question addressed whether the facility was equipped with any special provisions to handle a fluid spill. Most answered that there are none. The provision noted in five facilities is spill containment using a dike or pit in the fluid storage area where the floors are diked or sloped to a sump or trench drain to capture spills. The design found in the Seattle Metro system is a combined floor drain pretreatment and spill containment system that has an oil/water separator at the first stage. The discharge flows into two large holding tanks and the fluids from the tanks are alternately released into the sanitary sewer system. The tanks are designed to hold over seven days of discharge, with any sediment settling to the bottom. If any spill is suspected, the flow is contained and can be pumped from the holding tanks.

Two other agencies mentioned that they have absorbent pads and booms (interceptors) to capture and contain any minor spill. One agency locates absorbent pads around all outside drains to capture any impurities before they flow into the drainage system.

Special Shop and Garage Equipment

The surveyed agencies were asked to list any special shop and garage equipment they used. These items noted by the agencies, and the number of times each is mentioned, are summarized below.

Equipment	Number of Times Mentioned in Survey
Anti-freeze recycler	12
Freon recovery unit (Figure 6)	12
Paint spray booth*	6
Oil filter crusher	4
Waste oil heater	2
Solvent recovery system (Figure 7)	1

*For those agencies that do not contract out this item.

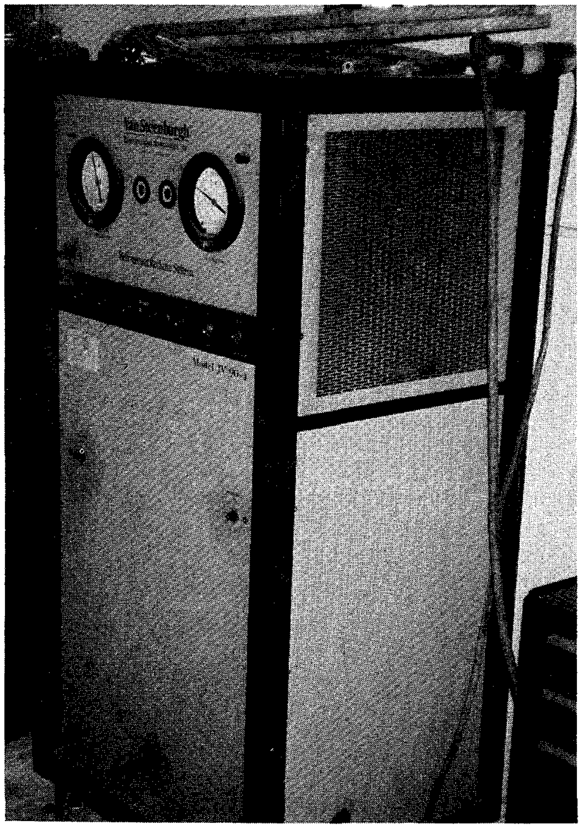

FIGURE 6 Freon recovery system.

The listed items are covered by current regulations. For example, Title VII of the CAAA of 1990 requires freon recovery to avoid the release of freon into the atmosphere. Freon contains chlorofluorocarbons (CFCs), which have a damaging effect on the ozone layer. Specifically, the requirements of the Stratospheric Ozone Protection Ruling, found in 40 CFR 82, state refrigerant CFC-12 known as R-12 must be recycled. This refrigerant is used in most bus air-conditioning systems. Some air-conditioning systems are designed to use CFC-22 or R-22, which are not considered motor vehicle air-conditioning refrigerants and are therefore not included in the law. However, R-22 will have a damaging effect on the atmosphere and should still be recovered even though such action is not required.

Other Facility Design Features

Survey responses also described facility design features that do not have a direct relationship to the recent federal legislation and implementing regulations. These include facility noise, floor treatment, facility lighting, and outside bus storage. Responses from the agencies are presented below and summarized in Table 6.

Facility Noise

Repair bay areas of a bus maintenance facility can be extremely noisy. In particular, noise is generated by the power units of automatic bus lifts when the lifts are raised and lowered. The air compressor units and air impact wrenches are also noisy. Operation of much of the shop and garage equipment can also cause loud sounds.

New bus facility designs have addressed the noise problem in several ways. First, the noisy components such as air compressors, steam cleaners, and bus lift power units are located in separate and enclosed rooms. Thus, the noise from these components is isolated from the working areas. Second, a number of machine shop functions that are noisy (e.g., dynamometers and brake drum lathes) are located in enclosed rooms and isolated from the other work areas. Finally, a number of sound isolation techniques were reported, including:

- Styrofoam on block walls,
- Sound isolation material within walls,
- Sound attenuation panels on walls and ceilings,
- Baffle plates on walls, and
- Resilient floor mats in tire area.

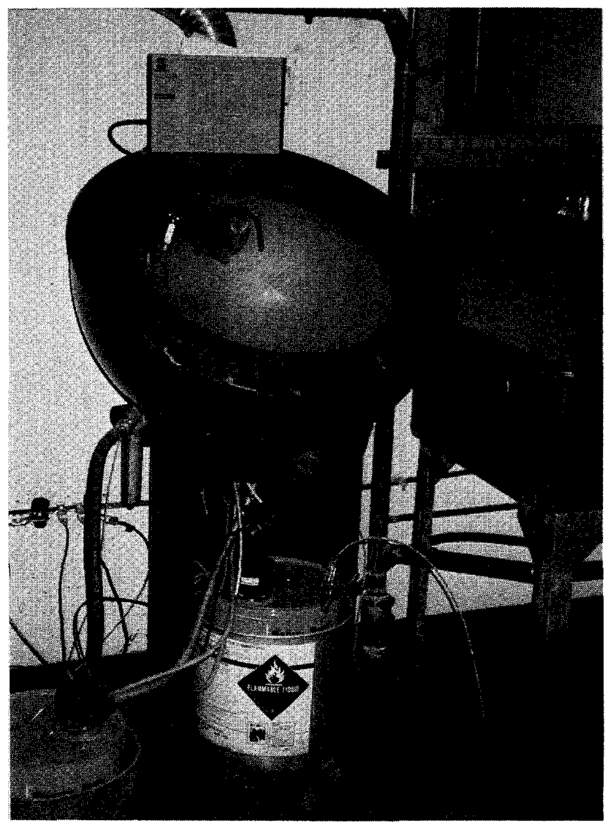

FIGURE 7 Solvent recovery system.

Floor Treatment

One of the most challenging things in the design of a bus maintenance facility is to have floors that resist oil and other spills, are easy to clean, look good, and are not too slippery. Floors need to be tough and hard enough to avoid chipping when heavy items such as wheel rims and tools are dropped,

TABLE 6
CURRENT PRACTICES OF TRANSIT AGENCIES-FACILITY AREAS NOT IMPACTED BY RECENT LEGISLATION

TRANSIT AGENCY	FACILITY NOISE	FLOOR SEALING TREATMENT	FACILITY LIGHTING	FACILITY HEATING	GARAGE DOOR SYSTEM	OUTSIDE BUS STORAGE
Alaska(1)						
Municipality of Anchorage	Baffle Plates on Walls	None	Fluorescent In Shop Area & High Pressure Sodium In Parking Area	Gas Fired Units With Energy Recovery In Repair & Storage Area, Gas Fired Unit Heaters\Boilers In Machine Shop & Offices	Plastic Strips	None
Arkansas(1)						
Central Arkansas Transit Authority	Resilient Floor-Mat In Tire Area	None	HB Industrial	Natural Gas Radiant	Snow-Melt Device	None
Canada(1)						
Mississauga Transit	None	Manually Applied Sealant	High Pressure Sodium	Gas Fired Unit Heaters In Shop Area, Radiant Heaters Washbay	Rapid Roll Doors, Standard Roll-Up Doors	UWE Outdoor Heating System
Florida(1)						
Lakeland Area Mass Transit District	None	None	Fluorescent & Sky Lights	None	None	None
Hawaii(1)						
Honolulu Public Transit Authority	Walls & High Insulated Ceilings	Metalic Floor Hardener	High Pressure Sodium	None	Triggered by Heat Sensor - Emergency Door	None
Minnesota(1)						
Metropolitan Transit Commission	None	Concrete Sealer	Fluorescent	Low Pressure Steam With Heat Recovery	Overhead Doors	None
New Jersey(6)						
Hilton	Separate Rooms	Penetrater Type Sealer	High Pressure Sodium In The Bus Storage Area, Florescent In Offices	Gas Fired Unit Heaters	Air Curtains, Safety Edge, Loop Detectors, & Heater Snow Melt	None
Howell	Sound Attenuation Panels & Enclosed Areas	Spray/Roll-On Liquid Hardener	High Pressure Sodium In Maint./Service/Storage, Florescent In Work Office/Locker Areas	Gas Fired Unit Heater, Baseboard Pin-Tube Heaters In Offices	Air Curtains	None

TABLE 6 (CONTINUED)

TRANSIT AGENCY	FACILITY NOISE	FLOOR SEALING TREATMENT	FACILITY LIGHTING	FACILITY HEATING	GARAGE DOOR SYSTEM	OUTSIDE BUS STORAGE
New Jersey(cont.)						
Meadowlands	Side-walls on Brake/ Machine Area, Enclosed Areas	Dry Shake Hardener	High Pressure Sodium In Maint./Service/Storage, Florescent In Work Office/Locker Areas	Gas Fired Unit Heater, Baseboard Pin-Tube Heaters In Offices	Air Curtains, Loops, Safty Strips & Signal Lts.	None
Newton Avenue	Sound Attenuation Panels & Enclosed Areas	Spray/Roll-On Liquid Hardener	High Pressure Sodium In Maint./Service/Storage, Florescent In Work Office/Locker Areas	Gas Fired Unit Heater, Baseboard Pin-Tube Heaters In Offices	Air Curtains	None
Orange	Overhead Doors & Separate Rooms	Penetrating-Type Sealer	High Pressure Sodium In Maint./Service/Storage, Flourescent In Work Office/Locker Areas	Gas Fired Unit Heaters	Air Curtains, Snow Melt & Safety Edge	None
Washington Township	Sound Attenuation Panels & Enclosed Areas	Spray/Roll-On Liquid Hardener	High Pressure Sodium In Maint./Service/Storage, Florescent In Work Office/Locker Areas	Gas Fired Unit Heater, Baseboard Pin-Tube Heaters In Offices	Air Curtains	None
New York(3)						
Casey Stengel	None	Concrete Sealer	Metal Halide In Maint./ Service, Flourescent In Work Office	Gas Fired Unit Heaters, Hot Water Radiators In Office Areas	Heated Air Curtains, Safety Edge	None
Kingsbridge	None	Silane Based Protective Sealer	Metal Halide	Gas Fired Unit Heaters, Steam Heating With Heat Recovery	Roll-Up Metal Door & Grille With Air Curtains	None
Manhattanville	None	Expoxy Coats	Flourescent & Metal Halide	Hot Water Heat Via Dual Fuel Boilers	Roll-Up Metal Door, Heated Air Curtains, Safety Edge	None
Pennsylvania(1)						
York County Transportation Authority	Sound Insulation	Expoxy Coats	High Pressure Sodium	Oil Furnace & Forced Hot Air	None	Block Heaters

TABLE 6 (CONTINUED)

TRANSIT AGENCY	FACILITY NOISE	FLOOR SEALING TREATMENT	FACILITY LIGHTING	FACILITY HEATING	GARAGE DOOR SYSTEM	OUTSIDE BUS STORAGE
Texas(1)						
Capital Metropilitan Transportation Authority	Sound Insulation	None	Fluorescent & Metal Halide	Electric Heaters, Hot Loop With Fans	Fiberglass Overhead Doors With Vents	None
Virginia(2)						
Peninsula Transportation District Commission	None	None	Fluorescent & Indirect Natural Light	Steam Coil In Shops, Heat Pumps On Hot Water Loop	None	None
Blacksburg	Styrofoam Poured Into Cement Block Walls	Linseed Oil Mix	High Pressure Sodium	Natural Gas Fired Infrared Radiant Tube	Roll-Up Metal Doors	None
Washington(1)						
Municipality of Metropolitan Seattle	Separate Rooms	Metalic Floor Hardener	High Pressure Sodium & Metal Halide	-----------	None	None
Wisconsin(1)						
Milwaukee County Transit System	None	Polyurethane Original	High Pressure Sodium	Forced Air, Natural Gas	None	None

and to avoid concrete dusting resulting from movement of steel wheelcarts and jacks. Further, the floor joints and cracks must be sealed to avoid leakage of fluid spills that could cause soil contamination. From the survey of new facilities, it appears that there are a number of options.

The agencies were asked to describe methods used to treat and seal floors throughout the shop and bus storage area. The responses varied widely. Five agencies indicated that the floors of their new facilities have no special treatment. The treatments in the remaining 16 facilities are summarized below:

- Hardener applied during concrete finishing and a sealer applied after,
- Concrete sealer only,
- Epoxy top coating,
- Penetrating type sealer,
- Silane-based protective sealer,
- Linseed oil mix, and
- Polyurethane coating.

Another design practice noted for the Honolulu Public Transit Authority and Seattle Metro is to work a white reflective metallic floor hardener into the top 5 in. of floor concrete and finish with a light texture to avoid slipperiness. The hardener is three to five times tougher than plain concrete and resists chipping. The light reflective quality is sufficient to light the undercarriage of a bus when it is on a lift, eliminating the need for a task light.

Facility Lighting

A question was asked about the lighting throughout the bus maintenance facility. For the office area, fluorescent lighting is used universally. In the maintenance, repair, and bus storage areas, three lighting types were used in various combinations: high-pressure sodium, metal halide, and fluorescent.

Facility Heating

Several facilities have no requirement for heating, e.g., Honolulu and Lakeland. However, the agencies that do heat their facilities gave a variety of responses concerning their heating systems. The criteria for heating system selection should consider worker comfort, air exchanges required by code, and potential for economic operation.

Most agencies have at least two different heating systems depending on the area to be heated. Several agencies even have a basic heating system for an area that is supplemented by another heating system. Because heat loss is very high in some portions of a bus maintenance facility, especially in areas containing garage doors, some facilities are designed so that the doors used most often are located with an eastern or southern exposure to minimize the heat loss.

MTA New York City Transit uses steam heat with heat recovery in its maintenance building and gas-fired air handling units in the bus storage area. The facility also has roll-up metal doors with heated air curtains to curb heat loss when garage doors are opened, a security grill for summertime use, and pressure-sensitive edges on the bottom of all doors.

New Jersey Transit Corporation has roof-mounted, gas-fired units supplemented by electric unit heaters in its maintenance building. Roof-mounted, gas-fired units are used in the bus storage area as well as in the service area, where gas-fired infrared heaters supplement the units. To regulate heat loss from opening and closing garage doors, New Jersey Transit Corporation uses roll-up metal doors with heated air curtains, an automatic door closure system actuated by a loop detector, buried electric wire to melt snow, and sensitive edges.

The Municipality of Anchorage uses two gas-fired units with an energy recovery feature supplemented by a waste-oil heater in its maintenance building. Certain shops have gas-fired unit heaters. The bus storage and service areas are heated by gas-fired units with an energy recovery feature.

Other agencies have techniques to avoid heat loss as well. Mississauga Transit uses rapid roll-up canvas doors at the main entrance to the bus storage area and at the entrance to service bays to curb heat loss, and places loop detectors in the service bays to actuate signals outside to note that the first station in the service bay is open and that the service worker can proceed to drive the bus inside. Honolulu Public Transit Authority uses heat sensors within the facility to trigger automatic garage doors and Seattle Metro interlocks a heat system with doors so that if a door stays open for more than 5 minutes, the heat system shuts down.

Outside Bus Storage

In warmer climates, buses can be stored outside overnight without any special provisions. Colder climates require some means to keep diesel engines warm, as they tend to be difficult to start if they are exposed to temperatures below freezing.

Of the 20 bus garages in the sample, 13 store their fleets indoors. Of the seven agencies where the buses are stored overnight outside, only two are located in relatively cold climates-York, Pennsylvania and Mississauga, Canada.

The York facility is a recently completed rehabilitation of a trucking maintenance facility for transit use. Buses are stored outside and are equipped with electric block heaters for keeping the engines warm. The outside bus storage area is equipped with strategically located posts containing electrical outlets to supply power to the block heaters.

Buses are also stored outside at the relatively new Malton facility of Mississauga Transit. The city of Mississauga is located in the Province of Ontario and borders on the south of Toronto. Winter climates are very cold and hard on buses. Therefore, outside bus storage is unusual. Mississauga Transit uses a UWE Multipoint System, modeled after a method used in Sweden, to accommodate storing buses outside. The system works by passing hot water through the heating system of the bus to heat both the engine compartment and the bus interior. The bus's own compressed-air system is supplied with dry air to make it ready to start at any time.

A number of facility and bus modifications are required: 1) the internal heating system of the buses is modified to permit both the external heated water to pass through it as well as the addition of a separate heating system for the engine compartment; 2) the exterior of each bus is equipped with a small access door covering three fittings: the first is where the warm

TABLE 7
FURTHER FACILITY IMPROVEMENTS TO ACCOMMODATE FEDERAL REGULATIONS

System	Further Facility Improvements
Metropolitan Transit Commission	Increase energy savings systems
Milwaukee County Transit System	Locate welding shop at outside wall for venting purposes
Mississauga Transit	Design buildings to accommodate CNG vehicles
Municipality of Anchorage	Larger trench drains, different oil/water separator, and better doors on all high-cycle doors
MTA New York City Transit	
Casey Stengel	Increase air changes
Kingsbridge	Increase air changes from 6 to 10 during peak hours, better floor finish, and tank farm closer to dispensing units
Manhattanville	Increase air changes, submersible pumps in lieu of suction type, and better floor finish
New Jersey Transit Corporation	
Hilton and Orange	Double-walled containment for USTs and piping, heavy-duty bypass valves for underground fluid control system
Howell	Use material other than fiberglass in USTs and piping in tank farm
Meadowlands	Use Type II double-walled tanks, use gas unit heaters instead of infrared in service lanes, increase air changes
Washington Township	Improved drainage in steam clean bay
Peninsula Transportation District Commission	Containment and leak detection system at tank farm

water is fed into the bus heating system; the second is for removal of the water once it completes the cycle throughout the bus; and the third is to supply the compressed air; 3) the outside storage area contains a canopy at the front of the bus where the access door is located. This canopy protects the front of the vehicle and provides the means for the water and compressed-air lines to be routed to the bus parking area. A flexible hose with two water fittings and a compressed-air fitting is mounted on the support columns for the canopy; and 4) the access door contains an interlock system whereby the bus cannot be started while the water fittings and compressed-air fittings are hooked up.

This system has been successfully operated for two winter seasons. The tradeoffs made by Mississauga Transit *(17)* indicate that the UWE system is more economical than constructing an indoor bus storage facility with associated capital and ongoing operating expenses. In fact, a number of Ontario based transit systems are following Mississauga Transit's lead and are building new facilities using the UWE system for outside bus storage.

One distinct advantage of the UWE system is that it is easily adapted to a slow-fill, compressed natural gas (CNG) system. In fact, Mississauga Transit has a number of CNG buses. The same unit that attaches to the bus for the water and compressed-air system includes a CNG fitting. The canopy and columns support the gas line.

Another advantage of the UWE system is that the bus is relatively warm when the driver first enters it for the morning pull-out. Further, having the air system at working pressure saves on engine wear, noise, and fumes caused by several minutes of idling while waiting for the air pressure to build up.

Facility Changes

Questionnaire respondents from the agencies were asked what they would do differently in the design of their facility if they could make improvements as a result of recent federal regulations. As seen in Table 7, the responses varied and addressed improvements in air quality as well as concerns over fuel tanks and other fluid containment systems.

FACILITY MODIFICATIONS TO ACCOMMODATE NEW TECHNOLOGY BUSES

Another element of this synthesis project was the survey of transit agencies that had modified a facility to accommodate new technology or alternative-fuel buses. As noted, new technology buses are appearing more and more as a result of Title II of the CAAA of 1990, which provides for aggressive improvement in transit bus emissions beginning in 1994. However, the research effort in this area was minimal because it was recognized that this topic was the focus of ongoing research for the FTA, *Transit Facility Guidelines for Alternative Fuels,* to develop guidelines to assist transit agencies in determining the scope of modifications that are required to be made to facilities to accommodate alternative-fuel vehicles, and of another concurrent synthesis project, *TCRP Synthesis 1: Safe Operating Procedures for Alternative-Fuel Buses,* published in June 1994. Therefore, only five agencies known to have made facility modifications to accommodate alternative-fuel buses were contacted and mailed a survey questionnaire, provided in Appendix C. Metropolitan Transit Authority of Harris County, known as Houston Metro, and the MTA Long Island Bus, located in Nassau County, New York, responded to the questionnaire.

Facility Modification Findings from TCRP Synthesis 1

Each of the five alternative fuels reviewed in the synthesis required some form of facility modification. The focus was on fueling and maintenance repair areas. The findings by fuel type are summarized below.

CNG

- There are no specific facility requirements for fueling area, although it must have a fire extinguisher and emergency shut-off switch.
- The maintenance repair area should have explosion-proof devices and wiring, be well-ventilated, and have methane detectors located near the ceiling that activate special ventilators. An alternative to the explosion-proof requirement would be a strict policy of closing off the bus CNG tanks and purging the fuel systems. A special clean and dry area should be set aside in the parts room for CNG parts.

LNG

- NFPA has developed codes for LNG fuel storage and dispensing, but these codes do not apply specifically to maintenance facilities unless refueling and maintenance occur in the same area.
- The maintenance repair area should be well ventilated and be free from any ignition sources. It should also have methane detectors to activate a high-flow ventilation system and to disable facility electric power.

LPG

- Facility requirements for the fueling area are defined in NFPA Standards for Storage and Handling of Liquefied Petroleum Gases (LPG), NFPA 58. The fueling area must have a fire extinguisher and an emergency shut-off switch.
- The maintenance repair area should have explosion-proof devices and wiring, and be well ventilated to remove LPG from the ground level. An alternative to the explosion-proof requirement would be a strict policy of closing off the bus LPG tanks and purging the fuel system. A special clean and dry area should be set aside in the parts room for LPG parts.

Ethanol

- Facility requirements for fueling are similar to those for gasoline.
- The maintenance repair area must have high ventilation rates in the pits and throughout the facility.

Methanol

- Facility requirements for fueling are similar to those for gasoline.
- The maintenance repair area must have high ventilation rates in the pits and throughout the facility. There is also the need for a special engine oil formulation that may require another oil storage and dispensing system.

It should be noted that the above information on facility design impacts resulting from new technology buses is an overview and not intended to be all inclusive. Battery-powered and other new technology buses are not addressed in *TCRP Synthesis 1*. As noted before, improvements are being made to the diesel engine to meet the CAAA of 1990 and, if successful, will eliminate many facility modifications listed above.

Houston Metro- LNG

The facility rehabilitation project at Houston Metro, completed in 1993, was to revise existing building systems to allow for safe handling of LNG-fueled buses. Modifications were accomplished in the bus inspection area of the Kashmere facility, which was built in 1982. The facility is assigned 131 buses of which 17 are LNG-fueled. However, Kashmere is primarily a major rebuild facility.

The modification work focused on reducing the accumulation of natural gas vapors in the Kashmere bus inspection area. Modifications were made to the electrical, exhaust, and heating systems. A methane detection system was also added. In summary, the work included the following:

- Relocation of all receptacles within the repair area and assurance that all new or existing equipment starters (such as fans, hot water heaters, and motors) are three-phase or explosion-proof;
- Provision for additional exhaust system throughout the facility;
- Provision for new ceiling ventilation system;
- Replacement of existing gas-fired furnaces with hot water heater units;
- Removal of existing CO gas monitoring system; and
- Installation of methane gas monitoring system with interlocking connection for one roll-up garage door. Detection of methane by the system will shut off all lighting, except emergency lighting, in explosion-proof fixtures.

Presently, Houston Metro can identify nothing it would do differently with the project. However, with continued operation, improvements may become evident.

It should be noted that the facility modifications on this project were costly and exceeded \$20.00/ft^2 of maintenance area. Houston Metro staff indicated that a cost in the \$20.00 to \$25.00/ft^2 would be a reasonable planning estimate for similar projects.

MTA Long Island Bus-CNG

The MTA Long Island Bus project included the installation of a slow-fill CNG fuel line at the Mitchel Field Depot. Mitchel Field is a relatively new facility completed in 1987 that accommodates 220 buses. As a result of the Clean Air Act, MTA Long Island Bus obtained 10 CNG buses for a demonstration project.

The current project includes the installation of a slow-fill CNG fuel system that can accommodate up to 40 buses. The project was developed and designed by the local power company (Long Island Lighting Company) with the expectation of increased sales of natural gas.

Currently, the CNG buses are stored outside. However, future retrofits of air handling units are planned to accommodate indoor storage. The facility is equipped with methane detectors.

CHAPTER FOUR

REGULATORY IMPACTS ON FACILITY DESIGN

Analysis of the impacts of regulations on bus maintenance facilities is organized into two sections. The first is a description of the comments made by the 14 responding agencies on regulations that were accommodated in facility design. The second uses the as-built or design drawings from the recently completed facilities to determine overall sizes of functional areas. These sample facility sizes are compared with the size requirements noted in the 1987 report, *Transit Garage Planning Guidelines, A Review (5).* Sample as-built drawings are provided in Appendix E.

COMMENTS FROM SURVEY RESPONDENTS

The surveyed agencies were asked to note what new design features considered ADA, EPA, local/state, and OSHA regulations. Findings from survey respondent comments are summarized in Table 8 and are described below by type of regulation.

ADA Regulations

The thrust of the facility portion of ADA regulations is to make the facility accessible to those who use it. Most of the facilities listed in this survey were designed before the ADA regulations became effective. However, many of the agencies reported on a number of facility features that were accomplished to comply with ADA, such as:

- ADA requirements affected the design of restrooms of 12 agencies.
- Ten agencies reported the need to locate ramps throughout the facility as well as outside curb-cuts throughout the site.
- Many agencies mentioned accessible parking spaces, and several also noted that the interior of the facility must be accessible in terms of door widths, door hardware, and aisle widths.
- A number of agencies noted the need for elevators as a result of ADA. It should be noted that elevators are not only required in second floor offices but also in second floor maintenance work areas (Figure 8).
- Only a few agencies noted that ADA imposes special design requirements on water fountains.

The only facility feature affected by ADA regulation that is not mentioned in the survey is the need for accessible telephones.

It should again be noted that the ADA regulations took effect after many of the facilities in this survey were designed and built.

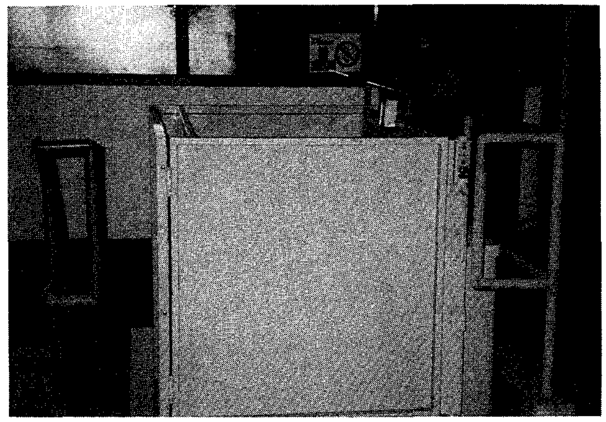

FIGURE 8 Maintenance work area elevator.

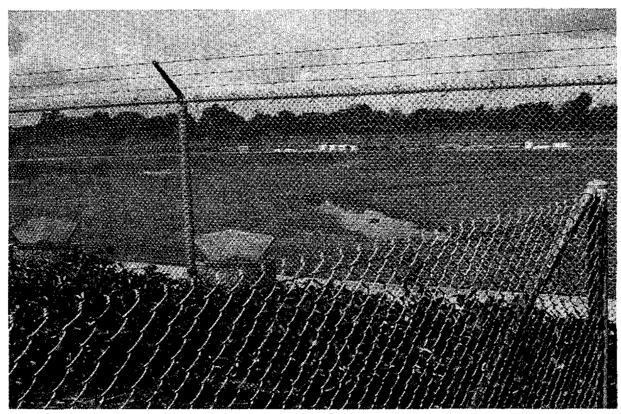

FIGURE 9 Detention pond-water is in pilot channel to outflow. (Courtesy of Houston Metro)

EPA Regulations

The surveyed agencies were asked a general question about types of design features that their facility contained to accommodate EPA regulations. Two major areas are identified. The first and most often cited is drainage systems, such as stormwater running off into a detention pond or oil/water separator system before being released into the municipal sewer/stormwater drainage system (Figure 9); feeding drainage within the maintenance and indoor bus storage areas into

TABLE 8
CURRENT PRACTICES OF TRANSIT AGENCIES-HOW REGULATORY REQUIREMENTS AFFECT FACILITY DESIGN

TRANSIT AGENCY	ADA REQUIREMENTS	EPA REQUIREMENTS	LOCAL/STATE REQUIREMENTS	OSHA REQUIREMENTS
Alaska(1)				
Municipality of Anchorage	-------	Waste Oil Burner, Industrial Waste System, Bus Wash Recycling System, Tank Monitoring System	Fire Codes In Placement Of Equipment, Electrical Outlets, & Lighting	Paint Booth, Exhaust Vent System, Explosive Proof Lighting and Electrical
Arkansas(1)				
Central Arkansas Transit Authority	Restrooms, Door Openings, Parking, Door Hardware, Drinking Fountains	Waste Oil Separator, Paint Booth, Run-Off Retention Pond, Bus Wash Recycling System	-------	General Safety Features, Ventilation System, FlameProof Cabinets, Paint Booth
Canada(1)				
Mississauga Transit	-------	Oil Interceptor, 10,000 Gal. Oil Separator Sump pumps In Hoist Pits	Environmental Assessment	CO Monitoring System
Florida(1)				
Lakeland Area Mass Transit District	Wheelchair Accessibility	Run-Off Retention Pond	Special Smoke Alarm System	Eye Washers, Safety Features Around Bus Lift
Hawaii(1)				
Honolulu Public Transit Authority	Restrooms, Sidewalk Ramps, Parking Elevators	Double-Walled UST's With Remote Monitoring System	-------	Emergency Eyewash & Showers, Exhausting System, Shielded Equipment
Minnesota				
Metropolitan Transit Commission	None	-------	All Building Codes	-------
New Jersey(6)				
New Jersey Transit Commission:				
Hilton	Elevators, Ramped Curbs, Restrooms Design	Monitoring Wells, Leak Detectors, Oil Water Separator	-------	Painted Curbs, Pedestrian Crosswalks, Anti-Skid Stair Treads
Howell	Depressed Curbs, Locker Room, Restrooms	Tank Farm Installations	-------	Pit Railings, Paint Booth Ventilation, Pit Ventilation
Meadowlands	Depressed Curbs, Locker Room, Restrooms	Leak Monitoring System, Storage Tanks & Piping, Under & Above Ground Fuel & Products	-------	Paint Booth Ventilation

TABLE 8 (CONTINUED)

TRANSIT AGENCY	ADA REQUIREMENTS	EPA REQUIREMENTS	LOCAL/STATE REQUIREMENTS	OSHA REQUIREMENTS
New Jersey(cont.)				
Newton Avenue	Depressed Curbs, Locker Room, Restrooms	Tank Farm Installations	-------	Pit Railings, Paint Booth Ventilation, Pit Ventilation
Orange	Ramped Curbs, Elevator, Restrooms	Monitoring Wells, Leak Detectors Oil Water Separator	-------	Safety Signs, Railing Around Pits, Paint Curbs, Pedestrian Crosswalks, Anti-Skid
Washington Township	Depressed Curbs, Locker Room, Restrooms	Tank Farm Installations	-------	Pit Railings, Paint Booth Ventilation, Pit Ventilation, Safety Signs Stair, Leak Detectors
New York(3)				
New York City Transit Authority:				
Casey Stengel	Elevators, Handicap Ramps, Handicap Accessible Toilets	High Efficiency Lighting, Recycle Bus Washer, Oil/Water Separator	Backflow Preventors	Bollards, Guard Rails, Ventilation, Eye Washers & Showers, Sprinkler System
Kingsbridge	Elevators, Ramps	-------	Tap Water Conservation System, Backflow Preventers	Bollards, Guard Rails, Painted Safety Yellow
Manhattanville	Elevators, Handicap Ramps, Handicap Accessible Toilets	Recycle Bus Washer, Oil Separators	Water Saver Toilets, Backflow Preventers	Bollards, Guard Rails, Painted Safety Yellow, Non-Slip Floor, Ventilation System, Eye Washers & Shower
Pennsylvania(1)				
York County Transportation Authority	-------	-------	Zoning, Requirements Of City Sewer	-------
Texas(1)				
Capital Metropolitan Transportation Authority	Fountains For Drinking, Restrooms	Underground Storage Tanks, Storm-Drains, Battery Acid Neutralizer	-------	Workers Safety, Guard Rails, Safety Chains Walkways, Exhaust Fans
Virginia(2)				
Peninsula Transportation District Commission	-------	-------	-------	-------

TABLE 8 (CONTINUED)

TRANSIT AGENCY	ADA REQUIREMENTS	EPA REQUIREMENTS	LOCAL/STATE REQUIREMENTS	OSHA REQUIREMENTS
Virginia(cont.)				
Blacksburg	Door Hardware, Water Fountains, Platform Lift On Stairs	Fuel Storage, Oil\Water Separator, Storm Water Management	Fire Protection, Landscaping, Parking	Pit Ventilation, Restrooms, Fueling Area Ventilation
Washington(1)				
Municipality of Metropolitan Seattle	Elevators, Door Widths, Restrooms, Handicapped Parking Stalls	Tank Liquid Level Monitor System, Double-Walled Tanks And Piping	Fire Sprinkler Deluge System Fueling Area	Guard Rail, Safety Locks on Lifts, Paint Storage Rooms, Leak Detectors
Wisconsin(1)				
Milwaukee County Transit System	-------	-------	-------	-------

an industrial waste system that included an oil/water separator (Figure 10); and using special drainage in battery rooms that included an acid neutralizer. In most cases, the key feature of the drainage system is pretreatment of the fluid before it is released into the sewer/stormwater drainage system.

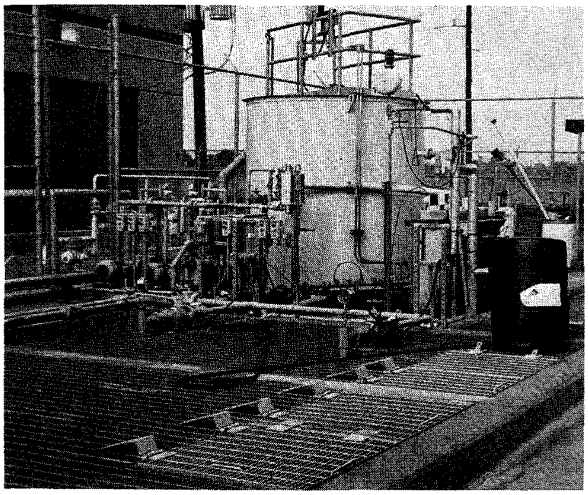

FIGURE 10 Industrial waste treatment plant. Oil/water separator is in foreground. (Courtesy of Houston Metro)

Design features for USTs are the second major area identified by many agencies as a result of EPA regulations. Some of the features noted are double-walled tanks, tank monitoring systems, and double-walled piping.

Several other facility systems are attributed to EPA regulations-automatic bus wash water recycling, waste-oil heaters, and high-efficiency lighting.

Local/State Regulations

In terms of the most recent legislation and implementing regulations that affect bus maintenance facility design, i.e., ADA, CAAA of 1990, Clean Water Act, and EPA regulations on USTs, a designer would have to specifically follow federal regulations only for ADA. Typically, the other federal regulations specify general guidelines that are incorporated into local and state regulations.

The importance of local and state regulations is verified by the responses of the surveyed agencies: many agencies noted that the design of their facility was entirely governed by local and state regulations; several agencies noted that regulations concerning water usage were imposed on their new facility in areas such as use of water-saving toilets, tap water conservation, and backflow preventor systems; and a number of agencies noted that fire protection systems including alarms and zoning for facility set-backs are important local requirements. Some unique features of facility design resulted from local and state regulations, including:

- Additional air-filtering system in the body shop;
- Fire sprinkler deluge system in the fueling area;
- Additional design criteria to consider wind loads on garage doors;
- Automobile parking lot constructed of blocks with holes to permit grass to grow within the blocks;
- Enclosed parking to avoid buses parking outside where they would be visible; and
- Special building exterior to be compatible with surrounding neighborhood.

OSHA Regulations

With regard to compliance with OSHA regulations, two items were the most frequently mentioned by seven agencies: railings for placement around pits when there is no bus over the pit; and special features along inside walking areas such as railings, painted walkways, non-skid walking surfaces, and step treads. Signage throughout the facility, ventilation in pits, and an eyewash/shower system (Figure 11) were each noted in

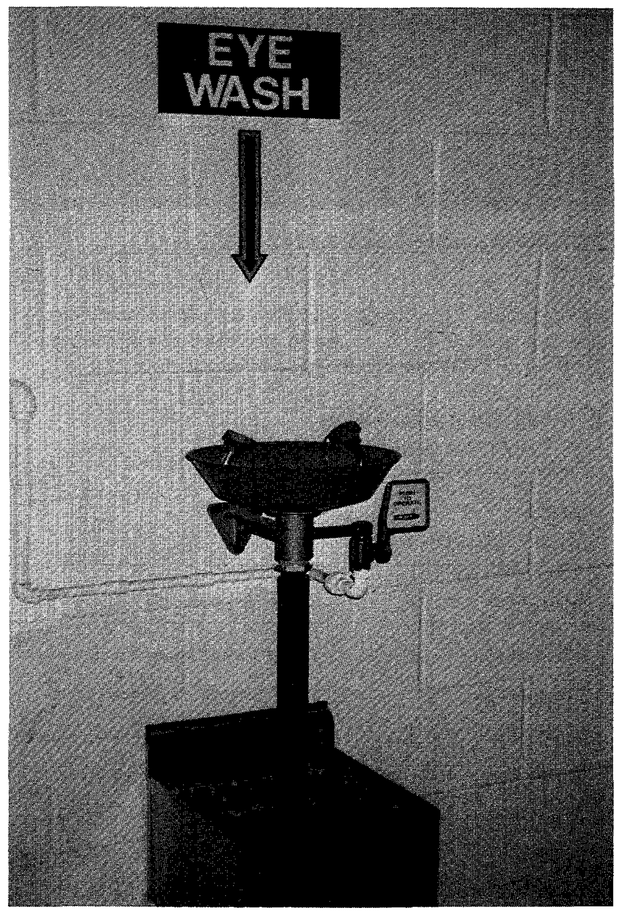

FIGURE 11 Eyewash system.

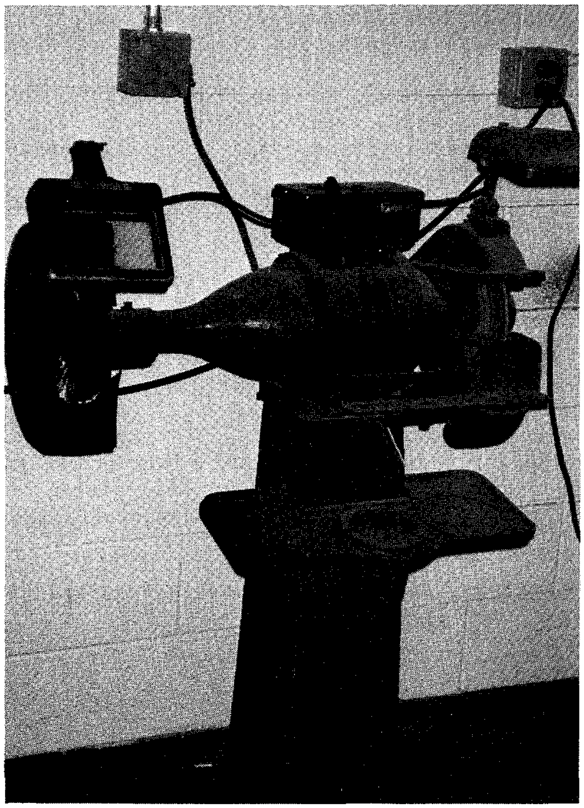

FIGURE 12 Shielded equipment.

six responses. Five facilities mentioned a facility exhaust system. Design features in response to OSHA requirements were noted by no more than three agencies and include:

- Bollards at garage doors,
- Ventilation in paint booths,

FIGURE 13 Explosion-proof lighting fixtures

- Full-sized paint booths,
- Sprinkler system,
- Vent system interlock in battery room,
- Methane detector,
- Shielded equipment (Figure 12),
- Lift locks for automatic bus lifts,
- Sprinkler catch basin in paint storage room,
- Fuel-level monitoring system,
- Explosion-proof fixtures (Figure 13), and
- Flame-proof paint storage cabinets.

The above list includes some items that are required by federal legislation and local codes other than OSHA.

FUNCTIONAL AREA SIZES

In the course of the survey of agencies, sizes of various functional areas of a new facility were obtained. This effort,

TABLE 9
FACILITY SIZE COMPARISONS

Facility Area	Design Guideline (5)	Survey Results
Administration	260 ft^2 times number of administrative staff	4 facilities smaller, 2 larger
Transportation	22 ft^2 per active fleet plus 900 ft^2	4 facilities smaller, 2 larger
Maintenance	1,400 ft^2 per 100,000 annual miles operated	5 facilities smaller, 1 larger
Repair Bays	2.34 bays per million annual miles operated plus 3.79 bays	All facilities the same or 1 or 2 bays less
Service Area	100 ft^2 times active fleet size	3 facilities smaller, 3 larger
Parts Room	230 or 130 ft^2 per 100,000 annual miles operated	All facilities much smaller
Bus Storage	500 ft^2 times active fleet size	2 facilities with indoor storage are larger

while not directly associated with facility changes resulting from recent federal regulations, provides another data point to aid architects and engineers in determining the appropriate size of a new bus maintenance facility.

The analysis of bus maintenance facilities, which is detailed in Appendix D, is organized according to four general areas of a transit system--administration, transportation, maintenance, and bus storage.

Sizes of the functional areas of a bus maintenance facility were developed in the 1987 report *Transit Garage Planning Guidelines, A Review (5).* The sizes were developed from design and as-built drawings from a number of bus maintenance facilities built before 1987. The sizes were tabulated and analyzed to determine a relationship that represented the sample. It should be noted that the relationship reflects the actual design experience of the sample and not necessarily what is the best size for a particular functional area. Appendix E provides examples of as-built drawings.

As seen in Table 9, for the major bus maintenance facility areas, the functional area sizes of sample facilities comply closely with size guidelines defined in the 1987 study. The major difference occurs in the parts room where all the new facilities are much smaller than the guideline.

However, the majority of facilities described here were designed before the full impacts of the recent federal legislation were known. Therefore, these results may not fully reflect the implications that the new federal legislation will have on size and functional layout of bus maintenance facilities.

CHAPTER FIVE

FINDINGS AND RECOMMENDATIONS

FINDINGS

Functional Area Review

The agencies surveyed were questioned about facility design features in a number of areas. Results from this review are summarized below by appropriate federal legislation.

ADA Regulations

The ADA regulations will affect bus maintenance facility size and functional layout in several ways: the restrooms will be larger; the parking area will accommodate fewer cars in the same space; more space may be required for elevators; if needed, ramps will be required for small elevation changes; and walkways will be wider throughout the complex. A number of special features will also be required, (e.g., signage, door hardware) which will add to the cost of a new or retrofit bus maintenance facility.

Clean Air Act Amendments of 1990

A number of facility design features are affected by CAAA of 1990. The biggest impact will be on facility maintenance area modifications required to safely accommodate new technology buses using alternative fuels. These include fuel handling, hazardous vapor venting, explosion-proof fixtures, special sensing devices, and other automatic controls to provide early warning of trouble. The specific requirements depend on the type of alternative fuel.

The CAAA of 1990 will also influence facility exhaust systems. More attention has been placed on providing clean air throughout the bus maintenance facility. Features such as special exhaust systems in the fuel area and repair areas are common. Further, most pits are designed with floor exhausts and many also are equipped with a make-up air system.

Additionally, new shop and garage equipment and more stringent requirements for old equipment are now associated with anti-freeze recycling, freon recovery, and paint spray booth containment.

Clean Water Act

The Clean Water Act has had an impact on facility design features. Most larger agencies with a fleet size of 100 or more buses recycle about 80 percent of wash water; many facilities have specific provisions to process site drainage before it drains into the municipal sanitary sewer system while others feed the runoff directly into the municipal system; and most agencies have a floor drainage system within the maintenance portion of the facility that includes industrial waste treatment in the form of an oil/water separator.

EPA Regulations on Underground Storage Tanks

All agencies store fuel in underground storage tanks. Tank sizes vary from 4,000 gal to 20,000 gal. A number of agencies use several smaller tanks rather than one or two larger ones to provide needed capacity. Many tanks are doubled-walled with spill prevention features, including leak detectors and level monitoring. Regulations have affected the fuel storage area of the agencies surveyed more than any other area. This may have been true only because the bus maintenance facilities of the surveyed agencies were neither feeling the full impact of ADA regulations nor were they accommodating new technology buses.

Other Design Features

As part of the survey, agencies provided information on a number of other bus maintenance facility design features, which are summarized below:

- Facility noise reduction-To address noise problems within the facility, two actions are found. In some agencies, the items causing excessive noise (such as power units for bus lifts and air compressors) are located in separate isolated rooms. Other facilities install sound isolation or absorption materials.
- Outside bus storage-A Canadian property, Mississauga Transit, equips buses with a modified heating system that is connected to an external hot water and compressed-air system. Buses are kept warm and are no trouble to start in very cold weather.
- Floor treatment-A variety of floor treatments are used in the new facilities. A unique treatment was the addition of a metallic hardener into the top layer of concrete. The additive not only hardened the concrete, but also provided for better reflection of light.
- Facility lighting-The majority of systems use high-pressure sodium for lighting throughout the maintenance and bus storage areas.

Bus maintenance facilities designed and built in the 1990s were constructed under one set of criteria. Now they are being asked to operate under an entirely new and more stringent set of criteria. The facility must be designed to be accessible and ensure that no aspect will adversely impact the environment. Because of the need to meet these new criteria, transit agencies will be forced to spend time, money, and effort.

RECOMMENDATIONS

This synthesis has identified the far-reaching impact that new federal legislation will have on the design and retrofit of bus maintenance facilities. Several recommendations are appropriate for agencies planning to design a new facility or to retrofit an old one, including:

- Involve professionals knowledgeable in environmental regulations early and throughout the design process so that federal, state, and local regulatory requirements and trends are addressed at the onset of the project.
- Use a peer review process to gain from experiences of other transit agencies. This may involve visiting other agencies, especially regarding facility modifications to accommodate new technology buses using alternative fuels.
- Design to full compliance with regulations. Many agencies surveyed for this synthesis commented that they underestimated what was required to meet state and local regulations.
- Be prepared for the additional cost that added regulations will have on a new or retrofit facility. Houston Metro estimates indicate that an additional $25.00/ft^2 will be needed to retrofit a bus maintenance facility to accommodate an alternative-fuel bus.

This synthesis also pointed to the need for further research in a number of areas including:

- Preparing minimum design standards for compliance with new regulations;
- Providing a summary of "best practices" related to bus maintenance facility design;
- Listing of state-by-state regulations covering accessibility and environmental requirements;
- Updating the 1987 design guide study to include more information on small transit agencies; and
- Identifying funding to support the facility modifications that are required to meet added regulations or new design guidelines.

GLOSSARY

Accessibility--The requirement resulting from ADA for transportation facilities to be barrier-free to persons with disabilities.

Alternative-Fuel Bus--A bus with a new technology engine designed to reduce the amount of pollution discharged. These new buses include engines powered by compressed natural gas, liquefied natural gas, liquefied petroleum gases, ethanol, methanol, and batteries.

Bus Maintenance Facility--The base of operation where a transit system has its offices, performs vehicle maintenance on its fleet, and stores its buses overnight.

Complementary Paratransit Service--ADA requires transit systems to provide a complementary form of service for persons who are unable to use fixed-route bus service. This service typically uses vans or small buses and includes direct service to and from the rider's home and trip destination.

Facility Retrofit--This refers to design changes made to an existing bus maintenance facility to meet additional functional requirements, such as accommodating alternative-fueled buses.

Fixed-Route Transit Service--The bus service typically provided by a transit agency, it follows a predetermined alignment and schedule.

Functional Layout--A bus maintenance facility comprises a variety of work areas where different activities are performed. The relationship of each work area to the other work areas is known as the functional layout.

Implementing Regulations--Federal, state, and local requirements that are established to implement federal legislation.

Pollution Prevention--Practices that reduce the use of hazardous materials, energy, water, or other natural resources, and practices that protect natural resources through conservation or more efficient use.

Regulatory Impacts--Changes in the design of a facility to comply with codes and other criteria that have been promulgated as a result of federal law.

Shop and Garage Equipment--Equipment needed to perform certain vehicle maintenance activities on a bus, such as an air compressor, bus lift, drill press, floor jack, parts cleaner, and tire balancer.

Transit Bus Accessibility--A requirement resulting from ADA for any new transit bus to be equipped with a wheelchair lift or other provisions, (e.g., low floor or ramp) to accommodate a person using a wheelchair.

Transit Agency--The operator of a local public bus system in an area. The agency is typically a public body that may be an authority or a form of a municipal government such as a city or county.

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APPENDIX A

Transit Facility Survey Form

AGENCY NAME:

CONTACT PERSON:

TITLE:

ADDRESS:

TELEPHONE NUMBER: DATE:

* *

What was the age of the facility prior to the new one?

In what year was the new facility opened?

Who was the primary architect and engineering firm for the facility?

How many bus maintenance facilities are there currently within your system?

What are the sizes of the maintenance facilities in terms of number of buses assigned?

Facility	Number of buses

New Facility Site Characteristics:

What is the history of contamination, if any on the site?

What was the prior usage of the site?

What is the site zoning?

What are the natural characteristics of the site? (i.e., near wetlands, etc.)

Describe the area surrounding the site? (i.e., suburban, urban, rural)

Operational Data For New Facility:

What is the capacity in terms of assigned buses?

Please describe assigned fleet below:

Number of buses	Year of Manufacture	Make/Model	Number of seats	Type of fuel
			--	
			--	
			--	
			--	
			--	
			--	
			--	

What are the peak period bus assignments?

What are the base period bus assignments?

What are the annual bus miles?

What are the annual bus hours?

Personnel Data For New Facility:

What is the total staff size?

What is the size of the Administrative staff?

What is the size of the Transportation staff (including drivers and others)?
What is the size of the Maintenance staff (including mechanics, service workers and others)?

Regulations Considered In Design

Please note what new design features considered OHSA requirements?

APPENDIX A (Continued)

Please note what, if any, new design features considered ADA requirements?

Please note what, if any, new design features considered EPA requirements?

Please note what, if any, new design features considered local and state requirements?

Features of New Facility:

Describe your bus fueling and fuel storage (including provisions for alternative fuels).

Describe the underground tank fuel storage system and any sensors to detect problems.

Describe the process for bus washing and water recycling.

Describe the types of exhaust systems used in the servicing area:
storage area:
repair area:
machine shop:
body/paint shop:

Describe the drainage system throughout the site (i.e., storm water pretreatment required, water testing, filtering system).

Briefly, describe the drainage system in the fluid storage area; and the steam clean area.

Describe the storage of fluids. (i.e., are oils, grease and other fluids stored in drums or tanks? above or below ground?)

Describe the dispensing of fluids. (i.e., the type of system used - drums or through reels)

What provisions are taken for the grease traps throughout the facility?

What kind of containment system do you have for the various spill types?

Describe your drainage and exhaust system within the pits.

What types of equipment are used to detect leaks in the hydraulic and fluid lines?

What special provisions do you use, if any, to measure air quality?

Describe the methods used to seal floors throughout the facility.

Describe special outdoor storage provisions, if any, (i.e., block heaters).

Describe the method(s) used to isolate and control shop noise.

Describe any special provisions for the battery charging room.

Describe the lighting system throughout the facility.

APPENDIX A (Continued)

Describe the heating system throughout the facility.

Describe the security system throughout the facility.

Describe any hazardous material ID and the storage methods.

Describe any special shop & garage equipment (e.g., freon recovery, anti-freeze recycling).

Describe any special garage door systems (e.g. air curtains).

Facility Deficiencies/Problems:

What would you do differently if you had to do it over again?

Describe any environmental incidents you may have had during the construction or operation.

Note:

Please attach more information for any of the review areas if you feel it would be beneficial to fully explain your particular situation. Also, if possible, please provide a copy of the site plan as well as floor plans for your new facility noting functional spaces and sizes. Further, if possible, please provide a copy of the environmental assessment report for the original project design.

THANK YOU

APPENDIX B

FACILITY SITE CHARACTERISTICS

Transit Agency and Bus Maintenance Facility	Age of Old Site (Years)	Prior Use of Current Site	Current Site Zoning	Natural Site Characteristics
Alaska (1)				
Municipality of Anchorage	10	Bus storage facility	Public lands	Near wetlands
Arkansas (1)				
Central Arkansas Transit Authority	30+	Vacant lot	Industrial	Developed area
Canada (1)				
Mississauga Transit	None	Farmland	Commercial	Flat terrain
Florida (1)				
Lakeland Area Mass Transit District	Unknown	Concrete company	Industrial	High and dry
Hawaii (1)				
Honolulu Public Transit Authority	85	Cement processing	Industrial	Flood zone area
Minnesota (1)				
Metropolitan Transit Commission	85	Bus garage	Industrial	Developed area
New Jersey (6)				
New Jersey Transit Corporation				
Hilton	80	Playing field	Commercial	Forest land
Howell	-	Vacant land	-	Light forest
Meadowlands	100	Truck terminal	Industrial	Developed area
Newton Avenue	100	Trolley barn	Industrial	Developed area
Orange	25	Residential	Industrial	Forest land
Washington Township	50	Bus garage	Industrial	Developed area
New York (3)				
MTA New York City Transit				
Casey Stengel	40	Bus depot	Commercial	In flood plain
Kingsbridge	30	Trolley barn	Industrial	Adjacent to river
Manhattanville	70	Bus depot	Industrial	Sloped toward river
Pennsylvania (1)				
York County Transportation Authority	50	Truck terminal	Industrial	Flat,small stream
Texas (1)				
Capital Metropolitan Transportation Authority	20	Residential	Light commercial	Sloping terrain
Virginia (2)				
Peninsula Transportation District Commission	90	Bus garage	Commercial	Flat, level land
Blacksburg	16	Agricultural	Industrial park	Steep slopes
Washington (1)				
Municipality of Metropolitan Seattle	None	Mix of vacant, residential, and utility company	Residential	10 feet below grade
Wisconsin (1)				
Milwaukee County Transit System	62	Residential	Commercial	Developed area

APPENDIX C

Alternative-Fuel Facility Survey Form

TRANSIT FACILITY SURVEY

AGENCY NAME:

CONTACT PERSON:

TITLE:

ADDRESS:

TELEPHONE NUMBER DATE:

* *

What was the purpose of the facility retrofit?

What was the age of the facility where the retrofit was done?

In what year was the retrofit completed?

Who was the primary architect and engineering firm for the retrofit?

How many bus maintenance facilities are there currently within your system?

What are the sizes of the maintenance facilities in terms of number of buses assigned?

Facility	Number of buses

Operational Data For New Retrofit Facility:

What is the capacity in terms of assigned buses?

Please describe fleet below:

Number of buses	Year of Manufacture	Make/Model	Number of seats	Type of fuel
			--	
			--	
			--	
			--	
			--	
			--	

What are the peak period bus assignments?

What are the base period bus assignments?

What are the annual bus miles?

What are the annual bus hours?

Personnel Data For New Retrofit Facility:

What is the total staff size?

What is the size of the Administrative staff?

What is the size of the Transportation staff (including drivers and others)?

What is the size of the Maintenance staff (including mechanics, service workers and others)?

Background on Retrofit Facility:

Describe your facility retrofit project.

What was the reason for the project?

APPENDIX C (Continued)

What were your environmental concerns related to the project?

Regulations Considered In Design

Please note what OHSA requirements were considered in your retrofit design.

Please note what ADA requirements were considered in your retrofit design.

Please note what EPA requirements were considered in your retrofit design.

Please note what local and state regulation requirements were considered in your retrofit design.

Facility Features of Retrofit Facility:

Were any types of exhaust system changes required as a result of the retrofit in the ......
servicing area?
storage area?
repair area?
machine shop?
body/paint shop?

Were any types of drainage system changes required as a result of the retrofit? (i.e., storm water pretreatment required, water tested, filtering system)

What kind of containment system do you have for the various spill types?

Were there any special provisions required as a result of the retrofit to measure air quality?

Describe any special bus storage provisions as a result of your facility project.

Describe any lighting system changes as a result of your facility project.

Describe any security system changes as a result of your facility project.

Describe any hazardous material ID and the storage methods.

Describe any environmentally special shop & garage equipment (e.g., freon recovery, anti-freeze recycling) utilized in your facility.

APPENDIX C (Continued)

Describe any special garage door systems (e.g. air curtains).

Facility Deficiencies/Problems:

What would you do differently if you had to do it over again?

Describe any environmental incidents you may have had during the construction or operation.

Note:

Please attach more information for any of the review areas if you feel it would be beneficial to fully explain you particular situation. Also, if possible, please provide a copy of the site plan as well as floor plans for your new facility noting functional spaces and sizes. Further, if possible, please provide a copy of the environmental assessment report for the original project design.

THANK YOU

APPENDIX D

NEW FACILITY SIZE REVIEW

The information contained in the 1987 *Transit Garage Planning Guidelines, A Review (5),* involved testing hypothesized relationships to determine sizes for different types of facility space. For example, the size of the administrative area was hypothesized to be related to the number of administrative personnel on site. In general, the study concluded that aggregate space allocation does in fact conform with the hypothesized relationships. Administrative space is related to administrative personnel on site; aggregate transportation space is related to the fleet size; aggregate maintenance space is related to annual vehicle miles; and bus storage is related to fleet size. Subareas within each primary component showed much more variation.

Design plans or as-built drawings were obtained from six of the 14 agencies that responded to the survey for this synthesis. Three of the garages were designed to accommodate 100 buses or more while the other three were less than 100 buses. Two of the larger agencies were part of multiple facility agencies. The agency size and single versus multiple facility distinction is made in the analyses that follow.

Administrative Space

The administrative services area may include a number of functions such as accounting, administration, data processing, marketing, planning, public information, personnel, and others. The size and function of the transit agency largely determine which functions are included in the administrative component.

From the 1987 study, there is a relationship between the number of administrative employees located on-site and the total space provided for the function. It was determined that approximately 260 ft^2 per administrative employee was provided regardless of whether it was a single or multiple facility agency.

Results from the sample of facilities included in this synthesis confirm this relationship. The two facilities that are part of multiple agencies are slightly smaller than the guideline by four and 18 percent. On the other hand, the administrative areas of two of the single facility agencies are larger than the guideline and two are smaller. Overall, the actual size of the administrative areas for the six facilities conforms closely with the guideline.

Transportation Services

Space for transportation services is provided in all garages surveyed. The space typically includes common areas for drivers such as a waiting room, lockers and restrooms; the dispatch area; and the supervisors' offices. The area is typically located near the bus staging and return areas to minimize the amount of time drivers spend walking to and from their buses. Typically, the area will be located so that the driver will not pass through the maintenance shop while traveling between the transportation services area and the bus storage area.

From the 1987 study, a relationship exists between the size of the transportation services area and the size of the assigned fleet. The guideline is that approximately 900 ft^2 plus 22 ft^2 per assigned bus is reasonable. It was also determined that there was no meaningful distinction found between single facility and multiple facility transit agencies.

Results from the current survey indicate that the guideline is indeed reasonable. Four of the agencies are slightly smaller than the guideline prescribes and two are larger. One of the larger facilities has space for transportation services that is nearly 80 percent more than the guideline. However, nearly 30 percent of this space is devoted to classrooms and recreational space (e.g., exercise room) which is typically not found in the transportation area. If these areas were not counted in the total space for this agency, the overall space would conform to the guideline.

Maintenance Services

The total maintenance function in this analysis is where the repairs are made, vehicles are serviced and all the support functions associated with repairs (e.g., parts storage, machine shop, other maintenance shops, maintenance offices, and mechanics welfare rooms) are housed. Bus storage is not included. Of the maintenance function, the largest space is devoted to the repair bays where most of the maintenance and repair work on the buses is performed. The shop area is the next largest and typically consists of dedicated space for a number of functions including battery, brakes, component rebuild, electrical, overhaul, tires, and welding. A parts storage room adjacent to the repair bays is also included. Other large functional areas sometimes contained in a maintenance complex are bodyshop bays, dynamometer room, farebox repair room, paint booth, parts cleaning area, radio repair room, and steam cleaning bay. The final area includes space for employees such as maintenance offices, mechanics' locker room, and mechanics' lunch room. These functional areas are typically the same in today's bus maintenance areas as they were in older facilities. An exception is the elimination of a clean room for diesel engine injector repairs in current facilities. Most systems now send injectors to outside vendors for rebuilds. The space for the injector room is now typically utilized for electrical component repair.

From the 1987 study, there is a relationship between the total maintenance service area defined above and the total vehicle miles operated. The guideline is that approximately 1,400 ft^2 of maintenance space is required for every 100,000 miles operated.

The total maintenance area of the two agencies with multiple facilities is much smaller than the guideline, by about 20 and 39 percent. The single facility agencies also have less space devoted to vehicle maintenance services than the guideline (by between two and 20 percent) for three of the remaining four agencies. Only one agency has more maintenance space than the guideline (nearly 100 percent more). One explanation for this is the fact that the facility was designed for 50 percent more vehicles than the current assigned fleet. Overall, results from the sample indicate that the guideline appears to slightly overstate the total space needed for the vehicle maintenance function.

Non-Special Repair Bays

Repair bays are where most of the vehicle work is performed. Most repair bays will be equipped with automatic bus lifts or pits. They are also equipped to handle a wide range of functions. To accommodate this flexibility, most repair bays are similarly designed.

The 1987 study indicates that about 80 percent of the bays within a facility are non-special bays. The special bays include those dedicated to steam cleaning or degreasing, body shop, paint preparation, paint booth, dynamometer and welding. Many of these special bays will be enclosed for safety and other reasons. The guideline indicates that a relationship of 2.34 bays per million vehicle miles of service plus a constant of 3.79 bays represents current practice.

The non-special bays in this synthesis sample were identified. The results show that the guideline either matches the actual number of bays or overstates it by one or two bays. However, overall, the actual facility designs closely comply to the guideline.

Vehicle Servicing

The servicing of buses is a daily occurrence. Farebox vault pulling, refueling, checking and replenishing fluids, interior cleaning, and exterior cleaning are all often done as part of daily servicing. Typically, a service line will be arranged in an in-line pattern. The first station is vault pulling; the second station is fueling, fluid checking and replenishing, and interior cleaning; the final station is the automatic bus washer for exterior cleaning. Variations occur to the in-line pattern where the vault pulling, interior cleaning and fluid checking may be done elsewhere.

The 1987 study indicated that the best statistical relationship for size of the service line is approximately 100 ft^2 times the number of buses in the active fleet.

From the sample obtained as part of this synthesis, the results indicate that the guideline is a good representation of current design practices. The service areas of three of the agencies are larger than the guideline by between five and 17 percent while three are smaller by between four and 27 percent. A long standing "rule of thumb" in facility design is that one service line is required for up to 100 buses. This is also followed by the sample with the larger facilities having two lanes and the smaller ones having one.

Parts Room

The parts room provides space for storage, inventory supply and exchange of small parts and maintenance supplies. The parts room typically contains bins, shelving units, and cabinets. It is located near the bus repair area for ready access by mechanics and on an outside wall for shipping and receiving. It also has controlled access. Tires, body parts and spare major components, such as engines and transmissions, are generally stored in another area.

The 1987 study found that different parts room size relationships existed for single and multiple facility agencies. The relationship for single facility agencies is about 230 ft^2 for each 100,000 annual vehicle miles. For multiple facility agencies, the size is about one-half or about 126 ft^2 per 100,000 annual vehicle miles.

For both single and multiple agency facilities, the actual parts room space indicated in the survey responses is much less than the guideline, by at least 36 percent in all cases. This difference can be explained in several ways. First, some agencies are providing storage cabinets instead of shelving units. This reduces the amount of space needed for storing the same number of parts. Further, many agencies have reduced the on-hand inventory of parts and thus need less parts storage space. Another point is that the current facility sample consists of fleets that are relatively uniform and therefore do not require as extensive a parts inventory. The sample includes three agencies with three different bus manufacturers, two with four different manufacturers and one with five different manufacturers. It is not uncommon to find more than five different manufacturers at one agency.

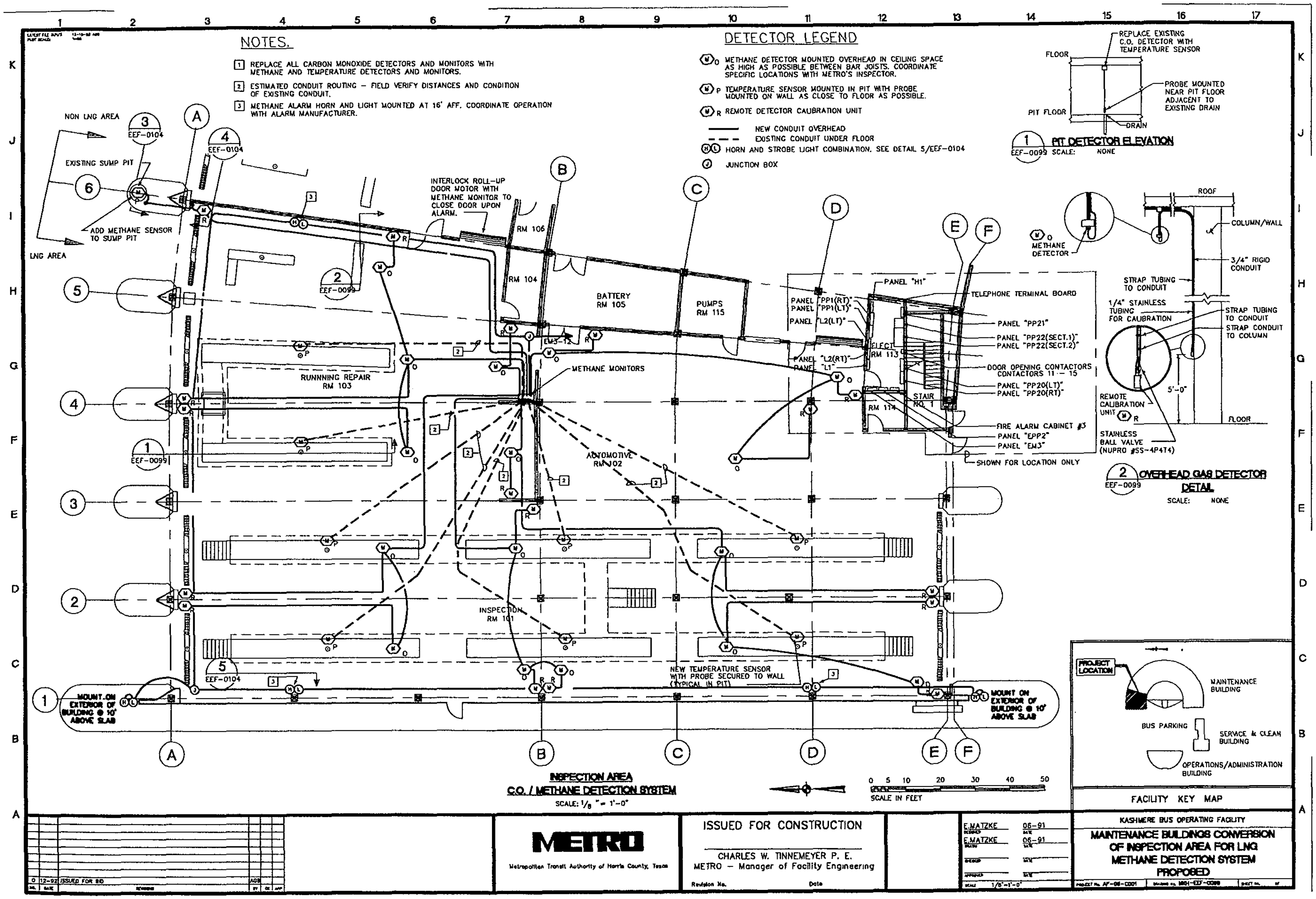
Bus Storage

One of the principal functions of any operating garage is bus storage. Indoor storage may be accomplished in one of several ways, which are fully described in the 1987 study. The choice is influenced by site and circulation patterns around the facility.

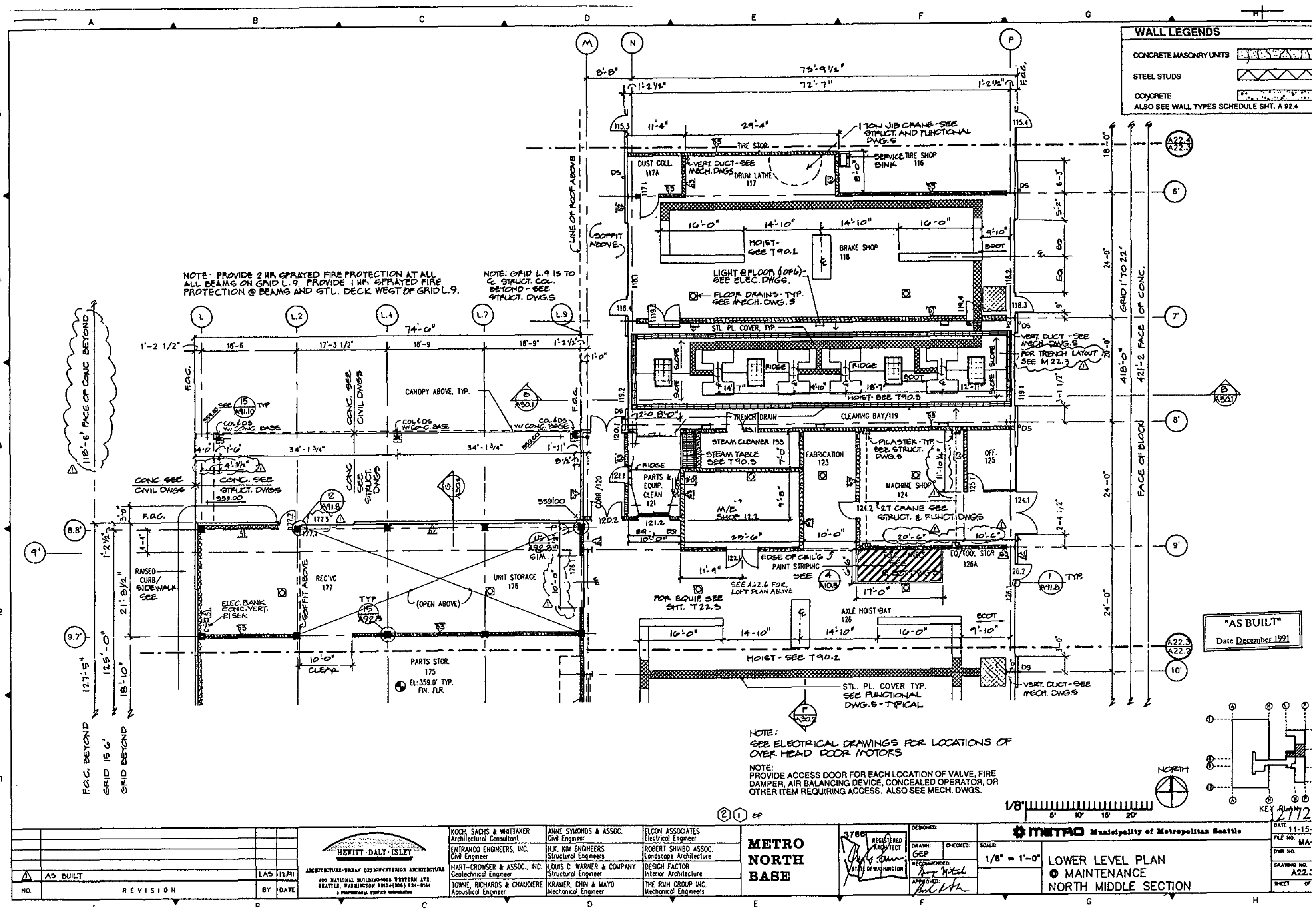
The 1987 study indicates that the best guideline for internal bus storage is approximately 500 ft^2 per bus in the active fleet plus about 2,700 ft^2. The study also indicates that bus storage will be provided for agencies located in northern climates where the temperature drops below freezing more than 100 nights per year. Only two of the agencies included in the sample provide indoor bus storage. In both cases the actual storage area was larger than the guideline by about two and 16 percent. It is understandable that one agency has 16 percent more space devoted to bus storage compared with the guideline because nearly one-third of the fleet contains 60-ft articulated buses.

APPENDIX E

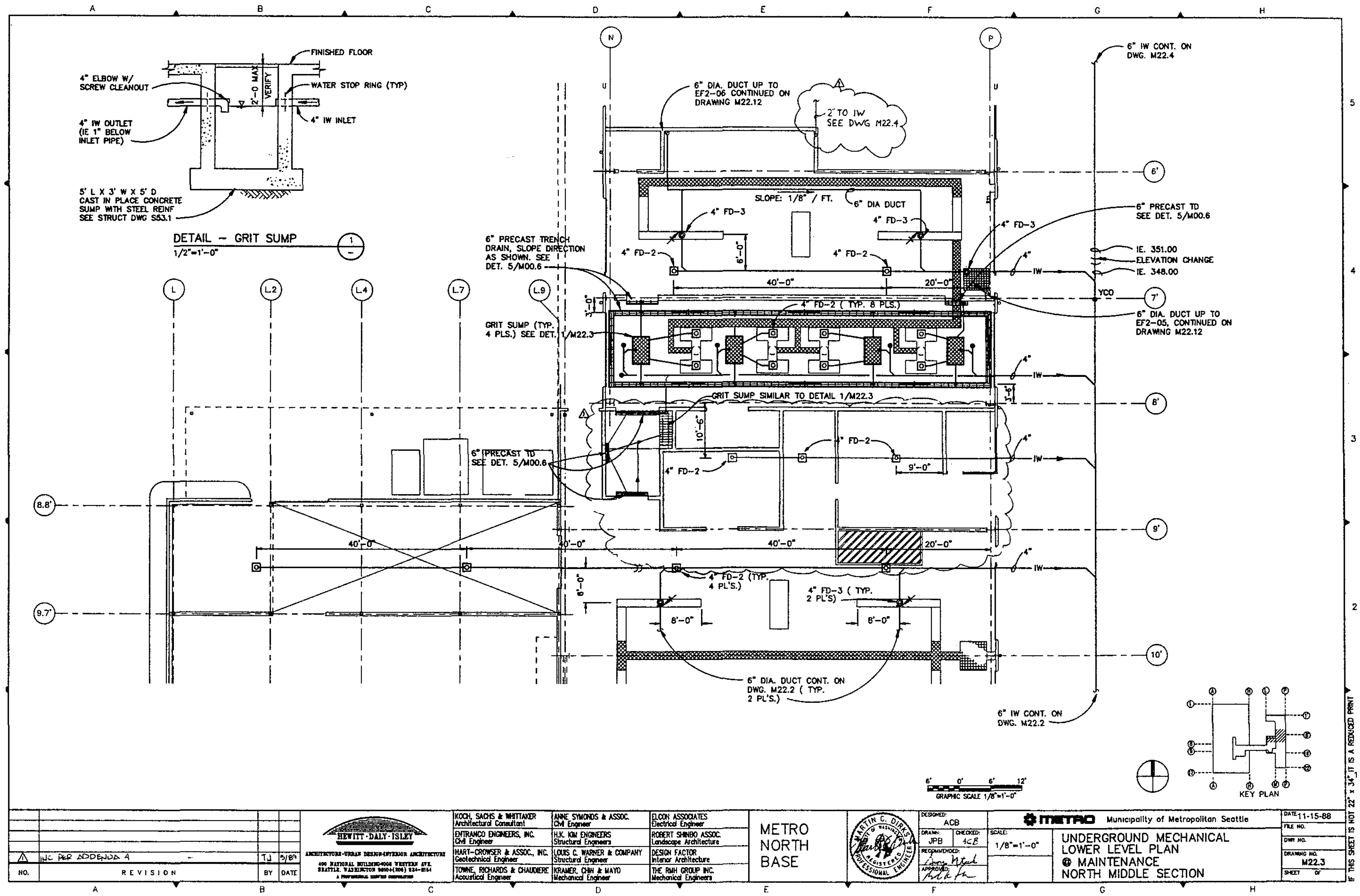
Sample As-Built and Other Construction Drawings



As-built drawing for Kashmere Bus Operating Facility. (Courtesy: Metropolitan Transit Authority of Harris County, Texas)



As-built drawing for Metro North Base. (Courtesy: Municipality of Metropolitan Seattle)



Mechanical drawing for Metro North Base. (Courtesy: Municipality of Metropolitan Seattle)

THE TRANSPORTATION RESEARCH BOARD is a unit of the National Research Council, which serves the National Academy of Sciences and the National Academy of Engineering It evolved in 1974 from the Highway Research Board, which was established in 1920. The TRB incorporates all former HRB activities and also performs additional functions under a broader scope involving all modes of transportation and the interactions of transportation with society. The Board's purpose is to stimulate research concerning the nature and performance of transportation systems, to disseminate information that the research produces, and to encourage the application of appropriate research findings. The Board's program is carried out by more than 270 committees, task forces, and panels composed of more than 3,300 administrators, engineers, social scientists, attorneys, educators, and others concerned with transportation; they serve without compensation. The program is supported by state transportation and highway departments, the modal administrations of the U.S. Department of Transportation, the Association of American Railroads, the National Highway Traffic Safety Administration, and other organizations and individuals interested in the development of transportation.

The National Academy of Sciences is a private, nonprofit, self-perpetuating society of distinguished scholars engaged in scientific and engineering research, dedicated to the furtherance of science and technology and to their use for the general welfare. Upon the authority of the charter granted to it by the Congress in 1863, the Academy has a mandate that requires it to advise the federal government on scientific and technical matters. Dr Bruce Alberts is president of the National Academy of Sciences.

The National Academy of Engineering was established in 1964, under the charter of the National Academy of Sciences, as a parallel organization of outstanding engineers It is autonomous in its administration and in the selection of its members, sharing with the National Academy of Sciences the responsibility for advising the federal government. The National Academy of Engineering also sponsors engineering programs aimed at meeting national needs, encourages education and research, and recognizes the superior achievements of engineers. Dr. Robert M.White is president of the National Academy of Engineering.

The Institute of Medicine was established in 1970 by the National Academy of Sciences to secure the services of eminent members of appropriate professions in the examination of policy matters pertaining to the health of the public. The Institute acts under the responsibility given to the National Academy of Sciences by its congressional charter to be an adviser to the federal government and, upon its own initiative, to identify issues of medical care, research, and education. Dr. Kenneth I. Shine is president of the Institute of Medicine.

The National Research Council was organized by the National Academy of Sciences in 1916 to associate the broad community of science and technology with the Academy's purposes of furthering knowledge and advising the federal government. Functioning in accordance with general policies determined by the Academy, the Council has become the principal operating agency of both the National Academy of Sciences and the National Academy of Engineering in providing services to the government, the public, and the scientific and engineering communities The Council is administered jointly by both Academies and the Institute of Medicine. Dr. Bruce Alberts and Dr. Robert M. White are chairman and vice chairman, respectively, of the National Research Council.