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GUIDELINES FOR IMPROVED RAPID TRANSIT TUNNELING SAFETY AND ENVIRONMENTAL IMPACT
Volume II: Environmental Impact

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16. Abstract

Two of the major objectives of the Urban Mass Transportation Administration (UMTA) Tunneling Program are to lower subway construction costs and reduce construction hazards and damage to the environment.

Volume I - Safety

Examination of construction safety regulations, tunnel construction accident data, and features of underground construction leading to unsafe work show that a systems approach to safety is required. Ten guidelines were drafted to supplement current construction safety regulations (OSHA 29CFR1926). Recommendations for further study and evaluation were made to complete the system safety approach.

Volume II - Environmental Impact

Investigation of subway construction jobs shows that at least two principles underlie treatment of environmental problems. First, planning and design should consider both short-term and permanent damage to environment, and second, a need for better communication of contractor's planned activities and public concerns so that disruptions can be minimized. Guidelines were developed along these principles and are grouped into the following categories: general, community relations, and specific environmental control techniques.

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PREFACE

This study to develop guidelines for improved rapid transit tunneling safety and environmental impact, described in this two-volume report, was sponsored by the Office of Technology of the Urban Mass Transportation Administration, Office of Technology Development and Deployment. The effort was conducted under contract with the Transportation Systems Center, Contract DOT-TSC-802, for the Urban Rail Supporting Technology Program.

Santo J. Gozzo was contract technical monitor for TSC. John D. Bledsoe of A. A. Mathews, Inc was Project Manager responsible for overall coordination and co-author with Arthur P. Chase of Volume I — Safety. Sylvia N. Morrison coordinated the workshop program to survey attitudes of interested agencies and organizations. William S. Shepherd, Sr., served as Project Manager for the initial work on Phase A. Andrew C. Lemer of Alan M. Voorhees and Associates, Inc. was principal investigator and co-author with C. Y. Cheng of Volume II — Environmental Impact. Howard Wright and Sally D. Liff conducted significant portions of the research for this volume.

There are significant differences among problems and potential users of guidelines for safety and environmental impact. For this reason, results of this study are presented in two volumes, dealing respectively with safety and environment.

The investigators gratefully acknowledge the assistance and information furnished by staffs of the Bay Area Rapid Transit District, The Washington Metropolitan Area Transit Authority, Metro Insurance Administration for WMATA, Metropolitan Atlanta Rapid Transit Authority, the National Loss Control Service Corporation, and the many professionals who contributed to the survey phase of the contractual effort.

METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.96	liters	l
gal	gallons	3.6	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
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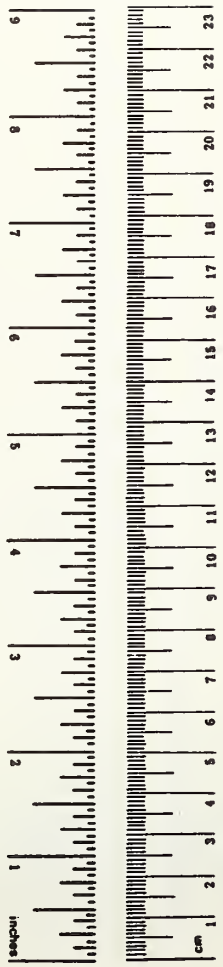
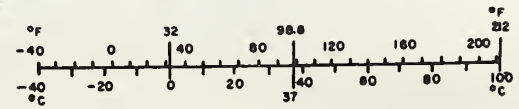
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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1. SUMMARY

The National Environmental Policy Act (NEPA) of 1969 formally states as a national goal the intent to act to promote good environmental quality and requires that a systematic interdisciplinary approach be used in decisionmaking and for review of all Federal actions to assure that this goal is achieved. The Urban Mass Transportation Act of 1964, as amended carries the NEPA goals and requirements further, stating that approval of any projects under the Act should take into consideration the cost of eliminating or minimizing such adverse effects as pollution, disruption of activities, and displacement of people.

The focus of efforts to meet these requirements has been on planning and design. However, many of the more severe adverse impacts associated with urban transit systems, and particularly with transit tunnels, occur during construction. Some of these impacts may cause lasting damage to the neighborhoods where they occur and to the city as a whole. The intent of these recommended guidelines is to help to control and reduce these adverse impacts of construction, and thereby to aid in the realization of the greatest possible positive long-term benefits of the transit system.

Dealing with environmental impact of tunnel construction activity is complex and difficult for several reasons:

There are generally many different aspects of impact to be considered, such as air pollution, traffic disruption, neighborhood activities, and noise.

There are different groups affected by and responsible for controlling construction impacts, each with its own interests, concerns, powers, and sensitivities.

There is considerable uncertainty in trying to predict what impacts might occur, as the impacts are dependent on actual construction methods and local conditions.

The various different aspects of environmental impact are classified here into a set of 14 distinct elements, shown in Table 1.1.

A review of case studies, legislation and regulations, and tunneling technology led to an assessment of the relative importance or severity of impact for these elements for various types of tunnel construction. This generalized assessment is summarized in Table 1.2 (see Section 3). Based on this assessment, effort was directed to development of recommended guidelines to address those impacts which are more generally and severely felt.

These recommended guidelines are directed at the system or project level of control, which is where the most immediate payoffs of attention

to environmental impact will be felt. Construction impacts are not as susceptible to treatment at a broad policy level as are those impacts which are controlled through planning and design. However, it may be suggested as a result of this study that UMTA should give consideration to the use of project funding to provide positive incentives for good environmental impact control.

Table 1.1
Elements Of Environmental Impact Of Urban Transit Tunneling Construction

• Traffic Circulation	• Terrestrial Biota
• Air Quality	• Aquatic Biota
• Surface Water	• Community Cohesiveness
• Ground Water	• Public Health and Safety
• Noise	• Public Services and Utilities
• Vibration	• Economic Climate
• Ground Stability	• Visual Quality

The various groups responsible for control of impacts are characterized as shown in Figure 1.1. The recommended guidelines have been organized in terms of the users who would implement them and the phases of activity—planning, design, pre-construction, and construction—at which the guidelines would be applied. These guidelines are formulated to utilize good planning, design, and construction practice to achieve better environmental protection. Many of the recommended guidelines can be implemented without major additional costs, relative to the present tunneling practice. However, additional costs may result from implementing some of the guidelines which require additional control devices, modifications of equipment, or changes in design, construction scheduling, and construction techniques.

The recommended guidelines for control of adverse environmental impacts are grouped into three categories:

General environmental guidelines represent actions which cover all elements of environmental concern. These guidelines are directed at the overall management of the tunnel construction process, including such items as contracts, specifications, and inspection. Table 1.3 summarizes the general guidelines (see Section 4).

Guidelines for community relations have been presented separately because of the importance of good communications among the many diverse interests involved in transit tunnel construction. An effective program of community

Table 1.2
Summary Of Generalized Assessment Of Impacts Of Transit Tunnel Construction On The Urban Environment

Construction Methods		Construction Phases	Assessed Importance of Impacts: Physical: Traffic Circulation	Air Quality	Surface Water	Ground Water	Noise	Vibration	Ground Stability	Terrestrial Biota	Aquatic Biota	Visual Quality	Socioeconomic: Community Cohesiveness	Public Health and Safety	Services/Utilities	Economic Climate
Cut-and-Cover	1.	Clearing, Grubbing Demolition, Site Preparation	■	■	■		■	■		■		■	■	■	■	■
	2.	Excavation, Utility Relocation and Maintenance, Underpinning, Dewatering, Ground Support, Decking, Spoil Storage and Disposal, Construction	■	■	■	■	■	■	■	□	□	■	■	■	■	■
	3.	Backfilling, Restoration, Clean-Up	■	■	■		■	□				□	■	■	■	□
Soft-Ground Tunneling	1.	Constructing Tunnel Access (e.g. Portal & Shaft), Site Preparation	□	□	□		□	□		□		■	□	□	■	□
	2.	Dewatering, excavation, Spoil Disposal, Primary Lining	□	■	■	■	■	■	■	□	■			□		□
	3.	Secondary Lining, Restoration, Clean-Up	□	□	□		□									□
Rock Tunneling	1.	Constructing Tunnel Access (e.g. Portal & Shaft), Site Preparation	□	□	□		□	□		□		■	□	□	■	□
	2.	Excavation, Dewatering, Mucking, Primary Lining	□	■	■	□	■	□	□	□	□				□	□
	3.	Secondary Lining, Restoration, Clean-Up	□	□	□		□									□
Sunken-Tube	1.	Site Preparation		□	□					□	□	□				
	2.	Dredging, Towering, Joining Tunnel Sections, Backfilling		□	■						■					
	3.	Restoration, Clean-Up		□	□						□					

■ Relatively high likelihood of serious impact; should receive specific control action.

□ Relatively low likelihood of serious impact; need for control will be dependent on local conditions.

Blank — Negligible likelihood of serious impact; control is not likely to be required.

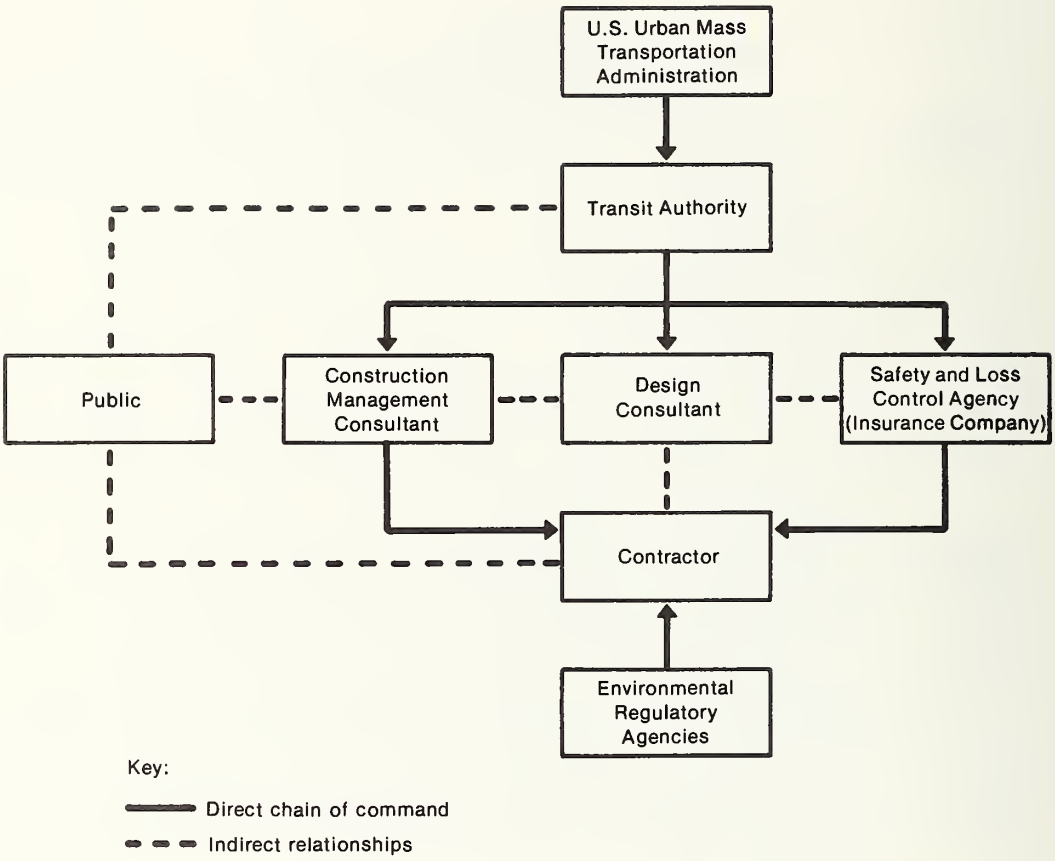

Figure 1.1
Responsible Groups In Environmental Control For Construction

Table 1.3
General Environmental Guidelines — Management Actions For Reducing Adverse Environmental Impacts During Tunnel Construction

Responsible Party	Applicable Stage in Tunneling Process			
	Planning	Design	Pre-Construction	Construction
Stett Plenner or Plenning Consultant	1. Conduct environmental reconnaissance to determine the community and environmental sensitivity of the adjacent area 2. Select route/station locations at the microscale to minimize impact			
Environmentsl/ Engineering Consultent		3. Prepare environmental specifications and provisions		
Transit Authority			6. Establish a coordinated permit system 7. Include environmental concerns in briefing 8. Community Relations	13. Staff to oversee resident engineer's enforcement of environmental provisions of specifications
Contractor			9. Apply necessary permits from local regulatory agencies 10. Community relations in conjunction with resident engineer and transit authority	14. Respond to and resolve complaints and unanticipated environmental problems
Resident Engineer			11. Community relations; receive and resolve complaints	15. Enforce environmental control plans and specifications
Regulstory Agencies		4. Review and comment on environmental provisions of specifications	12. Review contractor's applications and issue permits	16. Site inspection to correct violations; investigate public complaints
Insurance Compeny (Setety end Loss Control Consultsnt		5. Review and comment on environmental provisions of specifications		17. Inspection to correct violations; investigate and resolve public injury and damage claims

relations can reduce the level or increase tolerance to many of the disruptive effects of tunneling. Costly project delays may thereby be avoided and longer term benefits of good will may be gained. Table 1.4 summarizes the community relations guidelines (see Section 4).

Specific environmental control techniques are applicable to problems encountered for particular environmental elements of concern. These techniques may, in general, be grouped into several distinct types as shown in Table 1.5. While an overall assessment of the likely value of a technique for dealing with problems on a particular element of concern may be made, actual applications will depend upon local conditions (see Section 5).

To make the guidance materials most immediately useful, a user's cross-reference guide is provided (Appendix A). Thus, these materials may be used as a reference for dealing with particular elements of environmental impact or as a review document for the opportunities and responsibilities of the specific user.

Table 1.4
Guidelines For Community Relations

Phase	Guidelines	Responsible Party
Planning	• Train staff personnel in community relations	• Transit authority
	• Inform community (businessmen, residents and the general public) of the planning of the system; the likely disruptive effects of transit construction (best presented by showing slides of previous or ongoing transit construction)	• Transit authority planner/community relations staff
	• Obtain inputs from community as to their concerns, needs, and suggestions; consider these inputs in planning the system	• Transit authority planner/planning consultant
Design	• Inform community of the preliminary design schemes and the possible disruptive effects of the proposed construction method, including environmental, economic, and social impact	• Transit authority, environmental/engineering consultant
	• Solicit community's comments on the proposed design schemes and construction method, and suggestions of measures to mitigate the anticipated disruptive effects. Examples of this guideline include:	• Environmental/engineering consultant
	— Scheduling construction consistent with business and community timetable	
	— Restriction of working hours and certain construction activities in sensitive areas	
	— Traffic manangement and coordination of separate contracts/projects to minimize congestion	
	• Inform community of the incorporation of environmental specifications into contract, and the contractor's obligation to carry out the control measures	• Transit authority, environmental/engineering consultant
Pre-Construction	• Conduct seminar or training sessions on community relations for contractor, resident engineer, and community relations staff	• Transit authority
	• Establish communication channels with community	
	— Disseminate the information on the persons and telephone numbers to contact with respect to construction information and problems. (This can be done through the use of mass media, newsletters, bulletins or other means).	• Transit authority, resident engineer
	— Erect sign showing contractor's name and telephone number, resident engineer's name and telephone number, and emergency telephone number at construction site	• Contractor
	• Inform the public of the timetable of construction, and anticipated construction activity and potential impacts, and the mitigating measures to be used	• Transit authority
Construction	• Periodically inform the public of the status of construction including goals, progress and completion, current and anticipated construction activities	• Transit authority, resident engineer
	• Brief the businessmen, residents, and the general public on the construction method and process and measures to be used (or being used) to reduce impacts	• Transit Authority, resident engineer
	• Formally and informally meet with businessmen, residents, and the general public in the area	• Transit authority, resident engineer, contractor
	• Inform the community in advance of the time and duration of source impact-generating activities such as demolition, street closing, detour, pile-driving, etc. (This can be best done by the use of mass media and erecting signs at construction sites in advance.)	• Transit authority, resident engineer, contractor
	• Conduct public tours of construction sites and the newly completed sections	• Transit authority

Table 1.5
Summarized Specific Environmental Control Techniques During Construction

Type of Control Techniques	Exemples	Relative Likelihood That Such A Measure Can Be Effectively Applied To The Environmental Element Of Concern												
		Traffic Circulation	Air Quality	Surface Water	Ground Water	Noise	Vibration	Ground Stability	Biota (Aquatic and Terrastrial)	Community Cohesiveness	Public Health and Safety	Services/Utilities	Economic Climate	Visual Quality
Selection of Working and Storage Area	• Avoid sensitive areas such as hospitals	●	●	○		●				●	○	○	●	○
On-Site Source Control (Construction Site, Working, Storage and Stockpiling Areas)	• Use mufflers on equipment • Use devices to control erosion • Filter dewatering discharge • Provide accoustical enclosures • Maintain traffic and width	●	●	●	○	●	●	●	○	●	●	●	●	●
Off-Site Source Control (Spoil Dispersal, Site Access, Roads, Hauling Routes)	• Avoid routing trucks through residential or busy commercial districts • Clean and water access road and lower truck speeds to reduce dust • Institute erosion control at disposal site • Cover open-bodied dumping trucks	●	●	○		●							○	○
Timely Scheduling/Staging	• Schedule activity to be compatible with business timetable • Restrict construction activity on major arterials during peak traffic hours • Limit noise-generating activities during certain hours	●	●	○		●				●	○	○	●	
Monitoring/Inspection/ Enforcement System	• Regular and irregular inspection and monitoring spot checks	●	●	●	○	●	○	●	○	○	○	○	○	
Coordinations with Other Construction Projects	• Coordinate construction sequence to minimize cumulative impacts	●	○							○		○	○	
Good Construction Menegement	• Use skilled, experienced workers to assure good workmanship • Place skilled watchman on site or at safety barrier during non-working hours • Provide good maintenace of equipment, good housekeeping	○	○				○	●		○			○	

● Measure is likely to be effective in reducing impact on this element of concern.

○ Measure is moderately likely to be effective in reducing impact on this element of concern.

Note: Blank means measure is generally unlikely to be effective in reducing impact on this element of concern, but may be used if applicable to specific local condition.

2. INTRODUCTION

The occurrence of any construction within an urban area will usually cause disruption and local temporary deterioration of environmental quality. The density of activity in an urban area, the general lack of free space within which construction equipment and materials may operate and be stored, and the close proximity of construction to offices, stores, and homes where people work and live make this disruption and deterioration a virtual certainty. Hence, when a project of the size, geographic extent, and duration of an urban rapid transit system is undertaken, it is certain there will be problems and widespread public recognition of these problems. The social, economic, and physical environment of the city will be affected.

It is the basic premise of this study that the adverse environmental impacts of transit construction can be controlled to reduce overall disruption of the community. The particular focus here is upon urban transit tunnels, although much of the discussion could be applied to other aspects of transit system construction, such as elevated and at-grade transit systems.

The purpose of this document is to present specific guidance as to how the adverse environmental impacts of urban transit tunnel construction may be controlled. This guidance is presented with the specific user in mind: the transit authority and its engineering consultants, the tunnel constructor and his consultants, insurance companies and associated loss control consultants, and governmental regulatory agencies. The guidance is focused at the project level, where the most immediate pay-offs of reduced disruption may be expected.

At the higher level of national policy, there are steps which UMTA can take. An obvious first step is to encourage adoption of the measures presented here. A second, and quite substantial, step will be to alter the project funding and control procedures to foster incentives for improving environmental control. Such an alteration would include such steps as internalization of all community costs associated with the transit system and provision of incentives to contractors for performance better than the minimum contractual standard.

If these guidelines are successful, the benefits will accrue not only to the community surrounding the tunnel construction site. Experience in several projects indicates that the transit authority will derive public goodwill and reduced costs of complaint and litigation. The contractor will find that greater efficiency, reduced liability, and reduced vandalism may result. While some of the procedures proposed here involve distinct costs, it is anticipated that many of the recommendations could be implemented with little significant increase in construction expense. If environmental problems and discussions can be kept from becoming major issues and adversary proceedings, all parties will benefit.

2.1 DEVELOPMENT OF ENVIRONMENTAL GUIDELINES

Several distinct steps have been taken in developing these guidelines:

a. A survey was made of current projects and of the literature on past projects, and discussions were held with personnel representing the governmental agency, transit authority, engineering consultant, contractor, and insurance company components of the industry to identify and determine the extent of the various components of environmental impact.

b. A survey was made of procedures available and typically used to regulate environmental impact. Included in the survey was the range of such possibilities as technical procedures and equipment, codes and legislative controls, and specifications and insurance regulations. Particular attention was given to notable past successes—projects with good control and reduced impact.

c. A comparison of the problem areas and regulation possibilities was made. This comparison was made within a context of the tradeoff of various costs among the transit authority, the contractor, and the public-at-large, in an effort to identify which of the possible impact regulatory methods would yield the greatest benefit to all.

d. Specific recommendations were developed, based upon these impact regulatory methods. The guidance was developed with attention to particular users.

e. These specific recommendations were disseminated as a brief report to be reviewed by potential users. Written and verbal comments were solicited, and seminars were held in selected cities. The guidelines were then revised on the basis of this review.

The following sections of this chapter will present the framework within which this work was conducted, in terms of the types of tunnel construction to be considered, the elements of environmental concern addressed, and the user groups toward which the guidance is directed. As will be explained, this document is structured to be immediately and most efficiently useful to all of those who are concerned with the construction of urban transit tunnels.

2.2 CATEGORIES OF TUNNEL CONSTRUCTION AND ENVIRONMENTAL CONCERNS

For the purpose of reviewing environmental impact, construction methods for transit tunnels may be classified into four types within three broad categories of surface construction, underground construction, and open water construction.

Surface Construction — In this method of construction, a trench is excavated, subway structures are constructed within the trench, and the trench is then backfilled to bury the structures. The trench may be

left open during construction but is generally covered over with decking to permit use of the surface space. The latter approach, termed cut-and-cover procedure, is required when transit routes are within existing street corridors in order to maintain vehicular traffic and access to businesses and residences adjacent to the construction.

Underground Construction — After excavation of access points—typically at portals, stations, or ventilation openings—construction proceeds below the surface. Depending upon geological conditions, underground construction may involve drilling and blasting, use of tunneling machines, or direct digging in soft ground. In this analysis, soft ground and rock tunneling procedures are considered separately.

Open Water Construction — The principal means of open water construction consists of dredging a trench and lowering prefabricated trench sections into this trench. The sections are joined and covered by dumping of backfill materials. The method is termed sunken tube in the analysis.

Each of these four types of tunnel construction—cut-and-cover, soft ground tunneling, rock tunneling, and sunken tube method—may be viewed as having three phases:

Phase 1 comprises surface construction activities such as clearing, grubbing, demolition, initial excavation, and other site preparation activities. Most of these activities involve closing streets, operating heavy and noisy equipment, denuding soils, and other impact-generating operations.

Phase 2 includes excavation, utility relocation and maintenance, ground support, underpinning adjacent buildings, decking streets, spoil removal or storage, and construction of tunnel structures. Phase 2 of sunken tube construction refers to dredging the trench and towing, lowering, and joining tunnel sections in the trench.

Phase 3 comprises the finishing and restoration activities. Backfilling, restoration of streets, and landscaping are included in this phase.

It should be noted that the activities of different phases may be occurring simultaneously, particularly on adjacent sectons of the same project. The breakdown of construction activity into phases for evaluation does not necessarily imply that the specific environmental impacts associated with a particular phase occur entirely within that phase. The environmental impacts from a particular construction phase often extend well beyond the completion of that phase.

For purposes of these guidelines, impact has been characterized as falling into 14 principal elements of concern, as shown below. These elements of concern fall into two broad categories of physical and socio-economic environment, reflecting the current state-of-knowledge and attitudes toward analysis. A major part of this document is structured in terms of these elements of concern.

Physical Concerns	Socioeconomic Concerns
Traffic Circulation	Community Cohesiveness
Air Quality	Public Health and Safety
Surface Water	Public Services and Utilities
Ground Water	Economic Climate
Noise	Visual Quality
Vibration	
Ground Stability	
Terrestrial Biota	
Aquatic Biota	

2.3 USERS OF THE GUIDELINES

The various potential users of these guidelines reflect differing points of view and balance of interests relative to environmental impact. For purposes of this analysis, six user groups are defined:

Transit aurhority, including staff planners and consultants

Engineering design consultant

Contractor

Resident engineer

Insurance company and safety consultants

Regulatory agencies.

Guidance materials in this report have been cross-referenced to make them more immediately accessible to these users (see Appendix A).

2.4 REPORT STRUCTURE

The following pages will review the principal aspects of environmental impact of urban transit tunnel construction, and will present guidance on how to control adverse effects. In Section 3, each element of concern is presented in terms of a definition and a discussion of the likely impact of tunnel construction. Currently applicable regulations and standards are then investigated.

Section 4 presents general guidelines for reducing the adverse environmental impacts of transit tunnel construction. Separate attention is given to guidelines for community relations because of the particular importance of this aspect of control. In Section 5, specific control measures for each element of environmental concern are suggested.

The guidance materials in Sections 4 and 5 are cross-referenced in Appendix A by user. Hence, the document may be used to address specific environmental problems or as a general guidance document for individual users. Appendices B and C, which complete the report of the project, review aspects of the study which produced these guidance materials.

3. IMPACTS OF TRANSIT TUNNEL CONSTRUCTION ON URBAN ENVIRONMENTAL CONDITIONS

In this section, each of the 14 elements of environmental concern will be addressed to provide a background for guidelines presented in subsequent chapters. For each element of concern, a definition of the nature of the concern will be given. There is then a discussion of the possible impacts of tunnel construction on this particular element of concern.

The discussion of impact is organized in terms of the four types of construction and the three phases of the construction process specified in Section 2. A generalized assessment of the likelihood of impact was made and is presented in tabular form in the discussion of each element of concern. A summary of these assessments is presented in Table 3.1.

Following this discussion of possible impacts, a brief review is made of current regulations and standards applicable to the element of concern. This review is not meant to be exhaustive but, rather, is intended to present representative controls which serve as a basis for developing recommendations.

3.1 TRAFFIC CIRCULATION

Disruptions of traffic circulation are a pervasive impact of urban construction. Because of the noise, air pollution, public inconvenience, and safety problems associated with these disruptions, traffic circulation is included here as a major element of concern. Traffic impacts resulting from transit tunnel construction can be described in terms of six variables:

Vehicular Circulation — Movement of vehicles, both through and local to an area, but not including access to property on any type of public street or highway (local, collector, arterial, and expressway).

Pedestrian Circulation — Movement of pedestrians on sidewalks along public streets or in parks.

Vehicular Access — Access of vehicles to private or public property including a driveway and/or parking facility by owner, visitor, customer, or emergency vehicle (ambulance or fire engine). Also, access of utility vehicles to public utility facilities on public right-of-way or private property.

Pedestrian Access — Access of pedestrians to private or public property most often via a sidewalk by owner, visitor, or customer.

Parking — Temporary storage of a vehicle in a space, usually less than 24 hours, along a street curb (on-street) or in a public or private, off-street facility.

Table 3.1
Summary Of Generalized Assessment Of Impacts Of Transit Tunnel Construction On The Urban Environment

Construction Methods		Construction Phases	Assessed Importance of Impacts: Physical: Traffic Circulation	Air Quality	Surface Water	Ground Water	Noise	Vibration	Ground Stability	Terrestrial Biota	Aquatic Biota	Visual Quality	Socioeconomic: Community Cohesiveness	Public Health and Safety	Services/Utilities	Economic Climate
Cut-and-Cover	1.	Clearing, Grubbing Demolition, Site Preparation	■	■	■		■	■		■		■	■	■	■	■
	2.	Excavation, Utility Relocation and Maintenance, Underpinning, Dewatering, Ground Support, Decking, Spoil Storage and Disposal, Construction	■	■	■	■	■	■	■	□	□	■	■	■	■	■
	3.	Backfilling, Restoration, Clean-Up	■	■	■		■	□				□	■	■	■	□
Soft-Ground Tunneling	1.	Constructing Tunnel Access (e.g. Portal & Shaft), Site Preparation	□	□	□		□	□		□		■	□	□	■	□
	2.	Dewatering, excavation, Spoil Disposal, Primary Lining	□	■	■	■	■	■	■	□	■			□		□
	3.	Secondary Lining, Restoration, Clean-Up	□	□	□		□									□
Rock Tunneling	1.	Constructing Tunnel Access (e.g. Portal & Shaft), Site Preparation	□	□	□		□	□		□		■	□	□	■	□
	2.	Excavation, Dewatering, Mucking, Primary Lining	□	■	■	□	■	□	□	□	□				□	□
	3.	Secondary Lining, Restoration, Clean-Up	□	□	□		□									□
Sunken-Tube	1.	Site Preparation		□	□					□	□	□				
	2.	Dredging, Towering, Joining Tunnel Sections, Backfilling		□	■						■					
	3.	Restoration, Clean-Up		□	□						□					

■ Relatively high likelihood of serious impact; should receive specific control action.

□ Relatively low likelihood of serious impact; need for control will be dependent on local conditions.

Blank — Negligible likelihood of serious impact; control is not likely to be required.

Traffic Safety — Protection of pedestrians, vehicular occupants, and vehicles from hazards which could result in injury, death, or property damage during circulation.

Urban rapid transit routes are usually located within existing corridors which are heavily used by vehicles and pedestrians. The potential of transit construction, particularly station construction, for causing conflicts with traffic circulation is thus high.

3.1.1 Possible Impacts from the Tunneling Process

While traffic disruption will be initiated during site preparations, it reaches its peak during the surface excavation and support and decking stages. During this time, auto drivers are required to reorient themselves to new or altered conditions, including temporary roadway facilities once the decking is completed. Similar disruption and reorientation to new conditions also occur for vehicular access. Pedestrian circulation and access are affected by construction activity involved in the sidewalk area and by relocation of temporary walkways and connections to property. Disruption to parking occurs through access alteration or temporary closings of off-street facilities and probable curb parking restrictions. As for traffic safety, repeated disruptions and reorientation to new conditions create accident potential. This increased accident potential is created by wet or muddy road surfaces which increase vehicular skidding, lack of driver and pedestrian observance of construction signing, lack of warning signing, discontinuities in pavement or sidewalks, and direct conflict with construction activity.

Due to the generally rough nature of the decking surface, nuisances result for auto occupants. These surfaces also slow driving speeds and increase travel time. Street width is reduced and flow capacity is adversely affected. Vehicular access is sometimes affected by limited or temporarily relocated access. Pedestrian circulation and access are inconvenienced by the temporary and usually narrow walkway facilities. Parking is affected where curb parking restrictions are enacted for purposes of increasing traffic flow capacity or for construction storage areas. Accident potential during the latter portion of this phase is created by construction activity in the vicinity of vehicular and pedestrian movement areas, the hauling of materials and construction equipment to and from the site, and temporary surfaces for both vehicles and pedestrians. These effects can continue through backfill and restoration of street facilities. Particularly during restoration, street network capacity can be severely reduced due to temporary closings. Parking becomes severely limited and even eliminated. Both on-street and access to off-street spaces are affected.

The traffic impact created by partial or complete street closings, detours, traffic circulation/construction activity conflicts, and other activities may result in cost to the general public in the form of increased vehicle miles of travel (VMT), travel hours (TH), energy consumption, air pollution, and accidents (damage and/or injury). Business

loss, disruption of community services, and other similar effects can also be severe. Table 3.1.1 summarizes these points.

An assessment of the magnitude of the traffic impact of transit tunneling is greatly dependent upon the type of construction and the affected area. In general, the cut-and-cover method creates the most extensive traffic impact because of the substantial involvement of surface construction activities, while the impact created by soft-ground and rock tunneling is limited to the areas where the earth's surface is broken. The traffic impact will be more severe in central business districts than in other areas because the affected traffic volumes are larger.

3.1.2 Current Environmental Standards and Regulations

Current standards and regulations to minimize construction impact on traffic circulation are typically written for roadway and utility construction within street rights-of-way. Construction practices are regulated by specifications, permits, and authorizations (usually considered emergency conditions) by a jurisdictional agency. In general, the standards and regulations apply to all types of tunnel construction but are particularly important for the cut-and-cover method, since it creates the most severe impact on traffic circulation. In regard to vehicular circulation, requirements generally cover the following:

Staging and sequence of construction to minimize disruption

The number of lanes required to be open to traffic during construction (generally determined by street type)

Work scheduled to avoid restriction to vehicular circulation during peak hours of traffic flow and certain seasons of the year, e.g., Christmas shopping season or lunch hours

Contractor plan to assure maintenance of circulation.

Such requirements apply throughout the construction period, with the exception that, during restoration of street facilities, sections of the street may be closed in sequence for a period of several weeks as a compromise to facilitate construction and to minimize total disruption time. Convenient access must be maintained during construction and assistance, for activities such as deliveries to and collections at a commercial establishment, must be provided by the contractor when access is temporarily cut off.

The contractor must also maintain convenient pedestrian access. Regulations covering pedestrian circulation are analogous to those for vehicular circulation, and generally cover the same four items listed previously: construction sequence, minimum walk widths, scheduling during peak hours, and the contractor's overall plan.

Table 3.1.1
Generalized Assessment Of Traffic Impact

Construction Methods	Construction Phase		Principal Sources of Impact *	Likelihood of * Serious Impact *
Cut-and-Cover	1	Clearing, Grubbing, Demolition, Site Preparation	Partial or complete street closing, detour, diversion of traffic	High
	2	Underpinning, Dewatering, Excavation and Support, Decking, Spoil Storage and Disposal, Tunnel Structure Construction	Partial or complete street closing, detour, diversion of traffic, rough decking surface	High
	3	Backfill, Restoration, Cleanup	Street closing, detour, diversion of traffic	High
Soft Ground Tunneling	1	Site Preparation, Tunnel Access Construction	Possible reduction of street width	Low
	2	Dewatering, Underground Excavation, Muck Disposal, Primary Lining	Hauling truck	Low
	3	Secondary Lining, Restoration, Cleanup	Possible reduction of street width	Low
Rock Tunneling	1	Site Preparation, Tunnel Access Construction	Possible reduction of street width	Low
	2	Underground Excavation, Spoil Disposal, Primary Lining	Hauling truck	Low
	3	Secondary Lining, Restoration, Cleanup	Possible reduction of street width	Low
Sunken Tube	1	Site Preparation	Possible reduction of street width	Negligible
	2	Open Water Construction	Hauling of equipment and spoil	Negligible
	3	Restoration, Cleanup	Possible reduction of street width	Negligible

* N/A — Activities at this place will not likely result in direct impact on element

* High — Should receive specific control action
* Low — Need for control will be dependent on local conditions
* Negligible — Control is not likely to be required

Parking regulations require that (1) off-street access must be maintained by the contractor except for temporary cut-offs, and (2) curb spaces may be restricted or temporarily eliminated. Depending on the street capacity requirements for providing adequate traffic flow, curb spaces are sometimes eliminated throughout the entire construction period.

Standards promoting traffic safety during construction within street rights-of-way are addressed in national and local manuals covering design and use of signs, markings, and barricades. There are local requirements for the erection and maintenance of protective devices (signs, fences, barricades, pedestrian bridges, and watchmen), and enclosure of contractor's work and storage areas.

For example, the specifications of the Washington, D.C., transit system require the contractor to submit a working plan which includes a staging and decking plan prior to receiving a permit for construction. Closing streets, reversing lanes, and alteration and detour of traffic require a permit from the D.C. Department of Transportation. The contractor is required to maintain traffic movement and access to property for owners and customers. The same standards and regulations regarding circulation during transit tunneling, discussed above for the cut-and-cover method, also apply to the soft ground, rock tunneling, and open-water construction, although as mentioned previously, the traffic circulation problems associated with these latter methods of tunneling are much less severe.

The principal failure of existing regulations is that they are applied separately to each individual construction project. Activities on adjacent projects may combine to cause substantially greater disruptions than the individual projects would suggest.

3.2 AIR QUALITY

Atmospheric pollutants generated during construction activities may adversely affect health and general welfare and will frequently cause nuisance in the form of soiling, staining, odor, or decreased visibility. Fugitive dust and equipment exhaust fumes are the most significant air pollutants emitted during tunnel construction.

Fugitive dust is defined as solid airborne particulate matter emitted from any source other than through a stack, vent, or chimney. Dust can be generated during tunnel construction when a large area of cleared land or stockpiled material is exposed to wind action, when disaggregate material or earth is being transported, or by surface erosion from wind action. In addition, dust is generated by trucks or mobile equipment moving on a cleared construction site. The dust generated by such activities is primarily large particles which tend to fall to the ground quickly and very close to the point where they become airborne. Those particles which do come in contact with other objects may cause soiling or staining. Fugitive dust from tunnel activities is usually considered a nuisance because of these short-term, microscale impacts. It is also

a potential health hazard for people living in the vicinity. The localized impact of fugitive dust is significant, and Federal, state, and local regulations are being adopted to reflect this concern.

Vehicle and equipment exhaust fumes include smoke, sulfur oxides, nitrogen oxides, carbon monoxide, and hydrocarbons. These fumes are produced by both gasoline and diesel engines. While contribution from construction site vehicles to the total regional level of these pollutants is insignificant, the localized impact can be substantial where adverse meteorological conditions, structural barriers to dispersion, large numbers of construction equipment, and poorly maintained engines combine to increase the levels of the pollutants which are concentrated in a small area.

3.2.1 Possible Impact from the Tunneling Process

As mentioned above, the principal sources of air quality impact are from those site preparation activities which have the potential to generate fugitive dust or fumes. Clearing and site preparation may expose large areas of unstabilized surface to wind erosion, which will cause dust to become airborne (fugitive dust). The cut-and-cover method will expose the greatest amount of surface area and will therefore have the greatest potential for air quality impact. Building demolitions are another source of dust. Earth movers such as backhoes and loaders, and stationary equipment, such as diesel generators, are the principal sources of smoke and exhaust fumes during construction activities.

During excavation stages, soft ground and rock tunneling may have a significant localized air quality impact where venting to the surface occurs. Ventilation portals may cause localized, high concentrations of fumes. Muck hauling operations, wind erosion from stockpiles, and truck movements on dirty or unpaved access roads may be significant sources of dust in all types of tunnel construction.

In addition to these direct impacts, tunnel construction will have a secondary effect on air quality, which results from traffic congestion and detours. Air pollutant emissions will increase due to the reduction of speed from congestion and the additional miles of travel caused by detours. This secondary air pollution impact is particularly severe in central business districts where large volumes of vehicles are affected. Table 3.2.1 summarizes various air quality impact sources.

The impact of tunnel construction activities on air quality can be assessed in terms of the potential for these activities to generate amounts of pollutants which would significantly degrade the ambient air quality. Factors influencing the severity of impact include meteorology, topography, and distance from the source of emissions to a given sensitive receptor such as hospitals, nursing homes, or day care centers. The use of sensitive receptors to identify impact implies a value judgment that the air quality in areas where people are located is more

Table 3.2.1
Generalized Assessment Of Air Quality Impact

Construction Methods		Construction Phase	Principal Sources of Impact *	Likelihood of * Serious Impact *
Cut-and-Cover	1	Clearing, Grubbing, Demolition, Site Preparation	Clearing, grubbing	High
	2	Underpinning, Dewatering, Excavation and Support, Decking, Spoil Storage and Disposal, Tunnel Structure Construction	Truck moving on dirty or un-paved road, stockpiled materials	High
	3	Backfill, Restoration, Cleanup	Backfilling	High
Soft Ground Tunneling	1	Site Preparation, Tunnel Access Construction	Same as in Cut-and-Cover method limited to a smaller area	Low
	2	Dewatering, Underground Excavation, Muck Disposal, Primary Lining	Spoil disposal site, trucking hauling on unpaved or muddy roads	High
	3	Secondary Lining, Restoration, Cleanup	Same as in Cut-and-Cover method, limited to a smaller area	Low
Rock Tunneling	1	Site Preparation, Tunnel Access Construction	Same as in Cut-and-Cover method, limited to a smaller area	Low
	2	Underground Excavation, Spoil Disposal, Primary Lining	Trucking hauling on muddy or un-paved road. Exhaust vents	High
	3	Secondary Lining, Restoration, Cleanup	Same as in Cut-and-Cover method, limited to a smaller area	Low
Sunken Tube	1	Site Preparation	Same as in Cut-and-Cover method, limited to a smaller area	Low
	2	Open Water Construction	Land spoil disposal	Low
	3	Restoration, Cleanup	Same as in Cut-and-Cover method, limited to a smaller area	Low

* N/A — Activities at this place will not likely result in direct impact on element

* High — Should receive specific control action
* Low — Need for control will be dependent on local conditions
* Negligible — Control is not likely to be required

important than in areas devoid of people. However, it should be noted that where Federal, state, or local air quality standards or criteria apply, this distinction is not generally made.

3.2.2 Current Environmental Standards and Regulations

There is a relatively extensive body of existing laws, ordinances, standards, criteria, permit requirements, and contract specifications related to air quality control. Foremost among the regulatory mechanisms are the Clean Air Act Amendments of 1970 (P.L. 91-604).(1) This law's stated purpose is "to protect and enhance the quality of the Nation's air resources." The Act authorized the Administrator of EPA to establish national primary and secondary ambient air quality standards for each pollutant which has an adverse effect on public health and welfare. Ambient air quality standards for carbon monoxide, photochemical oxidants, nitrogen oxides, particulates, and sulfur oxide were published in the Federal Register, November 25, 1971.(2) Federal regulations recommending control of fugitive dust have also been published in the Federal Register.(3) The regulations suggest that "reasonable precautions" be taken to prevent particulate matter from becoming airborne. However, these precautions are not mandatory.

Various states have adopted rules, regulations, control plans and emission limitations to meet the Federally promulgated standards or more stringent state air quality standards. All states are required by the Clean Air Act Amendments of 1970 to develop pollution regulations. For example, the Georgia Air Quality Control Rules of 1973 include sections on both fugitive dust and construction permits.(1,4) The dust section is taken directly from the Federal regulations described above. Construction permits are required from the Georgia State Department of Public Health prior to the beginning of any construction which could result in air pollution.

Other states have promulgated similar regulations requiring permits to control a pollution source. In order to obtain, and to keep a permit, the contractor generally must have an approved plan to control dust. For example, Nevada has specifications written into state construction contracts requiring stabilization of all completed cuts and fills.(5)

Some states with large metropolitan areas have established more stringent air quality regulations in those areas. For instance, the Maryland Department of Health and Mental Hygiene issued Rules and Regulations Governing The Control of Air Pollution in Area III, effective February 12, 1974.(6) Area III is the Baltimore Metropolitan Area. These rules include a section which prohibits any construction activities that have not taken reasonable precautions to prevent particulates from becoming airborne. Ambient air quality standards for dustfall and suspended particulate matter are also specified in these regulations.

Local ordinances which regulate the impact of tunneling on air quality include emissions control and air quality control regulations,

open burning prohibitions, construction dust control measures or plans, and material loading and transport regulations. For instance, the District of Columbia air quality control regulations include sections on open burning, fugitive dust, visible emissions, exhaust emissions, odor and other air pollutants.(7) Some local areas also have diesel exhaust emission regulations and limits on visible emissions from such vehicles.(8) These regulations suggest the kind of maintenance and monitoring procedures that could be used to ensure that emissions from tunnel construction equipment are minimized.

Additional air pollution controls can be found in the construction contract specifications for individual tunnel projects. For example, the Washington Metropolitan Area Transit Authority has included articles in the METRO contracts which specifically address air quality impacts of construction activities.(9) The articles include regulations regarding dust control, open burning, vehicle cleaning, and material transport. Each of these relates to minimizing the impact of the construction process on air quality.

3.3 SURFACE WATER

Rapid transit tunnel construction can have impact on the water quality, drainage patterns, and navigability of lakes, reservoirs, streams, rivers, and harbors. Sedimentation and erosion from dewatering operations and construction site runoff may clog and fill lakes and streams, reduce drainage channel capacity, increase the likelihood of localized flooding, and raise the cost of municipal water treatment. Sediment may also threaten public health and safety by carrying runoff-borne pollutants such as nitrates, pesticides, petroleum products, or harmful bacteria into public water supplies.

3.3.1 Possible Impacts from the Tunneling Process

Exposed soil, construction debris and litter, and spoil stockpiles are principal sources of pollutants. Stormwater runoff can erode and transport these materials into surface waters. Sediment and dissolved chemicals in the effluent from dewatering operations are also likely to wash into surface waters. Cement, oil, and grease are examples of the types of pollutants contained in the runoff. In open water operations, dredging causes problems of increased turbidity and sediment deposition.

Alteration of drainage patterns may occur through direct stream blockage or through indirect effects. Indirect effects include exceeding a channel's capacity by increased runoff and reduction of capacity by sediment deposition.

Turbidity, erosion, and sedimentation are generally short-term conditions; however, sediment can become a long-term and costly problem if it fills up or clogs natural drainageways, water supply reservoirs, lakes, or streams. Alteration of biological balance in natural surface

waters are often long-term modifications which demand careful consideration prior to the commencement of potentially polluting construction activity. Spoil disposal by dumping in areas of substantial shellfish population can be a problem in particular areas. Runoff of fertilizers and soil conditioners during clean-up and landscaping can lend to entrophication of surface waters. Table 3.3.1 summarizes these sources of water quality impact.

3.3.2 Current Environmental Standards and Regulations

Two recent Federal laws which address surface water quality are the Federal Water Pollution Control Act Amendments of 1972 (P.L. 92-500)(1) and the Marine Protection, Research, and Sanctuaries Act of 1972 (P.L. 92-532).(2) The objective of P.L. 92-500 is "to restore and maintain the chemical, physical, and biological integrity of the Nation's waters."(1) Pollution from construction activities is mentioned specifically as non-point source pollution in Section 208(b) of this Act. Section 304(e) requires the Administrator of the U.S. EPA to issue process, procedures, and methods guidelines to control pollution resulting from all construction activity. Section 404 of the same Act gives the Administrator veto power over the specification of any defined area as a disposal site for the discharge of dredged or fill material whenever he determines "discharge of such materials into such area will have an unacceptable adverse effect on municipal water supplies,...or recreational areas."(1)

The Marine Protection, Research, and Sanctuaries Act declares it the policy of the United States "to regulate the dumping of all types of materials into ocean waters...which would adversely affect human health, welfare, or amenities..." Further, the Act requires that the Secretary of the Army issue permits for the transportation of dredged spoil for ocean dumping only with the consent of the Administrator of EPA. The Law authorizes the Administrator of EPA to establish and to apply criteria for reviewing and evaluating permit applications for transporting and dumping of material into ocean waters, and requires that no permit shall be issued for the dumping of material which will violate applicable water quality standards.(2)

EPA also promulgated both Criteria for Determining the Acceptability of Dredged Spoil Disposal to the Nation's Waters and Criteria for Evaluation of Permit Applications for Ocean Dumping.(3,4) The former criteria serve as guidelines for evaluation of proposals and applications to dredge sediments from fresh and saline waters and for their subsequent disposal. When concentrations of one or more certain pollutants in sediments exceed the specified limits, the sediment will be considered polluted, and therefore unacceptable for open water disposal.(3) The criteria also list those materials for which no permit will be issued and those materials for which special care must be exercised prior to disposal. The criteria also cover the disposal of unpolluted and polluted dredge material to ensure that water quality is maintained.

Table 3.3.1
Generalized Assessment Of Surface Water Impact

Construction Methods		Construction Phase	Principal Sources of Impact *	Likelihood of * Serious Impact *
Cut-and-Cover	1	Clearing, Grubbing, Demolition, Site Preparation	Erosion from cleared area, storm runoff	High
	2	Underpinning, Dewatering, Excavation and Support, Decking, Spoil Storage and Disposal, Tunnel Structure Construction	Discharge water from dewatering, erosion from stockpiling sites, or disposal areas	High
	3	Backfill, Restoration, Cleanup	Erosion from cleared area and backfilling sites	High
Soft Ground Tunneling	1	Site Preparation, Tunnel Access Construction	Erosion	Low
	2	Dewatering, Underground Excavation, Muck Disposal, Primary Lining	Discharges water from dewatering, spoil disposal	High
	3	Secondary Lining, Restoration, Cleanup	Erosion	Low
Rock Tunneling	1	Site Preparation, Tunnel Access Construction	Erosion	Low
	2	Underground Excavation, Spoil Disposal, Primary Lining	Spoil disposal, dewatering	High
	3	Secondary Lining, Restoration, Cleanup	Erosion	Low
Sunken Tube	1	Site Preparation	Erosion	Low
	2	Open Water Construction	Dredging activity, spoil disposal	High
	3	Restoration, Cleanup	Erosion	Low

* N/A — Activities at this place will not likely result in direct impact on element

* High — Should receive specific control action
* Low — Need for control will be dependent on local conditions
* Negligible — Control is not likely to be required

Executive Order Number 11507 (February 4, 1970) declares that "the Federal government, in the design, operation, and maintenance of its facilities, shall provide leadership in the nationwide effort to protect and enhance the quality of our air and water resources." This includes the application of sediment control measures on all Federally aided development and construction operations where there is a significant potential for pollution due to sediment.

Under the provisions of Executive Order Number 11574 (December 23, 1970), the U.S. Department of the Army, Corps of Engineers, requires permits for dreding, filling, and other activities in or affecting national, navigable waters. The issuance of the permit is subject to review by the U.S. Environmental Protection Agency, among others, in an attempt to assure water quality standard compliance. Further information on the permit application can be obtained from Division Offices of the Corps of Engineers.

The states often have counterparts to the Federal environmental laws and permit systems. Those of the State of Maryland are illustrative. The Maryland Wetlands Act of 1970 called for the preservation of the tidal wetlands to the extent possible, and established the Wetlands License in its current form.(6) Licenses for dredging and filling had been required by the State Board of Public Works for a number of years. This Act extended that procedure to state and private wetlands. If a proposed activity on wetlands requires a license or permit, the Water Resources Administration conducts an investigation to determine the probable impact of the action, prior to a public hearing on the issue. State law also requires that a permit be obtained for construction which might obstruct or pollute the state's rivers or coastal waters.(7,8)

The State of Maryland has also passed a Sediment Control Act of 1972 (8.05.03.01).(10) This Act specifies that any land clearing, grading, or earth disturbance of a certain size (public or private) shall require a plan for sediment control which must be approved by the appropriate state department, soil conservation district, or municipality. An earlier state act, Maryland Laws of 1970 (Chapter 245, "Sediment Control") made statewide sedimentation control mandatory by requiring state and local governmental agencies to implement sedimentation control measures during governmental development and construction activities, including subway tunnels.(11)

Local ordinances that are related to surface water impact may include local water quality criteria, rules and regulations, discharge permit systems, and sedimentation and erosion control specifications. An example of the latter is found in Sections 7013, 7017, and 7018 of Chapter 10 of the Los Angeles County Building Code(12). While these sections are intended to regulate grading for subdivisions, the measures may be applicable to any earthmoving work, such as the clearing and grubbing phase of cut-and-cover tunneling, in unincorporated areas. Montgomery County, Maryland, has a similar Sediment Control Amendment in its subdivision ordinance.(13)

3.4 GROUNDWATER

In many areas, groundwater is a vital source of water supply and is often relatively free of bacteria and man-made pollution because of the protection of the overlying natural filtering system of vegetation, soils, and rocks. Construction of rapid transit tunnels penetrates a portion of that filtering system, which generally occurs below the natural groundwater level, so that contaminants are provided direct access to the groundwater body.

If some form of groundwater control such as construction dewatering is employed, the natural hydraulic balance of groundwater is disturbed. This alteration of hydraulic balance may cause the movement of subsurface and even surface pollutants in and between groundwaters and surface waters.

3.4.1 Possible Groundwater Impact from the Tunneling Process

In cut-and-cover construction, a deep earth cut which is left open (or decked over for street traffic) for long periods of time before it is backfilled may permit pollutants to enter groundwater. The possible pollutants include street pollutants such as lead from gasoline, litter, oil and grease from construction equipment, and other construction wastes. Once the pollutants enter the groundwater they tend to move in the same direction as the free groundwater and at a velocity equal to or less than that of the groundwater. If the excavation site is up-gradient along natural flow lines, the pollutants may travel long distances and adjacent aquifers. Dewatering may also induce migration of pollutants from leaking sewage pipes or from polluted aquifers into adjacent ground and surface water bodies.

Grouting materials are often placed in direct contact with groundwater and slowly dissolve in water. If unsafe chemical materials are used, dissolution may result in groundwater pollution.

Blasting in poor rock during rock tunneling may cause rock fractures or fissures that could allow pollutants to infiltrate along these fractures or fissures and enter the aquifer. Table 3.4.1 summarizes these effects.

3.4.2 Current Environmental Standards and Regulations

Groundwater impacts of rapid transit system construction are relatively subtle compared to these impacts of waste injection wells, septic systems, or sanitary landfills. Thus, the possible contamination of groundwater resulting from construction activity is frequently overlooked by both the construction industry and environmental control agencies. Protection of groundwater resources was not mentioned in rapid transit system construction specifications reviewed for the study. Protection of the yield of a groundwater well is generally the responsibility of a local agency. However, no local ordinances or codes were found which

Table 3.4.1
Generalized Assessment Of Groundwater Impact

Construction Methods	Construction Phase		Principal Sources of Impact *	Likelihood of * Serious Impact *
Cut-and-Cover	1	Clearing, Grubbing, Demolition, Site Preparation	N/A	Negligible
	2	Underpinning, Dewatering, Excavation and Support, Decking, Spoil Storage and Disposal, Tunnel Structure Construction	Deep excavation, unsealed wells, dewatering	High
	3	Backfill, Restoration, Cleanup	N/A	Negligible
Soft Ground Tunneling	1	Site Preparation, Tunnel Access Construction	N/A	Negligible
	2	Dewatering, Underground Excavation, Muck Disposal, Primary Lining	Dewatering, grouting	HIgh
	3	Secondary Lining, Restoration, Cleanup	N/A	Negligible
Rock Tunneling	1	Site Preparation, Tunnel Access Construction		Negligible
	2	Underground Excavation, Spoil Disposal, Primary Lining	Grouting, dewatering, blasting	Low
	3	Secondary Lining, Restoration, Cleanup	N/A	Negligible
Sunken Tube	1	Site Preparation	N/A	Negligible
	2	Open Water Construction	Dredging if in groundwater recharge area	Negligible
	3	Restoration, Cleanup	N/A	Negligible

* N/A — Activities at this place will not likely result in direct impact on element

* High — Should receive specific control action
* Low — Need for control will be dependent on local conditions
* Negligible — Control is not likely to be required

specified any regulations relating to the effects of dewatering operations on the yield of a well, or to the impacts of other construction activities on groundwater quality.

However, there are a number of Federal and state regulations covering groundwater quality. The original law which initiated the establishment of water quality standards was the Federal Water Quality Act of 1965. This Act required states to set water quality criteria for interstate waters or portions thereof within the state. This Act was part of the Federal Water Pollution Control Act which has since gone through several amendments including the Clean Water Restoration Act of 1966, the Water Quality Improvement Act of 1970, and the Federal Water Pollution Control Act Amendments of 1972. The 1972 Amendments required states to adopt water quality standards for intrastate water and submit them to the U.S. Environmental Protection Agency for approval by April 1973. The U.S. EPA developed and published proposed criteria for surface and groundwater quality in October 1973. When finalized, the criteria will apply to all interstate, as well as intrastate, waters even though the states fail to set standards for intrastate waters. Rapid transit construction and related activities should not cause the quality of an affected freshwater aquifer to violate the criteria of such regulations.

3.5 NOISE

Noise is defined as unwanted sound and is a result of pressure changes in the air. The A-weighted scale in decibels (dBA) is the most commonly used measurement of sound for projecting environmental impact.

Noise is frequently separated into two components: the ambient or background level associated with a given area, and the intrusive noise level, a source-specific sound clearly distinguishable from the ambient level. The component of concern in tunnel construction activities is the intrusive noise level. The principal sources of intrusive noise during tunnel construction are blasting activites, earth movers, air compressors, rock drills, demolition tools, pile drivers, trucks, and pneumatic wrenches.

The effects of noise upon people are influenced by noise levels, exposure duration, and sensitivity of the receiver. Excessive noise is an annoyance, and has been shown to have physiological effects upon hearing and general health if a person is exposed for long periods.

Noise is generally one of the major environmental problems associated with construction of transit tunnels. Transit tunnels are usually contracted in densely populated areas—thus exposing more people to noise. There will also be a more severe noise impact because of the relatively long construction period required for transit tunnels. Generally, noise levels diminish little with distance from the source in densely built-up areas, due to reflection and channeling of sound by adjacent buildings. Noise is one of the most frequent sources of construction complaints received from the general public.

3.5.1 Possible Impacts from the Tunneling Process

During all phases of construction, earth-moving equipment and other internal combustion engines, jack hammers, pneumatic wrenches, and blasting operations are principal sources of noise. Operations conducted below ground surface will generally be less intrusive, so that cut-and-cover tunneling is more likely to produce serious disruptions due to noise.

Table 3.5.1 summarizes the principal elements of noise impact. Since many individual sources are involved in producing noise impacts during tunnel construction, control of noise emissions at the source appears to be a most promising approach to impact reduction. However, consideration should also be given to timing of construction activities and limitation of working hours in areas of high noise sensitivity.

3.5.2 Current Environmental Standards and Regulations

The problem of noise as an occupational hazard was recognized as early as 1942 by the Walsh-Healy Public Contracts Act.(1) The Noise Pollution and Abatement Act of 1970 (P.L. 91-604, Title IV of the Clean Air Act Amendments of 1970) was one of the first Federal laws that recognized the non-occupational, urban noise level as a potential, if not existing, hazard.(2) The Act established an Office of Noise Abatement and Control within the U.S. Environmental Protection Agency, and charged it with carrying out a "full and complete investigation and study of noise and its effect on the public health and welfare." The passage in 1972 of the Noise Control Act (P.L. 92-574)(3) represented a major Federal attempt to eliminate excess urban noise through control of the sources of this noise. The Act led to the listing of products that are major sources of noise in the Federal Register on June 21, 1974.(4). A variety of transportation and construction equipment was included on this list.

The Federal Highway Administration issued an interagency policy and procedure memorandum (PPM 90-2), Noise Standards and Procedures in 1973 to assure that measures are taken to achieve highway noise levels that are compatible with different land uses, with due consideration also given to other social, economic, and environmental effects.(5) Although the noise levels set by PPM 90-2 did not directly affect rapid transit tunneling projects, they did suggest standards of urban noise exposure and land use-noise relationships. The U.S. Department of Housing and Urban Development Circular 1390.2, Noise Abatement and Control: Departmental Policy, Implementation Responsibilities, and Standards set standards in 1971.(6) HUD encourages the use of quieter construction equipment and methods in population centers, and "in appropriate circumstances, HUD will allow certain additional costs for quieter construction equipment."(6)

The dominant response of state governments to noise caused by construction equipment and activities has taken the form of controlling

Table 3.5.1
Generalized Assessment Of Noise Impact

Construction Methods		Construction Phase	Principal Sources of Impact *	Likelihood of * Serious Impact *
Cut-and-Cover	1	Clearing, Grubbing, Demolition, Site Preparation	Equipment wrecking, demolition truck	High
	2	Underpinning, Dewatering, Excavation and Support, Decking, Spoil Storage and Disposal, Tunnel Structure Construction	Equipment, hauling truck	High
	3	Backfill, Restoration, Cleanup	Equipment, riveting	High
Soft Ground Tunneling	1	Site Preparation, Tunnel Access Construction	Equipment, but to a lesser degree	Low
	2	Dewatering, Underground Excavation, Muck Disposal, Primary Lining	Equipment, hauling truck	High
	3	Secondary Lining, Restoration, Cleanup	Same as in Cut-and-Cover method, but to a lesser degree	Low
Rock Tunneling	1	Site Preparation, Tunnel Access Construction	Equipment, drilling	Low
	2	Underground Excavation, Spoil Disposal, Primary Lining	Blasting, hauling truck	High
	3	Secondary Lining, Restoration, Cleanup	Same as in Cut-and-Cover method, but to a lesser degree	Low
Sunken Tube	1	Site Preparation	Same as in Cut-and-Cover method, but to a lesser degree	Negligible
	2	Open Water Construction	N/A	Negligible
	3	Restoration, Cleanup	Same as in Cut-and-Cover method, but to a lesser degree	Negligible

* N/A — Activities at this place will not likely result in direct impact on element

* High — Should receive specific control action
* Low — Need for control will be dependent on local conditions
* Negligible — Control is not likely to be required

the effects on receivers rather than the source of noise. Techniques such as curfews, spill-over limits, licenses, and permits are aimed at protecting the receiver from the effects of the noise emission.

State laws concerning noise frequently fall into one or more of three categories:(7)

General environmental laws which specifically include noise as an environmental problem,

Laws dealing only with noise,

Environmental laws which make no mention of noise but which may be interpreted and used to combat noise problems.

Examples of states with general environmental laws which include noise are New York, California, and Illinois. Some states with specific noise laws include Colorado, Florida, Hawaii, and North Dakota. The Colorado Noise Law (S.B. 197, 1971), for instance, sets noise limits on numerous activities measured at 25 feet from the line of the property on which the activity occurs. Any noise above the limits set forth constitutes a public nuisance. Pennsylvania is an example of a state which has implicit noise control authority within its environmental laws.

The National Institute of Municipal Law Officers (NIMLO) has drafted a model noise ordinance.(7) A large number of cities have adopted laws which are the same as or similar to the NIMLO ordinance. Certain "unnecessary" noises are prohibited by the model ordinance.

A major deficiency with the model ordinance is the use of the phrase "prohibiting unnecessary noise." It has been interpreted not as meaning capable of being muffled but, rather, as any noise without social utility. Thus, on the local level, where regulation of construction most frequently occurs, the noise from such activities continues virtually unabated.

Examples of other types of local construction noise regulations can be found. For instance, the Minneapolis, Minnesota, noise ordinance applies a decibel limit on construction activities.(7) The New York City Noise-Control Ordinance of 1972 lists numerous restrictions, noise emission levels, and permit requirements applicable to urban transit tunneling projects.(8) Restrictions on hours of construction, air compressors, paving breakers, and truck emissions, as well as tunneling permits, are required by the ordinance. It is the Environmental Protection Administration and the Police Department which have the responsibility for enforcing the noise control code.

A series of other controls and regulations can be found in construction contract specifications for individual tunnel projects. For example, the Washington Metropolitan Area Transit Authority has included an article in its METRO contracts on noise control, establishing permissible public and employee noise exposure levels, noise restrictions at affected structures, and equipment noise levels.(9)

3.6 VIBRATION

The levels of vibration to which humans respond are considerably lower than those levels necessary to induce damage to structures. Individuals can perceive vibration at particle velocities as low as 0.02 inches per second, approximately one-hundredth of the level required to cause structural damage.(1) Once vibration becomes noticeable, people may fear for their personal safety and the damaging effect such vibrations may have on their homes and property.

At higher levels of intensity, vibration can affect a structure in three ways:

Local rupture stresses can be exceeded and direct failure occur if sufficient motion is generated at any instant of time.

Repetition of stresses can result in fatigue damage.

Vibrations can cause additional stresses to be superimposed on an existing high concentration of stress, thus "triggering" a failure.

Ground vibration produced by construction activity generally decreases as the distance from the construction site increases. However, construction of a subway system is frequently carried out in built-up urban areas, and therefore it is not unusual to find buildings and sensitive equipment in close proximity to the construction site. Older historic buildings are frequently quite sensitive to such disturbance.

Tunnel construction-induced vibration has been shown to generate the following three types of impact in an urban area:

Impact on humans due to extreme sensitivity, generally manifested in terms of annoyance or fright

Impact on sensitive equipment such as computers, laboratory instruments, and electronic gear

Impact on structures manifested in terms of residual stresses and actual structural damage.

3.6.1 Possible Vibration Impacts from the Tunneling Process

Due to existing engineering knowledge and practice, vibration from tunnel construction should seldom reach sufficient magnitude to cause major architectural damage in urban areas. However, vibration of sufficient duration, repetitiveness, and intensity, may cause substantial annoyance and minor damage to sensitive equipment and older structures.

The principal sources of vibration include explosion-type activities (blasting, explosion, and demolition) and impact-type activities (pile-driving, demolition, hammer operation, wrecking, drilling, and compacting).

The vibration intensity produced by explosion-type activity is generally greater than that produced by impact-type activity.

Cut-and-cover operations may involve removal of pavements and sidewalks which can require wrecking and/or drilling activities. Demolition of obsolete structures in the right-of-way may also be required in some cases. This activity can be carried out either by explosion or wrecking methods, both of which can generate significant levels of vibration in the vicinity of the site.

Other potential vibration impacts are associated with underpinning, excavating, and ground supporting operations. Underpinning and ground supporting may require pile-driving or drilling. Actual excavation may employ heavy diesel-powered earth-moving equipment. All of these are potential sources of vibration.

Soft ground tunneling may produce a substantial vibration impact during ground excavation if compressed air is used as a ground support technique. Similarly, the drill-blasting-muck cycle in rock tunneling may generate significant ground vibration, particularly for the first 100 to 200 feet of the tunnel.

In backfilling operations, use of a vibratory compactor may produce undesirable vibration in the vicinity of the construction site. The passage of heavy trucks on local streets may also produce considerable vibration.

An assessment of the magnitude of the impact of vibration must consider the following three factors:

Sensitivity of adjacent area to vibration

Frequency of occurrence of vibration generating activity

Level or severity of impact at each occurrence.

Sensitivity is a function of land use category, building condition, and distance from construction site. In general, residential areas are more sensitive to ground vibration than are commercial or industrial areas because of the extreme sensitivity of humans. Building condition can influence sensitivity to vibration. Aged and unsound structures are more vulnerable to vibratory motion than are sound structures. The distance from the vibration source, because energy from vibration decays inversely with the distance, is probably the most important single factor in determining vibration impact.

The frequency of occurrence and severity of impact of each construction activity determines the degree of vibration impact. Frequency of occurrence depends on the design and type of construction. Severity of impact is a function of ground wave or particle velocity which is, in turn, a function of frequency and amplitude of vibration. Table 3.6.1 summarizes the causes of vibration impact.

Table 3.6.1
Generalized Assessment Of Vibration Impact

Construction Methods	Construction Phase		Principal Sources of Impact *	Likelihood of * Serious Impact *
Cut-and-Cover	1	Clearing, Grubbing, Demolition, Site Preparation	Demolition, wrecking, drilling	High
	2	Underpinning, Dewatering, Excavation and Support, Decking, Spoil Storage and Disposal, Tunnel Structure Construction	Pile-driving, drilling	High
	3	Backfill, Restoration, Cleanup	Compactor	Low
Soft Ground Tunneling	1	Site Preparation, Tunnel Access Construction	Wrecking	Low
	2	Dewatering, Underground Excavation, Muck Disposal, Primary Lining	Air compressor	High
	3	Secondary Lining, Restoration, Cleanup	N/A	Negligible
Rock Tunneling	1	Site Preparation, Tunnel Access Construction	Drilling, blasting	Low
	2	Underground Excavation, Spoil Disposal, Primary Lining	Blasting	Low
	3	Secondary Lining, Restoration, Cleanup	N/A	Negligible
Sunken Tube	1	Site Preparation	N/A	Negligible
	2	Open Water Construction	N/A	Negligible
	3	Restoration, Cleanup	N/A	Negligible

* N/A — Activities at this place will not likely result in direct impact on element

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* Negligible — Control is not likely to be required

3.6.2 Current Environmental Standards and Regulations

Controls on vibration, based on human perception, are virtually non-existent. Where structural damages are a possibility, controls are generally applied as part of the insurance program. Pre-construction surveys to predict damages are often used in place of possibly more costly efforts to avoid these damages.

The U.S. Bureau of Mines has published several documents on blasting vibrations.(2,3) These reports contain general criteria for safe blasting operations. A particle velocity of 2.0 inches per second is suggested as a criterion for safe blasting operations if the probability of damages to adjacent structures is to be small. If nuisance complaints and claims are to be kept below 8 percent of the potential number of complaints, a peak vibration level of 0.4 inches/second should not be exceeded. Imposition of controls to maintain operations within these criteria is, however, not required.

Because the general public frequently perceives the vibration problem, some states view construction-induced vibration as constituting a nuisance and as inherently dangerous. Other states, notably New York, deny liability for damage resulting from vibration in the absence of proof that construction work was done in a negligent manner. The former view is the more common approach.(4)

3.7 GROUND STABILITY

Excessive ground movement or settlement may result in damage to buildings and potential personal injury. Construction of either cut-and-cover or deep tunneling projects may cause ground movement or settlement.

3.7.1 Possible Impacts from the Tunneling Process

Excavation removes a mass of soil and reduces stress along the sides and in the bottom of the excavation. The reduction in stress during excavation may permit soil to move into the excavation from the sides and upward at the bottom of the cut. The adjacent ground surface may then settle due to this movement. The tendency for ground movement and settlement is higher near vertical cuts, which is the usual configuration in urban areas.

In some cases, large, erratic settlements outside excavations may develop if uncontrolled erosion and leakage cause excessive flow and migration of fine-grained, non-cohesive materials into an excavation. Large hydrostatic pressure differences inside and outside the boundary of excavations may cause groundwater to percolate up under the support walls, leading, in extreme cases, to boiling at the base of the excavation and severe ground surface settlement.

Vibrations produced by pile-driving may cause soil densification and and large surface settlement in loose, saturated deposits of sandy

soils. Piles driven through soft to medium clay may cause surface heaves and subsequent ground settlement because of changes in clay pore pressures. If compressed air is used in soft-ground tunneling, the air compressor plants may generate sufficient vibration to cause ground settlement through vibratory compaction.

As previously discussed, dewatering operations may cause settlements over wide areas when layers of compressible clays, silts, or organic materials are present.

In general, subsurface tunneling operations may cause ground stability problems. High hydrostatic pressures, mixed face activities, excavation in fractured rock, and related situations may lead to loss of ground in the tunnel and settlements overhead. Poor workmanship, in the form of improper shielding and bracing, may also cause such problems.

Geologic and soils conditions, groundwater conditions, tunnel design and construction method, and condition of adjacent structures all interact to determine the magnitude of impact relative to ground stability. Table 3.7.1 summarizes the main aspects of this element of concern.

3.7.2 Current Environmental Standards and Regulations

Engineers and contractors are generally held responsible for ground movement, settlement, and subsequent damages occurring in the vicinity of the construction project. Damages to property are usually covered by insurance. However, the insurance does not mitigate public inconvenience or nuisance.

Engineering knowledge is well developed in this area, and there are numerous studies and surveys which provide criteria and standards for allowable building settlement.(1,2,3,4) There is little specific regulation in this area, except as provided by laws and regulations dealing with damages to property and identification of liability.

3.8 TERRESTRIAL BIOTA

Terrestrial biota can be defined, for the purposes of this study, as land plants and animals indigenous to a given area. These may include shrubbery, grasses, trees, insects, birds, rats, mice, and other species frequently found in urban areas. Few of these species are of ecological significance in urban areas; however, some do assume importance because of their potential hazards to human health and welfare.

3.8.1 Possible Impacts from the Tunneling Process

Clearing of the right-of-way, demolition of structures, and preparation of storage, staging, and working areas are the principal sources of impact on terrestrial biota. Destruction of biota or alteration of

Table 3.7.1
Generalized Assessment Of Ground Stability Impact

Construction Methods		Construction Phase	Principal Sources of Impact *	Likelihood of * Serious Impact *
Cut-and-Cover	1	Clearing, Grubbing, Demolition, Site Preparation	N/A	Negligible
	2	Underpinning, Dewatering, Excavation and Support, Decking, Spoil Storage and Disposal, Tunnel Structure Construction	Deep excavation, pile-driving, dewatering	High
	3	Backfill, Restoration, Cleanup	N/A	Negligible
Soft Ground Tunnelling	1	Site Preparation, Tunnel Access Construction	N/A	Negligible
	2	Dewatering, Underground Excavation, Muck Disposal, Primary Lining	Dewatering, ground loss, air compressors	High
	3	Secondary Lining, Restoration, Cleanup	N/A	Negligible
Rock Tunneling	1	Site Preparation, Tunnel Access Construction	N/A	Negligible
	2	Underground Excavation, Spoil Disposal, Primary Lining	Blasting, tunneling in mixed face	Low
	3	Secondary Lining, Restoration, Cleanup	N/A	Negligible
Sunken Tube	1	Site Preparation	N/A	Negligible
	2	Open Water Construction	N/A	Negligible
	3	Restoration, Cleanup	N/A	Negligible

* N/A — Activities at this place will not likely result in direct impact on element

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habitat may occur during surface operations, leading to migration of rodents and insects from cleared and grubbed areas or demolished structures. Compaction of clayey soils may inhibit rates of soil aeration and water filtration, resulting in revegetation problems, and harborage and propagation of pests due to accumulation of demolition debris and solid waste.

Other tunnel construction activities which may affect terrestrial biota in special situations include the following:

Storm runoff containing heavy sediment loads can disturb, injure, or destroy plants and animals in the flow path and catchment areas.

Blasting vibration may disturb, injure, or destroy biota near the blasting site, particularly subterranean biota. This would be most common in rock tunneling.

Residues from pesticides used during pest eradication or control programs may reach species other than the target species (baits) or concentrate in soil (sprays) with possible long-term impact. Such actions are most likely to be found in cut-and-cover tunneling. However, the use of pesticides for spoil disinfection may occur with any type of tunnel construction. Table 3.8.1 summarizes the various aspects of tunneling impact on terrestrial biota.

3.8.2 Current Environmental Standards and Regulations

There are few existing regulatory mechanisms which relate directly to terrestrial biota. However, there are regulations which may be indirectly applied to tunneling impact on biota. The primary intent of these indirect regulations is pesticide control, soil conservation, water quality control, or air pollution control.

The Federal Environmental Pesticides Control Act of 1972 (P.L. 92-516) authorizes the Administrator of EPA, among other things, to register and classify pesticides, to issue procedures and regulations for the storage and disposal of packages and containers of pesticides, and to prescribe standards for the certification of applicators of pesticides.

In 1974, EPA issued regulations pursuant to the authority given by P.L. 92-516 concerning the acceptance of certain pesticides, and recommended procedures for the disposal and storage of pesticide containers. The applicability of these regulations to the control and eradication of specific organisms concerns improper use, storage, and disposal during the clearing and grubbing phase of cut-and-cover tunneling.

Some states have their own counterparts to the Federal law. For example, the New Jersey State Department of Environmental Protection adopted, in 1974, pesticide regulations prohibiting the sale and use of certain compounds and restricting the use of others.(3) The regulations established a registration requirement for dealers and applicators, and standards for pesticide use, storage, transportation, and disposal.

Table 3.8.1
Generalized Assessment Of Terrestrial Biota Impact

Construction Methods		Construction Phase	Principal Sources of Impact *	Likelihood of * Serious Impact *
Cut-and-Cover	1	Clearing, Grubbing, Demolition, Site Preparation	Clearing right-of-way, pest eradication and control program	High
	2	Underpinning, Dewatering, Excavation and Support, Decking, Spoil Storage and Disposal, Tunnel Structure Construction	Spoil disinfection, deep ground release of gases	Low
	3	Backfill, Restoration, Cleanup	N/A	Negligible
Soft Ground Tunneling	1	Site Preparation, Tunnel Access Construction	Clearing working area	Low
	2	Dewatering, Underground Excavation, Muck Disposal, Primary Lining	Spoil disinfection	Low
	3	Secondary Lining, Restoration, Cleanup	N/A	Negligible
Rock Tunneling	1	Site Preparation, Tunnel Access Construction	Clearing work area	Low
	2	Underground Excavation, Spoil Disposal, Primary Lining	Spoil disinfection	Low
	3	Secondary Lining, Restoration, Cleanup	N/A	Negligible
Sunken Tube	1	Site Preparation	Clearing work area	Low
	2	Open Water Construction	N/A	Negligible
	3	Restoration, Cleanup	N/A	Negligible

* N/A — Activities at this place will not likely result in direct impact on element

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The Federal and state governments have promulgated air quality standards for such pollutants as carbon monoxide, sulfur dioxide, nitrogen oxides, particulates, and photochemical oxidants, which have been shown to be injurious to vegetation, as well as humans.(5,6) Where tunneling operations generate or cause these pollutants to be formed in levels exceeding the standards, the tunneling operations are subject to these regulations.

A series of other controls can be found in the construction contract specifications for individual tunnel projects. For example, Washington Metropolitan Area Transit Authority has included articles in the GTRO contracts on "Work On or Under National Park Service Land," "Preservation, Restoration of Miscellaneous Surface Facilities," and "Protection of Existing Vegetation..."(7) All relate to minimizing the impact on terrestrial biota.

3.9 AQUATIC BIOTA

Aquatic biota refers to those plants and animals found living in either fresh or salt water. Included are fish, crustaceans, aquatic insects, zooplankton, phytoplankton, and higher aquatic plants. Aquatic organisms are frequently of both economic and ecologic importance.

The most commonly noticed problem occurs when there is potential for damage of commercial shellfishing, typically through spoil disposal operations. This element of concern becomes particularly important when designated coastal zones or wetlands are threatened.

3.9.1 Possible Impacts from the Tunneling Process

Dredging the trench and disposal of spoils in sunken-tube construction may physically alter the habitats of many aquatic species. In addition, dredging will generally disperse bottom sediments over a wide area. Bottom sediments are frequently found to contain many toxic chemicals such as pesticides, industry wastes, and trace metals. Dispersion of bottom sediments often increases the pollutant concentrations in the water during and even after dredging operation. Increased turbidity can also hinder the photochemical reaction of aquatic species. Resettlement of suspended sediments generally alters the physical condition of the bottom.

Erosion and sedimentation from spoil disposal sites, stockpiling sites, and cleared construction areas also has a potential for aquatic biota impact, but usually to a lesser degree than dredging impact. The products of erosion and sedimentation, including petroleum wastes and runoff-borne pollutants, are the principal sources of impact. As shown above, dumping of spoil materials into open water can be a much more serious source of impact. Table 3.9.1 summarizes the various sources of impact on aquatic biota.

Table 3.9.1
Generalized Assessment Of Aquatic Biota Impact

Construction Methods		Construction Phase	Principal Sources of Impact *	Likelihood of * Serious Impact *
Cut-and-Cover	1	Clearing, Grubbing, Demolition, Site Preparation	Erosion	Negligible
	2	Underpinning, Dewatering, Excavation and Support, Decking, Spoil Storage and Disposal, Tunnel Structure Construction	Spoil disposal, erosion	Low
	3	Backfill, Restoration, Cleanup	Erosion	Negligible
Soft Ground Tunneling	1	Site Preparation, Tunnel Access Construction	Erosion	Negligible
	2	Dewatering, Underground Excavation, Muck Disposal, Primary Lining	Spoil disposal	High
	3	Secondary Lining, Restoration, Cleanup	Erosion	Negligible
Rock Tunneling	1	Site Preparation, Tunnel Access Construction	Erosion	Negligible
	2	Underground Excavation, Spoil Disposal, Primary Lining	Spoil disposal	Low
	3	Secondary Lining, Restoration, Cleanup	Erosion	Negligible
Sunken Tube	1	Site Preparation	Erosion	Low
	2	Open Water Construction	Dredging, spoil disposal	High
	3	Restoration, Cleanup	Erosion	Low

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* High — Should receive specific control action
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3.9.2 Current Environmental Standards and Regulations

Two recent Federal laws applicable to aquatic biota are the Federal Water Pollution Control Act Amendments of 1972 (P.L. 92-500), and the Marine Protection, Research, and Sanctuaries Act of 1972 (P.L. 92-532).(1,2) P.L. 92-500 states as a national goal "water quality which provides for the protection and propagation of fish, shellfish, and wildlife...be achieved by July 1, 1983." Section 404 of the Act gives the Administrator veto power over the specification of any defined area as a disposal site for the discharge of dredged or fill material into navigable waters whenever he determines "discharge of such materials into such areas will have an unacceptable adverse effect on ...shellfish beds and fishery areas, wildlife..."(1)

The Marine Protection, Research, and Sanctuaries Act declares it the policy of the United States "to regulate the dumping of all types of materials into ocean waters...which would adversely affect...the marine environment, ecological systems..."(2) Further, the Act permits the Secretary of the Army to issue permits for the transportation of dredged material into ocean waters only if approved by the Administrator of EPA. The Law authorizes the Administrator of EPA to establish and apply criteria for reviewing and evaluating permit applications for transporting and dumping of material into ocean waters so that unreasonable degradation of the marine environment and ecological systems, among other items, does not occur.

Commensurate with this authority, EPA has promulgated Criteria for Determining the Acceptability of Dredged Spoil Disposal to the Nation's Water and Criteria for Evaluation of Permit Applications for Ocean Dumping.(3,4) Both have been discussed under the Surface Water section of this chapter. In addition, the Corps of Engineers, prior to such activities, must issue a Department of the Army Permit for Dredging and Filling which is subject to review by EPA, Bureau of Sport Fisheries and Wildlife, and the general public, among others. (5)

Also monitored in relation to surface water is Executive Order 11507, issued February 4, 1970, which requires that "the Federal Government in the design, operation, and maintenance of its facilities shall provide leadership in the nationwide effort to protect and enhance the quality of our air and water resources."(6) This includes the application of sediment control measures on all Federally-aided development and construction operations where there is a significant potential for the reduction of pollution due to sediment.

Some states have their own counterparts to the Federal environmental laws and permits. For example, the State of Maryland General Permits Division issues a Wetlands License and a Water Quality Certificate for activities in state wetlands and navigable waters.(7,8) State agencies reviewing the permit applications are interested in factors such as the type of dredged or fill material, provisions made to limit the amount

of wetland involved, and any beneficial or harmful effects of the proposed activity, including its impact on aquatic biota.

3.10 COMMUNITY COHESIVENESS

The perceived geographic and social framework into which the individual resident or business is integrated may be referred to as the community. Although the existence and importance of a sense of community is generally agreed upon, it is a fundamentally intangible phenomenon which is only partially measurable.

Any community functions as a delicate equilibrium of social systems, and evidence indicates that tunnel construction has a potential to cause community disruption. Impact on community cohesion is generally a secondary result, associated with direct impacts such as noise, air pollution, and traffic disruption.

This element of concern is particularly important in that resistance and obstruction to the construction process—and to the transit project as a whole—may be mobilized when community cohesiveness is affected. Such mobilization can lead to costly delays and general loss of public support for the transit system.

3.10.1 Possible Impacts from the Tunnel Construction Process

Two major categories of social interaction may be used to assess community cohesion—behavioral and perceptual aspects. The behavioral aspects are the more obvious social phenomena, i.e., the use and availability of local facilities, the degree of informal interaction (visiting among neighbors, socializing in parks and playgrounds), the degree of formal interaction (membership in clubs and other formal associations and friendship ties in the neighborhood), and residential and commercial stability. Perceptual aspects entail an identification of the more subtle impacts. In order to determine these impacts, changes in feeling and attachment toward neighbors, and commitment and identification with the neighborhood are important.

Behavioral aspects may be characterized in terms of four factors:

Degree of Formal Interaction (membership in churches, clubs, fraternal organizations, PTA's, and others). Membership or participation in local organizations will provide the basis for measuring the impacts on formal organizations. It is important to note that the types of formal organizations in each impact area will be a function of the socioeconomic character of that area. Variances in socioeconomic levels will influence participation in formal interactions. For example, in low-to-moderate income neighborhoods, churches may prove to be the predominant type of formal organization. Thus, it is important to determine the pattern of these interactions and to perform the tunnel construction activity in such a manner as to produce the least disruption.

Type and Degree of Informal Interaction (socializing in parks and playgrounds, block parties, extent of borrowing between neighbors, and others). If resources permit, measurements of the impacts on informal organizations can be made by field observation of informal interaction with the community, questionnaire-interview technique, and sociometric analysis of social patterns.

Use of Local Facilities (public and private). In the process of examining the impacts on the use and availability of local facilities, these types of services and institutions may be affected and should be considered:

Services	Institutions
Parks, playgrounds	Cultural facilities
Fire	Libraries
Police	Schools
Health care	Senior citizen centers
Day care	Religious centers.

Residential and Commercial Stability. Construction activity may alter residential and business community stability. Frequency of sales of commercial and residential property and length of tenure of residents will provide insights into the stability of the area. Frequently, a trend will be established prior to construction, as a result of earlier planning decisions. Construction may then merely support or strengthen the trend.

Perceptual aspects may be understood in terms of three essential elements of sense of neighborhood:

Feelings and attachments to the neighborhood

Extent of commitment to the area

Identification with the area.

An understanding of these perceived neighborhood attitudes can be obtained from public meetings and interviews with residents and business people. If appropriate, attitudinal surveys can be conducted.

Table 3.10.1 presents a summary assessment of sources of impact on community cohesiveness. It should be remembered that tunnel construction may actually serve to strengthen cohesiveness by mobilizing resistance to the project.

3.10.2 Current Environmental Standards and Regulations

Community cohesiveness is not treated directly in current regulations. Sections of specifications dealing with such items as property damage, public safety, noisy work, and liability insurance will have an indirect effect on this element of concern.

Table 3.10.1
Generalized Assessment Of Impact On Community Cohesiveness

Construction Methods		Construction Phase	Principal Sources of Impact *	Likelihood of * Serious Impact *
Cut-and-Cover	1	Clearing, Grubbing, Demolition, Site Preparation	Activity in neighborhood, noise, dirt, disruption	High
	2	Underpinning, Dewatering, Excavation and Support, Decking, Spoil Storage and Disposal, Tunnel Structure Construction	Loss of access, accident potential, strangers in neighborhood	High
	3	Backfill, Restoration, Cleanup	Dirt, noise	High
Soft Ground Tunneling	1	Site Preparation, Tunnel Access Construction	Activity in neighborhood, noise dirt, disruption	Low
	2	Dewatering, Underground Excavation, Muck Disposal, Primary Lining	N/A	Negligible
	3	Secondary Lining, Restoration, Cleanup	N/A	Negligible
Rock Tunneling	1	Site Preparation, Tunnel Access Construction	Same as in Soft Ground Tunneling	Low
	2	Underground Excavation, Spoil Disposal, Primary Lining	N/A	Negligible
	3	Secondary Lining, Restoration, Cleanup	N/A	Negligible
Sunken Tube	1	Site Preparation	N/A	Negligible
	2	Open Water Construction	N/A	Negligible
	3	Restoration, Cleanup	N/A	Negligible

* N/A — Activities at this place will not likely result in direct impact on element

* High — Should receive specific control action
* Low — Need for control will be dependent on local conditions
* Negligible — Control is not likely to be required

More directly relevant are Federal and local regulations and standards for community involvement and public participation in the planning process. Participation is required during the planning process for Federally assisted projects but is then neglected as design and construction progress. Contractors and resident engineers are left with the responsibility for dealing with the public, although there may be a person assigned within the transit agency to receive public complaints.

3.11 PUBLIC HEALTH AND SAFETY

Tunnel construction presents a variety of physical threats to the individual health and welfare of people in a project area. Accidents and potential health hazards are a wellrecognized problem which can be dealt with through a combination of safety planning and public information actions.

3.11.1 Possible Impacts from the Tunneling Process

Public safety impacts can be characterized as stemming primarily from the conflict of the general public with construction activity. The greatest concern is for the safety of children who do not perceive the dangers, the handicapped who because of their disability cannot recognize the danger signals (e.g., the deaf who cannot hear a warning, the blind who cannot see a warning), and the aged who because of inherent physical limitation are subject to hazards. (Accident reports show that people stumbling on imperfections in the pavement are predominately the elderly.)

Traffic hazards are aggravated by the mix of construction vehicles with normally present traffic and the failure to separate pedestrian and vehicular traffic. Accidents associated with slippery or rough decking in cut-and-cover operations are particularly prevalent. Large machinery and construction activity may divert drivers' attention, leading to auto collisions.

Physical irritation (eyes, respiratory tract) is caused by fugitive dust, unearthing of trapped gases, activation of infectious material, and transmission of organisms by introduction to open air. Physiological danger is also presented by blasting, or other noisy operations, transmission of organisms through spoil removal, untidy storage and staging area—inviting vermin, and accidental piercing of public water or sewage systems. Table 3.11.1 summarizes sources of impact on public health and safety.

3.11.2 Current Environmental Standards and Regulations

Specific regulations and site specifications are fashioned to control many of the potential adverse impacts mentioned under the individual tunneling processes. Federal, state, and local building codes provide safeguards, safety devices, protection equipment, and other necessary

Table 3.11.1
Generalized Assessment Of Impact On Public Health And Safety

Construction Methods	Construction Phase		Principal Sources of Impact *	Likelihood of * Serious Impact *
Cut-and-Cover	1	Clearing, Grubbing, Demolition, Site Preparation	Clearing, grubbing, heavy duty earth movers, demolition	High
	2	Underpinning, Dewatering, Excavation and Support, Decking, Spoil Storage and Disposal, Tunnel Structure Construction	Deep cuts or holes, rough decking surface, slipping temporary access as bridge, heavy construction activity limits access	High
	3	Backfill, Restoration, Cleanup	Alteration of street conditions, heavy construction activity	High
Soft Ground Tunneling	1	Site Preparation, Tunnel Access Construction	Same as in Cut-and-Cover method, but to a lesser degree	Low
	2	Dewatering, Underground Excavation, Muck Disposal, Primary Lining	Possible ground loss and settlement, truck hauling, spoil disposal	Low
	3	Secondary Lining, Restoration, Cleanup	N/A	Negligible
Rock Tunneling	1	Site Preparation, Tunnel Access Construction	Same as in Cut-and-Cover method, but to a lesser degree	Low
	2	Underground Excavation, Spoil Disposal, Primary Lining	Blasting, truck hauling, spoil disposal	Negligible
	3	Secondary Lining, Restoration, Cleanup	N/A	Negligible
Sunken Tube	1	Site Preparation	N/A	Negligible
	2	Open Water Construction	N/A	Negligible
	3	Restoration, Cleanup	N/A	Negligible

* N/A — Activities at this place will not likely result in direct impact on element

* High — Should receive specific control action
* Low — Need for control will be dependent on local conditions
* Negligible — Control is not likely to be required

precautions, although there are few explicit standards for judging the adequacy of these precautions.

It is notable that insurance covers liability for damages to third parties but does not generally prepare and enforce extensive off-site safety regulations. In fact, there are few statistics kept—in a manner useful for analysis—regarding frequency and severity of third-party claims.

3.12 PUBLIC SERVICES AND UTILITIES

Public services and utilities support or protect the residential, commercial, or business community and include such items as:

Services	Utilities
Fire protection	Sanitary and storm sewers
Police protection	Water supply
Health care	Gas supply
Garbage collections	Electricity supply
	Telephone system
	Alarm and other communication systems.

3.12.1 Possible Impacts from the Tunnel Construction Process

Possible impacts to service and utilities can be characterized as potential for breaking utility lines, interruptions to normal service, lack of adequate access to services, or possible overloads to service. The potential for such adverse impact is greatest with surface construction, because most utilities are located at shallow depths.

The most severe impact may be the accidential cutting or striking of utility lines which are not properly identified or located, or improperly replaced or relocated. Temporary interruption of utility services may be unavoidable. Disruption to surface circulation patterns may impede fire or police service unless carefully planned and controlled. Access to garbage collection points may be cut off. There is substantial danger associated with accidental breakage of gas, water, and power lines which endangers not only the workmen but residents and businesses as well. The added burden of construction may also outstrip the protective capabilities of the local police or fire, or the capacity of the sewer or solid waste systems. Table 3.12.1 summarizes sources of impact on services.

3.12.2 Current Environmental Standards and Regulations

State and local construction codes focus on minimizing disruption of service, but provide little specific guidance. For example, the phrase "use suitable precautions to prevent damage..." to pipes, conduits, etc., is frequently seen in construction specifications.

Table 3.12.1
Generalized Assessment Of Impact On Utility And Services

Construction Methods	Construction Phase		Principal Sources of Impact *	Likelihood of * Serious Impact *
Cut-and-Cover	1	Clearing, Grubbing, Demolition, Site Preparation	Clearing, grubbing, drilling	High
	2	Underpinning, Dewatering, Excavation and Support, Decking, Spoil Storage and Disposal, Tunnel Structure Construction	Utility support and relocation, excavation	High
	3	Backfill, Restoration, Cleanup	Utility maintenance and restoration	High
Soft Ground Tunneling	1	Site Preparation, Tunnel Access Construction	Drilling and excavation	High
	2	Dewatering, Underground Excavation, Muck Disposal, Primary Lining	Ground settlement	Negligible
	3	Secondary Lining, Restoration, Cleanup	N/A	Negligible
Rock Tunneling	1	Site Preparation, Tunnel Access Construction	Drilling, excavation	High
	2	Underground Excavation, Spoil Disposal, Primary Lining	Blasting	Low
	3	Secondary Lining, Restoration, Cleanup	N/A	Negligible
Sunken Tube	1	Site Preparation	N/A	Negligible
	2	Open Water Construction	N/A	Negligible
	3	Restoration, Cleanup	N/A	Negligible

* N/A — Activities at this place will not likely result in direct impact on element

* High — Should receive specific control action
* Low — Need for control will be dependent on local conditions
* Negligible — Control is not likely to be required

Many states have laws which require that utility companies be contacted before excavation begins. However, compliance can be poor, due to inability of the contractor to make contact with the proper party at the numerous companies involved. A new system, the "one-number" concept, is becoming very popular. This is a system in which all participating utility companies, within a defined area, can be contacted by a single telephone number. "Miss Utility", for instance, is the concept used in suburban Washington, D.C., encompassing four counties in Northern Virginia and 14 counties in Maryland. It has 17 participating utility companies and processes some 5,000-6,000 calls per month. The utility companies impacted by the proposed work respond to staking, marking, and/or identifying the horizontal route of their facilities.

3.13 ECONOMIC CLIMATE

Economic climate refers to the quality of business conditions in an area, in terms of basic values of property, vitality of going concerns, and conditions of employment. Tunnel construction will have indirect impact on economic climate in that it may disrupt local patterns of activity or provide unique opportunities for certain types of business and employment.

3.13.1 Possible Impacts from the Tunnel Construction Process

The economic climate of a community is dependent upon a variety of market activities which comprise the economic vitality of the area. These economic components may be addressed within three basic categories—business activity, property values, and employment opportunities.

Business Activity includes the production and exchange of goods and services on the wholesale and retail level. The activities of transit tunneling construction can cause normal business activity to be disrupted in several ways, either directly or indirectly. Impacts which occur from the construction process may include taking of a business, obstruction of access to business; or physical damage to buildings. Many adverse community effects relate to potential loss of retail sales due to customer inconveniences (limited vehicular and pedestrian access, reduced number of parking spaces, and dust and other unsightly conditions) as well as increased difficulty of delivery for wholesalers and manufacturers due to obstructions to vehicular access. In the long run, however, retail establishments may benefit from the completed transit system due to improved access to larger market areas and, in many cases, proximity to a transit station.

Property Values reflect market values of the area, which are influenced by prevailing market conditions. The value of property is a function of several factors, including distance from various "desirable" locations, size of land parcel, type of structure present on the site, character of the surrounding area, and amenity features. Tunneling activities could affect any one of these factors and, as a consequence, increase or reduce demand for a particular site. A property can be directly

impacted by construction by means of physical damage or actual taking of land, or indirectly due to the annoyance and disruption caused by the construction process. It should be noted, however, that although a property is adversely affected by the construction process, its value may remain stable or increase due to the parcel's access to a future transit station. (In some communities this may be undesirable to residents due to the additional activity in the neighborhood. However, studies indicate property value almost always increases with increased access to the transportation network.)

Employment Opportunities are provided by access to jobs. Tunnel construction provides jobs for blue collar and construction workers (approximately 2 to 3 years of work per tunnel segment) as well as for local service establishments catering to the needs of tunnel workers. These services include fast-food facilities, drug stores, etc. However, construction-generated disruptions and annoyances may reduce customer patronage to the degree that retail establishments will be forced to reduce their personnel. Small businesses may not survive the construction period. Table 3.13.1 summarizes these impacts.

3.13.2 Current Environmental Standards and Regulations

Adverse impact on economic climate is not generally covered by explicit regulations, except as it may be approached in terms of direct loss of business. Such losses may be covered by insurance or subject to litigation. The courts, however, are reluctant to award damages because of lack of clear relationships between construction activity and economic consequences. For this reason, most existing laws, regulations, and ordinances do not focus directly on mitigating economic impacts such as property or business value losses. Regulations are listed under legal relations or public responsibility sections of construction manuals and cover items such as those listed, which have an effect on economic climate:

Property damage

Maintaining utilities and services

Public safety

Maintenance of traffic

Cleanup

Noisy work

Retribution

Liability insurance

Preservation of property.

It should be noted that in some countries—Great Britain, for example—compensatory payments are sometimes made by the government as a matter of course. Such payments will often preclude more costly litigation.

Table 3.13.1
Generalized Assessment Of Impact On Economic Climate

Construction Methods		Construction Phase	Principal Sources of Impact *	Likelihood of * Serious Impact *
Cut-and-Cover	1	Clearing, Grubbing, Demolition, Site Preparation	Limitations on access, shoppers	High
	2	Underpinning, Dewatering, Excavation and Support, Decking, Spoil Storage and Disposal, Tunnel Structure Construction	Perception of physical disruptions as unattractive	High
	3	Backfill, Restoration, Cleanup	Dust, runoff	Low
Soft Ground Tunneling	1	Site Preparation, Tunnel Access Construction	Limitations on access, shoppers	Low
	2	Dewatering, Underground Excavation, Muck Disposal, Primary Lining	Perception of physical disruptions as unattractive	Low
	3	Secondary Lining, Restoration, Cleanup	Dust, runoff	Low
Rock Tunneling	1	Site Preparation, Tunnel Access Construction	Limitations on access, shoppers	Low
	2	Underground Excavation, Spoil Disposal, Primary Lining	Perception of physical disruptions as unattractive	Low
	3	Secondary Lining, Restoration, Cleanup	Dust, runoff	Low
Sunken Tube	1	Site Preparation	Little likely impact	Negligible
	2	Open Water Construction	Little likely impact	Negligible
	3	Restoration, Cleanup	Little likely impact	Negligible

* N/A — Activities at this place will not likely result in direct impact on element

* High — Should receive specific control action
* Low — Need for control will be dependent on local conditions
* Negligible — Control is not likely to be required

3.14 VISUAL QUALITY

Construction fences, sanitary facilities (i.e., job johns), and unsightly storage of construction materials and wastes represent potentially serious disruptions to visual quality in an area. Those disruptions may serve to produce unfavorable public reaction and resistance to other transit activity. The consequences of adverse impact on visual quality may often be felt indirectly, in terms of loss of business.

3.14.1 Possible Impacts from the Contruction Process

Substantial disruption of visual quality, relative to pre-construction conditions, is unavoidable during construction. The presence of heavy equipment and workmen, and the separation of construction and staging areas from public activity will be quite apparent to observers. However, certain steps can be taken to improve the visual quality of the site and surrounding area. Table 3.14.1 summarizes an assessment of the sources of adverse impact, which may be addressed.

Sanitary facilities, project office trailers, and laborers' rest areas are often located in front of stores, thus blocking apparent access and discouraging patronage. Temporary sidewalks with overhead protection often are designed to have a similar effect.

Construction fences are frequently unpainted or are painted a uniform drab color, producing an uninteresting facade. Decoration of fences can provide an opportunity for local students and artists to improve the image and public relations of the transit system.

3.14.2 Current Environmental Standards and Regulations

Visual quality is not generally covered in governmental regulations and there are no standards of quality. Construction specifications may include provisions regarding fencing of construction areas but do not provide for special decoration.

Table 3.14.1
Generalized Assessment Of Impact On Visual Quality

Construction Methods		Construction Phase	Principal Sources of Impact *	Likelihood of * Serious Impact *
Cut-and-Cover	1	Clearing, Grubbing, Demolition, Site Preparation	Clearing, grubbing, demolition, storage location, fencing	High
	2	Underpinning, Dewatering, Excavation and Support, Decking, Spoil Storage and Disposal, Tunnel Structure Construction	N/A	Negligible
	3	Backfill, Restoration, Cleanup	N/A	Negligible
Soft Ground Tunneling	1	Site Preparation, Tunnel Access Construction	Demolition, fencing, storage location	High
	2	Dewatering, Underground Excavation, Muck Disposal, Primary Lining	N/A	Negligible
	3	Secondary Lining, Restoration, Cleanup	N/A	Negligible
Rock Tunneling	1	Site Preparation, Tunnel Access Construction	Demolition, fencing, storage location	High
	2	Underground Excavation, Spoil Disposal, Primary Lining	N/A	Negligible
	3	Secondary Lining, Restoration, Cleanup	N/A	Negligible
Sunken Tube	1	Site Preparation	Storage and staging location	Low
	2	Open Water Construction	N/A	Negligible
	3	Restoration, Cleanup	N/A	Negligible

* N/A — Activities at this place will not likely result in direct impact on element

* High — Should receive specific control action
* Low — Need for control will be dependent on local conditions
* Negligible — Control is not likely to be required

Note: Basic presence of construction activity will be visible, and is not in itself considered to be adverse.

4. GUIDELINES FOR REDUCING ADVERSE ENVIRONMENTAL IMPACTS OF URBAN AND TRANSIT TUNNEL CONSTRUCTION

Section 3 presented an overview of the potential adverse environmental impacts associated with urban transit tunnel construction and of the types of regulations and controls that are applied in current practice. Based upon the review and assessment reported in Section 3, opportunities for improving control of environmental impact were identified, and recommendations were developed for realizing these opportunities.

These recommendations are presented in Sections 4 and 5. Here in Section 4, guidelines are proposed which would apply to the construction project as a whole. Guidelines are organized within the framework of responsible party and phase of activity described in Section 2.

The first set of guidelines in this chapter are termed "General Guidelines." These guidelines are administrative or management guidelines rather than technical measures and are applicable to all types of tunnel construction and to all environmental elements of concern. Following these General Guidelines, "Community Relations Guidelines" are discussed. These guidelines are presented separately, as this activity can have a significant positive effect on the efficiency and cost of construction by easing the community's response to construction impacts.

In Section 5, "Specific Control Measures" are given. These measures suggest onsite and off-site control techniques for specific environmental elements of concern.

Appendix A should also be noted. This Appendix provides cross-referencing of the guidelines so that information can be found for specific users of the guidelines.

4.1 GENERAL ENVIRONMENTAL GUIDELINES

The General Environmental Guidelines are presented for four different phases--planning, design, pre-construction, and construction. For each phase, the responsible agents are identified (refer to Section 2). Table 4.1 summarizes the general environmental guidelines presented in the following pages.

Table 4.1
General Environmental Guidelines —
Management Actions For Reducing Adverse Environmental Impacts During Tunneling

Responsible Party	Applicable Stage in Tunneling Process			
	Planning	Design	Pre-Construction	Construction
Staff Planner or Planning Consultant	1. Conduct environmental reconnaissance to determine the community and environmental sensitivity of the adjacent area 2. Select route/station locations at the microscale to minimize impact			
Environmental/ Engineering Consultant		3. Prepare environmental specifications and provisions		
Transit Authority			6. Establish a coordinated permit system 7. Include environmental concerns in briefing 8. Community Relations	13. Staff to oversee resident engineer's enforcement of environmental provisions of specifications
Contractor			9. Apply necessary permits from local regulatory agencies 10. Community relations in conjunction with resident engineer and transit authority	14. Respond to and resolve complaints and unanticipated environmental problems
Resident Engineer			11. Community relations; receive and resolve complaints	15. Enforce environmental control plans and specifications
Regulatory Agencies		4. Review and comment on environmental provisions of specifications	12. Review contractor's applications and issue permits	16. Site inspection to correct violations; investigate public complaints
Insurance Company (Safety and Loss Control Consultant		5. Review and comment on environmental provisions of specifications		17. Inspection to correct violations; investigate and resolve public injury and damage claims

Guideline No. 1: Reconnaissance Program

Phase: Planning

Responsible Party: Transit Authority Staff Planner and/or Planning Consultants

Guideline: Conduct environmental reconnaissance to determine the community and environmental sensitivity of the general area adjacent to proposed routes and stations

General Statement: Reconnaissance shall include the following factors:

- Conditions of physical environment:
  - Air
  - Noise
  - Water quality
  - Geological and soil conditions
  - Etc.
- Community (business establishments and individuals) sensitivity to disruption and displacement
- Public services and facilities
- Aesthetic and historical values
- Traffic conditions
- Other factors as may be important to the local area.

Basic information can be obtained from regional, state, and local government, public and private agencies, and through public participation and field inspection. Formal agreements with utilities companies can be made to assure mutual cooperation and support. The reconnaissance should be documented adequately to serve as a baseline for monitoring during construction.

Guideline No. 2: Route/Station Location

Phase:	Planning
Responsible Party:	Transit Authority Staff Planner and/or Planning Consultants
Guideline:	Select route/station locations at the micro-scale to minimize adverse effects of construction on community and environment within the context of long-term locational concerns
General Statement:	Route/station locations shall be selected to avoid, to the extent possible, sensitive receptor sites. The sensitive receptor sites will include, but are not limited to: Hospitals Nursing homes Historical sites Schools Residential concentrations of elderly persons. Location decisions shall be made in the best overall public interest. Coverage will take into account: Air quality Vibration Noise Traffic circulation Public health and safety. Efforts to locate routes and stations to provide service to particular users shall be balanced by a clear recognition of the damages which construction may cause. This balance is particularly important when immediate physical damage is a possibility, such as in the vicinity of hospitals or other institutions where sensitive instruments are employed.

Guideline No. 3: Environmental Specifications

Phase: Design

Responsible Party: Engineering Consultant/Environmental Consultant

Guideline: Incorporate explicit environmental specifications into contract documents

General Statement: Contract documents shall include specification of minimum acceptable levels of environmental control, and shall include explicit pollution control activities. Coverage as a minimum shall include:

- Noise
- Air, i.e., dust
- Vibration

Where possible, coverage should additionally include:

- Surface water
- Ground water
- Ground stability
- Biota
- Economic climate
- Services.

Other elements of concern should be included as dictated by local conditions. Compliance may be encouraged by establishment of a single lump sum pay item to be paid for performance. Performance should be established by monitoring conditions, relative to the baseline (see Guideline No. 1).

The preparation of environmental specifications will require several steps:

- Existing applicable standards and regulations should be identified and summarized. Federal, state, and local codes and ordinances should be included.

Attention should be given to all elements of environmental concern.

Criteria and standards for control should be established to meet local conditions, when regulations are non-existent or are judged to be inadequate for site conditions.

Impact monitoring and enforcement procedures should be established and described in the contract documents.

Guideline No. 4: Review of Specifications

Phase:	Design
Responsible Party:	Environmental Regulatory Agencies
Guideline:	Review and comment on environmental provisions of construction specifications
General Statement:	The review agencies shall include Federal, state, and local agencies which have jurisdicton by law or designated special expertise with respect to environmental requirements and controls. These agencies will include, but are not limited to, the following: U.S. Environmental Protection Agency, regional office State water, air, and noise control agencies City environmental protection agency, or city agencies vested with such authority Local traffic control agency Utility companies. The review shall focus on the compliance of the environmental specifications with existing environmental protection regulations.

Guideline No. 5: Review of Specifications

Phase:	Design
Responsible Party:	Insurance Company and/or Safety and Loss Control Consultants
Guideline:	Review and comment on environmental specifications with respect to general public safety and nuisance control provisions.
General Statement:	The insurance company and/or safety/loss control consultant shall review and comment on the soundness and applicability of the environment provision of the construction specifications based on their unique knowledge of the causes of relevant litigation, general public injury, and damage claims. Special attention shall be given to:

- Construction activities which are sources of vibration
- Requirements for protective devices and/or watchmen
- Adequate signing and traffic regulation
- Dust control
- Ground stability
- Services and utilities.

Guideline No. 6: Permit Coordination

Phase:	Pre-construction
Responsible Party:	Transit Authority
Guideline:	Establish coordinated permit system
General Statement:	The Transit Authority shall establish a coordinated program for obtaining required permits and easements during the construction process. The following considerations should be included in establishing this program:

Negotiation with third party agencies for working and temporary storage areas, stockpiling and disposal of spoil, right-of-access to construction sites, truck hauling routes, utility relocation and alteration of traffic circulation patterns, underpinning of adjacent and overlying buildings, etc.

Application for permits required by local environmental regulations, codes versus ordinances.

Contractors should be made familiar with the program at the pre-bid stage and should understand their responsibilities to individual agencies issuing permits.

Guideline No. 7: Environmental Briefings

Phase:	Pre-construction
Responsible Party:	Transit Authority
Guideline:	Include environmental concerns in briefings and training sessions for contractor personnel, resident engineers, and other responsible parties.
General Statement:	Attention shall be focused on the following items:

- Particular environmental, social, economic, and community problems related to the project
- Environmental provisions of specifications
- Impact control practices and community relations
- Contingency plans to handle unanticipated environmental problems.

Guideline No. 8: Community Relations Program

Phase:	Pre-construction
Responsible Party:	Transit Authority
Guideline:	Conduct Community Relations Program (refer to the discussion in Section 4.2).
General Statement:	The Transit Authority shall conduct a community relations program, which as a minimum, will include:

A training session on community relations for the Contractor, Resident Engineer, and the Transit Authority's community relations staff

Establishment of communication channels with community

Active involvement of the public through informational meetings

Informing the public of the timetable of construction, and anticipated construction activity and potential impacts, and the mitigating measures to be used.

Guideline No. 9: Permits

Phase:	Pre-construction
Responsible Party:	Contractor
Guideline:	Obtain necessary local construction and environmental permits from regulatory agencies or property owners
General Statement:	The contractor shall be responsible for obtaining necessary permits, easements, and other permission necessary for construction. The Transit Authority shall assist in obtaining these permissions (cf. Guideline No. 6). In general, the environmental permits may include:

- Anti-noise requirements
- Stockpiling and disposal of spoil permits
- Groundwater discharge permits
- Street closing, traffic detour, or diversion plans
- Disconnection or relocation of utilities
- Erosion and sediment control requirements
- Dust and smoke controls.

The contractor will in general be responsible for supplying such construction planning as is required to obtain permits within the context of the coordinated permit system.

Guideline No. 10: Community Relations Program

Phase:	Pre-construction
Responsible Party:	Contractor
Guideline:	Participate in Community Relations Program (refer to the discussion in Section 4.2)
General Statement:	The contractor shall participate in a community relations program which shall entail, as a minimum, the creation of signs showing the following information:

The name and telephone number of the person responsible for receiving complaints and questions

The emergency telephone number at the construction site

Guideline No. 11: Community Relations Program

Phase:	Pre-construction
Responsible Party:	Resident Engineer
Guideline:	Participate in the Community Relations Program (refer to the discussion in Section 4.2)
General Statement:	The Resident Engineer shall participate in the community relations program which, as a minimum, will:

Establish communication channels with the community

Disseminate information on the persons and telephone numbers to contact with respect to construction information and problems on individual projects.

Guideline No. 12: Review of Permit Applications

Phase:	Pre-construction
Responsible Party:	Local environmental regulatory agencies
Guideline:	Review contractor's applications and issue environmental permits
General Statement:	The review shall be based on the following factors: Compliance of specific environmental control measures with permit requirements Conformance to local standards and regulations Coordination with other construction projects that may be active and the combined impacts of these various projects. The coordinated permit system established by the Transit Authority (of Guideline No. 6) will provide assurances that coordination among projects is accomplished and that contractors understand their responsibility on environmental concerns.

Guideline No. 13: Oversight of Compliance

Phase:	Construction
Responsible Party:	Transit Authority
Guideline:	Assign staff to oversee Resident Engineer's enforcement of environmental provisions of specifications
General Statement:	Definite assignments of responsibility for environmental control shall be made. Authority to order withholding of payment (cf., Guidelines No. 3) shall be vested in such responsible party. The assigned staff may be the same as those who oversee the enforcement of engineering specifications, provided they are familiar with environmental concerns. Responsibilities may best be carried out through: Spot checks Irregular site inspections Scheduled site inspections Scheduled audit reviews The evaluation should be based on the thoroughness with which the contractor has complied with the specifications, and on measurements of conditions, as compared with those existing prior to construction (cf., Guideline No. 1).

Guideline No. 14: Response to Complaints

Phase:	Construction
Responsible Party:	Contractor
Guideline:	Respond to and resolve complaints and, as directed by the Transit Authority, correct unanticipated environmental problems
General Statement:	The contractor shall be sensitive to community and environmental problems and respond to them promptly. Costly construction delays and litigation may be avoided thereby. Examples of the unanticipated community and environmental problems are accidents, breaks in utility lines, flooding, community opposition, and vandalism.

Guideline No. 15: Enforcement of Specifications

Phase:	Construction
Responsible Party:	Resident Engineer
Guideline:	Enforce environmental provisions of specifications
General Statement:	Enforcement shall be done by following the monitoring and inspection procedures outlined in specifications. Monitoring should include periodic inspections and spot checks of environmental conditions. Establishment of a system of continuous monitoring may be required by local conditions (cf., Guideline No. 1). Enforcement may involve the following:

Verbal indication of violation

Written warning

Written correction orders

Orders for withholding payment (cf., Guideline No. 3)

Stop-construction orders.

Guideline No. 16: Site Inspections

Phase:	Construction
Responsible Party:	Local environmental regulatory agencies
Guideline:	Conduct site inspections to correct violations; investigate and help to resolve public complaints
General Statement:	The regulatory agencies shall assure that the conditions for permit issuance are being met. These conditions should, as a minimum, include the following:

Compliance of specific environmental control measures with permit requirements

Conformance to local standards and regulations. The agencies should avoid taking an adversary point of view in this enforcement.

Guideline No. 17: Inspections

Phase:	Construction
Responsible Party:	Insurance company/safety and loss control consultants
Guideline:	Conduct inspection on- and off-site to correct violations; investigate and resolve public injury and damage complaints which could lead to third-party claims
General Statement:	Inspections for insurance purposes shall endeavor to provide incentive for good environmental control. The inspection may be made in conjunction with the safety superintendent. The inspection shall concern the following: General public safety Third-party property safety

4.2 COMMUNITY RELATIONS GUIDELINES

An effective community relations program can reduce the degree of disruption experienced from construction. When people know what to expect and feel that efforts are being made to deal with their problems, they are more likely to be tolerant of the temporary changes imposed upon them. Even further, the understanding and goodwill developed may both reduce costly delays in construction, costs of accidents and vandalism, and yield long-term benefits to the transit system and city as a whole. Because the importance of a community relations program, guidelines for this area are presented separately from other general environmental guidelines.

A community relations program should be established during the planning and design phases of the transit system building program. The contacts made during these early phases can be used as a base on which to build a continuing, positive relationship with business people and residents once construction is underway. Also, experience and knowledge gained from the public hearings and community meetings can be effectively utilized in the preconstruction and construction phases.

The primary purpose of the community relations program is to reduce the direct conflict between subway construction activity and the community which is affected by the construction. The impacts of construction, perceived and real, can be addressed through a well-structured public information program carried on throughout all phases of planning, design, and construction. However, there will be specific, more immediate, questions and complaints which must be dealt with through a controlled referral or complaint-handling process.

Because of the continuity of the Transit Authority's role during the construction process and beyond, the primary responsibility for carrying out a community relations program is placed on the Authority. However, it is vital to the success of the community relations program that all participants in construction activity be sensitive to the community's concerns and appropriately involved in the community relations program.

The following sections describe the actions which can be taken to implement an effective community relations program. It should be noted that these are guidelines only, based in part on past experience, and it is anticipated that users will employ them in developing a program tailored to meet specific needs of project and community. Table 4.2 summarizes the discussion.

4.2.1 Phases Prior to Construction

The phasing and design phases of the program are foundations of an effective community relations process. It is important that the public be involved early in the system planning process through informational

Table 4.2
Guidelines For Community Relations

Phase	Guidelines	Responsible Party
Planning	• Train staff personnel in community relations	• Transit authority
	• Inform community (businessmen, residents and the general public) of the planning of the system; the likely disruptive effects of transit construction (best presented by showing slides of previous or ongoing transit construction)	• Transit authority planner/community reletions staff
	• Obtain inputs from community as to their concerns, needs, and suggestions; consider these inputs in planning the system	• Transit authority planner/planning consultent
Design	• Inform community of the preliminary design schemes and the possible disruptive effects of the proposed construction method, including environmentel, economic, and sociel impact	• Transit authority, environmental/engineering consultant
	• Solicit community's comments on the proposed design schemes and construction method, and suggestions of measures to mitigete the anticipated disruptive effects. Examples of this guideline include:	• Environmental/engineering consultant
	— Scheduling construction consistant with business and community timetable	
	— Restriction of working hours and certain construction activities in sensitive areas	
	— Traffic manangement and coordination of separete contracts/projects to minimize congestion	
	• Inform community of the incorporation of environmentel specifications into contract, and the contractor's obligation to carry out the control meesures	• Transit authority, environmental/engineering consultant
Pre-Construction	• Conduct seminar or training sessions on community relations for contractor, resident engineer, and community relations staff	• Transit authority
	• Establish communication channels with community	
	— Disseminate the information on the persons and telephone numbers to contact with respect to construction information and problems. (This can be done through the use of mass media, newsletters, bulletins or other means).	• Transit authority, resident engineer
	— Erect sign showing contractor's name and telephone number, resident engineer's name and telephone number, and emergency telephone number at construction site	• Contractor
	• Inform the public of the timetable of construction, and anticipated construction activity and potential impacts, and the mitigating measures to be used	• Transit authority
Construction	• Periodically inform the public of the status of construction including goals, progress and completion, current and anticipated construction activities	• Transit authority, resident engineer
	• Brief the businessmen, residents, and the general public on the construction method and process and measures to be used (or being used) to reduce impacts	• Transit Authority, resident engineer
	• Formally and informally meet with businessmen, residents, and the general public in the area	• Transit authority, resident engineer, contractor
	• Inform the community in advance of the time and duration of source impact-generating activities such as demolition, street closing, detour, pile-driving, etc. (This can be best done by the use of mass media and erecting signs at construction sites in advance.)	• Transit authority, resident engineer, contractor
	• Conduct public tours of construction sites and the newly completed sections	• Transit authority

meetings held prior to the public hearings. During this phase, the Transit Authority public or community relations department is primarily responsible. The timing, format, and coverage for the informational sessions are dependent on the specific community, the stage of planning, the funds available, the degree of public controversy surrounding the system or the specific impact area, etc. Basically, the effort should be directed not only toward informing the public of the system but also toward obtaining input from the citizens as to their needs, concerns, and suggestions for improvements.

Meetings should be provided as a part of an overall, systematic public program to include all citizens in the region. Specific interest groups may also request other sessions. In general, these meetings should be conducted by personnel representing the responsible public agency, generally the Transit Authority. Other staff personnel attendance should include engineers and planners as appropriate for the particular phase of planning and design to respond to technical questions. As importantly, it is at these meetings that the engineer and planners can become "sensitized" to the needs and concerns of the public. Consulting engineers or planners may be included to respond to technical issues; however, the Transit Authority should supply the bulk of the information and be responsive to policy issues.

A general format for such meetings should include a pictorial presentation of other rapid transit systems from planning and design phases through construction, illustrating the types of disruptive activities and their controls which can be expected to a completed system. Plans for the regional system and the immediate impact area should be presented and the tunneling process described. These sessions should be carefully prepared, and even rehearsed, with participants asking each other probable questions.

After presentations are made, a dialogue between planner and public should be initiated to permit exchange of questions and answers on the entire range of citizen concern, including the environmental aspects of the construction. Many of the primary concerns at these early stages will relate to house taking and station locations. It is at these sessions, however, that concerns about safety, vibration, noise, flooding, etc., may be addressed. Some of the negative aspects of existing rapid rail systems, such as crime, filth, graffiti, etc., should be covered at these sessions also.

These meetings are, of course, part of the larger planning process, and arrangements for notices, meeting places, and the timing must be determined in conjunction with the overall community interaction program.

It is important to identify the community leaders, whether they be the president of the downtown merchants' association or the homeowners' association in a residential area, and work with them and their membership. These relationships should be built and nurtured through the planning, design, and construction process to ensure continuity and support

for the program. In both San Francisco and Washington, individual community leaders, especially businessmen, have provided inestimable support to the transit construction as they have come to realize the importance of their cooperation to the satisfactory and timely completion of the project. In addition, these relationships allow the citizens to identify individuals in the system who can provide them with specific information or relief from adverse situations.

Early in the program businessmen should be apprised of the types of disruption they can expect; the use of photographs from projects such as BART or WMATA can be especially useful here. They should be aware of the trucks, cranes, storage areas, outdoor sanitary facilities, decking, catwalks, blasting, and all other activities which will take place in the vicinity of their businesses. At this time, they should also be made aware of the types of actions which will be employed to mitigate the adverse effects of the construction phase. To the degree possible, information should be provided on the extent, in terms of both intensity and time, that businesses may be exposed to adverse impacts.

They should be apprised of the fact that environmental specifications will be included in the contracts and that the contractor will be required to develop and carry out an Environmental Control Plan, a Traffic Control Plan, and a Safety Plan. They should learn who, e.g., Contractor, resident engineer, etc., will be the agent they can turn to for immediate action and that this agent will be available when needed.

Similar information should be provided to residents and community groups as appropriate. From these meetings, it may be anticipated that positive communication links may be formed, that many fears will be dissipated, or at least acknowledged, and that there will be constructive suggestions presented by the citizens. It is important that all avenues be provided to let the community be involved, to actively understand and participate in the process, and to communicate their findings to other members of the community.

These same principles should be followed at the public hearings. The requirements for hearings are stated in the Urban Mass Transportation Act of 1970.

Although the opportunity for dialogue is reduced at the hearings, due to the need for greater formality, they do provide a useful forum, because there will be many people attending who did not attend the informational sessions. It is at the hearings that the Transit Authority may acquaint the public with the steps being taken to protect them from safety hazards and environmental intrusion. Again, it may be expected that useful citizen input may be gained at these hearings which can be used in finalizing the construction specifications before bids are requested.

During the planning and design phases, the Transit Authority should also be educating its own community relations staff. If possible, staff

may be sent to a city where construction is in progress to work as a "shadow" staff to better learn the day-to-day operations, to observe the problems that arise, and to observe the construction process first-hand.

If funds permit, or if funds can be provided from private sources such as a Chamber of Commerce, a representative group of community and business leaders should be exposed to an ongoing transit construction program in another city. They should observe the terminals, the planking, the barricades, traffic and access solutions, etc.; listen to blasting, to exhaust fans, and even to rolling stock if possible. They should talk to their counterparts in the observed city and obtain sufficient information to be able to communicate, hopefully positively, their impressions of an ongoing process. From their observations, they too might be able to suggest additional controls to mitigate adverse effects.

If it is not possible to send a group of citizens, an alternative might be to show a good film or set of slides of a system under construction or to have a representative of the system make a presentation.

4.2.2 Construction Phase

During the construction phase, the community relations program is focused on maintenance of community information on construction progress, and on response to questions and complaints raised. There are a number of steps which can be taken to provide the structure for effective community relations:

Establish contractor responsibility

Hold meetings and briefings

Establish resident engineer responsibility

Respond to questions/complaints

Provide community information and involvement mechanisms

Each of these steps will be discussed below.

Establish Contractor Responsibility — A most effective vehicle for community relations is to require in construction specifications that the contractor have a person on the site responsible for community relations. This person should be a full-time employee who is familiar with the project as a whole and who is able to respond courteously and efficiently to citizen problems. He may perform other functions, such as serving as OEO (Office of Equal Opportunity) officer and/or safety officer. He should be in a position to make inspection of property damage complaints with the resident engineers and to file and expedite reports. In addition, he or the contractor's project manager should make visits to local businessmen and residents during construction, especially prior to initiation of some particularly disturbing action such as blasting. Other activities are described below.

Hold Meetings and Briefings — Using the area groups established in the planning and design phase, neighborhood and special interest meetings should continue to be held, especially prior to the introduction of any construction equipment in the area. At this time, the Transit Authority personnel who were present at previous meetings should be accompanied by the project manager or responsible community relations person for the contractor, and the resident engineer, or the resident engineer community relations specialist (see below). Again, these meetings should be informal, scheduled to meet the needs of the group. A presentation should be developed illustrating the types of tunneling processes and the impacts which may be expected. All details of the construction process should be fully explained, as well as the activities to mitigate adverse impacts relating to traffic, access, noise, dust, safety, etc. It may be expected that the citizen response will be to question if all alternatives have been considered. Useful suggestions may be presented by the citizens.

Pamphlets, brochures, or newsletter-style handouts may be distributed at the meeting and to as many residents and businesses in the area as possible. Information in the handout should include a small map showing the impact area and sites for vent shafts, fans, etc., as well as a verbal description of the process and its potential impact. To the extent possible, dates of construction activity should also be included; however, it is better not to specify a date if there is any possiblity that contract, weather, materials, or other delays could occur.

One of the most important elements in the handout is the list of responsible agents—names, affiliations, functions, addresses, and telephone numbers (home telephone numbers may be included if desired or at least given verbally at meetings and individual briefings). These should include the contractor representative, the resident engineer, the community relations specialist for the resident engineer, and the transit authority community relations representative. The public should know that in emergencies they may contact the police or fire department, which will also have these telephone numbers.

The contractor or resident engineer may hold briefings for individual businesses and residents in the immediate impact zone to alert them to expected effects. In addition, circulars should be distributed and signs posted immediately prior to the onset of severe actions such as blasting. As an alternative to briefings (or in addition), store-front information centers may be established to provide ongoing information and forums for discussion for local area residents. Such store-front centers may be established during the planning phase and maintained until the system becomes operational.

Establish Resident Engineer Responsibility — As stated above, the primary responsibility for a successful community relations program lies with the transit authority. However, the effective execution of the program, outside of the meetings, is often the responsibility of the contractor working closely with the resident engineer. The contractor

must respond quickly and effectively to damage complaints and should establish machinery for this quick response and filing of insurance claims where appropriate. The resident engineer and the insurance agent should be part of this response machinery.

It is also important that the community relations functions of the resident engineer are well defined and coordinated. In the case of Washington METRO, a satisfactory solution has been established through appointment of a representative of the resident engineering firm whose sole responsibility is community relations. As the system has expanded an assistant has been added. These are experienced engineers with a courteous, friendly approach to both the public and the construction engineers. They are on call at all times and function as a coordinating and enforcing layer between the resident engineer and the Transit Authority. They pay personal visits to merchants and businessmen and endeavor to provide solutions to difficult problems. Because of their broad perspective, they can provide information which ranges from locating rock spoils from one portion of the system to be used as rip rap in another community, to finding information useful to court cases, and in some cases preventing suits. This role is part of a larger management decision, but has proved effective in at least one area.

Respond to Question/Complaints — Once construction has commenced, or even before, a variety of questions from the public will be addressed to the various agents. These may be categorized as informational queries and impact queries or claims.

The following are examples of typical informational questions:

Will my home be taken?

There is an underground stream in this area—will we all have flooded basements?

How long will my street be closed?

These may be handled directly if the respondent knows the answer. If not, they may be referred to the real estate office, staff engineer, the resident engineer, or the contractor. It is advisable that the original respondent check to ascertain that the caller has received a satisfactory answer.

Impact queries relate to particular problems or complaints. For example, the most common type of complaint is noise-related. The general process of response is to determine if the noise can be stopped or reduced and to work with the contractor in so doing. If noise reduction cannot be effected, it will be necessary to explain why to the caller and to offer to meet with him or her to further explain the problem, its probable duration, etc. Damage complaints must be handled immediately and all attempts made to repair or prevent further damage if it is determined that the cause is transit construction. If the machinery and lines

of communication are established, the response phase of the community relations program should help to mitigate the adverse impacts of the tunneling process.

Provide Community Information and Involvement Mechanisms — Mechanisms for more active community involvement are useful as possible compensation or mitigation of disruption and hazards imposed by construction. Examples of such mechanisms include the following activities:

Conducted site tours for neighborhood residents (particularly children)

Transit authority support for special promotional activities for businesses in the area

Competitions for decoration of construction barriers and other temporary structures

"Completion" celebrations promoted jointly by local businesses and community groups.

Such activities serve to help to maintain effective dissemination of information during the construction process.

5. SPECIFIC ENVIRONMENTAL CONTROL MEASURES

This section suggests detailed control measures for reducing negative impacts on each element of environmental concern. These control techniques are organized to be compatible with the "General Environmental Guidelines" (Section 4). Emphasis of these control measures is placed on the design and construction phases. No specific control techniques are provided for the planning phase because of the generally low level of definition of the construction process at this stage.

These control techniques can be incorporated into the environmental specifications as possible mechanisms to achieve environmental requirements, or used as guidance for engineering and personnel. Table 5.1 shows that these techniques fall into six principal categories.

It should be noted that any specific measure must be accommodated to the particular problems of project and site. It should also be recognized that some added costs may be associated with particular control measures, but an effort has been made here to minimize these costs, to the extent possible.

5.1 TRAFFIC CIRCULATION

A certain amount of disruption is unavoidable during construction. However, if effective efforts are made to improve coordination of construction with the ongoing activities of the area in which construction is to occur, the adverse impact of disruption may be reduced.

5.1.1 Design Phase

Engineering Consultant —

Consider possible traffic impacts in the design of the tunnel and selection of the construction method. This is particularly important if the transit route/station is along a major arterial or runs through major intersections in the Central Business District. These include:

Consideration of underground versus surface construction, with respect to traffic impact

Use of prefabricated structure or under-the-roof construction in the cut-and-cover method to minimize traffic disruption

Evaluate Federal, state, and local manuals on traffic control and maintenance and determine applicability to local conditions. Specify applicable sections with which the construction specifications must comply.

Federal — Part VI, "Construction and Maintenance Operations," published by the U.S. Department of Transportation, Federal Highway Administration, provides general applications of signing, barricades,

Table 5.1
Summarized Specific Environmental Control Techniques During Construction

Type of Control Techniques	Examples	Relative Likelihood That Such A Measure Can Be Effectively Applied To The Environmental Element Of Concern: Traffic Circulation	Air Quality	Surface Water	Ground Water	Noise	Vibration	Ground Stability	Biota (Aquatic and Terrestrial)	Community Cohesiveness	Public Health and Safety	Services/Utilities	Economic Climate	Visual Quality
Selection of Working and Storage Area	• Avoid sensitive areas such as hospitals	●	●	○		●				●	○	○	●	○
On-Site Source Control (Construction Site, Working, Storage and Stockpiling Areas)	• Use mufflers on equipment • Use devices to control erosion • Filter dewatering discharge • Provide accoustical enclosures • Maintain traffic and width	●	●	●	○	●	●	●	○	●	●	●	●	●
Off-Site Source Control (Spoil Dispersal, Site Access, Roads, Hauling Routes)	• Avoid routing trucks through residential or busy commercial districts • Clean and water access road and lower truck speeds to reduce dust • Institute erosion control at disposal site • Cover open-bodied dumping trucks	●	●	○		●							○	○
Timely Scheduling/Staging	• Schedule activity to be compatible with business timetable • Restrict construction activity on major arterials during peak traffic hours • Limit noise-generating activities during certain hours	●	●	○		●				●	○	○	●	
Monitoring/Inspection/ Enforcement System	• Regular and irregular inspection and monitoring spot checks	●	●	●	○	●	○	●	○	○	○	○	○	
Coordinations with Other Construction Projects	• Coordinate construction sequence to minimize cumulative impacts	●	○							○		○	○	
Good Construction Management	• Use skilled, experienced workers to assure good workmanship • Place skilled watchman on site or at safety barrier during non-working hours • Provide good maintenace of equipment, good housekeeping	○	○				○	●		○			○	

● Measure is likely to be effective in reducing impact on this element of concern.

○ Measure is moderately likely to be effective in reducing impact on this element of concern.

Note: Blank means measure is generally unlikely to be effective in reducing impact on this element of concern, but may be used if applicable to specific local condition.

and channelizing devices, lighting devices, and control of traffic through work areas, including detouring.

State — State manuals are similar to the National Manual but may vary somewhat in specifics.

Local — Local manuals, if available, are usually general, as they apply to the protection of construction and maintenance operations on streets. The scope of the manual usually covers the maintenance of vehicular and pedestrian traffic in public space for the purpose of protecting the public. The manual may present samples of signs, barricades, and their placement for various situations. It may also specify that work schedule must avoid restriction of arterial roads during peak traffic hours. Local manuals are not always available and, if they are, are not always adequate.

Determine construction sequence and staging and include these in contract documents as provisions or specifications by:

Coordinating with other construction projects in affected areas in order to minimize adverse traffic impacts, particularly with respect to other segments of transit projects and street construction projects. This can be done by:

Determining the traffic impact for each project on the basis of time duration—weeks, months, years, or quarters—so that the number of lanes available to traffic can be adjusted to fit minimum circulation requirements for a specific period.

Coordinating traffic impact of each project by using a street base map and plotting the effects and status of each street with respect to traffic flow on overlays for each phase of the project in order to adequately determine the composite impact time.

Separating the transit tunneling projects into proper bidding sequence to minimize composite traffic impacts.

Adjusting, to the extent possible, the construction sequence of the project to minimize composite traffic impact. (This should be done in cooperation with the local traffic control or public works agency.)

Considering local business time tables and community activities, such as the Christmas shopping season, peak commuter hours, lunch hours, special festival activities, etc.

Cooperating with the local traffic control agency with regard to complete or partial street closings, detours, rerouting, shifting of traffic lanes, and other requirements.

Staging construction to minimize interference with major traffic flow.

Develop traffic maintenance specifications for the project. These should include, but not be limited to, the following:

Construction sequence and staging (see previous discussions)

Traffic Control Devices — Specifications for signing, lighting, channelization devices, barricades, pavement marking, watchmen, flagmen, and other protective devices.

Pedestrian and Vehicle Access — Specificatons for access to all property and alleys for deliveries, emergencies, and utility maintenance.

Detours and Bus Rerouting — Site permits required from local traffic control and transit agencies.

Operational Lane Requirements (e.g., number of lanes and width of each lane) — Specifications for each affected roadway for different time periods such as peak/non-peak hours, weekdays/weekends, daytime/nighttime.

Street Decking — In addition to engineering requirements, slip-resistant surfaces, maximum horizontal gap, and vertical deviation of decking surfaces should be specified. The decking sequence should be specified and discussed with the local traffic control agency and representatives of the communities.

Street Closing — Permits would be required from the local traffic control agency. Planning agency should also be consulted. A public hearing or meeting would most likely be required. If closing street is acceptable, except for emergency vehicles, the street should be closed in block sections in sequence in order to reduce the extent of the impact. Care should be taken to provide alternative pedestrian access.

Public Safety — Specify requirements for protective devices or watchmen to prevent, at all times, entry to the work site and storage areas.

Monitoring and Enforcement Responsibility — Specify agent responsible for monitoring and enforcing traffic maintenance specifications and procedures to be used.

5.1.2 Construction Phase

Contractor —

Give major consideration to maintaining traffic during construction in the process of preparing the work plan for application for a construction permit. Must also obtain traffic permit from traffic control agency, based on a traffic control plan prepared by the contractor.

The staging plan for construction should be in a logical sequence with consideration given to minimizing disruption to traffic circulation and parking.

Work should be scheduled in accordance with the recommendation in these guidelines and as required by the contract drawings. Input from the coordination model process regarding other projects should be obtained from the consulting engineer for consideration.

The working plan must comply with the contract specifications.

Special emphasis should be given to adequate signing during construction. Signs should be posted prior to changes and should be directed to pedestrians, as well as motorists.

Establish hauling routes to minimize traffic conflicts, particularly avoiding sensitive areas.

Training should be provided for flagmen or other persons involved in contact with the public to ease the interface. This training can be held in conjunction with the safety training program.

Follow good construction practice.

Provide adequate construction site management in order to give sufficient attention to traffic maintenance aspects.

Handle complaints promptly and follow by field inspection to correct the situation. The local traffic agency representative should be actively involved to the maximum extent possible.

Modify the approved work plan in response to any unforeseen problems, complaints, or emergency conditions.

Apply to the Resident Engineer and/or regulatory agency if appropriate for immediate authorization to make changes.

Provide a positive community relations program for the purpose of orienting the public to changing conditions in various phases of construction activity, location of that activity, and handling complaints. This is a joint responsibility with the Resident Engineer and Transit Authority.

Post signs at the project limits to provide information, including the location of the project office and telephone numbers for registering complaints.

Provide a mechanism for informing the public in advance of bus rerouting, detours, street closings, and traffic diversion.

Regularly meet with local residents and businessmen to keep them informed of progress and upcoming activities.

Be immediately responsive to complaints which are referred from the Resident Engineer, transit authority, police or the regulatory agency.

Resident Engineer —

Review, modify, and approve the contractor's Traffic Control Plan for compliance with the contract specifications for traffic maintenance.

Ascertain correct interpretation of the specifications.

Determine if the plan is practical for implementation.

Carefully monitor and effectively enforce the requirements for maintaining traffic in accordance with the approved plan, specifications, and guidelines.

Receive complaints directly from the public and through the transit authority.

Perform inspections where necessary, ensure that adjustments made to construction or traffic impedance practices. Follow-up to assure that the problem has been alleviated and the complainant informed of the action taken.

When unanticipated problems occur, ensure that necessary modifications to the contractor's working plan are made, if necessary, in order to correct impacts to traffic circulation.

Regulatory Agency —

Review, modify, and approve the contractor's Traffic Control Plan and working plan for compliance with traffic maintenance standards and regulations of that agency. This will be a traffic or transportation department or the public works department.

Determine that the Plan provides for a minimum impact in disruption to traffic and parking to the extent practical.

Suggest alternative methods for handling problem areas.

Issue a permit(s) on the basis of conformance to local standards and regulations.

Provide a point of contact for the project.

Inspect and effectively enforce standards and regulations covering the maintenance of traffic on a daily basis.

Authorize the modification of the contractor's Traffic Plan when conditions necessitate.

Respond to public complaints by referring them to the contractor. If necessary, handle traffic control aspects and hold contract work until the situation is resolved.

Transit Authority —

Review, modify, and approve Traffic Control Plan in conjunction with other agencies.

Establish a positive community relations program for the purpose of informing the public on changing conditions (coordinated with the contractor and Resident Engineer).

> The newspaper, radio, and television media should be used to publicize, in advance, any changes that will occur in normal traffic patterns, such as site preparation, reduction in street width, change in direction of travel, or detours. This should include an explanation of the problem and provide advice for persons traveling in the affected area, and, where appropriate, the inclusion of a map to orient the public to activities that will occur.

Maintain a complaint handling process which can efficiently handle complaints by referral, inspection, and the follow-up. A close working relationship with the Resident Engineer and contractor can expedite necessary improvements to traffic maintenance.

Maintain full communication with other local agencies in regard to other new construction timing for the purpose of reducing total potential impact. If other construction projects occur simultaneously with the tunnel construction, the regulatory agency should be requested to coordinate the work in order to minimize traffic and parking disruption.

> The traffic coordination process, described under design, should be updated and used as a control for minimizing impact.

5.2 AIR QUALITY

Specific controls for air pollution are possible primarily at the source.

5.2.1 Design Phase

Engineering or Environmental Consultant —

Identify existing applicable regulations relating to air pollution and include applicable regulations in the contract specifications. The U.S. Environmental Protection Agency published that "reasonable precautions" be taken to prevent construction-generated particulate matter from becoming airborne. Although these precautions are not mandatory at the Federal level, many states have adopted them in the State Implementation

Plan required under the Clean Air Act as control measures. Some of these construction dust controls include:

Use, where possible, of water or chemicals for control of dust in the demolition of existing buildings or structures, construction operations, the grading of roads, or the clearing of land. (The water pollution problem of chemical application should be considered.)

Application of asphalt, oil, water, or suitable chemicals on dirt roads, materials stockpiles, and other surfaces which can give rise to airborne dusts.

Installation and use of hoods, fans, and fabric filters to enclose and vent the handling of dusty materials. Adequate containment methods can be employed during sandblasting or other similar operations.

Covering, at all times when in motion, open-bodied trucks, transporting materials likely to give rise to airborne dusts.

Lowering vehicle speed limit on unpaved (or dirt) roads.

Conduct of agricultural practices such as tilling of land, application of fertilizers, etc., in such a manner as to prevent dust from becoming airborne.

The paving of roadways and maintaining them in a clean condition.

The prompt removal of earth or other material from paved streets onto which earth or other material has been transported by trucking or earth moving equipment, erosion by water, or other means.

Several states and local jurisdictions have regulations for air pollution controls which may be applicable to tunnel construction. These may include:

Control of exhaust from construction vehicles and other equipment

A Dust Control Plan as a requirement for application for construction permit

Identify those control measures which may not be specifically required by regulations, but which will minimize the impact or the size of the area exposed. Control measures which could be specified include:

Timely scheduling of operations so as to minimize exposure area size and time duration

Additional dust or exhaust controls in sensitive areas, such as a requirement for a screen on the air inlet on the ventilation system of adjacent buildings

Specify dust monitoring requirements to monitor the adequacy of the dust control program.

Specify minimum requirements for a dust control plan (on-site and off-site) where not already stated in existing regulations.

Criteria for selection of control measures include meterology, topography, climate and soil conditions, operations schedule, surface exposure, and sensitivity of adjacent areas. Such control mechanisms could include:

Maximum surface exposure limits

Erosion controls

Soil stabilization requirement for exposed area and stockpiled materials

Provisions for covering all transported materials

Vehicle cleaning

Avoidance of transport routes through residential areas

Dust control precautions at disposal sites.

Specify vehicle and equipment exhaust control requirements not included in existing regulations. These may include:

Maintenance of vehicles and equipment such as diesel engines in a condition which prevents visible emissions

Maintenance of gasoline engine exhaust control equipment and engines in good operating condition

Vehicle inspection requirements.

Identify other control mechanisms having indirect effects on air pollution. Applicable environmental guidelines which will address control mechanisms to minimize aid pollution impacts and include circulation, access, and parking maintenance.

5.2.2 Construction Phase

Contractor —

Dust Control Plan — The contractor is responsible for the preparation and submittal of the dust control plan. The contractor is responsible for carrying out the control plan and assuring its effectiveness during the entire construction period. As a minimum, the program must be responsive to pollution control regulations as specified in the contract. However, since all such control measures will be beneficial for both

community relations and maintenance of equipment, it is recommended that the contractor consider application of all reasonable cost-effective measures for dust control. A dust control plan is recommended to include those control measures described above (design phase) and specifically:

On-site dust control, such as watering unpaved truck routes or covering stockpiled materials and exposed areas by plastic sheet or mulch

Off-site dust control, such as cleaning trucks before leaving site, covering hauling trucks

Scheduling considerations to minimize surface exposure

Soil or storage pile stabilization

Vehicle and equipment smoke control

Sandblasting and handling controls

Lowering truck speed on unpaved roads

Wind and water erosion control

Dust monitoring instruments, monitoring frequency.

Preparation and Submittal of All Permit Applications — It is recommended that the contractor submit a Dust Control Plan with the permit application. This can ensure the consistency of this dust control plan with the permit requirements. The permits required from the local air pollution control agency may include:

General construction and land clearing

Open burning, if applicable

Diesel exhaust emissions

On-site fuel storage

Spoil storage area.

Resident Engineer —

Monitor Control Plan Effectiveness — It is recommended that the Resident Engineer be responsible for monitoring the effectiveness of the control plan. This would include:

Carrying out a program as specified in the contract document to monitor dustfall

Inspecting vehicles

Spot checking spoil hauling and disposal.

Modifications to Dust Control Plan — It is recommended that the Resident Engineer make recommendations to the contractor for control plan modifications where monitoring indicates control measures are inadequate. Such modifications might include:

Increasing the frequency of application of watering or soil stabilization techniques

Rerouting trucks

Construction of barriers around sandblasting or dust producing activities

Additional wind erosion controls including wind breaks, coverings, enclosures, especially downwind from sensitive receptors

Retrofitting of diesel or gasoline engines with pollution control equipment where such engines are used near sensitive receptors.

Public Information Program — The contractor, Resident Engineer, Transit Authority, and Regulatory Agencies should participate in the public information program to inform the public of:

Potential air pollution impact

Description of the dust control plan and other efforts to be employed to mitigate impact

A procedure for responding to public complaints including complaint investigation and follow-up

A schedule of operations of impact generating activities such as blasting, clearing, backfilling. Contractor is responsible for this.

Haul routes and disposal transport routes.

Transit Authority — It is recommended that the Transit Authority maintain staff familiar with environmental, and in particular, pollution control regulations and methods. This staff should perform the following functions:

Monitor the Performance of the Resident Engineer — In enforcing environmental contract specifications, including the following:

Dust control plan

Diesel and gasoline engine exhaust control

Off-site dust control.

This monitoring could be accomplished through scheduled and spot-check visits to the site to inspect compliance.

Assist the Resident Engineer in Resolving Citizen Complaints — If warranted, the Transit Authority staff should follow-up citizen complaints by visiting the construction site to monitor the actions of the contractor and Resident Engineer in resolving the complaint. The Transit Authority should be sensitive to the fact that citizen complaints frequently reflect the socioeconomic status of the area and that complaints from higher income areas may be more prevalent. In order to ensure compliance at all sensitive areas in the vicinity of construction, the Transit Authority staff may periodically visit the construction site and contact residents or businesses in the area.

Regulatory Agencies — The Regulatory Agencies are responsible for granting, monitoring, and enforcing the terms of permits, any applicable air quality standards and emission levels, and dust control plans. This monitoring activity can include:

Scheduled Site Visits — To examine dust control and exhuast control efforts

Participate in Meetings with Contractor, Resident Engineer, and Transit Authority — To periodically review pollution control progress and complaints

Investigate Citizen Complaints — Transmit these complaints to the Resident Engineer and direct follow-up actions

Assist Resident Engineer in Establishing Dustfall Monitoring

5.3 SURFACE WATER

Control of runoff and erosion is the principal means of reducing surface water impacts.

5.3.1 Design Phase

Engineering Consultant — It is recommended that the engineering consultant include specific control measures as pay items in the environmental specifications. Such measures include the following:

On-site measures to regulate drainage and erosion impact (necessary to erosion control plan)

Mechanically retard the rate of runoff water by dissipating the energy of flowing water, e.g., with straw bales, or other temporary devices on steep slopes

Use the existing or natural drainage system insofar as possible, e.g., storm sewer, drainage ditch

Avoid altering water courses

Cover large open areas of exposed soil with mulch, plastic sheets, or other appropriate cover

Save natural vegetation wherever possible

Construct berms on the top of embankments and take water down in paved downspouts

On-site measures to reduce sediment load (necessary to erosion control plan)

Diversion of storm water away from stockpiling area

Cover temporary spoil piles with protective materials such as mulch, tarpaulin, or plastic sheeting

Trap sediment around stockpiling area by enclosing stacks or sediment basin

Minimize the area and duration of soil exposure by timely scheduling and operation

Trap sediment in discharged and runoff water by retention ponds or sediment basins

Provide sediment traps upstream and downstream of every culvert

Excavate collected silt from such traps when necessary, i.e., when trap is full

Construct temporary sediment basins in staging, working, and spoil storage areas

Protect natural vegetation so far as possible

Measures to control on-site generated construction and human wastes:

Install and maintain portable toilet facilities in a location not offensive to residents of business foot traffic

Minimize the amount of spoil temporarily stored on-site

Provide adequate stockpiled spoil erosion control measures, e.g., covering temporary spoil stocks, enclosing stacks

Practice good housekeeping on-site

Establish regular construction debris and water container pick-up service for on-site waste accumulations

Provide equipment maintenance areas (for oil changes, lubrication), and equipment petroleum wastes retention basins and disposal procedures

On-site measures to control the dewatering and discharge process (necessary to dewatering discharge plan):

Identify the types of dewatering system to be used

Establish the type of sediment and mineral removal methods, e.g., filters, settlement basins, and efficiencies as required

Specify the maximum allowable soil particles or mineral concentration of discharge water after a certain number of continuous hours of initial operation

Off-site control measures

Trucks or other vehicles should be cleaned before leaving construction site

Minimize obstruction of navigable waters by avoiding construction methods which block shipping channels, e.g., use of caison/cofferdam, and timely scheduling of open water construction activities

Regulatory Agency — It is recommended that appropriate agencies such as the state and local environmental control agencies review the draft environmental specifications, in particular those relating to dewatering discharge, spoil disposal, and erosion control. This is especially important if public storm sewers are to be the means of conveying dewatering discharges to surface sources.

5.3.2 Construction Phase

Contractor — The contractor should incorporate specific control measures into an Environmental Control Plan. This plan should also contain an erosion control, dewatering, and spoil disposal discharge plan. It is recommended that these plans be submitted to and approved by the Resident Engineer and regulatory agencies. In addition, if sampling is required in the specifications, sampling procedures and frequency should be included in the control plan. It is recommended that it be the contractor's responsibility to secure all necessary permits relating to surface water. Such permits may include:

Public sewer use permission

Spoil disposal and site acceptance

Wetlands license

Water quality certificate, e.g., from the Maryland Department of Natural Resources

Dredging, filling, and quality of spoil approval

Local erosion control requirements

Dewatering discharge permission

5.4 GROUND WATER

While tunnel construction activities are certain to influence ground water in the area of construction, control attention must also be given to distant impacts caused by spoil disposal and related activity.

5.4.1 Design Phase

Engineering Consultant —

Conduct a survey of baseline groundwater conditions to secure the following data:

Quantity and quality of area's groundwater

Depth of groundwater below earth's surface in construction area

Groundwater usage, e.g., drinking water, agriculture, industry

Number of wells in area; depth and area of drain

Geological characteristics of water-bearing strata in area

Structures or foundations which would be affected by dewatering.

Identify all applicable regulations, criteria, or standards for water pollution control in the construction area.

Prepare environmental specifications for protection of groundwater. These will include minimum requirement for the following:

Dewatering procedures, e.g., well points, deep-well

Procedures for handling and disposing of discharge water, oil leaks, litter, etc.

Equipment maintenance facilities and procedures for disposal measures for petroleum wastes from such facilities

Sealing procedures for observation wells, explorative holes, etc.

Grouting materials, particularly chemical grouting materials

Designate party responsible for monitoring observation wells, instrumentation to be used, orientation of wells to construction activities.

Identify other control mechanisms having indirect effects on groundwater pollution. Applicable environmental guidelines which will address control mechanisms which may affect groundwater quality include:

Chemical stabilization of dust control

Surface water, e.g., spoil disposal, landfill disposal

Public health and safety, e.g., sewer relocation.

5.4.2 Construction Phase

Contractor —

Prepare and submit permit applications for:

Dewatering operations and methods

Spoil disposal (landfill), if applicable.

Provide a public information program in conjunction with Resident Engineer, regulatory agencies, and Transit Authority to provide information on:

Possible groundwater impacts

Control methods to be used

Scheduling

Procedure for responding to citizen complaints or questions.

Implement all specifications for groundwater considerations given in contract environmental specifications.

Utilize sound groundwater protection practices including:

Avoid excavating and dredging in a groundwater recharge area if possible

Use safe, tested chemical grouts as required by the contract

Have underground blasting activities conducted by experienced explosives engineer

Sink observation wells in directions oriented to the down gradient side of excavations.

Resident Engineer —

Enforce environmental requirements specified in contract document.

Regulatory Agency —

Review permit application for dewatering operations and methods.

Monitor dewatering operations and grouting for effects on water quantity or quality of groundwater.

5.5 NOISE

Noise controls are focused on protecting sensitive receptors from excessive exposure to noise.

5.5.1 Design Phase

Engineering or Environmental Consultant — It is recommended that the engineering or environmental consultant identify applicable existing standards, regulations, and permit requirements as background to preparing the environmental specifications. Such documentation relating to noise will include:

Existing noise criteria for different time periods and durations for different land uses in areas adjacent to the construction path (Federal and state agencies such as Department of Housing and Urban Development's (HUD Circular 1390.2) residential area noise criteria and Federal Highway Administration's PPM 90-2 noise criteria for different land uses can be used as references.)

Maximum noise levels allowable at the construction site for different time durations (from OSHA)

Local noise ordinances prohibiting certain noisy activities, e.g., pile driving, blasting in certain land use categories at specific times of the day, e.g., after 10 p.m. in residential areas (from local and county agencies)

Construction permit requirements; applications for which can include noise source identification, emission levels, source control measures, and receptor shielding techniques (from state and local regulatory agencies).

It is further recommended that the engineering or environmental consultant identify key noise considerations which existing standards do not adequately address. These may include the following:

Anticipated composite noise generated at the construction site, i.e., summation of all sources, from the tunneling activities, and the anticipated noise level at various distances from construction site

Masking of heretofore familiar noise sources by construction-induced sounds, e.g., noise as a street-crossing guide to sightless people, other special considerations of handicapped people.

Following these background and preparatory activities, it is recommended that the engineering or environmental consultant draft environmental specifications, including noise allowable emission level, control mechanisms, and monitoring procedures. There are two general types of noise control mechanisms--source and scheduling/siting controls. These include the following:

Possible Source Controls

Electric instead of diesel-powered equipment

Hydraulic tools instead of pneumatic impact tools

Mufflers, sound-absorbing shields, and baffles

Environmental cabs, soundproof housings, or other acoustical enclosures

Vibration-damping compound painted across piles to control the ringing

Drilled piles or vibratory pile drivers instead of impact pile drivers

Welding instead of riveting

Prefabricated structures instead of cast-in-place or assembly on-site

Premixed concrete instead of mixing on-site

Scheduling/Siting Controls

Scheduling noisy activities to coincide with peak ambient noise periods to reduce intrusive noise level if possible, e.g., during day instead of night time; limiting noisy activity during lunch hours in the business district; limiting noisy activity on weekends in residential areas

Selecting truck routes to avoid noise sensitive areas, steep grades, and to minimize traffic congestion and frequent stops

Siting noisy stationary equipment as far as possible from sensitive receptors

Moving exhaust fans back as far as possible into the tunnel (without unduly jeopardizing the health of workers).

As a minimum, noise monitoring specifications should include the following information:

Who is responsible for monitoring construction noise emissions levels? It is recommended that it be the Resident Engineer.

What type of instrumentation or other tests are to be used for monitoring noise emissions? It is recommended that portable sound level meters be employed by the Resident Engineer for compliance monitoring purposes. In addition, it is recommended that as an early warning device, a technique similar to the "Walk-Away Test" be used by the Resident Engineer (see Section 3.5.3, Reference 6). The principle behind this test is the distance at which voice communication becomes very difficult bears some association to the noise acceptability of a site. Because of the test's simplicity, i.e., requires only two people, a 100-foot tape measure, and some reading material, it is an excellent early warning procedure to apply during site visits for identifying potentially unacceptable noise levels. However, it is recognized that the original distance criteria for noise level acceptability of the test will require modification in light of the current state-of-the-art for construction noise control.

Who is responsible for furnishing the noise monitoring instruments, such as a sound level meter?

Who is responsible for noise level measurement locations and frequency? It is recommended that recordings of noise levels be at construction site boundaries. In addition, an averaging technique for sound level meter readings and standarized recording procedures should be explicitly stated in the environmental specifications.

5.5.2 Construction Phase

Contractor — It is recommended that the contractor assume responsibility for securing all requisite local permits relating to construction noise. Such permits will include:

Public street use by heavy-duty vehicles (from highway and traffic control departments)

Construction permit containing noise emissions control methods from applicable noise abatement and control agency, e.g., the requirement by New York City Noise Control Ordinance of 1972. It is further recommended that the contractor be the agent in cooperation with the Resident Engineer responsible for satisfying any self-reporting requirements specified by the regulatory agency;

Inform the adjacent residents, businessmen, merchants, and all concerned parties in advance the schedules of noisy activities such as blasting, pile-driving, and truck hauling.

5.6 VIBRATION

Construction vibration is a key control problem in areas where sensitive receptors, such as historic buildings or laboratory facilities, are located.

5.6.1 Design Phase

Engineering Consultant — The most important factor in controlling vibration is the selection of a tunneling method. Therefore, it is recommended that the selection criteria for the construction method include the vibration impact of the technique and the sensitivity of the impact area. The vibration generated from various construction activities will have to be estimated by specialists. The sensitivity of an area to vibration generally can be determined by identifying the existence of sensitive receptors such as:

Structurally susceptible buildings, e.g., aged structures, rotted foundations, historically significant buildings

Locations and types of sensitive equipment, e.g., computers, electronic equipment in radio and television stations

Human populations susceptible to the fright and annoyance frequently accompanying vibratory activities, e.g., nursing homes, mobile home courts, hospitals, day care centers.

Once the tunneling method is determined, it is further recommended the engineering consultant include control mechanisms such as the following in the environmental specifications:

The use of drilled piles in lieu of impact pile drivers

Restriction of blasting activity during certain time period of the day

The use of delayed charge techniques when blasting is necessary

To require all use of explosives to be under the supervision of a qualified explosives engineer

Stipulate the minimum criteria for protecting adjacent or overlying structures which may be affected by generated vibration.

It is recommended that the engineering consultant state the procedures, allowable limits, and responsibilities for monitoring vibration in the environmental specifications. Such information should specify the following:

The dimension to be used to measure vibration. It is recommended that peak particle velocity be used. The environmental specifications should state the allowable peak particle velocity at the receptor.

Who is responsible for taking the measurements, where measurements should be taken with respect to sensitive receptors, and the frequency of monitoring? It is recommended that the Resident Engineer be the principal agent responsible for measuring vibration.

Who shall provide the measuring instrumental devices and what type they should be?

Who shall be liable for damages due to construction-induced vibration and who should be responsible resolving vibration complaints?

When and where certain vibratory activities, e.g., blasting, impact demolition, or pile driving are prohibited?

Safety and Loss Control Consultants — The insurance company should review and comment on all proposed safety practices, explosives storage facilities, allowable peak particle velocities, etc., relating to vibratory construction activities and specifications.

5.6.2 Construction Phase

Contractor — The contractor should prepare an Environmental Control Plan which considers necessary actions to mitigate construction vibration impacts. In addition to requirements called for in the environmental specifications, the control plan can include the following mitigating actions:

Installing monitoring instruments, e.g., seisometer, vibrometer, at the locations of sensitive equipment

Hiring a qualified explosives engineer to do all blasting

Using millisecond-delay blasting to decrease the vibration level

Transporting, handling, using, and storing detonators and explosives in strict accordance with established regulations and under the supervision of the explosives engineer

If possible, scheduling vibratory activities during hours when masking of the impact is most likely to be effective as, for example, during mid-day while prohibiting night time activities

Participating in the community relations program which includes informing residents and business people in advance of the exact time, location, duration, and nature of vibratory activities through personal visits, written notice, posting of signs, distribution of notices and telephone calls.

It is recommended that it be the responsibility of the contractor to secure all necessary permits relating to vibratory activities. These will include blasting permits, and transporting, handling, and storing explosives and detonators permits.

Applications for these permits will require the contractor to specify explicitly proper precautions to be taken to protect all persons, work, and property during the period explosives are on-site and being transported.

Resident Engineer and Regulatory Agency — It is recommended that the Resident Engineer monitor and record construction-induced vibrations at regular intervals particularly during the most severe vibratory activities, such as blasting, impact pile driving, and demolition. The instrument readings, measured in peak particle velocity, should be recorded at sensitive receptors.

It is recommended that the regulatory agency work in cooperation with the contractor and Resident Engineer to monitor and regularly inspect vibratory activities.

5.7 GROUND STABILITY

Control of ground stability is generally covered under sound engineering design practice.

5.7.1 Design Phase

Engineering Consultant — Sound practice by the design engineer is essential to ensuring the protection of ground stability. This includes use of sound design and establishing specifications for support of the tunnel excavation and for protection of adjacent and overlying structures. In addition to engineering cost, it is recommended that the design engineer consider carefully the possible impacts caused by ground movement and settlement discussed in Section 3 of this document. Since design criteria and procedures are beyond the scope of the work of this study, references for design and construction of tunnels relating to the protection of ground stability are provided at the end of this section. The administrative guidelines for mitigating public inconvenience and nuisance caused by ground movement or settlement are discussed below.

In addition to details of design, construction procedures—installation, maintenance, or removal of the supporting system—should be specified to a certain extent. This can reduce the potential for damage that may be caused by poor construction execution.

The responsibility for monitoring and inspection with respect to ground movement and settlement should be established in the contract specification. This should include:

Identifying the agent responsible for providing, installing, and calibrating monitoring instruments. In general practice, the contractor should be responsible

Specifying the kinds of instruments which are required and where and how to install them

Identifying the Resident Engineer responsible for monitoring and at what intervals

Define allowable movements or settlements.

Specify procedures for correcting excessive ground movements, settlement, and accident situations.

Conduct engineering investigation of all buildings, structures, and utilities which may be affected by tunnel construction. Document their existing structure conditions and identify unsafe structures.

Design underpinning, shoring, or other supporting systems for those potentially affected structures and utilities; both detailed design and construction procedures should be specified and included as unit price bid items.

Specify the following in contract:

Agent responsible for obtaining permits, consents, and approvals for alternations or removal of existing structures and for construction of supporting systems for existing structures. It is recommended that the contractor be the responsible agent and the Transit Authority assist the contractor in the negotiations.

Specify when to obtain permits and approvals.

Allowable time period and duration for each type of construction on existing structures or utilities.

Prohibited types of construction activities such as pile driving too close to existing buildings

Time restriction for type of activities which may be disturbing to occupants or general public such as drilling, utility disconnection.

Specification requirements for restoration of existing buildings, structures, and utilities.

5.7.2 Construction Phase

Contractor —

Prepare and submit for approval the work plan for ground supporting system and/or for protection of existing structures. Guidelines for design and construction of supporting system, referenced in the list at the end of this section.

Employ skilled laborers and workers for supporting work— employ good workmanship, highly qualified supervisor to lead and enforce.

Communicate constantly with occupants of affected buildings and owners of utilities; provide adequate notice to occupants and owners prior to the start of supporting system construction.

5.8 TERRESTRIAL AND AQUATIC BIOTA

If careful construction procedures are applied, much of the damage to biota may be repaired by restoration of natural growth conditions.

5.8.1 Design Phase

Engineering Consultant —

Prohibit dredging, filling, and open water spoil disposal near valuable stationary spawning grounds and feeding areas of aquatic species.

Provide control mechanisms such as barrier shields, modified dredge equipment to limit turbidity generated by dredging activities.

Require restoration of bottom areas to original contours following dredging and filling activities.

Restrict dredging activities to specified times, i.e., avoid peak tidal periods to confine and control turbidity; avoid fish spawning period.

Provide measures to minimize the impacts of disposal of spoil.

Require restoration of any vegetation damaged or removed by contractors.

Preserve existing vegetation on or adjacent to the construction site which does not unreasonably interfere with the construction work.

Avoid damage to vegetation which is to remain in place while removing authorized vegetation.

Restore surface biota removed by relandscaping or replanting.

Institute rat control measures as necessary.

Regulatory Agency — It is recommended that concerned regulatory agencies review and comment on the proposed environmental specifications relating to biota. For instance, the agriculture or health department should review any pest control measures, and identify those areas where pest control techniques may be necessary. The Park or Planning department should similarly be involved where construction encroaches on public park lands and vegetation. In addition, the local governmental agency responsible for urban area vegetation, i.e., trash removal, landscaping, should review the environmental specifications.

5.8.2 Construction Phase

Contractor — The contractors should secure all necessary permits relating to biota, such as:

Use, application, and storage permits for pesticides, e.g., pest control sprays, and spoil disinfection substances

Construction permit for work on/or under public park land

Dredging and filling permit (see Surface Water)

Spoil storage, transport, and disposal permits

Tree removal permit

It is also recommended that the contractor use the services of experts from an agriculture or health department when implementing a pest control program. These agents can provide information such as rodent survey data, pest control guidance, and most effective control techniques. The subsequent treatment and demolition of infested structures and the excavation, storage, and disposal of spoil should also be monitored by these experts for detection of migration and to control effectiveness of the pest program.

5.9 COMMUNITY COHESIVENESS

Effective community relations programs (see Section 4.2) are generally the most effective means of dealing with this concern.

5.9.1 Design Phase

Engineering Consultant —

Maintenance of safe, clean working conditions with the least amount of visual intrusion will aid in reducing negative impacts.

Effort should be made to reduce to the extent possible estrangement from surroundings by preserving buildings, park areas, trees, and neighborhood focal points, historic sites, or gathering places.

5.9.2 Construction Phase

Contractor, Resident Engineer, and Transit Authority — By becoming familiar with the community, the contractor can be in a better position to be sensitive to avoiding or reducing actions which will tend to be most disruptive and to reinforce those which will make the construction, and hence, the transit system part of the community.

Monitoring access is highly important, especially for senior citizens. Special walkways might be necessary if they would save an elderly person a block or two for shopping. Also, children should have safe access to schools, playgrounds, etc.

If special community events are scheduled, work with the citizen or merchants group to integrate the activity with the construction work.

Hold special events, e.g., at mileposts in the construction, such as block parties, or suggest special promotional sales to merchants.

Transit Authority — Because the transit property is a publicly held operation, it is important that the Transit Authority continually monitor the community impact of the tunnel construction and provide inputs to the process through the actions described above and through the community relations program.

5.10 PUBLIC HEALTH AND SAFETY

Many of these concerns are best covered in conjunction with design of the insurance program. Care must be taken that use of "wrap-up" insurance does not imply that individual contractors are freed from taking proper safety measures.

5.10.1 Design Phase

Engineering Consultant — The engineering consultant should specify in the contract actions to be taken to minimize the impacts on public health and safety. Among these are:

Fencing the construction area. The choice of opaque or chain link fencing will depend on the local situation

Identifying and separating the "hard hat" area

Preventing children and other passersby from accidentally entering construction site by use of a watchman during work hours and control devices such as locked gates during non-work hours

Identifying the construction area, staging, or storage areas with proper signing, fencing, and lighting

Assigning trained watchmen to operations of crane booms, bulldozers, trucks, and other heavy construction work which may extend to general public areas

Using reflecting "Danger" signs or flashing lights to separate any construction area adjacent to a public area.

Provide pedestrian and vehicular safety mechanisms such as:

Employing pedestrian and/or vehicular bridges with guardrails and retaining walls

Employing slip-resistant materials for decking surface

Specifying maximum vertical and horizontal deviations of decking surface to the extent that it does not impede normal walking or cause difficult vehicle handling

Specifying access requirements for police, fire protection, and ambulances

Specifying minimum distance of street parking to construction site

Providing plywood planking or other guides for blind persons.

Detailed traffic safety guidelines should be considered, such as are discussed in "Traffic Maintenance" section.

Disinfect unsafe excavated materials in compliance with local pest control regulations and/or construction specifications.

Specify or refer to other environmental control mechanisms having effects on public safety and health.

5.10.2 Construction Phase

Contractor and Resident Engineer —

The contractor should prepare a work plan to include, but not be limited to inspecting construction area daily to see that health and safety specifications are followed.

Immediate attention should be given to repairing holes in decking surface, broken railings and fences, cleaning oil leaks, etc.

Signing and other information sources should be checked regularly for visibility and correctness.

Assist in conducting public tours and in informational sessions with the transit authority.

Transit Authority — Again, it is the ultimate responsibility of the Transit Authority to maintain the property in a safe condition for the public. This is accomplished through monitoring the construction work at the site, playing an active role in handling citizen complaints, and by conducting a positive community relations program to keep the public informed of hazards and how to avoid them.

5.11 PUBLIC SERVICES AND UTILITIES

Coordination of the activities of the various service companies will aid in controlling overall disruptions.

5.11.1 Design Phase

Engineering Consultants —

It is recommended that the engineering consultants locate all existing utilities, above or below ground, and draw exact locations on contract drawings. This should be done with the assistance of utility owners and other agencies. The utilities may include:

Water supply systems

Sanitary, storm and combined sewer facilities

Gas and liquid petroleum systems, steam lines

Power and electric systems

Street lights, and traffic controls

Parking meter installations

Fire and police alarm systems

Telephone and cable TV systems

Fire hydrants

Identify existing applicable standard requirements or specifications. Incorporate environmental specifications relating to utilities in contract specifications. These may include:

Permits required by public and private utility owners and by local jurisdictions for relocating, disconnecting, abandoning, maintaining and restoring utility systems

Specifications for work on each specific utility system, particularly for the accident-prone utilities such as gas lines, power cables, and water mains

Access requirements by local jurisdictions and utility owners, or recommendation for additional requirements in emergencies and for routine inspections and maintenance of utilities

Define the responsibility of contractor to ensure continuous utility service and to repair accidentally damaged or broken utility systems.

Utility Owners — It is recommended that the private and public utility companies work closely with the consulting engineers and the contractor to avoid duplication of effort and unnecessary community disruption. If possible, planned improvements to the utility lines should be made at the same time as the transit tunnel construction. It is also recommended that a system be provided by the utility companies through which all participating utilities can be reached by calling a single telephone number within a defined geographical area for the location.

5.11.2 Construction Phase

Contractor —

Verify utility locations provided in contract drawings by field investigation prior to the beginning of construction

Provide for protection, support, maintenance, relocation, disconnection, construction, reconstruction, and restoration plans of all utilities which may be affected by the construction

Issue press releases and written notice to all possibly affected utility owners and customers in advance concerning schedules of rerouting, constructing, disconnecting, and temporarily interrupting utility systems

Employ skilled and experienced laborers and workers to ensure good workmanship

Utility Owners and Regulatory Agencies —

Help stake, mark, and/or identify the horizontal route or facilities prior to the start of work on utilities.

Supervise contractor's work on utilities.

Establish a single reference telephone number so that callers may have one resource for identifying contacts.

5.12 ECONOMIC CLIMATE

Controls in this area are particularly important when there are many small businesses which might not survive disruptions of business during the construction period.

5.12.1 Design Phase

Engineering Consultant — It is recommended that the engineering consultant include the following control mechanisms in the specifications.

Minimize disruption to local business activity by:

Scheduling construction activity with regard to the business timetables, e.g., not scheduling disruptive, noisy work during lunch hour, limiting surface construction in Central Business District during Christmas shopping season, and other similar measures

Using prefabricated tunnel structures or under-the-roof construction method to minimize traffic disruption

Minimizing, to the extent possible, such work as clearing, decking, backfilling, utility relocation and maintenance, and similar activity which will hinder pedestrian and vehicular movement and cause neighborhood disruptions.

Reduce visual intrusion of site area by:

Placing a visual barrier (fence) around the site to the extent possible. (Safety requirements may specify a chain-link type fence, however.)

Observing strong signing controls on these barriers

Maintaining clean site area with regular waste collections

Erecting reasonably attractive storage areas and trailers.

Identify other control mechanisms having indirect effects on economic climate. Applicable environmental guidelines which will address control mechanisms to minimize economic disruptions are:

Noise, vibration

Air, dust, odor

Circulation, access, and parking maintenance

Federal laws requiring certain employment guidelines (where feasible use local labor, summer youth, etc.)

5.12.2 Construction Phase

Contractor — It should be the responsibility of the contractor to fulfill the requirements of the specifications with respect to minimizing the adverse impact on the economic climate in the construction area.

It is important that he be sensitive to the community needs as developed through the community relations program. Active steps to take include:

Making personal visits to business people at regular intervals, particularly prior to the inception of some new construction activity

Ascertain if there are specific problems that could be remedied for the individual business

Maintain a clean work area

Place storage areas and collection sites as far from entrances as possible

Inspect pedestrian overpasses for safety and clear access to business establishments

Provide special access and egress for deliveries if necessary

Place portable toilets so as not to offend pedestrians or block access to stores or buildings

Resident Engineer — The Resident Engineer should be equally responsible for assuring the least interruption of business activity in the vicinity of the tunnel construction. He, too, should make personal visits and participate in the community relations program, as well as to ensure that the contractor maintains a clean orderly work area with the least negative impact.

Transit Authority — The Transit Authority should develop an effective community relations program and specifically develop positive relationships with business and community leaders, as described in Section 4.2.

Set up meetings with local business people, merchants, property owners

Release news items on bus reroutings, detours, street closings, and other similar disruptions; construction schedule and progress

5.13 VISUAL QUALITY

The construction project cannot be hidden, but it is possible to use conditions into an advantage supporting effective community relations.

5.13.1 Design Phase

Transit Authority — It is recommended that the Transit Authority, with the assistance of the design consultant, establish a program to obtain participation of local students in decoration of construction fences. Local art schools or the public school system are likely to be interested in participating. The Transit Authority should provide a small budget

for materials and should be sure that the contractor is aware that painting activities will be conducted during the early stages of construction.

5.13.2 Construction Phase

Contractor — The contractor should be sensitive to the concerns of local residents and businesses in place of construction sheds, materials stockpiles, and equipment. He should assist the Transit Authority by cooperating with beautification activites, as part of the community relations program.

Transit Authority — The authority should respond to complaints about visual intrusions and should maintain the program of decoration of construction fences.

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APPENDIX A

USERS' CROSS-REFERENCE GUIDE

To assist the users of this document, two tables provide cross-referencing of guidance. Using Table 4.1, a particular user may review the general environmental guidelines for which he has proposed responsibility. Individual guidelines are then easily found in Section 4.1.

Table A-1, included here, provides similar information for the specific control measures suggested in Section 5. This table displays where specific reference to a responsible party is made in relation to the individual environmental concern. The section number for this concern is given so that the discussion may be found in Section 5.

It should be noted that lack of an explicit reference, in either Section 4 or Section 5, does not preclude a particular party from authority or responsibility for a particular environmental concern. The guidance given here is based upon a composite view of transit tunnel construction experience, in the absence of particular local conditions which might make other arrangements more effective.

Table A-1
Cross Reference To Specific Control Measures

Responsible Party	5.1 Traffic Circulation		5.2 Air Quality		5.3 Surface Water		5.4 Ground Water		5.5 Noise		5.6 Vibration		5.8 Terrestrial and Aquatic Biota		5.9 Community Cohesiveness		5.10 Public Health and Safety		5.11 Public Services and Utilities		5.12 Economic Climate		5.13 Visual Quality	
	Environmental Concern and Stage of Construction Process (1)*																							
	D	C	D	C	D	C	D	C	D	C	D	C	D	C	D	C	D	C	D	C	D	C	D	C
Staff Planner or Planning Consultant	(2)* ●		●		●		●		●		●		●		●		●		●		●		●	
Environmental/ Engineering Consultant	●		●		●		●		●		●		●		●		●		●		●		●	
Transit Authority		●		●												●		●				●	●	●
Contractor		●		●		●		●		●		●		●		●		●		●		●		●
Resident Engineer		●		●				●				●				●		●				●		
Regulatory Agencies		●		●		●		●				●		●										
Insurance Company (Safety and Loss Control Consultant)											●													

*Notes: (1) Stage of process — D = Planning, design, and pre-construction
C = Active construction

(2) ● indicates that explicit reference to responsible party is to be found in cited section. Lack of explicit reference does not preclude responsibility or authority for that concern.

APPENDIX B

FIELD TESTING THE ENVIRONMENTAL GUIDELINES

As a part of the research and development program upon which this document reports, an effort was made to "test" the draft environmental guidelines (Section 4). The purpose of this field test was to obtain review comments and positive suggestions regarding the practicality and likely effectiveness of the draft guidelines. An effort was made to solicit response from a broad cross-section of people concerned with urban tunnel construction, including contractor interests, designers, and local, regional, and Federal agencies.

The field testing program was conducted in three stages:

a. Letters were sent out to a relatively large number of people (approximately 400) to determine their interest and willingness to participate in a review of safety and/or environmental guidelines.

b. Copies of the draft guidelines were sent to all of those who responded to the letters. Additional copies of environmental guidelines were distributed through AMV regional offices.

c. Seminars were held in Washington, D.C., New York, and Los Angeles. At these seminars, attendees discussed the guidelines and exchanged views.

Separate seminar discussions for safety and environment were held. There were an average of approximately seven attendees at each seminar. In addition, telephone and written commentary was solicited. Little response was received here.

Results obtained in the field testing were of two general types: first, there were broad overview comments addressing format, style, overall context, and other such factors likely to influence the basic usefulness of the guidelines. Second, there were criticisms and suggestions on each individual section of the document.

Separate notes taken at each of the three seminars were assembled, along with the written comments received, into these two general categories. Subjective judgment was then applied to consolidate the comments and to extract recommendations for improving the guidelines. After a review of these recommendations, the guidelines and the report were revised to yield this document.

APPENDIX C

COST CONSIDERATIONS IN GUIDELINES IMPLEMENTATION

Throughout the course of this study, an effort has been made to minimize the degree to which environmental controls would mean increased costs in transit tunnel construction. However, such increases in cost are not totally avoidable, resulting from modifications of equipment, use of new control devices, and other such sources.

An attempt has been made to estimate in quantitative terms the increases in costs which might be associated with the guidelines and recommendations. The high level of uncertainty in many of the variables influencing costs, particularly with respect to local conditions, makes the estimates wide-ranging and often qualitative.

Table C-1 summarizes cost estimates associated with the general guidelines given in Section 4.1 of the report, based on an assumption that maximum recommended controls are employed. An indication is also given of where it is expected that added costs will be accrued.

These costs may be expected to eventually increase the overall system construction cost, regardless of where they are accrued. Viewed in these terms, the total added cost of the guidelines presented here is estimated to be less than 2 percent of the system cost (based on 1975 prices). Most of the added costs are estimated to be increases in labor, so that continuing increases in capital costs will tend to reduce the cost and increase the value of good environmental controls.

Table C-1
Estimated Cost Of Implementing Guidelines

General Environmental Guidelines	Cost To	Estimated Added Costs
1. Conduct environmental reconnaissance to determine the community and environmental sensitivity of the adjacent area	Staff Planner or Planning Consultant	Minimal, should be part of effective planning
2. Select route/station locations at the microscale to minimize impact	Staff Planner or Planning Consultant	0-2 percent increase in planning cost
3. Prepare environmental specifications and provisions	Environmental Engineering Consultant	0-3 percent increase in design cost
4. Review and comment on environmental provisions of specifications	Regulatory Agencies	Minimal, if properly coordinated
5. Review and comment on environmental provisions of specifications	Insurance Company (Safety and Loss Control Consultant)	Minimal, part of normal interests
6. Establish a coordinated permit system	Transit Authority	1 added staff member
7. Include environmental concerns in briefings	Transit Authority	Minimal
8. Community relations	Transit Authority	3-10 staff required (added to construction phase only)
9. Apply necessary permits from local Regulatory Agencies	Contractor	Minimal, part of normal responsibility
10. Community relations in conjunction with Resident Engineer and Transit Authority	Contractor	Minimal, part of normal responsibility
11. Community relations; receive and resolve complaints	Resident Engineer	Minimal, part of normal duties
12. Review Contractor's applications and issue permits	Regulatory Agency	Minimal, part of normal activities
13. Staff to oversee Resident Engineers' enforcement of environmental specifications	Transit Authority	1/2-1 staff required
14. Respond to and resolve complaints and unanticipated environmental problems	Contractor	Could require full-time staff assignment
15. Enforce environmental control plans and specifications	Resident Engineer	Minimal, part of normal duties
16. Site inspection to correct violations, Investigate public complaints	Regulatory Agency	Minimal, part of normal activities
17. Inspection to correct violations, investigate and resolve public injury and damage claims	Insurance Company (Safety and Loss Control Consultant)	Minimal, part of normal interests (extended to off-site)

APPENDIX D

REPORT OF INVENTIONS

The findings of the project, as reported in this document, are primarily management controls to be applied in tunnel construction. Application of these controls are expected to make a positive contribution to improve safety and environmental impact in tunnel construction. There were no patentable inventions or discoveries resulting from this work.

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