Chapter 3: Description of Construction Methods and Activities

A. INTRODUCTION

This chapter describes the construction process for the Second Avenue Subway. Potential environmental impacts that could result from its construction, as well as mitigation measures to lessen their effects, are discussed in subsequent technical chapters. A preliminary sequencing plan for the proposed construction activities is also identified, although this plan could still change as engineering evolves and depending on the availability of funding.

At this time, design of the Second Avenue Subway is still ongoing, and will continue to evolve over the next year. Consequently, this Final Environmental Impact Statement (FEIS) assesses the range of construction methods and activities that may be required, using a reasonable worst case approach throughout to describe potential impacts. In other words, where a variety of construction techniques could reasonably be used to build a particular project element, the method that would result in the worst overall impacts is the one that has been selected for analysis.

The Second Avenue Subway would consist largely of twin tunnels with outside diameters of up to 23½ feet. (The tunnels described in the SDEIS would have had outside diameters of 21 feet.) Each tunnel would be approximately 8.5 miles long, running from East Harlem to Lower Manhattan. Sixteen new stations, numerous fan plants and ventilation cooling facilities, pumping stations, electrical power substations, new train storage yards, and various other elements would also be built.

As described later in this chapter, where possible, construction would take place underground to minimize disruptions at the surface. Between approximately 92nd and 4th Streets (instead of 6th Street as described in the SDEIS), and again from Maiden Lane south, where Manhattan's hard bedrock is relatively close to the surface, tunnels and stations would mostly be constructed underground in the rock, by one of several mining techniques. However, even in these areas, some cut-and-cover construction would still be needed to build station entrances, mezzanines, and other features that require street-level access, or parts of stations that cannot feasibly be mined because there is not enough rock cover separating the caverns from the areas above them. Surface construction would also be required at shaft sites from which soil and rock would be removed. North of 92nd Street and between 4th Street and Maiden Lane, and at a few locations between those points, excavation would be in soil, requiring technologies other than those used in rock.

All of the stations in the soil areas between the Houston and Seaport Stations would be constructed using cut-and-cover techniques because this is the most effective method of excavating the large caverns required, while still ensuring that an adequate structural support system is in place. North of 92nd Street, the project would use two existing tunnel segments (beneath Second Avenue between 120th and 110th Streets and between 105th and 99th Streets) that were constructed in the 1970s. North of 92nd Street, a combination of cut-and-cover and earth mining techniques would be used. Since it is not economical to use mechanized tunnel boring techniques immediately adjacent to existing tunnel sections, cut-and-cover methods would be required to build the links to these segments. Once north of the existing tunnels, and beginning at approximately 122nd Street, mechanized mining methods could be used to construct the curve from Second Avenue onto 125th Street. From just east of Third Avenue to Park Avenue (where the 125th Street Station would be located), cut-and-cover methods would again be used. West of the 125th Street Station, mechanized mining would be used to excavate the planned storage tunnels extending approximately 525 feet west of Fifth Avenue. At the western end of the tunnel on 125th Street, a small amount of cut-and-cover construction would be needed to retrieve the equipment needed for mining.

South of Houston Street, the project's tunnels could be constructed using a variety of mining techniques.[1] An existing tunnel segment beneath Chatham Square would be used for ancillary space but is too shallow to be used for the tunnel alignment.

Although much of the construction work would be done underground and cause only limited surface disruption where access to the surface is necessary, there would also be significant above-ground activity related to certain tunneling operations, station construction, and the removal of materials from all underground excavations. Building the new tunnels and stations would require excavating more than 6.3 million cubic yards of rock and soil, and then transporting these materials out of Manhattan.[2]

Overall, a number of construction methods would be used, depending on geological and environmental conditions, cost, schedule, alignment, and other factors. Construction is expected to begin in 2004 and is expected to take approximately 16 years to complete.[3]

As described below, construction staging and methodology decisions for the Second Avenue Subway's construction are largely influenced by practical considerations regarding Manhattan's geology, funding, and a desire to minimize the degree of construction disturbances. Because final decisions regarding such issues have not yet been made, this FEIS analyzes the spectrum of possible methodologies using the reasonable worst case approach described above. Together, these options would encompass the full range of potential environmental impacts that could reasonably be expected to occur with the project's construction.

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[1] As discussed in Chapter 2, both the Shallow Chrystie and Forsyth Street Options described in the SDEIS have been eliminated from further consideration. The Shallow Chrystie Option was eliminated prior to publication of the SDEIS because it would have resulted in significant adverse impacts in a number of environmental areas. The Forsyth Street Option has since been eliminated because it would create construction disturbances in a wider area and also attract a lower number of transfers between the new Second Avenue Line and the existing B D service than the Deep Chrystie Option.

[2] The estimated amount of spoils that would be removed has more than doubled from that described in the SDEIS (3 million cubic yards). This is primarily because the diameter of each tunnel has increased by 1½ feet along much of the 8½-mile alignment, some station volumes have increased, and additional underground train storage space is now proposed. An explanation of why the increased amount of spoils would not alter traffic conditions from those described in the SDEIS is provided later in this chapter.

[3] The SDEIS described that the construction period could last from 12 to 16 years, and the analysis conservatively assumed the 16-year period. The FEIS assumes that, using the sequencing plan described in this chapter, construction would last 16 years.

Section B of this chapter ("Overview of Construction Methods") briefly describes the various technologies that could be used in combination to construct the Second Avenue Subway, and identifies the factors that determine each technology's potential use. More detail is provided than was available when the SDEIS was prepared; this is a result of ongoing engineering efforts. Construction activities that would occur above ground (at staging areas, shaft sites, and rock and soil removal operations) are then discussed in Section C ("Above-Ground Construction Activities: Shaft Sites, Staging Areas, and Spoils Removal"). Next, in Section D ("Construction Options for Tunnels and Stations"), a description of the proposed construction phasing plan is presented. FTA indicated in its Fiscal Year 2005 Annual Report on New Starts[1] that, given the Second Avenue Subway project's total capital cost and requested New Starts share, a minimum operable segment (MOS) will be required before the project is permitted to advance into final design. The MOS must be fully operable, with access to maintenance and storage facilities, so that it offers transportation benefits even if no further federal investment in the larger project is made. To comply with this, construction of the Second Avenue Subway will be phased. The phasing plan described in the FEIS reflects information obtained through ongoing engineering and achieves the best balance between constructability, operability, and the availability of funding. In addition, the phasing plan responds to public comments on construction schedule and sequencing. The four phases, which could potentially overlap, are as follows:

- Phase 1: 105th Street to 62nd Street, including the tunnel connection to the 63rd Street/Broadway Line;
- Phase 2: 125th Street to 105th Street;
- Phase 3: 62nd Street to Houston Street, including the 63rd Street tunnel connection to Queens for non-passenger services; and
- Phase 4: Houston Street to Hanover Square tail tracks.

Building the project in phases with interim operating segments will maximize the Second Avenue Subway project's ability to receive Section 5309 New Starts funding. The costs of the four phases in year of expenditure dollars are as follows: Phase 1—$3.8 billion: Phase 2—$3.4 billion; Phase 3—$4.8 billion; and Phase 4—$4.8 billion. These estimates may change depending on the actual construction schedule for each phase, which could be affected by the amount and availability of federal funding.

Section D of this chapter explains how these phases would be constructed and the subway service that would be provided in each phase. It also explains which portions of the alignment area would be affected during the four construction phases, and provides information on the other phasing alternatives considered before this alternative was selected. Finally, Section D also provides a matrix summarizing the location of the various construction techniques that would be used along the alignment.

Construction required to connect the Second Avenue Subway to existing stations is described in Section E ("Other Construction Elements"), along with information on construction at yards and maintenance facilities. The chapter continues with a description of how and where access could be limited during certain construction activity periods in Section F ("Access Limitations During Construction"). The chapter concludes with Section G ("Improvements Following

[1] U.S. Department of Transportation, Federal Transit Administration, *Annual Report on New Starts, Proposed Allocation of Funds for Fiscal Year 2005*, Report of the Secretary of Transportation to the United States Congress Pursuant to 49 USC 5309(o)(1), Report No. FTA-TBP10-2004-1, 2004.

Construction"), a description of the improvements that would be made after the subway construction is completed.

B. OVERVIEW OF CONSTRUCTION METHODS

For most of the Second Avenue Subway's route, two tunnels would be constructed, one for northbound trains and one for southbound trains. Each tunnel, as well as the new stations along Second Avenue, would be constructed using a combination of three main tunneling techniques:

- Mechanized boring machines (referred to throughout this document as tunnel boring machines, or "TBMs");
- Other conventional forms of mining techniques, including "drill-and-blast" construction and road headers; and
- Cut-and-cover construction.

In some areas, it may be necessary to use protective measures to support building foundations before tunnel or station excavation, to provide the structures with sufficient support and reduce the potential for damage to them. Such protective measures are described later in this section.

Both mechanized and traditional tunneling—or "mining," as these techniques are called—allow for tunnel or station excavation to occur below the street surface without substantially disrupting the street above (see Figure 3-1). Typically, the only visible evidence of a mining operation to the general public occurs where a vertical shaft connects the ground surface to the tunnel below, and where associated lay-down areas for equipment and supplies are located. For the Second Avenue Subway, vertical shafts would have to be constructed at every station (see Chapter 2, "Project Alternatives," for a list of proposed stations) and in certain other areas. Generally, most of the shaft areas would be covered with temporary decking; however, several vertical shafts measuring between 30 feet by 30 feet and 30 feet by 50 feet could be open to the street level at any time to permit materials and workers to enter and exit the tunnels. Alongside each shaft, cranes and other construction machinery would be located, allowing materials and the labor force to enter and exit the tunnels. As explained in detail below, these shafts are necessary for inserting tunneling equipment and removing the excavated rock and soils (together, called "spoils").

Because mining would generally cause fewer environmental and community disruptions than cut-and-cover construction and is quicker and more cost-effective than other underground construction methods, this construction technique would be used to the maximum extent feasible for the Second Avenue Subway project. However, mining would still require some work at the surface. Above-ground sites would be required for removal of spoils from the tunnels and station areas, and for construction materials, machinery, and workers to enter and exit the areas being excavated. Also, above-ground construction would be required for station entrances and exits, and for such ancillary facilities as vent shafts. Staging areas for construction material and personnel would also be required.

A basic description of these three construction methods is provided below.

TUNNEL BORING MACHINES (MECHANIZED MINING)

OVERVIEW

Tunnel boring machines (TBMs) are commonly used to excavate rock, soil, or both. TBMs are basically large-diameter horizontal drills that continuously excavate predominantly circular tunnel sections. Different machines are designed for different geological conditions. In rock, a rock TBM is used; as a general rule, tunnel boring in mostly self-supporting rock is the least disruptive of all tunneling methods. In soil and degraded rock, a different type of TBM is used that is specifically designed for drilling through materials that are not self-supporting. Examples of TBMs used in soil include earth-pressure-balance boring machines (EPBMs) and slurry shield TBMs, both discussed below. Multi-purpose machines are now available that combine the attributes of both rock and soft-ground machines so that a single machine can be used through both ground types, as well as through "mixed face" (that is, rock and soil within a single excavation section) conditions. A combination of these machines would be used for different parts of the Second Avenue Subway alignment.

Since TBMs are expensive to build and operate, as well as difficult to maneuver, their use is generally only appropriate when they can be employed for relatively long, straight runs, typically at least 1,500 feet long, where other methods would likely prove more disruptive and less economical. (In places that are less congested than Manhattan, TBMs would generally only be used for even longer lengths of tunnels than 1,500 feet.)

Both rock and soft-ground types of TBMs consist of a cutter head followed by several hundred feet of machinery; this machinery powers the cutter head, conveys the spoils, and propels the TBM forward. Figures 3-2 and 3-3 illustrate a typical boring machine and the boring process. The circular cutter head is outfitted with numerous hardened steel bits, which cut rock, soil, or mixed materials as the cutter head rotates, producing a circular tunnel. At the rear of the cutter head, hydraulic jacks exert high pressure to push the machine's cutter head against the tunnel's rock or soil face. In rock TBMs, the cutter head also sprays water to control dust generated during drilling. The cutter head moves forward in short strokes (approximately 6 feet each time); after each stroke, the rest of the machine is moved forward, braced in position by the hydraulic jacks, and the process is repeated.

Using either type of TBM, concrete tunnel liners, either pre-cast or cast in place, are then put in position to complete the tunnel. This is done immediately in a soil tunnel but may be a follow-up operation in a rock tunnel. After the concrete tunnel liner is placed, voids between the lining and the rock are sealed by injecting cement grout, under pressure, into the voids. The grout fills any voids between the tunnel lining and the excavated opening, thereby reducing the amount of settlement at or near the ground surface.

With a rock TBM, the exposed rock tunnel wall is secured directly behind the drilling head via the use of rock bolts, precast concrete, or other techniques. Soil TBMs use a shield to provide support around the excavation area. Most soil TBMs also have a means of supporting the tunnel face as well. Typically, this is accomplished by using "thrust rams" to exert physical pressure on the area requiring support. Tunnels created with slurry shield TBMs are secured by locating an enclosed pressurized compartment at the tunnel face, and then exerting pressure provided by pumping a bentonite slurry—a natural clay-like liquid material—into the area. Often, the top of the excavation chamber is also pressurized with air (an "air bubble slurry machine"). The slurry TBM constantly removes the soil and slurry mixture from the tunnel and replaces the mixture with new slurry at the tunnel face. The removed slurry is then separated from the excavated soil at a slurry plant near the tunnel alignment, and returned to the tunnel for reuse. An "Earth Pressure Balance Machine" (EPBM) TBM is similar to a slurry shield TBM, except that the pressure at the tunnel face is provided by a plug of excavated soil.

Behind the cutter face, TBMs have extended compartments or "trailing gear" that may contain computerized control rooms from which the boring operations are conducted. Behind those compartments, trailing equipment on wheels supports the drilling operations. This equipment includes pumps, transformers, and grouting equipment, as well as mechanisms for removing the excavated rock or soil and conveying it back behind the machine either by rail or conveyor.

With all these components, TBMs are very large pieces of equipment that are brought to the start of the tunnel operation and lowered into the ground in pieces, where they are assembled at the base of a shaft in a large underground chamber. TBMs excavate circular openings typically inches bigger (in diameter) than the TBMs themselves. The openings are subsequently lined or supported immediately behind the TBM, which effectively reduces the opening diameter to less than that of the TBM. Thus, the machines cannot be pulled backwards unless pieces of the machinery are disassembled and reassembled elsewhere. Generally, it is faster (and therefore more economical) to remove the machines entirely rather than attempt to reverse them or pull them back.

TBMs are powered by electricity brought to the machine from substations near or along the tunnel route. This power is supplied to a substation generally located at the ground surface by a direct feed from Consolidated Edison. This power is then fed to the TBM via transformers. The project's overall energy needs and consumption are described in Chapter 13, "Infrastructure and Energy." Overall, the total annual electrical consumption for TBMs is expected to be small (i.e., 3.7 megawatts for each TBM, and approximately 2 megawatts for machinery needed for station construction, as described in Chapter 13) compared with the city's peak load demand of approximately 11,000 megawatts.

TUNNELING MACHINE USE FOR THE SECOND AVENUE SUBWAY

For the Second Avenue Subway tunnels, various types of TBMs would allow for much of the tunneling operation to be performed well beneath the streets, with little disruption to the ground surface, and with only low-magnitude noise and vibration above ground. The TBM would be designed for the specific tunnel section in which it would operate and is generally expected to have a bore diameter of between 21 and 23½ feet, depending on the location. Generally, a TBM would be installed and driven to excavate one tunnel, and then it would be dismantled and reinstalled to drive the adjacent tunnel. The two Second Avenue Subway tunnels would typically be located within a range of 35 to 50 feet apart (centerline to centerline), so that the tunnel walls would be between approximately 10 and 25 feet apart at the closest points. A typical cross-section of the tunnels is shown in Figure 3-4.

Rock TBMs would likely be used to excavate all the tunnels between approximately 92nd Street and about 4th Street, since bedrock is relatively close to the surface in this area. Soft ground TBMs would be used on the curve between approximately 122nd Street on Second Avenue and 125th Street and Third Avenue. With selection of the Deep Chrystie Option for the tunnel alignment since the SDEIS, a TBM would also be used between the Houston Street Station and the Hanover Square tail tracks in Lower Manhattan. The TBM used for this section of the route could consist of a TBM designed to bore through both rock and soil. For the section of the tunnel between Houston Street and Maiden Lane, it would operate as a soft ground TBM. South of Maiden Lane, it would operate as a rock TBM. At the soil/rock boundary, the machine would be stopped to change operational type. A similar TBM would be used to construct the tail tracks extending from the western edge of the 125th Street Station to approximately 525 feet west of Fifth Avenue. Overall, the amount of TBM use has increased since the SDEIS. As described throughout this chapter, increased use of TBMs will result in a reduction in the amount of disruptive surface construction activities.

Because the Second Avenue Subway tunnel would mostly consist of two separate tunnels, it may be constructed using two TBMs simultaneously to expedite the construction schedule. To reduce the amount of spoils that would need to be removed in any one location, two TBMs are not expected to run parallel to each other in the same direction. This FEIS assumes that each TBM could operate in three 8-hour shifts for 24 hours each day, resulting in tunneling advances of an average rate of approximately 30 to 55 feet per day per machine, depending on ground conditions. Consequently, based on past experience, excavating one typical 250-foot-long block along Second Avenue using TBMs could take up to 10 days per tunnel bore.

To facilitate the TBM tunneling below ground, a number of excavations would be required at street level at various points along the alignment. To launch a TBM, an underground space of up to 350 feet long is generally required. These caverns would mostly be covered by removable decking, so that only relatively small areas would be open at any given time. These openings, referred to throughout this FEIS as "shaft sites" (see Figure 3-5), are needed to install the pieces of the boring machines into the ground and to remove the excavated material that would be generated as the machines progress forward. Shaft sites would also be needed to permit workers to enter and exit the tunnels, and to transport materials into and out of the tunnels. In most cases, conveyor systems or muck hoppers would be used to move materials (including excavated soil and rock) out of the shaft sites. In some cases, where space and conditions permit, enclosed vertical conveyors, hoisting systems, or unenclosed cranes and spoils buckets could be located at the shaft sites. While truck hoists were one of the options considered for use in the SDEIS, they are no longer contemplated, because their use results in slower production because of limits on the number of trucks that can access the hoist elevators. Instead, another of the options considered—acoustic barriers—would be used, as described in more detail in Chapter 12, "Noise and Vibration."

The shaft sites from which TBMs are launched would also provide numerous support services to the tunneling operation, including substations to provide electricity to power the TBM, ventilation equipment for workers in the tunnel, employee facilities, and equipment repair shops. This is described later in this chapter in Section C, "Above-Ground Construction Activities: Shaft Sites, Staging Areas, and Spoils Removal."

Tunneling operations, and the shaft sites that support them, are expected to operate for up to 24 hours each day. Depending on whether boring occurs in soft ground or hard rock, approximately 105 to 160[1] trucks, respectively, would drive to and depart from each shaft site per day to remove spoils; this assumes that spoils would only be removed from one tunnel at each shaft site at any given time. Approximately 50 trucks arriving and departing per day would also be needed

[1] The number of trucks has decreased from the number described in the SDEIS (130 to 230 round trip trucks per day) because although the SDEIS assumed construction would take 12 to 16 years, the truck estimates were conservatively developed based on a much more aggressive project construction schedule in which some tunnels were bored concurrently from the same location, whereas in the current phased schedule, tunnels would be bored sequentially. The traffic analyses conducted for the SDEIS and this FEIS use the larger number to be conservative.

at each shaft site to transport various construction materials. (A detailed description of shaft sites, including their proposed locations and accompanying staging areas, is presented later in this chapter.)

Once the tunneling machines reach the ends of their respective runs, they would need to be disassembled. This is most likely to occur at either a shaft site or station excavation area, where cranes could be used to remove pieces of the machines as they are dismantled. Once removed, the various pieces would be transported to the next TBM launch site, where they would be reassembled for continued use constructing the tunnels. In total, the disassembly and removal process would take approximately 2 months.

As described in further detail in Chapter 12, because the operation of TBMs—particularly those in rock—can result in noticeable ground-borne noise within buildings in their immediate vicinity during their operations, prior to their use in any given area, advance notice would be provided to residents, community facilities, or businesses within the vicinity.

CONVENTIONAL MINING

TYPICAL CONVENTIONAL MINING OPERATIONS

Like mechanized mining, conventional mining is conducted primarily underground, with work at the street surface only at entry and exit points for spoils and supplies, as well as for such permanent design features as station entrance and egress points, emergency egress areas, and vent shafts. Conventional mining in rock is typically accomplished by controlled drilling and blasting, which involves drilling many small holes within a rock area and then placing small amounts of explosive in each hole. Figure 3-6 is a conceptual drawing of the conventional mining process.

Drilling is usually done by drills that can be mounted together to form a "jumbo" drill rig, but can also be done individually by hand in special circumstances. Under carefully controlled and monitored conditions, explosives are then detonated sequentially, breaking the rock while spreading the release of energy from the explosives over a period of several seconds, lessening potential ground vibration and air blast effects at nearby structures. Water-gel explosives are used for drill-and-blast excavation. These explosives are very safe to handle because they are extremely insensitive to shock and virtually impossible to set off without the proper detonators and boosters—not even heat from a fire or high-velocity firearms will cause them to explode.

Hydraulic, gas, and chemical splitters can also be used as an alternative to explosives in particularly environmentally sensitive areas to minimize disruptions. However, because they are significantly slower and more expensive, these methods would only be used in isolated cases where small rocks need to be removed in sensitive areas. In extremely sensitive areas, hand mining can also be conducted, where rock and soil are removed with drills and other low impact splitting tools. Alternatively, continuous mining using roadheaders—small rotating heads attached to the ends of tractor-mounted booms—would also be considered. Roadheaders are more flexible than TBMs and can excavate profiles of almost any shape, but have limitations based on rock hardness and abrasiveness.

Mined excavations are typically supported by rock bolts and specialized steel supports, which are frequently used in combination with either or both welded steel mesh and pneumatically sprayed concrete known as "shotcrete."

CONVENTIONAL MINING FOR THE SECOND AVENUE SUBWAY

For the Second Avenue Subway, conventional mining would likely be used where use of a TBM is impractical. These areas include the following:

- The larger caverns required for certain stations and more complicated trackwork, such as connections to existing subway lines and tunnels, turn-outs, and crossovers;
- Caverns for the mined stations at 86th Street, 72nd Street, 42nd Street (including the potential 42nd Street transfer connection to the ❼), 23rd Street, 14th Street, and Hanover Square;
- The curved connections to the bellmouths allowing linkages between the Second Avenue Subway and the existing 63rd Street Line; and
- Portions of the 125th Street Station under the existing 125th Street Station on the Lexington Avenue Line.

NYCT and its engineers will continue to explore the feasibility of increasing the amount of mining that would occur at the various stations as a means of limiting construction effects at the ground surface. However, some cut-and-cover excavation (described below) would be required at every station including those identified above to create access points for elevators, escalators, and stairs.

In sections of the alignment where the controlled drill-and-blast method would be used, there would typically be two to four controlled blasting periods per day, each lasting for only a few seconds. More frequent blasting using smaller charges is also possible. Properties along the alignment in proximity to these activities would be documented and monitored before, during, and following each blasting period, and strict parameters would be established and maintained by a safety officer at all times. While controlled blasting for the underground tunnels could occur for up to 24 hours each day, blasting in vertical shafts where airborne noise from blasting would be more noticeable would not occur late at night except under extraordinary circumstances. The intervening time between the controlled blasts is required to remove debris and set up for the next blast. As with mechanized mining, some vibrations at the street surface and from inside adjacent properties may be detected due to drilling and blasting activities. The extent of vibrations would vary based on the density of the material being mined, with hard rock more efficient at transmitting vibrations than soft ground; how deep below ground the mining takes place; proximity to structures; the foundation configuration of the adjacent structures; and the response to vibration of the adjacent structures. This is analyzed in more detail in Chapter 12, "Noise and Vibration."

Other potential environmental impacts would be similar to those that would occur with mechanical mining, since like mechanized mining, conventional mining would also occur below grade and would not cause substantial disturbance to people or structures on the surface. As with mechanized mining, some settlement is likely in areas where soil is located. In addition, the use of conventional mining would still require shaft sites, where excavated materials could be removed and where workers and materials could enter and exit the tunnels. Staging areas for materials storage and other purposes would also be required; however, with conventional mining, the large excavations that would be needed to insert TBMs or EPBMs would not be necessary. Typically, with conventional mining the types of equipment that would be visible on the street surface near the shafts would include cranes, trucks, hoists, or conveyors used to bring materials into and spoils out of the tunnels; loaders; cement mix trucks; stockpiles of various supplies; and construction trailers. Sidewalk sheds and barriers would also be erected. Because spoils would be removed at a slower rate with conventional mining than with boring machines, between 60 and 80 trucks would arrive and depart on average per day to remove spoils, with an additional 25 daily truck trips needed to transport materials. This is larger than the 20 trucks per day described in the SDEIS for spoils removal from conventional mining. However, the traffic, air quality, and other analyses in the SDEIS and this FEIS were conducted for the much higher traffic volumes associated with cut-and-cover stations, so this increase does not affect the conclusions of the environmental analyses.

As with mechanized mining, the tunnel would be finished by placing concrete liners and grouting any voids behind the liners.

CUT-AND-COVER METHOD

TYPICAL CUT-AND-COVER CONSTRUCTION OPERATIONS

Cut-and-cover construction entails cutting the ground surface open and then backfilling over the surface once construction is complete. During construction, a temporary surface covering (or deck) is generally placed over portions of the cut to minimize disruption at the surface and to facilitate traffic flow. Once construction is complete, the excavation above the finished structure is backfilled, and the streets repaved and fully reopened for traffic. Because of the disruption that cut-and-cover construction can cause, it would only be used in areas where there is inadequate cover to allow safe and stable underground mining.

Most of the existing subway tunnels in New York City, including the Lexington Avenue Line (and the tunnel segments beneath Second Avenue built during the 1970s), were built using cut-and-cover construction techniques. While the cut-and-cover work for those older segments was quite disruptive, newer technology allows less disruption at the street surface from cut-and-cover work. A current, more technologically efficient example of this method in New York City is the subway rehabilitation at 53rd Street/Lexington Avenue; however, the extent of the Second Avenue Subway construction would be more extensive than the construction there.

While cut-and-cover construction can sometimes be combined with conventional mining techniques, the cut-and-cover method always requires some excavation of the tunnel and station areas from the street surface. Typically, using various methods of bracing to support the excavation sides and to limit movement of the surrounding ground, the street is excavated to a depth sufficient to allow the opening to be covered by a deck system. Once the deck is installed, portions of the streets and sidewalks can be reopened to allow limited vehicular traffic and pedestrian flow while construction continues underneath the decks. However, as for any construction below ground surface, covered cut-and-cover construction still requires continuous vehicle lane and partial sidewalk closures to permit access and egress by workers, equipment, and materials, and to accommodate spoils removal.

CUT-AND-COVER CONSTRUCTION FOR THE SECOND AVENUE SUBWAY

Substantial advances in cut-and-cover technology have occurred since the three existing tunnel segments of the Second Avenue Subway were constructed in the 1970s. For example, 30 years ago, once excavated, excavations were covered with timber, resulting in rattling every time a car passed above. Excavated areas for the Second Avenue Subway would be covered by concrete decks, which would reduce noise from traffic and muffle the noise from construction occurring beneath the decks. Another problem in the 1970s was that some nearby buildings experienced foundation problems. For the Second Avenue Subway, advanced construction techniques that would control groundwater draw-downs outside of the excavations, together with stiff watertight support walls and monitoring, would greatly reduce the effects of such construction on the surrounding structures. Before doing any construction, surveys would be conducted at all buildings along the alignment within the anticipated zone of construction influence to record the condition of these existing structures and identify potential problems. For the Second Avenue Subway project, construction monitoring plans would be developed and adhered to during construction. Afterwards, if any problems are reported, buildings would be surveyed again to determine whether any damage has been caused by construction, and to mitigate such problems if necessary. In addition, substantial community outreach would occur throughout the construction period. Recent successful cut-and-cover construction projects undertaken by NYCT include the Times Square and 53rd Street/Lexington Avenue Stations in Manhattan, and the 63rd Street Connector Project in Queens.

Overall, the amount of cut-and-cover construction planned has been reduced since publication of the SDEIS. For example, this technique would no longer be required between Park and Fifth Avenues or east of Third Avenue on 125th Street. Some cut-and-cover construction would be necessary at all 16 station locations to create entrances to the stations. In each case, station construction would be expected to affect a three- to five-block length of Second Avenue for three to five years. Within that length, the stations to be constructed in rock could be constructed partially underground, and would use mining methods to the extent practicable, so that only surface access points would require cut-and-cover work. Also, under no circumstance would the entire, several block-long excavation area be open to the air simultaneously.

Cut-and-cover technologies would also be used to construct short tunnel segments in soil, because the labor and cost associated with setting up a soft-soil mining operation would not be cost-efficient. Second Avenue Subway segments on Second Avenue from approximately 122nd Street to 120th Street (to link the existing stretch of tunnel located south of 120th Street), on Second Avenue north of the 106th Street Station to the existing tunnel at 110th Street, at stations primarily located in soil (125th Street, 116th Street, 106th Street, 96th Street, 55th Street, 34th Street, Houston Street, Grand Street, Chatham Square, and Seaport Stations) would be constructed primarily by using this method. If storage tunnels are constructed under Second Avenue north of 125th Street, cut-and-cover construction would also be required in that area.

Following is a description of a typical cut-and-cover excavation at a Second Avenue Subway station (see also Figures 3-7 and 3-8). As described below, the work consists of several sequential steps: temporary lane closures on Second Avenue and potentially some side streets; support or relocation of existing utilities; construction of retaining walls to support the excavations; pile installation in the center of Second Avenue to support decks (which could potentially be done using alternative methods to reduce construction noise); street excavation; decking; and continued construction below the deck. A similar process would be followed where the cut-and-cover technique would be required to construct tunnel segments; for those segments, the area affected would typically be shorter than for station construction.

Lane Closures on Second Avenue and Some Side Streets

The first step in cut-and-cover construction would involve closing off approximately half of the Second Avenue right-of-way in the affected area using barriers and sidewalk sheds, or street and sidewalk protection. (Second Avenue is typically 70 feet wide from curb to curb with a total of seven lanes.) At each station, two moving lanes and one parking lane of Second Avenue would typically need to be closed along a length of between three and five blocks. Such lane closures would occur in stages, alternating between the east and west sides of the avenue.

During construction, it might also be necessary to close off portions of side streets adjacent to the proposed station or tunnel areas; limited construction would occur on these side streets for retaining walls (described below), and portions of these streets might be needed to store construction materials that are trucked to the site, accommodate worker support areas, accommodate utility diversions, and other similar activities. At almost all times, traffic would be maintained on half of both Second Avenue and adjacent cross streets; however, because traffic lanes would be reduced within the construction area, vehicles—including passenger and school buses and taxis—would not be permitted to stop to pick up or discharge passengers in the construction zone. Delivery and service vehicles (such as garbage trucks) would also not be permitted to stop in this area; instead, designated delivery, pickup, and drop-off areas would be established on the nearest side streets. Traffic would be maintained in the construction zone through the implementation of curb parking prohibitions and signal timing modifications, although it would move more slowly than without construction. Some traffic diversion to parallel streets and avenues can also be expected. Cross-street traffic flows may also be restricted across the construction zone, which may limit use of these streets to local traffic only. (For more information on the effects of construction on traffic flows, see Chapter 5, "Transportation.")

In the construction zones, sidewalk widths on each side of Second Avenue would also typically be reduced from the existing 15 feet to 10 feet, with possible reductions to 5 feet at some locations. As described below in greater detail, during construction every effort would be made to maintain uninterrupted access to buildings along the alignment. Pedestrian circulation paths would typically be maintained, and temporary signage highlighting entrances to stores, businesses, or other uses would be provided. Emergency access for fire trucks and ambulances would be provided at all times.

As with the mechanized and conventional mining techniques, cut-and-cover construction would require staging areas close to the underground work areas. These would be set up within the Second Avenue right-of-way, in the area closed to traffic.

Relocation of Utilities

After closing off portions of the right-of-way, the contractor would need to relocate some utility lines (see Figure 3-9). Typically, utility work would occur one block at a time; however, it is possible that several blocks could be done simultaneously. Pavement breakers, jackhammers, or saws would be used to break through the street surface, and backhoes, dump trucks, and cable pulling trucks would be used. Typically, a utility work crew includes approximately 10 workers. In most cases, utilities would be relocated within several feet of their existing locations; however, this would not be possible in all cases because of construction or operational constraints. In such instances, utilities could be relocated to adjacent side streets.

Construction of Retaining Walls

Once the utilities in each area are relocated, construction of the retaining walls that would be needed to support the soil laterally during excavation and to prevent water from the surrounding water table from seeping into the future tunnels or stations could begin. In most locations where cut-and-cover construction is used (including at all stations), various types of retaining wall systems would be built to provide support to the sides of the excavation:

- Slurry walls—concrete walls constructed through the use of a slurry of bentonite, a natural, clay-like liquid material. As the excavation continues, using pumps, the trench would be filled with bentonite to temporarily support the sides of the excavation.
- Steel sheeting—a manufactured construction product with a mechanical connection "interlock" at both ends of the section. These mechanical connections interlock with one another to form a continuous wall of sheeting (see Figure 3-9 for a photo showing this process).
- Secant piles—individual drilled holes filled with concrete and steel, reinforced and installed adjacent to one another to form a continuous wall.
- Soldier piles and lagging—the use of piles installed at regularly spaced intervals combined with timber planks or steel sheeting.

For areas where slurry walls would be constructed, as each section (or "panel") of the construction site is excavated, a steel reinforcement cage, carefully measured to match the width and depth of the panel, would either be fabricated on the site or brought to the site in smaller sections for final assembly. Each such reinforcement cage is likely to measure between 60 and 80 feet long, though some may exceed 100 feet. Given the length of the reinforcement steel (and the fact that it would not be possible for trucks or cranes to negotiate tight corners once the cages are fully assembled), it would be necessary to construct most reinforcement cages nearby the construction sites where they would be needed; this would entail using portions of either the Second Avenue roadbed or off-street properties with significant Second Avenue frontage. Once completed, the reinforcement cages would be lowered into the clean bentonite-filled panels. The panels would then be filled with concrete, which would be poured down tubes lowered to the panels' base. The rising level of concrete in the panel would displace the bentonite, which would be pumped into a recycling facility near the site. The recycling facility would likely consist of a pump, a mixer, several silos, and a separator, known as a "desander." At the recycling facility, suspended soil and sand would be removed from the bentonite, so that the clean bentonite could be reused for another panel.

Slurry wall construction would occur in stages, working on one side of the street at a time. Slurry wall panels are constructed in a staggered configuration, so that no two adjacent panels are worked on consecutively. The concreting operation is very time sensitive, and panels have to be completed swiftly (typically within 15 hours or less). In total, it may take two to three days to complete excavation and concreting of each individual panel. The work would begin with construction of concrete guide walls adjacent to the locations where the final wall would be. These concrete walls, each measuring approximately 3 feet wide by 3 feet deep, would be installed along a portion of the sidewalk. Next, the trench for the permanent wall would be dug between these guide walls, using a clamshell shovel suspended from a crane. The trench would be excavated in 10- to 15-foot-long segments, or "panels." The soil excavated by the clamshell would be lowered directly into trucks for transport out of Manhattan. (More details on proposed spoils removal methods are presented later in this chapter.) Prior to the excavation process, utilities would be relocated as necessary to maintain service.

As each panel is completed, another would be constructed (but not immediately adjacent to the constructed segment, to allow time for the panel to harden), and this process would continue until the up to five-block length of each station area is completed. (As described in Chapter 2, each station platform itself would be approximately 615 feet, or two and a half blocks, long, but the overall station facility would be between 800 and up to 1,400[1] feet long to accommodate a variety of ancillary spaces, such as ventilation plants and power substations needed to operate the trains.) Some cut-and-cover construction areas for stations would be longer if they are adjacent to cut-and-cover tunnel segments. Work on each 10- to 15-foot panel would take about three days.

Once the slurry walls are constructed on one side of the street, steel support columns would be installed into the center of the road. These columns would eventually support the temporary road deck that would be used to carry traffic while excavation continues beneath the surface. After this column installation, slurry walls would be constructed on the opposite side of the street. Given the typical three- to five-block length of a station, it would also be necessary to build the slurry walls across the adjacent side streets. This would result in narrowing the traffic lanes on these side streets for up to several days at a time. Completing the entire slurry wall phase of the cut-and-cover operation on both sides of the street at an entire station area would take approximately one year. Construction of slurry walls is likely to occur for approximately 15 hours each day, and would require work crews of up to 50 workers at any point assuming several areas are constructed at once. Except for a few supervisors, workers would not be permitted to park at the construction sites.

During the busiest phases of slurry wall construction, approximately 100 round-trip truck trips on average per day would be needed for spoils removal. In addition, approximately 40 truck trips per day would be needed to deliver materials.

Street Excavation and Decking

Once some support walls are installed, street excavation would begin. The initial phase would involve excavating half of the right-of-way to the depth of any remaining utilities, and hanging the utilities from the future deck frame above to ensure minimal service disruptions. Subsequently, a temporary road deck would be constructed over the excavated portion of the roadbed, allowing traffic to be diverted while comparable excavation and utility rerouting occurs on the other half of the street. In all cases, the temporary road deck would be supported on the retaining walls and support columns. This deck would allow vehicles and pedestrians to continue to use the street while construction occurs below the deck. Openings in the decking would only be required for the supply and removal of labor, materials, and excavated soil or rock.

Rock or soil from the excavation site would either be loaded by cranes directly into trucks for transport off-site (see below) or be loaded into storage bins (also called silos) for temporary storage. These storage silos could be up to 40 feet tall in order to accommodate the required volume. Upon completion of all construction below the deck, a station roof would be constructed out of concrete, and the station area above the roof would be backfilled (including the area between the utilities), the temporary deck would be removed, and the roadway surface would be reconstructed. Potential street closures would be required throughout this process; the effects of these closures are discussed in Chapter 5, "Transportation."

The excavations for the station areas would affect most of the width of the generally 70-foot-wide street and portions of the sidewalk as well. To minimize disruption to traffic and pedestrians, the

[1] The SDEIS described stations that would be up to 1,000 feet long; since then, ongoing engineering refinements have increased the length of the longest stations. This does not change the overall nature of construction from what was described in the SDEIS, since the longer cut-and-cover stations (125th Street, 106th Street, and 96th Street) are within segments of tunnel that were assumed to be constructed via cut-and-cover in the SDEIS as well.

work in each segment would be done in two sections using approximately half the width of the street at a time. Each section would involve excavating soils, removing utilities, installing temporary decking in an area of approximately three to five blocks, and supporting any remaining utilities. During this process, approximately 70 to 100 trucks would arrive at and depart from the construction site each day to remove spoils, and an additional 50 trucks would arrive at and depart from the site to make deliveries. (This is a smaller number of trucks than the 200 reported in the SDEIS for spoils removal from cut-and-cover stations, because the SDEIS assumed a more aggressive construction schedule for each station.) The segments would be excavated one section at a time, with the section decked over before the next section is excavated. The decking would likely be pre-cast concrete panels with neoprene pads at all weight-bearing locations to minimize noise and vibration resulting from traffic passing over the road decking. Steel plates or timber decking may be used in certain areas where frequent access below the deck may be required; however, even these types of decks can be secured to result in less noise than that which occurred in previous generations of such construction, when decks were noisier because timber decks were used to cover excavated areas, resulting in rattling every time a car passed above.

Removal of Underground Piles in Certain Areas

As engineering for the project continues, a number of obstructions have been identified in several locations where construction would occur. These include:

- Second Avenue north of 125th Street, where old masonry remnants and piles from the Second Avenue Elevated Line ("El") are located at approximately 20-foot intervals, along both sides of Second Avenue;
- Along Houston Street near Chrystie Street, where steel piles were left beneath the surface during construction of the existing F V Lines in this area;
- Under Sara D. Roosevelt Park to the north of Delancey Street, where steel piles were left behind after the construction of the subway line linking the B D tracks in this area to the J M Z tracks (see Figure 3-10);
- At the Bowery near the planned Chatham Square Station, where steel piles as deep as 150 feet below the surface near the existing Second Avenue Subway box are located in the Manhattan Bridge approach area; and
- Beneath a 1960s-era Brooklyn Bridge traffic ramp, where several large steel piles are located.

Since it is not possible to tunnel *through* any of these pile structures, the project would either have to avoid them or remove them. As described in Chapter 2, south of Houston Street, the alignment has been adjusted somewhat to avoid as many of these structures as possible while still locating the alignment where service is intended (e.g., the Second Avenue Subway corridor). In each case, however, it would still be necessary to remove a number of these piles. Doing so would require cut-and-cover construction operations generally lasting approximately 4 to 6 months, although at the Brooklyn Bridge viaduct area, the duration would be 6 to 9 months because underpinning would also be needed (see below). Since most of these piles were not recorded during these earlier construction efforts, project engineers will not be able to determine the precise extent of the construction until the work actually commences.

The masonry remnants and piles north of 125th Street would only have to be removed if the 129th Street underground storage yard were to be constructed. In this case, too, cut-and-cover construction would be required.

USE OF EXISTING TUNNELS

As mentioned earlier, three tunnel segments were constructed in the 1970s for the Second Avenue Subway. Those segments were constructed using that generation of cut-and-cover technology, and are close to the street surface. The proposed Second Avenue Subway would make use of these tunnel segments. In East Harlem, work in the existing tunnel segments would be conducted from the cut-and-cover portions to their north and south, but some limited excavation could also be required to allow repositioning of tunnel deck supports. In addition, the 116th Street Station would be created within an existing tunnel segment, which would necessitate demolition and reconstruction within that area of the tunnel, some cut-and-cover construction for the station's entrances, and cut-and-cover removal and replacement of the tunnel's roof. In Chinatown, with the Modified Deep Chrystie Alignment, it would not be possible to use the existing length of tunnel near Chatham Square for the subway operation because of the shift in the horizontal and vertical alignment. The existing tunnel segment could instead be used for ancillary facilities, such as a power substation or ventilation facility, adjacent to (and higher than) the subway tunnel.

PROTECTIVE MEASURES FOR EXISTING STRUCTURES

The Second Avenue Subway alignment and stations have been planned to avoid construction beneath existing buildings and other structures wherever possible. However, there are a few areas where this cannot be avoided. In addition, in some other areas, existing structures would be very close to excavation sites or the tunnels' alignment. In these and certain other cases, a variety of measures, including underpinning, grouting, and building external support frames, would be used to protect nearby structures during and following construction.

While many protective technologies exist, all of these methods can themselves produce varying degrees of construction disturbance. The choice of which method(s) to use depends on a number of factors, including:

- Proximity of the building to the construction excavation;
- Soil conditions;
- Groundwater conditions and control techniques;
- Foundation types and conditions of existing structures;
- Type of structure used;
- Type of tunnel method used;
- Loads carried by the existing structure;
- Dimensions of excavation;
- Sequence of construction operations; and
- Rock quality.

In most cases, it will not be possible to determine which support measures would be needed until structural surveys and soil borings are completed in areas where protective measures may be required.

Following is a brief summary of the types of protective methods that could be employed along the alignment.

TYPES OF PROTECTIVE MEASURES

Ground Improvement

In isolated cases where the project would require construction in soil beneath existing structures (such as the curve at 125th Street), one type of protective measure that may be employed is ground improvement by "grouting." The purpose of a grouting operation would be to increase the strength and decrease the permeability of the soil near tunnels, stations, buildings, or utilities. These techniques have many uses, among them, allowing TBMs to bore through limited areas without suitable rock, and supporting building foundations during construction.

Several types of grouting exist, and include:

- Compensation grouting—With compensation grouting, grout is injected between the tunnel excavation and overlying structure. This operation is performed continuously and concurrently with excavation in order to compensate for any settlement that may occur. In order to conduct this operation, an excavation pit must be created for access. Often, this pit is located in a building's basement. Grouting operations of this nature can sometimes themselves cause settlement (see below).
- Local grouting—With this method, grouting is more localized, and is limited to activity in a building's basement. Work of this sort can be difficult to perform, because of the limited headroom. In addition, during the grouting operation, there would be restricted use of the basement space.
- Jet grouting—This method involves injecting a jet of cement grout at high pressure through rotating nozzles into the zone of soil that requires improvement. The cement grout mixes with the native soil to create a form of weak concrete above the roof of the intended excavation area. The grout is injected from street level through small-diameter (approximately 4-inch) holes drilled using 50-foot-tall hydraulic drill rigs. About three of these rigs would likely be required in each area requiring ground improvement treatment. As each hole is completed, the rig would be moved, and work would commence on another drill hole; over a one-block length, up to approximately 2,000 grout injections could be required.

Other Protective Measures

Among the other types of supportive measures that could also be employed at places like the 125th Street curve are the following:

- Star Bolts—Star bolts are a means of tying a building's façade to its frame. To employ star bolts to secure an above-ground structure, the building would first have to be evacuated. The buildings' interiors would have to be rebuilt, and permanent impacts to the buildings' facades would be created.
- External Support Frames—External building frames can be erected around a building's façade. While no interior alterations are required, external frames can also leave a permanent imprint on a building's façade. While the frames are removed following construction, during their use, they are unavoidably unattractive, as they obscure much of a building's façade.
- Groundwater Recharge—In circumstances where it is judged that there may be an unacceptable risk of lowering the groundwater table, which could negatively affect existing structures, wells may be installed and water pumped into the ground to maintain the groundwater table at an acceptable level.

Underpinning Nearby Structures

Finally, where other measures would not provide enough protection, a technique called "underpinning" could also be employed. Underpinning is a common construction technique that involves supporting the foundations of an existing building, to protect the building once work begins in the soil near that foundation. It is a method of construction that permanently extends the foundations of a structure adjacent to a construction activity site—in this case, the Second Avenue Subway alignment—to an appropriate lower soil level or stratum beyond the range of influence of the construction activity. The purpose of underpinning is to protect structures adjacent to construction areas from major settlement or lateral movement.

Underpinning work would typically be constructed from the street surface in front of an affected building or within the basements of affected buildings. The work would require construction directly in front of buildings or within basements, but in most cases, a building could remain occupied while the work was underway. In some cases, construction access could be required above the underpinning area from a higher floor of the building.

Underpinning would typically begin with excavation of a deep trench in front of an affected building. From that trench, pits would be excavated, by hand, below existing building foundations. The pits would then be filled with concrete, in effect creating a new support for the building's foundation. With the new supports in place, the structure's load would no longer be affected by the area of soil to be excavated for the subway.

Piling can also be used as an alternative form of underpinning. Small diameter piles are installed on either side of the building foundation and then connected by needle beams. These transfer the building loads to the piles from the existing foundation. Still another technique—"needle beams and jacking"—could be used in extreme circumstances, as it involves building a complex external support system.

In areas where underpinning is required, backhoes and cranes would be used to move materials to and from the excavation sites, and to place bracing along the sides. In locations where the crane would be required to swing over the sidewalk, sidewalk sheds would be installed to protect pedestrians. Figure 3-11 illustrates the general steps involved in underpinning.

SETTLEMENT AND OTHER POSSIBLE EFFECTS

Even with the measures identified above, some movement or settlement could occur. Acceptable limits of movement would be determined before construction for each building; these would be determined based on the foundation design, construction method, and functionality of each building. Just before construction, baseline surveys and visual inspections and photographic documentation would be completed for buildings that are directly adjacent to the alignment to establish and document the pre-construction condition. During construction, a geotechnical instrumentation program would be used to monitor the performance of braced excavations, tunneling operations, and the identified critical structures; this program would be conducted for the entire alignment during construction.

During these activities, every effort would be made to maintain uninterrupted access to buildings along the alignment during construction. However, though emergency access for fire trucks and ambulances would be provided at all times, in certain areas, it may not be possible to maintain continuous access to all buildings. The locations and extent of disruptions are described later in this chapter. See also Chapter 8, "Displacement and Relocation."

POSSIBLE LOCATIONS WHERE PROTECTIVE MEASURES WOULD BE REQUIRED

The specific locations where protective measures would be required along the Second Avenue Subway alignment have not yet been determined. Borings and detailed building and utilities surveys are being conducted as part of the ongoing engineering effort to help make these determinations. Generally, however, supportive measures would not be required where tunnels would be constructed entirely in rock using a TBM. General areas where the protective techniques identified above may be required include the following:

- Entrance, egress, and ventilation points for each station;
- Alongside any area constructed by cut-and-cover construction;
- Locations where the Second Avenue Subway would be constructed near existing transit structures, particularly in the Lexington Avenue 125th Street Station and Chrystie/Grand Streets areas;
- The Metro-North Railroad viaduct at Park Avenue and 125th Street;
- Portions of the alignment along 125th Street between Fifth and Second Avenues;
- The curve connecting 125th Street with Second Avenue and between Hester and Canal Streets, where the alignment would be partially beneath existing buildings;
- The 63rd Street curved connection tunnels near the existing bellmouths;
- Portions of the alignment between Fulton and Wall Streets; and
- Potentially beneath utilities at all cut-and-cover construction areas (alternatively, utilities could be relocated).

GROUND IMPROVEMENT MEASURES EMPLOYED TO FACILITATE USE OF TBMS

As mentioned above, TBMs are designed to excavate tunnels in hard rock. While most of the Second Avenue Subway route between approximately 92nd and 4th Streets would be entirely within very hard Manhattan bedrock, several locations along this segment of the route have conditions where the bedrock cover may not be thick enough for a stable tunnel roof or to control groundwater inflow during construction. In these areas, the tunnel must either be routed to improve the expected excavation conditions by lowering the vertical alignment of the tunnel (in other words, by making the tunnel and adjacent station deeper), or the strength of the ground must be improved through ground improvement techniques.

There are many types of ground improvement techniques, but most involve grouting (see the description above under the section entitled “Ground Improvement”). Jet grouting in particular may be used for portions of the Second Avenue Subway tunnels. As described above, this method requires injecting cement into soil at high pressure using rigs. Near the rigs, a staging area would support the ground improvement operation. Facilities at this area would include a batch plant to mix and pump the cement grout mixture. The batch plant would measure about 100 feet by 40 feet, and could be located up to 200 feet away from the area being treated. This operation could therefore be located on an adjacent property or in the nearby Second Avenue right-of-way. The plant would require a variety of equipment, including a cement silo, tanks for storing liquid, a mixing plant, and a pump house. An air compressor may also be required for each drilling rig to increase the effectiveness of the grout penetration. Some of this equipment could increase local noise levels; please see Chapter 12, “Noise and Vibration,” for more information.

The jet grouting operation would be undertaken within approximately half the width of Second Avenue at a time, requiring partial road closures, partial sidewalk closures, and some traffic diversions. Some operations might also take place on portions of side streets adjacent to Second Avenue. The time required to complete the work would depend on the extent of the area to be treated and the number of rigs used. Typically, it would take about 7 to 10 months to complete one block; however, multiple blocks could potentially be worked on simultaneously.

As with other construction techniques, continuous monitoring would occur during this process to limit the potential for damage to building foundations and underground utilities, and sewer and water main pipes during the ground improvement process. As a general rule, most of the grouting would occur well beneath these structures, so there is minimal risk of inadvertent damage.

At present, based on the geological data currently available, four areas have been identified where ground improvement appears necessary: along the curve in the alignment between Second Avenue and 125th Street, between 65th and 62nd Streets, between Hester and Pell Streets, and between Maiden Lane and John Street. (These areas have shifted from the areas identified in the SDEIS for such treatment.) However, more locations could be identified in the future as engineering continues. At these locations, the bedrock profile appears to dip beneath the proposed tunnel alignment. Since rock TBMs cannot dig through soil, some type of ground improvement work could be required to allow this type of TBM to continue through these areas without changing the TBM's cutter head. Ground improvement measures may also be used at the junction points between tunnels in soft ground and the station structure to form a block of improved ground adjacent to the station. This would facilitate the entry and exit of the TBM from the station area.

DEWATERING

Because a substantial amount of construction for the Second Avenue Subway would occur beneath the water table, water would have to be removed from excavation areas during construction. This process, "dewatering," would be needed in the cut-and-cover areas, shafts, and at station locations throughout the subway's construction. In these locations, the installation of slurry walls (described above) is intended to cut off the flow of groundwater into the excavation and minimize the need for dewatering. Some dewatering would likely also be needed in rock areas, since groundwater can seep through fractures in the rock. The purpose of dewatering is to maintain dry working conditions during construction. Possible methods of dewatering include pumps, wells, and sumps (submersed pumps). In circumstances where it is determined that there may be an unacceptable risk of lowering the groundwater table, wells may be installed and water pumped into the ground to maintain the groundwater table at an acceptable level. Dewatering typically occurs when an area is being excavated; the retaining walls or tunnel liners provide a watertight seal, so that no further dewatering is necessary once excavation is complete.

Prior to excavation, watertight cut-off barriers would be installed to minimize the potential for lowering groundwater in adjacent areas. As water is pumped from the excavation area, sediments are separated from water, and the water is then pumped into the existing sewer system with prior approval from the New York City Department of Environmental Protection (NYCDEP). (Chapter 14 describes the measures to be taken to avoid pumping contaminants into the sewer system.) If very large volumes are pumped from a particular excavation area and the water there meets water quality standards, it can be pumped directly into the nearest surface water body with an appropriate permit. While dewatering equipment would not be very noticeable from above-ground, special care would be taken during the dewatering process to protect against settlement of adjacent structures and to avoid lowering the water table excessively. As described in Chapter 4, "Public Outreach and Review Process," a number of permits and approvals will be required prior to pumping water into the sewer system or directly into the river.

CONSTRUCTION IN VICINITY OF EXISTING TRANSIT FACILITIES

The construction activities discussed above have the potential to affect 13 existing subway lines and two commuter rail lines where the new tunnels pass under or over existing transit structures. In addition, additional or new escalators, stairways, elevators and underground passageways might be necessary at some existing stations in order to make them accessible to the new Second Avenue Subway.

Several factors would determine whether it would be necessary to protect these existing subway or rail structures before Second Avenue Subway tunnel or station excavation. These factors include geological conditions, the vertical and horizontal separation between the rail lines, and whether the Second Avenue Subway would pass over or under an existing subway or commuter line.

In general, if the new Second Avenue Subway tunnel were to be excavated in rock, it would have less impact on each rail service it crosses than if it were excavated in soil. Similarly, if the new tunnel were to pass above the existing transit or rail structure, it would have less impact than if it were to pass below the existing structure. Please see Chapter 5, "Transportation," for a description of how the Second Avenue Subway would interface with existing transit facilities.

Generally, as much of this construction as possible would occur when stations and commuter rail facilities are least busy—e.g., on weeknights and weekends. In some cases, service might need to be rerouted from the local to express tracks and vice versa.

RODENT CONTROL

Construction contracts would include provisions for a rodent (mouse and rat) control program. Before the start of construction, the contractor would survey and bait the appropriate areas and provide for proper site sanitation. During the construction phase, as necessary, the contractor would carry out a maintenance program. Coordination would be maintained with appropriate public agencies. Only U.S. Environmental Protection Agency and New York State Department of Environmental Conservation (NYSDEC)-registered rodenticides would be permitted, and the contractor would be required to perform rodent control programs in a manner that avoids hazards to persons, domestic animals, and non-target wildlife.

STATION FINISHES

Following the excavation phase, the amount of construction activity that would occur above-ground would be substantially reduced. Although it would still be necessary to bring materials such as rails, precast liners, structural steel, and mechanical and electrical equipment to each station construction site, and to insert these supplies into the ground through shafts, the number of round-trip truck trips that could be needed is approximately 30 per day. Nevertheless, staging areas near the underground sites would still be needed to accommodate stock piles and the materials delivery trucks. Once the station work is complete, permanent decking would be placed above the station to support the permanent roadway.

C. ABOVE-GROUND CONSTRUCTION ACTIVITIES: SHAFT SITES, STAGING AREAS, AND SPOILS REMOVAL

Regardless of which mining method is used to construct the Second Avenue Subway stations and tunnels, it will be necessary to transport the excavated rock and soil by truck or some other method out of Manhattan. It will also be necessary to deliver a wide variety of materials into the underground tunnels. Excavation and materials delivery could not begin until the "shaft sites"—or the areas where the spoils would be removed, and where workers and construction materials would enter and leave the tunnel—are established. In addition, near the shaft sites and at each station location, various staging areas would need to be set up where construction machinery and other equipment and materials would be delivered, stored, and operated. Operating the shaft sites and staging areas and removing the spoils would involve complex activities that together could cause some of the more noticeable disturbances to the surrounding community during the Second Avenue Subway's construction. At each shaft site and staging area, conveyors, trucks, substations, exhaust fans, sidewalk sheds, construction fencing, traffic lane closures, and other similar equipment are likely to result in noise, air quality, traffic, and aesthetic effects on their surroundings. In locations where slurry TBMs would be used, a slurry processing plant would also be required to separate and then recycle the slurry. While some of these disruptions and impacts could be mitigated using techniques described in the subsequent analysis chapters, in certain areas, the temporary impacts that would be created during the construction period would be significant, and would not lessen until completion of the construction activities in these areas. To the extent practicable, it would be desirable to locate the most disruptive equipment away from occupied buildings and sensitive uses (such as hospitals and parks), but as described below, given Manhattan's extreme density, few such sites have been identified along the alignment. This section describes the types, scale, and duration of the activities that would typically take place at various construction locations along the subway corridor. It also identifies the locations being considered as staging areas and shaft sites for the various tunnel construction options, and identifies those non-road sites under consideration as potential construction staging areas.

REQUIREMENTS FOR SHAFT SITES AND STAGING AREAS

Shaft sites and their associated staging areas would serve various purposes. Depending on the site, they could be used to:

- Insert and remove the TBMs at the beginning and possibly ends of the tunnel segments where rock and soil conditions change;
- Remove soil and rock being excavated from the tunnels;
- Store materials needed for tunnel construction;
- Provide ventilation to the workers in the tunnels below;
- Enable tunneling workers to get in and out of the tunnels;
- Provide power to TBM and other operations via electrical service equipment or substations; and
- Serve as permanent locations for such ancillary facilities as power substations and vent facilities, which would be constructed during the station construction process.

In addition, as described in Section B ("Overview of Construction Methods") above, staging areas would also be needed at other locations along the alignment—for example, at each station location—to accommodate a variety of other essential functions, including the retaining wall operations, required maintenance, truck loading and unloading, and rebar cage fabrication.

The size and location requirements for each of the activities above would vary. The general size, location, and operational requirements for the shaft sites and their staging areas are discussed below.

SHAFT SITES AND STAGING AREAS FOR ASSEMBLING, INSERTING, AND REMOVING MECHANIZED BORING MACHINES

Shaft sites that would be used for inserting or removing each TBM should be located within or immediately adjacent to the alignment (to avoid any unnecessary excavation between the shaft site and Second Avenue). They should also be sited as close as possible to the beginning of each tunnel segment (in other words, to the areas where the rock and soil meet) to allow the TBM to move from one end of the planned tunnel to the other without reversing direction, since these machines need to be dismantled and reassembled to be turned around. Consequently, shaft sites would be needed close to 125th Street east and west of the new 125th Street Station to launch and retrieve TBMs needed to construct the 125th Street tail tracks and the 125th Street curve;[1] 92nd Street, where the rock is at an appropriate level to launch a TBM headed south; 66th Street in the vicinity of the 63rd Street connector tunnels, where a TBM removal shaft may be required;[2] 34th Street to launch and retrieve a TBM, where the tunnel elevation needs to be shallow to avoid the existing Amtrak tunnels, resulting in a required cut-and-cover excavation at this location in any case; the Houston Street vicinity, where the rock transitions to soil; at Water Street and Coenties Slip (near Wall Street) in Lower Manhattan, where a TBM could be launched heading north; and potentially on Water Street at approximately Whitehall Street to facilitate construction of the Hanover tail tracks. In all cases, shafts sites for launching mechanized boring machines are proposed in areas where stations would be located, and that would consequently require cut-and-cover construction under any case. Therefore, while the duration of the disturbances would be longer at shaft sites, the actual construction activities would be comparable to those at station areas along the entire alignment.

In soil, to assemble each boring machine, a shaft measuring up to approximately 350 feet long would need to be constructed from the surface to the eventual tunnel depth. In rock, a 30-foot by 30-foot shaft at the surface would be built, and a cavern about 350 feet long would be excavated by underground mining at the bottom of the shaft. The TBM would be inserted through openings in the deck panels covering this area. As each section of the shaft is completed, it would be

[1] No TBM shaft sites were identified in the SDEIS in the vicinity of 125th Street for either the 125th Street tail tracks or the 125th Street curve. At the time the SDEIS was prepared, it was anticipated that the 125th Street tail tracks would be constructed using cut-and-cover techniques, and that the 125th Street curve would be built using conventional mining. In an effort to reduce the extent of construction disruption at these locations, further engineering studies were conducted, and it was determined that TBMs could be used instead. Accordingly, launch and retrieval sites for these machines have now been identified. The TBM launch site for the 125th Street curve work would be located at Third Avenue and 125th Street, where a crossover is planned.

[2] As described below in the discussion of the proposed construction phasing plan, it will be necessary to remove the TBM that will be used to bore the tunnels between approximately 92nd and 62nd Streets somewhere near the southernmost point of Phase 1. The most likely locations are on 66th Street near Second Avenue and at the 72nd Street Station (either 72nd or 69th Street), where cut-and-cover shafts would be needed in any case to build this station.

decked over so that most of the surface area would be covered by temporary panels. Once a large enough initial tunnel section has been mined below the deck, pieces of the TBMs would be brought to the shaft sites on flatbed trailers. Often, oversized, overweight, or wide-load trucks would arrive during off-peak hours to minimize disruptions to traffic in the surrounding areas. Otherwise, the loads would be delivered during regular working hours. Appropriately sized portions of the TBM would then be assembled prior to their installation into the tunnel through openings in the deck panels. Cranes would then be used to lower the pieces of the TBM into the launch site. This would occur through one or more street-level openings into the shaft.

In addition, equipment storage and construction activities at each shaft site would require that a staging area with a minimum of 40,000 square feet surface area (and a preferred 50,000 to 80,000 square feet) abut each shaft site. The minimum of 40,000 square feet is the equivalent of approximately half the width of Second Avenue for approximately four blocks. Ideally, each staging site would measure about 200 feet by 200 feet; however, given the approximate 100-foot width of Second Avenue from building line to building line and the density of development along the avenue, sites with those dimensions would be difficult to find, even if adjacent off-street properties are identified for use in combination with portions of the street right-of-way. Consequently, if a 200-foot-wide site cannot be identified, it would be necessary to extend the shaft site and accompanying staging area's length along the Second Avenue right-of-way to set aside the necessary total minimum square footage. The duration would depend on the construction sequencing method selected, but could last for up to 8 years in a few locations, as described below.

Shaft sites for insertion of the boring machines could be used only for that purpose, and then closed, or they could be used for removing excavated materials from the tunnels once tunneling begins.

SHAFT SITES AND STAGING AREAS FOR REMOVING SPOILS FROM BORED TUNNELS

When excavation begins, rock and soil must be taken from the tunnel to the surface at a shaft site. At the start of the work, those materials must be removed from the shaft where the work began. Later, other sites can be used to remove materials, as described below.

At the start of construction, shaft sites and associated staging areas for removing spoils must be located near every location where boring machines would be inserted. As discussed above, this would occur where geological conditions and the length of the tunnel segment to be bored are appropriate for starting mechanized tunnel excavation. This would enable each shaft site to be used as productively as possible over a long period, which would both save time and be cost-effective.

Additional shaft sites and related staging areas could also be used along the alignment. The chief advantage of using multiple shaft sites is that the subway could be completed more quickly. Other advantages of using these extra shaft sites include minimizing the distance necessary to move spoils underground between the excavation and the spoils removal sites; shortening the time each shaft site would need to be used; distributing the truck movements and construction activities required to build the subway over a greater number of locations; and allowing station construction to occur sooner in areas where the tunnels are already excavated. (Station construction takes longer than tunnel mining, and except for construction of the structural shell, it cannot start until the tunnel is no longer in use for conveying spoils from behind the TBM operations.) However, multiple shaft sites also could increase costs, due to the cost of setting up each shaft site, or create additional disruptions from construction in certain areas.

In addition to being located along the alignment, the shaft sites must be located directly over the tunnel alignment. Shaft sites for spoils removal would ideally be located near entry points to New York City's highway system, to allow quick access to and egress from Manhattan; this would expedite the movement of spoils out of Manhattan with fewer traffic conflicts and fewer impacts on nearby communities. Alternatively, shaft sites could be located near the East River to allow barges to be used.[1] The sites should also be located adjacent to the Second Avenue Subway alignment and oriented to allow efficient handling of spoils and construction materials, because inefficient handling can result in increases to the project cost. In addition, potential sites for removal of excavated material would in many locations be best situated on the east side of Second Avenue, since this would simplify truck movements needed to access the highway network, which is generally to the east of the avenue. In addition, locating spoils removal and staging areas on the east side of Second Avenue would also be more efficient for bus movements on Second Avenue, since the design of NYCT's buses—with doors opposite the driver's side of the bus—means that southbound Second Avenue buses must pull over to the right (the west side of the avenue) to pick up and discharge passengers. Finally, it would also be most effective if the shafts used to insert and remove boring machines could also be used to remove spoils.

As with shaft sites used for inserting boring machines, shaft sites for spoils removal and their staging areas must be a minimum of 40,000 square feet. Again, if a large enough area cannot be identified adjacent to the tunnel alignment or station location, it would be necessary to make up the difference by temporarily closing some traffic lanes within the Second Avenue right-of-way and using adjacent side streets.

Depending on how construction is staged, there could be multiple spoils removal sites operating either simultaneously or separately for different periods of time.

STAGING AREAS AND SHAFT SITES AT STATION LOCATIONS

At each station, all spoils for that station would have to be removed from shafts created during the station's cut-and-cover construction process. Consequently, much of the same equipment that would be needed at the shaft sites for tunneling operations would also be needed at each station site, including silos or storage bins for spoils, cranes, and other equipment. Two shafts—one each near the limits of the station box—would be required for all stations. While the shafts themselves would typically measure approximately 30 feet by 30 feet, laydown and spoils removal facilities (such as hoppers) would occupy a larger area on the street surface. Together, the shaft, laydown area, and spoils removal facilities are expected to be located across half the width of Second Avenue, and would extend for one block beyond the station's limits. If off-street areas can be identified for staging activities, it is possible that less space on Second Avenue would be required, depending on the size of the off-street space. Moveable construction fences mounted on jersey barriers would separate the construction activity from traffic and pedestrians. To minimize surface excavation and disruption, shafts required for stations may also be used for tunnel excavation as well.

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[1] As described elsewhere in this document, the barge operation at 129th Street and the Harlem River assessed in the SDEIS is no longer under consideration because the New York City Department of Transportation (NYCDOT) has stated that the site would not be available for the project's use. No other viable barge sites have been identified along the alignment other than the Pier 6 barge site described below. Should NYCDOT's plans change in the future and the 129th Street (or other) barge site become available, supplemental environmental review would be conducted prior to any use of the site by NYCT.

As described above, slurry walls would need to be built at most cut-and-cover station areas to support the excavation process. In order to build these slurry walls, a slurry plant would be required in the vicinity of cut-and-cover stations, as slurry cannot be effectively pumped for distances over approximately 700 feet. Each slurry plant would occupy approximately 15,000 square feet (in addition to the area where the actual construction is occurring), and would include a variety of equipment, including the rebar cage fabrication operation, a bentonite silo, desanding units and centrifuge, recirculation tanks, and settlement tanks, cranes, an air compressor plant, an electrical generator, storage containers for tools, and a laydown area for piles measuring approximately 100 feet long. If a large enough area cannot be identified adjacent to the station location, it would again be necessary to make up the difference by temporarily closing some traffic lanes within the Second Avenue right-of-way and using adjacent side streets. Staging areas would also be needed to store equipment and supplies needed to construct the other retaining wall options discussed above. Some such storage areas could be located at a greater distance from the alignment than with slurry wall staging areas.

SPOILS REMOVAL AND SUPPLY DELIVERY OPERATIONS

As detailed above, creating the Second Avenue Subway tunnels, stations, and other underground spaces would result in a large volume of excavated materials that would need to be removed to an off-site location. This process is referred to as “spoils removal.”

A total of nearly 6.3 million loose cubic yards of spoils would be excavated along the alignment. This is a substantial increase from the 3 million cubic yards estimated in the SDEIS. Of this amount, about 2.4 million cubic yards would come from tunnels and associated launch sites, with the remaining 3.9 million cubic yards coming from stations. The reasons for this increase are: 1) because the diameter of each tunnel has increased by 1½ feet along much of the 8½-mile alignment; 2) because a larger average volume needs to be removed at stations than was assumed in the SDEIS; and 3) because a larger percentage of train storage space will be located underground, requiring additional tunnel areas.

Despite this increase in the overall amount of spoils that would need to be removed throughout the project’s construction period, construction impacts from trucking and other operations would not be more intense than those identified in the SDEIS. The SDEIS included conservative assumptions about construction duration at tunnel shaft sites. It also used conservative assumptions about the number of trucks that would be required daily at each construction activity site to remove spoils (and all stations were assumed to be constructed via cut-and-cover). Consequently, the new trucking numbers and durations are within the ranges included in the SDEIS to conduct traffic, air quality, and other analyses. While the number of truck trips that would be generated project-wide would increase, the daily volumes at any spoil removal site would not increase beyond volumes assessed in the SDEIS. Therefore, construction impacts from trucking and other operations would not be more intense than those identified in the SDEIS. However, the overall duration of the activities in each location would increase.

The amount of spoils that would be excavated from the various project components would vary according to the type and amount of construction required. The greatest amount of spoils that would need to be removed from any one station would be from the 125th Street Station area, where approximately 460,000 cubic yards of loose fill would be excavated. At this station, excavation would occur for the deep multilevel terminal station, which would pass below the Lexington Avenue 125th Street ❹❺❻ Station. Spoils would also be removed at this station from the TBM operations used to create tunnels on 125th Street. Other stations where the amount of spoils to be removed are also relatively high include the 55th Street Station (415,000 cubic yards of loose fill), 72nd Street Station (382,000 cubic yards of loose fill), Grand Street Station (344,000 cubic yards of loose fill), and Hanover Square Station (320,000 cubic yards of loose fill).

The least amount at any station would be from the 116th Street Station, which is in an area where tunnels have already been constructed, where only about 9,500 cubic yards of loose spoils would need to be removed, but this is an exception. At a typical station, approximately 200,000 cubic yards of loose fill would be removed.

For tunnels, the amount of spoils to be removed at any section of the tunnel would be constant, because the tunnels' dimensions would be constant. However, as described below, spoils removal sites for the tunnels themselves would only be located in several places along the alignment. Therefore, while the typical daily volumes removed from tunnel shaft sites would be the same, the total amount of spoils that would be removed in any one place would depend on the length of alignment being excavated by a particular TBM. At present, it is anticipated that the longest TBM run would be conducted in the area between 62nd Street and 4th Street.

In addition to removing spoils from the tunnels, it would also be necessary to bring a large quantity of a wide range of supplies and materials to the various shaft sites throughout the project's duration. Ultimately, precast concrete tunnel liners, tracks, rail, structural steel beams and columns, internal cladding, station tiles, plumbing and lighting fixtures, pipes, electrical equipment, vents, and other items needed to complete the tunnels or stations would be transported to each shaft and station site.

In addition, each shaft site must have a staging area to house the facilities necessary to support the tunneling below ground. Equipment to be located at the staging area includes electrical service equipment or a substation to provide power to the TBM operations below ground; generators, silos or storage bins; a maintenance shop for tools and machinery; facilities for workers to change and shower; compressors and water treatment areas; and ventilation equipment for the tunnels. If a slurry TBM is used, a slurry plant would also be required. The specific use of different shaft sites is described in more detail later in this chapter under the heading, "Description of Most Viable Tunnel Shaft and Staging Sites."

Even though the tunnel and station construction can be staged to minimize the impacts of the spoils removal and materials delivery on Manhattan streets, these processes would generally be disruptive, since supplies and excavated rock and soil would need to be transported on a continuous basis until construction operations are complete.

Because a large volume of trucks would arrive and depart from certain shaft sites each day, removing spoils from Manhattan by barge was seriously considered as a way to minimize disruption to the surrounding communities where shaft sites may need to be constructed. As described below, however, the use of barge sites is impractical unless 1) trucks can easily reach the river; 2) a large staging area can be located at the barge removal sites; and 3) the barge operations would not conflict with other waterborne uses in the river. Therefore, except for the tunnel areas south of Houston Street, transport of equipment and spoils in and out of Manhattan would occur by truck, directly to and from each work site.

All spoils removed from stations would be trucked away from the construction site. For tunnels, spoils would be removed using one of three ways: they could be shuttled by truck between the construction site and barge site; they could be trucked without the use of barges; or they could be shuttled underground between the construction and barge sites.

In addition, options for transferring spoils by rail through the 63rd Street Tunnel under the East River, perhaps in coordination with the MTA's LIRR East Side Access Project, were explored. However, these options would not be feasible because of the conflict with operating rapid transit service on the upper level of the 63rd Street Tunnel and with construction activities for the East Side Access Project on the lower level.

However, before a final decision is made on whether to use trucks or barges for spoils removal, such other factors as the number of times the spoils would need to be handled before reaching their final destination; the distance between the off-loading site for the barge and the final location of the spoils; the potential environmental benefits and disadvantages of each method; and the potential risk to the overall project schedule related to the need to secure permits for barging operations must be considered, as discussed below.

SPOILS REMOVAL AND SUPPLY DELIVERY BY TRUCK

Truck Loading

Most materials that would exit or enter a tunnel or station would likely be moved by crane or vertical conveyor to and from the street. This could occur for up to 24 hours each day. In most cases, spoils would be removed and loaded directly onto trucks. However, in some cases, spoils could also be loaded into containers while still underground; these containers could be stored below ground at night to avoid disrupting the surrounding communities overnight, or they could be stored above-ground for subsequent transfer to trucks. Alternatively, truck loading could theoretically occur below-ground, with trucks lowered into the tunnel by a truck hoist, but doing so would severely limit the productivity of the tunneling operation, substantially lengthening the overall duration of the work in each excavation area and increasing the time during which any particular neighborhood would be disturbed by construction activities. Consequently, below-ground loading is not contemplated for the Second Avenue Subway project.

At any given point, there would likely be a queue of trucks at the shaft sites for loading of spoils and unloading of construction materials, such as tunnel liners. This queue would be formed in a location designated for the purpose, to minimize the impact on other traffic in the construction area.

In general, the machinery that would be used to move spoils above-ground is typical of that found at other construction sites, and would include cranes ranging in size up to 150 feet tall, as well as vertical conveyors averaging about 20 feet tall to permit 14½-foot-tall trucks to load. If a storage hopper is used to store spoils before loading the trucks, the vertical conveyor could be 5 to 10 feet higher. To control dust and noise, the conveyors and hopper would be covered, the hopper could be lined with rubber, and the trucks could be enclosed; nevertheless, loading and unloading rock and other materials into trucks would be noisy.

Summary of Truck Volumes

Excavation of the Second Avenue Subway tunnels alone would require more than 200,000 truck trips entering and leaving Manhattan over the course of the project;[1] this number has doubled since the SDEIS was published. During the tunnel/station excavation phase, trucks would haul

[1] Throughout this FEIS, it has been conservatively assumed that 10-cubic-yard trucks would be used to transport spoils and the various construction materials. If larger capacity trucks were used instead, the number of truck trips would decrease substantially.

spoils from the station sites and shafts and deliver materials to these sites. Trucks would also bring supplies and other deliveries to the construction sites, including tunnel lining and other construction materials and equipment (i.e., structural steel, roadway deck panels, rock anchors, etc.). The approximate number of round-trip truck trips required at each type of construction site during peak period construction periods for the various activities would be as follows:

- Slurry wall construction—Total of 140, with 100 trucks entering and exiting the site per day on average to remove spoils and an additional 40 trucks per day bringing deliveries.
- Cut-and-cover station excavation—Total of 120 to 150, with 70 to 100 trucks entering and exiting the site per day on average for spoils removal (vs. 200 identified in the SDEIS) and another 50 trucks entering and exiting for deliveries. Once excavation is complete, the number would drop to about 30 trucks arriving and departing at the site to bring deliveries.
- Mined station excavation—Total of 85 to 105, with 60 to 80 trucks entering and exiting the site per day on average for spoils removal (instead of the 20 cited in the SDEIS, because the proposed station volumes are larger), and another 25 trucks bringing deliveries.[1]
- Soft ground tunneling with TBMs—155 total, with 105 trucks entering and exiting the site per day on average at shaft sites to remove spoils and another 50 trucks making deliveries daily.
- Hard rock tunneling—Total of 210, with 160 trucks entering and exiting the site per day on average at shaft sites to remove spoils and another 50 trucks making deliveries.[2]

For comparison purposes, during a typical morning or evening peak traffic period, approximately 2,000 vehicles run along Second Avenue in the East 90s; of these, between 250 and 400 of these vehicles could be classified as heavy vehicles (i.e., tractor-trailers, buses, or vehicles with three or more axles).

As noted previously, it is not anticipated that spoils from two TBMs would be removed from the same location simultaneously. In most locations along the alignment, the four activities listed above would not occur at the same time. For example, slurry wall construction would be complete before cut-and-cover activities would begin. Station construction would typically not occur while that section of tunnel was being bored using a TBM. At stations located close to shaft sites from which TBM tunnel spoils are being removed, however, the TBM activities and some construction activities for the station (e.g., slurry wall construction) could occur at the same time. In this case, approximately 350 trucks would arrive at and depart from the area each day.

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[1] To be conservative, the traffic analysis in the FEIS assumes all stations would be constructed by cut-and-cover.

[2] In some rock or soil conditions, TBMs would be able to excavate spoils more quickly than in others. Therefore, on certain days, more spoils could be excavated than on others, requiring a greater number of trucks. Other variables affecting the required amount of truck movements are the length of the construction day, the number of shift changes, and the need to fix machinery (and therefore slow production). However, in all cases, the maximum amount of spoils that could be removed on any given day would be constrained by the speed at which the tunneling activity can occur. Conservative assumptions for the analyses presented in this document were made regarding the intensity with which these activities can take place.

In general, spoils removal from the open-cut stations would generally happen at a faster rate than at the stations constructed predominantly by mining. Therefore, as a rule, a greater number of spoils removal trucks would arrive at and depart from open-cut stations on a daily basis. For the Second Avenue Subway, the average number of spoils removal trucks coming and going from the open cut station at 125th Street would be the highest, at approximately 120 trucks per day, and the amount at the 116th Street Station would be lowest, at only 20 trucks per day. At most other open cut stations (106th Street, 96th Street, 34th Street, Houston Street, Grand Street, and Chatham Square, and Seaport), the average number of trucks arriving and departing for spoils transport would range from approximately 70 to 100 trucks per day for the spoils removal operations. At 55th Street, an open cut station, the number would be somewhat lower, at about 80 per day. At the various mined stations—86th, 72nd, 42nd, 23rd, 14th, and Hanover Square—the typical number of daily trucks arriving and departing would range from 60 to 70. As noted above, an additional 50 round-trip truck trips could also be needed per day at each site for materials delivery.

Once excavation and lining work for each tunnel segment or station area is complete, the construction/installation phase would begin. During this time, rail and equipment would be installed through the tunnels and platforms, mezzanines, stairwells, etc., would be constructed within the stations; and fan plants and other ancillary equipment would be installed. During this phase, an estimated 25 truck trips per day would be made to each site for delivery and removal of construction/installation materials.

Potential Truck Routes for Spoils Removal

Depending on the locations where spoils would be removed and the ultimate destination of the materials, the trucks transporting spoils and construction materials could take various routes to and from the alignment. If barges (discussed below) are not used to transport spoils generated south of Houston Street, trucks carrying spoils would travel to the closest available river crossing to exit Manhattan; the river crossings that might be used include the Willis Avenue Bridge, Third Avenue Bridge, Triborough Bridge, or Queensboro Bridge for activities north of 63rd Street; the Queens-Midtown Tunnel for activities in Midtown Manhattan; the Manhattan Bridge or Williamsburg Bridge for activities between the Houston Street and Chatham Square; and the Brooklyn-Battery Tunnel for activities in Lower Manhattan. Once out of Manhattan, the trucks would use various routes to reach their final destinations. If barges are used to bring materials to and from Pier 6, trucks or a covered above-ground conveyor system would operate between construction sites and the barge site. If trucks are used, they would travel on Gouverneur Lane or Old Slip to the barge site near Pier 6 for loading and unloading. As described in more detail immediately below, barge operations are no longer proposed at 129th Street and the East River because the site would not be available when needed during project construction. More information on how and where spoils might be managed off-site is presented later in this chapter.

SPOILS REMOVAL AND SUPPLY DELIVERY BY BARGE

The Harlem and East Rivers are relatively close to the Second Avenue Subway alignment at several locations, providing the opportunity to transport spoils and other materials to and from Manhattan by barge. To take advantage of waterborne transportation opportunities, riverfront sites were explored along most of Manhattan's East Side. Two sites initially stood out as potentially viable: at 129th Street along the Harlem River, and near Pier 6 on the East River in Lower Manhattan.

The implications of using the Pier 6 site, including dredging and other necessary permits, are discussed later in this FEIS in Chapter 15, "Natural Resources." However, since issuing the SDEIS, NYCT has decided to eliminate the barge site at 129th Street. The New York City Department of Transportation has a series of three major bridge reconstruction projects planned in the vicinity, with completion of the third bridge scheduled for October 2009. These projects will require use of the upland site needed to accommodate any planned barge activities undertaken by the Second Avenue Subway project. Consequently, the site is no longer available for use as a barge site, and has been eliminated from further consideration by the project as a barge site. If NYCDOT's plans change, this site could potentially be used as a staging area. Should NYCDOT's plans change in the future and the 129th Street (or other) barge site become available, a supplemental environmental review would be conducted.

At Pier 6, the potential barge site would likely require three (instead of two described in the SDEIS) barge cranes to be located next to the bulkhead (see Figure 3-12). These cranes would be used to load spoils and materials on or off the barges. If underground conveyors are used to transport spoils, a shaft would also have to be located near the bulkhead on the land side or in the water. Various stockpiles and construction trailers would also be needed. Approximately 12 barge trips would be made from the barge site every day. In addition, approximately three additional barges could be moored in the vicinity to store materials; this additional storage space would be needed because of the narrowness of the land between the East River and the FDR Drive at Pier 6. Details about construction needed to install the barge facility are provided below.

OPTIONS FOR MANAGING SPOILS

As described above, a total of some 6.3 million cubic yards of rock and soil would be removed from the Second Avenue Subway tunnels and station locations. This material could be transported from Manhattan to one or more disposal sites. Most of the material excavated between 92nd and 4th Streets would be clean, crushed rock, which can be reused beneficially at other locations. (The rock removed for the project is less likely to be contaminated because of both its depth and impermeability.) Reuse opportunities for uncontaminated rock could include filling abandoned mines, building artificial offshore reefs, reinforcing bulkheads, or use in road paving materials, depending on the consistency of the spoils materials. For example, crushed rock from the large water tunnel that the NYCDEP is constructing is being transported by rail to Long Island, where it is being used as base material for road construction, and by truck to Staten Island, where it is being used as cover for the Fresh Kills Landfill. NYCT would work with federal, state, and local agencies to identify reuse opportunities. Accordingly, NYCT would seek designation by the New York State Department of Environmental Conservation as a beneficial use project.

Materials excavated from soil segments of the project are more likely to be contaminated because they are typically nearer the surface, where contaminants from previous or current industrial uses can collect or be carried by groundwater. Soils are therefore less likely to be suitable for beneficial reuse, although opportunities may still exist; for example, it may be possible to reuse clean soil spoils on-site as fill. Chapter 14, "Contaminated Materials," provides more information on the procedure to be used to identify contaminated spoils and manage them at appropriate locations.

Numerous factors affect the selection of the ultimate destination of the Second Avenue Subway's spoils. The crushed rock could be used at numerous different locations, particularly since it would be removed over a period of several years. The final destination for the spoils materials cannot yet be determined, because:

- The sequence and duration of construction, and hence the timing for when spoils would be generated, has not yet been finalized.
- Only limited results of site testing to determine suitability of spoils for disposal or reuse are known at this time.
- Construction methodologies have not yet been finalized.
- It is not currently known what other large construction projects, landfill reclamations, mine reclamations, or similar opportunities, might be underway that could use fill materials generated at particular time periods in the future by the Second Avenue Subway in a beneficial manner.

The project is currently developing a spoils management plan to address the ultimate management of the project's spoils. The spoils management plan will be consistent with federal and state requirements for solid/hazardous waste management.

ANALYSIS OF POTENTIAL SHAFT SITES, STAGING AREAS, TUNNEL EXCAVATION, AND SPOILS REMOVAL SITES

As mentioned earlier, shaft sites and staging areas would be needed at several locations along the alignment where the various types of TBMs or conventional mining operations would commence and possibly where they end; where construction materials enter the tunnel; and/or wherever excavated rock and soil are removed. To minimize construction duration and community impacts, it may be possible and desirable to locate shaft sites at stations or other locations where cut-and-cover construction or ground openings would have to occur anyway. If possible, these activities should be located away from sensitive uses such as residences or community facilities. The process for selection of potential sites for these activities, and a description of the characteristics of each site, are presented below.

SITE SELECTION AND SCREENING PROCESS FOR TBM AND MINED CAVERN OPERATIONS

An investigation was undertaken to identify potential shaft sites and staging areas that might be used for the subway's construction. Given the potential for adverse environmental and community impacts at shaft sites and staging areas, identifying sites removed from residences, businesses, and community facilities was a key initial priority. However, despite extensive research, given Manhattan's overall density, finding sites that would not create any environmental impacts or neighborhood disturbance proved to be impossible. No vacant lots were located anywhere along the alignment that were large enough, dimensioned appropriately (i.e., provided enough Second Avenue frontage to support required operations) *and* located away from occupied buildings or other sensitive uses. Consequently, the investigation team instead focused on finding sites that would create the least disruptive environmental impacts and then explored construction methodologies that would take advantage of the various sites.

The task of identifying and evaluating potential shaft, staging, and spoil removal sites along the entire alignment entailed a combination of map review, field research throughout the areas where shaft and related sites appeared most likely to be needed, and supplemental research. This effort was conducted primarily from August 2001 through February 2002, although some studies continue during ongoing engineering. Generally, the process for identifying potential sites involved listing those sites that appeared potentially viable (i.e., underdeveloped) and then considering a variety of screening factors to choose the best sites. Evaluations included consideration of the following factors:

- *The suitability of each site for construction purposes.* This included consideration of the site's location in relationship to the alignment, the approximate measurements of the site, and an evaluation of how the site would function operationally.
- *Whether the sites are publicly or privately owned.* Publicly owned sites were sought, where possible, to avoid the need to acquire private property.
- *The extent to which residents and businesses might be displaced.* Because its impact would be permanent, and because it would most directly affect people's lives, residential or business displacement was considered to be a significant environmental effect. Nevertheless, in certain cases, if the only impact a potential shaft site would have is displacement, and if the alternative were identifying a site that created other significant adverse impacts, it could be preferable to displace some residents or businesses instead of creating multiple adverse impacts. In such cases, for obvious reasons, alternatives that would displace the fewest number of people were considered to be preferable.
- *The extent to which any nearby sensitive uses, such as residences, schools, houses of worship, hospitals, parks, playgrounds, and community facilities, might be adversely affected by noise and other disturbances*. Since activities occurring on the shaft sites are likely to be quite disruptive for long periods almost every day of the year, for a number of years, the project seeks to avoid locations proximate to such sensitive uses.
- *Whether the shaft sites might affect parks and playgrounds*. Parks are used by many people and are critical recreational and visual outlets for a city as compact as New York. Parks are also protected under Section 4(f) of the Federal Department of Transportation Act (see the Section 4(f) Evaluation included at the end of the main volume of this FEIS). This Act requires that properties such as parks cannot be "used" unless there is no feasible and prudent alternative to their use and all possible planning has been undertaken to minimize harm to the properties.
- *Whether the shaft sites might adversely affect historic and archaeological resources*. Certain historic and archaeological resources are also protected under Section 4(f) of the Department of Transportation Act. In addition, avoiding or minimizing impacts upon such resources is a general project goal and a requirement of the National Environmental Protection Act (NEPA) and Section 106 of the National Historic Preservation Act.
- *How existing traffic patterns and conditions could be affected—for example, reviewing whether sites would be located in areas where traffic is particularly congested*. To the degree feasible, shaft sites should not be located in places where they will exacerbate problematic traffic conditions, or where they could result in air quality impacts. This said, traffic concerns already exist in much of Manhattan and the region, and it may not be feasible to meet this condition in certain areas—particularly Midtown. The sites' proximity to bridges, highways, and tunnels that would provide easy access and egress for construction vehicles with minimal disturbance to local traffic was also evaluated.
- *The likelihood that hazardous materials are present.* Indicators of possible hazardous materials were sought based on a review of historic land use maps.

- *Other environmental concerns*. For example, given that shaft sites and staging areas could curtail sidewalk and street access adjacent to shops and businesses in certain areas for extended periods of time, consideration was given to locating such activities away from businesses. Similarly, consideration was also given to environmental justice concerns, natural resources, land use patterns, and other issues.
- *Input received through meetings with and outreach to resource agencies.* Meetings were held with the New York City Department of Parks and Recreation, The New York State Historic Preservation Office, and the New York City Landmarks Preservation Commission regarding potential project effects on existing parks or historic resources. In addition, outreach was conducted to the U.S. Army Corps of Engineers and the New York State Department of Environmental Conservation regarding permitting issues.

These environmental factors were studied at a preliminary screening level for purposes of identifying potential sites. Detailed environmental evaluations of the potential sites follow in the technical chapters included in this FEIS.

DESCRIPTION OF MOST VIABLE TUNNEL SHAFT AND STAGING SITES

Based on the factors identified above regarding construction needs and environmental priorities, the locations identified as most appropriate in view of the considerations summarized in the previous section of this FEIS were as follows. It should be noted that in addition to the sites identified below, spoils would also need to be removed at all 16 stations and at the various underground storage tracks under consideration. Shafts at certain stations or at other locations where cut-and-cover excavation would already occur would also be used to remove TBMs at the end of their runs. The sites for TBM spoils removal and staging activities are as follows:

- Trucking site along Second Avenue north of 125th Street for potential underground storage tracks constructed as part of Phase 2 (Site A);
- Trucking site at 125th Street and Third Avenue, within the right-of-way to be used during construction of Phase 2 (Site B);
- Trucking site near 96th Street or 92nd Street (Sites C, D, and E) during construction of Phase 1;
- Trucking site at 66th Street in the vicinity of the 63rd Street connector tunnels (Site F) during Phase 1's construction;
- Trucking sites near 35th and 32nd Streets (Sites G, H, I, and J) to be used during construction of Phase 3;
- Possible trucking site near Houston Street (Sites K and L), used during construction of Phase 3; and/or
- Trucking or barge sites in Lower Manhattan (Sites M, N, O, and P) during Phase 4's construction.

These sites are described below (see Figures 3-13 and 3-14). Please also see the photographs provided in Appendix C.

Site Along Second Avenue North of 125th Street

Several potential staging or shaft sites were initially identified at the northern end of the project, either used alone or in conjunction with a barging operation at 129th Street. However, with elimination of the barging operation at 129th Street and the Harlem River, most of these sites are no longer viable as significant spoils removal areas supporting tunneling operations. Additionally, with the substantial reduction in the footprint of any underground storage yard north of 125th Street (see Chapter 2), the need for large spoils removal areas in this vicinity has been substantially reduced. Finally, the New York City's Economic Development Corporation has announced plans to construct a large auto showroom complex on Second Avenue between 128th and 127th Streets, eliminating two of the sites previously considered in this area for project use.

At this time, the only site north of 125th Street being considered as a staging area for spoils removal is owned by NYCT and is located between 129th and 128th Streets on the west side of Second Avenue. This site, known as Site A (see Figure 3-13), is used for bus storage. Provided that the bus operations can be relocated, the small building currently on the site would be removed and the site used for materials storage if the 129th Street underground storage yard were to be constructed during Phase 2 of the project's construction period. Site A could also be used for trucking out of Manhattan, given its proximity to bridges and highways.

Site A would provide excellent access to the Willis Avenue, Third Avenue, and Triborough Bridges. Weight limits on these bridges would be respected. This site is also well situated to minimize disturbances to residences and businesses, as it is not adjacent to such uses. However, the noise, dust, and activities associated with construction could affect recreation in the park. be trucked directly to their ultimate destination, without using a barge to transport the spoils.

Sites at 125th Street and Third Avenue and at Second Avenue near 121st Street, both within the Right-of-Way

As described previously, the alignment in the vicinity of 125th Street has been refined since publication of the SDEIS, and the project's engineers have determined that it would be possible to reduce the amount of cut-and-cover construction needed in this area and use a dual mode (rock and soft ground) TBM instead. This requires creating a shaft to launch and retrieve the TBM and spoils generated by its operation. The least disruptive way to create the TBM shaft in this area would be to use the eastern end of the 125th Street Station box at Third Avenue to insert the TBM, which would then bore south around the curve onto Second Avenue to approximately 122nd Street, where it would be removed. A portion of the alignment immediately north of the existing tunnel segment south of 120th Street would need to be created using cut-and-cover techniques in any case, because the TBM cannot drill directly into the existing tunnel box. Consequently, the engineers have determined that the least disruptive way to create a TBM removal shaft in this area would be to extend the area of cut-and-cover construction from approximately 120th Street to midblock between 121st and 122nd Streets. In the project assessed in the SDEIS, cut-and-cover construction and excavation would have been needed in this location under any case.

At approximately 122nd Street, the TBM would be removed and reinserted at 125th Street and Third Avenue (known as Site B) for the second tunnel bore needed to complete the second tunnel. The spoils from the curved tunnels would be removed from the shaft site at 125th Street and Third Avenue as well.

In addition, to reduce the amount of cut-and-cover construction on 125th Street and to enable the lengthening of each of the tail tracks located west of the 125th Street Station, a dual mode TBM would be used to excavate through the station to the underground storage tunnels extending between the station and approximately 525 feet west of Fifth Avenue, and to remove the tunnel spoils. A TBM retrieval shaft may be built within the 125th Street right-of-way to withdraw the

TBM for a return run from the 125th Street Station box west, again requiring some cut-and-cover construction.

The sites described above would only be used during a limited period when Phase 2 of the project is being constructed, and would not be required to support any additional construction activities for the subway.

Site Near 96th Street

As described in more detail in Chapter 6, "Social and Economic Conditions," the area between 99th and 92nd Streets is predominantly residential, with the highest concentration of residential uses located south of 96th Street. In addition to some retail, the area also includes several large institutional uses, such as Metropolitan Hospital located between 99th and 97th Streets, the Islamic Cultural Center of New York between 97th and 96th Streets near Third Avenue, and a school on 96th Street between Second and First Avenues.

Overall, the area from 99th to 92nd Street must be excavated using cut-and-cover technology and a significant volume of spoils would be removed from the Second Avenue Subway alignment in this vicinity. There are three main reasons for this:

- First, the area between 99th and 98th Streets would need to be constructed by cut-and-cover construction under any case, because of the need to connect to the existing shallow tunnel in soil that begins at 99th Street.
- Second, between 99th Street and 92nd Street, the tunnel alignment would travel through soil, rather than rock; consequently, the tunnel and 96th Street Station would need to be constructed by cut-and-cover construction in this area.
- Finally, from approximately 92nd Street southward, the tunnel would be built through hard rock, making use of TBM appropriate. The northernmost point where the rock profile is close enough to the street surface to facilitate the start of the project's TBM operation to mine rock to the south is in the vicinity of 92nd Street. Consequently, some kind of shaft to launch the TBM operation is required at or near 92nd Street. As discussed above, this shaft site would need to be between two and three blocks long to launch the TBM, assuming the use of park space at Playground 96 in conjunction with TBM mining.

Because a substantial open cut would need to be made from 99th Street to 94th Street to construct the tunnel and 96th Street Station, and because another cut would need to be made between 94th and 91st Streets for the tunnel and to use the TBM, a large amount of spoils would have to be removed along Second Avenue in this area. From a cost and schedule perspective, once this cut is open (Site C), it would be most efficient if the excavated area could also be used to remove spoils excavated from the TBM as it moves south to the southernmost limit of Phase 1 at 62nd Street. The amount of spoils coming from both the open station cut area and the TBM mining operation would account for nearly 700,000 cubic yards of loose spoils—over 10 percent of all spoils generated by the Second Avenue Subway.[1] Barge operations were considered in this area but rejected given the difficulty of accessing the waterfront.

Spoils from the 99th to 91st Street vicinity would be transported using trucks. Vertical conveyors up to 40 feet in length and crane booms up to 150 feet in length would be used to lift

[1] Please see the section above entitled "Spoils Removal and Supply Delivery Options" for an explanation of why the amount of spoils has increased since the SDEIS.

spoils from the tunnels and load them onto trucks. These trucks would travel directly out of Manhattan.

In the 96th Street vicinity, a large staging area near the alignment would be necessary to manage the construction activities. This staging area would support a large variety of equipment and materials needed to build the 96th Street Station and tunnels associated with Phase 1 to the immediate north and south, including bulldozers, a substation, generators, silos or other types of storage bins to store materials, a maintenance shop for tools and machinery, a “hog house” (area where tunnel workers can shower), and compressors and water treatment areas. As described previously, some of these operations would be quite disruptive despite all of the measures that would be implemented to minimize adverse impacts. (Such measures are described in subsequent chapters.) Therefore, in addition to closing two moving lanes and one parking lane on Second Avenue to accommodate construction activities, NYCT has determined that it would be desirable to locate some of the more disruptive activities as far removed from occupied buildings as possible. Within this area, the only suitably-sized, off-road staging site not already occupied by residential buildings, a hospital, or active businesses is Site D, the western portion of the existing Playground 96 (referred to in the MESA DEIS as Manhattan Vocational Playground), a City park located between 97th and 96th Streets on the east side of Second Avenue (see Figure 3-13).[1] Only the playground immediately adjacent to the Second Avenue right-of-way would be used; the recently refurbished ballfield farther east, adjacent to the High School for Cooperative Technical Education, would not be directly affected. With the decision to build and operate the project in phases, the period of time during which the park area would be used for subway construction activities has been reduced from the 10 years identified in the SDEIS to a maximum of 8 years. By the end of 8 years, the park area would be reconstructed and restored to park use. With the exception of utility trench excavation, no subsurface disturbance is anticipated within the park’s boundaries. A wall would be constructed to separate the portion of the park where construction would occur from the remainder of the park and school to the east. In addition, ongoing communication with the school and the New York City Department of Parks and Recreation would occur to minimize disturbances to the extent feasible.

Two different construction operations would occur in the 96th Street vicinity: tunnel excavation and station construction. Following is a detailed description of how the construction would be staged within the 90s. (The term “the 90s” is used throughout the rest of this document to indicate the entire area between 99th Street and the 92nd Street vicinity that would be affected by station and tunnel construction activities.) In all cases, it is assumed that spoils from both the tunnels and 96th Street Station would be trucked from the 90s and transported out of Manhattan via a bridge to the north. Construction of all activities in this area would occur during Phase 1.

93rd to 91st Street Shaft Site. As described previously, the northernmost location where the TBM could be launched is located at approximately 92nd Street (Site E).

To launch the TBM, the first activity that would occur is utilities relocation in the area from 93rd Street to near 91st Street; this would take approximately 1 year, and would require closing up to half the width of Second Avenue. Afterwards, slurry wall construction would start in the area from 93rd Street to 91st Streets. Traffic lanes on half the width of Second Avenue would be

[1] See Chapter 7, “Public Open Space” for an assessment of impacts. Also see the “Section 4(f) Evaluation” for the parkland evaluation required by the Department of Transportation Act of 1966.

closed in this area; these lanes would be used to stage construction activities and allow trucks to queue. Many staging activities would also occur in the westernmost portion of the park between 97th and 96th Streets which would be needed to accommodate the slurry pumps, bentonite recycling facility, water treatment facility, and other equipment. Underground slurry pipes would be installed to connect the slurry operation at the park with the slurry wall excavation site to the south; some construction disturbance would occur in the area from 96th to 94th Streets due to the installation of this pipe. Workers would next excavate the TBM launch box from approximately 93rd to 91st Streets, and would continue to use the staging areas along the roadway and at the park. This would occur for approximately 2 years, while the two-block shaft in this area is built. As portions of the shaft are constructed, areas at the street level could be temporarily decked to limit dust and noise from below-ground activities, but traffic would not be permitted to traverse this area except at cross streets.

Following completion of the TBM launch box, the TBM would be installed; this process would last for about 2 months, and some adjacent side street closures might be needed during this period. As soon as the TBM is installed, it would be launched into the rock face, and would commence tunneling south. It would take approximately 1½ to 2 years to mine both tunnels south to 62nd Street, which is expected to be the southern end of Phase 1's construction. (See below for a discussion of construction sequencing.) During this period, spoils would be removed from the shaft constructed to install the TBM; at this time, spoils are expected to be removed through a vertical conveyance structure that would be located at 92nd Street. Though most spoils would be loaded onto trucks near the shaft, some spoils might be temporarily stored within the park staging area. Typically, between one to three traffic lanes on Second Avenue from 94th Street to the 91st Street vicinity would remain closed during this spoils removal period, as would the park. The lane closures would allow for truck queuing, materials storage, and a connection to the park, which would also be used for staging and storing materials.

Once the first tunnel is excavated from 92nd Street to 62nd Street, the TBM would be backed up to the launch box between 93rd to 91st Streets, where it would begin boring the second tunnel length to 72nd Street. At 72nd Street, the TBM would again be backed out to the launch box, where it would be removed, and the tracks and other tunnel finishes could be installed in the excavated areas.

Tunnel Connection to the Existing 1970s Tunnel. While spoils are being excavated from the tunnels described above, construction of the block-long tunnel linking the existing 1970s tunnel at 99th Street to the north end of the 96th Street Station box at 98th Street would also occur. This would entail relocating the utilities between 99th and 98th Streets, constructing slurry walls, and then excavating the tunnel to the required depth.

96th Street Station Construction. With completion of the tunnel between 99th and 98th Streets, construction would begin on the 96th Street Station box, which would extend from 98th Street south to connect with the TBM launch box. Once again, utilities would be relocated; this process would again last for approximately 1 year. Afterwards, excavation in the area between 98th Street and 93rd Street would commence, requiring another 1½ years of cut-and-cover construction. Finally, the station finishing phase of construction would occur over another 2 to 3 years. During this period, the park and some lanes would remain closed to provide room for construction operations and equipment.

With the construction plan described above, multiple activities would occur simultaneously within this zone. During assembly of the TBM, utility relocation for the tunnel connection to 99th Street and for the 96th Street Station box would occur; this would take approximately one year. Once the TBM is approximately half way through its first tunnel run to 62nd Street, construction of the connection to 99th Street and then the 96th Street Station box would commence from the north (including utility relocations, slurry wall installation, excavation, deck beam installation, and decking). The period during which TBM operations might occur simultaneously with slurry wall and station construction activities would last for about one year. During this time, the TBM would complete its first and second tunnel runs to 62nd and 72nd Streets, respectively.

To limit the amount of disturbance in the 90s during the year when TBM and slurry wall construction would overlap, slurry wall construction would begin at the north. Slurry wall contractors would be obligated to work on the same side of the street as the tunnel contractor. Still, up to 350 truck trips could be needed in this zone during the one-year period when construction would overlap. (For the 90s, the traffic analysis in the SDEIS assumed that open cut station excavation and TBM operations could occur at the same time, so this number is comparable to the SDEIS numbers on which the analyses were based.)

Summary of Construction Activities in the 90s. In summary, construction in the area from 99th to approximately 91st Street would require four discrete components: excavation between 93rd and approximately 91st Streets for tunnel excavation and to install the TBM; tunnel spoils removal activities from a shaft site located at 92nd Street and extending between approximately 93rd to 91st Streets, plus the park; tunnel excavation between 99th and 98th Streets to connect with the existing tunnel to the north; and station excavation and construction from 98th to 93rd Street. It is not likely that the entire eight-block area would be under construction simultaneously; however, the one-block area between 97th and 96th Streets could experience construction activity for up to 8 consecutive years, with the western portion of the park occupied for this entire time. As stated above, the chief benefit of using the western portion of the park is that it would help to minimize environmental impacts from disruptive construction operations within the area from 99th to 91st Streets.

Site in the Vicinity of the 63rd Street Connector Tunnels

As discussed in Chapter 2 of this SDEIS ("Project Alternatives"), the project would have two curved tunnels in the rock approximately 60 to 80 feet beneath private property near 63rd Street, to connect the main line Second Avenue tunnels to the 63rd Street Line. These tunnels would be constructed using mining techniques. Spoils from the two curved tunnels could be removed at the closest station locations (at the 72nd Street and 55th Street Stations), but this would mean that the relatively slow process of mining the curved tunnels would have to wait until those stations had been excavated. Spoils from these tunnels could also be excavated through the main line Second Avenue tunnels, which would mean that the curved tunnels could not be constructed until the main line was complete.

If separate spoils removal locations can be used near the curved 63rd Street connector tunnel, the construction schedule for Phase 1 would be substantially reduced. In addition, if an appropriate site for spoils removal can be found in this area, its use could shorten the length of time that a spoils site farther north would need to be used. Consequently, sites near the 63rd Street connector tunnels were reviewed.

One site was identified for possible use as a spoils removal site to remove spoils from the western 63rd Street connector tunnel (Site F). (As no adequate sites were identified for the eastern connector tunnel, spoils for this tunnel would be removed during construction of the 55th Street Station.) This site consists of a portion of the roadway right-of-way on 66th Street just west of Second Avenue, as well as an adjacent portion of Second Avenue (see Figure 3-13). This cross street is wider than most and includes a planted median separating two traffic lanes. It is a densely populated residential block, with a high-rise building and numerous six-story walk-up buildings on the north side of the block near Second Avenue, and a large mid- and high-rise apartment building lining the block on its south side. Use of the block for a shaft site and spoils removal area could be quite disruptive for residents on the block, but less disruptive from a traffic perspective than other surrounding sites, including using a wider area of Second Avenue because of its extra width and the fact that it is less trafficked than Second Avenue. However, a portion of Second Avenue would still need to be used for construction staging activities in this area.

Sites Near 34th Street

Sites were explored along Second Avenue from 57th to 29th Street to see whether siting a shaft site/staging area for removing spoils by truck in East Midtown would be possible. Benefits to using a shaft site in this area are the same as those above for the area between 66th and 60th Streets: the distance that spoils excavated as the TBM bores south would need to travel would be shortened. As in the 90s, potential barge sites were also explored along the East River in the area between 42nd Street to 29th Street, where the distance between Second Avenue and the river is relatively short. However, for a combination of reasons, including the difficulty of accessing the waterfront in this area because of several sensitive land uses such as hospitals, it was determined that fewer environmental impacts would result from trucking spoils from this area, since trucks would leave the local street network quickly and enter the Queens-Midtown Tunnel.

Two shaft sites/staging areas were identified for further consideration in East Midtown near the Queens-Midtown Tunnel; both of these sites would only be used during construction of Phase 3 of the project. The first is Site G, the western section of St. Vartan Park, between 36th and 35th Streets on the east side of Second Avenue (see Figure 3-14). This site, along with a portion of the Second Avenue right-of-way (Site H), would function as a staging area, and would operate similarly to the park between 97th and 96th Streets described above. The second site, Site I, consists of the service road between 33rd and 32nd Streets on the east side of Second Avenue, together with a portion of the Second Avenue right-of-way and a portion of 33rd Street between Second and First Avenues (Site J). If this site were used, vehicular access to the service road would be provided south of the shaft site, at 32nd Street. Spoils from either or both areas would be trucked via the Queens-Midtown Tunnel to their ultimate destination. (See Chapter 7 and the Section 4(f) Evaluation for more information on use of St. Vartan Park.) Combined, these sites would provide an adequate construction, staging, and spoils removal area.

Site Near Houston Street

Houston Street is under consideration as a possible location where mechanized boring machines could be installed or removed, and where some spoils removal could occur during construction of Phase 3 of the project. As in the 96th Street area, geological conditions require that a large cut-and-cover operation occur here in any case both to construct the Houston Street Station and possibly to insert or remove mechanized boring machines. In this area, the Second Avenue right-of-way would be used for most of the construction activities (Site K). One small site adjacent to the right-of-way, known as Site L, could be used to support those activities. That site is on the northeast corner of 1st Street and Second Avenue and is currently occupied by an Exxon gas station (see Figure 3-14 and Chapter 8, "Displacement and Relocation"). This approximately 8,600-square-foot site could be used to install or disassemble TBMs or as a staging area coupled with a portion of the right-of-way. This would be the best site in the area for use by the Second Avenue Subway, since the remaining underdeveloped or vacant parcels nearby are all slated for redevelopment in the near future (for more information of future development along the project alignment, see Chapter 6, "Social Conditions"). If development plans at those sites were to change or stall prior to their construction, one of these sites could be a viable construction staging area. No barge operations were considered in this area, given the long distance to either the East River or Hudson River.

Site in Lower Manhattan

In Lower Manhattan, an option to remove spoils by barge is being considered as part of the plan for building Phase 4 of the Second Avenue Subway. Additionally, a site on Water Street would be needed to remove spoils generated by construction of the Hanover tail tracks, and excavation of the portion of the alignment north to Houston Street.

Pier 6. Barges could operate from Pier 6 (Site O), the East River barge site near Coenties Slip that was recently used to remove debris from the World Trade Center site (see Figure 3-14). (The barging facilities used for that recovery effort have been removed.) Tunnel spoils would be removed from a shaft at the southern terminus of the alignment on Water Street near Coenties Slip (Site P) and conveyed to the Pier 6 barge site, where they would be removed by barge. At Pier 6, a docking facility for several barges would be operated.

Spoils from the alignment would be removed at the shaft site on Water Street near Coenties Slip and then conveyed to Pier 6 via trucks or a conveyor system traveling along either Gouverneur Lane or Old Slip (Sites M and N). Once at Pier 6, the spoils would be processed and removed from Manhattan. A slurry plant could be located at this site to facilitate this process.

The barging facility proposed just north of Pier 6 would involve the placement of three barge cranes; these would be fixed in the water for the duration of construction at this site, which could last for up to 7 years, the estimated total duration of Phase 4's construction. Permits from the ACOE and NYSDEC would be required before the barge facility could be constructed; Chapter 4 describes permitting issues at this site in more detail.

The Pier 6 barge facility would require one crane barge, approximately 240 feet long and 70 feet wide, adjacent to the existing bulkhead to allow vehicles to drive over the water to facilitate their loading and unloading. This barge could be fixed in place using piles or attached to the bulkhead. Pile driving equipment could be required. Two barge cranes (120 feet by 60 feet) placed to the north and to the east of this storage barge would be used to load and unload materials to and from the vehicles. Piles would also be likely used to secure these two crane barges. In addition, up to four hopper barges, two at approximately 260 feet by 50 feet and two measuring about 200 feet by 50 feet, would be temporarily moored near the barge cranes. Because these four barges would be used for transporting materials to and from the site, they would move frequently; at many points, only one or two barges would be located at the construction site at any one time. In contrast, the crane barges (storage and barge cranes) would remain as fixed platform coverage, totaling approximately 30,000 square feet, for the duration of the construction period—up to 7 years. Trucks would be used to move construction spoils from storage and construction sites to the waterway for transport.

The site's existing bulkhead could need some repair or replacement to accommodate the activities that would occur on the upland portion of the site. Detailed plans for such construction are not yet available; however, the project would likely use common replacement practices for bulkhead restoration. Depending on the type and condition of the bulkhead and relieving platform that exist currently, replacement methods could include driving steel sheet piles 18 inches outward from the existing bulkhead and then tying back the top of the sheeting to a support located landward of the new sheeting, or constructing a new high- or low-level relieving platform for support. A concrete cap could be poured in place on top of the sheeting to form a new edge, and the area behind the new sheeting would be filled with clean soil. Pile clusters might also be needed to bulkhead and to moor barges safely.

Trucking from a Shaft Located on Water Street. Another option would be to truck the spoils excavated from the Hanover Square Station directly from the station's Water Street shaft through the Brooklyn-Battery Tunnel or over the Williamsburg Bridge to their final destination. This same shaft on Water Street could be used for inserting the TBM, which would then operate northward toward Houston Street. Spoils from the tunnel north to Houston Street could be removed here as well; if so, this would require a slurry plant to be located on site. Additionally, if underground storage tracks were to be constructed south of the Hanover Square Station, the Water Street shaft site could also be used to remove spoils generated by construction of the tail tracks. Any spoils removed at this location would also be trucked through the Brooklyn-Battery Tunnel or over the Williamsburg Bridge to their final destination. All of these activities would occur as part of Phase 4 of the subway's construction period.

D. CONSTRUCTION OPTIONS FOR TUNNELS AND STATIONS

Building on the general construction techniques to be used (described in section B, above) and the locations available for shaft and staging sites (discussed in section C), the specific methods that might be used to construct the full-length Second Avenue Subway are described below. These include several different options for constructing the project, followed by a summary of the general technologies to be employed and the sequencing that might be used.

CONSTRUCTION GOALS

A number of construction scenarios have been identified to allow for analysis of a range of options that would provide flexibility to MTA and NYCT over the life of the project while still addressing the full range of likely environmental issues that could reasonably be expected. These scenarios could be "mixed and matched" with each other in different combinations; for example, boring machines could be inserted into any of the shafts identified, and spoils could also be removed at any of the locations that will be assessed throughout this FEIS. Variations to these scenarios could also occur, but these would still encompass the same basic types of activities at the sites identified in this FEIS. All of the construction options being considered in this FEIS were designed to achieve the following goals:

- Facilitate a range of alternative construction sequencing plans that will ultimately be synchronized with the project's cash flow and desired project completion date;
- Include an evaluation of all the reasonable and feasible finalist shaft sites identified in the various alternatives, although it is unlikely all would be used;
- Accommodate multiple methods of spoils removal;
- Minimize community and environmental disruptions while still permitting the project to be constructed within a reasonable amount of time and with reasonable costs; and

- Allow for the possibility of opening sections of the system for operations before construction of the whole project is complete while allowing construction to continue on the remaining sections.

CONSTRUCTION SEQUENCING PLAN

OVERVIEW

Once the design team had obtained sufficient geological and other technical information to determine which construction methods could be used to build each project element, MTA, at the request of the FTA, began to consider the feasibility of implementing incremental operating segments. This investigation also addressed public comments on construction schedule and sequencing. Given the project's 8½-mile length and its overall complexity, building and operating the new subway service in phases is the fastest way to provide many passengers with new subway service while also relieving some of the severe overcrowding on the Lexington Avenue Line.

To this end, NYCT began identifying goals around which the operating segment approach could be developed. Foremost among these goals were providing improved service to subway passengers, minimizing environmental impacts where practicable, and designing the operating phases in a way that resulted in manageable financial outlays that could be distributed across the lengthy construction period. In addition, it was determined that any interim operating segment would have to be connected initially to the 63rd Street Line to allow trains to enter the system and reach NYCT's maintenance shops,[1] although as described below, options that did not use the 63rd Street Line initially were also considered.

Upon consideration of all of these factors, a construction plan was developed with four logical operating segments that meet these criteria. These operating segments are described below under the section entitled, "The Selected Sequencing Option (Option 5)." Importantly, each operating segment would result in a new and fully functional portion of the overall subway project, and operation of each phase could begin upon completion of construction of that phase and the preceding phases. Moreover, construction of each of these phases could occur separately from construction of any other phase; once construction of a particular length of the alignment is completed, the surrounding neighborhood would not experience further impacts during construction of the additional phases. Equally important, the proposed phasing plan is extremely flexible, in that it would permit multiple phases to be constructed simultaneously. Passengers could still benefit from new subway service once the first phase is complete, and the connection to the 63rd Street Line is achieved.

Prior to selecting Option 5, however, NYCT and its engineers also considered other options for sequencing the Second Avenue Subway's construction, which can be summarized in the five

[1] The initial connection to the 63rd Street Line is essential, because aside from this connection, there is no other practical means of transporting subway cars for passenger service to the Second Avenue alignment or allowing subway cars to reach NYCT's existing maintenance facilities once the initial segment is operating. The only alternative would involve transporting subway cars to Second Avenue on trucks, and then lowering the cars onto the new subway tracks. Obviously, this alternative would both create additional disruption in the affected neighborhood, be more costly, and would not allow for effective maintenance. Therefore, alternatives that take advantage of the 63rd Street connection were identified as being preferable for the project.

broad categories below. While many of the construction methods and features would be identical under all construction sequencing options, there are also some key differences among them. Most of these differences relate to where and how spoils would be removed from the various tunnel sections, which results in differences in the overall project schedule and the locations and duration of street-level disturbances. Another important difference between the options relates to whether or not portions of the subway could be made operational while construction continues along other reaches of the alignment. As described above under the section entitled "Construction Goals," this is one of the construction goals. Ultimately, however, all of the options considered present both advantages and disadvantages.

Following is a summary of some of the options considered during the sequencing selection process. First is an overview of four options that have since been rejected. Afterwards, the selected option—Option 5—is presented in detail.

Please note that this entire section has been updated substantially since the SDEIS as a result of ongoing engineering and the decision to operate the subway incrementally while construction continues on the rest of the alignment.

SEQUENCING OPTIONS CONSIDERED BUT SUBSEQUENTLY REJECTED

Option 1: Construct the Entire Project Simultaneously

In Option 1, the entire project would be constructed at the same time. The chief advantages of this approach are that by building the entire subway at once, the project could be built most quickly (approximately 9 years), and therefore with the lowest cost in year of expenditure dollars. However, this option would also result in severe disruptions to residents and businesses along virtually the entire East Side of Manhattan for this entire period. The entire Second Avenue Subway corridor would experience lane closures, noise, and other disturbances simultaneously, resulting in significant adverse impacts along the entire alignment simultaneously and compounded disturbances. At the same time, NYCT would face tremendous procurement risks, as the prospects of obtaining enough supplies and contractors to accomplish all of the simultaneous construction activities would be uncertain. This results in corresponding financial risks. Additionally, the level of early funding needed to enter into the various contracts would be enormous. Scheduling the various pieces of construction activities to avoid conflicts among the various contractors would also be a severe challenge. For all of these reasons, this option is not considered viable.

Option 2: Construct the Alignment Sequentially, Beginning at the South

By building the alignment sequentially from the south to the north, the project could avoid many of the problems caused by Option 1. Because construction activities would proceed one at a time, in order, the impacts to the surrounding communities would be relatively low. People would be affected while the construction activity is located in their vicinity; once construction shifted to the north, for the most part, no additional activities would occur in that location. The cash demands required to build the subway in this fashion would also be relatively predictable, staggered somewhat evenly over the construction period. The problem with this methodical approach is that it would take approximately 25 years to construct the entire project, and 17 years to reach 63rd Street. No service could begin until that connection to 63rd Street is made, because without a link to the existing subway system, there would be no practicable way to get the trains operating on the Second Avenue Line into service or out of Manhattan to a maintenance facility. This very long schedule would also mean high overall costs.

Option 3: Construct the Alignment Sequentially, Beginning at the North

Building the alignment sequentially from the north to the south would pose the same advantages and disadvantages as Option 2. However, in this case, the length of time required to reach 63rd Street from 125th Street would be reduced to 13 years.

Option 4: Construct the Alignment Sequentially from the North and South and Work Toward the Middle

By working simultaneously from both ends of the alignment towards the middle, this option would result in a shorter construction period than Options 2 and 3. Overall, it would take an estimated 16 years to complete the project. While the environmental impacts to any particular area would be somewhat limited (because each area would only be disturbed once), the financial outlay required to work in this fashion would be very high because the amount of equipment and contractors needed to work in two disparate geographic areas simultaneously would essentially need to be doubled. Procurement risks would also be substantial; because of the scale of the construction operations and the geographic distance between them, contractors would generally not be able to share resources among the various sites, making it likely that more contractors would need to be hired to do the work. Given the relatively small number of contractors who would be qualified to perform the necessary tunneling work, this could limit NYCT's flexibility in negotiating with contractors during the bidding process. The other chief disadvantage of this option is that it would require completion of the entire alignment before any train service could commence.

THE SELECTED SEQUENCING OPTION (OPTION 5)

Summary

Option 5 entails building from the middle of the alignment first to take advantage of the 63rd Street connector tunnels. As with Option 4, this option would take approximately 16 years to complete. With this approach, the first construction contract would be driven by a combination of geography and the ability to get an initial segment of Second Avenue Subway service operational within the shortest time possible. In Phase 1, this option would entail using a TBM between 92nd and 62nd Streets, where the amount of rock cover is sufficient to avoid cut-and-cover construction for all tunnel construction (excluding stations). The other critical element of Phase 1 in this sequencing option would be construction of the 63rd Street connector tunnels to allow trains to access the new Second Avenue Line from the Broadway Line. In this way, portions of the new service could come on line as tunnels and some stations are completed while other areas are still under construction to the north and/or south of the operational portion of the alignment.

With Option 5, procurement risks would be lower than with Options 1 and 4 because this option would involve several smaller contracts based on geographic and/or geological parameters, combining similar tasks with manageable financial outlays. For the most part, neighborhood disruptions would be consolidated, so that most locations would only be disturbed once during the relevant station construction period. An exception would occur at several construction hubs, such as the spoils removal areas for the tunnels, where construction activities would serve larger geographic areas. Financial outlays would be more predictable and flexible than with some of the other options as well.

NYCT has determined that Option 5 would result in the greatest number of advantages and the fewest disadvantages for the overall project. However, even within Option 5, there are still numerous ways in which the alignment could be constructed. Following is the sequencing plan currently under consideration by the project's engineers.

As a general rule, except at shaft sites used for construction equipment access, which would also serve as parts of the future stations, the tunnels in rock would typically be constructed before the stations. Doing so would reduce the amount of trucking at these sites, because labor, materials, and equipment for the tunnels could be transported to and from the station sites via the tunnels instead of roads. However, the extent to which labor, equipment, and materials are brought into a station construction site via the tunnel may be limited. Using the tunnel to access station sites could cause conflicts between nearby station locations under construction at the same time, particularly if different construction contractors are working in each area. In certain areas, it may be preferable to build two adjacent stations simultaneously if this would result in lower construction costs.

As described elsewhere throughout the FEIS, no significant adverse impacts would result from the partial operation of the Second Avenue Subway under the selected sequencing plan that were not already identified for the fully operational subway. After completion of Phase 3 but before completion of Phase 4, it may be necessary to mitigate bus overcrowding in the Lower East Side south of Houston Street by adding a total two bus runs to the South Ferry and Park Row/City Hall branches of M15 local bus route and a total of five bus runs to the South Ferry and Park Row/City Hall branches of the M15 Limited bus route during the AM peak hour. NYCT would monitor bus ridership levels on each route and would increase or decrease bus service to accommodate actual ridership demands (for more information, see Chapter 5C, "Transportation—Surface Transit").

Description of the Selected Sequencing Plan

The sequencing plan currently under consideration would construct the subway in four phases, as follows:

- Phase 1: 105th Street to 62nd Street, including the tunnel connection to the 63rd Street/Broadway Line;
- Phase 2: 125th Street to 105th Street;
- Phase 3: 62nd Street to Houston Street, including the 63rd Street tunnel connection to Queens for non-passenger services; and
- Phase 4: Houston Street to Hanover Square tail tracks.

These phases are described below and illustrated in Figures 3-15, 3-16, 3-17, and 3-18.

Phase 1. The first operating segment includes three entirely new subway stations—96th Street, 86th Street, and 72nd Street—plus new Third Avenue subway entrances at the existing Lexington Avenue/63rd Street subway station. It also includes tunnels and tracks connecting the Second Avenue Line to the 63rd Street Line and on Second Avenue from 105th Street to 62nd Street, as well as a third track at the 72nd Street Station to be used for train storage or to accommodate train diversions if necessary. Phase 1 is illustrated in Figure 3-15.

There are several major advantages to including these components in Phase 1. First, once operational, this phase would serve the area with the highest residential densities in New York, and would have a ridership of approximately 202,000 passengers per day. Opening this segment would consequently provide some immediate relief to the most crowded portion of the Lexington Avenue Line north of 42nd Street in Manhattan.

Second, this phase uses infrastructure built in the 1970s, which is currently not functional, thereby maximizing the use of existing available infrastructure. This section will fulfill a necessary train storage function at relatively minimal expense. As described previously in this chapter (see "Design Refinement Criteria" under Section C, "Second Avenue Subway"), a length of tunnel already exists in the area from 105th Street to 99th Street, but this tunnel is currently unused, and has not been outfitted with tracks, signals, etc. With the relatively inexpensive addition of these elements, once the first phase is functional, this area would be used to store up to four of the trains that would be used to operate the new service. Then, once the segment to the north of this area is complete in Phase 2 (see below), these same tracks would be used for passenger service, at no additional cost to NYCT and the public.

Third, this length of subway could be completed within 7 years; assuming construction begins in 2004, this phase would be operational by 2012.

Finally, with this phase, the same people who would be affected by the construction activities required to build this phase would also be the initial beneficiaries of the new subway service.

Because this phase would link a portion of East Harlem and the Upper East Side with the existing Broadway Line at 63rd Street, passengers from those neighborhoods would be able to have a one-seat ride from their homes or businesses to Midtown (including Times Square) and, with an across-platform transfer, to Lower Manhattan. No new subway yards or maintenance facilities would need to be built in Manhattan or any other boroughs as part of this phase, because the trains serving it could access existing yards and maintenance facilities via the Broadway Line. This makes Phase 1 relatively cost-effective, because it involves only facilities that would be used directly for the service provided by Phase 1.

During construction of Phase 1, the area along Second Avenue from 105th Street to 62nd Street would experience disruptions from surface construction activities; however, the entire area would never be under construction simultaneously. Although a final construction plan has not yet been developed for this or other areas, under the current conceptual plan, the first activities likely to occur would entail the following (more information on activities in the 90s is provided earlier in this chapter, in section C, "Above-Ground Construction Activities: Shaft Sites, Staging Areas, and Spoils Removal"):

- Creating a TBM launch site between 93rd and 91st Streets. From there, the TBM would bore two tunnels to 62nd Street. All spoils generated by the TBM proceeding south from 92nd Street would be loaded into trucks at 92nd Street. Those spoils would be removed by truck for transport out of Manhattan.
- Establishing a staging area at Playground 96 to accommodate the construction activities that would occur in the 90s throughout Phase 1's construction period. As described above, this staging area may be used for up to 8 years for TBM operations, connection to the existing tunnel at 99th Street, and construction of the 96th Street Station. (While the construction period for Phase 1 is estimated to last for 7 years, an additional year may be required to restore Playground 96 once this park is no longer needed for construction operations). During TBM operations, approximately 160 trucks would drive to and from the site each day for spoils removal, and another 50 trucks might arrive at and depart from the site for deliveries.
- Excavating the area between 99th Street (where the existing 1970s tunnel starts) and 98th Street (the northernmost edge of the 96th Street Station). This would involve approximately 100 trucks driving to and from the site for slurry wall activities and another 40 trucks

bringing deliveries. For the last year of TBM operations at Playground 96, slurry wall construction could be under way at the same time. This would result in a total of approximately 350 trucks each day driving to and from the construction zone in the 90s.

- Creating the shaft site on 66th Street on the west side of Second Avenue and beginning excavation of the 63rd Street connector tunnels. The tunnels connecting the Second Avenue Subway from north of 63rd Street to the 63rd Street Line would be mined from a shaft site on 66th Street. This would be a smaller shaft that is in use for less time than the 92nd Street spoils removal shaft. On average, approximately 60 trucks per day would be needed for approximately 3½ to 4 years for the construction activity at 66th Street. The duration of the construction activities at this location has doubled since issuance of the SDEIS, and the number of trucks needed in this area has also increased.

Subsequent to these activities, the other activities required to complete Phase 1 would then be undertaken. These include:

- Excavating the 96th, 86th, and 72nd Street Station areas, including the third track at the 72nd Street Station;
- Constructing the upgrades and modifications to the Lexington Avenue/63rd Street Station, including the new station entrances. The construction in this area will include:
  - Creating a necessary construction staging area and shaft site on the northwest corner of 63rd Street and Third Avenue, where cut-and-cover construction would be required in any case to build the new entrance at this location. This would include temporarily using some street and sidewalk area and building an access shaft measuring approximately 15 feet by 30 feet;
  - Constructing a new entrance on the southeast corner of Third Avenue at 63rd Street using cut-and-cover construction techniques. This would require temporarily using two lanes of 63rd Street and some adjacent sidewalk; and
  - Building a temporary shield to be used during construction of the existing wall dividing the passenger tracks from the non-passenger tracks at this station.
- Completing all stations and tunnels, including installing tracks and station finishes and building required ancillary facilities; and
- Restoring Playground 96 and any affected roadways or other properties as described in the mitigation sections of this FEIS.

Once these activities are complete, Phase 1 could begin operations while construction commences on Phase 2, as described immediately below.

Phase 2. The second phase of operations ("Phase 2") would link the rest of the East Harlem neighborhood to the new subway service (see Figure 3-16). Like Phase 1, it would entail building three new subway stations—at 125th Street, 116th Street, and 106th Street. Tunnels and tracks would be built along 125th Street from approximately 525 feet west of Fifth Avenue to Second Avenue. On Second Avenue, connections would be made between the existing tunnel segments, so that the tunnels would connect to Phase 1 at 105th Street. This second phase would again use infrastructure created during the 1970s, since the existing tunnels between 120th and 110th Streets would be outfitted with tracks and other essential features as part of this phase. Finally, in Phase 2, the bellmouth to permit a future connection to the Bronx would also be built.

Because the tracks north of the 96th Street Station would no longer be used for storage once Phase 2 is operational, this phase would include the underground storage tracks extending west of the 125th Street Station for this purpose. (The additional track at the 72nd Street Station constructed as part of Phase 1 would continue to be available for train storage during operation of Phase 2 and beyond.) If an underground storage yard north of 125th Street on Second Avenue is included as part of the project (the 129th Street storage tracks described previously), this would also be built as part of Phase 2.

Additionally, some improvements to two of NYCT's existing yards/maintenance facilities—the 36th-38th Street Yard in Brooklyn and the Concourse Yard in the Bronx—may also be made during Phase 2. In both cases, the improvements would be confined entirely to the existing NYCT properties. At the 36th-38th Street Yard, the improvements would be limited largely to surface disturbance, although a retaining wall on the south side of the property would need to be partially reconfigured. At Concourse Yard, some tracks would be reconfigured and a new maintenance shop would be constructed to replace (and double in size) the existing facility.

During construction of Phase 2, spoils generated north of 105th Street would generally be removed at the various cut-and-cover stations and tunnel sections. Spoils from the tunnels and underground tail tracks on 125th Street would be excavated from the shaft at 125th Street and Third Avenue.

Phase 2 would support the project's purpose and need by attracting riders who currently use the Lexington Avenue Line, in particular, at the 125th Street Station. This would have the benefit of reducing the number of passengers on the Lexington Avenue Line in Manhattan. The 125th Street Station would also allow Metro-North passengers to transfer easily to the new subway system, providing a new benefit to transit riders in Westchester, Connecticut, and northern New York, as well as to reverse commuters. Ultimately, once the second phase becomes operational, over 101,000 additional subway riders would ride the new subway service each day. Combined with Phase 1, the new subway is expected to attract approximately 303,000 riders per day by the completion of this stage. As with Phase 1, the beneficiaries of Phase 2 would be the same as those affected by its construction, as well as Bronx riders that would now be able to transfer to the Second Avenue Subway at the new 125th Street Station.

Completing the Phase 2 activities described above is expected to take approximately seven years. It is possible that construction on Phase 2 could start before Phase 1 is completed.

Phase 3. In Phase 3, tunnels would be constructed from 62nd Street (the southernmost point of Phase 1) to Houston Street, and stations would be opened at 55th Street, 42nd Street, 34th Street, 23rd Street, 14th Street, and Houston Street (see Figure 3-17). During this phase, the 63rd Street tunnel connection to Queens for non-passenger services would also be completed. Completion of this phase would yield an operating system that would stretch from the 125th Street Station to Houston Street, and passenger service would be provided on both the Broadway and Second Avenue Lines. With completion of this phase, over 75 percent of the subway alignment would be operational, and approximately 456,000 daily passengers, an addition of 153,000 trips per day, would ride the subway line.

Another important component of Phase 3 involves construction of two additional storage tracks in the area between approximately 21st and 9th Streets. These tracks would be used to store trains during the operation of Phase 3, and also once the entire alignment is completed, similar to the storage tracks at 129th, 125th and 72nd Streets that would be built as part of Phases 1 and 2.

Trains would continue to use the Broadway Line to access existing maintenance facilities as required.

Because Phase 3 is the longest of the four operational segments, its construction is expected to take approximately 9 years. It is likely that construction on Phase 3 would start before Phases 1 and 2 are completed.

During construction of Phase 3, a major locus of activity would be at the shaft sites/staging areas in the 30s. As described above, portions of St. Vartan Park and an existing service road between 33rd and 32nd Streets, plus a portion of the adjacent Second Avenue roadway, would be used to launch the TBMs that would be used to excavate the tunnels between 62nd Street and the 30s, as well as the tunnels from the 30s to 4th Street. St. Vartan Park would also be used as a staging area for activities related to excavating both these tunnels and the 34th Street Station. By locating activities near the Queens-Midtown Tunnel, the project can minimize the number of trucks that would otherwise need to travel on local Manhattan streets.

To excavate the tunnels, a TBM would first be launched in the 30s. It would then head north to 62nd Street. Upon reaching the completed Phase 1 tunnels, the TBM would be backed up to the 55th Street Station area, where it would be removed, reassembled in the 30s, and then relaunched to bore the second tunnel north to 62nd Street. Once again, the TBM would be removed and brought back to the 30s, where it would next excavate the tunnels—including the storage tunnels between 21st and 9th Streets—south to 4th Street. In total, the shaft sites/staging areas in the 30s would be used for up to 8 years. Approximately 180 trucks would arrive and depart each day to transport spoils from and deliver materials to this area during the peak tunnel excavation period.

The excavation at the Houston Street Station could also be used as a shaft for insertion of the TBM, tunneling support, and spoils removal, and/or for removal of the TBM used to construct the rock tunnels in Phase 3.

Once the tunnels north to 62nd Street are completed, conventional mining of the 63rd Street connection for non-passenger service to Queens would occur from the 55th Street Station box or from the 36th Street TBM launch site/staging area. Next, construction on the 55th and 42nd Street Stations could occur. Similarly, the 34th, 23rd, 14th, and Houston Street Stations would be built once the tunneling operation is completed in this area. Spoils from each station would be removed and trucked away directly from each station.

Phase 4 (Completion of the Full-Length Second Avenue Subway). The final segment in the project is Phase 4, which would extend from Houston Street to south of the Hanover Square Station. It includes new stations at Grand Street, Chatham Square, Seaport, and Hanover Square, as well a fully reconstructed Grand Street Station on the existing B D service at Grand Street. The components of this phase are illustrated in Figure 3-18. Phase 4 alone is expected to serve over 103,000 additional passengers daily, for a total of 560,000 daily passengers when added to the other three phases. Construction of Phase 4 would take approximately 7 years to complete, and its construction would likely overlap with that of Phases 2 and/or 3. With the completion of Phase 4, the Second Avenue Subway would be fully operational,

As part of Phase 4, all tracks and systems from Houston Street to the Hanover tail tracks would also be completed. As described in further detail below under the section entitled "Second Avenue Subway: Storage and Maintenance Facilities," the Hanover tail tracks would be used both to provide for train storage and to facilitate a possible extension of the Second Avenue Subway to Brooklyn.

In Phase 4, a temporary barge facility would also be built at Pier 6 to facilitate the removal of station and tunnel spoils associated with Stage 4. This facility would only be used during construction of Stage 4, and would be removed subsequent to its completion. The barge facility is described in greater detail earlier in this chapter, and its environmental impacts are assessed throughout this FEIS.

The boundaries of Phase 4 were largely determined by geological conditions. Almost all of Phase 4 would be constructed in soil, as opposed to rock, which is the case along most of the rest of the alignment. Consequently, different machines are needed to excavate the tunnels in this area than those that would be used in Phases 1, 2, and 3.

As described in Chapter 2 ("Project Alternatives"), the area immediately south of the Houston Street Station was a focus of study because of the construction difficulties inherent in this area. With the selection of the Deep Chrystie Option, a dual mode, rock and soft ground TBM would be used to construct all the tunnels between Houston Street and the Hanover Square Station vicinity. This would require tunneling beneath the existing B D lines and Grand Street Station along Chrystie Street, and beneath the J M Z lines at Delancey Street. The TBM would be installed in soil at a shaft site in rock in the vicinity of the Hanover Square Station to allow mining to the north to just south of the Houston Street Station. Spoils would be removed from the Water Street shaft site. Tunnel spoils would be trucked or moved by above-ground conveyor a short distance to the potential barge site at Pier 6. A combination of trucks or barges could be used. If trucks are used to remove the spoils, approximately 100 10-cubic-yard trucks on average per day would be needed at the Hanover Square shaft site to handle spoils removal from the stretch of tunnel created to the north.

Summary

While the phasing plan described above has now been identified, final decisions about how to sequence specific elements of the Second Avenue Subway have not yet been made. However, it is expected that construction activity would begin in 2004, peak in approximately 2010, and conclude in approximately 2020. These projected timeframes are contingent on the extent of available funding and on whether concurrent tunneling can occur in several locations simultaneously.

Table 3-1, below, lists the construction activities anticipated to occur in each phase of the project by location, from north to south. These activities are also illustrated in Figure 3-19.

E. OTHER CONSTRUCTION ELEMENTS

In addition to the work required to construct new tunnels and stations described in detail above, the project would also require some other construction work related to connections to existing stations and to the storage tracks and maintenance facilities that would be used by Second Avenue Subway trains.

CONNECTIONS TO EXISTING STATIONS

As described in Chapter 2, "Project Alternatives," the project would require some construction at existing stations where connections or transfers are proposed. Connection work could require disruptions to existing stations. Transfers would consist of underground passageways connecting the new and existing lines. Construction of the transfer tunnels would most likely be done by a combination of cut-and-cover and shielded mining during construction in stations.

Table 3-1
Description of Likely Construction Methods

From[1]	To[1]	Activity	Typical Construction Activity
Phase 2 Construction Activities			
525 feet west of Fifth Ave on 125 St	450 feet west of Fifth Ave on 125th St	Cut and cover (shaft site for TBM retrieval)[2]	Underground boring Utility relocation Pile installation Excavation of street to depth sufficient to permit decking to be installed and to retrieve TBM Transfer of materials through shaft opening Trucking of TBM components
450 feet west of Fifth Ave on 125 St	Park Avenue on 125 St	Bored tunnel[2]	Underground boring
Park Ave on 125 St	Third Ave on 125 St	Cut and cover station (125th Street)	Underground boring Spoils removal Pile installation Excavation of street to depth sufficient to permit decking to be installed and to construct station Transfer of materials through shaft opening Trucking
Third Ave on 125 St	Third Ave on 125 St	Cut and cover (shaft site for TBM launch and spoils removal for curve and tail tracks)	Underground boring Utility relocation Construction of retaining walls (e.g., slurry wall) Pile installation Excavation of street to depth sufficient to permit decking to be installed and to launch TBM Transfer of materials through deck opening Spoils removal Trucking
129 St	122 St	Cut and cover tunnel (storage tracks)[2]	Utility relocation Construction of retaining walls (e.g., slurry wall) Pile installation Excavation of street to depth sufficient to permit decking to be installed and to construct storage tracks Spoils removal Trucking
Third Ave at 125 St	122 St	Soft ground bored tunnel	Underground mining Ground improvement

Table 3-1 (cont'd)
Description of Likely Construction Methods

From[1]	To[1]	Activity	Typical Construction Activity
Phase 2 Construction Activities (Cont'd)			
122 St	120 St	Cut and cover (tunnel and TBM retrieval)	Utility relocation Construction of retaining walls (e.g., slurry wall) Pile installation Excavation of street to depth sufficient to permit decking to be installed, to construct tracks, and to retrieve TBM Transfer of materials through deck opening Trucking
120 St	119 St	Existing tunnel	None
119 St	115 St	Cut and cover station (116th Street)	Utility relocation Construction of retaining walls (e.g., slurry wall) Pile installation Excavation of street to depth sufficient to permit decking to be installed and to construct station Transfer of materials through deck opening Spoils removal Trucking
115 St	110 St	Existing tunnel	None
110 St	108 St	Cut and cover tunnel	Utility relocation Construction of retaining walls (e.g., slurry wall) Pile installation Excavation of street to depth sufficient to permit decking to be installed and to construct tracks
108 St	105 St	Cut and cover station (106th Street)	Utility relocation Demolition of existing station wall Construction of retaining walls (e.g., slurry wall) Pile installation Excavation of street to depth sufficient to permit decking to be installed and construct station Transfer of materials through deck opening Trucking
Phase 1 Construction Activities			
105 St	99 St	Existing tunnel	Demolition of some existing walls Construction of new walls Trucking
99 St	98 St	Cut and cover tunnel	Utility relocation Construction of retaining walls (e.g., slurry wall) Pile installation Excavation of street to depth sufficient to permit decking to be installed and to construct tracks

Table 3-1 (cont'd)
Description of Likely Construction Methods

From[1]	To[1]	Activity	Typical Construction Activity
Phase 1 Construction Activities (Cont'd)			
98 St	94 St	Cut and cover station (96th Street)	Utility relocation Construction of retaining walls (e.g., slurry wall) Pile installation Excavation of street to depth sufficient to permit decking to be installed and to construct station Transfer of materials through deck opening Trucking
97 St	96 St	Construction support and staging site (Playground 96)	Various staging processes and tunneling support facilities
94 St	92 St	Cut and cover shaft site	Utility relocation Construction of retaining walls (e.g., slurry wall) Pile installation Excavation of street to depth sufficient to permit decking to be installed and launch and retrieve TBM
		Shaft site	Spoils removal Trucking
92 St	87 St	Bored tunnel in rock	Underground boring
87 St	83 St	Bored tunnel in rock	Underground boring
		Mined station (86th Street)	Underground horizontal blasting to create cavern Vertical blasting to create shafts Openings to bring materials in and out and to create station entrances Spoils removal Trucking
		Cut and cover station component (86th Street)	Utility relocation Construction of retaining walls (e.g., slurry wall) Pile installation
83 St	73 St	Bored tunnel in rock	Underground boring
73 St	69 St	Bored tunnel in rock	Underground boring
73 St	69 St	Mined station (72nd Street)	Underground horizontal blasting to create cavern Vertical blasting to create shafts Openings to bring materials in and out and to create station entrances Spoils removal Trucking and other activity
		Cut and cover station component (72nd Street)	Utility relocation Construction of retaining walls (e.g., slurry wall) Pile installation

Table 3-1 (cont'd)
Description of Likely Construction Methods

From[1]	To[1]	Activity	Typical Construction Activity
Phase 1 Construction Activities (Cont'd)			
69 St	62 St	Bored tunnel in rock	Underground boring Underground drill and blast Ground stabilization (65th to 62nd Street)
65 St	63 St	Mined tunnel (63rd St connector—curve west)	Underground drill and blast Vertical blasting to create shaft site at 66th Street/Second Avenue Spoils removal Trucking
Phase 3 Construction Activities			
63 St	61 St	Mined tunnel (63rd St connector—curve east)	Underground drill and blast
62 St	52 St	Bored tunnel in rock	Underground boring
		Cut and cover station (55th Street)	Utility relocation Construction of retaining walls (e.g., slurry wall) Pile installation Excavation of street to depth sufficient to permit decking to be installed and to construct station Transfer of materials through deck opening Spoils removal Trucking
52 St	45 St	Bored tunnel in rock	Underground boring
45 St	41 St	Bored tunnel in rock	Underground boring
		Mined station (42nd Street)	Underground horizontal blasting to create cavern Vertical blasting to create shafts Openings to bring materials in and out and to create station entrances Spoils removal Trucking
		Cut and cover station component	Utility relocation Construction of retaining walls (e.g., slurry wall) Pile installation
41 St	36 St	Bored tunnel in rock	Underground boring

Table 3-1 (cont'd)
Description of Likely Construction Methods

From[1]	To[1]	Activity	Typical Construction Activity
Phase 3 Construction Activities (Cont'd)			
36 St	33 St	Bored tunnel in rock	Underground boring
		Cut and cover station (34th Street)	Utility relocation Construction of retaining walls (e.g., slurry wall) Pile installation Excavation of street to depth sufficient to permit decking to be installed and to construct station Transfer of materials through deck opening Spoils removal Trucking
		Construction support and staging site (St. Vartan Park)	Various staging processes and tunneling support facilities
		Shaft site at 35th and 32nd Sts (TBM insertion and spoils removal)	Spoils removal Trucking
33 St	26 St	Bored tunnel in rock	Underground boring
26 St	23 St	Bored tunnel in rock	Underground boring
		Mined station (23rd Street)	Underground horizontal blasting to create cavern Vertical blasting to create shafts Openings to bring materials in and out and to create station entrances Spoils removal Trucking and other activity
		Cut and cover station component (23rd Street)	Utility relocation Construction of retaining walls (e.g., slurry wall) Pile installation
23 St	15 St	Bored tunnel in rock	Underground boring
15 St	11 St	Bored tunnel in rock	Underground boring
		Mined station (14th Street)	Underground horizontal blasting to create cavern Vertical blasting to create shafts Openings to bring materials in and out, and to create station entrances Spoils removal Trucking and other activity
		Cut and cover station component (14th Street)	Utility relocation Construction of retaining walls (e.g., slurry wall) Pile installation

Table 3-1 (cont'd)
Description of Likely Construction Methods

From[1]	To[1]	Activity	Typical Construction Activity
Phase 3 Construction Activities (Cont'd)			
11 St	4 St	Bored tunnel in rock	Underground boring
4 St	Houston St	Cut and cover station (Houston Street)	Utility relocation Construction of retaining walls (e.g., slurry wall) Pile installation Excavation of street to depth sufficient to permit decking to be installed and to construct station Transfer of materials through deck opening Trucking
		Possible shaft site	Spoils removal Trucking
Phase 4 Construction Activities			
Houston	Delancey	Bored tunnel in soil	Cut and cover to remove steel piles and TBM Underground boring
Delancey	Hester	Bored tunnel in soil	Underground boring
Delancey	Hester	Cut and cover station (Grand Street)	Utility relocation Construction of retaining walls (e.g., slurry wall) Pile installation Excavation of street to depth sufficient to permit decking to be installed and to construct station Transfer of materials through deck opening Trucking
Hester	Pell	Bored tunnel in soil	Ground improvement Cut and cover construction to remove steel piles Underground boring
Pell	Madison	Bored tunnel in soil	Underground boring
		Cut and cover station (Chatham Square)	Utility relocation Construction of retaining walls (e.g., slurry wall) Pile installation Excavation of street to depth sufficient to permit decking to be installed and to construct station Transfer of materials through deck opening Trucking
Madison	Dover	Bored tunnel in soil	Underground boring Underpinning beneath certain Brooklyn Bridge approach ramps
Dover	John	Cut and cover station (Seaport Station)	Utility relocation Construction of retaining walls (e.g., slurry wall) Pile installation Excavation of street to depth sufficient to permit decking to be installed and construct station Transfer of materials through deck opening Trucking

Table 3-1 (cont'd)
Description of Likely Construction Methods

From[1]	To[1]	Activity	Typical Construction Activity
Phase 4 Construction Activities (Cont'd)			
John	Wall	Bored tunnel in rock	Underground boring Ground stabilization (John Street to Maiden Lane)
Wall	Coenties Slip	Bored tunnel in rock	Underground boring
		Mined station (Hanover Square)	Underground horizontal blasting to create cavern Vertical blasting to create shafts Openings to bring materials in and out and to create station entrances Spoils removal for stations, tunnels, and tail tracks Trucking and other activity
		Cut and cover station component (Hanover Square)	Construction of retaining walls (e.g., slurry wall) Pile installation Utility relocation
Coenties Slip	Broad	Bored tunnel in rock (storage tracks)[2]	Underground boring or mining
Pier 6 on East River		Barge operation for spoils removal	Possible bulkhead repairs Installation of piles Placement of barge cranes Operation of barges transporting spoils and materials
Broad	South	Bored tunnel in rock[2]	Underground boring or mining
Whitehall		Cut and cover construction for ancillary facility [2]	Utility relocation Construction of retaining walls (e.g., slurry wall) Pile installation Excavation of street Transfer of materials through deck opening Trucking

Notes:
[1] Unless otherwise stated, construction would occur on the extended Second Avenue corridor at the indicated cross-street.
[2] Construction in these areas would only occur if train storage tracks are constructed.
This table has been revised for the FEIS to reflect design refinements.

This work would be as follows:

- Transfer to the Metro-North Railroad Station at 125th Street would be created at the western end of the new 125th Street Station. Stairs, escalators, and an elevator from the new subway station would lead to the Metro-North station. Existing staircases at the Metro-North station could be affected for short periods during construction. Protective measures (described earlier) would be used to support the Metro-North viaduct during construction.
- The transfer to the Lexington Avenue Line 4 5 6 at 125th Street would be built beneath the existing Lexington Avenue Station structure through a new lower-level mezzanine that would connect to the existing downtown platform level and the direct connection to the upper mezzanine stairways would be reconfigured. Within the station, some disruptions would occur for existing passengers as extensive construction work would occur within the

station. This work would be conducted primarily during late nights and weekends for up to a year. All work on this station would occur during Phase 2.

- The Second Avenue Subway's Broadway Line service would use the existing Lexington Avenue/63rd Street Station. Portions of the existing Lexington Avenue/63rd Street Station must be completed before the station can serve the proposed new subway service; hence, as described above, they would be undertaken during construction of Phase 1. The station is structurally complete, but the two platform levels are currently only finished on the south side, and are separated from the unfinished portions by a partition. Most of the finish work for the north side of the platform, serving Tracks 3 and 4, can be done with the partition in place without affecting current operations. After the work behind the partition is completed, temporary barriers would be placed to allow the remaining center portions of the platform to be completed with only minor inconvenience to passengers.

  The Third Avenue entrance at the Lexington Avenue/63rd Street Station is also structurally complete but unfinished. It does not include wall and floor finishes, lighting, signs, escalators, etc. At the time of the Lexington Avenue/63rd Street Station's original construction in the early 1980s, street-level entrances were built within the sidewalk area at the northeast, northwest and southwest corners of Third Avenue and 63rd Street. In addition, another entrance on the southeast corner was designed to come up into private property. These have been temporarily sealed with a concrete slab, and remain available. The Second Avenue Subway could use some or all of these entrances from the Third Avenue end of the station with minimal new construction. Some disruption to sidewalk areas near Third Avenue would occur when the new entrances are created.

- The proposed connection between the south end of the new 55th Street Station on the Second Avenue Subway and the Lexington Avenue/53rd Street Station's E V lines would be constructed using either cut-and-cover or shielded mining techniques. Some construction would also be required within the existing station. This work would be performed during Phase 3.

- The proposed pedestrian tunnel connecting the Second Avenue Subway station at 42nd Street with the 42nd Street/Grand Central Terminal Station on the Flushing Line (7) would require construction along 42nd Street between Second Avenue and the west side of Third Avenue. This new approximately 900-foot tunnel would be mined beneath 42nd Street, requiring slow and difficult construction. Significant construction could be needed within the existing 7 station to provide adequate capacity and ADA access for this transfer. Cut-and-cover construction would also be needed for vents and emergency egress facilities. This work would also be part of Phase 3.

- The proposed connection to the 14th Street Station on the Canarsie Line (L) currently under consideration would require a 200-foot-long passageway between Second and Third Avenues, and would be built during Phase 3.

- The construction of the connection between the Second Avenue Subway at Houston Street and the F V trains on the Sixth Avenue Line would require some construction activity at the existing station during Phase 4.

- The transfer to the Grand Street Station on the B D Line would require a mezzanine below the existing station that would permit a vertical transfer to the new Second Avenue Subway platform. In addition, the existing Grand Street Station would have to be reconstructed during construction of Phase 4 to safely accommodate the anticipated large number of passengers transferring between the existing Grand Street Station platforms and the new Second Avenue Subway platforms.

YARDS AND MAINTENANCE FACILITIES

In addition to work on station and tunnel infrastructure, construction of maintenance support facilities would be required for the new Second Avenue Subway. Several alternatives for train storage and for inspection and maintenance are under consideration. As described in Chapter 2, a new storage yard in Coney Island is no longer under consideration by the project. Construction work for the alternatives still under consideration is described below.

NEW 129TH STREET STORAGE TRACKS AND 125TH STREET STORAGE TRACKS

New underground storage tracks are under consideration both north of 125th Street on Second Avenue and west of the new 125th Street Station at Park Avenue. Both of these elements would be built as part of Phase 2 of the construction process. The tracks on Second Avenue would have to be constructed using cut-and-cover techniques, while those west of the 125th Street Station would be built using mechanized mining techniques. During construction of the tracks on Second Avenue, it would be necessary to close portions of 125th Street and Second Avenue near some of the Triborough Bridge ramps. As discussed in Chapter 5, "Transportation," NYCT would work with MTA Bridges and Tunnels to minimize traffic impacts in this area.

NEW UNDERGROUND STORAGE TRACKS BETWEEN 21ST AND 9TH STREETS

Underground tracks are now planned between approximately 21st and 9th Streets. Examination of the alignment in the vicinity of 23rd to 9th Streets has demonstrated that the rock profile (depth) in this area is sufficient to allow two additional tracks to be constructed adjacent to the east and west sides of the main alignment to provide for storage of up to 8 trains. These tracks would be built using TBMs during Phase 3's construction. No surface disturbances would be required except those needed in any case to build the 23rd and 14th Street stations, and for a tunnel vent facility on the west side of Second Avenue between 23rd and 22nd Streets, which would need to be larger than that required for the 23rd Street Station only.

NEW UNDERGROUND STORAGE TRACKS SOUTH OF HANOVER SQUARE STATION

As described above, since issuing the SDEIS, ongoing engineering studies have resulted in a recommendation that two tail tracks be constructed south of the Hanover Square Station in order to provide for storage of up to four trains. The tracks would be constructed deep below ground at a depth of approximately 110 feet along Water Street using a TBM. A vent facility would be located at a traffic island located at Water and Whitehall Streets, requiring cut-and-cover construction. All of this work would occur as part of Phase 4 of the project's construction period.

ALTERATIONS AT OTHER EXISTING SUBWAY YARDS

If the 36th-38th Street Yard were used to provide storage for Second Avenue trains, some improvements would be required within the existing yard; these improvements would be made during Phase 2. Construction on the yard would be limited largely to surface disturbance, although a retaining wall on the south side of the property would need to be partially reconfigured.

At Concourse Yard, some tracks would be reconfigured and a new maintenance shop would be constructed to replace (and double in size) the existing facility. This would also occur during Phase 2. This new facility could be constructed in the same location as the existing shop, necessitating disruptions to existing operations at Concourse Yard. During continuing engineering for the Second Avenue Subway, the feasibility of removing the shop from service during construction of the new shop will be investigated, should this Concourse Yard option be selected for advancement. This new, larger shop would extend over existing yard tracks, also changing the train operations at Concourse Yard. Alternatively, a new shop could be constructed at Concourse Yard in an area now occupied by storage tracks, which would allow the existing shop to remain in service during construction of the new shop. This would, however, seriously limit storage capacity during construction until new storage could be constructed in the site of the existing shop. These issues will be explored in further detail if the Concourse Yard shop is selected for further study. If any of these proposals were to advance, the necessary construction would occur during Phase 2.

At 207th Street Yard, construction would occur within the existing maintenance shop, to expand its capacity. The 207th Street maintenance shop is a six-track shop that serves 215 cars of the A line. This shop is scheduled for reconstruction starting in 2007 independent of the Second Avenue Subway project, and the adjacent overhaul shop is scheduled to be rehabilitated starting in 2003. A design for this expansion will be developed during the continuing engineering process.

F. ACCESS LIMITATIONS AND DISPLACEMENT DURING CONSTRUCTION

During construction, it would be necessary to limit or curtail vehicular and pedestrian access in certain areas to ensure public safety and to accommodate the variety of machinery, storage areas, and construction activities that would occur. Generally, the method of construction would determine the extent of access limitations that would occur along the various lengths of the alignment. In most cases, access would be provided to residential and commercial buildings, including retail businesses, at all times. However, in limited areas, it would be necessary to restrict access to buildings for periods ranging from several hours to up to 6 months. Temporary displacement for up to one year is possible in isolated locations as described immediately below.

As described above, at present, the only place where long-term but temporary displacement during the construction period has been specifically identified is at the curve connecting 125th Street with Second Avenue. This location is sensitive because it is the only location along the alignment where construction would need to travel directly beneath buildings supported on shallow-founded timber frames resting on poor quality soils. While it might be possible for some occupants of 9 of the 10 buildings located on the southwest corner of Second Avenue at 125th Street to remain in place during construction through the use of various protective measures, the FEIS conservatively assumes that all of these buildings' occupants would need to relocate temporarily during the construction period. The duration of such displacement would be up to 12 months. More information on legal requirements, including compensation, provided for displaced residents and businesses is provided in Chapter 8.

In other locations, construction might need to occur within the basements of certain buildings. Though access to the ground and upper floors would generally be provided, access to some basement areas might be temporarily restricted. In such cases, it is not anticipated that NYCT will need to acquire buildings or permanently displace residents and businesses from buildings adjacent to the construction work. However, as mentioned above, at the 125th Street curve, businesses and residents may have to relocate for up to 12 months due to safety concerns or significant access restrictions. It is possible that some businesses and residents at the 125th Street curve would choose not to return to their former building locations, and that some businesses could be displaced permanently. NYCT would make extensive efforts to avoid such displacement. Please see Chapter 8, "Displacement and Relocation," for more information.

In certain areas, the need to close traffic lanes and sidewalk areas at various times will result in temporary restrictions to vehicular and pedestrian access. The extent of these disruptions will depend on the type of construction required. For example, in areas where construction would occur entirely below ground, little, if any, disruptions to pedestrian or vehicular access would occur. In contrast, in areas where slurry wall and cut-and-cover construction is necessary to build the tunnels or stations, traffic lane closures or sidewalk narrowing could last from less than 6 months to approximately 4 years. (The longer durations would generally occur where stations would be constructed.) Sidewalk narrowings in limited areas, such as near shaft sites, could last up to 8 years. During this time, vehicles would be prohibited from stopping, standing, or parking alongside construction sites, and bus stops located within affected areas would be temporarily relocated. Possible reductions in sidewalk width to as narrow as 5 feet could also occur, as could some minor detours around construction equipment. Except in the very limited cases described below, it is expected that pedestrian access to buildings would be maintained at all times. However, drop-offs and deliveries for both residences and businesses as well as some bus stops may have to be relocated to nearby points outside of the construction areas.

At the various shaft sites and spoils removal areas, access disruptions would be similar to those discussed above for cut-and-cover construction, though they could be longer in certain cases—chiefly, at the spoils removal areas in the 90s, 30s, the Houston Street vicinity, and on Water Street near Coenties Slip. Pedestrian access to some residential and commercial buildings in these areas (Second Avenue from 99th to approximately 91st Street, 36th to 32nd Streets, from 6th to Houston Streets, and on Water Street between Wall Street and Coenties Slip) might have to be provided through protected portions of the construction zones and on temporary pedestrian walkways. Vehicular access to these areas would also be restricted for longer durations than with typical cut-and-cover activities.

In some cases, where tunneling beneath buildings or other structures (such as the viaduct at the Metro-North 125th Street Harlem Station) would be necessary, a variety of protective measures may be applied. These include rockbolts, jacking, compensation grouting and other ground improvement techniques, internal bracing, and external trusses. (For information on where measures could be required, see the section above entitled "Protective Measures to Support Existing Structures.")

As described in other chapters of this FEIS, a variety of measures would be taken to minimize the effects of access restrictions on residential and commercial properties. For example, in each zone where heavy construction would occur (such as at station locations, cut- and-cover tunnel construction areas, and shaft sites), a detailed analysis would be conducted prior to any construction to consider the access needs of the affected properties, and a plan would be prepared that responds to the specific needs of the individual properties to the degree possible. At this early stage in project design, it is not feasible to provide specific proposals for each construction zone, but it should be understood that a number of elements will be considered.

First, uninterrupted pedestrian access would be provided to nearly all properties throughout the construction period via safe and protected routes. Methods for providing access would generally focus on keeping the property's normal principal entrance in service during construction. In instances where buildings have workable alternative entrances that can provide safe and functional service to pedestrians, these secondary entrances might be used at certain stages of the construction period. If needed, special signage would be provided to direct pedestrians to buildings and businesses within the construction zone. NYCT and its contractors will adhere to all applicable safety codes and regulations governing pedestrian facilities in construction zones.

Second, because vehicular access to curb areas in front of businesses along the alignment would be interrupted in the construction zones, consideration regarding the effects of these interruptions will be thoroughly evaluated in the analysis on access needs, and measures would be employed to reduce such disturbances. These may include creation of new drop-off and loading areas on nearby cross streets for use by residents and businesses, and special signage if needed. The potential to employ alternative entrances would also be considered in the analysis.

Third, the access evaluation plan and the resulting mitigation program would be developed in close consultation and coordination with affected residents and businesses. In addition, as construction progresses, if any specific issues arise that require modifications to the access system, NYCT and its contractors would continue to communicate with local residents and businesses to ensure that concerns are addressed promptly.

G. IMPROVEMENTS FOLLOWING CONSTRUCTION

When construction of the new subway is complete, all streets, sidewalks, parks, and other areas that were disturbed by construction would be returned to normal or improved condition. As work at a particular station or excavation site is completed, streets and sidewalks would be reconstructed and repaved. This reconstruction would be conducted in coordination with NYCDOT and any other relevant city agencies. As part of this effort, street furniture would also be replaced and updated in coordination with NYCDOT.

All parks used during construction would be restored following completion of construction activities in the park. This work would be conducted in consultation with the New York City Department of Parks and Recreation (NYCDPR). NYCT would work with NYCDPR to design and fully restore all affected parks after subway construction in the area of each park is complete. The replacement amenities would be designed to meet current recreational demands in the area. Any trees in parks and along streets that had to be removed during construction would be replaced, in consultation with NYCDPR. Trees would be replaced according to NYCDPR's basal area replacement formula, as described in Chapter 7. NYCT would consult with NYCDPR regarding identifying tree replacement species, with consideration of whether maturation height would be affected by subway construction. NYCT would make every practicable effort to ensure that future tree replacement would not be constrained by subsurface or surface subway elements or activities.

At the potential barge site at Pier 6, the barges and other construction equipment would be removed after their use is no longer necessary. However, this facility could potentially be retained, if appropriate for another public use.

Overall, once the subway construction is complete, all construction sites would be fully restored and those improvements would remain in place. The subway stations, vent structures, and other subway facilities would become a permanent part of the city's infrastructure, in combination with the other elements of the urban environment. ✷